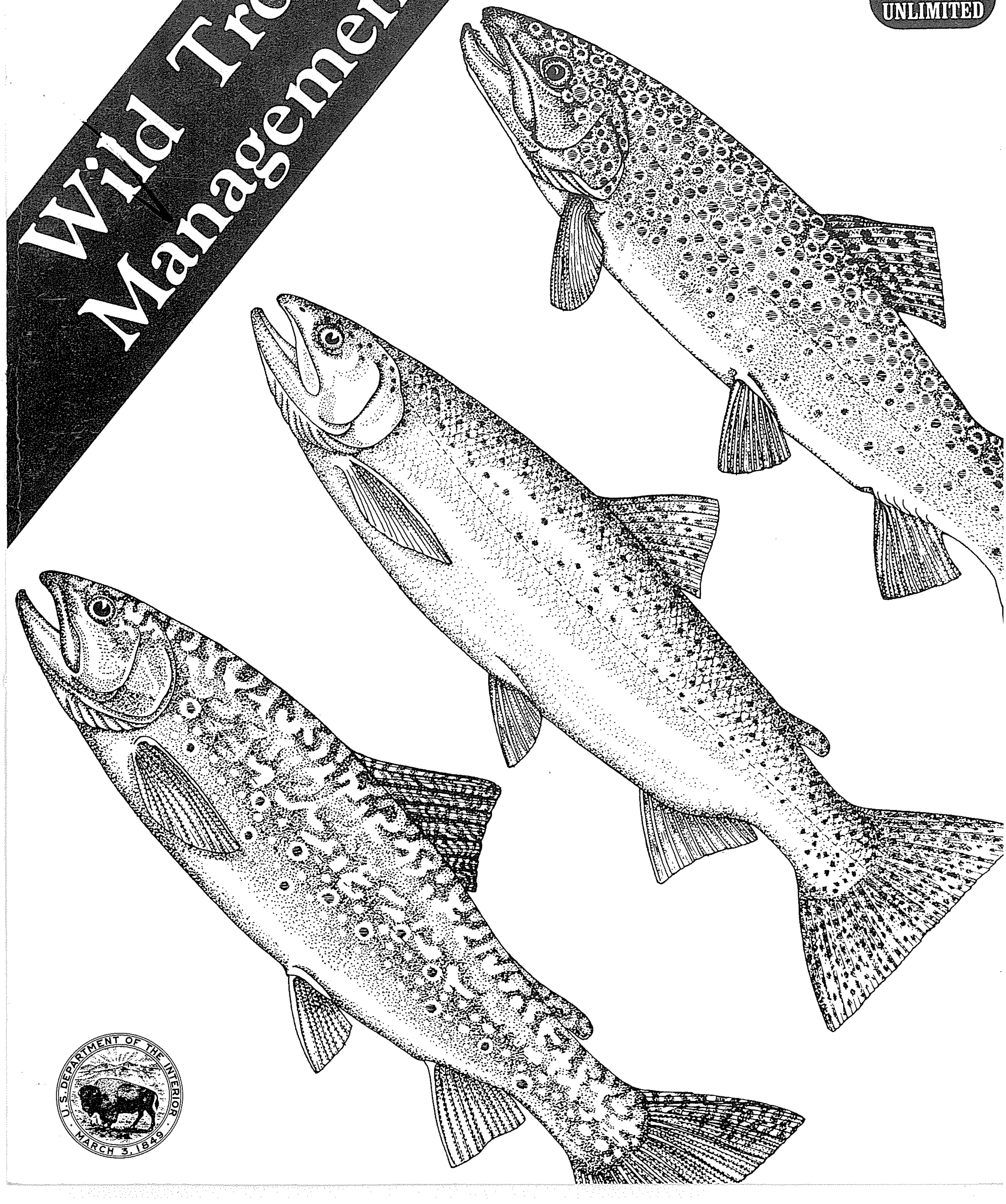
Wild Trout Management

$3.95

TROUT UNLIMITED



U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849

Publication made possible by a grant from Gulf Oil Corporation

PROCEEDINGS

OF THE

WILD TROUT MANAGEMENT SYMPOSIUM

AT YELLOWSTONE NATIONAL PARK

SEPTEMBER 25-26, 1974

SPONSORED BY

TROUT UNLIMITED, INC.

and U.S. DEPARTMENT OF INTERIOR

Symposium Organizers:

Jack Anderson
John Peters
Frank Richardson
Pete VanGytenbeek

Editorial Committee

Willis King, Editor
Frank Amato, Assisting
Frank Richardson, Assisting
B. M. Bakke, Design

Cover illustration by Sharon Torvik

Published by Trout Unlimited, Inc., 1975

CONTENTS

INTRODUCTION

The idea of holding a meeting to discuss Wild Trout Management is nothing new or unique. In fact, such meetings occur every year. The uniqueness of the Yellowstone meeting was the diversification of personalities and the national, even international, flavor of the Symposium. Biologists, managers, administrators, teachers, students, writers, anglers and conservation leaders – some 300 plus – from every trout region in the United States and Canada, all interested in trout management, met on common ground to talk trout. They talked at the formal sessions, they talked in the hotel lobby, they talked in cabin rooms, they talked on the banks of Yellowstone's famous trout streams, they talked in automobiles and planes coming to and leaving Yellowstone, they talked while dining – they talked about Wild Trout Management.

No one individual can take credit for the idea, the compilation, or the success of the Symposium. However, without the support of Nat Reed, Assistant Secretary of Department of Interior for Fish and Wildlife and Parks, the Symposium would never have come off. The Program Organizers, Frank Richardson, the unofficial leader of this group, Pete VanGytenbeek, Trout Unlimited principal representative, John Peters, another TUer and representing the American Fisheries Society, Jack Anderson, who handled the on-site logistics at Yellowstone, and, finally, Willis King, who handled several assignments including Symposium Moderator, Keynoter, and Editor of the Proceedings, all made a significant contribution to the success of the Symposium. If any names are to be mentioned, these should be the foremost.

OPENING STATEMENT

By Jack A. Anderson

Superintendent, Yellowstone National Park

Ladies and gentlemen, welcome to Yellowstone and the first Wild Trout Management Symposium. The first thing I would like to do is recognize Nat Reed, Assistant Secretary of the Interior for Fish and Wildlife and Parks, and Bill Luch, President of Trout Unlimited, as the co-sponsors of this symposium. Nat and Bill, will you please stand up?

When Frank Richardson and I first started the logistics planning of this symposium, we estimated that a maximum of 150 people would attend. When the registration passed 300 a few days ago, we were in contact with all transportation agents, including Amtrack. We hope that our miscalculation does not inconvenience any of you. Please bring all your travel problems to me.

If any of our National Park Service staff here in Yellowstone can do anything to make your stay here more pleasant, including fishing, please don't hesitate to call on us. We have a number of cars with drivers. Ladies who do not plan to attend the Symposium sessions and wish to participate in a tour should contact the front desk. Our Ranger force is at your service.

Trouters, the Symposium is now open, and with that, it gives me a great deal of pleasure and pride to introduce to you an old Park Service employee, Dr. Willis King. Willis began his professional career with the Park Service over 40 years ago. His qualifications for moderating this meeting are outstanding. He recently retired from the U.S. Fish and Wildlife Service where he had a most distinguished career. His contributions as a professional biologist to the trout resources of the world are not unknown to most of you. His assignment here will include a keynote address. Willis, the next two days are in your hands.

KEYNOTE STATEMENT

By Dr. Willis King

U.S. U. S. Fish and Wildlife Service (retired), Hendersonville, N.C.

Thank you, Jack! First, let me say "Aloha." I am not quite as far off as you might think because I just spent the last two weeks over in Hawaii with a number of my distinguished colleagues at the annual conference of the American Fisheries Society. It is not very often that one gets to visit four islands in Hawaii and Yellowstone National Park in one month. I am surprised that most of you have not left after the announcement Jack Anderson just made.

I think it is appropriate that this meeting come to a national park, particularly Yellowstone, to discuss the subject of wild trout management. I started my career in fisheries work just 40 years ago in Great Smoky Mountains National Park. One of the first problems that I encountered was what should we do about our native fish populations and particularly the wild native brook trout down in the Great Smokies. It seemed no one had worried about that very much. I must confess that several of us have been worrying about it ever since, and we don't yet have all the answers. Certainly the national parks are a most suitable place for the preservation of our native species including our extremely important game fishes. When I was first approached by Secretary Reed's office if I would be for this meeting (you know when you are asked to do something like this it is sort of a command performance, even though you have just announced your retirement), I wasn't sure what the meeting was all about or what its purposes might be. I did find out that it was a symposium but that didn't help me very much. Down in our summer home in North Carolina, there is a poster that has only one word on it, "Symposium". All it is, is some abstract art with a one-eyed jack staring at you, so that didn't help me very much. I asked my wife, who is an authority on such matters, and she said a symposium is something where people get together and talk. Sometimes they don't come to any conclusions, they just talk, and this habit got started back with the old Greeks. Probably Socrates himself was the first and most famous leader of symposia. I don't claim to be a Socrates. He invited special people to come and meet with him to discuss various subjects. She said one of the most important subjects that they seemed to get around to sooner or later was love. Well, I don't know whether we'll end up on that subject, but we certainly are here to exchange information and talk. Supposedly, the guy who talks the best and longest, eats the most and drinks the most, and if he is still up at the end, he is the one that wins; so we'll see who comes out ahead at this meeting.

We do have some serious business to do and it seems to me that if we are to come to a determination of what we think is the right thing to do about managing wild trout populations, it is going to center around two things. The first is how do we perpetuate a natural fishery? What can we do to assure preservation of the species of fish that are of such importance to us and to the future of recreation of this country?

The symposium program says we are concerned with "Wild Trout". What is a wild trout? Nearly everyone has his own definition; I didn't find any two that are quite the same. Maybe by the time we get through we'll agree on our criteria. There are all kinds of wild trout. Some of them are wilder than others, for different reasons. I know that the trout in my pond down in North Carolina were scared to death after my grandchildren fished for them for two days, and as of now, they won't take anything. After some of the experts have been here in Yellowstone for a few days there may be wild trout all over the place.

The other major subject that we are going to devote our attention to is: "What can we do to provide a satisfactory angling experience?" This is what we are really looking for in all of our fishery management programs. It is no doubt a highly personal and variable thing. There is a phrase that I kept running into in several of the papers, one paragraph after another. It is called "quality fishing," and the more I read about quality fishing the less certain I am just what it means. Quality fishing to me is like beauty, and beauty is only in the eye of the beholder. So when we talk about quality fishing we can't rule out the ideals and preferences of the individual and what it takes for him to have a truly satisfactory fishing experience. And this I think is what we are really talking about. We want first to find out how to perpetuate natural fisheries and secondly how, whenever possible, to provide a satisfactory angling experience.

I think there are three approaches and the program has been organized more or less on this basis. The first thing that we need to have is a basic knowledge of the fishes that we are dealing with. We need to know their life histories, their habitat requirements, their behavior characteristics. Secondly, we must have an understanding of the aquatic ecosystem in which these fishes live; call it habitat, if you like, and we have to know what is required for them to live and reproduce. Then the third phase, which we take up in the last panel, deals with relationships with the angler. Here, we bring in the sociological aspects, the political aspects, and the regulatory features. So keep these in mind as most of the papers are related to one of these three aspects: basic knowledge of the fish; an understanding of the aquatic ecosystem; and relationships with the angler.

I believe we must also accept the fact that there is going to be management of any fishery in some form – even setting up a wilderness area and closing it to fishing does not remove it from management. Management is a broad term and includes protection, regulation, fact finding, and includes many things that will contribute to the well being of that particular ecosystem. So we can't rule out management regardless of the population or the type of fishery that we are talking about.

Now what is it that makes this meeting unique, different from other meetings that many of us have attended over a long period of time? I think the thing that characterizes this session is something that Nat Reed pointed out in conversation a while ago, that he had not seen such a mixed group as we have here. We have research people to give us our basic information, we have many field biologists who are here either on their own or sent by their directors, we have quite a few administrators (I think they thought they would get in a few days fishing on the side), and we have quite a few anglers, people who are here primarily because they are interested in fishing. If we can bring these disciplines together and get the benefit of their ideas, certainly we should come out with some worthwhile thoughts that we can carry home with us.

Now, that is the "keynote". I do have a few other things to say on procedure. I will open each session with a few remarks, and then turn the meeting over to the Panel Discussion Leader. The Discussion Leader is responsible for the meeting while he is here at the podium. He will introduce his members and tell you something about them. We want to hold discussion until the end of the panel and then we will allow as much time as we possibly can for discussion. I do urge that speakers endeavor to stick to their subject and that the audience ask questions that are related to the papers presented.

If we can get the papers together in a reasonable time and if they are the quality that we believe they will be, we are going to try to work out some means of publishing them. We don't know exactly the form, and we don't have a schedule, but Trout Unlimited and Secretary Reed are very much interested in getting it done. I have agreed to assist in this undertaking to the best of my ability and time available.

At the end of the session tomorrow afternoon, I will attempt to summarize some of the conclusions. Maybe by that time we will have a definition for wild trout.

We'll start the first panel, and our first Panel Discussion Leader is Jack Ayerst, Assistant Chief of the Fisheries Management Division of the Washington Department of Game.

ANADROMOUS SPECIES MANAGEMENT PANEL

Mr. Ayerst: *Good morning fellow fishermen, fellow biologists, ladies and gentlemen. First I would like to express my compliments to the symposium organizers on the selection of Yellowstone Park to hold this meeting. It is certainly the most picturesque and most beautiful place in the country and most appropriate for a wild trout conference.*

This morning our panel will discuss anadromous fish management along the Pacific slope, the Great Lakes, and the Atlantic Coast. We will have a discussion period after all three of the panel speakers have presented their papers.

Steelhead trout, for those of you who are not familiar with the name, are merely sea-run rainbow that leave the rearing streams and move out to the Pacific Ocean and return as adult fish upon maturity. The Pacific coast steelhead generally reach 7 to 9 pounds with an occasional fish exceeding 30 pounds. This particular quality makes them a highly sought trophy trout.

The first speaker is Dr. Roger Barnhart, Leader of the California Cooperative Fishery Unit, who will discuss the status and management of the Pacific slope steelhead.

PACIFIC SLOPE STEELHEAD TROUT MANAGEMENT

By Roger A. Barnhart

California Cooperative Fishery Unit, Humboldt State University, Arcata, California

This paper will emphasize wild steelhead trout management, but, because in most states wild and hatchery steelhead management are intermeshed, certain aspects of hatchery steelhead management will also be discussed. Steelhead occur in streams along the Pacific Slope from central Alaska to central California. The steelhead is renowned for its fighting ability and is truly one of the big-game fish of freshwater angling.

CURRENT STATUS OF STEELHEAD FISHERIES

Alaska:

Steelhead are distributed from southeast Alaska north to Kodiak Island. Runs of fish are widely scattered, but individually the runs are small. Most steelhead populations ascend Alaskan streams in May and June and are termed "spring run" fish. So called "summer runs" are limited in number. Fishing pressure is light and is controlled largely by access. Most of the fishing pressure is located in southeast Alaska. The annual estimated number of steelhead caught by anglers in southeast Alaska is 1,000 fish. Kodiak Island has a run of steelhead in the fall, and the catch is estimated to be 400 fish per year. Fishing is excellent and averages about one fish per angler hour. Steelhead are harvested incidentally in the commercial salmon fishery; the catch ranges from approximately 800 to 2,500 fish annually. Hatchery steelhead programs in the past have been limited to pond stocking for trout fisheries. The State is now attempting to develop a brood stock at one hatchery to introduce steelhead in streams near centers of population where the run has disappeared or only a remnant population now exists.

British Columbia:

Steelhead are distributed along the entire coastline of British Columbia, and steelhead populations may occur in as many as 600 streams. Steelhead ascend British Columbia spawning streams throughout all months, but winter fish generally peak in January and February, and summer runs occur from May through September. Vancouver Island has 17 summer run streams alone.

British Columbia now sells nearly 50,000 steelhead angler permits annually (12% of total angler license sales), and these fishermen harvest 35,000 to 65,000 steelhead each year. Commerical fishermen average about 20,000 steelhead annually, which are harvested incidentally in the salmon fishery. Most of these fish are taken by drift gill nets.

The British Columbia hatchery program is small and confined to the southern end on streams where heavy fishing pressure exists. About 50,000 hatchery steelhead are produced annually and are released to streamside rearing ponds. The Fish and Wildlife Branch hopes to confine future steelhead hatchery operations to streams with low runs of wild steelhead.

Washington:

Washington has about 180 steelhead streams. Steelhead populations exist in streams along the entire coastline of Washington and in many tributaries of the Columbia River. Steelhead enter the Columbia River every month of the year. All runs of steelhead spawning above Bonneville Dam are summer-run fish. Winter-run steelhead dominate in the coastal rivers but often coexist with smaller populations of summer-run fish (Royal, 1972).

Washington now averages about 145,000 steelhead fishermen and 500,000 total anglers. Steelhead fishermen catch approximately 225,000 winter steelhead and 50,000 summer steelhead annually. About 50% of the steelhead taken are hatchery fish; in some streams hatchery steelhead can accout for 75% to 80% of the total catch. An extensive Indian commercial fishery for steelhead exists in the Columbia River. Commercial catches in the Columbia average approximately 40,000 to 50,000 steelhead annually, and about the same average number of fish are taken from coastal areas and Puget Sound each year.

Washington has an extensive hatchery program. Three million summer steelhead smolts and two million winter steelhead smolts are released annually. During the period 1949-1970 the number of Washington anglers increased nearly five-fold, and an almost four-fold catch increase occurred during this same period (Sheppard, 1972).

Only a few major streams in the State have not been stocked. Washington's total steelhead population has increased markedly during the past 20 years, while wild steelhead stocks have declined during this period.

Idaho:

Idaho has three major steelhead stream systems. The Salmon River contributes about 50% of the total catch, the Clearwater 35%, and the Snake River 15%. All Idaho steelhead are summer-run fish, and the State provides approximately 25% of the total Columbia River summer steelhead population. The annual estimated steelhead catch has remained relatively constant for the past 20 years, an average of 21,000 fish. About 20,000 steelhead permit cards are sold annually. The sport fishery occurs during two periods – a fall fishery (60%) and a spring fishery (40%).

Two hatcheries are responsible for most of Idaho's hatchery production of steelhead. Dworshak National Fish Hatchery on the Clearwater River is geared to release 3.6 million smolts yearly, and Niagra Springs Hatchery on the Salmon River system is programmed for 1.6 million smolts yearly. These hatcheries mitigate for steelhead runs blocked by high head dams. Wild steelhead in Idaho are presently declining while hatchery steelhead are increasing. In 1973, steelhead catches on the Salmon River contained about 50% hatchery-reared fish. On the Clearwater River the fall 1973 catch contained about 70% hatchery-reared steelhead. Idaho Fish and Game hopes to continue to manage the Selway River in the Clearwater drainage and the Middle Fork of the Salmon River in the Salmon River drainage as wild steelhead rivers.

Oregon:

Oregon has 78 streams, counting large tributaries, which contain populations of steelhead. Only 44 of these support runs of sufficient size to produce an annual catch exceeding 100 fish. Oregon has both winter and summer run steelhead populations. Famous summer-run streams are the Rogue, Umpqua, and Deschutes Rivers. The Rogue and Umpqua Rivers have winter-run steelhead also.

Oregon now averages nearly 150,000 steelhead anglers annually. The total steelhead catch averages about 200,000 fish. Biologists estimate that the catch consists of 25% hatchery-reared steelhead (50,000 fish) and 75% naturally reproduced fish (150,000 fish).

The production of hatchery steelhead smolts has increased eight fold from 250,000 in 1960 to 2 million today. The catch has doubled during this period. Oregon has classified all its steelhead streams as "summer-run," winter-run," or "both." Some streams are stocked heavily; about 10 steelhead streams are not stocked at all. Certain streams are managed as wild summer-run and hatchery winter-run streams or the reverse.

California:

In California steelhead occur in all streams emptying into the Pacific Ocean from the northern border to central California. The Ventura River is probably the southernmost stream supporting an annual steelhead run. The two most important river systems in terms of steelhead production are the Klamath River in northern California and the Sacramento River, which empties into San Francisco Bay. California has both summer and winter run steelhead.

California does not have a steelhead permit card system, so statistics on number of steelhead anglers and steelhead catch are lacking. The California Fish and Wildlife Plan estimated that in 1963 123,000 adult steelhead were harvested during 302,000 man-days of angling. Steelhead angler use has increased markedly in the last ten years, and it is possible that 200,000 steelhead are now harvested annually. However, runs of wild, naturally produced steelhead have declined drastically since the 1940's and are probably at an all time low level.

Over 2 million hatchery-reared yearling steelhead are released each year into the Sacramento River system, and the total adult return is probably larger now than historically. Nearly 2 million hatchery steelhead yearlings are introduced into coastal streams as well. However, this program has not been too successful, and coastal steelhead stocks remain at a low level. The Klamath River system still has good runs of naturally produced steelhead, perhaps approaching 200,000 fish in good years. California also releases over 3 million steelhead fingerlings annually.

CURRENT MANAGEMENT OF WILD STEELHEAD STOCKS

Presently the management of wild steelhead on the West Coast consists of two techniques: fishing regulations and habitat management. Habitat management is comprised mainly of efforts to maintain and protect the existing habitat. The reduction in wild steelhead stocks observed up and down the West Coast is largely attributable to the deterioration and loss of stream habitat through man's activities. The construction of dams on the Columbia River system has resulted in the loss of spawning and rearing habitat plus actual fish loss due to migration problems through complex reservoir systems. Idaho rates existing and impending dams as a major problem in its steelhead management programs.

The close relationship between steelhead spawning and rearing streams and timbered watersheds has created what is probably the most widespread cause for the decline in wild steelhead stocks – stream damage resulting from the harvest of timber and its associated activities, primarily road construction. Juvenile steelhead normally spend 1 to 3 years in freshwater before migrating to the ocean. This freshwater phase of life is certainly the most critical. Improved forest practices and rules and legislation dealing with water quality standards have enabled many fishery management agencies to become more directly and actively involved in protection of stream habitats.

From the State of Washington south, resource management agencies know fairly well which streams are the primary producers of wild steelhead stocks. These agencies use either a formal stream classification system or some type of informal classification to recognize those streams requiring highest priority protective measures. Alaska and British Columbia both recognize the need for further inventory of their steelhead stocks.

Regulation of the fishery is the major tool employed directly by management agencies to maintain wild steelhead stocks. Regulations are directed mainly to limiting the catch, the protection of spawners, and the protection of juvenile steelhead prior to and during their downstream migration.

Alaska, British Columbia, and California have limits of three fish daily on steelhead, and Washington, Idaho, and Oregon have two-fish limits. Only fish over 20 inches in length are considered steelhead by the above agencies, except California, which makes no size distinction. Idaho, Washington, and Oregon use a permit card system which limits the angler to 10, 30, and 40 steelhead respectively per year. In Oregon streams above Bonneville Dam, the seasonal harvest of steelhead (20 inches plus) is restricted to 20 fish. Alaska, British Columbia, and California have no restrictions on total season catch. It's interesting that Oregon reports that 90% of the total steelhead catch is by anglers who catch less than 10 fish for the entire season, and Idaho states that about 81% of its steelhead catch is by anglers taking less than 10 fish. Both states have daily limits of two fish, and Oregon biologists feel that the two-fish limit has the greatest impact on total catch.

Most states have established seasons for steelhead and salmon which help to differentiate trout seasons from salmon and steelhead seasons. Generally during the steelhead season small tributaries used for spawning and rearing are closed to protect spawners. Alaska has no closed season, but the season is limited by weather, and fishing pressure is definitely limited by access. British Columbia, Washington, and Oregon have 8-inch, 10-inch, and 8-inch minimum size limits respectively on their coastal streams to protect steelhead smolts during the trout season. Both Washington and Oregon have delayed the opening day of trout season on coastal streams to late May to protect outmigrating steelhead smolts, most of which have left freshwater by that time. Special steelhead seasons have been established on selected streams by some states to harvest early or late runs of steelhead. Idaho manages the Salmon and Clearwater systems to spread the catch out over a larger area of the state. Downriver areas are closed earlier to allow escapement to upriver fisheries.

Some states have special gear restrictions on certain streams or sections of steelhead streams. "Single hook lures only" restrictions are used primarily to prevent snagging. British Columbia, Washington, and Oregon all have special "fly fishing only" sections for steelhead. Generally, these are on summer steelhead populations. A portion of the Babine River, British Columbia is "fly fishing only" with a catch-release restriction. It is reported that many of the steelhead in this section are caught and released several times. Washington has one stream, the Grande Ronde, set aside with a "lures only" catch-release management program. Idaho currently has no catch-release program and reported that in a small experiment unplayed fish returned to the creel eight to one over played fish, indicating that perhaps a significant mortality factor may be ascribed to catching and releasing steelhead, at least to those fish that have migrated long distances in freshwater before being caught. However, a more recent small experiment in Idaho concerning mortality of hooked-released steelhead gave results which indicated that there was little difference in mortality of caught and uncaught steelhead.

As more pressure is brought to bear on steelhead resources, the trend is to manage each stream separately regarding regulations as to season, gear restriction, even creel limit and the use of hatchery stocks. Most agencies are trying to minimize the effects of their hatchery steelhead introductions on wild stocks. Experience has shown that if yearling steelhead are released at a large enough size and at the right time, they migrate rather rapidly to the ocean, thus minimizing intraspecific competition for space and food with native stocks. The streams are then used simply as a highway to the sea, and the problem of residualism of hatchery juveniles is avoided. Most agencies strive to get hatchery yearlings to a size of at least eight per pound before stocking, and many prefer six per pound size smolts. Optimum release time is in the spring, and the exact time of release can be determined by the external appearance of the smolts (loss of parr marks) accompanied by a sharp decline in coefficient of condition, and changes in behavior.

Wild steelhead spawn throughout the watershed of any specific river, but tend to migrate to the upper portions of the main river and its tributaries. Accordingly, most agencies restrict the planting of hatchery smolts to the main river and when possible, to the lower portion of the main stem. Theoretically this procedure minimizes the interaction of wild and hatchery produced juveniles and returning adult steelhead.

PROBLEMS AND NEEDS

One problem in maintaining wild steelhead stocks while building up total steelhead runs through hatchery introductions is the possibility of overfishing the wild stocks. Idaho considers this a major problem. In order to justify the expense of a hatchery program, the management agency tries to obtain an angler harvest of most of the adult steelhead excess to the number required for the continuation of the hatchery program. Increased fishing pressure generally results. It is nearly impossible to distinguish between hatchery and wild stocks in the fishery. Wild steelhead are undoubtedly harvested in greater numbers than before the successful hatchery runs were created. In this way, and perhaps in other ways, hatchery programs do not supplement natural reproduction but replace it to some degree.

Oregon feels that hatchery steelhead are more vulnerable to the angler than wild steelhead, and biologists believe that statewide about 25% of the wild steelhead runs are harvested. This may be partly due to the fact that wild runs tend to be spread out over a longer time period during any one season than hatchery runs. There may be other behavioral characteristics of wild steelhead which make them less vulnerable.

There has been criticism by some steelhead anglers that on streams in which the run consists primarily of hatchery fish, the length of the steelhead fishing season has gradually been reduced because the adults all tend to enter at one time period. I did not obtain data to substantiate or invalidate this criticism. There are good data which show that steelhead runs in streams with long time hatchery programs have gradually become earlier until the peak migration may occur a month earlier than it did historically. This happens primarily because the hatchery manager tends to spawn the first fish returning to the hatchery to insure a yearly egg supply.

Another criticism by certain steelhead fishermen is that steelhead which originated in hatcheries are inferior to wild steelhead in fighting qualities and stamina. One small experiment by steelhead anglers on the North Umpqua River, Oregon indicated that some experienced anglers could distinguish a hatchery fish from a wild fish with fair accuracy by its behavior on the end of a line. However, most anglers are happy just to catch a steelhead. In Idaho, however, anglers have been critical of the small size of hatchery steelhead compared to the wild fish. Washington has selected for large fish in their hatchery program with apparent success.

There are several research needs identified for steelhead management. One question of concern to most agencies is the effect of genetic mixing of various steelhead stocks. A major concern is that desirable characteristics of wild populations will be lost in this manner. Data are lacking in this regard. It is probably valid to assume that changes in the genetic makeup of populations of wild fish have occurred in the presence of hatchery fish in the spawning population. The success of hatchery-produced steelhead in reproducing themselves naturally needs further documentation. Everest (1973) found that adult steelhead of hatchery origin did contribute to the spawning population of summer steelhead on the upper Rogue River, Oregon.

All steelhead used in hatchery programs originated from wild stocks. However, availability of the particular stock used has generally been the criterion for selection rather than using stocks from the particular stream slated for hatchery supplementation. Some introductions may have failed because of this. Differences in resistance to disease, resistance to pollution, or differences in migration and spawning time which subject eggs and fry to conditions not suitable to survival are possible causes of unsuccessful transplants.

Washington and Oregon are concerned with the possible existence of a density barrier related to stocking. There are indications from records on certain streams that beyond a certain number of smolt released, additional fish releases do not result in additional returning adults. This phenomenon needs further investigation, and the factor or factors creating this barrier should be defined. These factors may also affect wild steelhead smolts migrating downstream with hatchery yearlings.

More data are needed on the survival of adult steelhead subjected to a catch-release program. In the future, management agencies may want to consider this management alternative to preserve unique wild stocks.

Stream improvement generally has not been successful on Pacific slope streams, which are subject to severe fluctuations in stream flow. Most instream devices have silted in rather rapidly or were washed out by floods. Stream improvement work in California has consisted largely of stream clearance projects to remove log jams. Nevertheless stream improvement, if successful, is a direct and rapid way to restore damaged habitat. Further research is needed in this area, but the investigations are not likely to be undertaken by fishery management agencies because of the expense involved and established priorities.

There is a need for management agencies to discern the preferences and behavior of steelhead anglers. It's quite possible that steelhead fishermen will accept a more restricted fishery to protect an endangered stock. An angler survey by Idaho in 1968 revealed that 42% of steelhead anglers favored reduced limits and 30+% favored season reductions. Questionnaires by British Columbia and Oregon showed that steelhead anglers were willing to pay more for a fishing license. The surveys also revealed that steelhead anglers are concerned about esthetics. In the British Columbia survey the desire to fish in an unspoiled environment was number one in importance. The Oregon survey showed that steelhead anglers were very concerned about the problem of crowding. Both Washington and Oregon are recognizing a conflict between boat and shore-based steelhead anglers on certain streams. An important area largely neglected to date is the education of the angling public in the esthetics of the fishing experience.

Finally, management agencies need to establish long term goals for the management of their steelhead resources. The varied interests of the resource users and the uniqueness of the resource should be considered in establishing goals. Because of the unique characteristics of a steelhead fishery it probably cannot and should not be operated under the concept of maximum sustained yield in terms of fish caught or even number of recreation days generated. Qualitative aspects need equal consideration with the quantitative. Agencies possess the ability to return to each stream large numbers of steelhead of hatchery origin. However, the need to maintain wild stocks to perpetuate unique inherited characteristics should be considered in establishing priorities. A wild river, like the Middle Fork of the Salmon, will somehow lose some of its wilderness quality if the native steelhead and salmon runs are replaced by fish sustained by hatchery operation. As pressures on steelhead resources increase, management becomes increasingly complex. The steelhead, like most other seemingly inexhaustible resources, is exhaustible – both qualitative and quantitative aspects of the fishery can be lost without good management.

ACKNOWLEDGMENTS

I wish to give special acknowledgment to the fishery managers of Alaska, British Columbia, Washington, Oregon, Idaho, and California for the information I received through correspondence, telephone conversations, and unpublished and published reports, all of which helped so much in the preparation of this paper.

REFERENCES CITED

Everest, Fred H. 1973. Ecology and management of summer steelhead in the Rogue River. Fish. Res. Rept. No. 7, Oregon State Game Commission; 48 p.

Royal, Loyd A. 1972. An examination of the anadromous trout program of the Washington State Game Department. Special Rept., Wash. Dept. of Game; 176 p.

Sheppard, Douglas. 1972. The present status of the steelhead trout stocks along the Pacific Coast. From "A review of the oceanography and renewable resources of the northern Gulf of Alaska," D. H. Rosenberg, Ed. IMS Rept. R72-23, Sea Grant Report 73-3. Inst. of Marine Sci., U. of Alaska, Fairbanks; 519-556.

Mr. Ayerst: *Over the past century there have been some dramatic changes in the species composition of fish in the Great Lakes. Man's activities have basically caused these changes. David Borgeson, our next speaker, will discuss some of these species changes and how the fishery is now managed for the benefit of fishermen. Dave is in charge of the Inland Fishery Section of the Fisheries Division, Michigan Department of Natural Resources. Dave will now tell us about anadromous trout management in the Great Lakes.*

ANADROMOUS TROUT MANAGEMENT IN THE GREAT LAKES

By David P. Borgeson

Michigan Department of Natural Resources, Lansing, Michigan

Anadromous fish are those fish that migrate from the sea up rivers to spawn. In the case of anadromous trout and salmon and some other anadromous species, large freshwater lakes have proven to be suitable substitutes for the sea.

The alewife and sea lamprey, although they are not the most popular anadromous fish in the Great Lakes are, in some respects, the two most important. These two species have had the biggest impact on species composition and population dynamics of these lakes, and they have had the greatest influence on fisheries management.

Neither the alewife nor the sea lamprey is native to the upper Great Lakes (Lakes Huron, Michigan, Superior). They are recent immigrants from the Atlantic, entering Lake Erie via the Welland Canal. They have become a major ecological force only since World War II.

The devastating impact of these two species on the fish and fisheries of the upper Great Lakes gave impetus to the extensive research and management efforts of the past two decades that culminated in the truly spectacular trout and salmon fishing we are now enjoying. It was not that major changes in fish biota were new to the Great Lakes. Throughout recorded history their fish populations have undergone profound sequential changes (Smith 1968). It was just that these two species, acting together, changed the fauna of the Great Lakes so thoroughly.

Early records indicated that the lakes were abundantly populated by sturgeon, whitefish (common lake whitefish, along with many lesser corregonid species) and lake trout. Settlers prized the whitefish as food, and they, along with lake trout, were first to be heavily exploited by commercial fishing. Indirectly, sturgeon felt this early commercial fishing pressure because of the damage they caused to whitefish nets. Sturgeon were slaughtered, dried and burned by untold thousands of tons.

Prior to 1950, sport fishermen enjoyed fine yellow perch angling from piers and breakwalls, some deep trolling for lake trout in the northernmost waters, primarily Lake Superior, some inshore and bay fishing for walleye and smallmouth bass, and stream fishing for steelhead trout. Commercial lake trout fishing was closed on Lake Superior in 1962 with only a remnant population existing at offshore reefs and in the extreme western end of the lake.

Whitefish and lake trout remained the mainstay of commercial fishing on the upper lakes until their drastic decline around 1950.

By 1950 the lamprey had, in combination with increasingly desperate commercial fishing, essentially eliminated lake trout and lake whitefish from Lakes Huron and Michigan. Burbot, steelhead trout and walleye were also decimated. To further complicate matters, at this time the linen and cotton gill nets were being replaced by the much more effective nylon nets, and more and more were being used by fishermen to compensate for the decline in abundance. This increased fishing power greatly speeded the decline of high value target species, and commercial fishermen were forced to divert their efforts to associated lesser value species: the yellow perch, whitefish chubs, and lake herring (ciscos).

The near absence of predator species in Lakes Huron and Michigan paved the way for the alewife *Alosa pseudoherengus*. Alewives had already dominated the biomass of Lake Huron by 1955. Lake Michigan tow net samples changed from 75 percent whitefish chubs in 1961 to 75 percent alewives in 1962. By 1967, western Michigan's valuable beaches were littered by thousands of tons of alewives. Educated guesses at the population of alewives in Lake Michigan ranged between 200 million and 2 billion pounds.

Since some lake trout still remained in Lake Superior it was the first lake where wide-scale lamprey control was attempted. Electric barriers on key lamprey spawning streams were used with some success. After the U.S. Fish and Wildlife Service screened some 6,000 different chemicals, one, 3-trifluormethyl-4-nitrophenol–(TFM), was found to be highly toxic to larval lamprey and less toxic to other fishes. Since lamprey live three to 13 years in a non-parasitic stage in their parent stream prior to migrating to the Great Lakes, and only one year to 20 months in the predatory stage prior to spawning, a single application of TFM to a spawning stream kills many generations of sea lamprey. Like Pacific salmon, sea lamprey die following spawning.

Application of TFM to Lake Superior lamprey streams commenced in 1958 and had dramatic results. Lamprey abundance dropped by 90 percent after two rounds of stream treatments and remains at low levels.

Lamprey control was followed by restocking with lake trout fingerlings from State and Federal hatcheries, and lake trout abundance soon approached pre-lamprey levels in Lake Superior. Successful lake trout restocking followed as lamprey control was extended to Lakes Michigan and Huron in the late 1960's, but anadromous species were also utilized and with such success that they overshadowed the lake trout success.

This is a long prelude to anadromous trout management, but it is necessary. Anadromous trout management in the Great Lakes is much much more than just stocking fish. It includes assessing the impact stocked fish have on other Great Lakes fishes. It includes an assessment of the magnitude of available forage and an apportionment of this forage among the mix of predator species. It includes the judgment necessary to choose and to establish the levels of abundance of each controllable predator species.

To make these judgments requires knowledge, so fact finding is a necessity. Estimates of fish stocks must be made. Survival, growth, and behavior of planted fish as well as angler catch must be monitored.

STEELHEAD TROUT

To most Michigan fishermen anadromous trout management means steelhead trout management.

Steelhead trout management began on the Au Sable River in 1876 when a famous sportsman, Daniel C. Fitzhugh, Jr., of Bay City, made a private plant to see how the California trout would do in his favorite stream. Many official and unofficial plants of rainbow and steelhead trout followed from so many different egg sources that tracing the lineage of present-day Great Lakes steelhead ends in confusion.

By the early 1900's the rainbow or steelhead was well established in the tributaries of the upper Great Lakes, and they were providing some extremely fine fishing. There were, however, some vociferous disbelievers in the rainbow who feared they were driving out the brook trout. Jim Seeley, a famous character of the Little Manistee River, once stated that the sorriest day of his life was when the rainbows were planted in that river (Smedley, 1938).

Although it was believed that the rainbows would be a stream fish, it was quickly learned that they migrated to the Great Lakes to return as steelhead. Steelhead runs had begun in the Little Manistee in the 1890's.

Steelhead suffered a serious set-back with the construction of hydro dams on major spawning streams, notably the Muskegon, Manistee and Au Sable Rivers during the early 1900's. But, steelhead fishing remained good until the lamprey caused decline of the late 1940's and early 1950's. When I began fishing for steelhead in the 1950's, the spawning run on the famous Platte River had already deteriorated to where a five-pound fish was a large one, and only a few good fishermen could claim a two-pounder on opening day. Sea lamprey, which are selective for the largest members of any species, had all but eliminated the large spawners; but for 15 years steelhead held on.

When chemical lamprey control was extended to Lake Michigan in the mid-1960's, steelhead were quick to recover. Spawning runs in indicator streams (the Platte and Little Manistee) doubled and re-doubled for four successive years. By 1967 the average steelhead in the Little Manistee River run weighed over 11 pounds. Long-time residents along the river said that the 1967 run exceeded anything in their memory (the Little Manistee has never been blocked by dams); yet steelhead numbers continued to increase through spring, 1970. Their population has now dropped somewhat, but it remains at a relatively high level.

Although we began stocking substantial numbers of steelhead smolts (silvery seven-inch migrants) in 1968, and some of these plants were spectacularly successful, most of the resurgence of steelhead in Michigan can be credited to lamprey control and the change in the food base on Lakes Michigan and Huron to alewife.

Steelhead grow to much larger size now than they did prior to 1950, and the survival from smolt to adult is substantially higher. Prior to 1950, runs of adults on the Little Manistee and Platte River as judged from records kept at Department weirs numbered about 1,000 to 3,000 fish annually. In 1969-1970 the run on the Little Manistee was 17,000, and in 1973-1974, a poor year, it was 4,000. I expect that efforts to restore lake trout in the Great Lakes, combined with our Pacific and Atlantic salmon program, will act to increase both competition and predation in the

Great Lakes. I do not foresee steelhead numbers being sustained at the levels reached in our best streams in the late 1960's even though many of our anglers have adopted such levels as their standard.

Steelhead are a part of an overall Great Lakes management program which involved many predator species, none of which will be maintained at maximum abundance. That can only be done through single species management which is, of course, impractical and undesirable. Steelhead are managed to provide a stream and estuary fishery in Michigan. Although some are taken incidentally by salmon and lake trout fishermen in the open lakes, they have never supported such a fishery on their own.

I think it is possible to improve our steelhead fishing over what it was in peak years even though our key wild streams may have fewer fish. That will sound like bureaucratic doubletalk to most steelhead fishermen, but let me elaborate.

Michigan's best natural steelhead streams actually contained more steelhead in the late 1960's than was needed to support high quality angling. This abundance of fish caused extremely crowded fishing conditions and drew large numbers of new fishermen who had relatively little appreciation for steelhead or its environment. Some stream damage resulted, land owners became upset with the traffic and litter, and long-time steelhead fishermen resented the competition and lack of angling etiquette brought by the new army of anglers.

Michigan's top-quality wild steelhead streams, particularly the ones most accessible to southern Michigan fishermen, are neither numerous nor large. More moderate numbers of steelhead spawners in these streams are best in the long run.

The opportunity to provide more steelhead angling lies on other sizable streams that for one reason or another have less than optimum wild steelhead runs. The headwaters of large streams like the Muskegon, Manistee and Au Sable are blocked (by power dams) to spawning steelhead, and because of limited natural reporduction wild steelhead runs are limited. We have been supplementing runs on this type of stream in several ways. Large steelhead plants (numbering 25,000 to 100,000 smolts) have been made in these sizable streams.

We have a program of dam removal and fish ladder construction that has opened up some spawning areas. Removal of Newaygo Dam on the Muskegon River opened up 11 miles of big water fishing and spawning area, and the removal of Homestead Dam on the Betsie River in 1973 unblocked 40 miles of steelhead water. Homestead Dam was replaced with a lowhead barrier designed to block lamprey yet pass trout and salmon.

We have found that the introduction of spawners to headwater areas blocked by dams is also successful. Relatively few adults are needed to bring young steelhead numbers up to the carrying capacity of the stream. Good steelhead spawning areas on the Huron River (Upper Peninsula), Pine and Manistee Rivers have been brought into production through these adult transfers. The young steelhead so produced are able to migrate safely downstream over natural or artificial barriers to the Great Lakes. After maturing, they produce a fishery in the lower reaches below the barriers.

The major thrust of our steelhead hatchery program is to produce about a half million seven-inch yearling steelhead which migrate from the planted streams into the Great Lakes within a month after stocking. To provide fish of this size within one year, the fingerlings are sorted in the fall, and only the largest are reared to yearling size. The smaller fish are free to be used elsewhere. Some of these steelhead fingerlings are used in our lake management program, but they are also stocked in streams having adequate food and space and water temperatures, but which lack good natural trout reproduction. Sometimes these streams are chemically treated with rotenone to eliminate competing species prior to being stocked with trout. These efforts are providing good steelhead fishing where little or none existed before and on streams which have the elbow room steelhead anglers like.

ATLANTIC SALMON

Michigan recently renewed efforts to establish Atlantic salmon in the upper Great Lakes. I say renewed because Atlantic salmon introductions have been tried many times in the past. Large numbers of Atlantic salmon fry were planted in scores of streams throughout Michigan between 1873 and 1880. Attempts were again made during the 1920's with fewer but somewhat larger fish (year old fingerlings).

There has been much speculation as to why all these plants failed, but probably several unfavorable factors were involved including the small size of the fish, the scattering of many small plants, the poor timing of the plants, and the fact that the Great Lakes had strong predator populations at that time.

Interestingly enough, Atlantic salmon are native to Lake Ontario. They thrived there prior to

1850. Salmon were reported to be so abundant in the early 1800's that Follett (1932) concluded that the St. Lawrence River, Lake Ontario and their tributaries once supported the greatest freshwater salmon population in the world (Parsons 1972).

An idea of former salmon abundance in Lake Ontario can be drawn from the comments of Messrs. Whitcher and Venning in a report to the Department of Marine and Fisheries dated June 30, 1869. They had the following to say about salmon fishing in Wilmont Creek, a tributary to Lake Ontario at Newcastle (from MacKay 1963):

"In early times it was famous for salmon, great numbers of which frequented it every autumn for the purpose of spawning. They were so plentiful forty years ago that men killed them with clubs and pitchforks, women seined them with flannel petticoats, and settlers bought and paid for farms and built houses from the sale of salmon. Later they were taken with nets and spears, over 1,000 being often caught in the course of one night. Concurrently with such annual slaughter, manufactories and farming along the banks had obstructed, fouled and changed the creek from its natural state, and made it less capable of affording shelter and spawning grounds. The yearly decreasing numbers at length succumbed to the destruction practiced upon them each season from the time of entering the creek, until nearly the last straggler had been speared, netted, or killed."

Lake Ontario's salmon were extinct by 1898. A combination of this knowledge of Atlantic salmon's former abundance in Lake Ontario and our success with Pacific salmon gave us confidence that Atlantic salmon could be successfully established in the upper Great Lakes.

In 1972 10,000 Atlantic salmon smolts (ten per pound) were stocked in the Boyne River, a tributary to Lake Charlevoix in the northwestern part of the Lower Peninsula. These fish from the Grand Cascapedia River, Quebec, were purchased from Domtar Hatchery with funds donated by Everett Kircher of Boyne City. Another group of 9,000 fish from Domtar Hatchery were planted in the Lower Au Sable River, Iosco County in 1972. In 1973 the Boyne River was again stocked, this time with 15,000 yearling smolts. This plant was repeated in 1974. Also in 1974, 8,000 smolts were stocked in the Platte River, Benzie County. Because of the small size of these first few plants, they were made in streams where returning adults could be captured or where we would learn the most from the plants.

Atlantic salmon brood stock of Grand Cascapedia strain are being reared in our Wolf Lake Hatchery. In the fall of 1973 50,000 eggs were taken from these fish, and we expect to plant 15,000 smolts in 1975. Added to these will be a like number of smolts from eggs received directly from Quebec. Thus, we expect to plant 30,000 smolts in 1975, and if our success continued we hope to reach a planting level of a quarter million by 1978 or 1979. The ultimate level of stocking will depend upon success of early plants and the type of sport fishery that develops for Atlantic salmon in Michigan.

Our initial plants of salmon have given us encouragement. Three hundred of the 10,000 planted in the Boyne River are already accounted for. This is a minimum figure of 3% survival. Many additional catches of salmon have been reported but have not been confirmed. Others must have been caught but mistaken for steelhead, brown trout or coho. Now in their third summer, adults returning to the Boyne River are running 8 to 16 pounds (largest 16 lbs. 3 ozs.). Sport fishermen in the area are excited. A number of salmon in the 10 pound class have also been taken from the Lower Au Sable by anglers.

Besides good growth and survival, we are happy with the fact that the salmon have entered our streams in good numbers as early as May, and they continue to enter in July and August. They have been taken on all types of sporting tackle including flies (one on a dry fly) and spinners, and the fresh-run fish give spectacular accounts of themselves.

From our experience so far, we feel confident we can develop fine Atlantic salmon runs in several Michigan streams. In the spring of 1975 we may extend our plants to include a river capable of supporting a sizable Atlantic salmon sport fishery. Although the Boyne has provided some fishing, most of it has been at the stream's mouth. The river itself is so small that most fish hooked upriver are quickly lost in brush or logs. No rivers have been definitely selected for the development of a major Atlantic salmon sport fishery, but logical candidates include the Pere Marquette, Manistee, Au Sable, and Two Hearted. The Platte will again be stocked, and although it is of modest size and the plants there are largely for research purposes, a good quality sport fishery is expected to develop.

REGULATIONS

No discussion of Atlantic salmon or steelhead management would be complete without discussing angling regulations. Many of our fishermen are already worrying over the sport fishing regulations we will impose on Atlantic salmon and have taken for granted that we can build salmon numbers easily to any desired level.

Considerable thought has been given to regulations that might be imposed, but our experience with setting regulations on resident trout and Pacific salmon tells us that development of detailed regulations at this time is premature. It is likely that we will protect salmon in at least parts of every stream we stock by reduced creel limits and special gear restrictions. But because of the similarity of Atlantic salmon to steelhead, brown trout, and even Pacific salmon in the eyes of our average fisherman, it would be completely impractical to attempt to impose special rules on Atlantic salmon throughout the Great Lakes and their tributaries.

Atlantic salmon taken in the open waters of the Great Lakes and incidentally as strays in unstocked tributaries will be subject to the same sport fishing regulations as now apply to our steelhead and brown trout; namely, a ten-inch size limit and a five-fish creel limit. The ten-inch size limit protects both steelhead and Atlantic salmon through the smolt stage in our streams so that the largest,healthiest smolts are allowed to enter the Great Lakes subject to no sport fishing harvest (the only angling loss would be to hooking mortality of released fish). Once they reach the Great Lakes we find that these fish do not enter the catch until they approach 20 inches.

Surprisingly, there is some concern that Atlantic salmon will be too successful in the Great Lakes. There is a fear that too many Atlantic salmon will dilute the quality of fishing, just as too many Pacific salmon did in our streams. There is a fear that some Atlantic salmon will be snagged.

We have no intention of allowing snagging of either steelhead or Atlantic salmon, but since we do have a few areas open to snagging for Pacific salmon there is a possibility that both of these species may be accidentally hooked and illegally kept. If Atlantic salmon prove to be a more popular open water gamefish than either coho or chinook, it is quite possible that plantings will be increased and that more than modest runs of Atlantic salmon will develop in several of Michigan's tributaries to the Great Lakes. This will mean that Atlantic salmon may be taken by sport fishing gear other than flies in the Great Lakes as well as in many of their tributary streams.

When I consider this possibility of abundance I view the problems of wrestling with the quality angling question minor and in fact enjoyable when compared to the rest of the world's Atlantic salmon problems.

ANGLING QUALITY AND CATCH -- AN INVERSE RELATIONSHIP

It has long been my personal view that angling quality is inversely related to catch (or catch rate). Since this view is directly opposed to the instincts of my co-workers and clientele, I can assure you it has been fire-hardened.

Understanding the relationship between catch and quality of fishing is basic to the management of any sport fishery, particularly a trout fishery. Since I believe this to be an important yet a poorly understood relationship, I would like to impose some of my views on this subject on the reader.

Let me cite some average catch rates that I carry around in my head as benchmarks of angling quality. In reasonably accessible waters in Michigan (and in the United States for that matter) the average daily catch per angler of wild trout is consistently very close to a quarter of a pound. For catchable trout it will run closer to half a pound, and for typical warmwater species such as perch, panfish and bass it will be about a pound. These are long term averages, of course, but they have withstood repeated personal testing. I know of no important sport fishery for which the average daily catch is less than that for wild trout, yet I know of no higher quality angling. Angling quality, in terms of pounds (not numbers) of fish caught is inversely related to catch rate. If such were not the case I assure you the brown trout would not rank where it does as an esteemed sportfish.

This brings me to another observation. Consistent and predictable success kills quality fishing. An occasional good catch interspersed with many blank sessions on the stream is more rewarding than catching larger numbers of good sized trout every time out. This suspense factor forms a big part of the appeal of steelhead and Atlantic salmon which may be here one day and gone the next. As a matter of fact, amid a persistent abundance of trout many anglers soon handicap themselves by self-imposed gear restrictions that will artificially supress their catch. Often groups of like minded anglers work to impose these special restrictions on everyone that fishes their favorite area. This is clearly done not only to reduce the catch of the group but to hopefully eliminate competition from fishermen who are strongly motivated by food gathering instincts.

To gain further perspective into the matter of angling quality I like to imagine how a "man from Mars" would record his observations on our fishing. His notes might read something like this:

"Earth, September 25, 1974:

For many desirable fish species, in addition to commercial harvest and personal food gathering, earth men practice what they call quality angling. When fish abundance is high the quality anglers depress their own catch artificially, either by using relatively ineffective gear which they call sporting tackle or by setting severe limits on the number and size of fish to be taken. In extreme cases of fish abundance, quality anglers resort to extremes in sporting tackle to keep their catch down -- barbs are filed from essentially invisible hooks of artificial flies and the flies are tied, often with great difficulty even under ideal conditions of eyesight and light to extremely fine leaders. These, in turn, are cast by the most delicate of fishing rods to fish feeding on floating insects. Fishing aids such as landing nets and creels are scorned, as are anglers that, in spite of all contrary precautions, take too many fish. To make things more difficult for themselves, quality anglers never seem pleased with typical fish specimens – only the largest in any one locality are sought even though, in many instances, the very existence of larger fish seems open to question. Often the presence of larger fish is only inferred from loud noises made while feeding, by the ease with which certain specimens damage tackle, or by the presence of preserved specimens (allegedly caught from the area) displayed prominently in places of business having a vested interest in perpetuating local angling.

In contrast with commercial fishermen and food gatherers, true anglers seem to thrive on adversity rather than success. Undaunted under almost any hardship imaginable, the quality angler loses interest in fishing rapidly under conditions of consistent assured success.

Apparently well fed, he seems less interested in the catch than in honing and testing his angling ability against the most interesting and desirable of fishes. These fishes he calls trout."

REFERENCES CITED

MacKay, H.H., 1963. Fishes of Ontario. Bryant Press LTD., 300 pp.

Parsons, John W., 1972. History Of Salmon In The Great Lakes, 1850-1972. Technical Papers of the Bureau of Sport Fisheries and Wildlife, No. 68, U.S. Dept. of the Interior, Fish and Wildlife Service.

Smedley, Harold H., 1938. Trout Of Michigan. Copyrighted 1938, 49 pp.

Smith, Stanford H., 1972. Factors Of Ecologic Succession In Oligotrophic Fish Communities Of The Laurentian Great Lakes. J. Fish. Res. Bd. Can. 29(6): 717-730.

Mr. Ayerst: *Our next speaker will be Dr. Wilf Carter, who represents the International Salmon Foundation. He is a recognized authority on Atlantic salmon, and comes from St. Andrews, New Brunswick, Canada. He will talk to us and show some interesting slides on the Atlantic salmon.*

ATLANTIC SALMON MANAGEMENT

By Wilfred M. Carter

International Salmon Foundation, Inc., St. Andrews, New Brunswick

No animal lives alone. Plants, birds, mammals, fish, and humans too, support one another in an endless quest for food, shelter and contentment. The intricate interrelationship among all living creatures and their surroundings is the essential basis of creation and survival. To deny this through ignorance, or still worse to be indifferent, is to invite disaster.

Research managers have frequently sought to manage the animal instead of the system in which that animal is only a small part. While this approach can in some instances be successful, as when dealing with localized, non-migratory animals, it simply does not work with migratory animals which move through several different environmental systems as a regular part of their living rhythm. Very few animals complete their life cycle without being exposed to radical habitat changes which affect their abundance and well being. In populations of non-migratory animals this can be brought about by a forest fire, prolonged drought, or any number of natural or man-induced events which upset or interfere with the natural system. Migratory animals are frequently affected by events which occur hundreds or sometimes thousands of miles away. These populations cannot be effectively managed unless the resource manager has a total awareness and makes allowance for the impact of those events on the lives of the animal he is attempting to manage.

The salmon portrays a good illustration of an animal which can only be successfully managed as part of a complex system. Reference is specifically to the anadromous *Salmo salar,* although there appear to be few significant management differences between *Salmo* and *Oncorhynchus.* Successful salmon management is an unattainable objective unless the entire system is considered. In attempting to restore Atlantic salmon into the Merrimack River for example, one needs to provide not only essential environmental quality within the river itself and its tributaries, but the effect of commercial fishing off Greenland and Canada, pollution, food supply and temperature change in the marine areas needs to be injected into the restoration formula.

The former abundance of *Salmo salar* throughout Europe, The British Isles and North America has been well documented, although precise statistical data are scarce (Netboy 1968). We do know the fish was present, apparently in great numbers in most of the major rivers of eastern North America between Long Island Sound in the south to the western shore of Ungava Bay in northern Canada. Anthropologist Enhard Rostlund, in his study of freshwater fish in North America, concludes that there is a theoretical reason for thinking that Atlantic salmon, per unit area, was at least as plentiful as Pacific salmon.

We have now learned that young Atlantic salmon from parts of Europe, The British Isles and North America congregate off southwest Greenland to fatten before returning to rivers where they had hatched and lived as juveniles. Discovery of those ocean feeding pastures in the late 1950's and their rapid exploitation by fishermen from many nations provoked sharp international protest. While salmon had been known to be present in Greenland waters for a long time, their numbers were believed insignificant, and in any event the natives were more interested in cod. Catches of Atlantic salmon in Greenland soared to a high of 800,000 fish in 1971, (see table 1), but the fishery wasn't halted as a result of scientific data showing its harmful impact upon homewater stocks of salmon (Tetreault and Carter 1972), (Paloheimo and Elson 1974). The conservation message was finally conveyed, and understood, by the threat of direct economic sanctions in the United States against those countries which continued to ignore the international pleas for voluntary restraint.

West Greenland is not the only sea feeding pasture of the Atlantic salmon. Stocks from Norway and Sweden are not found there, nor salmon from Iceland, as well as other salmon producing countries. Grilse, which feed only one year in the sea before returning to their river of origin, have not been observed in the West Greenland fishery in significant numbers. Salmon from the rivers of northern Canada, where smolt age may be up to seven years, have not been recorded among the Greenland catch. We must conclude that there are still other seafeeding areas where the salmon remain undetected. It is probable, for example, that Iceland's Atlantic salmon feed off the southeast Greenland coast. Understandably, Iceland would like to see the same prohibition of salmon fishing applied there as was obtained for the West Greenland region. It is entirely possible that as temperature and other marine factors change, fish distribution alters in response to the continuous search for food. Salmon may again become rare off Greenland's coast as conditions alter (Hansen, Paul 1970). It is clear that migratory stocks of fish and animals require special protective arrangements to prevent indiscriminate harvesting when stocks are intermingled and inseparable. Canada and the United States have been seeking to gain recognition of a special status for anadromous fish at the recent Conference on the Law of the Sea in Caracas, Venezuela. While not entirely acceptable to some countries, the management proposal assuring coastal producing states increased management authority over anadromous fish throughout their life cycle has gained important support.

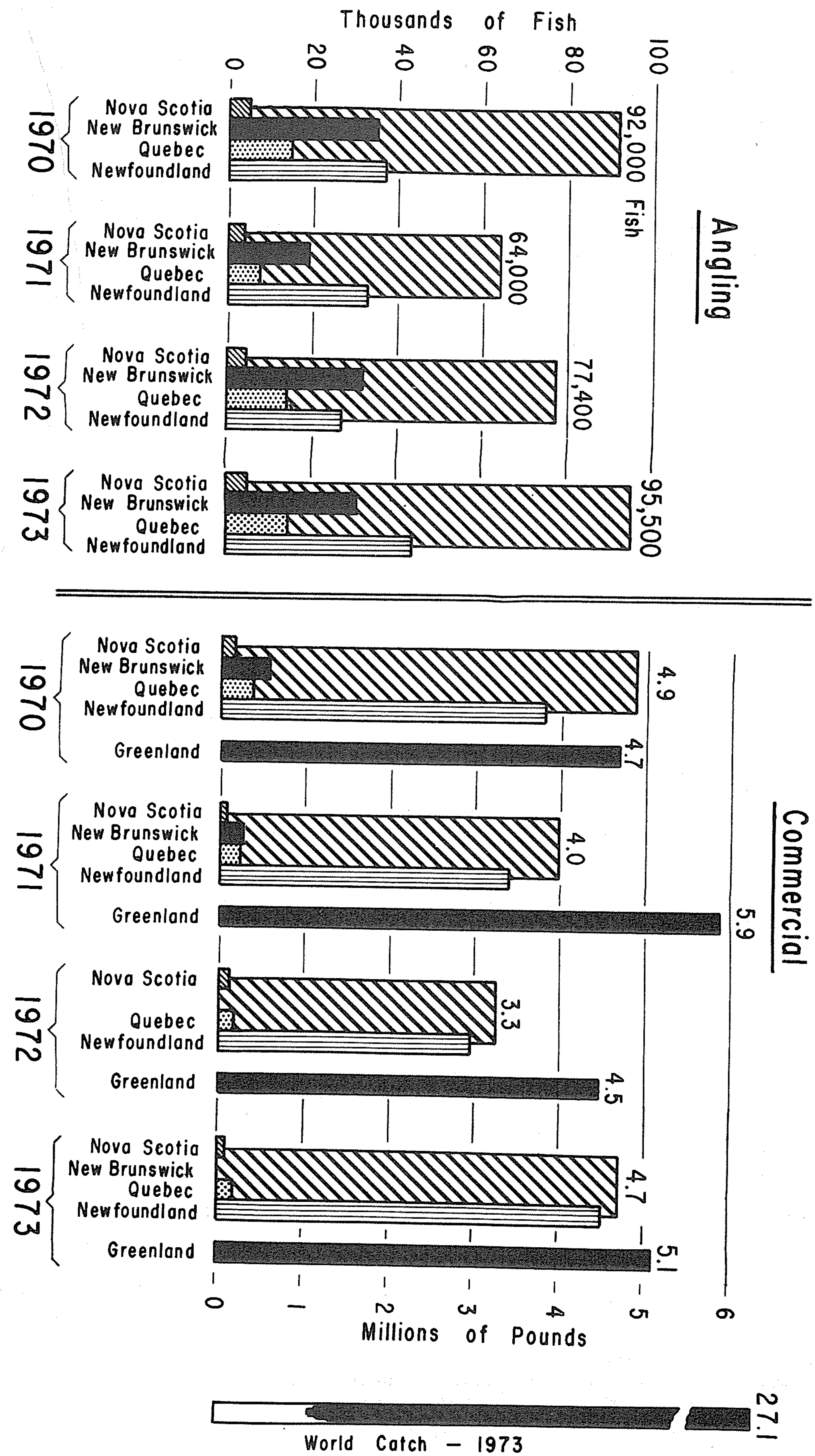
The Atlantic salmon has disappeared entirely from much of its formerrange, and in the remainder its numbers have declined. It has vanished completely from Portugal, Switzerland, Denmark, the Low Countries and hangs on only by a slender thread in France, Spain, and the United States. Rivers like the Seine, Moselle, Rhine, Gudenaa, Duro, Nansa, Elbe, Oder, Connecticut, Merrimack and Kennebec lead the roll call of once famed Atlantic salmon rivers, but have not produced a native salmon in more than 100 years. While the total world catch of Atlantic salmon is still appreciable, (Fig. 1), this relative abundance is not an accurate reflection of the total stocks. Although catch numbers have remained high or even increased in some areas they have dropped drastically in others, and the statistics do not relate catch to either increased effort or efficiency. While various exploitation rates and mortality percentages have been estimated, these do vary from year to year and are at best an educated guess. We really don't know accurately what the average annual level of world stocks of Atlantic salmon is.

It is undeniable that the main causes of the Atlantic salmon's decline, and in some instances its

Table 1. Atlantic salmon catches at West Greenland, 1965-1973.

Year	1965	1966	1967	1968	1969	1970	1971	1972	1973
Landings in pounds (x 1,000)	1,898	3,021	3,530	2,485	4,873	4,732	5,929	4,498	5,149
Landings in fish (x 1,000)	257	408	477	336	658	639	801	609	696

Figure 1


Atlantic Salmon Catches
Angling
Thousands of Fish
0
20
40
60
80
100
1970
Nova Scotia
New Brunswick
Quebec
Newfoundland
92,000 Fish
1971
64,000
1972
77,400
1973
95,500
Commercial
Greenland
4.9
4.7
4.0
5.9
3.3
4.5
4.7
5.1
Millions of Pounds
0
1
2
3
4
5
6
World Catch — 1973
27.1

disappearance, have been environmental alteration and overfishing. Concrete dams on a river or invisible pollution barriers in the estuary are equally effective in denying salmon access to natural spawning areas. Erosion and water impoundments alter temperature and reduce natural food abundance, limiting the carrying capacity of the river and thus reducing fish populations.

Nets drifting in the sea, some up to 18 miles long, are indiscriminate harvesters–capable of destroying the entire gene pool of salmon from a single river tributary overnight. Set nets in river estuaries can, and in some instances have removed more of a river's brood stock than both natural predation and angling combined.

We now know that Atlantic salmon do not all have a common denominator. Differences may be inherited from one generation to the next or may be the result of environmental influences. Some stocks may have disappeared recently because of the rapidity of environmental change and the salmon's inability to adapt as quickly. We are not yet certain which differences are attributable to the one or to the other. For example, it is thought that the migratory pattern of salmon may to some extent be an inherited characteristic. If so, this alone could explain some of the very poor returns obtained from smolt stocking programs using salmon from a variety of sources as brood stock. It seems clear now that the salmon in tributaries A, B, C, and D of the river system ABCD can be of differing strains, exhibiting slightly different characteristics, although they are all of the species *Salmo salar*. As a result, we may have given insufficient attention to the choice of parent stock to be used in hatchery programs.

Atlantic salmon management has not been as successful as hoped for. Returns have not justified the cost and effort in many instances. Fishway construction is complex and expensive, and frequently insufficient biological assessment precedes the installation of costly structures; upriver sections simply cannot produce the number of juvenile salmon to justify the expenditure. The building of hatcheries to stock rivers has given very poor returns in North America, although they have been much better in Sweden, and recently in Iceland also. Now, however, as smolt quality improves and more care is taken in selecting good brood stock, this picture is improving. The artificial spawning channels which were so successful in bolstering stocks of some species of Pacific salmon have proved of little use with *Salmo salar*, a species which spends from 2 to 5 years in freshwater after hatching, requiring more food and space than can be provided in such artificial structures.

In Canada the principal problem of Atlantic salmon management is to maintain what is still there, and if possible, to add to it. Where natural stocks are still relatively abundant, improvement can be obtained by maintaining a healthy freshwater environment, by providing efficient protection for naturally occurring brood stocks and by limiting exploitation pressure, particularly on stocks known to be low. Stocking rivers with hatchery smolts of known parentage can help to increase runs of adults, particularly if care is taken to ensure that the hatchery is disease free and the fish vigorous and healthy at release.

Accelerating smolt growth by using improved diets and warmed water has resulted in higher survival and better adult salmon returns. In an experimental program at the Kollafjordur Fish Farm in Iceland, returns in 1974 from one-year old smolts released in 1973 have averaged 14%, which is quite a remarkable achievement. Some of the Swedish programs, using selected salmon stocks have produced equally good results.

In the northeastern United States the problem is much more difficult. Environmental degradation of rivers is more advanced, and in some instances the changes may be irreversible. A series of dams on some river systems has altered the entire river regime. Consequently, the animal and fish populations have changed too. Atlantic salmon have been absent from some of the rivers there for 100 years and even longer. Only in the state of Maine are there still some naturally occurring runs of Atlantic salmon, and these are maintained at considerable cost, with great dedication. In a few of the rivers of Maine, notably the Penobscot, the run has been slowly increasing. Five years ago Atlantic salmon were non-existent there (Meister 1972). In 1972 the fishway count at the Bangor Dam was 333 salmon; in 1973, 297; and to date in 1974, 540. For the first time in more than fifty years 1,000,000 salmon eggs will be taken from native stock in Maine.

What will be needed to restore runs of Atlantic salmon to other rivers of northeastern New England?

First, the determination to do it, and assurance of sufficient funding to support the restoration effort. Then in practical terms and in order of importance are:

(a) Restoration of habitat quality

This involves the provision of adequate fish passage facilities over dams and other obstructions, both for adults to go up and smolts to get down. It includes control of water extraction and strict regulation of effluent discharge levels. It means enlightened forest management to restore cover and vegetation to stream banks, the removal of accumulated heaps of sunken wood and the scouring of silt-laden spawning gravel.

(b) *Identification of stock characteristics*

Knowing now that each river has evolved its own strain of Atlantic salmon and that both genetic and environmental factors may have been influential in selection of the various strains, it is important to identify the type of salmon stocks which frequented each river before natural runs expired. Much of this information is available in historical records, e.g., time of runs, size of salmon, physical configuration, water temperatures, physical geography of the river and estuary, etc. In other words, what evolutionary and inherited characteristics did the Atlantic salmon which occurred naturally in those rivers possess?

To successfully restore natural runs of Atlantic salmon into New England rivers it may be necessary to begin with seed stock which closely resembles the original, and cross it with the nearest available local stock to retain the important environmental factors which have evolved through the natural selection process. In that way it may be possible to begin restoration attempts with a salmon which sets its course NE on striking salt water instead of heading south for the Florida Keys, grows more quickly, will remain at sea only one full year or less, thereby feeding closer to the North American shore, thus avoiding distant fisheries, and will return to its river of origin earlier, when the temperature in the estuary is 60° instead of a lethal 80°. An Atlantic salmon which harmonizes with the habitat it is expected to occupy and can thrive there should be the management objective.

In other words, it is no longer good enough to proclaim that "a salmon is a salmon is a salmon...." Hatchery programs which have operated on that premise, showing little or no result, attest to its inadequacy. Beginning with the most suitable stock should put the restoration program well on the way to success.

(c) *Restocking programs*

Build simple hatcheries, preferably small ones on or near the rivers to be restored, and begin an annual stocking program with selected strains of smolts developed by using the techniques described in (b). The initial eggs will have to be obtained from an agency with a selective breeding program, such as the North American Salmon Research Center in St. Andrews, New Brunswick. Smolts reared in an accelerated program could be planted out one year later, using self-releasing ponds located in the lower sections of the rivers. Returning adults, trapped at the river mouth and kept in the hatchery, would form brood stock to provide a regular supply of smolts for subsequent years.

(d) *Regional effort*

The Atlantic salmon cannot be restored to the Vermont section of the Connecticut River without first having assured that the fish can safely get through the lower river which traverses other states. A regional approach to management, involving all of the northeastern States, with the full assistance and support of the Federal government, will be needed to successfully undertake Atlantic salmon restoration. Full agreement and support for regional programs, including hatcheries, pollution abatement, water extraction limitations, etc. is essential. Political expediency and the restoration of Atlantic salmon to New England are completely incompatible.

Those are the essential ingredients for successful restoration of Atlantic salmon runs to New England rivers. Obviously other factors have to be considered too, before embarking on the restoration attempt. It may be that some rivers will prove to be totally unsatisfactory candidates for restoration or that the agencies involved are unwilling to pay the price. There is no doubt, however, that it can be done.

The preceding points have dealt with management of anadromous *Salmo salar*. There is, however, growing interest in the Atlantic salmon for freshwater fisheries and in fish farming programs. *Salmo salar ouananiche* is a naturally occurring strain present in northern Canada, which, although not physically landlocked, does not make a seaward migration. *Salmo salar sebago* and other indigenous freshwater strains are frequently physically landlocked. All, however, exhibit the characteristic of spending their entire life cycle in freshwater.

Atlantic salmon will thrive very well in a permanent freshwater habitat, seeming to adapt very easily to the changed conditions. The lake system is used by the fish as its sea, and spawning migrations are made up the brooks and rivers which supply the lake. Michigan has had initial encouraging results from its attempts to introduce Atlantic salmon into Lake Michigan. The incentive to try freshwater introductions is the enviable tribute paid the Atlantic salmon by many fishermen as the finest freshwater game fish of them all. In the case of Lake Michigan it will provide an additional recreational species, occupying a niche not now being used by any other fish.

Farming Atlantic salmon has proven more difficult than some of the Pacific species. Initial attempts to raise *Salmo salar* to marketable size have been costly, and the failure rate has been high. More recent attempts in Norway and Scotland, where cold Atlantic seawater is warmed by the Gulf Stream flowing not far offshore, have been more successful. In the northeastern United States and Canada cage rearing in the sea is being attempted, although cold temperatures may limit the prospects of raising a market size fish at an acceptable cost. Using selectively bred strains of Atlantic salmon to obtain higher survival and a more rapid growth rate could easily make the prospects much more favorable. There is also considerable interest in the use of warm water effluent from thermonuclear plants in aquaculture programs. Early indications are highly promising.

The other side of management concerns the use of a resource. Fishery managers presumably have a responsibility to see that the best use is made of a renewable resource. It is the term "best use" which is subject to a variety of interpretations. Is it the greatest economic return which should be sought, or use of the resource by the greatest numbers? Is high quality of the recreational experience, which necessarily limits access to a recreational opportunity, more important than perpetuating an unrestricted access concept? Is it possible to provide Atlantic salmon fishing for all who seek it and still maintain a healty, viable resource?

There are both biological and aesthetic arguments against the "open fishing" concept. There may be places such as Lake Michigan where it can work, but on the smaller rivers of the northeastern United States and in Canada, failure to impose reasonable restraints upon public use of a renewable resource could be an invitation to disaster. As put so aptly by Leopold, "excessive dilution of a recreational experience leads inevitably to qualitative bankruptcy". He might have added that the unrestricted use of a depleted resource struggling to regain a foothold assures almost certain failure.

REFERENCES CITED

Netboy, Anthony. 1968. The Atlantic Salmon, A vanishing species? Houghton Mifflin Company, Boston.

Rostlund, Erhard. Freshwater fish and fishing in native North America. P. 26.

Tetreault, B., and W. Carter. 1972. Adult salmon recaptures from a 1968 smolt stocking program. ICNAF Res. Doc. 72/49, Ser. No. 2786, Annu. Meet., 1972.

Paloheimo, J. E., and P. F. Elson. 1964. Effects of the Greenland fishery for Atlantic salmon on Canadian stocks. IASF Spec. Pub. Series. Vol. 5, No. 1.

Meister, Alfred. 1974. Personal communication.

Hansen, Paul. 1966. The Atlantic salmon in Greenland waters. (Manuscript).

WATER QUALITY AND QUANTITY MANAGEMENT PANEL

Dr. King: *The Chairman of the Water Quality and Quantity Management Panel this afternoon will be Dr. Richard Graham. Dick presently directs the Cooperative Fishery Unit program for the U.S. Fish and Wildlife Service, Washington, D.C. He has excellent training and experience in the field of water quality having gained much of his expertise as the Leader of the Montana Cooperative Fishery Unit. He will introduce the speakers.*

Dr. Graham: *We have a subject there that is extremely broad. It is so broad that we could have a symposium on Water Quality as it affects trout streams and Water Quantity as it affects trout streams. Out first speaker will discuss "Tailwater Trout Management". This is not necessarily a wild trout fishery, because it implies that we are dealing with a man-made environment. How might a tailwater be managed as a wild trout fishery? Mr. Donald Pfitzer of the U.S. Fish and Wildlife Service, Atlanta, will present his paper on this subject.*

TAILWATER TROUT FISHERIES WITH SPECIAL REFERENCE TO THE SOUTHEASTERN STATES

By Donald Pfitzer

U. S. Fish and Wildlife Service, Atlanta, Georgia

Trout tailwater management is a relatively new science. It has been less than 25 years since the first trout tailwaters were seriously managed. The potential for recreational fishing in tailwaters that can support trout is great. In the southern states alone there are more than 800 river miles altered by high dams, most of which have trout management potentials. This is not intended to imply that all of them sould be managed as coldwater fisheries. However, now that the design and operation of these dams is, for all practical purposes, fixed and favors a cold discharge, every effort should be made to obtain the maximum trout fishery that can be managed economically.

The first high dams which discharged cold water with the potential for year-round trout management were Hoover Dam, completed on the Colorado River in 1935, and Norris Dam, constructed by the Tennessee Valley Authority in 1936 on Clinch River in Tennessee. It was not until the early 1950's that fishery management activities were started at Hoover Dam tailwater. Soon after impoundment of Norris Reservoir fishery biologists began to study not only the reservoir but also the tailwater.

Eschmeyer and Smith (1943) noted that warmwater species of fish were not reproducing below Norris Dam, even though they occurred there in relatively large numbers for a few years after impoundment. They described for the first time the egg-bound condition in sauger and crappie. In the years that followed this phenomenon was repeated each time a high dam was completed and discharged cold water into a formerly warmwater river.

By 1950 there were throughout the country a dozen dams discharging cold water, representing more than 300 river miles converted from warm- to coldwater streams. Most of these were in the Tennessee River valley below dams constructed by TVA and on the North Fork of the White River (by the U.S. Army Corps of Engineers) that changed a section of that famous river system in Arkansas.

In the southeastern states the Tennessee Valley Authority, Corps of Engineers, and private power companies in the ensuing years constructed many large multi-purpose dams most of which included flood control and hydroelectric power generating features. The height of the dam, the location of the penstock intake, and the very large storage capacity were the key features in modifying the formerly warmwater streams. The construction of these huge dams and the large reservoirs has been described as the most striking man-made phenomenon since the ancient pyramids.

In the States of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia there are more than 260 dams constructed by public agencies. They run the gamut from small (500 acres) city water supply reservoirs to projects such as Kentucky Dam which at the top of the flood gates impounds 261,000 acres of water in two states or Fontana Dam in North Carolina which controls water to a depth of more than 400 feet.

All of these projects effectively block or slow down the movement of fish in the stream. Fishing success is generally good below most of the low-head dams. The purpose of this discussion, however, is to take a closer look at the trout fisheries that have been developed below some of the high-head dams and examine some of the reasons for the wide variation in the quality of the fisheries.

In order for a year-round manageable tailwater trout fishery to occur it is necessary for certain basis conditions to exist in the design of the dam and in physical characteristics of the stream segment below the dam. Some of the more important conditions are:

A reservoir deep enough to produce a fully stratified condition during the summer months.

A storage volume large enough to permit a volume of winter-stored water greater than the volume of warmwater inflow during the warm months of the year.

A penstock level situated to take advantage of the cold, winter-stored water for release into the tailwater.

A release pattern that will prevent long periods of no-flow in the river below the dam or a satisfactory minimum flow to accommodate the fishery.

A river profile that has a fall/mile and pool:riffle ratio compatible with trout stream requirements. This will also produce a satisfactory reaeration coefficient to regain the loss of dissolved oxygen caused by BOD of the reservoir stored water in the last stages of summer stratification.

A significant length of unchanged river channel below the dam, the longer the better.

A stream bottom composed of a texture suitable for bottom organism production and/or a stream bank vegetative type that will create a substantial amount of terrestrial fauna that can fall into the stream and serve as trout food.

There are other factors important to the tailwater fishery depending on latitude or elevation, especially in those streams that were trout fisheries prior to impoundment. The conditions mentioned are more or less universal and apply to cold tailwaters almost anywhere.

A major problem in the management of tailwaters below hydroelectric projects is the erratic flow of water. Variations in flow during a 24 hour period may range from zero to maximum capacity (5,000 to 10,000 cfs) for the generating facility. For instance, at a project like Dale Hollow Dam on the Obey River in Tennessee, maximum discharge is more than 5,000 cfs. Minimum flow is near zero. Average annual unregulated stream flow was 1,600 cfs. Thus, at this project a normal operating schedule would call for full discharge one or two times a day during peak power demands and a zero flow for 8 to 10 hours during any 24-hour weekday. Needless to say, this results in a harsh environment.

The effects of no-flow periods in the tailwater are two-fold. First, if the no-flow period occurs during the warm months for an extended period of time, say 36 to 48 hours, the water begins to warm beyond the limits desirable for trout. Second, the periods of no-flow expose areas of stream bottom which seriously reduce or eliminate the productivity over much of the stream. The riffle and shoal areas, which are potentially the most productive of important food organisms, are the first to be exposed.

In order to overcome the effects of the zero flow a minimum flow pattern must be incorporated into the operating schedule. The ideal minimum flow pattern for trout management is a continuous minimum flow of not less than some fixed volume of flow. Kent (1963) and Jackson, et al (1964) demonstrated on the North Platte River and the Green River in Wyoming that a very exact minimum acceptable flow could be determined on the basis of photographs and other studies of the shoal and riffle areas at given waterflows. For instance on the Platte below the Kortes project a minimum flow of 200 cfs had been recommended by U.S. Fish and Wildlife biologists. The recommendation had not been made a part of the operating plan for the project, and fish losses occurred. A pool to riffle ratio was calculated. Photographs were made of the river at carefully scheduled and measured flow rates. The studies concluded that a flow of 207 cfs barely approached the minimum necessary to maintain the trout fishery. Flows of 500 cfs were found to be optimum for a proper trout fishery and habitat. This minimum flow was then recommended for the project.

A continuous flow of proportions necessary to correct this condition in most cold tailwaters of the southeast would seriously interfere with the economics of hydroelectric power production according to the operating agencies. A compromise type minimum flow based on time and water volume is practical and can greatly improve the conditions for trout.

Time-volume release is a release of some relatively large volumes of water in a short time during any period of otherwise no discharge. For instance, at a project where periods of no-flow for 2 or 3 days may frequently occur from March to October, a release schedule could be adopted which would provide for a discharge of perhaps one full load on one generator for a one-hour period during any 24-hour period. At a project like Dale Hollow Dam this would be about 1,500 cfs. Such a discharge schedule may occasionally result in a minor loss in total system economy; however, the benefit to the fishery and the recreational potential to the fishermen would more than offset any power supply loss. The discharge of water in this fashion would permit electrical power to be generated and, at the same time, provide a fresh volume of cold water in the tailwater.

Because the best trout fishing occurs during the periods of relatively low-flow, a time-volume release would not be dangerous and would have the effect of stimulating trout feeding, especially in the segments of the stream from 2 to 3 miles below the dam to the end of trout water. Also, at this distance from the dam the wave created by the discharge would have flattened out to such an extent that it would be only slightly noticed. The exact volume of water to be released must be calculated for each stream based on such factors as speed of travel of the translatory wave, riffle area exposed, and the effective or optimum level for fishing. Since the power projects provide frequent volume changes, the transport times can be calculated quite easily from data recorded at the U.S. Geological Survey gauging stations or by setting up temporary stations to determine the time of occurrence of the peak waves and low flow periods at given locations along the river.

Aquatic food productivity in a tailwater is directly dependent upon minimum flow. All the tailwater areas with good aquatic food organism production have some kind of minimum flow. One of the best examples in this regard is the Little Tennessee River below Chilhowee Dam. For historical reasons that are not too clear, a minimum flow of 1,000 cfs has been maintained for this large river, at least since Fontana Dam was completed in 1945. This volume of flow, although released for other purposes, served to cover all the major food producing shoal and riffle areas. One such area

(Scona Shoals) was 1/4 mile wide and one mile long, or about 160 acres. At 1,000 cfs the water level was ideal for wading. This shoal has now been covered by Chilhowee Reservoir (Pfitzer 1962). The remaining shoal and riffle areas in Little Tennessee River, although not as extensive, are maintained very productive because of the minimum flow. The low flow periods occur mainly on weekends because of electrical power demand. This also conincides with the period of greatest fishing pressure.

Tailwaters without minimum flow discharges have greatly reduced aquatic insect production. Some have maintained an acceptable trout growth rate because of the adaptable feeding habits of trout which includes a combination of algae, terrestrial organisms that fall in the stream and a limited amount of aquatic fauna (Pfitzer 1962). If an abundant supply of aquatic fauna is available much less use is made of the other forms of food. Because the volume of discharge at hydroelectric projects during peak periods is almost equivalent to flood stage and is always much greater than the average unregulated flow, activity is limited to boat fishing with other types of fishing being very difficult. Wade-fishing is limited to low flow periods which usually occur on weekends. This limits the use that is made of these waters and should be charged to the cost of the project as a loss of days of stream fishing per year compared to the number of days of fishable conditions in the unregulated stream. This loss should then be calculated for the life of the project and included in the cost/benefit ratio for the project.

Sixteen years ago it was proposed that the large dams being constructed should be designed to release water from multiple levels within the reservoir rather than the one usually low-level release point (Pfitzer 1958). The purpose was to permit variable releases to obtain desired water temperature and oxygen concentrations as well as appropriate minimum releases for the downstream flow. This was rather forcefully contested at the time, and rightly so, by a person I respect very much, Richard Stroud of the Sport Fishing Institute. He was concerned that such a modification in the design could have adverse effects on future reservoir fisheries. Much more research was needed in both the reservoir and tailwater to evaluate such a design modification.

At that time, as now, the reservoir fisheries were very popular and supported an enormously valuable industry of tackle manufacturers, boat manufacturers, outboard motor manufacturers, and the many, many supporting services such as fishing camps, marinas, motel and other tourist accommodations and shoreline developments. Also at that time, there were still many miles of large rivers that had not yet been dammed. The value of the river, although just as important then as now, was not recognized or utilized as extensively by the public. State and Federal fishery management biologists were devoting all or most of their energies to the reservoirs rather than warmwater streams. This was not only the logical and popular thing to do, it was very necessary to gain as much knowledge as possible about this still relatively unknown and unique habitat, the reservoir.

Attempts were made several times by the Fish and Wildlife Service through its Office of River Basin Studies to get the Corps of Engineers or private power companies to design a dam with multilevel penstock outlets. One such attempt in 1957 at Greer's Ferry project in Arkansas on the Little Red River failed after long negotiations with the Corps. The design modification would cost too much. The cost to the project if included early in the design was estimated at approximately one million dollars. Later after the project was under construction the cost estimate was six million dollars, and the cost/benefit ratio would not accommodate such an increase in costs.

At U.S. Fish and Wildlife Service request two flood control projects in Kentucky, the Barren River and Nolin River dams, were designed with multiple-level water discharge ports. These two tailwaters were first managed as warmwater fisheries. However, the Kentucky Department of Wildlife Resources carried out studies retaining the warmwater fisheries and, by water control, adding put-and-take trout fisheries in the same streams. The success was not phenomenal. Without water quality control, however, it would not be possible to even experiment with such a management plan that could materially improve the value of the fishery. Still later, after much study and deliberation, the DeGrays Dam on Saline River in Arkansas was the first hydroelectric project with a multiple-level discharge design. This is an experimental design, and a full scale research project has just this year gotten underway by the U.S. Fish and Wildlife Service.

Unfortunately, this study is coming at a time when it might be expected that most of the major dam construction is over. Nonetheless, it is much needed research so that full advantage can be taken of the many miles of river yet to be altered by dam construction. These studies may also show that existing projects could be economically modified to improve the quality of the tailwater fishery.

A phenomenon not completely peculiar to trout tailwaters is the feeding activity caused by rising water. When discharges for power generation follow the low flow periods in a tailwater, it frequently produces the same physical effect as that caused by summer showers in the headwater of a natural stream. As any trout fisherman knows, the rising water, if it is not overly intense or turbid, stimulates an increased trout feeding activity. In the tailwater, trout respond similiarly on the leading edge of the translatory wave as it moves downstream. Many of the larger brown and rainbow trout, those in the 5 to 10 pound class, are caught on this rising water. To encourage fisherment to stay in the stream and fish during the rising water is to invite trouble. This is because the volume of water discharged for peak power generation causes the wave to continue beyond the ability of wading fishermen to stay in the stream. To avoid a tragedy he must execute a hasty retreat to the bank. If he is caught in the rising water without quick escape route or without some type of floating device, like a float ring, he is in serious danger in most tailwaters. The closer the fisherman is to the powerhouse, the more dangerous the rising water becomes. As the wave moves downstream and the discharge volume is absorbed in the volume of the stream channel, the leading edge of the wave becomes more subtle and the crest flattened. Because of this, the beneficial effect of the rising water is more important farther downstream.

When a hydroelectric project is constructed and commences operation, the total number of generating units planned for the project are not usually in place. As an example, Fontana Dam on the Little Tennessee River in North Carolina was designed for three turbines. Initially (1945) two were installed. It was not until 1954 that the third turbine was in operation. At Bull Shoals Dam on the White River in Arkansas the project was designed for eight units. Originally four were installed. Later two more were added. The final two were installed only a few years ago. The same pattern of turbine installation occurs at most hydroelectric projects. The effects are that the volume and velocity of water discharged during peak load are less during the early years of the project. When total capacity is reached with all turbines in place and on line, the volume of water at peak loads is greater and the velocity much greater. This difference in load capacity changes the scouring effect on the stream channel especially in the first few miles below the dam. Early in the project life it is not noticed because the project is not at full capacity. Below Buford Dam on the Chattahoochee River in Georgia the stream channel in the first two miles below the dam has been lowered as much as 3 to 4 feet with great segments of the bank sloughing off into the channel and carried downstream to be deposited elsewhere. The increased volume and velocity of the project in full operation not only has a detrimental effect on scouring and bottom organism production, it also reduces the quality of the fishery. There is perhaps no way to avoid this problem in most tailwaters; however, it is an effect that is seldom ever discussed while a project is in the planning stage.

Of the project designs resulting in significant losses in fishery potential, the most permanent is the condition in which the volume of winter-stored water above the penstock intake is insufficient to maintain a year-round trout fishery but great enough to discharge cold water in spring and early summer, thereby eliminating the possibility for adequate warmwater fish reproduction. Because of this condition many miles of tailwater rivers are virtually unmanageable with our present knowledge (Pfitzer 1962 and 1967). This problem is directly related to the volume of flow of the stream to be impounded and the storage volume in the reservoir between the penstock intake level and the lower level of the epilimnion during summer stratification. As the cold winter-stored water is discharged from below, it is replaced by warm water flowing into its density level in the upper levels of the reservoir (Churchill 1957). If the cold water in the reservoir is exhausted before the reservoir destratifies during the fall months, warm water (as high as 78°F in some recorded instances) is discharged into the tailwater. Thus the tailwater is too cold in spring and early summer for warmwater fish reproduction and too warm during late summer and fall for trout.

Low dissolved oxygen alone is apparently not as degrading to the trout fishery as some of the other factors such as no-flow or excessively high temperatures. Nonetheless, it is a problem and must be dealt with at some projects especially when the water from one project is discharged immediately into the headwater of the downstream reservoir. The U.S. Army Corps of Engineers and the TVA have sought ways to overcome low oxygen, both in the reservoir and in the tailwater. Reaeration methods are being investigated, and devices are being experimentally installed or planned in several projects.

Trout reproduction is very limited or non-existent in most tailwaters of the south and east due to the uneven flow schedules which change velocities every day or expose riffle areas suitable for construction of redds. On the other hand, growth rate is exceptional for stocked fish in most trout tailwaters. Thus the management programs depend on stocking rainbow and brown trout. From the results of repeated attempts to stock brook trout it is quite evident that this species is not adaptable to the harsh tailwater environment. Although a few survive and are returned to the creel, the number is totally inadequate to support a tailwater fishery.

The size and number of rainbow and grown trout required for stocking varies with the tailwater. Stocking of fish less than 4 inches has been very successful in initial stocking of tailwaters and as supplemental stocking in some streams (Pfitzer 1962). However, in recent years stocking of larger fish (5 to 6 inches) has proven to be more practical (Boles 1968). In the White River below Shoals Dam, the Arkansas Game and Fish Commission has advocated the stocking of much larger trout, i.e., 10 to 12 inches, in order that they may contribute immediately to the creel (Baker 1960).

Regardless of stocking size, with few exceptions, the average rate of growth for tailwater trout is very good so that instead of a put-and-take fishery, as so many smaller "natural" trout streams become, the tailwater fishery can best be described as a put-grow-and-take fishery.

Most states today have eliminated a season on tailwater trout fishing and have opened the waters to year-round fishing. Likewise, size limits have been dropped in most states. Creel limits are in the range of 7 or 8 fish per day. The states generally feel, and most managers agree, that these liberal regulations take fullest advantage of the trout while not sacrificing the quality of the fishery or the number of trophy fish available. Fishing pressure is compensated for by increasing stocking within reasonable and economical limits.

As stated earlier in this paper, perhaps the greatest problem facing the agencies managing tailwaters today is the loss of existing stream segments to more and more impoundments.

There is no question about the value of the existing trout supporting tailwaters. The impoundments and resulting tailwaters in the southern tier of states have created a trout fishery resource equal to hundreds of miles of natural coldwater streams. Some of these states did not have a significant natural trout fishery. Now that we have these valuable tailwater areas we are faced with a new problem, how to retain them. Already in Tennessee and in Georgia people interested in saving the Little Tennessee River below Chilhowee Dam and the Savannah River below Hartwell Dam are waging losing battles with the construction agencies in an attempt to prevent impoundment of the last remaining stretches of these outstanding tailwater trout fisheries. These and many other trout tailwaters are programmed for destruction to make way for more reservoirs, the shorelines of which become valuable speculation property when completed. The Tellico project, which will inundate the last remaining 32 miles of Little Tennessee River, has as a part of the benefits the differential in land value before and after impoundment. The land is purchased at a lower price from the private landowner and calculated to be sold at a higher price as the shoreline of the future reservoir of very doubtful fishery value is developed for residential, commercial, and recreational use.

We can no longer afford to produce conditions like the many miles of almost barren water below such dams as Cherokee in Tennessee, Allatoona in Georgia, Narrows in Arkansas, and Pomme de Terre in Missouri. More than 160 miles of recreationally important streams have been lost in these four projects alone. There are an additional 200 miles of streams that are contributing virtually nothing to the recreational needs of the fishing public. From a fishery management standpoint, these stream segments are just as useless as if they received an overload of industrial or domestic waste.

Neither this generation nor any other has the right to fix the operation of the great hydro projects so rigidly that they can never be changed. We have done this at an accelerated pace for almost a half century. It is time now that we design for the future.

REFERENCES CITED

Baker, Robert F. 1960. Historical review of the Bull Shoals Dam and Norfork Dam tailwater fishery. Proc. Thirteenth Annual Conf. Southeastern Assoc. Game and Fish Comm., pp. 229-236.

Boles, Hallet D. 1968. Little Tennessee River Investigation. Proc. Twenty-second Ann. Conf. S.E. Assoc. Game and Fish Comm., pp. 321-338.

Churchill, M. A. 1957. Effects of storage impoundments on water quality. Jour. San. Eng. Div., Proc. Amer. Soc. Civ. Eng. Paper 1171, Vol. 83:1-48.

Eschmeyer, R. W. and C. G. Smith. 1943. Fish spawning below Norris Dam. Jour. Tenn. Acad. Sci., 18(1):4-5.

Jackson, Helms, Wiley and Baldes (first names not shown). 1964. An evaluation of data and observations on trial flow-releases in the Green River below Fontenelle Dam. Admin. Rep. Wyo. Game and Fish Comm., Fish Div., 1964:14 pp.

Kent, R. 1963. North Platte River fish loss investigation. Wyo. Game and Fish Comm., Federal Aid Project, 763-6-1:62.

Pfitzer, D. W. 1958. Some problems in tailwater fishery management. Proc. Eleventh Annual Conf. Southeastern Assoc. Game and Fish Comm., 23 pp.

-------, 1962. Investigations of waters below large storage reservoirs in Tennessee. Tenn. Game and Fish Comm., Fed. Aid Proj. F-1-R Final Report:233 pp.

-------, 1967. Evaluation of tailwater fishery resources resulting from high dams. Proc. Reservoir Fishery Resources Symposium presented by Reservoir Committee, Southern Div. Amer. Fisheries Soc., pp. 477-88.

Dr. Graham: *We will continue our look at tailwater trout fisheries by going to the west. Bob Wiley, Area Fisheries Biologist with the Wyoming Game and Fish Department will give a paper on the Green River (Fontenelle) tailwater fishery. The paper was coauthored with James Mullan of the U.S. Fish and Wildlife Service.*

PHILOSOPHY AND MANAGEMENT OF THE FONTENELLE GREEN RIVER TAILWATER TROUT FISHERIES

By Robert W. Wiley and James W. Mullan

Wyoming Game and Fish Department, Green River, Wyoming — U. S. Fish and Wildlife Service, Vernal, Utah

Tailwater trout fisheries generally represent an intermediate level between "pure" wild trout management and total dependence on put-and-take stocking of large trout in creating a fishery. They may also qualify as intermediate relative to aesthetics in that the environment and applicable management depart from the untrammeled natural, used by some as the optimal measure of quality (Wilkins 1968). Shifts away from the natural generally include the need for stocking, altered water quality, scarring of the landscape with a dam, and altered flow regimens. Accordingly, a discussion of tailwater trout fisheries in a symposium on wild trout management may seem out of place; in reality it is not.

PHILOSOPHY

A continuum of fishing opportunities: The Outdoor Recreation Resources Review Commission's special study (King et al 1962) provided a prospectus of the national fisheries resources and their uses for the latter half of this century. It concluded that the resource potential was sufficiently great in total, given aggressive resource management, to meet the projected increasing demand for angling. However, it also called attention to short falls in certain types of angling opportunities primarily relating to trout.

Demand for quality trout fishing is growing rapidly, and can't be met solely by wild trout management – management premised on fish born and reared in natural streams – without destroying its intrinsic quality of being wild or natural. Elsewhere within the constraints of the relatively limited coldwater habitats available we need to create nearly primitive – not really wild or natural – trout fishing opportunities. Otherwise, all those who crave essentially wild trout fishing will be forced to head for what little truly wild trout fishing that remains. Carried a step further, this is why it is not especially constructive to lend support to the idea carried by some elitist trout fishermen and a few fishery biologists, that the judicious planting of catchable-size trout for anglers to catch is not an aspect of fish management and, therefore, contributes little to wild trout fishing.

Wild trout management is only one kind of fishery use. And each kind of fishery use is related to other uses in a continuum of management allocations and options, ranging from preserving isolated remnant populations of native trout to purely catch-out streams.

Quality: For many years all of us in fishery management have seen the debate accelerate as to what constitutes quality fishing and how it is to be achieved. It is important to recognize that the debate has focused on what constitutes quality and how it is achieved in a fishing experience, not on whether there was any need for improvement.

Undoubtedly a hundred or more different ideas on what constitutes quality fishing can be found. This reflects the fact that the idea of quality is rooted in the human psyche and related to personal experiences – education, upbringing, home situation. Quality obviously includes consideration of the species, the sizes of the fish, the situations in which they are sought or caught. Provision of maximum variety in species and fishing situations is certainly an element in the quality equation in concert with optimum yield as opposed to maximum sustained yield as stressed by Stroud (1970).

Inherent in these expressions is the need to limit the use of the different fishery resources within the constraints of sustained utilization which calls for their allocation.

Allocation: Allocation of fishery resources is essentially a question of politics. Final decision should be made by the public based on input from fishery biologists and other resource professionals who assist the public in making informed decisions. All the alternative uses that are possible and feasible for particular water areas need to be defined as well as the consequences of each alternative. Resource professionals will have to interpret the public desires using the rapidly developing public involvement techniques to solicit, analyze, and evaluate public sentiment so as to insure the inclusion of this input in the decision making process. And they will have to identify values desired from these waters and develop management programs to produce them.

MANAGEMENT

The Green River, largest tributary of the Colorado River, rises in the Wind River Mountains near the Continental Divide in Western Wyoming. It flows southward across an arid desert plateau and enters the deep canyons of the Uinta Mountains in Utah where it has been dammed (1962) to form the 42,000 surface acre Flaming Gorge Reservoir, part of the Colorado River Storage Project (C.R.S.P.), which backs water to within five miles of Green River, Wyoming. Another C.R.S.P. dam was constructed (1964) 73 miles upstream to form the much smaller, 8,058 surface acre, Fontenelle Reservoir. It is the 73 mile reach of river between the two impoundments that constitutes the Fontenelle tailwater.

Stocking: As described by Pfitzer (1967) for the southeast, and apparently elsewhere across the United States, cold tailwaters are essentially dependent upon stocked trout to provide angling. Stocking constitutes the principal management of such waters to the present time. Regardless of whether fingerling or catchable-size trout are released, this represents "put-grow-and-take" management as illustrated by the stocking of catchable-size trout in the 100 miles of White River tailwater below Bull Shoals Reservoir, Arkansas (Cooperating Agencies Report 1974). The estimated harvest was 846,000, 783,000, and 408,000 trout in 1971, 1972, and 1973 respectively. Comparing total weight of trout stocked with estimated weight harvested indicates a net gain of 33,000 pounds in 1971 and 21,000 pounds in 1972, but a net loss of 80,000 pounds in 1973. Considering that much of the estimated loss in biomass may still be present in the tailwater, and the acknowledged inefficiencies of attaining high numerical returns from stocking catchable size trout in such a habitat, especially considering abnormally high stream flows in 1973, the production (growth) potential in such management should be clear.

The Fontenelle tailwater fishery is maintained by stocking about 170 fingerling rainbow and brown trout per surface acre. There is an additional unknown, but limited, amount of natural reproduction and contribution from fingerlings stocked in the upper (400,000 annually) and lower (3,000,000 annually) reservoirs. Maximum fishing pressure recorded averaged about 13.0 fishing trips per surface acre (Table 1). Maximum yield averaged about nine trout or nine pounds per acre. Although yield to the creel is low, without considering extrinsic sources of recruitment, growth of trout is excellent. Stocked fingerlings (3 to 5 inches) grow to 10 to 15 inches in length in a year's time. Survival from stocking to standing crop is only fair; 33 trout or 50 pounds per surface acre in 1970 and 41 trout or 41 pounds per acre in 1972 (Banks, et al 1974).

Fishing quality: Creel data in 1970, 1971, 1972, and 1973 show about 16,000, 28,000, 38,000, and 33,000 fisherman days on the Fontenelle tailwater during those years (Table 1). About one-half of the fishermen were non-residents originating in 33 other states with Utah, Colorado, California, Texas, and Nebraska most frequently represented. Rainbow (80 to 90 percent) and brown trout (10 to 20 percent) averaging one to one and one-half pounds but with fish up to 12 pounds not uncommon, made up most of the catch. The catch rate, 0.22 to 0.32 fish per hour, was one of the lowest for all Wyoming rivers, but the size of the average fish taken was larger than for any blue ribbon stream. Average length, growth, condition, and catch rate have changed little over the years even though fishing pressure has grown dramatically. The trend in growth indicates 75,000 to 100,000 fishing days annually by the year 2000. The 1971 estimates represented about 3.5 percent of the total stream fishing that occurred in Wyoming during that year. The number of anglers per mile ranked with the heaviest fished rivers.

Unique quality factors readily identified with this fishery are: a big, deceptively swift river, resembling a verdant ribbon immersed in the enormity of the sagebrush covered high plains, and

Table 1. Fishery statistics for the Fontenelle - Green River tailwaters, 1970 through 1973.

Parameter	1970	1971	1972	1973
Number of angler days	15,734	28,258	37,818	32,642[1]
Fishing pressure in trips per S.A.	5.4	9.7	13.0	11.2
Fishing pressure in hours per S.A.	13.5	26.3	28.5	23.9
Trout harvest, number[2]	8,769	19,293	25,166	19,247
Average weight of trout harvested	1.51	1.40	1.00	1.16
Catch rate in fish per hour	0.22	0.25	0.32	0.29
Yield, pounds per S.A.	5.4	9.7	8.6	7.7

[1]The decline represents a typical response to a 100 percent increase in non-resident license fees.
[2]Harvest composed of about 80 percent rainbow and 20 percent brown trout.

offering fishing opportunity for essentially wild trophy-size trout.

Allocation: Allocation of this fishery resource would seem to be clear-cut based on the criteria and input developed: perpetuation as an essentially wild big trout stream fishery. Alas, this is not the case in that the allocation process involves not only the fishing public but all the people of Wyoming due to conflicts arising from apportioning a fixed water resource among increasingly competitive demands in a very arid state. In other words, the public must decide first on how to allocate their basic water supply: for irrigation, industrial use, recreation, fisheries. To help in deciding what should be, fisheries biologists have attempted to provide the objective information on what can be by exploring various flow regimens and the consequences of each alternative on the fishery (Banks, et al 1974).

This was accomplished by developing a conceptual synthesis of information about trout requirements and environmental factors pertinent to the Fontenelle tailwater. This explains how the trout population is regulated under variable conditions of stream flow.

Four flow options were explored and are presented as follows:

1) Perpetuation of the existing fishery with no change in flow patterns; that is, 1,600 cubic feet per second (cfs) average daily flow, maximum flows of 10,000 to 15,000 cfs, and low flows of 300 to 400 cfs. Water quality and nutrient base are good, but excess water velocities and lack of shelter result in low population densities. Those trout surviving these conditions do very well, exhibiting the excellent growth and condition already described.

With this option, increases in fishing pressure and harvest may be limited within the constraints of management objectives which, of course, are governed by fish production as affected by flow regimens. It is expected that a harvest of 20,000 to 26,000 pounds of trout can be maintained with a fishing effort of 30,000 to 40,000 angler days.

2) Enhancement of the fishery through reduction in flows. Test flow studies of 1973 showed that a flow of 800 cfs offered the most balanced habitat diversity in meeting the needs of all sizes of trout. As flows were reduced from 1,600 cfs to 800 cfs it was indicated that small trout would benefit but that no significant diminution in the production of large trout would occur. Included with the production flow of 800 cfs were: a minimum wintertime flow of 500 cfs and an emergency (30 days) winter survival flow of 300 cfs.

Assuming an increase in survival of small fish with reduced flows and no decline in the numbers of large trout an increase in potential use and harvest can be expected. It is not unrealistic to expect a harvest of 15 pounds of trout per acre; total yield of 48,000 pounds from 50,000 angler days.

3) Realization of the full potential of the Fontenelle tailwater through correction of limiting factors, reduction in flows and increase in shelter. Full potential is defined as: no change in average size of trout harvested, increase in yield to 50 to 100 pounds per acre; total yield of trout 130,000 to 260,000 pounds; 65,000 to 130,000 fisherman days; and an increase in catch rate to about 0.5 trout per hour. The optimized flow regimen would include a production flow of 800 cfs, a winter flow of 500 cfs, and a habitat maintenance flow in the range of 800 to 1,600 cfs as necessary. Additional shelter would be provided through placement of apartment-space type structures as described by Stroud (1966).

4) Flow regimen of 300 to 500 cfs. Such a pattern would favor the production of smaller trout and rough fish because of changes from swift flow to a relatively slow moving stream characterized by warm temperatures and heavy silt loads. To make full use of the reduced environment perhaps a put-and-take system employing the catchable sized trout with no creel limit could be employed. The tailwater would, then, be serving as a short-term holding pond for the catchable product and would little resemble the large, essentially wild stream of more bountiful times but would provide a source of recreation for large numbers of people.

The preceding evaluation suffers many limitations. Biological effects of any of the stream flow regimens on the ecosystem as a unit -- on the upstream and downstream reservoirs – are not defined as described by Stroud (1967). The importance of this is amply illustrated in being unable to quantify the contribution that trout stocked in the tailwater make to the lower reservoir, or the contribution that trout stocked in either of the reservoirs make to the tailwater. Cost-benefit analysis between opposing uses of the water are not defined, and despite the disrepute of such indicators they represent a means by which the public may weight the merits of complex issues. Nevertheless the direction taken was correct even though it does tend to highlight the disparity between theory and reality.

REFERENCES CITED

Banks, R.L., J. W. Mullan, R. W. Wiley, and D. J. Dufek. 1974. The Fontenelle Green River trout fisheries – considerations in its enhancement and perpetuation, including test flow studies of 1973. U.S. Department of the

Interior, Fish and Wildlife Service. 74 p.
Cooperating Agencies: U.S. Corps of Engineers, Arkansas Game and Fish Commission, Missouri Department of Conservation, Bureau of Sport Fisheries and Wildlife. 1974. Estimates of sport fisherman use and harvest, Bull Shoals Reservoir and tailwater. Mimeo., 32 p.
King, W., et al. 1962. Sport fishing – today and tomorrow. O.R.R.R.C. Study Report 7. U.S. Government Printing Office, Washington D.C., 84 p.
McFadden, J. T. 1969. Trends in freshwater sport fisheries of North America. Am. Fish. Soic., Trans. 98:1, 136-150.
Pfitzer, D. W. 1967. Evaluation of tailwater fishery resources resulting from high dams. Reservoir Fishery Resources Symposium,(1967), University of Georgia Press, 477-488.
Stroud, R. H. 1966. Artificial reefs as tools of sport fishery management in coastal marine waters. Sport Fishing Institute Bul. 170, 8 p.
———————. 1967. Summary – reservoir fishery resources symposium. Reservoir Fishery Resources Symposium (1967), University of Georgia Press, 556-569.
———————. 1970. Future of fisheries management in North America, p. 291-308. In N. Benson (ed.) A century of fisheries in North America. Am. Fish. Soc., Special Publ. No. 7, Washington, D.C.
Wilkins, B. T. 1968. An ecological criterion for evaluating an environment. In A. W. Eipper (ed.) Aspects of planning, evaluation, and decision making in sport fishery management. Fourth Fishery Biologists Seminar, Ithaca, New York, 23 p.

Dr. Graham: *Our next speaker is Stacy Gebhards of the Idaho Fish and Game Department. Stacy has an interesting and provocative subject.*

WILD TROUT NOT BY A DAMSITE

By Stacy Gebhards

Idaho Fish and Game Department

When asked to participate in this symposium and discuss wild trout management in impoundments, I warned that my paper would no doubt be the shortest one of the session, simply because I could think of no reservoirs in Idaho or neighboring states that had sizable wild trout populations. This afforded a challenge to see if this were really the case, and, if so, what were the reasons.

Two separate questionnaires were sent out: one to the other western states and a more detailed one to regional fishery managers in Idaho. Some difficulty was encountered with the questionnaires in identifying significant wild trout reservoir fisheries. I arbitrarily picked a level of 20 percent or more of the creel comprised of wild trout as representing a "significant" fishery. Such a statistic has some obvious shortcomings: if a reservoir is not stocked with hatchery trout, then all of the fish are wild. However, the population size may be so low or the reservoir so small as to be totally insignificant in terms of fishing interest or harvest.

The questionnaire excluded artificial lakes or impoundments with non-fluctuating water levels. Also excluded were natural lakes with outlet structures designed to elevate the natural high water mark and operate the upper level of the lake basin as a reservoir. Both situations are atypical of the familiar multi-purpose impoundments in the West for irrigation, power, and flood control. Wild trout were defined as self-perpetuating populations, although they may have originated initially from hatchery releases.

RESERVOIR FISHERIES - WESTERN STATES

Using these criteria, the total count of reservoirs in the western states was 1,335, with only 62 (less than 5 percent) having wild trout fisheries (Table l). California, Oregon, Utah, and Arizona tallied a total of 496 reservoirs, none of which were considered as having wild trout fisheries.

If additional criteria had been imposed, such as listing only reservoirs larger than 100 surface acres; catch rates above 0.5 trout/hour (as suggested by Utah); annual harvest of a certain level; the list of significant wild trout reservoir fisheries would shrink drastically. Six of the 14 Idaho reservoirs would drop out on the acreage limit and probably another five or six scratched on the basis of catch rates and annual harvest. Several other states commented that the 20 percent criteria alone inflated the number of wild trout fisheries.

Trout species found to be self-sustaining in reservoir environments were brook trout, rainbow, cutthroat, Dolly Varden and brown. Brook trout were the principal wild species in one-half of the 14 reservoirs in Idaho and in all of the 30 reservoirs listed by Colorado. The most successful wild salmonid (but not a trout) in Idaho reservoirs has been kokanee. So much so, that in one instance

Table 1. Fluctuating reservoirs in western United States with wild trout fisheries.

State	Total number reservoirs	Reservoirs with Wild Trout comprising 20% of creel
Wyoming	330	2
California	270	0
Colorado	250	30
Idaho	105	14
Utah	99	0
Oregon	99	0
Nevada	61	3
Washington	50	6
Montana	31	3
Arizona	28	0
New Mexico	12	4
	1,335	62

we had to rotenone the entire population (Deadwood Reservoir in Valley County in 1973).

LIMITING FACTORS

Each state was asked to identify the primary limiting factors to wild trout production in reservoirs. These were identified as: lack of spawning/nursery area; excessive fishing pressure; drawdown; competition; and water temperature.

1. Lack of adequate spawning area was listed by all eleven states and is unquestionably the key factor in wild trout production. Reservoir sites nearly always seem to occupy the prime spawning areas of a stream system. This is usually a broad floodplain with a flat stream gradient and meandering channel characterized by a series of pools and gravel riffles. After a dam is built, displacement of spawning fish is into stream sections with steeper gradient, larger rubble size, colder water temperature, and increased competition for space.
2. Six states listed excessive fishing pressure that results from hatchery stocking programs and access development.
3. Fluctuating water levels, which I thought would have been a universal problem, was noted only by five states. Extreme drawdown naturally will flush fish as well as good organisms from a reservoir unless there is a sizable volume of water retained as minimum storage. Most reservoirs built for irrigation, except for a very few constructed in recent years, do not have a minimum storage pool. Maintaining wild trout or any fish under these conditions is a bit difficult unless they have wheels. Emigration of fish will also take place during peak storage when large volumes of surface water exit over spillways.
4. Competition with nongame species, such as suckers, squawfish, shiners, Utah chub, and carp, was listed by three states. These species invariably proliferate in new impoundments. Massive stocking of hatchery trout in reservoirs must also be considered serious competition for wild trout.
5. Water temperatures unsuitable for salmonid production were listed by Idaho and Oregon.

As with other western states, adequate spawning area was found to be the leading critical factor in 73 of the 105 Idaho reservoirs (Table 2). In addition to drawdown, competition, and temperature, we also listed food supply and dissolved oxygen as limiting factors. Food supply problems were often related to high turbidity, pollution, or reservoir size.

Table 2. Factors limiting wild trout production in Idaho reservoirs.

Limiting factors	Number of reservoirs
Spawning/nursery area	73
Drawdown	66
Competition	53
Temperature	33
Food supply	20
Dissolved oxygen	16

DISCUSSION

This rather cursory survey of 11 western states tends to support conclusively my premise that reservoir construction and operation of the impoundment are not compatible with maintaining wild trout populations. Lengthy discussion of water quality and reservoir limnology would be rather academic, since these were not listed singly as principal limiting factors in any impoundment.

Many reservoirs afford expansion in fishing area, opportunity and harvest, but not for wild trout. In Idaho, at least, we are not searching for additional reservoir fisheries at the expense of quality stream fisheries. In 1966 we found that although streams comprise only 22 percent of the water area in Idaho, they supported 56 percent of the estimated fishing pressure. This preference for stream fishing has since been further verified by three public opinion surveys, one by the University of Idaho in 1957 and two by the Idaho Water Resource Board in 1972 and 1973.

Dam builders should be made aware of the increasing, intense interest in and management efforts directed toward maintenance and development of wild trout. They must also recognize the fact that a project will not only destroy existing wild populations, but the prognosis for establishing a self-sustaining trout fishery is poor.

Wild trout reservoir fisheries? . . . not by a damsite.

Dr. Graham: *Our final speaker on the panel for this afternoon is Warren McNall of the New Mexico Department of Game and Fish. He will give us some insights on the management of wild trout streams.*

MANAGING FOR WILD TROUT IN STREAMS, A THING OF THE PAST, A CHALLENGE FOR THE FUTURE

By Warren J. McNall

New Mexico Department of Game and Fish

My paper discusses planning, management, and techniques that can be used to maintain, improve, increase, and manage our wild trout fishing opportunities in natural stream environments. By design, this paper is non-technical and does not discuss specific situations. The literature bank is rich and should be perused prior to preparing a wild trout management plan.

Wild trout management in our nation's streams is not a new concept. It has been practiced longer than most of us have lived. Talking and hearing about wild trout management is "new" and perhaps spawned by the increasing desire to revert to a pristine environment few of us recall. With a constantly growing list of new expressions such as "back to nature," "aesthetic values," "environmental movement," "quality outdoor experience," etc., "wild trout management" is becoming a commonly heard expression.

Fishery administrators are also thinking "wild trout" in view of the rapidly increasing cost of hatchery trout, *Salmo pelleti*. The beginning point in wild trout management is defining a meaning or meanings for the term "wild trout". Each state has to make this definition(s) before a wild trout management plan can begin.

Attributes of a wild trout stream generally show little variance from state to state. Good water quality is probably most important. Ideal water temperatures and minimal amounts of sediment and pollution are essential. Water flows are very important, and, with higher mean flows, production of trophy-sized trout is more likely to occur. Stream bottom habitat for shelter, food production, and spawning gravels are recognized qualities demonstrating a stream's potential for wild trout. Bank vegetation providing shade and habitat for insects is beneficial but not necessary in all situations. The presence of naturally reproduced trout usually identifies the presence of most habitat requirements.

Determining the supply of wild trout stream habitats and identifying angler demand for wild trout stream fishing opportunity are two important criteria needed for developing a wild trout management plan. Inventories showing stream classifications should identify current wild trout streams and candidate streams. The inventory will identify the percent of total trout stream miles where wild trout management is occurring or where it could be practiced.

Once supply is determined, angler surveys should be conducted to determine demand for wild trout fishing. States have conducted angler preference surveys and find the information most useful when justifying new or expanded fishery programs. Anglers hearing the results of preference surveys quite often accept these instead of the same proposal recommended by a state game and fish department. Determining age composition of licensed anglers as it relates to angler preference is also beneficial for planning. We have a new generation of anglers wetting their lines, and many already prefer the "back to nature" trout fishing experience. Using angler preference surveys other states have conducted to sell your program should be used cautiously since angler attitudes vary considerably from one state to another.

After these two important aspects of a wild trout management plan are gathered, fishery managers and administrators can "crystal ball" the data and develop a plan. The plan itself should take into accout future expected demands and not be limited to immediate needs. Once the department's administration has accepted the plan, the public should be informed of what is being planned and why.

The first part of the plan should show action objectives for protecting and/or maintaining the existing wild trout fisheries. Protection of watersheds, full evaluation of any new dams, preventing any possibility of diseased fish from entering the drainage, appropriate harvest regulation, restricted access, and barriers to prevent upstream movement of unwanted species are only a few techniques that could be used. I believe the federal and state pollution acts and regulations can be considered monumental achievements of recent date designed to protect our limited stream resources.

The second part of the plan should address ways of improving existing habitat. Stream inventories identifying habitat deficiencies should be prerequisite to improvement programs. Fencing some portions of a stream bank to promote increased vegetation might be practical for providing shade and stabilizing stream banks. Placement of suitable gravels could aid in supplementing limited spawning habitat. Stream improvement structures might be needed, and only proven beneficial habitat improvement practices should be used; however, candidate improvement techniques could be tested for determining benefits.

The final part of the plan should indicate ways of increasing wild trout fishing opportunities. There are four approaches. The first is by acquiring private sections of streams for public use. Most states have been involved in a stream acquisition program for many years. The second and perhaps most difficult way of increasing additional wild trout stream fishing opportunity is by eliminating hatchery management from a stream that is presumed capable of producing its own wild trout. The third way is to eliminate the existing fish population and reestablish wild trout. And fourth, the easiest, is to tell the angling public what is already available. Let's discuss each of these.

Starting with number four, telling the angling public of wild trout fishing should encourage use of available opportunities. It can also help distribute use to unknown and low use wild trout streams. A department may wish to print and distribute a wild trout fishing map. Articles can be prepared for national magazines and department publications ballyhooing wild trout fishing opportunities. Thirty-five mm slide programs (or if your department is wealthy, 16 mm movies) can be used to promote and encourage wild trout fishing. However, caution should be used while selling wild trout fishing opportunity. Be a Howard Cosell in your information-education endeavors, "tell it the way it is". If a stream is remote and foot travel is the only means of access, let the people know. If a trout population is stunted, tell the public that most of the trout will be eight inches or smaller.

Redirecting stream management from hatchery plants to self-sustaining management is the most difficult way of increasing wild trout fishing opportunity. Anglers become acclimated to our management schemes (truck following syndrome), and when they find out hatchery stocking is terminated, they react. If a wild trout management plan includes removal of hatchery plants from a stream, use the soft-sell approach months prior to making the change. Advise the local business community, if there is one, of your intended plans and point out how this change can benefit the community. Also advise key sportsmen and sportsmen's groups in the area asking for their support. If possible, suggest the change for research purposes. Quite often the public will accept this approach knowing the future management of the stream will, in part, rest on the outcome of the findings, and make certain you actually conduct research.

The second method listed, eliminating the entire fish population in a stream and reestablishing wild trout stock, can increase wild trout fishing opportunities. Nowadays, however, receiving federal and state permission to use fish poisons is becoming difficult.

The last approach (listed above as number one) for increasing wild trout fishing opportunity is outright purchase or leasing private sections of streams. Purchasing trout streams should be the focal point of agency plans. Land is becoming more expensive each day with a greater number of individuals and corporations interested in purchasing bottom lands. National legislation in the form of House Bill 3830, "National Stream Preservation Act," would, if passed, supply funds for purchasing private sections of streams. In addition, funds from the Federal Aid in Fish Restoration

Act (Dingell-Johnson) can be used for stream acquisition, lease, and development. There are also other sources of Federal and private money that can be used for stream purchase. Priorities should be listed for the acquisition program.

Management of a wild trout stream fishery is actually quite simple if a department is adequately staffed. Unfortunately, most state game and fish departments do not have and probably will never have a staff or fishery managers to properly manage all wild trout streams, or for that matter, even 50 percent of them.

I am certain that all of us would like to manage our fisheries *biologically*. However, we in the management business realize that our fisheries also have to be managed politically since a state's fisheries may produce considerable income for private businessmen and the state's economy. Therefore, most of the management programs are the result of administrative "bio-political" decisions. Most field biologists prefer to shun the political aspects in management. It behooves the biologist to approach a department administrator with sound data supporting recommendations for management of any wild trout fishery. He especially needs sound data when hatchery trout are cancelled from a stream in favor of wild trout management. With good biological data, the final weighing by department administrators becomes easier, and the bio-political decision much more pleasant.

Angling regulations are probably the best tool currently in the fishery manager's toolbox for managing wild trout in streams. By establishing season length, angling methods, creel and size limits, we can control angler use and harvest. In order for a regulation to be an effective management tool, public support is important, and enforcement a must. Also, periodic population sampling is needed to determine the regulation's effectiveness.

In closing, I would say that most states have recognized the current and future importance of wild trout management in streams. I believe efforts to this point in time have been commensurate with demand; however, skyrocketing hatchery costs and increasing public awareness and pressures brought about by sportsmen's organizations have forced many departments to begin developing their wild trout potentials.

Managing wild trout in streams is a challenge of the future that will require intensified planning and management to meet demands. A wild trout management plan for stream resources is a must if we are to keep the fishing public advised of our goals. The management approach used in the past, I believe, is best identified by the phrase: "If you don't know where you're going, any road will get you there." Wild trout resources are deserving of planned management identifying the road to take.

ACKNOWLEDGMENTS

The author wishes to express his thanks to fisheries administrators from California, Idaho, Colorado, Michigan, Montana, Washington, Arizona, Pennsylvania, Wyoming, Utah, New York, Maine, Oregon, and New Mexico who supplied answers to 13 questions concerning the status of wild trout management in streams for their states.

HABITAT AND SPECIES MANAGEMENT PANEL

Dr. King: *Dr. Howard Tanner of Michigan State University had expected to attend the Symposium and serve as Panel Discussion Leader for this session. He was unable to be here, and we are fortunate to have a replacement in Dr. William T. Helm. Bill has been at Utah State University since 1959, where he is a Professor in fishery and environmental sciences. We are pleased and fortunate to have Bill Helm take over this assignment on short notice for he is eminently qualified to fill such a role.*

Dr. Helm: *Yesterday we heard that it is good to get the brush off of the bank of a stream in Wisconsin, and I will remind you, not very gently, that it is not good to fool around with Mother Nature. In Utah we value the brush, there it is an absolute necessity, but we are talking about brown trout and not brook trout. I also noted that stocking has an effect on the resident or wild trout population on both brown and rainbow. Since the topic of quality keeps popping up, I see a connection between the idea that high quality fishing occurs when the catch rate is lowest and the idea that an ice cold shower is good for you.*

In each case it appears that pain is good; I doubt very greatly if Bob Hunt, who caught a pile of fish yesterday, will agree with you that his fishing was of lower quality than that of his companian who caught fewer fish. Now for the business of the morning: first we will lead off with Dick Lantz on land use management, then go to Dr. Ray White who will talk about instream habitat manipulation – in each case we are talking primarily of habitat. Then we go to Dwight Webster on species management and Dr. Alex Calhoun on insights into hatchery support of the wild trout fishery.

LAND-USE MANAGEMENT—A CASE HISTORY OF THE EFFECTS OF LOGGING ON AQUATIC RESOURCES

By Richard L. Lantz

Oregon Wildlife Commission

Land-use or watershed management in the broad sense is involved with all of man's activities associated with the terrestrial environment that may have an impact on aquatic resources. This subject encompasses many areas of concern.

Major terrestrial activities that can affect aquatic resources include grazing, logging and surface mining. Other activities of man could also be included in our discussion. For example, installation of electrical power transmission lines can have the same impact on aquatic systems as logging because timber is removed and roads are built the same as in a logging operation. We could generalize even further and include revetments and channelization projects in our discussion, but then we are beginning to impinge on instream activities. Similarly, land-fills, dredge spoil placement, gravel removal operations, dams for irrigation, farming, herbicide programs, and industrial water pollution sources all fall into the broad subject of land-use management. The main point here is that many of man's activities can have an impact on our aquatic resources.

In order to boil the subject of land-use management down to one that we can handle in the time allotted, I will concentrate my discussion on the effects of logging on aquatic resources. However, some of the principles involved apply equally as well to other land management practices. The effects of logging are of concern throughout much of the United States, although most of the research has been done in the Pacific Northwest where potential conflicts exist between valuable stands of timber and anadromous fisheries of value both to sport and commercial interests.

Until the 1950's research into the effects of logging on the equatic environment was sporadic. Since that time, a number of agencies have become involved in comprehensive research programs concerned with the total watershed management picture, including the impacts of logging and road construction on fish and their habitats. Examples of such research include work done in Alaska (James, 1956; Meehan et al., 1969; Sheridan & McNeil, 1968), in British Columbia (Narver, 1972), in Oregon (Brown, 1973; Fredricksen, 1970; Froehlich, 1971; Hall and Lantz, 1969; Rothacher et al., 1967), and northern California (Kopperdahl et al., 1971; Burns, 1972). An annotated bibliography summarizing the effects of logging on fish of the western United States and Canada recently became available (Gibbons and Salo, 1973).

As knowledge increased and public concern resulted in legislation establishing water quality standards, methods to implement research results into our management programs developed. In Oregon, the Wildlife Commission developed guidelines for stream protection in logging operations (Lantz, 1971) as a result of the Alsea Watershed Study. Emphasis was placed on training sessions and active on-the-ground coordination with state and federal land management agencies and private industry. Passage of the Oregon Forest Practices Act in 1971 added impetus to this effort.

My objective today is to briefly review the results and management implications of Oregon's research into the effects of logging on aquatic resources, and to discuss implementation of its Forest Practices Act and the efforts of federal agencies concerned with timber harvesting to provide increased protection for water quality as part of their land management programs.

RESEARCH RESULTS AND MANAGEMENT IMPLICATIONS

The Alsea Watershed Study in the Douglas fir region on the central Oregon coast was initiated in 1958 by the Governor's Committee on Natural Resources. The objective of this interagency

The Alsea Watershed Study in the Douglas fir region on the central Oregon coast was initiated in 1958 by the Governor's Committee on Natural Resources. The objective of this interagency program was to determine the impact of logging on the aquatic resources of three watersheds. A detailed discussion of the management implications of this research is available in the Commission's guidelines for stream protection in logging operations.

The effects of two patterns of clearcutting on water quality and fish populations, coho salmon and cutthroat trout, were evaluated. Clearcutting of an entire watershed (175 acres), where no streamside vegetation remained, was compared to clearcutting in patches on a larger watershed (750 acres), where about 30 percent of the area was logged and vegetation was left along the stream. The third watershed (500 acres) remained as an unlogged control unit. Pre-logging information was collected for seven years, access roads were built into the two watersheds in 1965, logging was initiated and completed in 1966, and post-logging data were collected for another seven years.

After logging took place in 1966, major changes in the stream draining the entirely clearcut water watershed were documented. By comparison, changes that occurred in the stream draining the patch-cut watershed where streamside vegetation remained have been relatively minor. Primary changes noted in the stream environment following logging of the entirely clearcut watershed included:

(1) a significant decrease in dissolved oxygen content of surface waters during the summer of 1966 when logging debris was in the stream;

(2) a long-term decrease in dissolved oxygen levels in the sub-gravel waters measured during the time that salmonid embryos are developing in the gravel;

(3) an increase in stream temperatures from a pre-logging maximum of 61 degrees F. to a post-logging maximum of 85 degrees F. with daily fluctuations as high as 29 degrees F. after logging compared with pre-logging fluctuations of 4 degrees F. or less;

(4) an increase in suspended sediment loads.

Coastal cutthroat trout populations, as estimated from mark-recapture data during the summer low flow period, decreased to about 30 percent of their pre-logging levels for eight years after logging occurred in the stream draining the completely clearcut watershed, and there is no indication that trout numbers are yet returning to pre-logging population levels. In contrast, coho salmon populations appear to be more hardy under the conditions encountered. Similar changes in the physical and biological environments of the other two study streams have not been observed.

Changes that occurred in the stream draining the completely clearcut watershed could have been avoided to a large extent by (1) keeping streamside vegetation intact, and (2) taking precautions to minimize soil disturbance and erosion, particularly that associated with logging roads.

By keeping streamside vegetation intact, the land manager can control water temperature changes which result from increased exposure of the stream to solar radiation (Brown 1971). Shade can be provided in many cases by non-commercial shrubs and hardwood species such as red alder that are less valuable than commercial softwoods. Maintaining streamside vegetation requires falling and yarding commercial timber away from the stream and its bordering vegetation. Vegetative strips left along streams do not have to be a rigidly fixed width. Often a relatively narrow vegetative unit will provide fish habitat protection, and will reduce stream clearance needs and dissolved oxygen problems in surface and subgravel waters.

Corridors of streamside vegetation can be important to our wildlife populations, too. Such areas would be available to elk and deer as travel lanes, would provide cover near a water source, and would also increase the variety of habitat available near a recently logged unit. Streamside corridors also have potential for non-game species, such as some cavity nesting birds, since snags can be left within these streamside management units.

Sediment transport from landslides associated with logging roads poses a significant problem to fishery resources throughout the Pacific Northwest, and can eliminate some of the benefits derived from other positive land management practices such as maintaining streamside buffer strips. For example, the Oregon Wildlife Commission was involved in a cooperative study of Park Creek, tributary to the North Fork of the Coquille River. Streamside vegetation remained intact following logging of a 100-acre clearcut, but two landslides from roads reduced coho salmon fry populations in the 1,000-foot study unit from more than 1,000 fish before logging to about 60 coho after the road failures. Removal of large logging debris from the stream cost the administering agency $46,540, or more than 12 percent of the value realized from stumpage for the entire 100-acre unit. There was no way to remove sediment from the streambed gravels. For perspective, it should be mentioned that in the Pacific Northwest less problem oriented roads have been built, and that current and future road building programs will occur in steeper terrain and areas containing unstable soils.

THE OREGON FOREST PRACTICES ACT

In 1971 the Oregon Legislature passed the Forest Practices Act which updated the Conservation Act of 1941. The original Conservation Act spoke only to reforestation. In contrast, the 1971 Forest Practices Act sets minimum standards in five major areas which include reforestation, application of chemicals, slash disposal, road construction and maintenance, and timber harvest operations.

The Act applies to all private timber holdings in Oregon, and has been supported by the forest industry. The Legislature allowed one year to publicize the Act, develop operational rules, and train personnel before the law became fully effective on July 1, 1972.

The Oregon Department of Forestry was given responsibility for enforcing and administering the Act, and they appointed three regional committees to develop rules to implement the Act. The rules contain words that are subject to personal interpretation (i.e., whenever or wherever practical, significant numbers of fish, etc.); however, the Act does require compliance with State water quality standards as administered by Oregon's Department of Environmental Quality, and the rules place emphasis on stream and water quality protection measures. The timber industry had strong representation on the regional committees.

Streams were classified into two categories. Class I streams are waters which are valuable for domestic use, or are important for angling or other recreation and/or used by significant numbers of fish for spawning, rearing or migration. Class II streams are headwater streams or minor drainages that generally have little or no direct value for angling or other recreation, and their principal value lies in their influence on water quality or quantity downstream in Class I waters.

The Act placed a considerable enforcement burden on the Department of Forestry, although most of the effort required has been in preventive activities, including training and inspections prior to operations. The Wildlife Commission's input into the Act originates at this level between our district biologists and the forest practices officers. This input is coordinated at the staff level through our Environmental Management Section.

In general, my impression of the Act is that it is working in Oregon. It is not perfect, and there are problems to be solved, but this relatively new legislation does provide a means for developing a coordinated approach to timber harvest operations on private land that was previously lacking.

Some of the problems encountered with the Act result from the fact that the Legislature did not provide the Department of Forestry and other cooperating agencies with additional manpower to handle their added responsibilities. The Department has utilized their fire control and farm forestry personnel as forest practice officers. Currently, existing personnel are only able to get to about half of the active logging operations, and are falling behind in their preventive training program. More training in, and a better understanding of, water quality criteria is needed. The 10-day prior notification procedure does not allow adequate lead time in many cases to get coordinated responses from all interested agencies. Prior planning and the notification procedure should be strengthened for total watershed management to become a reality.

Some strong points of the Act are that it has received relatively broad support from the timber industry, and that the Department of Forestry has an excellent working relationship with other state agencies involved, such as the Fish and Wildlife Commissions and the Department of Environmental Quality. The timber industry supported this legislation because it gave them a chance to get effective but practical regulations at the state level, to get coordinated input from one agency, and to have a strong voice in developing the rules.

The Forest Practices Act is alive and operational in Oregon. From July 1, 1972 through November 30, 1973, more than 14,200 notifications to operate were processed and more than 11,000 inspections of forest operations were made by forest practices officers and personnel from cooperating agencies. Of these inspections, 93 percent were determined to be in compliance with the law. To date, a total of 182 citations for violations has been issued, and fines have ranged up to $1,000. One jail sentence was issued, but later suspended. Sixty percent of the violations were either for failing to provide the required notice of operation or failing to protect Class I streams (J. E. Schroeder, State Forester, 1974).

COORDINATION WITH FEDERAL AGENCIES

More than half of Oregon's land is owned by the federal government. The U.S. Forest Service and Bureau of Land Management both administer large acreages of valuable forest lands which contribute significantly to the fishery resource base of the Pacific Northwest and provide high quality water for both on-site and downstream uses.

The Oregon Forest Practices Act does not apply to federal lands. Both federal agencies, however, have formal agreements with the appropriate state organizations and policy statements that say they will meet or exceed state water quality standards. This provides the basis for a cooperative effort to implement water quality protection measures. In addition, both agencies have soil scientists, hydrologists, and fishery and wildlife biologists on their staffs to provide inputs into the planning process as well as during on-the-ground reviews of difficult sites.

The Forest Service has been a leader in trying to apply multiple use land management principles to their forest practices. They have developed a stream classification system that encompasses four stream classes. Class I streams require the highest level of protection since they include domestic water supplies, recreational sites, or streams used by large numbers of fish for spawning, rearing or migration. Class IV streams are primarily important insofar as they affect downstream areas (i.e., the intent in these areas is to prevent landslides, or debris accumulations that would contribute to mass soil movement). Classes II and III are intermediate.

Management goals for each class of stream have been defined in the Forest Service manual as part of their Streamside Management Unit (SMU) policy. The SMU concept does not imply that no activity will occur near streams, but stresses the need for applying special care in management, for example such as the use of certain contract clauses to require that timber be felled and yarded away from streams. The Bureau of Land Management does not yet have a stream classification system or a formalized SMU policy.

The stream classification system developed as part of the Oregon Forest Practices Act rules (Classes I and II), and the U.S. Forest Service's stream classification system (Classes I through IV) are compatible. By agreement, Oregon's Class I streams include the Forest Service's Class I and II streams, and Oregon's Class II streams include the federal government's Class III and IV streams. The basic difference is the degree of land management activity that the agency can prescribe for each class of stream. Implementing such guidelines in the field is similar for either system, providing that there is agreement on the stream classification assigned.

The Wildlife Commission's input with the Forest Service and Bureau of Land Management originates at the local level between our district biologists and the district ranger's and area manager's staff, respectively. Timber-sale plan reviews are held annually in the office, and allow for continuity as the plans develop. Our input is most meaningful for sales about two years in the future, where plans are well-developed but can still be modified. After the annual meeting, suggestions we have on specific sales are sent to the federal agency in writing and included in their environmental analysis reports.

We are making progress together utilizing streamside buffer strips, preserving meadows that are important as habitat for big game, and coordinating the timing of logging activities on critical elk and deer winter ranges while still harvesting timber. However, we need to make more progress together in minimizing sedimentation and mass soil movement from roads into stream systems.

No forest management activity carries with it more potential for soil and water degradation than does road building (Bakke et al., 1973). The basic need is to identify unstable soils and avoid road construction in high-risk areas. The Forest Service recently established a task force on one of their forests to deal with this concern. The goal of the task force is to develop a practical process for identifying high-risk areas that can be used by foresters in the field. The process should be applicable throughout the Pacific Northwest in steep terrain containing pockets of unstable soil.

Inadequate or untimely road maintenance also contributes to sedimentation into streams. The engineering staff on one forest estimated that it would take $78,000,000 to put their existing road system into adequate shape. At the same time, more than 3,000 miles of new road are being built annually in the Northwest by the Forest Service alone. The Bureau of Land Management also has an active road building program underway. Therefore, the scope and nagnitude of implementing effective land management programs to protect aquatic resources is large, and continuous training and on-the-ground coordination is required.

CONCLUSIONS

Public concern and private initiative has resulted in the establishment of state water quality standards and legislation such as the Oregon Forest Practices Act. Research into the effects of logging on aquatic resources has provided a factual basis upon which to develop watershed management programs. Implementing such programs requires a continuous effort and effective working relationships among state and federal land management agencies, concerned citizens, and industry. Emphasis has been placed on training sessions and active on-the-ground coordination. The scope and magnitude of the task is large. Sedimentation from logging roads into aquatic systems is of primary concern.

Our forest watershed management program is not perfect, but we have come a long way in a relatively short time. The approach used in Oregon to implement a more balanced forest management program should be applicable to other land management practices. If we can keep our momentum, we can prove that Oregon's land can be managed for the continued production of timber, fish, wildlife, and high quality water.

REFERENCES CITED

Bakke, K. et al. 1973. Timber purchaser road construction audit. USDA, Forest Serv., Region 6, Portland, Oregon. 31 p.

Brown, G. W. 1971. Water temperature in small streams as influenced by environmental factors and logging. pp. 175-181. In: Proceedings of a Symposium on Forest Land Uses and Stream Environment, Oregon State Univ., Corvallis. 252 p.

______. 1973. The Impact of timber harvest on soil and water resources. Ext. Bull. 827, Oregon State Univ., Corvallis. 17 p.

Burns, J. W. 1972. Some effects of logging and associated road construction on northern California streams. Amer. Fish. Soc., Trans. 101 (1): 1-17.

Fredriksen, R. L. 1970. Erosion and sedimentation following road construction and timber harvest on unstable soils in three small western Oregon watersheds. USDA, Forest Serv., Pac. N. W. Forest and Range Exp. Sta., Res. Pap. PNW-104, Portland, Oregon 15 p.

Froechlich, H. A. 1971. Logging debris – managing a problem. pp. 112-117. In: Proceedings of a Symposium on Forest Land Uses and Stream Environment, Oregon State Univ., Corvallis. 252 p.

Gibbons, D. R., and E. O. Salo. 1973. An annotated bibliography of the effects of logging on fish of the western United States and Canada. USDA, Forest Serv., Pac. N. W. Forest and Range Exp. Sta., Tech. Rep. PNW-10, Portland, Oregon. 145 p.

Hall, J. D., and R. L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. pp. 355-375. In: T. G. Northcote (ed.) Symposium on Salmon and Trout in Streams, Univ. of British Columbia, Vancouver. 388 p.

James, G. A. 1956. The physical effect of logging on salmon streams of southeast Alaska. USDA, Forest Serv., Alaska For. Res. Cent., Stn. Pap. No. 5, Juneau. 49 p.

Kopperdahl, F. R., J. W. Burns, and G. E. Smith. 1971. Water quality of some logged and unlogged California streams. Calif. Fish and Game, Inland Admin. Rep. 71-12, 19 p.

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

Meehan, W. R., W. A. Farr, D. M. Bishop, and J. H. Patric. 1969. Some effects of clearcutting on salmon habitat of two southeast Alaska streams. USDA, Forest Ser., Pac. N. W. Forest and Range Exp. Sta., Res. Pap. PNW-82, Portland, Oregon. 45 p.

Narver, D. W. 1972. A survey of some possible effects of logging on two eastern Vancouver Island streams. Fish. Res. Bd. Can., Tech. Rep. 323, 55 p.

Rothacher, J., C. T. Cyrness, and R. L. Fredriksen. 1967. Hydrologic and related characteristics of three small watershed in Oregon Cascades. USDA, Forest Serv., Pac. N. W. Forest and Range Exp. Sta., Portland, Oregon. 54 p.

Schroeder, J. E. 1974. A contribution to quality forest management – the Oregon Forest Practices Act. An unpublished report. 8 p.

Sheridan, W. L. and W. J. McNeil. 1968. Some effects of logging on two salmon streams in Alaska. J. Forest. 66(2): 128-133.

Dr. Helm: *Next Dr. Dwight Webster will present a paper he is co-authoring with William Flick. Dwight and Bill are well known for their work with brook trout, both as researchers and as anglers.*

SPECIES MANAGEMENT

By Dwight A. Webster and William A. Flick

Department of Natural Resources, Cornell University, Ithaca, New York

The topic "Species Management" may be developed in several ways, but because of the special interest of this group, it appears appropriate to focus on intraspecific diversification as it relates to management or potential management. The special case of wild *vs.* domestic strains will be noted in somewhat greater detail as a practical example of the benefits of how certain stocking requirements can benefit from the attributes of wild trout.

Historically, we have tended to regard a species of salmonid as a homogenous organism, regardless of origin. True, certain life history differences were strikingly apparent within anadromous species, and these were more or less taken into account when fish culture was involved in management. But with more readily domesticated trout, it has been easier, indeed customary, to develop brood stocks as a convenient source of eggs. Thus with the commonly cultured species. . brook, brown, rainbow and cutthroat trouts. . there has been the opportunity to evolve a different philosophy and management procedure based on the fact that the entire operation could be conducted independently of the realities of natural environments. Not so with the cultural programs for salmon and such species as steelhead and lake trout, where either availability, economics or logistical constraints have worked against widespread establishment of brood stocks. The genetic consequences of these two divergent procedures are potentially considerable. The management consequences are no less so, but do seem to be well recognized or considered. Generally, culturists of anadromous species and lake trout lack the brood stock option and are forced to more or less maintain the integrity of the gene pool as it relates to performance in the natural environment. Alternations in genetic make-up inevitably occur, though perhaps inadvertently, within the cultural phases of the life cycle. It does not necessarily follow that these changes are favorable when judged by the ultimate objectives of the program or by standards set by native stocks in natural habitat.

Examples of species or intraspecific diversity are numerous,and only a sampling can be included in this review. We note in passing the substantial evidence for racial or stock differences in certain anadromous species and concentrate on sometimes more subtle variations that may be of equal management importance to inland fisheries. One sport fishing example in the anadromous group, however, that demands attention, is the summer steelhead program developed in Washington (Millenbach 1972). Summer steelhead *Salmo gairdneri* are more desirable from an angling standpoint than winter steelhead, since they enter freshwater from May to late summer in prime condition, with the spawning season upwards of a year away. Through selection of the earliest spawners of the summer run, by advancing the spawning time another two months by light control and by the development of improved fish cultural techniques, it has been possible to produce the smolt-sized yearlings in time to coincide with the natural spring outmigration. The spectacular success of this program is well known.

Production of one-year hatchery smolts has long been the goal in cultural programs for Atlantic salmon *Salmo salar*. But production of smolt-sized salmon does not necessarily mean production of physiological smolts, as a number of agencies have found out. A series of experiences currently underway in Iceland may be cited to illustrate the need to meld manipulation of growth with physiological requirements. This country is especially favored to accelerate salmon growth in hatcheries as abundant geothermal water greatly facilitates raising rearing water temperatures. But returns from releases of smolt-sized yearling salmon, reared inside at elevated temperatures, were much lower than 2-year smolts reared under an ambient temperature regime (Isaakson 1973). When the former group was exposed to the normal natural light cycle and several weeks of winter temperatures, survival response, measured by return to the stream, was immediate. Returns from the cohort of the 1972 year class reared under these conditional manipulations, released in spring 1973 and returning as grilse in 1974, was the highest among several groups, including those of the traditional two-year smolts (Isaakson, personal communication).

In Norway, Professor Skjaerwold is currently conducting an elaborate experiment to test for differences in growth of juveniles among a number of stocks of Atlantic salmon. Norwegian colleagues inform us that already there are indications of substantial strain differences in this parameter that could have application in management (Kjell Jensen, personal communication). Earlier, Carlin (1969) showed striking differences occurred in survival, ranging from one to seventeen percent, between different families of salmon reared under comparable conditions.

A New York example illustrates different results from stocking two forms of indigenous lake trout *Salvelinus namaycush*, one from the Adirondack uplands, another from the Lake Ontario – Finger Lakes basin. These forms represent two different stocks that invaded the area following the retreat of the Laurentian ice sheet. A stock from an eastern refugium gained access to the mountain areas via high level glacial lakes that predated the opening of waterways to the west, when lake trout from a Mississippi refugium invaded the Great Lakes basin. Both Adirondack and Finger Lakes stocks of trout were used for stocking purposes, but since eggs were much more readily obtainable from the latter source, use of the Finger Lakes strain in the Adirondacks was inevitable. Marked plantings over the past 25 years have shown virtually no survival of the Finger Lakes strain when planted in Adirondack waters, although companion releases of native strains did show reasonable recoveries. Reasons for this difference have not been inevstigated, but the management implications are obvious.

Some of us have given thought to the need for chemical lamprey *Petromyzon marinus* control in Lake Ontario. Lamprey were there for some time before the lake trout declined, and lamprey and substantial salmonid populations coexist in two of the Finger Lakes tributary to Lake Ontario. Was there some significance to the high recovery of a token planting of Finger Lakes strain lake trout made in Lake Ontario in the 1950's, recoveries that were made in commercial nets that completely decimated the hatchery stock after two or three years? A group of scientists discussing for two days the apparent anomaly of lamprey-trout relation in central New York lakes, *vis-a-vis* the upper Great Lakes, came up with the euphemism of "accommodation". In our simplistic approach to solving an immediate problem have we overlooked something in species management that may have been already worked out by nature?

Acute environmental degradation through acid precipitation is developing regionally in parts of eastern Canada and the United States and the southern tip of Scandinavia, where increased acidity of precipitation originating in the Ruhr Valley of Germany and from Britain has rendered many lakes and streams fishless (Oden and Ohl, 1970). In the past two decades, many lakes in the southwest corner of New York's Adirondack Mountains have experienced 10 to 100 fold increases in acidity, and, as in Scandinavia, entire fish populations of all native species have been decimated in some of these waters. Solutions to the problem are long term, and, while local alkalization may be practical on a limited basis, what about the existence of strains of fish more tolerant of low pH? Recent findings in Pennsylvania, where the problem is acid mine drainage, have indicated a wide range in acid tolerance of brook trout *Salvelinus fontinalis*, both by individuals in the same group as well as between groups (Dunson and Martin 1973). One of the several strains involved in these tests was a domesticated New York strain that proved the least resistant to this kind of environmental stress. A remarkable body of water exists in New York, however, Honnedaga Lake, where brook trout live at pH values fluctuating about 5.0 and with the additional burden of concentrations of zinc at 0.02 to 0.15 ppm. Nonacclimatized test fish live only 1 to 2 days under most conditions (Schofield 1965). We do not know if there is any genetic basis for this adaptation.

Thermal degradation has claimed many former trout waters. There is a marginal range of habitat where a more thermally resistant strain of trout might be useful in management. Unfortunately, the choice of "ideal" water for hatchery purposes, i.e., spring water with minimal seasonal variations in temperature, probably mitigates against retention of genes controlling extremes of temperature tolerance when brood stocks are maintained as closed systems. Studies on the hybrid splake *fontinalis x namaycush* where temperature preference and lethal temperatures differ widely in the parental stocks, demonstrated thermal inheritance of resistance to high temperatures in one of the backcross hybrids involving the brook trout maternal parent (Ihssen 1973). Geographical intraspecific variations in lethal temperatures have been demonstrated for two subspecies of Arctic charr *Salvelinus alpinus* (McCauley 1958).

Splake are a new breed of salmonid filling a useful ecological role in management. Experience in Ontario (Martin and Baldwin 1960), New York and elsewhere indicated that the hybrid had satisfactory survival and excellent growth in lakes containing non-trout species such as suckers, minnows and sunfish. Like lake trout, splake turn readily to a piscivorous diet, but seem more readily available seasonally for shallow water angling.

Ontario has also conducted a forthright selection program for splake retaining the deep swimming habit of lake trout, but earlier age at maturity of brook trout (Berst and Spangler 1970; Tait 1970; Ihssen and Tait 1974). The objective was to develop a fish occupying the niche vacated by lake trout with the advent of lamprey, but mature at a size below that most subject to lamprey attack. The breeding program was successful in retaining these characters by the F_6 or F_7 generation, although it is not yet clear if management objectives have been achieved.

Food habits of salmonids, either intra- or interspecifically, provide some interesting biological differences and probably more management options than we now take advantage of. Scandinavians, especially in Sweden, have long been preoccupied with interactions of populations of charr *Salvelinus alpinus* and/or brown trout *Salmo trutta* because of the intense program of river impoundment and lake level regulation. Nilssen and Pejler (1973) and Aass (1973), among others, have shown that when charr or brown trout occur allopatrically, food habits are quite different than when they occur sympatrically. In the former case, both tend to feed on benthic organisms, while in the latter, charr become plankivorous, leaving the benthic littoral fauna to trout. In North American lakes it is common to manage for more than one species, frequently with rainbow trout *Salmo gairdneri* as one of the combination. Since this species tends to utilize plankton more efficiently than either brook or brown trout, for example, differences in the feeding habits and other requirements provide for variations in season and methods of capture, a good example of management at the full species level.

Sympatric populations of Arctic charr showing great divergencies in growth rates are most intriguing and common throughout the range of this species. A stunted form, rarely exceeding 9 to 10 inches in length, is largely a plankton feeder, while a larger or "normal" form has benthic or even piscivorous food habits. Both forms also occur allopatrically. Recent studies making use of electrophoretic techniques have confirmed that observed ecological and morphometric characters (size and number of gill rakers, position of mouth) are indicative of real population differences (Lenart 1972). This differentiation is believed to have taken place prior to the last deglaciation (Behnke 1972 and others). What use can be made of this kind of ecological diversity?

In some of the European lakes containing both dwarf charr and brown trout, trout may reach a large size feeding on charr. Evidence is accumulating that fish eating proclivities are, at least to some degree, under genetic control. Aass (1973, and personal communication) describes instances of where strains of fast growing, charr-eating brown trout retained this habit when introduced into other high-mountain Norwegian stunted charr lakes, but were out-performed by the native strain of brown trout when transferred to lowland lakes. Aass points out that while the fish eating habit may have evolved over thousands of years in some populations, there are examples of its development in reservoirs during the past 40 years, and that transfers from these populations also retained the fish eating habit.

In North America we have similar examples of predator-prey relationships that may be more than casual or opportunistic: the giant Lahontan cutthroat of Pyramid Lake *Salmo clarki henshawi*, the pure form of which may be extinct (Behnke, MS 1971); the Gerrard strain of Kamloops rainbow trout from Kootenay Lake (Hartman 1969), and Kamloops trout in Pend d'Oreille, both populations utilizing kokanee salmon as forage; and the large brook trout fomerly inhabitating the Rangeley Lakes of Maine that fed on the now extinct population of stunted charr or blueback trout *Salvelinus alpinus oquassa* (Kendall 1918).

There is much evidence bearing on differences in vulnerability to angling, a reflection of varying food habits and/or behavioral characteristics. Many of these involve domesticated stocks and are not considered here. Two strains of cutthroat living in the same body of water in Colorado showed up quite differently in angling catches over a two year period (Trojnar and Behnke 1974). One, the Snake River cutthroat, appeared three to four times as often as expected on the basis of the proportion present in the lake. This same phenomenon is commonly evident in Adirondack test waters stocked with more than one strain of brook trout. One experiment involved a native Adirondack strain (Horn Lake), a Canadian strain (Assinica Lake) and domestic fish, and the angling catch expressed as a percentage of the stock on hand at the beginning of the season was: Assinica 70, Domestic 50, Horn Lake 20. Trout caught while surface feeding during the heat of mid-day were invariably of the Assinica strain.

We have reviewed a sampling of options that have been employed in species management, others that might be explored to a greater extent. In either case, the innovation in some way usually exploits diversification combined with an awareness of physiological or ecological needs. These examples refute the notion of a homogeneous equally useful strain for multipurpose management.

The examples have focused on natural populations or those resulting from plantings of fish from non-domestic stocks. Of particular relevance and interest in this Symposium is the relative performance of wild and domesticated strains of trout. A substantial body of information of wide-spread origin has accumulated on this subject, but at the risk of being provincial, we have to review the essence of this phase of species management on the basis of our New York experiments and experiences (Vincent 1960; Flick and Webster 1962, 1964; Flick 1971; and unpublished data). Current awareness and contributions in this area in California, however, should be noted in passing (for example, Cordona and Nicola 1970, and W. D. Weidlein, personal communication).

New York fish managers, as well as others, have noted that generally low angling or test netting recoveries followed plantings of domesticated strains of brook trout in the Adirondack Mountains, New York (Zilliox and Pfeiffer 1960). These observations included the mitigated environment of reclaimed waters devoid of competitive fish, where few survivors were found after age two. The longevity of natural populations of wild brook trout, in contrast commonly extended to three or four years, and age five fish were not rare (loc cit and personal observations of authors). An early experiment by Greene (1952) suggested that wild hatchery reared trout offered management potential. This and other considerations prompted a program initiated in 1958 to quantify more precisely relative performance between domestic and F_1 wild[1] hatchery reared strains. The investigation was funded from private sources and conducted on private lands, thus greatly enhancing flexibility of operations and control over angling.

Data on survival within the first year of life was obtained from a small (0.5 acre) drainable pond fed by a small cold brook. Spring fingerlings, released in spring, were inventoried in autumn, and sometimes returned to the pond and inventoried a final time the following spring. Data on survival through the life span of any given cohort was obtained by planting spring or fall fingerlings in natural ponds containing no fish or only brook trout, and estimating standing crop at semiannual intervals. All of the waters used (Long, Bear and Bay Ponds) were located within distances of five miles of one another in the headwaters of the St. Regis River in the northern Adirondack Mountains.

Six wild strains of trout were involved in these studies, four native to the Adirondacks and two recently naturalized in New York waters from the James Bay area of Quebec; performance of only four will be cited in this paper. The New York locations were a mountain-top pond containing only native trout (Horn Lake), a large, deep, acidotropic body of water (Honnedaga Lake), and a small upland brook (Long Pond Outlet). Longevity in all populations was a minimum of five years, but the stream population was stunted, averaging 6 to 7 inches in length in trap and angling samples, and natural mortality was excessive after age two. Canadian strains of trout were from the Assinica or Temiscamie area southeast of James Bay, where they attained a size of over five pounds and longevity extended to nine years (confirmed by known age naturalized trout).

Domestic strains of trout were from two sources, a so-called "Berlin" strain cultured at the National Fish Hatchery at Cortland, New York, and a "New York" strain, generally used for stocking in that State. Both had been propagated from brood stocks with a long history of a closed gene pool. Under cultural conditions, both showed rapid growth, attaining lengths of 4 to 6 inches as fall fingerlings and an early age at maturity (0+ in larger males and I+ for females). Compared with wild hatchery reared groups, they were robust in appearance and exhibited a wide range of behavioral differences (Vincent, loc cit).

Results of a series of experiments involving five year classes comparing two to seven different New York brook trout strains in each experiment were consistent in showing substantially higher survival of wild groups between spring and fall of the first year of life (Flick and Webster 1964 and unpublished). Among the twelve paired comparisons, survival in wild strains averaged 25 percent higher, with a range of 12 to 43 percent. Two experiments evaluated the effect of parental history on survival, but it made no difference whether all groups were reared to maturity in a hatchery environment on a standard hatchery diet or in a natural environment on natural food: survival of wild strains was always higher. One experiment included two interstrain hybrids between wild and domestic stocks, and both hybrids also proved superior in survival to that exhibited by the domestic parent.

Survival and production data over the life span of the several strain cohorts obtained from semiannual estimates of population size and growth in natural ponds were no less convincing on the positive attributes of wild strains in a pond management program for brook trout. All five experiments with two or more strain-cohorts led to essentially the same conclusions. The 1960 year class in Long Pond provides an example of the results obtained and data on planting is given in Table 1. The larger size of domestic fingerlings reflects the adaptation of this strain to cultural practices and would be regarded of positive survival value. To eliminate possible effects of fin clipping, one of the ventral fins was used to identify the domestic group and one of the wild strains.

Population size of the three cohorts in the 1960 year class is shown in Figure 1. Domestic strain fish were essentially extinct at age three, while both wild strains existed in substantial numbers. Wild fish at all ages dominated the population. Since angling took place from age two onwards, the curves reflect losses due to this source as well as natural causes. Domestic strain fish were initially larger in weight, but all groups reached a climax size of about 0.8 pounds (Figure 2). This size is not a definitive parameter, since it merely relfects response to conditions of stock density during the course of the experiment.

The combined effects of growth and survival are depicted by the biomass (population size x mean weight) present through the life span (Figure 3). Also shown are the pounds of fish in each strain removed by angling. After age one, it is clear that a substantially high biomass is on hand in the two wild strains, also reflected in angling catch. Here a total of 40, 73 and 68 pounds was harvested from Domestic, Long Pond Outlet and Honnedaga strains, respectively. Reduced catches during ages 4 and 5 were due to decreases in fishing effort.

Comparison of the three groups is facilitated by computation of gross production (Table 2); this eliminates the effects of angling and includes an estimate of all biomass elaborated, including losses to natural causes during each semi-annual interval (Ricker 1958). Gross production is readily transformed (after subtracting the weight at stocking of the strain-cohort) to a ratio showing the number of pounds produced in the pond per pound of trout stocked. For the Domestic strain, this amounted to 7 pounds, for the two wild strains, 80 and 51 pounds or a proportional rating of 1:12:7. A similar, but independent rating, can be calculated from biomass harvested by angling divided by biomass stocked, or 1:13:8. These relative ratings were calculated for five experiments, and without exception, wild strains gave substantially higher recoveries when judged by these parameters (Table 3).

Performance of the interstrain hybrid of Assinica x Domestic in Bay Pond was especially notable. This cohort exhibited faster initial growth and higher survival than either of the pure parental strains, resulting in lifetime gross production estimates of about 1,600 pounds for the hybrids, compared with 460 and 265 pounds of the wild and domestic parental stocks. In five angling seasons, 432 pounds of hybrids were removed, averaging 1.4 pounds. In several other waters, these interstrain hybrids have consistently outgrown domestic strains stocked at the same time, suggesting hybrid vigor in this character.

Aside from intrinsic values in data showing wide disparity of performance under natural field conditions, the ratios in Table 3 have direct bearing on benefit-cost judgments when hatchery reared fish are used in the kind of management programs under consideration. They form a viable alternative for judging the effectiveness of a hatchery product compared with traditional methods based on hatchery performance alone. The several experiments exhibited a range of values in favor of wild strains, but an average of about five times higher weight recovery can be taken as the basis for a working estimate (Table 3). Thus, for any given unit cost per pound of fish in the hatchery, wild strains produced five times as much poundage in nature as domestic strains. This assumes no differential in rearing costs between the two groups, but there is considerable cushion to absorb any likely additional cost associated with raising wild strains. Furthermore, most hatchery techniques and diets have been developed with domesticated strains in mind so that changes favoring wild strains could modify potential added production costs.

The use of wild strains of trout for stocking appropriate waters in rehabilitation or maintenance programs may constitute only a small part of the total propagation program of governmental agencies. But economic payoffs seem assured, and the development of high quality angling experiences through appropriate regulations and use of special strains has a definite spot in the repertoire of fishery managers.

Finally, we would like to echo the plea, so earnestly expressed on numerous occasions by Dr. Robert Behnke of Colorado State University, that we preserve the genetic integrity of such of our heritage of salmonid fishes as we will have left, and that as managers, we recognize the genetic diversity and plasticity of salmonid fishes in the context of species management and use it when appropriate for innovative improvements in the more traditional approach to management (Behnke 1971).

[1]The term F_1 wild is used here to clarify the semantics connected with the term wild as loosely applied in the literature, and signifies the first generation of hatchery reared stock from original native populations unaltered (presumably) by previous cultured introductions. This convention was suggest by Moyle (1966 MS).

Table 1. Stocking data on the 1960 Year Class released in Long Pond. October 1960.

Strain	Number	Average Length (inches)	Total Weight (pounds)	Fin Clip
Domestic	350	4.9	17.5	RV
Long Pond Outlet	350	2.7	2.4	Ad
Honnedaga	350	2.9	3.8	LV

Table 2. Computation of relation of the biomass of gross production to biomass of trout stocked. 1960 year class - Long Pond.

Strain	Gross Production (pounds)	Biomass Stocked (pounds)	Gross Prod. / Biomass Stocked	Rating
Domestic	116	17.5	7	1
Long Pond Outlet	193	2.4	80	12
Honnedaga	194	2.9	66	10

Table 3. Gross production and yield to angling of brook trout in relation to biomass stocked in five experiments. (Angling ratio in parentheses.)

Strain	Bear '59s	Long '60f	Long '61s	Bear '61s	Bay '68f
Domestic	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Long Pond Outlet	3 (4)	12 (13)			
Honnedaga	4 (5)	10 (10)			
Horn			7 (6)	4 (3)	
Assinica					3 (3)
Assin x Dom					7 (12)
Temiscamie					2 (4)

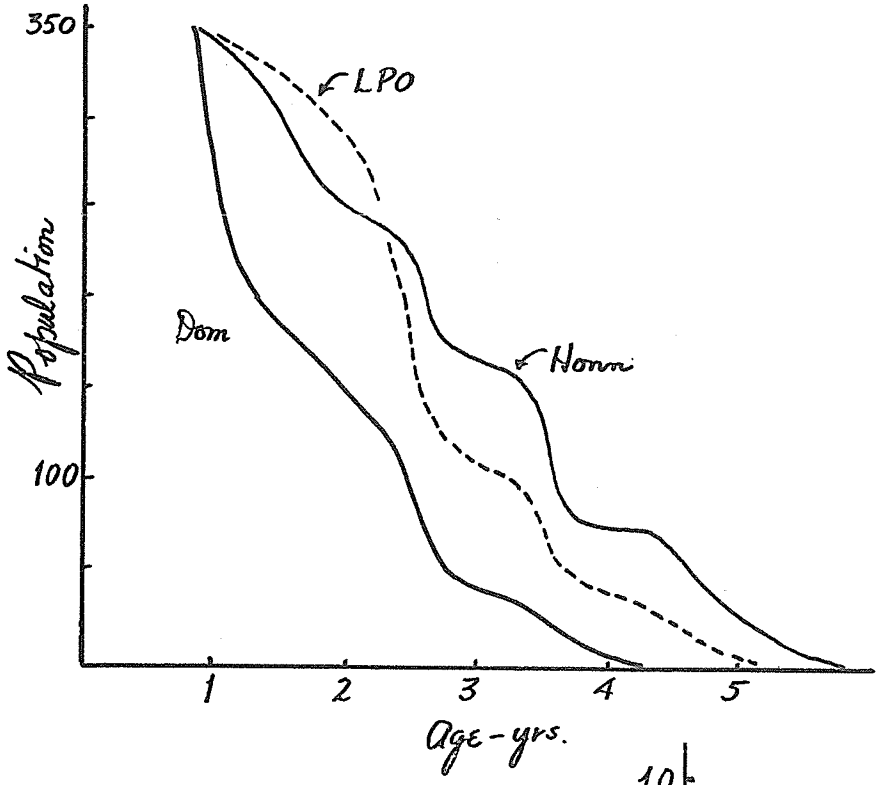


Figure 1. Population size of three strains of brook trout planted as fall fingerlings and estimated at semiannual intervals. 1960 year class, Long Pond.

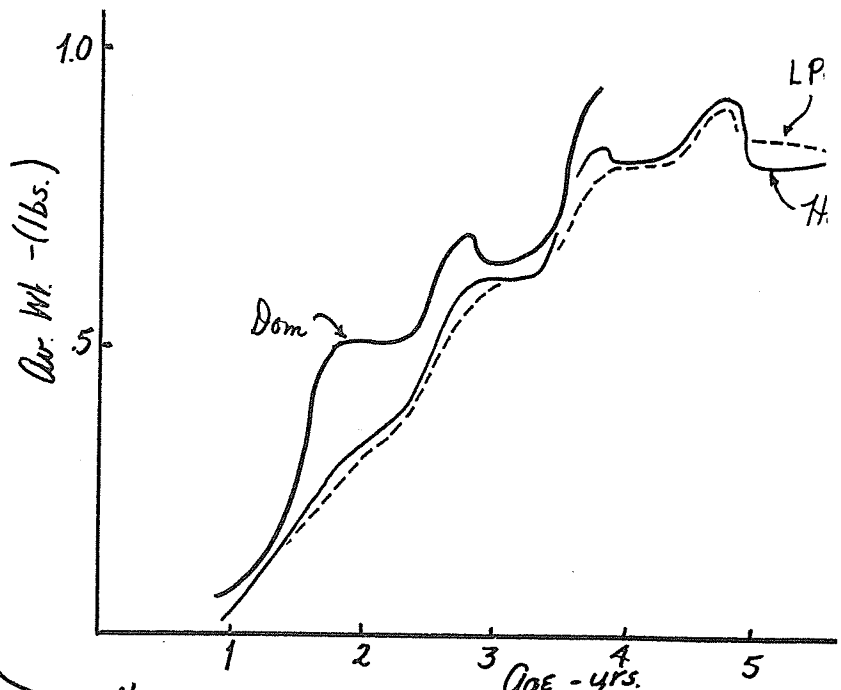


Figure 2. Growth in weight of three strains of brook trout. 1960 year class, Long Pond.

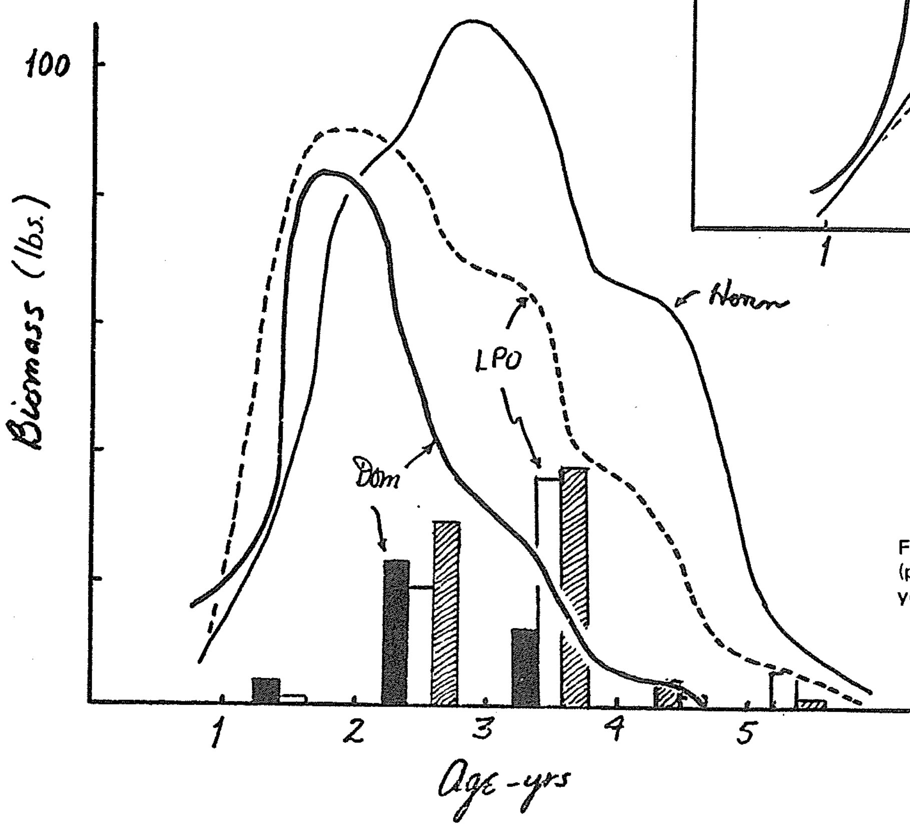


Figure 3. Estimated biomass and angling catch (pounds) in three strains of brook trout. 1960 year class, Long Pond.

REFERENCES CITED

Aass, Per. 1973. Some effects of lake impoundment on salmonid in Norwegian hydroelectric reservoirs. Abstracts of Uppsula Dissertations from the Faculty of Science. Number 234, 13 p.

Behnke, Robert. 1971 MS. The zoogeography, systematics and management of cutthroat trout. Presented at American Fisheries Society Exhibit. Salt Lake City. Mimeo 8 p.

Behnke, Robert. 1972. The systematics of salmonid fishes of recently glaciated lakes. J. Fish. Bd. Can. 29(6): 639-667.

Berst, A. H. and G. R. Spanger. 1970. Population dynamics of F_1 splake *Salvelinus fontinalis* x *S. namaycush* in Lake Huron. J. Fish. Bd. Can. 27(6):1017-1032.

Carlin, Borge. 1969. Salmon tagging experiments. Swed. Sal. Res. Inst. Report LFI MEDD. 2-4:8-13.

Cordone, A. J. and S. J. Nicola. 1970. Harvest of four strains of rainbow trout, *Salmo gairdnerii*, from Beardsley Reservoir, California. Calif. Fish and Game. 56(4):271-287.

Dunson, W. A. and R. R. Martin. 1973. Survival of brook trout in a bog-derived acidity gradient. Ecology. 54(6): 1370-1376.

Flick, W. A. and D. A. Webster. 1962. Problems in sampling wild and domestic stocks of brook trout *Salvelinus fontinalis*. Trans. Amer. Fish. Soc. 91(2):140-144.

Flick, W. A. and D. A. Webster. 1964. Comparative first year survival and production in wild and domestic strains of brook trout *Salvelinus fontinalis*. Trans. Amer. Fish. Soc. 93:58-69.

Flick, W. A. 1971. New trout for old waters. N. Y. State Conserv. 25(6):18-21.

Green, C. Willard. 1952. Results from stocking brook trout of wild and hatchery strains at Stillwater Pond. Trans. Amer. Fish Soc. 81:43-52.

Hartman, G. F. 1969. Reproductive biology of the Gerrard stock rainbow trout. In T. G. Northcote (ed.) Symposium on salmon and trout in streams, H. R. MacMillan Lectures in Fisheries. Univ. British Columbia, Vancouver, B. C. pp 53-67.

Ihssen, Peter. 1973. Inheritance of thermal resistance in hybrids of *Salvelinus fontinalis* and *S. namaycush*. J. Fish. Res. Bd. Can. 30(3):401-408.

Ihssen, P. and J. S. Tait. 1974. Genetic differences in retention of swim bladder gas between two populations of lake trout *Salvelinus namaycush*. J. Fish. Res. Bd. Can. 31(8):1351-1354.

Isaksson, Arni. 1973. The result of tagging experiments at Kollafjordur Experimental Fish Farm from 1970 through 1972. ICES C.M. 1973/m:26, 7 p.

Kendall, W. C. 1918. The Rangeley Lakes, Maine; with special reference to the habits of the fishes, fish culture and angling. Bul. Bur. Fish. 35:487-594.

McCauley, R. W. 1958. Thermal relations of geographic races of *Salvelinus*. Can. J. Zool. 36:655-662.

Martin, N. V. and N. S. Baldwin. 1960. Observations on the life history of the hybrid between eastern brook trout and lake trout in Algonquin Park, Ontario. J. Fish. Res. Bd. Can. 17(4):541-550.

Millenbach, C. 1972. Genetic selection of steelhead trout for management purposes. Int. Atlantic Salm. Found. 4(1):253-257.

Moyle, P. B. 1966 MS. Comparative behavior of different strains of hatchery reared brook trout *Salvelinus fontinalis Mitchill.* Masters Dissertation, Cornell Univ. 107 pp.

Nilsson, Nils-Avid and Birger Pejler. 1973. On the relation between fish fauna and zooplankton composition in north Swedish lakes. Insti. of Freshwater Res. Rep. 53:51-77.

Nyman, Lennart. 1972. A new approach to the taxonomy of the "*Salvelinus alpinus* species complex." Inst. of Freshwater Res. Drottningholm. Report 52:103-131.

Oden, S. and T. Ahl. 1970. The acidification of Scandinavian waters. Ymer, Arsbok:103-122. (Translation Ser. No. 2535, Fish. Res. Bd. Can.)

Ricker, N. E. 1958. Handbook of computations for biological statistics of fish populations. Bull. 119. Fish. Res. Bd. Can., 300 p.

Tait, J. 1970. A method of selecting trout hybrids *Salvelinus fontinalis Mitchill.* Trans. Amer. Fish. Soc. 89(1): 35-50.

Trojnar, J. R. and R. J. Behnke. 1974. Management implications of ecological segregation between two introduced populations of cutthroat trout in a small Colorado lake. Trans. Amer. Fish. Soc. 103(3):423-430.

Vincent, R. E. 1960. Some influences of domestication upon three stocks of brook trout *Salvelinus fontinalis Mitchill.* Trans. Amer. Fish. Soc. 89(1):35-50.

Zilliox, R. G. and Martin Pfeiffer. 1960. The use of rotenone for management of New York trout waters. Can. Fish. Cult. 28:3-12.

Dr. Helm: *Dr. White has had a great deal of experience conducting research on the effects of stream environment alterations – sometimes called stream improvement devices and sometimes called stream channelization. Ray, I'm looking forward to your thoughts.*

IN-STREAM MANAGEMENT FOR WILD TROUT

By Ray J. White

Michigan State University, East Lansing, Michigan

INTRODUCTION

Suitable habitat is essential to wild trout. This is so by definition, yet many people, even some who prefer to think they are fishing or managing for wild trout, sometimes overlook the key role of stream conditions or take them for granted. Without habitat that fulfills the requirements of every phase and phenomenon of the trout's life cycle, a stream can have no abundance of wild trout.

There should be no doubt about what a wild trout is. It can be nothing other than one spawned, hatched and grown in the stream, a true product of the stream.

Where shortcomings of habitat prevent a thriving population of wild trout, or preclude them completely, hatchery-reared trout can often be stocked instead. But many anglers and biologists feel that fish stocked from hatcheries, no matter how laudable as a recreational supplement if properly handled, cannot fully substitute for wild trout. Owing to appearance, flavor and behavior, hatchery fish may be unsatisfactory. Moreover, any stocked hatchery fish may represent an injection of artificiality into the natural streamscape which is out of keeping with the spirit of angling practiced by some.

Stream channel manipulation to increase carrying capacity for trout has been an approach to better fishing that has intrigued anglers and biologists who sense the importance of habitat. Such manipulation has been generally termed "stream improvement". But, owing to vague objectives, to misunderstandings of the trout's ecologic requirements, and to hydraulically and esthetically unsound constructions, it has often achieved the opposite effect.

Even where habitat management, as we now prefer to call it, is done well, artificiality presents a dilemma. At best it can only be hidden. Purists exist who, quite rightly from their standpoint, object to the unnaturalness of any stream management, whether it is stocking "factory fish" or creating a better channel form for wild trout. Surely there are places for utter protection among the numerous streams in many of this continent's trout regions.

Major state and federal programs of stream habitat management have been waxing and waning for about 50 years. Barriers of distance, bureaucracy and inertia have hampered exchange of ideas and experiences among the far-flung projects. Some organizations, perhaps most of them, proceed or regress in their own ways without benefitting from the innovations and mistakes of others. Meetings concentrated on the subject have seldom been held. Publications have been few and badly lag the needs and deeds. In some quarters there is avid thirst for new information, and in some others a disinterest stemming from solidified technical tradition.

It is high time, then, that we try to pull ourselves together as a "field" and more clearly define our activities. I believe we should do this especially in terms of recently gained understandings of physical and biotic processes in streams. While keeping and strengthening basic principles and philosophies, perhaps we can break some tactical ties, discard some methods that experience or new ecologic knowledge tell us are useless or harmful, express constructive skepticism and caution in some of the less clarified areas, and focus primary attention on those aspects of habitat management that promise to be ecologically rational.

We now realize it is not terribly important to define "what a trout stream is" or to be able to typify "the trout zone" (it must, after all, be wherever a trout exists, and this takes in a variety of habitats); but it is vital to look at streams as ecosystems and to try to understand the processes by which they function. We can still pay special attention to those stream ecosystems supporting trout, and we can continue to build our arsenal of tools and techniques, but it is the building of an understanding of the physical and biotic processes that will count in the long run.

For useful framework, we can take a tip from our friends, the truly lacustrine limnologists, and view our stream ecosystems as having features and functions that are climatic, morphometric, edaphic and biotic. Climatic considerations include generally the incoming sunlight and storm energy, as well as stream temperature, gas exchange, turbidity and the supply of water and its pattern and speed of flow. Morphometric aspects involve the channel shape; slope, depth, width, sinuosity, cross-sectional profile and bed roughness. Edaphic matters are those of the channel soils and possibly of soils beyond the channel, as well as of plant nutrients dissolved and suspended in the water. Biotic features and processes, of course, involve the plants, animals and bacteria of the stream, and let us not forget, the biota of the drainage basin, including ourselves.

Also at our disposal in understanding streams and in planning, conducting and evaluating habitat management are such ecologic concepts as succession, energy flow and dissipation, nutrient cycling, limits, diversity, stability, efficiency, and regulation. For example, it may be useful to conceive of the trouts as thriving at relatively low levels of stream stability and not being able to withstand competition from the fishes of a more diverse biota that exist under more stable conditions. Compared with the warm water environment and biota farther downstream, the trout stream is likely to be steeper, smaller, more variable day-to-day in flow and day-to-night in temperature, more rapidly eroding and more changeable in shape. Often the only fishes there will be one of the trouts, a sculpin and one or two kinds of minnows. Some measures designed to make the trout stream physically more stable and biotically more diverse, if carried too far, risk favoring some fishes other than trout.

There is also the hydrologic concept of conservative dynamic equilibrium in stream morphology (Curry 1972). If expressed in biotic terms as well, it would probably summarize or integrate the aforementioned ecologic concepts.

What follows is an attempt to reexamine trout stream habitat management, less with an eye to technical detail than to an ordering of the main threads of the subject, or at least making them a bit less tangled and frazzled. For more detailed background and diagrams, I refer the reader to our *Guidelines for Management of Trout Stream Habitat* (White and Brynildson 1967).

PURPOSE AND GENERAL CHARACTERISTICS OF STREAM HABITAT MANAGEMENT

In trout stream habitat management, we seek to achieve abundance of trout by manipulating stream characteristics, primarily channel form, streamflow and surrounding vegetation in such ways that living conditions for these fish are improved. When managing for wild trout, one must consider living conditions at all phases of life history, from egg to adult—probably I should add "trophy-sized" adult. One must take into account the processes of survival, growth and reproduction. Where one chooses to circumvent the egg and some of the other early stages of the trout's life by conducting a fishery with stocked fish, then habitat for reproduction need not be considered, and habitat management can be concentrated on conditions for better survival and growth beginning with stage or size of trout stocked. Besides shape, flow and vegetation, one can also sometimes alter water temperature and the character of streambed materials.

In the most basic terms, the objective is to funnel more of the stream's resources of energy and material through the trout part of the ecosystem, and in such a way that as much as possible of the resources accumulate in the form of desirable-sized trout. We must do this without violating the esthetic character of the stream so essential to its sport fishery value.

We can split habitat management into four, sometimes overlapping, categories: habitat protection, habitat restoration, habitat enhancement and habitat maintenance. The latter, upkeep of restorations and enhancements, is often neglected. I hasten to emphasize the need for it. Habitat protection is, of course, basic and essential. Many people may not regard it as management at all, but it should always be kept in mind as an option, because we must often take action through politics, purchase, or a fence to achieve it; and where such non-management will suffice to maintain desirable abundance of trout, it will be the wise course to take.

Within the categories of active managements, habitat restoration comprises repair of abused or deteriorated habitat. Often this involves simply giving nature a better chance to do the restoration. We can also exert energy to augment and speed up natural stream recovery from such damages as overgrazing of banks, dredging, straightening, improper bank filling, and damaging (among human abuses), or rock and mud slides (among natural catastrophies).

By habitat enhancement, we mean creation in a stream of a greater amount of suitable habitat than would naturally occur. You might call the result "hyperhabitat". Phrasing it that way should arouse some healthy misgivings. Be that as it may, this is what people may usually have in mind at the heart of the vague bundle of procedures known as habitat management. An array of methods is available for this, many of them the same as those for habitat restoration, often perhaps carried further. I think in the sport fishery situation we should recognize when we are stepping beyond protection and restoration into enhancement, and we should proceed in that extension with caution. Too great a manipulation becomes agriculture, or in this case, aquaculture. The more aquaculturalized a waterscape becomes, the more its artificiality interferes with opportunity for high quality angling—angling being regarded as an experience in and with nature.

Although some certain kind and amount of habitat manipulation will be the key to increased abundance of trout in many streams, in-stream habitat management in general should not be regarded as a panacea. Rather, it is a group of practices to be conducted in parallel with pollution control and land use regulation, which are also managements or protections of habitat in a broader sense. Indeed it is difficult even to talk about in-stream management without talking about land use. As H. B. N. Hynes has put it, "a stream cannot be divorced from its valley," nor, might I add, from many activities of people in that valley.

In-stream habitat management should also be integrated with the other fishery managements that may be applied to a stream. It can scarcely eliminate the need for angling restrictions. Although it may reduce or remove the need for stocking in many situations, in others it can increase stream capacity for stocked fish. Also at the intensive end of the management scale, where habitat restoration or enhancement improves previously poor channel form to the point that morphometry no longer constrains trout production and the limitation becomes climatic or trophic, then such managements as rough fish eradication or nutrient enrichment would be necessary to further increase trout production. Therefore, habitat management should not be thought of as entirely separate from other types of management, but rather as part of an integrated stream management package.

Determining what factor limits trout abundance implies investigations on a stream-by-stream basis by capable biologists with sufficient resources for the task. Premanagement examination and diagnosis are essential for effective operation. They should be considered part of any stream fishery management, habitat management included.

Most in-stream habitat managements are directed toward restoring or enhancing seven elements of a stream's life support system for trout: (1) space per se, but especially that suitable for individual territories; (2) concealment from predators and from social competitors; (3) favorable water velocity; (4) shelter from adverse currents; (5) avenues of movement for migration, escape and dispersal; (6) spawning sites; and (7) favorable water temperatures. The effect of any stream manipulation on each of these features must be kept in mind. Always to be considered, but seldom direct objectives of the managements, are the food supply, dissolved salts and gases (notably oxygen), as well as refuge adverse low and high water, from extreme temperatures and from certain ice conditions. Physical characteristics and potentials of the stream must also be understood. Chief among these are the slope, the pattern of flow and hydrologic regime.

A SURVEY OF METHODS

Habitat Protection:

Trout stream protection primarily involves preventing human activities that would damage the habitat. This is something akin to preventive medicine, and we have to regard ourselves as the disease. To say what not to do is probably the easiest task for the ecologist and the one that he can do with greatest confidence. When in doubt about the effects of taking some action to change the natural land or waterscape, the surest way to avoid damage will almost always be to do as little as possible. Almost any large-scale human activity on a stream or in its drainage basin will have some detrimental effect, and some seemingly small disturbances will result in great damage.

The knotty problem arises when one is approached by people who wish to "develop" a highway, a dam, mineral resources, tourism, a town, or whatnot, and they ask how to do it in the way that will be least destructive. Usually in the past they have not asked ecologists this, but increasingly they are, and this gives us a welcome opportunity for guiding events. Unfortunately, society has pumped much less support into our profession in the last century than it has into the analogous ones of agriculture and medicine. Naturally, we cannot advise and operate with anywhere near the precision that the physicians and agriculturalists do, and even they occasionally make some glaring blunders. But this does not mean ecologists should shrink from opportunities to serve and influence.

Among the specific activities to guard against are: channel straightening; gravel mining in channels; use of large mechanized equipment in logging and damming; withdrawing water from the stream or from the ground aquifers which feed it; streambank grazing; erosion from agriculture and from construction of highways and buildings; chemical over-enrichment and, of course, toxic pollution. Much of this comes with urban and industrial expansion across the landscape, especially that occurring right along streams. Certainly the sprawl of suburbia onto our trout streams is to be avoided. Where unavoidable, then suburban expansion should be guided to reduce its accompanying damages such as streambank lawn mowing, trash dumping, streamside duck ponds and use of streams as playthings for landowners and others.

The large scale damages can be summarized as detrimental land use (especially that which intensifies runoff and erosion); dams, stream straightening or "channelization," and streamflow depletion.

The effects of dams, large as well as small ones, are well understood and thoroughly publicized. The detriments of channelization, though certain of them are quite obvious to biologist and angler, have only recently been measured and widely exposed to the public, largely through efforts of those such as Gebhards (1973). I have recently tried to summarize his and similar work and to tie this in with the basic information that is available on channel-fish interrelationships (White 1973). The problem of flow depletion, long a cause of alarm in the western states (Giger 1973), has been lower in the eastern U.S. consciousness but is coming increasingly into perspective there too. The same principle seems to apply in all streams: the more water (at low flow), the more fish. It is critical that this be recognized now in conservation laws and the actions of fishery agencies everywhere. The agricultural sector, having eliminated soil fertility and genetic barriers to increased crop production, is now finding rainfall to be the limiting factor, even in water-rich regions of North America, and is looking to our streams and groundwater for irrigation. Where trout streams lie in agricultural areas, or in areas which the rising food demand will press back into production, fishery personnel and anglers take heed!

Habitat Restoration:

Restorations are mainly matters of repairing effects of human activities someone failed to prevent. The general approach may often be to enable nature to take her own course in getting back on course.

Even where streams have been quite badly abused, favorable conditions can often be restored. I believe it very important for professionals and the public to realize this. Once one's favorite fishing stream has been ruined, the inclination is to throw up the hands and resign to an imagined futility of trying to do anything about it. The same psychology is used by those who desire to further abuse an already polluted or misshapen waterway. They argue, "Why not let us do what we want? The stream is so far gone anyway." Often, however, when the stress of human activity is removed from an ecosystem, it will pull itself back toward proper functioning with surprising speed. Examples of this are found in recovery from overgrazing when the livestock are fenced out and from impoundment when the dams are dismantled or washed out. Here, in both cases, natural regrowth of vegetation does much of the work, but we can exert efforts to hasten the process. A general case where fast natural recovery seems not to apply, however, is channelization.

Restoring Overgrazed Streams: Fencing cattle and other livestock away from streambanks has long been recognized as desirable (Figure 1). Its benefits have been demonstrated in southern Wisconsin dairy country.

Restoring Dammed Streams: Removing impoundments, including those of beaver and simple accumulations of debris, as well as those people have built for many purposes, is in many regions an essential step in restoring stream habitat. This is especially true in terms of reclaiming spawning beds, improving temperatures and reopening migration routes. The recovery of proper channel form in former impoundment beds can be speeded by use of deflectors and by planting low vegetation. With regard to dams, it must be remembered, that some stream trout fisheries depend on them for maintaining adequate flow and temperatures. So-called tailwater fisheries are an example. Also, systems of beaver dams in mountains may have a moderating effect on the low water hazard, as well as other benefits.

Restoring Channelized Streams: We are also at the stage now where we can recommend rerouting channelized streams back into their former meanders. Not only can we tell the large federal water project agencies loudly and clearly that no more straightening and very little "snagging" is any longer acceptable from the fisheries standpoint, but that their spirit of cooperation and compromise could well be extended back to projects already carried out. Here they could mitigate the damages by putting streams back into the sinuous shape they were before. Through the work of L. B. Leopold, R. R. Curry and other hydrologic-geomorphologists, enough is now known to give good recommendations in restoring streams to channels that represent the natural conditions to which stream fishes have adopted during a million years or more.

Restoring Shallow, Braided Channels: Braided watercourses are formed by drastic removal of water (e.g., irrigation, hydroelectric diversion, severe drouth) or by injection of a greater bed load of rock or sand than the flow can accommodate. If current deflectors are used to reconcentrate flow where this situation occurs, the structures must extend far enough back into the streambank that the stream will not reroute itself around them during floods. Where dredging is the method chosen for recreating a channel usable by trout, the new watercourse should be laid out in meandering form according to proportions brought out in Leopold *et al* (1964) and Leopold and Langbein (1966).

Restoring Migration Routes: The most obvious blockage of stream migration routes is by dams. Also, such impediments as logging slash and other accumulations of woody debris, as well as rock slides may block movements. Other barriers include stream sections impassably polluted by chemicals, sediments or heated water, by improperly constructed culverts, channel alterations causing velocities against which trout cannot swim and head erosion creating insurmountable falls. Strangely enough, many structures designed specifically as fish passes have been impassable, and even the demolition of waterfall precipices to make them lower and more negotiable has sometimes transformed a cliff that could be leaped by only the largest and strongest fish into one that could not be jumped by any (Stuart 1962).

If the barrier cannot be removed, then the task is to get the fish around the obstacle. I would just point to the existence of a vast literature on fish pass construction and single out for present purposes the paper on fish passage and culvert installations by Gebhards and Fisher (1972), and intriguing observations of the Scottish salmonid researcher T. A. Stuart (1962). Stuart determined that trout and salmon are well adapted to leaping vertical barriers, if these falls have a plunge pool of the proper shape to form a standing wave near the point of impact. Fish "ladders" designed on this principle would seem most reasonable. Stuart also studied the relationship of channel form to downstream migration of smolts, clarified some of the reasons why they will not readily follow vertical dams to the overspill, and suggested louvered ramps to guide the young fish upward, away from turbine intakes and toward intended outlets.

Restoring Favorable Flow Regime—Low Water: Where a stream's discharge has been diminished, we can now tell the taker of the water and the regulatory agency that the fish population and fishery will suffer to the extent the baseflow is reduced and that this will continue until it is restored. Moreover, reduction of flow at seasons of natural low water may severely affect trout populations for the rest of the year or for several years. It is evident, however, that the effects of low flow can be ameliorated by improvement of channel form, namely by narrowing, deepening and creation of overhangs that function at low stream state (White 1972 and in press).

In some cases of diversion of large amounts of water away from the channel, as for irrigation or for generating electricity, a small proportion of previous discharge is stipulated to be released for a fishery in the old channel. The original width and sinuousity of channel are then far out of proportion to flow, and the usually shallow, often braided residual stream must be helped to carve an appropriate new, deeper channel with narrower banks and tighter bends. This seems a necessary though inadequate mitigation. It is fitting that the diverter bear the full costs. For an excellent review of the subject, the reader is referred to *Streamflow Requirements of Salmonids* by R. D. Giger (1973), obtainable from the Oregon Wildlife Commission.

Restoring Favorable Flow Regime—Floods: The other discharge extreme to be considered is high water. Where we have disturbed the landscape so as to make runoff faster and flooding more intense and forceful, the damage to fish habitat is often well recognized. Runoff-retarding land managements seem generally to be the best remedy. Dams placed above the trout zone may also be a useful measure. Even flood control can be overdone, however. Fraser (1972) tells of the destruction of salmon spawning beds by silt and vegetation after gravel-winnowing annual freshets were stopped by dams. In many other respects, floods are the governors of river events and provide much of the energy that regulates stream ecosystems. Their near or complete elimination could be disastrous to trout populations in ways not fully understood. I think it is clear at this point, however, that a discharge regime with timely and moderate floods but with consistently substantial base flow seems ideal for salmonid production.

Restoration Following Natural Disasters or Changes: Restorative actions will often be desired following certain natural or semi-natural changes, particularly such catastrophic ones as rock or mud slides, extreme floods, and forest fires. Another natural but often unfavorable condition may be forest cover at a state of succession beyond that stage promoting greatest trout productivity. Just as there are certain terrestrial animals that prosper in early or intermediate plant successional stages and dwindle as vegetation approaches climax, trout may be keyed to some optimal successional state. I think it a fair hunch that this is a pioneer or intermediate one. Opening up the canopy by selective tree cutting sets succession back a few notches. This restores low streamside grasses and bushes that help narrow the channel and that also directly provide trout with concealment. Where a stream is of marginal quality with respect to summer temperatures, tree removal may not be advisable, however.

Cautions in Stream Restoration: One pitfall I have observed in the restorative approach, or maybe I should say, one unfortunate kind of restorative mentality, becomes evident in some "stream clean-up" programs. Here, in the admirable enthusiasm of ridding trout streams of unsightly bottles, cans, oil drums, bedsprings, boxes and other refuse, efforts are often extended to pulling out tree limbs, stumps, rocks and other objects which may be providing the channel's best trout cover. As in channelization, our misguided sense of neatness and orderliness needs to be held in check. Stream clean-up campaigns should be closely supervised by qualified fishery personnel. Where towns and villages border trout streams and where the need for trash control is greatest, it may be municipal workers that do the most damage. There could well be informational programs for them.

HABITAT ENHANCEMENT

The widely divergent characteristics of streams must always be considered. Methods must not only be tailored to the needs of the fish population but to limitations imposed by the stream and by local climate. Certain techniques are applicable only where the streambed is within a particular range of steepness or where there is a certain amount of water flowing. For example, promotion of beaver ponds may be quite beneficial to trout in steep upland streams but ruinous of habitat in low gradient streams. There are artificial structures that have admirable effects in streams of moderate slope but would impound water and silt for detrimental distances in low gradient situations, filling pools with sediment and smothering spawning gravels. Placed in mountain streams, the same devices would soon be swept away by high water. Low water may also render certain managements useless in streams that shrink greatly during dry spells. One good rule of thumb is to design for effectiveness during low flow, when space and cover are likely to be critical to the fish, and to build for withstanding high water.

Enhancing Streambank Vegetational Cover:

Natural growths of brush and grass that trail into the water or very closely overhang it, may be just about the best of all possible hiding cover, especially for trout that dwell in small streams. Various plantings may be undertaken, but it will often be more important to relieve one or the other of two common vegetational problems: overgrazing and overshading. The forest canopy may prevent existence of the low streamside and in-channel vegetation which is useful to trout. The canopy may also reduce food supply and growth of trout. With prevention of too much shade and of too much grazing a sufficient stand of grass and bushes will often arise without planting. The problem is to maintain it at an optimal condition.

Biologists in Wisconsin have been making observations on the effects of low, as opposed to forest, vegetation since about 1960 (White and Brynildson, 1967:12-19), and more recently have been experimenting with it (R. L. Hunt, pers. comm.). Here at the Yellowstone Symposium, some of the first reports presented indicated that the initial effect of shade removal from brook trout streams is increased food supply, increased body growth, and increased standing crop of trout (T. Scullin, unpublished).

While vegetational management can play a key role in improving stream habitat in many regions, there are reportedly some quite good trout waters in dry climates where occasional devastating floods are the usual situation. Here, few plants can persist on the streambanks or in the stream. The cover for trout must be rock, turbulence, or sheer water depth, and it would be futile to try to nurture streamside vegetation.

Deflectors, Bank Covers, and Revetments:

Some of the most basic and effective in-stream manipulations are those designed to guide the current closer to the outside (concave) bank of stream bends while reinforcing that bank against erosion and building on it some overhead cover for trout. This is achieved by combinations of current deflectors, also termed "wings," "jetties" or "groins," and revetments and artifical overhangs, called "bank covers". Sometimes in engineering zeal for bank stabilization and neatness the overhead cover is neglected.

To achieve reinforcement and hiding niches with a single simple device, massive revetments or "rip-rap" can be made with large angular rock, piled in a jumbled arrangement along the outside bend. Curvature of the bend should be maintained or even made somewhat tighter.

Michigan habitat management crews are revetting outside banks of large and small trout streams with jumbled logs and smaller sections of tree limbs, as well as stumps, fastened with spikes and wire. This appears effective in slowing erosion and furnishing cover, but it is not expected to last as long as rock, even though rot-resistant wood is used.

Log cribbing or sheet piling are used as deflectors or revetments in some areas. These tend to have an extremely artificial appearance, as does neatly piled rock. Sheet piling provides no overhang; cribbing and straight rock walls give little if any cover. These devices prevent undercutting of banks in cases where it would be beneficial.

A step beyond revetment is the construction of shelf-like overhangs. These should be at least slightly below the water level. To build them durably is costly. People often attempt to make such cover with ledges of logs or even smaller pieces of wood. Where wood is used at or above the water surface, the devices will soon rot.

In contrast, a combination bank overhang and deflector structure was developed about 1960 in Wisconsin for small streams of low to moderate slope. Its construction of piling, plank, rock, soil and sod (all woodwork under water!) is relatively complicated. It cost about $20,000 per mile of stream affected (1960 prices). The result simulates the best of natural hiding cover, and with a year or two of plant growth upon it, the untrained eye cannot distinguish it from the natural streambank. This so-called "bank-cover-wing" is of proven effectiveness in creating greater abundances of age-II and older wild trout in small streams (Hunt 1971; White 1972 and in press).

Rock Stair-Stepping for Very Steep Streams:

To create more and deeper pools, as well as lateral concealment in steep mountain streams, large rocks seem to be the key material. Building stair-stepped streambeds of such rocks was suggested in our 1967 booklet (White and Brynildson), based on observations of natural stream formations in mountain areas.

Low Dams or Ramps:

In streams of intermediate slope, more pool space can be achieved with low dams of rocks or logs. Logs will often be the more available material, but will rot away in a decade or two if not kept completely submerged. Where streambed materials can be moved by the force of falling water, the so-called "Hewitt ramp" of logs and planks is very effective in creating a plunge pool. This undercuts back beneath the ramp. By electrofishing and by angling I have found these almost always to hold impressive concentrations of large-sized trout.

Scattered Boulders:

Overhead and lateral concealment as well as shelter from current can be enhanced in most any stream by placing rocks of appropriate size here and there on the streambed, usually in or near the thalweg. This may have greatest benefit where the water is swift and shallow.

Wooden "Hides":

Where slope and flow permit, shelters can also be formed with isolated, well anchored logs, log-jams, and tree stumps. One of these is the so-called half-log device in which a log, sawed longitudinally, is held submerged close above the streambed by iron rods. Other sorts of submerged wooden platforms are often installed.

Improvement of Spawning Grounds:

Enhancement of existing spawning habitat is often achieved as a consequence of installing current deflectors. The newly concentrated water currents sweep silt and sand from underlying gravels, opening increased areas for redd building. The U.S. Forest Service has developed a large amphibious machine, the "riffle-sifter," which dislodges silt from gravel beds with jets of water, sucks it up, and sprays the sediment laden slurry onto nearby streambanks. The device can clean about 4,000 square feet of streambed per hour. Spawning grounds normally producing 100 salmon fry per square yard yielded more than four times that number when cleared of silt by the riffle-sifter. Its primary use is undoubtedly in the large streams of the Pacific Northwest.

Creating spawning riffles in streams or parts of streams naturally lacking gravel does not presently seem to be a worthwhile procedure. Gravel is expensive to obtain and transport. Simply piling gravel in the channel has seldom, if ever, yielded significant increases in offspring production over any useful span of years, although there are many cases of intensive redd building and spawning by trout on such artificial deposits in trout streams. In fast streams, the gravel soon washes away unless elaborate retaining structures are built. In lowland streams, drifting silt soon clogs the gravel. Until there is some further technical development, modest efforts to improve existing spawning gravels with deflectors are likely to be more worthwhile than trying to create riffles where they do not occur.

Increasing Streamflow Discharge:

A final area of hyperhabitat creation is streamflow augmentation. As low flow seems to be the limiting factor in trout abundance for at least part of the year in many parts of the nation, adding more water during low flow periods is an intriguing procedure. In effect, this is what is accomplished by storing water in headwaters impoundments for release at critical times in areas experiencing distinct annual dry seasons (Calhoun 1966, p. 43). This practice might well be extended to humid areas of the trout range, for even there, droughts depress trout abundance. There have been preliminary experiments to augment streamflow with water pumped from the ground during summer.

The energy costs of continuously pumping a useful amount of water (several cfs in most cases for periods of several days or weeks), might be prohibitive. Moreover, problems of groundwater depletion with eventual damage to future flows might occur unless there were some compensatory phenomenon of more effective aquifer recharge. Whatever the case, thought should be given to streamflow augmentation also during winter base flow, as this may often be the most critical period for a trout population.

Habitat Maintenance:

After habitat restoration or enhancement, an on-going program of upkeep will usually be necessary if we wish to maintain what has been achieved. From what I have seen, maintenance work is often neglected. This may be one of the weakest aspects of past habitat management. Especially in the case of creating hyperhabitat, the stream will eventually return to some less productive state. Repeated inputs of energy and materials will be required to sustain the hyperhabitat. The benefits of restoration or enhancement may be lost if, for example, streamside vegetation is not periodically brought back to a successional state that is less advanced but more favorable for trout production.

Maintenance requires thorough inspection of the complete length of the managed area, in some instances several times each year. Greatest need for inspection will probably be after spring runoff, after other major high water, following periods of intensive human use, and to detect barriers to migration just before spawning runs.

Some Undesirable Practices:

Certain techniques have proven to be physically unsound, biologically ineffective or aesthetically unacceptable. Some of these deserve special mention. Flimsy baffles of boards or brush are no enduring substitute for solidly built deflectors. They soon disintegrate, their remains being unattractive and sometimes having effects on the current that damage trout habitat. So-called "digger logs," usually spanning the channel perpendicular to flow so as to force a scoured depression beneath them, have the disadvantage of collecting debris and becoming dams; moreover, in several years of electrofishing we seldom caught many trout from beneath such devices; whereas, many trout would be found along similar sized logs angled gently into the current or almost parallel to it. Metal or concrete structures of any sort are objectionably artificial in appearance, as are wooden sheet piling bulkheads and the wire and rock gabions. Sheet piling and gabions are often used in making deflectors. If these materials and devices must be used, they should be thoroughly disguised with natural appearing materials and live vegetation. As a general matter of design, almost any straight device will appear glaringly unnatural in the stream setting. Sheet piling and gabions have usually been laid out along straight lines. Curving the devices might help to blunt their inherent obtrusiveness. It is preferable to omit them entirely.

MEASURING THE SUCCESS OF HABITAT MANAGEMENT

For decades, biologists and natural resource administrators have been asking for biologic evidence of the effects of stream habitat management. Proper studies are costly and time consuming. As stream dwelling trout populations fluctuate greatly year to year even without human interference, the detection of responses to a treatment requires several years of pre- and post- treatment data. Treated and untreated (control) sections of stream should also be studied simultaneously for comparison.

To date, I am aware of 11 evaluations that were based on population measurement over series of years. The results are briefly summarized in Table 1. It is in Eastern North America, and in relatively small streams there, that most testing of trout population responses to such management has occurred.

In all of the 11 streams, some form of increase in trout population and/or fishery yield followed the managements. Brook trout and brown trout seem to be similarly benefitted by in-stream managements. Importantly, the greater benefits accrue to the larger trout.

Several of the more detailed studies showed that it takes a number of years for optimal habitat to develop following completion of restorative or enhancement measure, and still more time is required for trout populations to peak out after the full habitat change to a higher carrying capacity. (Figure 2.)

The in-stream structures that seem most effective are those that simulate undercut banks and create greater stream depth. Increases in trout abundance will usually be greatest: (a) where badly abused habitat has been restored, or (b) where the productive capacity of fairly undisturbed natural habitat is intensively enhanced.

In-stream managements, as we presently know them, may have greater usefulness in smaller streams. Streambank vegetation has been seen to play an important role in trout habitat restoration and enhancement of such streams. Vegetational management, particularly the creation and maintenance of dense grass, small brush and other low plants at the stream's edge, may often suffice as the best stream management.

Seasonal or annual variation in streamflow discharge may often be the primary determiner of trout abundance. This is true in some (if not most) streams in regions of substantial rainfall, as well as in water-poor areas.

SOME BASIC PRINCIPLES

In conclusion, I believe we can list a few general principles to guide in-stream habitat management:

1. It will be helpful to distinguish between protection, restoration, enhancement and maintenance.
2. Every stream has unique characteristics, but the processes affecting these characteristics will be common among streams. Restoration, enhancement and maintenance of habitat features should be tailored to the individual stream and be based on scientific diagnosis and design.
3. Proper habitat management requires professional guidance.
4. Habitat management should be based on an understanding of the healthy stream ecosystem.
5. The habitat management professional should be a biologist with major grounding in ecology and with thorough appreciation of trout fishing values. He should have the services of hydrologists, geologists, engineers and other professions at his disposal.
6. Enhancement and maintenance of habitat, carried too far, becomes a sort of aquaculture incompatible with sport fishery esthetics. Keeping in mind a distinction between unmanipulated nature and fabricated nature ought to be helpful in striking a balance of action and restraint. Where fabrication is chosen, disguise it.
7. Undertake the least possible manipulation of the channel. Forcing radical departures from natural channel forms is to be avoided, and if already accomplished, then remedied.
8. Habitat preservation without manipulation ought to be appropriate for many of the more scenic and "healthy" streams among North America's vast offering of trout waters. Let's not try to manage everything!
9. Habitat management should be subject to continual innovation, critical examination and informational exchange. This will be possible only if management and the scientific study of it are better funded than in the past. The opinion was voiced over a decade ago that ". . . at present most stream improvement can only be regarded as experimental and . . . this labeling carries with it the obligation of evaluation . . ." (Mullan 1962). I suspect most of us would agree that this still holds true. Much remains to be done in filling the gaps in our knowledge of habitat and its management. Habitat is the basis of our wild trout resource.

REFERENCES CITED

Calhoun, A. (ed.) 1966. *Inland Fisheries Management.* California Department Fish and Game. :456 p.

Curry, R. R. 1972. "Rivers–A Geomorphic and Chemical Overview." Pages 9-31 in R. T. Oglesby, C. A. Carlson and J. A. McCann, eds. *River Ecology and Man.* Academic Press, New York.

Frankenberger, L. 1960. *A preliminary report on evaluation of the habitat management program in Bohemian Valley Creek, La Crosse, County, Wisconsin.* Conservation Department West Central Area Investigations. Memo. 11:8 p.

Frankenberger, L. 1968. *Effects of Habitat Management on Trout in a Portion of the Kinnikinnic River, St. Croix County, Wisconsin.* Wisconsin Department Natural Resources Bureau Fish Management. Report 22:8 p.

Frankenberger, L. and R. Fassbender. 1967. *Evaluation of the Effects of the Habitat Management Program and the Watershed Planning Program on the Brown Trout Fishery in Bohemian Valley Creek, La Crosse County, Wisconsin.* Wisconsin Department Natural Resources Bureau Fish Management. Management Report 16:9 p.

Fraser, J. C. 1972. "Regulated Discharge and the Stream Environment." Pages 263-285 in R. T. Oglesby, C. A. Carlson and J. A. McCann, eds. *River Ecology and Man.* Academic Press, New York.

Gebhards, S. 1973. "Effects of channelization on Fish." Pages 23-24 in R. J. White, ed. Panel on Stream Channelization and Trout Fisheries. *Trout Magazine* 14(1).

Gebhards, S. and J. Fisher. 1972. *Fish Passage and Culvert Installations.* Idaho Fish and Game Department :12 p.

Giger, R. D. 1973. *Streamflow Requirements of Salmonids.* Job Final Report, Anadromous Fish Project AFS-62-1, Oregon Wildlife Commission, Portland :117 p.

Hale, J. G. 1969. *An Evaluation of Trout Stream Habitat Improvement in a North Shore Tributary of Lake Superior.* Minnesota Fishery Investigations 5:37-50.

Hendrickson, G. E. and C. J. Doonan. 1972. *Hydrology and Recreation on the Cold-water Rivers of Michigan's Southern Peninsula.* U.S. Geological Survey Water Information Series Report 3:83 p.

Hunt, R. L. 1971. *Responses of a Brook Trout Population to Habitat Development in Lawrence Creek.* Wisconsin

Department Natural Resources Technical Bulletin 48:35 p.
Hynes, H. B. N. 1974. *The Stream and Its Valley.* Baldi Lecture, XIX Congress, International Association of Lunnology, Winnipeg, 26 August 1974. :p 6.
Latta, W. C. 1972. *The Effects of Stream Improvement Upon the Anglers' Catch and Standing Crop of Trout in the Pigeon River, Otsego County, Michigan.* Michigan Department Natural Resources Research and Development Report 265:57 p.
Leopold, L. B. and W. B. Langbein. 1966. "Rivers Meanders." *Scientific American* 214:60-70.
Leopold, L. B., M. G. Wolman and J. P. Miller. 1964. *Fluvial Processes in Geomorphology.* Freeman Press :522 p.
Lowry, G. R. 1971. *Effect of Habitat Alteration on Brown Trout in McKenzie Creek, Wisconsin.* Wisconsin Department Natural Resources Research Report 70:27 p.
Mullan, J. W. 1962. "Is Stream Improvement the Answer?" *Trout Magazine,* 1962.
Saunders, J. W. and M. W. Smith. 1962. *Physical Alteration of Stream Habitat to Improve Brook Trout Production.* Trans. Am. Fish. Soc. 91(2):185-188.
Shetter, D. S., O. H. Clark and A. S. Hazzard. 1949. *The Effects of Deflectors in a Section of a Michigan Trout Stream.* Trans. Am. Fish. Soc. 76:248-278.
Stuart, T. A. 1962. *The Leaping Behavior of Salmon and Trout at Falls and Obstructions.* Fresh Salmon Fish. Res. 28:46 p.
White, R. J. 1968. *So Baut Man Forellenunterstaende: Ein Schwerpunkt der Bachpflege. Creating Shelters for Trout: A Stream Management.* Verlag Paul Parey, Hamburg-Berlin :126 p.
White, R. J. 1971. "Stream Improvement." Pages 106-110 in R. D. Teague, ed. *A Manual of Wildlife Conservation.* The Wildlife Soc., Washington, D. C.
White, R. J. 1972. *Trout Population Responses to Habitat Change in Big Roche-a-Cri Creek, Wisconsin.* Ph.D. Dissertation, University Wisconsin, Madison :296 p.
White, R. J. *Stream Channel Suitability for Coldwater Fish.* Proc. 28th Annual Meeting Soil Conservation Soc. Am. 61-79.
White, R. J. in press. *Trout Population Responses to Streamflow and Habitat Management in Big Roche-a-Cri Creek, Wisconsin.* Verh. Internat. Verein. Limnol. 19.
White, R. J. and O. M. Brynildson. 1967. *Guidelines for Management of Trout Stream Habitat in Wisconsin.* Wisconsin Department Natural Resources Technical Bulletin 39:65 p.

Figure 1a. Heavily pastured streambanks along Mt. Vernon Creek, Wisconsin.
See following page.

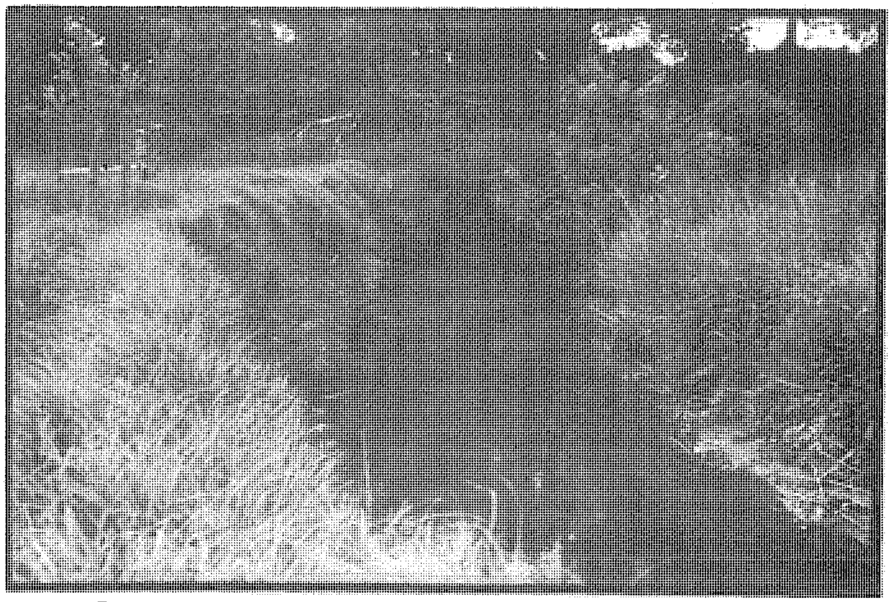


Figure 1b. A nearby area of the same stream. Overhanging grass forms ideal cover for trout. (Photos by R. J. White)

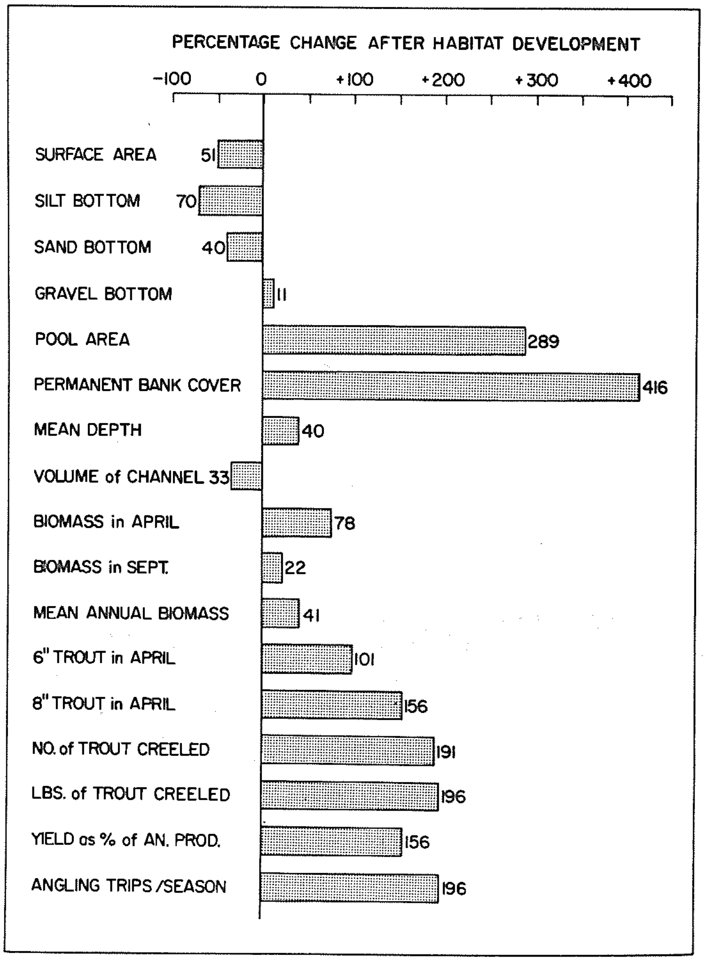


Figure 2. Positive results of channel alteration with bank-cover-deflectors in the 1.7-km headwater of Lawrence Creek, Wisconsin. This study compared 3 years before habitat management with the first 3 years afterward. (From Hunt, 1971)

Dr. Helm: *We are concluding this morning's panel with a presentation by Dr. Alex Calhoun. His title is intriguing, especially at this Wild Trout Management Symposium. Alex has been involved with trout throughout his professional career – as a manager, an administrator, and as an angler.*

Dr. Alex Calhoun was the next speaker at the Symposium. Dr. Calhoun's remarks were taken from a Report of the National Task Force for Public Fish Hatchery Policy of which he was the Editor. This report was made to the U.S. Fish and Wildlife Service. Limited copies are available – because of this Dr. Calhoun's remarks are not being printed. The Introduction, Summary, and Task Force Recommendations of the report are reproduced here. It is important to note that comments found in this report do not represent the official policy of U.S. Fish and Wildlife Service.

HATCHERY SUPPORT OF WILD TROUT FISHERIES

By Dr. Alex Calhoun

California Department of Fish and Game (Retired)

INTRODUCTION

This is the report of the task force set up by the U.S. Fish and Wildlife Service in January, 1974, to examine the national program for fish culture and directly related activities. The Service specifically asked us to review state and federal roles and responsibilities and to recommend any changes needed to achieve maximum efficiency through a coordinated national program whose state and federal components supplement each other fully while avoiding duplication of effort.

We were also requested to predict the future shape of the various phases of fish culture to the extent possible and to recommend ways to guide the anticipated changes so the program will be strengthened.

Early in its review, the task force decided not to include private fish culture in its study. Recognizing the desirability of doing so for the sake of completeness, we regretfully concluded that we could not gather the necessary data in the time available.

First of all, we reviewed current state and federal fish cultural programs and examined responsibilities as they now exist. In the process, we gathered a broad spectrum of fish production and distribution data from state fish and game agencies, using the questionnaire in Appendix 1, to which all fifty states responded. We combined state returns with corresponding federal data to describe the national program as a whole, outlined in Part II of this report. Federal data on allocations to waters under various jurisdictions in each state was provided by the regional offices of the U.S. Fish and Wildlife Service on the same forms the states used for this purpose in the questionnaire.

A second questionnaire (Appendix 2) asked the directors of state fish and game agencies for their views on the roles which state and federal levels should play in fish culture. All but two states responded. The results are summarized in Part I of this report. We also sent this policy questionnaire to the manager of each of the six administrative regions of the U.S. Fish and Wildlife Service and the district headquarters in Alaska with a clear request to express their personal convictions rather than to reflect existing policy, and with the understanding that their responses would not be identified.

It is important to emphasize, at this point, that all task force recommendations made in this report relate exclusively to fish culture, fish stocking, and directly related activities. They do not apply to any other types of fishery programs or activities.

The term "waters under federal jurisdiction," used frequently in the report, applies only to land ownership and directly related matters. The task force considers the states responsible for the fish in such waters.

SUMMARY

A task force appointed by the Director of the U.S. Fish and Wildlife Service surveyed state and federal fish culture during fiscal 1973. It also gathered the opinions of fish and game officials about appropriate responsibilities for the state and federal levels of government in this field. Finally, it developed a series of recommendations concerning such responsibilities.

The states operated 425 fish hatcheries, of which 297 produced trout and salmon, 73 produced warmwater fishes, 29 produced midrange fishes (walleye, etc.), and 26 produced various combinations. The U.S. Fish and Wildlife Service operated 90 hatcheries, 49 for trout and salmon, 19 for warmwater fishes, and 22 for various combinations.

Coldwater fish dominated fish culture associated with inland waters. States produced roughly 180 million weighing 18 million pounds. Federal production totalled 36 million coldwater fish weighing over 4 million pounds. Rainbow trout was the major species.

State hatcheries used 425 million trout eggs, of which 65 percent came from domestic broodstocks, 24 percent from wild fish, 9 percent from private breeders, and 2 percent from federal hatcheries. The latter produced 87 million trout eggs.

The states produced 86 million trout fingerlings, which were used most heavily in the West. Rainbow accounted for 77 percent. Geographical patterns of use are described for the five principal species. Federal trout production totalled 18 million fingerlings (70 percent rainbow trout).

States produced 53 million large trout weighing 16 million pounds, three-fourths rainbows. Most of the rest were brown and eastern brook trout. The mean size of 3.3 per pound represents a fish about 10 inches long. Levels of production were rather uniform over the sections of the country involved. Geographical patterns of use of the principal species are described. Federal production was about a third of the state total.

State and federal production of the warmwater species totalled 44 and 56 million fish, respectively. They were mostly bluegill, largemouth bass, and channel catfish fingerlings used to establish breeding populations in new or reclaimed waters. Nearly all of these fish were produced in the eastern two-thirds of the country. Geographical patterns of use are described for the principal species.

State and federal hatcheries produced 2 and 4 million striped bass fingerlings, respectively. Corresponding figures for walleye are 7 and 3 million; for northern pike, 4 and 2½ million. The states reared 371,000 muskellunge fingerlings. Geographical patterns of use are described. Production of striped bass and the midrange species is hampered by the inability to feed their fragile fry on artificial diets.

Five Pacific slope states produced 250 million anadromous salmonids weighing 8 million pounds. Federal hatcheries reared another 68 million weighing 1.5 million pounds. Chinook and coho salmon and steelhead trout dominate the program. New England states also produced a few Pacific salmon for anadromous programs.

Production of Atlantic salmon totalled 225,000 smolts weighing 25,000 pounds. Federal hatcheries reared 80 percent, and Maine accounted for most of the rest. Production of this species is expected to increase substantially as the Atlantic salmon restoration program, now getting underway in New England, expands.

Cultural operations involving marine and estuarine fishes were negligible.

A long standing national policy governing distribution of fish from federal hatcheries assigns top priority to waters under federal jurisdiction. Federal hatchery supervisors commonly view this responsibility as the primary mission of the federal hatchery system. However, existing patterns of responsibility did not generally reflect that concept. For example, the states stocked nearly four times as many trout fingerlings in public fishing waters under federal jurisdiction as federal hatcheries did; the federal hatcheries stocked nearly as many in non-federal waters. Only 3.5 percent of the sunfish fingerlings which federal hatcheries produced went to public fishing waters under federal jurisdiction. Corresponding percentages for largemouth bass and channel catfish were 29 percent and 16 percent, respectively. Although federal hatcheries did handle nearly all stocking of warmwater fishes in public waters under federal jurisdiction, this program did not amount to much.

The task force concluded that this policy needs to be reviewed and revised to provide more substantial and meaningful program goals.

The survey also revealed serious geographical inconsistencies in federal responsibilities for stocking large trout in public fishing waters.

Opinions of state fish and game administrators concerning appropriate state and federal responsibilities for fish culture diverged widely on many issues. For example, 53 percent believed the states alone should produce the fish which are routinely stocked in public waters. The other 47 percent thought federal hatcheries should share this responsibility, although nearly all favored primary responsibility for the states. A strong consensus favored complete state responsibility for determining the kinds and numbers of hatchery fish going to inland waters, including those from federal hatcheries.

The percentage favoring shared state and federal responsibility increased to 56.5 percent for public waters under federal jurisdiction.

When the issue was narrowed down to large federal reservoirs, 43.5 percent of the fish and game administrators said the states alone should stock them, 6.5 percent favored complete federal responsibility, and 50 percent favored shared responsibility. Of the latter, 43.5 percent said it should be more state than federal, 39 percent thought it should be equal, and 17.5 percent believed it should be more federal than state.

About half of the respondents said states alone should stock waters on state boundaries. The other half thought federal hatcheries should share the responsibility.

A substantial majority of state administrators favored federal responsibility for stocking waters on military reservations closed to public fishing. In the case of waters on Indian reservations with access fees, 55 percent favored federal responsibility, 10 percent favored shared responsibility, and 33 percent said that neither state nor federal hatcheries should stock them.

Only two states said the federal level alone should stock farm ponds. Half believed the owner should assume responsibility, a fourth thought the states should stock them, and 7 states favored shared federal and state responsibilities.

A substantial majority of the states favored private responsibility for stocking waters closed to public fishing, particularly when trout and other species requiring repeated stocking were involved.

In the case of catchable sized trout for public waters, 54 percent said the federal government should not provide such fish to the states; 46 percent said it should. Three-fourths of the states opposed federal participation in urban put-and-take stocking programs.

The questionnaire also probed the views of state administrators on the appropriate federal role in research and development activities relating to fish culture. Most respondents favored high federal priority for these functions. The support for federal research on fish genetics and nutrition was overwhelming. Support for a strong federal fish disease control program was also strong.

Most state administrators favored federal assistance in training state personnel, particularly in the field of disease control.

The recommendations developed by the task force are listed in the next section.

TASK FORCE RECOMMENDATIONS

1. That the states assume full management and financial responsibility for stocking the inland public fishing waters within their respective boundaries except for special situations which justify assistance from federal or local government or from private utilities or other appropriate sources.
2. That public fishing waters located on federal lands be treated like any other public waters for purposes of fishery management, and that the states assume full responsibility for stocking them, except for large federally developed reservoirs or situations where such action is precluded by statute; further, that responsibilities be shifted in a manner which does not abruptly burden any state financially.
3. That the states assume full responsibility for managing fisheries in federal reservoirs within their boundaries, but that the U.S. Fish and Wildlife Service assist them with stocking programs as required to develop and maintain the optimal recreational potential of such waters. However, in line with the heavy state responsibility, the federal contribution should not exceed the state contribution. Further, that all cooperative stocking programs for federal reservoirs be formalized with written interagency agreements defining the justification for them and the kinds and amounts of fish to be provided by the state and by the Service.
4. That states be responsible for stocking public fishing waters on state boundaries, which should be treated like other public fishing waters. However, the Fish and Wildlife Service should stand ready to coordinate stocking programs involving a number of states when the latter request such assistance.
5. That states assume responsibility for providing fish for the initial stocking of warmwater fishes in waters on military reservations with restricted public access; further, that the users assume financial responsibility for stocking such waters with trout and other fish which need to be planted repeatedly.
6. When national policy dictates that fish reared at public expense be stocked on Indian lands, that federal hatcheries provide such fish in situations where the state concerned desires them to do so; but only in accordance with a sound, predeveloped fishery management plan.
7. That the existing federal fish stocking program for Indian lands be evaluated, element by element, from economic and fishery management standpoints.
8. That decisions concerning fish stocking responsibilities for individual national parks and monuments be made by the federal and state agencies concerned with them, on the basis of local circumstances.
9. That the U.S. Fish and Wildlife Service continue to implement the decision already made to remove the federal level of government from responsibility for stocking private farm ponds;

further, that responsibilities be shifted in a manner which does not abruptly burden any state financially.

10. That the U.S. Fish and Wildlife Service adopt a policy prohibiting the stocking of federal fish in private waters lacking public access.

11. That the U.S. Fish and Wildlife Service not provide fish for put-and-take programs, except in large federal reservoirs under heavy fishing pressure when the state involved cannot develop the optimal recreational potential without assistance; provided, however, that the Service should not provide more than half the fish used in such reservoir situations.

12. That the federal service should not provide fish for put-and-take stocking in urban areas or for urban recreational programs.

13. That substantial fish cultural operations involving endangered species which are found to be necessary be carried on in new facilities built and operated for that purpose.

14. That the custody of gene pool remnants of fishes with no hope of reestablishment in the wild be assigned to special facilities established for that purpose rather than to hatcheries geared to routine production of game fish.

15. That federal and state levels of government continue to share responsibility for the culture of Pacific salmon and steelhead.

16. That the U.S. Fish and Wildlife Service and the National Marine Fisheries Service increase their emphasis on research and development activities relating to the culture of Pacific salmon and steelhead; further, that they encourage and participate in a state-federal review of existing and proposed projects in this field; and further, that they encourage and participate in the development of a state-federal system for jointly assigning priorities to and responsibilities for research and development goals.

17. That the federal and state levels of government continue to share responsibility for producing the Atlantic salmon smolts needed to restore runs in Northeastern watersheds.

18. That the two federal fisheries services, in concert with the New England states, develop a comprehensive state-federal-international Atlantic salmon plan for the entire New England area which is mutually satisfactory giving careful attention to both the evaluation and restoration of river environments and the hatchery production and distribution of smolts.

19. That the federal level in concert with the states strengthen its role in research and development relating to fish culture; further, that the state and federal agencies concerned look to the advantages of geographical and problem coordination of their research and development efforts.

20. That the Fish and Wildlife Service review the goals and operations of its developmental program for fish culture to determine whether it will function best under regional or central leadership.

21. That the U.S. Fish and Wildlife Service make an in-depth review of its research and development activities associated with fish culture, giving particular attention to relevance, priorities, and productivity.

22. That the U.S. Fish and Wildlife Service in concert with the National Marine Fisheries Service and the states assign a much higher priority to the development of procedures for culturing the larvae of striped bass and the midrange species using artificial diets.

23. That each state or federal agency assume responsibility for routine disease control within its own hatchery system.

24. That the U.S. Fish and Wildlife Service concentrate its program for the control of fish diseases in the general areas of research, of assistance to states with unusually difficult problems, of interstate and international aspects of fish disease control, and of routine control of disease in federal hatcheries.

25. That the U.S. Fish and Wildlife Service and the National Marine Fisheries Service in concert with the states and the private sector set up a problem solving team of individuals who are knowledgeable about the technical, social, and political aspects of national fish disease problems, directing this team to develop plans for an action program, including any corrective legislation which may be necessary, to control the spread of the more serious diseases.

26. That the U. S. Fish and Wildlife Service in concert with the states continue to develop and strengthen the national system for disease appraisal and certification of salmonid eggs.

27. That the U.S. Fish and Wildlife Service continue the important role of maintaining disease free broodstocks and providing states with supplies of disease free eggs for use in starting their own broodstocks; but that the Service not attempt to become a routine source of supply for disease free eggs or fingerlings for production purposes.

28. That state fish and game agencies and the federal service assume responsibility for training their respective employees; further, that the U.S. Fish and Wildlife Service continue to provide opportunities for non-federal workers to participate in its training sessions related to fish culture and

fish disease control.

29. That the U.S. Fish and Wildlife Service adopt policies and operating philosophies which will encourage federal hatchery personnel to view the national program for fish culture as a unified operation with federal and state components working together toward common goals.

30. That the U.S. Fish and Wildlife Service and the National Marine Fisheries Service in concert with the states define the problems associated with inadequate inter-communications within the national program for fish culture and formulate solutions.

31. That the U.S. Fish and Wildlife Service explore in concert with the states concerned the various ways in which the federal level can assist in coordinating fish cultural programs which interlock many states.

REGULATIONS, POLITICAL REALITIES AND THE ANGLER PANEL

Dr. King: *This is the fourth and final technical session of our Symposium. We must shift our thinking and approach from a consideration of the habitat and the fish contained in those habitats to the human side of fishery management. Dr. James McFadden of the University of Michigan will be our Chairman for this session. Jim is a well-known researcher who has won the respect of many of us for his rapid rise in fishery science and his ability to tackle difficult problems.*

Dr. McFadden: *Through this afternoon's panel we are going to attempt to tie some important things together – important threads that run through all that's gone before. We're going to hear about the inputs from the anglers themselves, from an angler who has been very much involved with public process in protection of aquatic resources, and we're going to also take a look at the legal process, as it today determines the future for many of our waters. We are also going to tie in with the political area of agency administration and have presentations in addition from the research and technical management point of view.*

I want to introduce this session of the Symposium by stressing the importance today of achieving integration among these different areas of input. I think it's truer today than it's ever been before, that we have to integrate efforts from the scientific, managerial, administrative, political, and public areas and present a united front to resist the many forces at work that threaten undoing of resources such as our wild trout resources.

I know when I was a researcher, I used to spend most of my time cussing managers and administrators. When I became a manager and an administrator, I stopped cussing those people, and now that I'm about to cease being an administrator, maybe I'll go back to cussing some of the other people all over again; but there is a level at which we have to achieve a presensitive feedback, I think, from the public to the management agency on what the public needs are at the administrative level, to the research and management areas where information gathering and action management programs are developed. There is no longer room for pursuing our own interests and considering other inputs as our adversaries. The external adversary, all the forces at work in society that threaten our resources, is too large an adversary for anything less than a unified effort to resist it.

So, I want to call your attention to what I think may be the most important aspect of this particular panel, and that is its multi-faceted makeup – people from a wide variety of backgrounds pursuing problems associated with coldwater resource management and protection. The second thing I want to point out is something about the structure of this afternoon's session. The first is fairly specific; it deals with the use of creel limits, size limits, seasons, and angling method limitations as management approaches for trout fisheries; and we'll have both the management and research point of view presented here.

The second major part of this afternoon's presentation pulls together considerations from the political area, the legal area, and the anglers' own input as a vitally interested segment of the public. In a sense, the second half consisting of the last three presentations really relates to all that's gone before in this conference, I think. We're going to begin now with our first presentation dealing with creel limits, size limits, seasons, and angling methods; and Art Whitney is going to give us the manager's viewpoint.

CREEL, SIZE, SEASONS AND ANGLING METHODS– THE MANAGER'S VIEWPOINT

By Arthur N. Whitney

Montana Fish and Game Department

Creel, size, seasons and angling methods (in other words, fishing regulations), in this manager's viewpoint, comprise one of the least important fishery management tools we have in Montana, as far as the long-range future of our wild trout resource is concerned. I would rank our management tools in descending order of importance as follows:

1. Habitat preservation, restoration and improvement.
2. Access purchase and development.
3. Population manipulation.
   A. Stocking sub-catchables.
   B. Chemical rehabilitation.
4. Regulations.
5. Planting catchable-sized trout.

Since this Symposium is concerned only with wild trout management, number five can be ignored. Perhaps some would like to drop number three as well, but our experience has been that few anglers see any difference between a hatchery fingerling grown to catchable size in the wild and a fish of the same size that was spawned naturally. The use of fingerling trout is quite limited in Montana's streams, but these fish do provide the bulk of our trout fishing in reservoirs.

I rank regulations low in importance, not because I consider them ineffective, (although some undoubtedly are) but rather because their effect is very short term. Thus an error in setting too liberal a season or limit is not nearly as serious as is an error about what restrictions should be imposed on a streamside construction project. Since we have yet to have set a sport fishing regulation liberal enough to decimate a fish population in Montana, I will have to use a severe pollution problem as an example. In the winter of 1960 a strike-associated cessation of some rather primitive, but effective, pollution control operations at Butte and Warm Springs caused the Clark Fork River to turn an opaque brick red from Deer Lodge to Missoula, a distance of over 75 miles. As nearly as we could determine with the sampling gear available at that time, all fish in that 75+ miles of the Clark Fork River died that winter. Super-liberal fishing regulations would be hard pressed to achieve the same result, although with several years of allowing nets, seines and dynamite and possibly offering a bounty on brown trout, suckers and whitefish, we might have approximated the same situation. I had never seen such a devastation of a stream trout fishery. When asked by reporters how long it would take the Clark Fork to come back, I said, "We just haven't had enough experience to know the answer to that question. I would guess 5 to 10 or maybe even 15 years." I was wrong. Within two years fishing was fairly good in the upper Clark Fork again. Today, even after sustaining a smaller, but still serious, pollution kill in 1967, the upper Clark Fork is one of the best wild stream trout fisheries in Montana.

Regardless of what importance fish managers attach to them, regulations are a matter of great concern to most of the anglers we work for. In sport fisheries management, as in most businesses, you don't survive unless you have at least half of your customers satisfied. Therefore, it behooves us to propose the best regulations we can that are commensurate with the capabilities of the resource, and then to temper these proposals with the desires of the majority of the anglers.

The major function of fishing regulations under Montana's relatively light fishing pressure is not to preserve fish stocks, but rather to attempt to provide a more equitable distribution of fish among anglers. However, studies have shown that the best 25% of the anglers take over 75% of the fish, and that about 45% of the anglers consistently catch nothing at all. Thus, a really equitable distribution of the catch is impossible under any regulation. But at least daily limits keep the differences between zero and a fairly low number.

Because the function of regulations is simple, it would seem logical that the regulations themselves could be simply written. Unfortunately, fishing regulations become more complex as both people and information on the fishery resource increases. In 1911 the Montana fishing regulations consisted on one sentence which, along with a few paragraphs that comprised Montana's hunting regulations in that year; all appeared on the back of each license. The fishing regulations said, "Fish may be caught at all times with a hook, line and pole." Today's fishing regulations fill the back of a large map. More people and more information have caused this change. In 1965, I bought a fishing license in Yukon Territory. The entire regulations were on the front of that license and said I was licensed to "fish by means of hook and line." One can infer that people pressures in Yukon Territory in 1965 were similar to what was found in Montana 50 years earlier.

I believe the history of Montana's fishing regulations can be categorized into four periods. The first, the period of the single sentence regulation I have already mentioned. It was probably supported by a belief that planting large numbers of trout fry everywhere would provide an inexhaustible supply of fish for anglers limited to the use of hook and line.

During the second period people must have had an intense desire to protect the resource, but apparently had no better understanding of how fish populations worked than before. The regulations during the second period consisted of a county by county listing of limits, seasons and closed waters that was quite complex and repetitious. These regulations filled a small book. Persons trained in the science of fishery biology and equipped with skills and tools that enabled them to get a better understanding of what goes on beneath the surface of the waters appeared in the latter part of this period and eventually were instrumental in bringing it to an end.

Montana's third period of fishing regulations came with a better understanding of fish population dynamics, a desire to allow as much fishing as the resource could provide, and a realization that habitat preservation, not fishing regulations, is the real kay to the future of our wild trout fishing. We are still in this period, with regulations printed on the back of a map and containing many year-round seasons, liberal creel limits and no restrictions on type of lure.

Montana fisheries managers can see a new period of fishing regulations on the horizon. Changes will be prompted by a growing group of anglers who prefer catching large trout (even if they have to release them) to catching and keeping larger numbers of smaller fish. This group is still in the minority, and I am confident that all regulations will not be revised immediately to serve their interests. However, I think their desires represent a valid request of the resource and that it will be logical for us to meet these demands in some areas.

To do this will result in fewer trout being taken by anglers and more trout dying of natural causes than do so now. We know in certain areas we have studied, such as the Madison, that total mortalities are about 60 percent each year and that the anglers' catch represents only 20 percent of this (or 12 percent of the total population). Reducing the anglers' percentage even further would not be "good business" as far as providing maximum fishing opportunities is concerned. However, it certainly can be done in some areas for the anglers who really prefer catching and releasing a few larger trout to catching and keeping more small fish.

We are fortunate to be concerned with fish and not with elk or deer. Every severe winter I am thankful that surplus trout merely die unobserved under the ice rather than spectacularly on the highways or around haystacks as deer and elk do. The big game manager simply cannot go along with regulations which would allow a surplus the same way a fisheries or game bird manager can. Big game can destroy its habitat, fish and birds cannot. Managing for surplus fish or birds will only deprive some fishermen (or hunters) of their sport. And if that is what these fishermen or hunters want, the management agencies can certainly give it to them. It may not be "good" management in the classical sense, but it will have no long lasting detrimental effect on the resource.

Therefore, persons wanting this different type of management should let their desires be known. But I hope they will state such requests in the terms of what they want to catch and not as a set of regulations they would like to see tried. Researchers like Bob Hunt have evaluated enough restrictive regulations so we have a pretty good idea of what will work and what won't. Thus, while we would react rather violently to a request simply for fly fishing only on some stream or streams in Montana, we would have a much more agreeable reaction to a request to provide more larger fish in some waters. And also, I would hope that management agencies would not be deluged with requests to evaluate new combinations of restrictive regulations that somebody feels will produce really fantastic fishing. In Montana, I am sure any dissipation of our present investigative efforts into what qualities of stream trout habitat it is most essential to preserve will be most vigorously resisted. This would not be because we think such requests do not have merit; it would only be because we are not nearly as concerned about how best to increase the size of the wild trout you and I catch today as we are about whether we can save enough habitat so that our grandchildren will still be able to catch wild trout.

Dr. McFadden: *I want to make one comment in relation to what can sometimes seem to be an inconsistency of restrictive regulations from one situation to another. Obviously, the importance of restrictive regulations is going to have a lot to do with the harvest rate of the fish, and I see that harvest rate as being determined largely by two factors. One is the obvious one, fishing pressure; and the other is the size of the population that is being fished. A small population, for example* *headwater stream resident cutthroat, is likely to be much more susceptible to depletion by fishing than a very large population, numerically speaking, and occupying a much larger habitat. Secondly, as was said earlier, the species of trout that you're talking about is of immense importance in relation to utility of restrictive regulations, running the gamut from brook trout, which most people are smarter than, to brown trout, which are smarter than most people.*

The final point I wanted to make about restrictive regulations is that their utility is very directly related to the productivity of the waters on which they're imposed. In a very highly productive situation, where the emphasis is on a lot of biomass turning over in the system, you probably can't stockpile very extensively, and, if you remove fish from the population, they are rapidly replaced. When you go to very unproductive streams, the rate of elaboration of new biomass, new fish flesh, is very slow because of limited productivity. When you remove a fish from the system, it's not very rapidly replaced; in fact, the lag time for replacement may be of the order of years. Stockpiling to maintain a fairly high standing crop for a fishery can be a very effective objective that's implemented through restrictive regulations.

We will move along now to our next speaker, who is Bob Hunt, who will continue our discussion of angling regulations in relation to wild trout. Bob is a fishery biologist with the State of Wisconsin.

ANGLING REGULATIONS IN RELATION TO WILD TROUT MANAGEMENT

By Robert L. Hunt

Wisconsin Department of Natural Resources

I am in thorough agreement with the list of management priorities established by Art Whitney, the preceding speaker. Habitat preservation, restoration and improvement certainly belong at the top of my list of trout management priorities too, at least when viewed on a broad management perspective such as that of managing all the trout waters in a state or province. However, I believe it is also necessary that at the local focus of managing a specific stream, watershed, or sector of a state or province, trout fishing regulations 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.

Evidently excessive fishing pressure is not a problem yet in Montana, hence the biological implications of managing (or satisfying) fishermen. But such may not always be the case.

Close by the site of this Symposium it has become necessary to apply highly restrictive fishing regulations to restore and maintain a high quality fishery for wild cutthroat trout in Yellowstone Lake and in Yellowstone River within the Park. Preserving the pristine quality of these trout waters has not been enough to assure perpetuation of a high quality sport fishery (Anderson 1974).

A second example of first priority on fishing regulations is the proposed management scheme to preserve the world's finest trophy fisheries for lake trout in huge Great Slave Lake (11,000 square miles) and even larger Great Bear Lake (12,000 square miles) in Canada's Northwest Territories. Despite their remoteness, vastness, short fishing season (about four months), light angling pressure, and a sport fishery only 20 years old, it is evident that overharvest of trophy lake trout is occurring even though harvest rates approximate only one pound/acre/year in Great Slave Lake and 11 pounds/acre/year in Great Bear Lake. Deteriorating habitat quality in these lakes is no management problem now or in the forseeable future. The problem is excessive harvest of trophy-size lake trout to take home and smaller lake trout to eat on the spot, and from a fragile arctic environment that has low carrying capacity and low growth potential.

Strong management recommendations (Falk, Gillman and Dahlke 1973) have, therefore, been proposed to preserve these lakes for trophy lake trout fishing only by limiting anglers to one lake trout of 15 pounds or more per year and use of barbless hook lures.

The team of investigators concluded that the ultimate aim of their recommendations is to provide a method of preserving the unique fisheries of Great Bear and Great Slave lakes for future utilization. "As good sports fishing becomes rarer and numbers of fishermen increase, Great Bear and Great Slave lakes' appeal of unmarred wilderness and trophy fishing will become increasingly valuable, both aesthetically and economically."

Somewhere I read that there are two contrasting philosophies of life that prevail in West Germany. In the northern industrialized half of the nation, the attitude to life is characterized by the phrase, "The situation is serious but not hopeless." In the southern, more agrarian half, people view life with the philosophy that, "The situation is hopeless but not serious."

I suspect these same contrasting attitudes can be accurately applied to the future of wild trout fishing in American. If the opportunity to fish for wild trout should completely disappear, the vast majority of our fellow citizens would experience no disruption of their lifestyle. Threatened extinction of the last wild trout stream, like that of the last passenger pigeon, would simply be accepted as an inevitable consequence of social "progress" – one more "hopeless but not serious" event.

We who have gathered here for this Symposium realize, I'm sure, that we represent a minority segment of our society. But the fact that such a gathering as this has been called is an encouraging sign. We recognize that we face a "serious but not hopeless" battle to preserve the wild trout resources of our country. Hopefully, as a result of this Symposium there will be accelerated efforts to: (1) develop more rational programs for managing wild trout fisheries by applying knowledge available now; (2) stimulate our concerned minority to get involved in the biopolitical processes that influence resource management policies; and (3) initiate new research efforts to supply the biological facts and social insights we need to effectively manage our still substantial but dwindling supply of wild trout.

REVIEW OF 1974 STATE AND PROVINCE REGULATIONS

In preparation for this Symposium and the topic assigned to me, I obtained copies of the 1974 fishing regulations from the natural resources agencies of all states and Canadian provinces. Information on trout fishing regulations (where applicable) was then tabulated for 43 states and 11 provinces according to:

1. Creel restrictions – the legally allowed number and/or pounds of trout that could be kept daily.
2. Size restrictions – the legally allowed length a trout must be to be kept, if there is a minimum size limit.
3. Season – tabulated as either year-round or less than year-round.
4. Lure restrictions – any special regulations other than normal hook and line fishing gear.

Daily Creel Limit:

Natural resource agencies in all 43 states and 11 provinces providing trout fishing have concluded that a daily creel limit of some kind is desirable. The degree of allowable harvest is quite variable, however. On about 40% of the reservoir lakes of North Dakota the limit is three trout/day. In several management regions of Montana the creel limit is 10 trout whose weight must not exceed 10 pounds plus one more trout. Manitoba has a daily creel limit of two for wild brook trout, whereas in Newfoundland 24 trout/day is the creel limit (or 10 pounds plus one more trout); in Quebec the limit is 25 trout/day (or 15 pounds plus one more trout).

The most common creel limits are five trout/day in nine states and 10/day in nine states. Seven states and four provinces have number and weight combinations for their creel limit. For example, 12 trout or five pounds in Vermont, eight trout or 7.5 pounds in Maine. Four states and one province combine number and size of trout in their allowable creel limit. For example, 12 trout but only six over 10 inches in Massachusetts, 15 trout but only three over 20 inches in some Alaska management units, eight trout but only two over 20 inches in British Columbia. A summary of the total sample of creel limits in effect in 1974 is as follows:

Daily Creel Limit	U.S. – States	Canada – Mgt. Units
None	0	0
Yes	43	11
Number limitation	32	6
Number and weight combination	7	4
Number and size combination	4	1

Size Limits:

Evidently on the basis of present application, size limits are considered to be less important than creel limits (except on "special" regulation waters as discussed later). Only 10 states and two provinces have a minimum size restriction on one or more species of trout, and none of the limits exceed eight inches.

Season:

Eighteen states and three provinces allow trout fishing on a year-round basis, and 25 states and eight provinces have less than year-round trout seasons.

Size Limit	U.S. – States	Canada – Mgt. Units
None	32	9
Yes	11	2
6 inches	8	
7 inches	2	
8 inches	1	2

Special Regulation Waters:

In all states and provinces, methods and lures normally legal for other fish are also legal for trout. However, in 30 states and five provinces some trout waters have been designated as "special regulations" waters. The most common special regulation is "fly fishing only," but on many of these special waters any kind of artificial lure can be used. Only fishing with natural baits is prohibited. In most instances more restrictive size and/or creel limits also apply to special regulation waters. In a few cases only one or two "trophy size" trout may be kept, and less frequently yet, all trout caught must be released ("no kill").

Such special regulations are too numerous to thoroughly review here, but their widespread and growing use reflects a trend in trout management toward providing greater variety of angling opportunities with greater emphasis on the recreational aspects of fishing and less emphasis on catching fish to eat. A few examples of such special regulations waters are:

Waters Creek in Georgia where the minimum size limit is 22 inches for brown and rainbow trout, 18 inches for brook trout, a creel limit of one trout/day and artificial lures only.

Hosmer Lake in Oregon and Chopaka Lake in Washington, where only fly fishing is allowed and all Atlantic salmon caught must be released.

The McKenzie River system in Oregon where no rainbow trout over 14 inches may be kept – an application in this instance of a maximum legal size limit.

Eighty miles of fly fishing only water on seven streams in Michigan including an 8.7 mile stretch of the Au Sable River, where year-round fly fishing is permitted but no trout can be killed during the January 1 to April 25 period. During the remainder of the year size limits are 8 inches for brook trout, 12 inches for other trout and a creel limit of three.

Fly fishing only on 25 lakes and streams in Washington; barbless hook flies and one trout daily over 20 inches on Rocky Ford Creek.

A portion of the Amawalk River in New York, where the rules are artificial lures only, two trout/day over 10 inches.

Flies only or artificial lures on 21 lakes and 35 streams in Colorado.

Flies only and release of all trout over 14 inches on a portion of the Henry's Fork (Snake River) in Idaho.

Such special regulations as these I've cited can also be an element in the management of streams on a regional basis and in the management of wild trout waters specifically, as discussed under the subheadings that follow.

Regional Regulations:

In nine states and five provinces trout fishing regulations are administered on a less than statewide or provincewide basis as an attempt to tailor regulations to differing biological conditions or fishing pressure. In Montana, regulations are administered on a seven-region basis with each region including one or more of the major river basins. In Maine eight trout/day may be kept except in Aroostook County, where the creel limit is 12/day. California has a complicated system of 11 management districts. New Mexico manages "winter trout waters" and "regular" trout waters differently. Alberta is apportioned into six management regions, British Columbia into seven management regions, and Ontario into 25 management divisions.

Management of Wild Trout Waters:

No state and only one province is presently using fishing regulations to broadly manage wild trout waters differently from those periodically stocked with domestic trout. The exception is Manitoba, where "natural brook trout waters" are closed to fishing September 1 to September 29, and the creel limit is only two brook trout/day. In waters that are stocked with trout the creel limit is 10/day, and most are open to year-round fishing.

The Alaska Department of Fish and Game has developed a "Trophy Sports Fish Management Program" aimed at maintaining high quality fishing for large rainbow trout in several streams entering Bristol Bay. In 1968 the daily creel limit was reduced from 10 to 5, of which only one can exceed 20 inches. In addition only single hook artificial lures can be used, and helicopter travel is prohibited because it is considered to be an incompatible distraction to a wilderness fishing experience.

In Georgia a wild trout management program is being developed for a few streams in ten public wilderness areas. The program calls for no stocking, and a shorter fishing season. On one of the streams, Noontootley Creek, special regulations include use of artificial lures and a daily limit of one trout over 16 inches.

In Oregon separate recommendations for managing wild vs. hatchery stocks of cutthroat trout have been published (Giger 1972) but have not been implemented. Pollard and Bjornn (1973) proposed a special size limit of 8 inches to provide additional protection for juvenile steelhead trout in Idaho's Snake River system. To my knowledge this recommendation has not been adopted either.

In my own state, Wisconsin, a partial step has been made toward special management of wild trout streams. All known trout streams have been assigned to three classes. Class One streams are considered to be "wild trout streams" where little or no supplemental stocking should be needed to provide satisfactory fishing. Gradually during the past few years stocking of these streams has diminished almost to zero. However, size limits, creel limits, and seasons are applied with no major regard to stream classification.

As a generalization, I believe it is fair to say that natural resource agencies have developed more innovative programs to effectively manage stocked trout waters than they have to maintain and manage wild trout waters due in large part to their awareness of the economic cost of stocking trout and their desire to get back a high return on such investments. "Return" in this case being normally measured by the pounds of trout creeled in relation to pounds stocked.

License and Trout Stamp Requirements:

In no state is trout fishing considered to be an inherent right of citizenship. At varying ages, from 9 (in Hawaii) to 16 years, a fishing license is required. In two Canadian provinces, Newfoundland and New Brunswick, no fishing license is needed by resident citizens. In 18 states a special trout stamp must also be purchased, ranging in price from $1.00 to $5.00 (average of $2.70).

SOME RESULTS OF ANGLING REGULATIONS STUDIES

Creel Limits:

Creel limits are usually imposed to restrict the daily kill of trout by individual anglers. Hopefully, by limiting the daily harvest of individual anglers the cumulative effect is to lower exploitation rates from what they would be if catches were not restricted. Consequently more trout should survive to spawn or be caught later at larger sizes.

Creel limits can also be viewed as a management procedure to distribute the total catch more evenly among more anglers by reducing the potential catch of skillful fishermen, thereby leaving more trout for the less skillful to fish for. One could also reason that by reducing early season harvest with a creel limit, more trout will live longer and grow larger before being caught, so that over the course of a season more pounds of trout are harvested.

Non-biological reasons for creel limits are also used to justify their application, such as: prevention of waste of fish taken but not utilized; providing a "satisfaction goal" for anglers to attain; or in the case of very low creel limits, encouraging anglers to fish simply for the enjoyment of catching and releasing trout.

Nearly all evaluations of creel limits for trout, especially those involving wild trout fisheries, have provided similar conclusions (Allen 1951) for the Horokiwi stream in New Zealand; Latta (1973) for the Pigeon River in Michigan; Spence (1971) for Rock Creek in Montana; Shetter for Michigan's Au Sable River; McFadden (1961) and Hunt (1970) for Lawrence Creek in Wisconsin:

1. Daily creel limits are usually too liberal to have much management value in reducing the yearly kill of trout. Most of the catches on all waters studied consist of one to three trout per trip.
2. Most of the trout temporarily saved because an angler stopped fishing are probably caught later on that same year. Consequently, the reduction in total catch by all anglers is less than the cumulative reduction of individual catches. Moreover, it is primarily the skillful anglers who benefit from such temporary savings.
3. Reductions in creel limits provide about the same proportional measure of added protection for dense trout populations as for sparse ones. Proportionately greater protection for sparse stocks would be biologically more desirable.
4. In some instances creel limits actually encourage expert anglers to continue fishing until the limit is attained.

Facts such as these made Allen and Cunningham (1957) conclude that: "In general existing bag limits (of 5 to 20 with an average of 13 for 22 management districts) have no significant effect on angler's catches or on conservation of fish stocks" (mainly wild brown trout). Reducing all limits to five trout/day probably would have reduced the harvest by 7% at a maximum for one district and by less than 2% in most districts.

As part of an experimental study conducted by Latta (1973), the creel limit for wild brook trout and wild brown trout was increased from two to five. Total catch did not increase significantly with an increase in the creel limit.

My own summary conclusion (Hunt 1970) regarding the value of a creel limit for wild brook trout based on 13 years of testing regulations at Lawrence Creek was that a daily limit throughout the season as liberal as 10 or even five/day was of little value. Over the course of a season a limit of five rather than 10/day would reduce the total catch by no more than 20% if angling effort remained unchanged.

Size Limits:

Use of minimum size limits rests on the assumption that of the undersize trout released, enough will survive to increase the total catch for the year by being captured again at legal size, or increase future catches by adding to subsequent generations by spawning. Size limits have also been viewed as a means of protecting all or part of a generation of fish from being harvested until they have had an opportunity to spawn at least once. Size limits may also be applied to simply delay taking fish until they have reached some agreed-upon "desirable size" independent of any biological ramifications.

To be effective as a means of reducing the cropping of wild trout, a size limit must be larger than the size of trout most anglers would consider worth keeping if it were legal to do so. In other words, a size limit provides no protection if anglers wouldn't keep trout of that size or less.

For example, few anglers kept brook trout less than 6 inches long during two seasons when there was no size limit at Lawrence Creek (Hunt, Brynildson and McFadden 1962). Graynoth and Skrzynski (1974) concluded that it would be biologically desirable to reduce the size limit from 12 inches to 10 inches to allow anglers to take a larger crop of brown trout in the Nelson District of New Zealand, but it "was debatable whether the anglers in this District would keep fish" under 12 inches.

What the majority of anglers in a given fishery consider "acceptable" is quite variable, however, and probably depends in large part on the average size of trout caught from that water. After the size limit of six inches was removed on several infertile mountain streams in New Hampshire, approximately 60% of the wild brook trout creeled in 1957 and 75% of those creeled in 1958 were less than six inches. Some four-inch and even a few three-inch brookies were kept (Seamans 1959).

The degree of deliberate or unintentional law breaking by anglers is another factor that can influence the effectiveness of a size limit. In a study relative to testing of a 12-inch size limit for rainbow trout in Parvin Lake, Colorado (Klein 1972), eight percent of the trout kept by anglers were less than 12-inches even though anglers knew they would have to present their catches for examination at a creel census station. A few trout kept were as much as three inches undersized. Klein concluded that fishermen would undoubtedly keep even more undersize trout in situations where their catches would not be routinely examined.

If a wild trout population needs regulatory protection to prevent overharvest, most investigators have agreed that a size limit is more effective than a creel limit (Ricker 1945; Allen 1951; McFadden 1961; Hunt 1970). Under progressively restrictive size limits for wild brook trout in Lawrence Creek, angler exploitation was reduced from 32 percent with a six-inch limit to 9 percent with an eight-inch limit and to less than four percent with a 9-inch limit.

A size limit can also be chosen which will protect all, some, or none of the individuals of a year class from being removed until they have reached spawning size. A size limit applies to every trout caught – it either is or is not large enough to keep – whereas the creel limit provides no protection until the limit is reached. A size limit can also be keyed to three fairly stable characteristics of a trout population – growth rate, size at sexual maturity, and number of brood fish needed to sustain adequate recruitment of young trout.

If improvement of a wild trout fishery is primarily dependent on building up spawning stocks by reducing the harvest, an increased size limit will do the job, provided throw-back mortality does not negate the benefit of reduced harvest.

For example, spawning stocks of wild brook trout and wild brown trout were substantially increased by raising the size limit from seven inches to 9 inches on experimental portions of the Au Sable River and Hunt Creek in Michigan (Shetter 1969). Increasing the size limit for brook trout from six inches to 9 inches also benefitted spawning stocks in Lawrence Creek (Hunt, Brynildson and McFadden 1962). Numbers of first and second-time spawners increased, and exploitation of adult trout was reduced from 32 percent to less than four percent.

For these three productive streams (Au Sable River, Hunt Creek, and Lawrence Creek) more brood fish were not needed to maintain adequate levels of recruitment. Consequently, marked improvements in the number of legal trout were not realized by increasing the size limit. Within-season stockpiling of trout in the seven to 9-inch range were documented (trout that were available to be caught and released), but carryover of these trout to legal size the next fishing season was poor. Deficient winter carrying capacity for adult fish negated the long-term benefits of increased size limits. However, both experiments demonstrated that more brook fish could be saved by an increased size limit if more brood fish are needed.

After studying the effects of angling on juvenile steelhead trout in a tributary of the Snake River in Idaho, Pollard and Bjornn (1973) recommended an 8-inch size limit to protect most of these young steelhead prior to their migration to the ocean. They found that sport fishermen may be taking "as many as half of the catchable size (age II or older) juvenile steelhead" under the present no size limit provision.

Giger (1972) reported that exploitation of wild stocks of coastal cutthroat trout in Oregon was probably not excessive at present, but, "if greater protection against harvest of pre-migrant juvenile cutthroat is desired in the future, the minimum size limit should be set at 10 inches."

Appropriate use of minimum size limits was also advocated by Allen (1951) in his study of brown trout in the Horokiwi stream. "The size limit is the most important of the restrictive regulations in its effect upon the trout population, and upon the crop of fish, because it determines the point at which a year class is first cropped." The existing 11-inch limit appeared "to be fixed at almost exactly the point which is most desirable" for the lower half of the stream, but for the upper half, where growth rate was slower, a size limit of 9.5 inches "would probably be more effective."

Length of Fishing Season:

McFadden (1967) concluded that because of the close parallel between angling pressure and catch over a 19-week trout season in Wisconsin, an increase in exploitation could be expected if the season were extended. Some anglers would continue to fish and continue to catch fish.

Where the threat of excessive exploitation is not critical, year-round fishing would be a desirable management strategy providing more opportunities to enjoy high quality outdoor recreation and reducing the undesirable congestion and carnival atmosphere that often typifies "opening day" angling on popular trout waters. Extended seasons are also a reasonable approach to managing waters set aside for "catch and release" fishing or where the goal is a small harvest of trophy size trout.

In Wisconsin special trout seasons before and after the normal May to September season apply to several of the streams receiving anadromous runs of trout and salmon from Lake Superior. Creel limits and size limits are more restrictive in keeping with the larger size of these adult trout and salmon which are entering these streams for spawning. All of Wisconsin's streams trubutary to Lake Michigan, upstream to the first dam, have recently been opened to year-round fishing for salmon and trout, in recognition of the fact that these streams have little potential for natural reproduction. There is, therefore, little justification to limit the harvest of these stocks which are primarily of hatchery origin and have put on most of their growth in Lake Michigan where they were stocked.

After studying the wild brook trout fishery in Jo-Mary Pond in Maine, Andrews (1973) proposed a management plan of "alternate year angling" for this and similar spring ponds in Maine. He concluded that more and larger brook trout would be caught from these ponds if they were not fished every year.

Lure Restrictions:

Nearly all sport fishing in public waters is limited to some modification of hook and line gear. This in itself represents an often overlooked but radical limitation on the efficiency of capture as compared to the improvement which could be attained by employing electrofishing gear, toxicants or anesthetics, nets, seines, or explosives – all of which are used legally by commercial fishermen or scientists. Any further restriction on the various methods of hook and line fishing, imposed either legally or voluntarily, will further tend to reduce the total catch of trout from a body of water regardless of what methods are eliminated. This is because over the course of a fishing season, the variable conditions of weather and water make each method more efficient on some days than all other methods (Allen and Cunningham 1957). Moreover, most anglers are more proficient at one method of fishing than at several methods. If their favored method is prohibited, they must then choose to fish elsewhere or fish less proficiently.

Recently, as the number of trout fishermen has tended to increase and fishing quality has tended to decrease, two fishing restrictions are receiving increasing emphasis. One involves the concept of releasing all or nearly all of the trout caught. This type of trout fishing has been labelled "fishing for fun" by many anglers and authors, but as Stroud (1964) has convincingly demonstrated, "catch and release fishing" is a more appropriate designation because most fishing is done for recreation, not economic gain. The second concept receiving increasing emphasis is prohibition of bait fishing and the attendant high mortality it inflicts on trout that are hooked and released. However, even the high mortality rate inflicted on undersize trout hooked and released by bait fishermen could be substantially reduced if such anglers could be educated to cut their lines and release deeply hooked trout with the hooks still in them. As Mason and Hunt (1967) demonstrated, approximately two thirds of such released trout would probably survive and continue to grow.

Despite growing use of special regulations to manage select trout waters, there are few good evaluations of such fisheries. It is apparent from the studies that have been done that the effectiveness of such regulations has varied considerably. McLaren's (1971) investigation of a "no-kill" project on a portion of Spruce Creek, a wild brown trout stream in Pennsylvania, revealed some favorable results after two years: an increase in the number of age III trout, an increased catch/hour of trout released, multiple captures of individually marked trout during the season, and a few cases of captured and released trout surviving through the winter to be caught again the second season. Chrystie's (1965) semi-technical report of a similar "no-kill" experiment on a 1.9 mile stretch of the Amawalk River in New York also contained mostly favorable results. After two years of special regulations (single hook artificial lures, release of all trout), the number of brown trout in the fall had increased by 130 percent, and the number over 10 inches had increased by 482 percent, from 155 to 902. Angling pressure was also distributed more evenly throughout the fishing season, and catch/hour was greatly improved. (Note: 1974 fishing regulations indicate that some harvest is now being allowed under a creel limit of two trout/day over 10 inches.)

Restricting anglers to use of artificial lures to catch stocked rainbow trout in Parvin Lake did not prevent high exploitation (82 percent). Fly fishing proved to be an especially effective method in this shallow but cool lake. Since a high return of stocked trout was desirable, Klein considered the high proficiency of artificial lures to have given a favorable result. Prior to the experiment there was some doubt as to whether a good return would be attained if bait fishing were eliminated – either because too few anglers would fish with artificial lures or such lures would not be effective (Klein 1972).

The lower half of Lawrence Creek was designated as flies-only water for a period of seven years (1961-67), and an intensive study was carried on of both the trout population and the sport fishery by inventorying the trout population three times yearly and allowing fishing only by a compulsory permit registration system. In my summary conclusions of this study (Hunt 1970) I said, in part:

"Designation of part of Lawrence Creek for 'fly fishing only' proved to be popular among fly fishermen. They were attracted by the regulation, and they enjoyed high quality fishing for wild brook trout without abusing the trout population. However, except for the fishing methods, there was little difference in other aspects of the fisheries in the flies-only zone versus the any-lure zone, and there were no detectable responses by the trout populations that could be attributed to the presence or absence of the flies-only restriction. In both zones the amount of fishing pressure and the restrictive impact of the eight-inch size limit and bag limit of five overshadowed effects on the harvests and residual populations related to fishing methods. The only difference associated with fishing methods that may have had some impact on the fisheries in the two fishing zones was the consistently higher catch/hour by fly fishermen versus all anglers using the any-lure zone. The greater success rate in the flies-only zone may have been only a reflection of the slightly greater number of legal trout normally present there or the possible attraction of better-than-average fly fishermen to Lawrence Creek in response to the flies-only regulation."

"If such a regulation does attract expert fly fishermen, and if nearly all of them keep the legal trout they catch, as they did at Lawrence Creek, the imposition of a flies-only regulation may not, of itself, prevent over-exploitation."

Tests of fly-fishing regulation in Michigan reported by Shetter and Alexander (1962), Shetter (1969), and Latta (1973) provided results similar to mine. Simply eliminating mortality of undersize trout caught and released by bait fishermen is not the key to unlimited trout populations. Where the emphasis is on a substantial harvest, there is no biological justification to limit the harvest to anglers using artificial lures.

Where the management emphasis is to reduce the harvest to only a few trophy size trout or to allow no harvest at all, there is ample evidence that restricting anglers to artificial lures is valid, but not to just fly fishing only.

A precautionary note in interpreting the few studies of special regulations should be added, one especially applicable to the studies on Lawrence Creek in Wisconsin and Hunt Creek, Pigeon River, and Au Sable River in Michigan. Quoting Shetter (1970): "It should be pointed out that almost all of the tests involving special regulations have been conducted to date in streams or stream areas with good to excellent natural reproduction, where potential differences in hooking mortality between natural and artificial lures are masked or offset by other causes of death. There is still the possibility that in submarginal trout waters, where recruitment is limited, but growth is good, an increase in trout production might be obtained, with a combination of lure restriction and minimum size limit that permitted better survival."

REGULATIONS AND THE FUTURE FOR WILD TROUT MANAGEMENT

If future management of wild trout populations is to be more effective than it is today, fishing regulations must remain an important phase of that management effort. Until such time as most trout fishermen voluntarily drastically limit their kill of wild trout, statutory regulation of exploitation is essential.

What McFadden (1961) concluded regarding wild brook trout fisheries in Wisconsin is, I believe, broadly applicable to management of most wild trout fisheries in North America today:

"In the apparent absence of natural controls effective enough to prevent depletion of brook trout stocks by sport fisheries, it seems essential that some artificial restrictions eventually be employed to maintain an ecological balance between trout and man. Because of constantly changing conditions, either the regulations or the regulating agencies must be flexible if the equilibrium is to be an enduring one."

More research, factfinding, and testing is needed (and probably always will be), but much present knowledge is not being widely or always wisely applied. This is especially true in the management aspects of trout habitat improvement and somewhat less so in the application of fishing regulations. But as my survey of 1974 state and province regulations showed, there is universal use of creel limits, despite their low biological value, and sparse use of size limits, despite their much greater biological value if properly chosen.

Increased emphasis is also needed on innovative experiments to test new management approaches to dealing with wild trout fisheries. Trout streams dependent on repeated stocking of domestic trout seem to be receiving proportionately more management attention than do those that sustain wild trout populations. Especially inadequate is our knowledge of existing exploitation rates of wild trout and the allowable rates these populations can sustain year after year.

I believe a better management job can be done now to maintain and enhance our wild trout fisheries. Hopefully, as a result of this Symposium, a better job will be done soon if we and others concerned about the future of our wild trout resources resolve to be more vociferous and persuasive in the future than we have been in the past.

REFERENCES CITED

Allen, K. R. 1951. The Horokiwi Stream. A study of a trout population. New Zealand Marine Dept., Fish. Bull. 10, 238 p.

Allen, K. R. and B. T. Cunningham. 1957. New Zealand angling. 1947-52. Results of the dairy scheme. New Zealand Marine Dept. Fish. Bull. No. 12, 153 p.

Anderson, J. K. 1974. Wild management creates quality angling, restores Yellowstone cutthroat. Action Line Vol. 4(5): p. 4.

Andrews, P. S. 1973. Trout pond management investigations. Maine Dept. Inland Fish & Game. Federal Aid Final Report. Proj. No. F-16-R., Job No. A-1, 31 p.

Chrystie, E. L. 1965. Experiment in fun. The New York Conservationist. Vol. 19(6): 2-4.

Falk, M. R., D. V. Gillman, and L. W. Dahlke. 1973. The 1972 sport fisheries of Great Bear and Great Slave Lakes, Northwest Territories. Tech. Rept. Series No. CEN/T-73-8. Dept. of the Environment. Fisheries and Marine Serv., 100 p.

Giger, R. A. 1972. Ecology and management of coastal cutthroat trout in Oregon. Oregon State Game Comm. Final Rept., Proj. F-72-R., 61 p.

Graynoth, E. and W. Skrzynski. 1974. The Nelson trout fishery. New Zealand Ministry of Agric. and Fish., Fish Tech. Report No. 119, 35 p.

Hunt, R. L. 1970. A compendium of research on angling regulations for brook trout conducted at Lawrence Creek, Wisconsin. Wis. Dept. of Nat. Resources, Research Report 54, 37 p.

Hunt, R. L., O. M. Brynildson, and J. T. McFadden. 1962. Effects of angling regulations on a wild brook trout fishery. Tech. Bull. No. 26. Wis. Conserv. Dept., Madison, Wis., 58 p.

Klein, W. D. 1972. Influence of special regulations and stocking on fishermen and the trout population at Parvin Lake, Colorado. Colorado Dept. of Nat. Resources. Tech. Pub. No. 29, 22 p.

Latta, W. C. 1973. The effects of a flies-only fishing regulation upon trout in the Pigeon River, Otsego County, Michigan. Michigan Dept. of Nat. Resources. Fish Research Report No. 1807, 28 p.

Mason, J. W. and R. L. Hunt. 1967. Mortality rates of deeply hooked rainbow trout. The Prog. Fish. Cult., 29(1), 87-91.
McFadden, J. T. 1961. A population study of the brook trout, *Salvelinus fontinalis*. Wildl. Monog. No. 7, 73 p.
McLaren, J. B. 1971. The Spruce Creek catch and release study revisited. Trout magazine 12(3): 15-16, 38, 40.
Pollard, H. A. and T. C. Bjornn. 1973. The effects of angling and hatchery trout on the abundance of juvenile steelhead trout. Trans. Amer. Fish. Soc. 102(4): 745-752.
Ricker, W. E. 1945. A method of estimating minimum size limits for obtaining maximum yield. Copeia (2): 84-94.
Seamans, R. G., Jr. 1959. Trout stream management investigations of the Saco River watershed. New Hampshire Fish and Game Dept., Survey Report No. 9, 71 p.
Shetter, D. S. 1969. The effects of certain angling regulations on stream trout populations. In Symposium on salmon and trout in streams. T. G. Northcote ed., The Univ. of British Columbia, p. 333-353.
Shetter, D. S. and G. R. Alexander. 1962. Effects of a flies-only restriction on angling and on fall trout populations in Hunt Creek, Montmorency County, Michigan. Trans. Amer. Fish. Soc. 91(3): 295-302.
Spence, L. 1971. Rock Creek creel census. Montana Fish and Game Dept., Federal Aid Final Report. Proj. No. F-27-R., 28 p.
Stroud, R. H. 1964. Most fishing is for fun – what else? Sport Fishing Institute Bull. No. 150:1.

WILD TROUT—THE POLITICAL AREA

By Ralph W. Abele

Pennsylvania Fish Commission

I am the Executive Director of the Pennsylvania Fish Commission, an independent administrative agency 107 years old, which employs 423 men and women. Basically, we are broken into three Bureaus; the smallest of which (about eight percent) is the Bureau of Administrative Services; 20 percent in the Bureau of Waterways, which covers both marine services and law enforcement; and the balance in the Bureau of Fisheries and Engineering. Engineering, construction, and maintenance take up about 56 people, so you can see by simple arithmetic that the bulk of our employees are in the Division of Fisheries. By and large, most of those employees are in cold and warmwater propagation sections, and they operate our 12 hatcheries, eight of which are devoted entirely to trout. The year 1974 saw 4.3 million catchable size (9.8 inch) trout stocked in 904 streams and 87 lakes, and that's about 5,000 miles of streams or 10 percent of the total stream mileage in the Commonwealth. The warmwater production, mostly fry and fingerlings, totaled 39 million, most of which were walleyes, followed by esocids, channel catfish and panfish, etc. In addition to a research staff, we also have a management section for both lakes and streams which we have doubled in size since 1972, and now have 12 aquatic biologists backed by a new class of employee called "Fisheries Technician". We operate on a budget of approximately $8 million per year, about one sixth of which involves boating activities.

I thought best to give you that background before launching into a nebulous subject, such as the title of the paper.

Certainly, some definitions would be in order, and I find just by perusing the mail from another panel member that the very definition of wild trout itself is subject to argument. Our answers to the queries from that panel member were that we do not consider the following as wild trout: hatchery hatched fry and planted as fry, fingerling trout planted in streams, combinations of fry and fingerling plants in streams. While we believe that these other categories do produce a catchable size fish that is for all intents "wild," our definition would indicate that wild trout are: (a) trout spawned and reared naturally in streams, (b) indigenous trout species reproduced naturally in stream stiuations. We have for the last seven years been managing about five percent of the Commonwealth's trout streams for "wild trout" in response to increasing demands from certain segments of the public over the last 10 years. We have established 73 "wilderness trout streams" throughout the Commonwealth, and are presently in the process of trying to insure proper land use policies in the watersheds within which these streams flow to ensure their perpetuity. I have brought with me a supply of our current description of the wilderness trout stream program in Pennsylvania for your background information, and I will not dwell on the program's details any further.

Perhaps another necessary definition would be what you consider – since I am giving the paper, what I consider – "the political area." I do not think that you wish to hear the details of attempted interferences by individuals in the General Assembly of Pennsylvania into personnel management, law enforcement, union negotiations, the general operations of the Commission, our stocking formulas, etc. I presume that you mean, really, the persuasions by classic politicians, the red-neck sportsmen, the worm fishermen, and the purists on the attempted implementation by a responsible independent government agency of a viable program, such as wild trout management.

To speak of the political area of wild trout is rather difficult. Certainly wild trout have a certain public image to which lip service is paid in the era when "environment" is in vogue – they're in the category of patriotism and puppy dogs; no decent American will speak out against them. Perhaps the problem or the subject is better defined in terms of the politics of stocked trout. Social or political pressures are not exerted against wild trout; they are exerted for stocked trout. The dissent and appeal to elected officials begins when managing as a wild trout fishery means the curtailment of a traditional stocking program.

If we are to establish management for wild trout as a viable and growing program in the populous Northeast, it requires more than establishing through biological survey that sufficient poundage per acre exists to meet some arbitrary criteria. Unless we can convince the public and those who represent them that a specific change in management practices works for their benefit, all the technical data in the world is of no use; the administrator who does not use social wisdom and political acumen may not be around long enough to know who was right.

Implementation of recommendations to manage a fishery for wild trout often does not proceed as quickly and completely as the technical staff or special interest groups (those in attendance at this meeting) might prefer. The administrator has an obligation to conduct a broad program, of which wild trout is an important part, but only a part. Judicious selection must be made as to when to fight and when to compromise. It is inexcusable for an administrator to move in the wrong direction in the face of proven facts – but one has to carefully base decisions on fact and public acceptance. The delayed victory is better than immediate defeat.

The fact that the management of our public fisheries does fall into the realm of a governmental function, and as such is subjected to some political pressures, frustrates many technicians, idealists, and academics who feel everything can be done overnight. No doubt the actions of fisheries administrators responding to public pressures have antagonized many of those who advocate sweeping changes to favor wild trout.

The politics, if that is the correct term, clearly come into play at the administrative rather than the technical level of wild trout management. Fishery biologists may have impressive technical expertise; unfortunately, this expertise is not always matched by social wisdom. Often the technician makes the assumption that the general public or their elected representatives will, when presented with study or survey results, make an unbiased judgment in favor of management for wild trout fishing.

All areas of trout management, social or biological, are not black or white. Contrary to inferences one may gather when talking to a special interest group or biologists sympathetic to a certain viewpoint, there are gray areas. The excuse that stocking can be justified because "that's what the people want and it isn't hurting anything" has been labeled invalid by some fishery scientists, and they have promulgated data to support the theory that stocking does hurt. Sometimes, I believe, we all seek data to sustain our own biases, but there are hazards in applying specific results as representing the general case. It is these embarrassing exceptions that constitute the gray area and result in "politics" in trout management.

Perhaps an illustration of what would be, in my judgment, a gray area will serve to better convey the political realities encountered. In Pennsylvania we have some fine trout streams which have good populations of wild trout. Some of these streams are also stocked with catchable size hatchery trout. At the end of our trout season there is little or no doubt that the overwhelming majority, virtually all, of the trout in these streams are of wild origin. The hatchery trout have, for the most part, disappeared. Certainly much of this disappearance might be attributed to angling, but not all – many are lost to undetermined causes, perhaps competition. However, technically correct it might be to say such streams need no stocking, it is difficult to sustain the argument that catchable trout stockings are damaging them.

It places the administrator and frequently the technician in an untenable position to terminate stocking because it damages wild populations – the streams are teeming with wild trout which obviously survived any problems the introduction of hatchery fish posed. The technician's perception is that such a demonstration of a substantial population of wild trout at the close of a rather long angling season should provide strong evidence to pressure groups or their representative that stocking is not needed. The pressure groups' perception will be, "Well then, what does stocking hurt?" There is no way to respond. This is the gray area, and decisions have to be made on the basis of political and social realities rather than technical niceties. When encountering traditional values and without a preponderance of specific evidence to counter these values, the administrator has no feasible alternative to seeking compromise.

The political aspects of such seemingly nonpolitical activities as managing trout are often quite surprising to the uninitiated. The university researcher or the staff biologist is isolated or at least insulated from political pressure by their positions and really do not fully appreciate the sorts of pressures which can be brought to bear over a relatively few stocked trout. A public service agency is regarded as just that, and, when people do not feel they are receiving the service they want, one avenue of appeal is through the elected official. Pressures exerted come in all varieties, but one theme comes through loud and clear: "This is what my constituents want; they're the customer; why not give them what they want?" It is like being nibbled to death by ducks; if only a single confrontation had to be dealt with, it would be easy, but the confrontations are numerous and virtually continuous.

In managing for wild trout one encounters conflicts with resource users who have different desires. We, as the managing agency, try to manipulate use patterns to protect the resource and provide recreation. Under the duress produced by selecting against hatchery trout one has to decide: "At what point is the value accruing to management for wild trout not worth the battle in terms of staff energy and vitality (a psychological cost), the cost of time away from other tasks for administrators and technical staff to defend a change in management, the loss of fishing opportunity for those who do not fish for wild trout, and finally in animosity from individuals who may be in a position to influence legislation or policies of far greater impact to both the agency and the resource?" We can be wiped out by a single bill in the General Assembly, and our Executive Authorization Budget can be delayed.

I might add that not all who oppose management for wild trout only are uninformed meat fishermen. Consider if you will the most recent threat by one of our stockholders to file a class action suit against the Fish Commission for discrimination in setting aside fly-fishing-only areas. We have such projects on 35 streams (87 miles), and yet we have such threats via litigation, or outright fishing in one of these special regulated areas, getting arrested and charging us with discrimination. On the other side of the coin, there are campaigns by people whom you may consider to be legendary in their writings, who advocate the trout refuge system and who consider that until such time as the percentage of fly fishing water for trout equals the percentage of fly fishermen for trout, discrimination is against the fly fisherman. The wild trout enthusiast feels that those who oppose him or his interests on an individual project lack an interest in or an awareness of research and informed management of the resource. Sometimes this is true, but it is a dangerous generalization. Labeling and characterization of those who oppose projects designed to promote wild trout as uninformed simply leads to mutual distrust between those holding differing views. Some of those, including elected officials, who support a program of stocking in a particular situation, are quite well informed and soon realize whether or not the agency can logically and totally support wild trout management as the best approach.

If the situation is not clearly defined, if it is one of those gray areas, the elected officials will respond to the public needs as they perceive them and try to provide the greatest amount of acceptable recreation consistent with not damaging the resource. This means the agency must use discretion and judgment in moving into projects where there is a likelihood of public opposition. We have to avoid the appearance of being complete purists or of carrying the flag into the wrong battle.

The only realistic approach to wild trout management and the political area, at least in the Northeast, is to phase wild trout management in slowly and carefully. I think we must establish its validity and legitimacy as a part of the fisheries program by developing good projects which win public support. Don't fight every battle as if it were the end of the world. Shocking as it may seem to the idealist, each decision on how to stock or not stock a given trout stream, each decision on whether or not to impose special regulations on a given trout stream – things considered important in wild trout management – is not the ultimate battle between good and evil. It is, and has to be, to the administrator an objectively considered action in a much greater overall program. It is unavoidable that consideration of public and, there, "political" acceptance is an important part of each such decision. Our real number one priority in activities is acting as the really conscientious surveillance agency in fighting pollution. All other activities are worthless if that fails.

Building public acceptance through good projects will result in political support for wild trout management. Some of the secondary meanings of the word "politic" are "characterized by shrewdness," "sagacious in promoting a policy." It is this sagacity and shrewdness that I am advocating; pick the confrontation or projects carefully, and then stand firm. Do not try for sweeping changes overnight – don't tilt with windmills. Politics is developed on the conflicts between competing interest groups. You have to demonstrate why wild trout deserve consideration over those competing interests, no matter what they might be. Strong public acceptance and outstanding examples in our own jurisdiction are the surest way of establishing the management of wild trout as a high priority for all government resource management agencies. To lose credibility fighting such an insignificant skirmish may mean the loss of the whole war.

AMNESTY FOR YOUR RIVER—BASIC CONSIDERATIONS

By Joseph P. Congleton

Attorney, Knoxville, Tennessee

Assume that you have a great trout stream. When you ask any trout fisherman to make such an assumption, his memory and imagination will conjure up bits and pieces of many streams he has fished. Put all those together with a few improvements he would prefer, and the image will be that of the "perfect" stream. But probably none of us has fished a stream which we would accept as the ideal stream in every respect. The fisherman and the biologist could always think of improvements that could make any stream a better one. Some streams would be better if chemical or thermal pollution were alleviated; others would be improved for the fishing public if more access was provided; the possible improvement list could go on and on. We are always full of ideas about improvements, innovations, protective devices, and other means by which a favorite stream could be moved a little closer to the ideal stream. We utilize the experience of others in improving streams.

Consider the ultimate issue for the ideal stream or any other trout stream: Whether or not that stream will continue to exist. This question stymies our otherwise fruitful imagination, but it is the most basic issue which faces the trout fishermen or scientists in the field of cold water fisheries. On this question, our innovations and ideas have not obtained the successful results that we have in areas such as stream improvement. When faced with the prospects of, for example, a dam which will inundate a great stream or perhaps reduce the flow to a mere dribble, the fisherman and the scientist have not been able to achieve the results that they were able to achieve on a relatively less significant issue, such as elimination of a rough fish population from a cold water fishery. Part of the reasons for our shortcomings results from a failure to make good use of the experience of others who have fought this kind of fight before.

Make no mistake about it, when you are faced with the prospects of losing a great river or stream, and you decide to seek amnesty for the stream you are faced with a monumental task; and anyone undertaking such a job should realize that from the outset. First of all, consider the opposition. Although the physiological effect to our side may not be helpful, let's call the opposition the "Giant". The Giant has many cousins around the country, well known to all of us, and a listing of the family tree is not necessary. When it happens that one of the Giants decides our ideal cold water fishery or the closest thing to it must be sacrificed for the public good, our immediate reaction is often to proclaim that both the Giant and his project are illegitimate.

The Giant has taken a lot of streams over the years. He has the time and financial backing to stay in a fight for a long time. Undoubtedly some of these losses could have been avoided had those who are opposing the death of the river had the benefit of another's experience who had previously fought for the life of a river. One would think that after a river had been spared by the efforts of interested individuals, others would copy the successful game plan in their efforts to gain amnesty for other rivers around the country. The benefits to be gained from past experiences of one who has fought this kind of fight before should be of inestimable value to those who decide that the objects and purposes stated by the Giant for disposing of a river are not worth the sacrifice of the stream. Likewise, the mistakes of those who were not successful in defending a river should be discussed and avoided. But there has not been significant communication of the experiences of the successful and the unsuccessful to those who are or may be entering the fray for the first time. Some would say this has occurred because each river fight is unique. I would agree that each fight is unique, but would urge that it is not so unique that we should disregard all that has gone before in other areas in mapping our own strategy.

It is the purpose of this article to outline basic considerations for developing a strategy to defend your river if the need ever arises. These suggestions are derived from the experience of working to prevent the Tennessee Valley Authority from inundating the last stretches of the Little Tennessee River with the Tellico Dam Project. Hopefully, our experience will help you gain amnesty for your stream. The Little Tennessee has probably been lost, but our experience in defending it should not likewise be lost.

Once you learn of the plans to dispose of your river, it is essential that an objective evaluation be made concerning the environmental impacts of this project. The environmental impact statements which some of the Giants are required to issue concerning a proposed project should, in the ideal, adequately describe *all* the environmental impacts which a project will have. However, sometimes the Giant does not do the objective job it should in preparing such impact statements. There is often much room for clarification, expansion, and correction of the supposedly scientific data which the impact statements contain. Do not forget that many of the environmental impact statements are prepared and written by attorneys for the Giant based upon information supplied by scientists. Attorneys are advocates, and they are trained to use facts and statements to obtain a desired end. As a result, some impact statements lose their objectivity in the mill. The best way to obtain reliable scientific data on the overall effects of the project is to obtain the expertise of persons who are disinterested in the project of the Giant and have those persons make an objective evaluation of the environmental impacts of the project. It is essential that these alternatives of evaluations of the environmental impacts be entirely objective and scientifically derived. If those who are interested in obtaining facts about a project allow their findings to be biased and undertake their studies in a manner that will derive the results thay they may think they want to obtain, then the group which is opposing a project may, in the belief that they are doing something to benefit the river, actually be harming it and therefore their own self interest. It just may be that a project which appears on first blush to be one which will eradicate a fishery resource may be one which will have no effect upon or possibly even benefit the trout stream. It is essential that facts relating to a project be derived by the scientific method.

Environmental impact statements are not required for every project that a giant may undertake. And in those cases where the data supporting environmental impact statements is not available to be compared with independently derived data concerning the impacts of a project, then it is likely that the individually derived data will be the most conclusive scientific evidence concerning the effects of the project. The weight given independent data by the public will probably vary according to the individual's view of the value and position of environmental groups. The objectivity of the data is key because if discrepancies can be shown within the data or the results can be shown to have been biased from the method of research then the Giant can use resulting publicity to discredit your opposition. But, if your data is valid and demonstrates a lack of objectivity on the part of the Giant, it can be used to devastate the appeal of the project.

At the same time that this data is being assembled, it is essential that those interested in protecting the trout resource should have meaningful contacts with those organs of the Giant working for the project. Voice your concern about the project's effects on the trout resource to the Giant before you voice it to the newspapers. It may be that a compromised situation could be obtained and a full-fledged battle over the river could be avoided. For example, TVA proposed a dam height for Tellico which would inundate nearly all of the prime trout water on the river. A dam of less height, a low water dam, would have left half of the 33 miles of the river in a stream setting while still providing the factors which TVA cited as the economic impetus for the project. But the low water dam concept was not pushed hard enough or soon enough. It would have been a good compromise for both sides. Don't hesitate to fully explore alternatives or compromises. A good faith effort by your group to work out a viable alternative to the project or a compromise which would pose less threat to the resource might be achieved.

When you have the opportunity to meet with the Giant, it is essential that these sessions do not turn into shouting matches. Remember that the Giant thinks his project will be of great benefit to the public. You are generally going to be regarded as a special interest group which is trying to protect its interest at the expense of the public's good. Calm discussions based on fact will achieve far greater results than emotion.

When TVA began working in earnest on plans for Tellico Dam in 1964, Chairman of the TVA, Aubrey Wagner, met to discuss the proposed dam with parties who would be affected by it. The discussion turned into an emotional shouting match; some feel that the result of the meeting was that Wagner became determined to build Tellico no matter what the opposition.

In the early stage it is also essential that efforts be made to coordinate your individual efforts and your group's efforts with others who are concerned about the results of a proposed project. This coordination cannot be done soon enough. As soon as the project is announced and groups begin taking a serious look at the results which the project is likely to bring, they should make a conscious effort to seek out other groups who may have concerns about adverse results. Make attempts to coordinate the scientific fact finding efforts. At the same time, you will be establishing a framework which will be a workable format for carrying the battle to a larger stage should initial attempts at stopping the project not be successful.

Coordination efforts should include all groups which are concerned with possible resulting harm from the proposed project; they should not be limited to environmental groups, and the environmental groups should not be off in a group by themselves. It is important to include groups which may suffer adverse economic repercussions from the project. For example, in the Tellico controversy the farmers' groups in Monroe and Loudon Counties and Blount Counties were raising questions about the dam in their area with no effective coordination with the environmental groups who were opposed to the project.

It is very important at this stage that prominent local individuals be brought onto the scene. If you have individuals with political clout which are on your side, they should be pushed to the forefront of the coordinating efforts.

At an early stage of reviewing a project your group's leaders should inform the local political leaders that you have questions concerning the project and that, while they have not yet completed their investigation of the overall impact of the project, they would like to let the political leaders know that they are extremely concerned about the possible adverse consequences of the project. The political leaders will then be put on notice that a significant group of their constituents are concerned with the project. Otherwise, your group may later hear what we heard in Tennessee: "We didn't know there was so much opposition to the project until we had made such a large investment that we could not afford to halt the project."

Once the framework of coordination has been established and initial contact with the Giant and political leaders has been established, full attention must turn to obtaining the proper scientific data for determining the total impact of the project.

Now let's assume that the data, economic and scientific, which has been derived concerning the project shows that the project is either an economic disaster or an environmental disaster, or both. At this point, the coordinating framework of all groups which are opposed to the project must make some very serious decisions. It must determine what alternatives are available for further opposition to the project and the feasibility of implementing the various alternatives. In these situations the groups must always remember that the Giant has a deeper financial pocket than most of the groups do and that they have the staying power to carry a fight for a long time. At this point the groups' interest in protecting the resource must be balanced with financial prerequisites required for backing a successful campaign in opposition to the project. Often times this financial requisite is overlooked and can cause serious problems for groups at critical times in the campaign.

It is crucial that the availability of legal remedies to the group be fully examined. It is essential, however, that the analysis of legal remedies include an accurate description of what the ultimate result of a successful court ruling would be in relation to the ultimate question of whether the project could be implemented or built. For example, many groups have found out too late that demonstrating the inadequacy of an environmental impact statement in Federal Court is not going to ultimately save the river. Environmental impact statements are designed to accurately describe what effects on the environment a proposed project will bring about. If an environmental impact statement says that a project will have the effect of destroying all life in a river, or turn the stream into a sewer, or generally cause environmental havoc, it does not necessarily follow that the courts have the power or will exercise power to stop a project under current environmental law. An environmental impact statement is designed to describe what the impacts will be; the decision as to whether the project is worth the environmental results it will create is a political decision. Philosophically, there are strong arguments to support the proposition that the courts should not have the power to decide whether a project will be ultimately built. It should be a political decision; and the courts have construed the environmental law in this country in such a manner that the decision on the construction of a project will generally be a legislative decision. Many people do not realize this to be the case.

When the lawsuit based on compliance with the adequate disclosure requirements for environmental impact statements was filed on the Tellico Project in early 1970, many people stopped their private efforts in opposition to the dam because they believed that the court would decide whether or not the project would be built. This was clearly not the case. The decision to file the suit was based partially on a desire to give political opposition to the project an opportunity to congeal and stop the project or obtain an alternative compromise in the meantime. However, many interested in opposing the dam did not apply the political pressure at that time. There was a lack of coordination. Opponents to the project unfortunately had the impression that the entire matter was in the hands of the courts. However, environmental law had only developed to the point that the courts could only decide whether the effects of building the project were adequately described. So what happened in the Tellico controversy was that the people relaxed the political fight, and public interest over the project waned because the issue was not kept before the public. This could have been the crushing blow to those who opposed the project, and it could have been very easily avoided if the groups which were involved made it clear to their members that the lawsuit was not going to ultimately decide the fate of the river, but was merely a delaying tactic.

When the legal and political remedies available to oppose the dam have been explored and the availability and costs of each reasonably ascertained, then the groups must as a whole decide which plan of action will offer the best results.

In deciding what political plan of action should be implemented, the groups must determine what political groups or individual officials will be able to do them the most good in this fight. The political ear which is most easily accessible and which may have sympathy with your position may not be the one to help you significantly in your efforts. The distinctions between local, state, and federal governments are frequently overlooked. When it comes to asking an official to oppose a project which is not in his domain, he will quickly tell you that he has no control over it if he doesn't want to get involved. This same attitude is most prevalent in various agencies of the state, local, and federal governments. Rather than wasting a lot of time going to people in state government who have no control over federal agencies and vice versa, find out who has ultimate control over the project and concentrate on that source first. Push state officials the hardest on state related projects and give the **proper** federal officials primary emphasis in matters concerning federal projects. Of course, there are many interrelationships between state, local and federal officials through party lines and organizations, but you usually will not obtain significant results unless you concentrate on the proper agency.

Applying pressure to the wrong agency can backfire; it may make the agency whose project you are opposing even more adamant in its position, if it feels that some other agency is trying to tell it how to run its affairs.

A primary example of this occurred in the Tellico controversy when Governor Winfield Dunn of Tennessee came out very strongly against Tellico Dam and urged the Tennessee Valley Authority, an organ of the Federal Government, to abandon the project. However, TVA was not subject to Governor Dunn's funding power or other means of control and chose to ignore Dunn's pleas. Likewise, Justice William Douglas of the Supreme Court wrote an article opposing the Tellico project in a national magazine and was very outspoken in his opposition to the project, but he was not in a position to exert the kind of political influence on the project which could stop the dam. Secretary of the Interior Udall's questions about the project also went unanswered. Apply pressure where it will count, seeing the right officials first. Then don't hesitate to go to others if you don't get results; but do go to the right one first. The persons who could have stopped the Tellico Project and the persons on whom the political power should have been concentrated in that Project were the United States Senators and Representatives from the districts affected.

Politicians know who "butters their bread." You can't expect to win the support of the politician if your group or significant individuals in your group have been active or prominent in elective campaigns of individuals who were opposed to the persons now holding the offices of Senator or Congressman, for example. After Senator Howard Baker refused to take a stand against the Tellico Project, but actually came out in favor ot it, billboard slogans appeared on raods near the river which stated "Defeat Howard Baker and Save the Little T." Obviously, from that point forward, Senator Baker was not going to lend an attentive ear to those who were opposed to the dam.

As Jack Raven of the Environmental Protection Agency stated in the Keynote Address to the Trout Unlimited National Convention in Atlanta in 1973, you can't go to a politician and expect him to have an attentive ear to your wants and needs if you haven't been active in helping him in his political campaigns. In other words, if you are going to try to achieve political results, you have to make some political investments. This was one of the factors which hurt significantly in the Tellico Project because many people who had no previous political experience suddenly found themselves in a position where they were asking the United States Senator to help them. A good way to avoid this kind of problem in the future is for members of groups to take an active role in political campaigns and assume a responsible position in the elective decision making process.

The phrase "at an early stage" has appeared with regularity in this article for very good reason. If you are going to successfully defend your river, you must begin your campaign when you have the first hint that a project is forthcoming. There was not adequate coordination among groups opposing the Tellico Project in the period prior to actual construction of the dam. If you can establish strong coordinated opposition to a project while it is still on the drawing boards, you will immensely increase your chances for successfully halting a project or reaching an acceptable compromise.

Each river fight is unique in that you cannot flatly say "do the scientific research before you explore the legal remedies" or "meet with the Giant before you go to the politicians." These are decisions you have to make after fully evaluating the available approaches. The important thing is to consider the alternatives.

And the basis for evaluating your approaches and remedies is a sound organization with good communication among its member groups. It was the lack of such an organization which cost the Tellico opposition dearly. The efforts of Trout Unlimited, Association for the Preservation of the

Little T, Environmental Defense Fund, and other groups opposed to the project were not well coordinated. Groups involved in such efforts should develop a "tribal council" of sorts for complete coordination: one person should oversee the whole operation. Establishing a workable communications and coordination format is the primary prerequisite to success in this area. Through it you can more adequately consider your remedies and establish your priorities.

The communications problem is the most serious obstacle to a successful river fight. If you can build a coalition of interested groups which will communicate fully, coordinate efforts and get started soon enough, you can get the results you want and the river deserves. We didn't do these things as well as we should have in opposition to the Tellico Project, and we've probably lost a great river. But don't let our experience be wasted. Learn from it.

WILD TROUT AND THE AMERICAN ANGLER

By Gardner L. Grant

White Plains, New York

I'm the last speaker. Usually the best is saved for the last, but I'm afraid someone missed the evening rise here. Nevertheless, it has been written "The last shall be first," and as a representative of the American trout angler, that is as it should be. The trout angler must come first in our deliberations. He is the object of our exercise, and he will be the ultimate judge of our efforts. Will he know and appreciate what we have done here? To answer that, we must ask ourselves three basic questions, and in dealing with these I think we'll derive a conclusion.

1. What do most American trout fishermen want from their fishing experience now?
2. What is the current state of angler awareness with respect to wild trout?
3. What will American trout anglers look for in the future?

The first question is easy to answer, and we had all better keep that most simple and never changing answer clearly in mind. The trout fisherman, firstly, wants the same thing that all fishermen want – he wants to catch fish! When I was in college, our football coach, Hermann Hickman, used to say about keeping a coaching job, "You've got to do well enough to keep the alumni sullen but not rebellious." Well, the fishery manager, administrator, and researcher must somehow blend their efforts to provide enough trout where enough fishermen, regardless of method or skill, can catch enough of them to fulfill this football analogy.

Fishermen aren't known for agreeing with each other on many subjects. Trout fishermen, in particular, seem to avoid consensus like the fishery biologist would like to avoid Columnaris. In trying to speak fro them, we have to break down the whole into major segments of opinion.

Education, affluence and its corollary increased leisure time, have helped to create a growing body of more sophisticated trout anglers. Twenty-five years ago *Fly Fisherman* magazine would not have found the market to justify its publication. What does this segment of the trouting public want? It wants to catch fish, surely, but most times would prefer to release the catch. Undoubtedly, there is growing awareness that as Lee Wulff so well puts it: "A trout is too valuable to be caught only once." This segment emphasizes knowledge of habitat, entomology, and of the ecosystem which supports the fishery, a fishing methodology based on that knowledge and on the desire to release trout unharmed. This segment has been active and vocal in demanding of fisheries administrators and managers that more waters be set aside for special regulation fishing, which will require and permit all or most trout to be released unharmed.

While this approach is gaining favor, we must recognize the counter pressure now exerted by inflation, especially in food prices. This can't help but urge many trout anglers to catch and kill their limit when possible. The importance of this factor is hard to determine, but I would hazard an opinion that emphasis on trout for food will be a short term proposition whereas emphasis on trout for sport –the sport of catching, not necessarily killing – will be a continuing trend.

Strangely enough, those fishermen who live in trout country are often those who most strongly oppose regulations designed to support and protect the resource. It seems there is a body of opinion that those who live in such areas should have the same freedom in fishing that their forebearers enjoyed in earlier times. Often, those from centers of population who travel to trout country are the strongest advocates of regulation for sound biological reasons. Here the manager and administrator must employ Solomonic wisdom. He must get the help of the native human population if an adjacent native trout population is to survive.

American trout fishermen want clean water and clean unspoiled shorelines for their own sake as well as for their importance to the fishery. Many fish for trout rather than for other species simply because they like to be where trout live. Curt Gowdy often speaks of "the spiritual quality of the out-of-doors," and it is this which trout anglers also seek from their fishing experience, many without consciously realizing it. The manager and administrator would be wise to provide for the aesthetics as well as the quarry.

On another but related tack, I think too many anglers continue to prefer trout fishing to the virtual exclusion of other fishing opportunities. As a kid who received his fishing education in Maine, I could never fathom the overwhelming opinion of the "natives" that all fish, including some of the best bass anywhere, were "trash" unless they were trout and salmon. This is a throwback to an earlier time when there were more trout and more places to fish for them relative to the human population. Fishery managers and administrators, in my judgment, have done a disservice in some areas by failing to highlight the advantages of fishing for other species and in failing to encourage the allocation of funds to support this. One of the best ways to help the trout is to take some of the fishing pressure off of him.

What about angler awareness with respect to wild trout? Most trout fishermen can't tell a wild fish from a hatchery product when laid side by side. Many don't care about a trout's genealogy or even his combative qualities just as long as they catch fish. There is a significant number of anglers who not only delight in "wild trout" but also in that species, and if possible, that strain, which is indigenous to a particular body of water. There is a strong emotional appeal in this which cannot be overlooked.

However, a greater and ever increasing number of anglers are demanding quality rather than quantity and are telling us they prefer to angle for fewer fish, perhaps, but certainly for larger, better fighting trout which seek natural foods rather than a handful of pellets. Nowhere is this better demonstrated than on the special regulation, catch and release sections of New York's Willowemoc and Beaverkill.

Carl Parker, Chief, Bureau of Fisheries, New York State Department of Environmental Conservation, said of these famous trout streams: "With over 35 miles of excellent trout water open to the public, day after day, most of the fishermen can be found concentrated on the 6.9 miles of special regulation catch and release water. Apparently, they are willing to give up solitude and accept crowded pools to be assured of high quality fishing."

I don't think it makes much difference to these New York anglers whether the fish in these special sections are native stream bred products or are hatchery hold-overs, in the stream long enough to acquire those characteristics which make them indistinguishable from the wild product so far as the angler is concerned. What they cherish is what we can term "quality fishing," and I think they reflect in this the sentiment of a growing body of trout anglers across the nation.

Many favor "wild trout" over their hatchery cousin because they usually taste so much better. We can't argue with that, but this does pose a problem. Wild trout are a prime tool in providing quality fishing (especially when supported by special kill-limiting regulations), and their food value makes it especially hard for many to "limit their kill, not kill their limit." On this score, I would like to invite the research people here to visit the New York-Pennsylvania border and study the upper Delaware River, where our trout are all stream bred, grow big, fight like hell, but taste God-awful. The secret to this phenomenon may give us a real breakthrough in trout management.

In summary, aside from the gastronomical factor, I think there is substantial and increasing awareness of wild trout as they relate to quality fishing, and I think the emphasis is and should be on quality fishing, not on the background of the trout that provides it. Those who advocate quality fishing would surely favor the establishment and maintenance of a wild trout fishery where it can do the job. Common sense economics support this. They would also favor hatchery support where natural reproduction or other factors do not permit a completely wild trout fishery to provide quality fishing.

What will American trout anglers look for in the future? My crystal ball is too cloudy to read unless I make these assumptions: that the current recession will be short-term, that relative food costs will return to more traditional levels, that the American standard of living will remain high and will resume its gradual rise with corresponding increase in leisure time and general educational level, that our population will continue to level off.

With these assumptions, there will be no return to colonial times when the fish of the streams were a vital part of the food supply. Obviously, stocking trout primarily as a food supply has to be one of the least economical ways to furnish protein. Economics make it increasingly clear that trout fishing can only be regarded by all its adherents as a sport and not as food supply, and that sport will be increasingly defined as the catching and not the killing of trout.

The future balance will swing from quantity to quality, but the rate at which this balance shifts will largely depend upon the leadership provided by many of you attending this Symposium. What will the fisherman look for in the future? Well, what are you going to educate him to look for? As managers, administrators, biologists, you must always listen and be responsive to your angling constituents, but I think you also have an obligation to yourselves and to the public to educate and to lead. If, for example, your studies show that funds should be diverted from hatchery operations to habitat improvement on natural reproduction trout streams, then as professionals you must make your position known, propose it, explain it, and defend it against the political pressure of those whom you have thus far failed to educate. Too often, I've seen changes based upon valid research and good economic judgment occur not at the urging of fisheries administrators, but rather in response to enlightened angler pressure. Personally, I look forward to more guidance and leadership from the professionals, and most important, to a concerted educational program directed at trout anglers of all ages, showing that trout fishing can only be maintained as a sport, and that sport is the catching of trout, with killing regulated to foster the best quality angling a given body of water is capable of supporting.

SPECIAL SESSIONS

SOME THOUGHTS ON THE EFFECTS OF STOCKING HATCHERY TROUT ON WILD TROUT POPULATIONS

By Robert L. Butler

Pennsylvania Cooperative Fishery Research Unit, University Park, Pennsylvania

It is perhaps strange to begin a technical paper with a quotation from the *Bible.* However, a reference to the above subject in the Old Testament seems apropos. The importance of space and spacing in man was recognized by Isaiah 5:8 as noted by the warning, "Woe unto them that join house to house that lay field to field til there is no place where one can be alone in the midst of the earth." I am interested in space and spacing of fish and am convinced that the behavioral interactions that cause spacing in wild trout and hatchery trout within their own populations as well as the behavioral interaction of populations of wild trout with populations of hatchery trout are not unlike those related to spacing in man and other vertebrates. The purpose of this talk is to explore some recent developments in animal behavior and ethology that may explain in part the difficulties of managing hatchery and wild trout. The emphasis will be upon space and spacing as they affect behavior.

In the recent AAAS international symposium on the use of space by animals and man (Esser 1971), there was not a fishery biologist among the 50 contributors to the symposium. Furthermore, there was not a single reference to space in relation to fish in all the references given by the contributors. Are we out of date, behind the times, or is the subject of space more difficult to study in fish than in man, rats, mice, rabbits, and birds?

One of our difficulties may be in not recognizing individual differences among fish of the same species and within the same population. There is a great variety of nuances in behavior, so subtle as not to be seen by those watching from above the water level. Such differences are completely lost in annual summaries of "population dynamics" expressed as instantaneous mortality rates, instantaneous growth rates, etc.

There is a general feeling, not limited to laymen, that fish have no unique and superior features; and that by and large, there is little difference among individuals of the same species in fish. In many respects fish are superior to other vertebrates. The lateral line, a morphological structure of fish and a few amphibians, provides keen sensitivity to nearby objects – sensitivity characterized by the inverse cube relationship of water displacement and distance. In many fish their olfactory sense is far more sensitive than that of terrestrial animals and the gustatorial sense in some species is distributed over the entire surface of the body. Their capacity to taste exceeds that of man's taste of salt, sweet, bitter, and sour.

The many hours I spent viewing fish a Sagehen Creek Research Station, a University of California, Berkeley, facility in the Sierra Nevada Mountains, have provided me an opportunity for seeing fish certainly as distinct as are individuals among humans. Admittedly, there is a mode or mean of behavior and morphology that cannot be denied; however, within any group of fish will be found those that have much behavioral distinction, form, and color as that we find in man.

If we therefore begin with the prologue that fish are animals; that they have some sensory mechanisms far keener than those of some other vertebrates and that they are distinct as individuals, we should expect them to have ethological analogies with other vertebrates. They are as much victims of their genetic and "cultural" backgrounds as we are.

If wild trout remain under wild trout conditions, they act as a population of wild trout. If hatchery trout are placed in a situation having environmental conditions suitable for wild trout, the behavior of the hatchery trout is largely unpredictable. There is a lack of experience, entrainment, or reinforcement in the hatchery for a behavioral repertoire needed for natural conditions. What we think the hatchery fish will do has no previous basis from which we can make judgment. He is in large part a product of the hatchery environment, an environment of which we have assumed some understanding, but of which little is known as to how it affects behavior and ultimately survival after planting.

I propose that behavior, genetically based and influenced by interaction with other fish in the environment, through time, produces differences in wild and hatchery trout that may not at first appear reasonable. Let me go back several years to work that was done on rainbow catchable (legal-sized) trout in California.

During studies of catchable trout at Rush Creek, California (Butler and Borgeson 1965), we noted an increase in catchability of wild trout for a short period after each planting (Figure 1). The increased catchability was at that time discussed by ourselves as competition for the fisherman's lures and bait. A more meaningful explanation may be proposed as a behavioral phenomenon (synchronous behavior) in which a fish is compelled to do what several fish are doing. It may be initiated as social facilitation, a follow the leadership type of behavior (Greenberg 1947). Synchronous behavior appears to have evolutionary adaptive significance and especially so in feeding. When food is abundant, during a hatch of aquatic insects, the population of fish feed as a group. This provides high energy intake with low metabolic cost. Agonistic behavior with its high metabolic cost is greatly reduced. Also, extensive movement per food item is reduced.

In 1958 during our studies (Butler and Borgeson 1965) on upper Rush Creek, 18,353 trout were planted per stream mile – a factor of increase in density of wild trout population well above 100. More than 300 angler hours per stream mile per day were developed with this intense planting. Under this type of angler pressure a simulated "hatch of food" may have induced synchronous feeding behavior in the wild population. Perhaps with high-density planting of hatchery trout in "wild trout" waters, coupled with high angler effort, the wild trout become susceptible to the fisherman's lure and suffer an abnormally high fishing mortality. The dominant fish that occupies the preferred feeding site thereby having precedence in feeding over other members in his area may become under synchronous behavior more susceptible to being caught than smaller wild trout.

Another aspect of space and spacing that may relate to the problems of wild-hatchery trout management is that presented in the literature as "territoriality". It is unfortunate that our concept of space in fish has been developed largely from observations of juveniles, parr, and smolts (Fenderson et al 1968, Fraser 1969, Kalleberg 1958, and Moyle 1969). Numerous papers involving stream aquarium studies where such factors as light, temperature, and food have been controlled have given us an incomplete concept of territoriality. Concepts of fixed topographic territory or territorial mosaics developed in these studies are certainly applicable to conspecifics of the same small size; however, they are not applicable to adults. The few studies on adults by Newman (1956), Nielson et al (1956), and Jenkins (1969) provide us with hints of quite different aspects of territoriality.

Wild adult trout in a stream do not have a territory as understood in the traditional sense. They do, however, have a private space immediately upstream, especially while feeding. It is not fixed but moves with the fish. Furthermore, it changes and even collapses within parts of diel and seasonal periods. This private space described by McBride (1964) as a "social force field" for other animals is applicable to fish.

I have watched many times during our studies of covert behavior (Butler and Hawthorne 1968) the sharing of an overhead cover by conspecifics of different size (Figure 2). When the cover was used as a preferred feeding site, individuals occupying the cover stratified the use of food by its size and position as related to their own size and position. Small fish were much more active in attempting to feed on all small items drifting in the current. The larger fish made fewer forays for food and fewer errors in selection. The dominant fish remained in the upstream portion of the cover, and its "territory," more appropriately termed social force field, was in the form of a cone immediately in front of its head and in the upstream section of the cover. The most vigorous defense of the dominant was directly upstream, as was the feeding intensity. In resting positions (most obvious in the early morning) the social force field appeared to be very small or nonexistent. At such times the fish were on the bottom and inactive. Similarly, no social force field was noted during the periods of winter when the streams had complete ice cover.

Although the social force fields may contract or expand depending upon the "normal" density of wild trout and diel and seasonal influence, under high densities the social force fields break down and fish may suffer a nonspecific stress. Such stress has been only briefly mentioned in the fishery literature (Erickson 1967, Wedemeyer 1970, and Davis and Fenderson 1971).

High densities imposed by planting catchable trout on wild populations may bring about physiological stresses in wild fish characterized by aspects of the general adaptation syndrome referred to as the acronym, GAS (Selye 1973). "Natural mortality" of wild trout as measured in mixed populations of wild and hatchery trout may be due in large part to GAS rather than predation or emigration (Vincent 1972). The "natural mortality" of planted catchable trout often is the unaccounted catch in poaching. Thus, I suspect the "natural mortalities" of wild and hatchery-reared trout in mixed populations are of different causes.

Stress is the nonspecific response of the body to any demand made upon it (Selye 1973). It is not simply nervous tension. It would not be stress as measured in fish through "stamina" experiments in a respirometer tunnel. It has been described in rats as having three stages: (1) alarm reaction or hardship, (2) adaptation, or getting used to the stimulus, and (3) incompatability with life, which leads to exhaustion and death. Selye's general adaptation syndrome has the following features and may have some application to fish under high-density conditions. In rats there is lowered testicular activity, adrenal exhaustion, hypoglycemic convulsions, exhaustion of the adrenal pituitary system, gonadal atrophy, suspended reproductive activity, lower ranking individuals have increased adrenal weight and decreased body weight, excessive parasympathetic stimulation, absorption of embryos, and "hole in the wall" behavior – more often characterized as "behavioral sink" by Calhoun (1962). The behavioral sink in rats and mice is characterized by homosexuality, cannibalism of young, hyperactivity, extreme withdrawal, poor nest building, disrupted courting behavior, and poor nursing and care of the young. Of course, all these characteristics in rats cannot apply to fish. However, we should be prepared to examine some form of GAS under high densities of trout.

Although this is a trout symposium, I must refer to some of the work done on GAS in centarchids. High quantities of adrenal-cortical tissues were found in the least aggressive sunfish by Erickson (1967). He suggested that the least aggressive fish was under the higher stress. In yearling smallmouth bass Yorty (1968) reported that subordinates gave no indication of aggression. The subordinate positioned itself head-down and became dark in color. Although the dominant made no vigorous attack and the subordinate suffered no obvious external damage, the subordinate usually died within 24 to 36 hours. Continuous tremor of all fins was obvious. I assume death was in part related to too close a contact – insufficient space for the subordinate.

Davis and Fenderson (1971) found no differences in adrenal-cortical levels of landlocked wild and hatchery salmon parr under hatchery conditions. They suggested that this lack of difference may have been related to the low population densities for each part of the experimental work. The lack of differential mortality in wild brown and hatchery rainbow trout in the same sections of Convict Creek (Nielson et al 1956) may also have been related to the low experimental densities compared with those developed in most streams in California in which catchable trout were stocked.

James McLaren has nearly completed comparative studies on wild and hatchery adult brown trout at the Pennsylvania Cooperative Fishery Research Unit. He has examined spatial behavior of trout through quantification of activity, cover use, agonistic behavior, and feeding. The origin of the trout (hatchery vs. wild), season of observation, experimental stream section, density and prior residency have been examined for effects singly or in combinations of the above mentioned behavioral characteristics. Fienberg (1970) provided a statistical approach for the examination of such effects and their interactions, using a nonparametric test that yields standard normal values (SNV), analogous to Z values of a normal distribution. Fienberg's analysis of multidimensional contingency tables partitions effects of factors much like an analysis of variance. The SNV 1.96 or -1.96 denotes a significant effect ($\propto = 0.05$) of a variable or interaction of variables on the behavioral characteristic in question.

McLaren found that most (83%) of the main effects and interaction effects tested for the six behavioral characteristics were highly significant. Most notable is the highly significant main effect of origin (hatchery vs. wild). Hatchery fish in a seminatural environment were more active than wild fish, utilized cover less, exhibited greater agonistic activity, and fed more frequently. Only 3 of the 30 two-way interactions of the origin with other variables were nonsignificant. The decreased use of cover by hatchery-reared trout is directly related to their great activity and more frequent agonistic encounters. Although hatchery trout in McLaren's studies appeared to feed more than did wild trout, it is possible that high bioenergetic demands of swimming in the current coupled with the hatchery environmental background provide no reinforcement for cover seeking, even though there may have been a genetic capacity to do so. On the contrary, artificial feeding provides a positive reinforcement for avoiding cover. Piscivorous birds and other predators that might reinforce or bring about cover responses are scarce in the hatchery environment.

In the past most studies of the interaction of wild trout and superimposed hatchery trout have been at the population rather than the individual level. The results of such work have in effect been a summation of genetics, physiology, behavior, density, and interaction with environment and fishermen generally for a season or year. Fishery biologists know nothing of what goes on within the population at a given time even though the studies are called population dynamics. It is essential that they begin to examine the interaction of these individual variables if they are to learn to understand the real population dynamics. In the past they have assumed the system to be rather simple and in part have been compelled to reduce it to statistical summations. A lack of observational facilities and lack of support and interest in behavior has held back these approaches. Many factors are involved. There are some circumstances where a priori reasoning fits the results; however, the more atypical the system, the less one can make use of a priori and the more one is obligated to use statistical techniques similar to those of Fienberg (1970) and observational systems like those used by Jenkins (1969) and, currently, by James McLaren.

REFERENCES CITED

Butler, Robert L., and David P. Borgeson. 1965. California "Catchable" Trout Fisheries. Calif. Dep. Fish Game, Fish Bull. 127. 47 p.

Butler, Robert L., and Vernon M. Hawthorne. 1968. The reactions of dominant trout to changes in overhead artificial cover. Trans. Am. Fish. Soc. 97: 37-41.

Calhoun, John. 1962. Population density and social pathology. Sci. Am. 206: 139-148.

Davis, Robert M., and Owen C. Fenderson. 1971. Histological comparisons of the adrenal-cortical cells of hatchery and wild landlocked Atlantic salmon *(Salmo salar)*. J. Fish. Res. Board Can. 28: 505-508.

Erickson, James G. 1967. Social Heirarchy, territoriality and stress reactions in sunfish. Physiol. Zool. 40: 40-48.

Esser, Aristide H., editor. 1971. Behavior and Environment: the Use of Space by Animals and Men. Plenum Press, New York. 411 p.

Fenderson, Owen C., Harry Everhart, and Kenneth M. Muth. 1968. Comparative agonistic and feeding behavior of hatchery-reared and wild salmon in aquaria. J. Fish. Res. Board Can. 25: 1-14.

Fienberg, Stephen E. 1970. The analysis of multidimensional contingency tables. Ecology 51: 419-433.

Fraser, F. J. 1969. Population density effects on survival and growth of juvenile coho salmon and steelhead trout in experimental stream-channels. pp. 253-268. *in* Symposium on Salmon and Trout in Streams. H. R. MacMillan Lectures in Fisheries, University of British Columbia, Vancouver.

Greenberg, Bernard. 1947. Some relations between territory, social hierarchy and leadership in the green sunfish *(Lepomis cyanellus)*. Physiol. Zool. 20: 267-298.

Jenkins, Thomas M., Jr. 1969. Social structure, position choice and microdistribution of two trout species *(Salmo trutta* and *Salmo gairdneri)* resident in mountain streams. Anim. Behav. Monogr. 2: 57-123.

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

McBride, G. 1964. A general theory of social organization and behavior Univ. Queensland Pap., Fac. Vet. Sci. 1: 75-110. Univ. Queensland Press, St. Lucia.

Moyle, Peter B. 1969. Comparative behavior of young brook trout of domestic and wild origin. Prog. Fish Cult. 31: 51-56.

Newman, Murray A. 1956. Social behavior and interspecific competition in two trout species. Physiol. Zool. 29: 64-80.

Nielson, Reed S., Norman Reimers, and Harry D. Kennedy. 1956. A six-year study of the survival and vitality of hatchery-reared rainbow trout of catchable size in Convict Creek, California. Calif. Fish Game 43: 5-42.

Selye, Hans. 1973. The evolution of the stress concept. Am. Sci. 61: 692-699.

Vincent, Richard E. 1972. Double haul. Trout, Summer 1972: 21: 40-41.

Wedemeyer, Gary. 1970. The role of stress in the disease resistance of fishes. pp. 30-35. *in* A Symposium on Diseases of Fishes and Shellfishes. Am. Fish. Soc. Sp. Publ. 5, Wash. D.C.

Yorty, Lois Jane. 1968. Agonistic and shelter-seeking behavior of juvenile smallmouth bass *Micropterus dolomieui* in a stream aquarium. M.S. thesis; Penn. State Univ. 43 p.

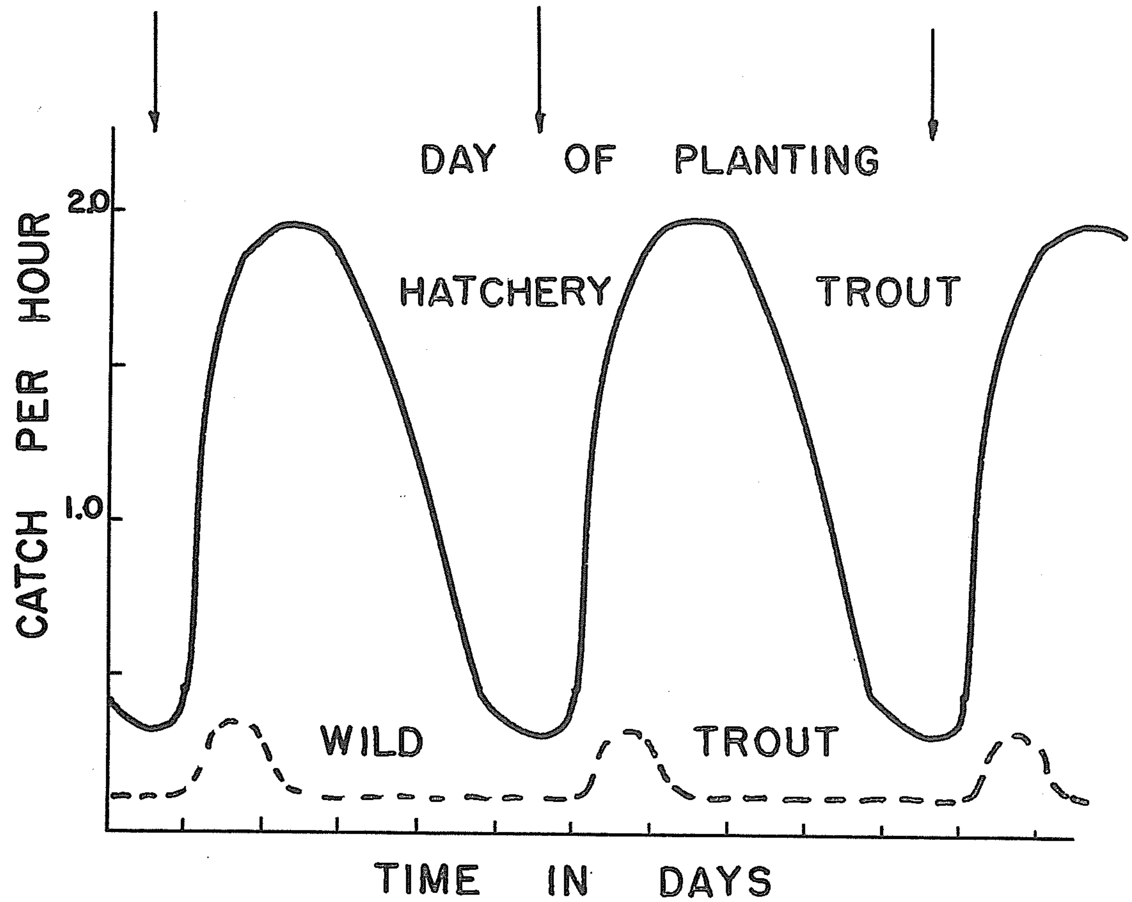
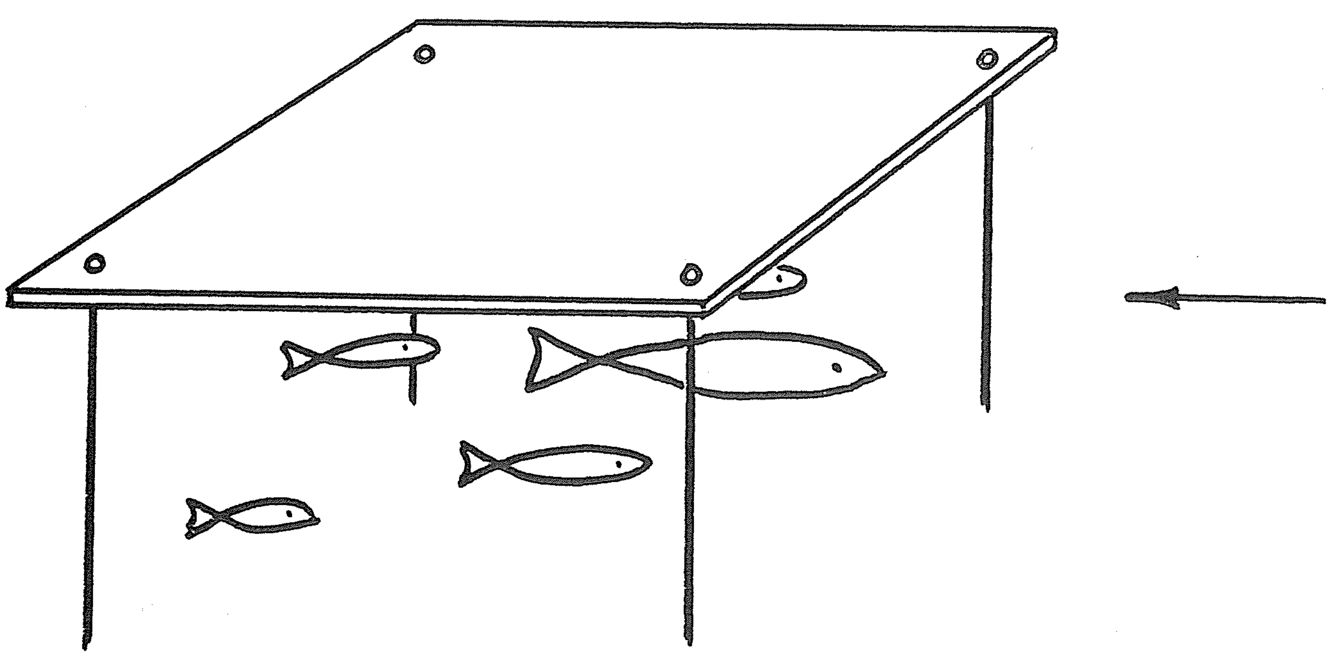


Figure 1

Figure 2. Utilization of cover in a stream by trout of different sizes.



EFFECT OF STOCKING CATCHABLE TROUT ON WILD TROUT POPULATIONS [1]

By E. Richard Vincent

Montana Department of Fish and Game

This trout population study was started on the Madison River and O'Dell Creek in the spring of 1967 and continued through the fall of 1971. The study was initially set up to determine the effects of low spring water flows on Madison River wild trout populations. Later, this study developed into the effect of stocking catchable hatchery rainbow trout on wild trout populations.

The Madison River, located in southwestern Montana, originates in Yellowstone National Park and flows approximately 140 miles in a northerly direction, joining the Jefferson and Gallatin Rivers to form the Missouri River. There are two man-made impoundments on the river: (1) Hebgen Reservoir, located three miles downstream from the Park boundary, and (2) Ennis Reservoir, located 67 miles downstream from Hebgen Reservoir. O'Dell Creek is a valley spring creek which arises about 11 miles south of Ennis Reservoir.

Hebgen Reservoir storage patterns caused problems with the late-winter and early-spring water flow levels in the Madison River. During the early spring of 1967 and many other previous years, water storage in Hebgen Reservoir would begin in late February and continue through the spring runoff. This left a low water period from late February through mid-May in the river below the dam. It was often dewatered as much as 50 percent in some areas. Two study sections were set up on the Madison River, one near the town of Ennis (Varney) and the other below Ennis Reservoir (Norris). Population estimates were made during the spring and fall in Varney and during the spring in the Norris section. Before the 1968 storage was started, the local dam operators agreed to change the storage pattern. The storage would not begin until the spring runoff occurred in mid-May. Thus, from 1968 through 1971, there has been no early spring dewatering and normal flows have occurred. Since the change in water flow patterns, the adult wild trout (browns and rainbows) population in the Norris section has increased 80 percent from 6,800 in the spring of 1967 to 12,250 in the spring of 1970. But, even with improved flows, the Varney section did not show similar results. The spring 1967 adult wild brown trout population estimate was 1,760, and by the spring of 1970 it was 2,121, or 21 percent increase.

So, some other factor must have been controlling the Varney trout population size. Since the Norris area had the most liberal angling regulations –year around angling versus a closure in Varney from March 1 through mid-May; the best access roads on both sides of the river versus access only on the beginning and the end of the section in Varney; and the highest angling pressure – there was a possibility that the heavy fish stocking in the Varney section (8,000 to 10,000 per year) could be inhibiting the wild trout population size. The Norris section had not been stocked since 1960.

The present catchable trout study was set up during the spring of 1970 on the Varney section of the Madison River and a tributary stream, O'Dell Creek. Three study sections were set up as follows: (1) Varney on the Madison River – since this section had received catchable plants since the early 1950's through 1969, stocking ceased in 1970; (2) lower O'Dell Creek – no stocking had occurred in this area since 1963, but with the summer of 1970 stocking was initiated; and (3) upper O'Dell Creek – no stocking had occurred since 1963, and this would continue. The Varney section prior to 1970 had received up to 8,000 rainbows annually. In lower O'Dell Creek the experimental plants were 4,000 in 1970 and 4,500 in 1971. Trout population estimates were made on Varney from 1967 through 1971, lower O'Dell Creek from 1967 through 1971, and on upper O'Dell Creek from 1970 through 1971.

METHODS

Electrofishing gear was used to sample fish populations in the Madison River. Electrofishing was carried out while floating through each section of stream in a flat-bottomed fiberglas boat. This boat contained a stationary negative electrode (fastened to the bottom of the boat), a mobile positive electrode, a portable 2,500 watt AC generator with a rectifying unit which converted the alternating current into pulsed or continuous direct current, a container to retain captured fish, and other necessary gear to weigh, measure and tag the fish. Captured fish were periodically anesthe-

[1] Field work was performed under Federal Aid in Fish Restoration projects F-9-R-15 through F-9-R-20.

tized with MS 222 (Tricane Methanesulfonate), measured to the nearest 0.1 inch in total length, weighed to the nearest 0.02 pound, tagged with a Floy anchor tag or fin clipped, and then released.

Estimates of the trout population (trout two years old and older) were based on the mark-and-recapture technique of Peterson, using Chapman's formula as shown in Ricker (1958). Total number, total biomass, and confidence intervals were calculated for each estimate. The actual mathematical computations were made by an IBM computer programmed to use methods described by Vincent (1971). Angler harvest data was obtained from the use of numbered plastic tags which were inserted in the fish just behind the dorsal fin with the barbs engaging in the pterygiophores. These tags were placed in the fish during the spring estimates. The tags, when returned by anglers, were used to compute a percent angler harvest for a year.

RESULTS

During the years 1967 to 1969, when the Varney section was stocked with catchable rainbow trout, the fall wild brown and rainbow trout population estimates ranged from 275/mile in 1969 to 306/mile in 1968, or an average of 294/mile (Tables 1 and 2). The average biomass was 359 pounds/mile. Then in the fall of 1970, after the first summer of no trout stocking in this section, the total numbers of wild trout increased to 549/mile, or an increase of 87 percent over the three year average, when catchables were stocked. By the fall of 1971 the wild trout number had increased 180 percent to 833/mile. The biomass increased from a three year average of 350 pounds/mile in stocked years to 1,026 pounds/mile in the fall of 1971. This constituted a 186 percent increase.

In the lower study section of O'Dell Creek where no stocking of catchables occurred from 1963 to 1969, the fall brown trout population estimate ranged from 303/mile in 1969 to 428/mile in 1968, or a three year average of 354/mile. The 1970 fall estimate made after the first summer of catchable stocking showed no appreciable change, but by fall of 1971, after a second summer of stocking, the population decreased 49 percent to 182/mile. This total biomass also showed a similar drop from an average of 338 pounds/mile in nonstocked years to 182/pounds mile after stocking.

Table 1. A comparison of wild brown trout population estimates between years with catchable stocking and years of no stocking. Population estimates are for trout two years old and older. Estimates are expressed as numbers and pounds per mile. Confidence intervals at the 95 percent level are shown in parentheses.

	Madison River – Varney		O'Dell Creek – Lower		O'Dell Creek – Upper	
Year	No.	Lbs.	No.	Lbs.	No.	Est.
	Stocking		No Stocking		No Stocking	
1967	253 (±93)	353	331 (±92)	317	-	-
1968	225 (±70)	279	428 (±107)	404	-	-
1969	239 (±75)	298	303 (±58)	292	-	-
	No Stocking		Stocking			
1970	364 (±87)	561	390 (±64)	345	344 (±52)	405
1971	615 (±156)	790	182 (±33)	182	367 (±86)	406

The control section on O'Dell Creek (upper) showed only a slight increase in total numbers from 344/mile to 367/mile. This constituted a 7 percent increase in total numbers.

Table 2. A comparison of wild rainbow trout populations between years of catchable stocking and years with no stocking on the Varney section of the Madison River. Estimates are for trout two years old and older. Estimates are expressed as number and pounds per mile with confidence intervals at the 95 percent level shown in parentheses.

		Stocking		No Stocking	
	1967	1968	1969	1970	1971
No.	48 (±20)	81 (±62)	36 (±26)	185 (±113)	218 (±89)
Pounds	24	84	39	169	236

Angler return rates showed a steady 11 to 12 percent return in stocking years on the Madison, with a slight drop of 2 to 3 percent in 1970 and 1971 after stocking ceased. In the lower O'Dell Creek section, there was a slight drop after stocking was initiated in 1970 and 1971. The unstocked section of O'Dell Creek showed a slightly higher return rate than the stocked section in 1970 and 1971.

Table 3. Angler tag return rates of wild brown trout for the stocked and unstocked years in the Madison River and O'Dell Creek. Numbers are expressed as percent of total tagged in the spring.

Year	Madison River Varney	O'Dell Creek Lower	O'Dell Creek Upper
	Stocking	No Stocking	No Stocking
1967	12.8%	5.7%	-
1968	11.0%	9.4%	-
1969	12.1%	-1	-
	No Stocking	Stocking	
1970	8.6%	4.6%	5.9%
1971	9.3%	3.7%	8.8%

[1]Insufficient data for computation

DISCUSSION

The stocking of catchable rainbow trout is commonly used with the idea of maintaining or improving trout harvest. The idea was to supplement the wild trout harvest with some additional hatchery trout. It was assumed that these additional trout would have no detrimental effect on the existing wild trout population.

This study has shown that when hatchery-reared rainbow trout are added to existing self-sustaining wild trout populations, the wild trout numbers decrease drastically within the first two years after stocking starts. Abnormal mortality rates occur both in the summer and winter periods. This study has also shown that in O'Dell Creek the stocked rainbow adds little to the overall population size, because of an annual mortality rate exceeding 99 percent. When stocking of catchables ceased in the Varney section of the Madison River, the wild trout population was able to almost triple in two years.

Angler tag returns indicated that none of the three study sections exhibited enough angling pressure to affect the total population size.

The angler harvest was less than 20 percent of the annual mortality. The slight decrease in angler harvest (2 to 3 percent) on the Madison section could not account for the large population increase (180 percent). Lower O'Dell Creek also had a decrease in angler harvest, but the population decreased 50 percent instead of increasing. The upper section of O'Dell Creek which did not receive catchables had a lighter harvest rate than the lower stocked section, but the population remained about the same. All of this information would indicate that factors other than angler pressure control the trout population sizes in these streams.

A possible reason why the losses in wild trout occur could be due to some social stress involving space and/or food. The stocked section of O'Dell Creek showed some signs of this stress-increased movement, decreased condition factor and a decreased growth rate over previous unstocked years. The changes were not noted in the unstocked section of O'Dell Creek.

SUMMARY

In 1967, Montana started a trout population study on two sections of the Madison River. We were trying to find out if unusually low spring flows affected the numbers of trout. The flows were regulated by Hebgen Dam.

In 1968, releases from the dam changed, and spring flows were improved. However, trout increased in only one of our two study sections. There was only one major difference in management between them. The section which didn't show improvement was being stocked annually with catchables, while the section that improved hadn't been stocked for over 10 years.

In 1970, the study was changed to check on the effect of planting. We continued sampling the two Madison River sections and stopped planting the one that had been stocked annually. We also began sampling two sections of O'Dell Creek, which is a tributary of the Madison. One of the O'Dell Creek sections had been sampled before, the other hadn't. The Creek had not been planted

for seven years. We began planting one O'Dell Creek section; the other remained unstocked.

By 1971, in the Madison section where we stopped planting, wild trout had increased over 180 percent, both by numbers and by weight. At the same time, in the O'Dell Creek section that we started stocking, wild trout decreased over 45 percent in both numbers and weight. In the O'Dell Creek section that remained unplanted, both number and weight of wild trout stayed about the same. In the Madison River section that has remained unplanted for over 10 years, wild trout have continued to increase. This is probably still in response to the better spring flows the river has had since 1968.

Fish were sampled by electrofishing, which was conducted by floating through the study sections. A basic mark-and-recapture method was used to estimate total numbers and pounds. These estimates were made only for two-year-old and older, wild brown and rainbow trout. Trout were marked with tags in the spring. Return of these tags by fishermen was used to estimate angler harvest. This harvest appeared to drop slightly both in the Madison section where stocking ceased and in the O'Dell section where stocking was started.

REFERENCES CITED

Rickers, W. E. 1958. Handbook of computation for biological statistics of fish populations. Fish Res. Bd. Canada, Bull. 119, 300 p.

Vincent, E. R. 1971. River electrofishing and fish population estimates. Prog. Fish Cult. 33(3): 163-167.

THE YELLOWSTONE FISHERY

By John U. Varley

U. S. Fish and Wildlife Service

In 1962, the Outdoor Recreation Resources Review Commission concluded that by the year 2000 the population in the United States will have increased by 98 percent over the 1960 population. More important to fishery managers was the conclusion that sport fishermen would increase 150 percent by the year 2000. This indicates that within 26 years there will be 100 million anglers in this country. The report further suggested that the increase in total fishing demands in the future could best be handled in three principal ways: (1) by adding new waters, (2) by increased fishing in coastal waters, and (3) by better management of existing waters (King *et al*, 1962). In the future, solutions 1 (adding new waters) and 3 (better management of existing waters) are likely to include significant roles by native and non-native or exotic salmonids throughout the country.

When fishery managers speak of better management, the role of improved hatchery stocks, stocking procedures and introductions are frequently mentioned. The use of these methods is not new in North America nor in Yellowstone Park. When widespread development of trout hatcheries and rearing stations occurred in the 1880's, the remoteness of Yellowstone did not hinder workers from getting the "planting job" done. Despite the rather well stocked condition of many of Yellowstone's waters when white men first arrived in the area, by 1900 numerous lakes and streams in the Park had been stocked with exotic lake, brown, brook and rainbow trout, and other species.

Research regarding trout stocking during this early period indicates there were a number of reasons for this widespread and very rapid expansion of exotic salmonids. They were: (1) to initiate yields - this would apply to barren waters; (2) to maintain yields – or to restock waters thought to be depleted; (3) to increase and enhance yields of existing stocks; and (4) to provide greater diversity, interest, and quality to sport fishing.

Until about 1950, trout management practices in the West consisted almost entirely of the introduction of salmonids. Often, introductions were made on a "give it a whirl" basis (Northcote 1970). Many of the travesties which occurred as the result of introductions of exotic trout species over native species are well known. The extirpation or genetic dilution of many of the subspecies and/or novel races of cutthroat and grayling are a prime example (USDI 1966).

Diverse stocking activities in the past 87 years in Yellowstone included some notable failures: Atlantic salmon, rainbow trout, and mountain white fish were stocked in the Yellowstone Lake drainage and failed to survive; largemouth black bass were planted in the Gibbon River and failed; yellow perch in the Firehole basin; and brown trout in the Yellowstone Lake drainage were chemically removed before they could expand their ranges. Fortunately, some of the Park is reasonably intact with regard to having pure populations of native species. Conversely, Yellowstone is the home of robust populations of exotic salmonids such as the lake, brown, brook, and rainbow trouts. In some waters, they have totally replaced native sport fishes including some subspecies and/or races that may be rare or endangered (Dean and Varley 1974).

Beyond the documented decline and sometimes extinction of native species, one might ask what became of the other objectives cited as being the reasons for the widespread expansion of exotic species? Did these widespread introductions, for instance, maintain, increase, and enhance yields? Did they provide greater diversity, interest, and quality to sport fishing?

In Yellowstone Park, there is a unique opportunity to study some of the consequences of past stocking activities that began in 1887 and came to a gradual end in the 1950's. With the end of stocking activities, native and non-native species have had to depend totally upon their own resources for self-perpetuation. Populations were aided only through what might be considered as quite restrictive regulations by national standards and by virtue of being in a natural area within the National Park System.

In Yellowstone, approximately 60 lakes comprising 112,000 surface acres and 170 rivers and streams totaling about 2,500 miles probably receive angler exploitation. Park visitation has increased at a steady rate since the Park's creation in 1872, and travel to back-country areas has recently increased at a high rate. It is thought that exploitation of the fishery resources in the Park has increased at approximately the same rate as visitation, although data are lacking.

In 1973, a new Federal law was implemented in the Park that required all anglers to obtain a free fishing permit. The new requirment provided the basis for the first reliable estimates of the total number of Park anglers in several decades. It also provided a means for personal contact with fishermen. Beginning in August, 1973, each angler obtaining a permit was also issued a stamped, self-addressed postcard entitled "Volunteer Fisherman Report". This card requested pertinent use, effort, catch, and harvest information. It also requested that the angler detail his feelings about the quality of his fishing experience. The card was issued to approximately 18,000 of the 175,000 anglers fishing in the Park in 1973. Eleven hundred were returned, giving a return rate of 6.2 percent. It was expected that a lower percentage of cards would be returned than is often the case because of the technical and detailed nature of the questionnaire. The mail-in card was again issued in 1974 at the beginning of the season with the free fishing permit, and the returns through August, 1974 are used in this paper.

Approximately 3,500 cards from 1973 and 1974 representing about 9,950 anglers were compiled. These yielded data on 83 different waters in the Park; for the majority, it was the first data ever collected.

To define the element of quality, some 500 anglers were randomly interviewed on Yellowstone River and Lake and were asked to describe a high quality angling experience. The results of this survey were remarkably simple. Thirty six percent thought that the numbers of fish caught were the most important element in a high quality angling trip. One-third of those interviewed spontaneously ranked the surroundings as being the most important factor. Some seven percent ranked "big fish" as being most important. The remaining 24 percent represented a variety of diverse feelings that most often related to a previous specific angling experience; such as marlin fishing, northern pike fishing, etc. Based upon this information, criteria were developed for analysis of the 83 waters in Yellowstone. The numbers of trout caught or landing rate (as opposed to the creel or harvest rate) was selected as being the single most important element because the anglers themselves chose it. Closely correlated to the numbers of fish caught is the percentage of anglers in the total population that were successful, that is, the percentage that caught at least one fish.

A third criteria selected dealt with the element of fish size. Though only seven percent of the anglers interviewed ranked large size as being the most important factor, it was later calculated that a correlation existed between satisfied anglers and the size of fish that made up their catch. Not knowing precisely what "threshold" size was acceptable, 12 inches and above was arbitrarily used because fish this size begin to tax the light tackle commonly in use by fishermen.

The three criteria presented are referred to herein as being the elements comprising a "sustained recreational yield".

In developing these criteria, the important element of physical surroundings was ignored. This was done because essentially no negative feedback is received from anglers about the setting in Yellowstone. In fact, some 27 percent of the anglers, when asked to describe a high quality angling experience on the Yellowstone River, responded, "This is it."

The sport fishing performance of native and exotic species for 13 lakes where native species predominate and six lakes were exotics are most prominent were first contrasted (Table 1). It is apparent that in lakes, native fishes provide superior landing rates by a factor of three to one. The percentage of successful anglers and fish caught over 12 inches in length are reasonably comparable, although in each case the performance of native species is greater. The percentage of anglers which were satisfied with their fishing experience is seven points greater in "native" waters than in "exotic" waters. Also, there were 36 waters considered native rivers, and 28 considered as streams dominated by exotic species. Here the landing rates are only slightly higher in native waters; but the percentage of successful anglers, fish caught over 12 inches, and the percentage of anglers satisfied with their fishing experience are significantly higher.

Table1. Some measures of angling quality comparing 83 Yellowstone Park waters with native species versus waters with exotic species.[1]

	Lakes (19)		Rivers-Streams (64)		All Waters (83)	
	Native (13) Species	Exotic (6) Species	Native (36) Species	Exotic (28) Species	Native (49) Species	Exotic (34) Species
Landing rate (fish/hour)	1.62	0.59	1.88	1.72	1.81	1.52
% of successful anglers	80.9	78.6	91.5	79.1	88.7	79.0
% fish caught over 12 in.	46.3	43.2	42.3	15.0	43.3	19.9
% of satisfied anglers	67.7	60.4	72.8	48.9	69.9	51.4

[1]Native species are cutthroat trout, Arctic grayling, and mountain whitefish. Exotic species are rainbow, brook, brown and lake trouts.

When all waters are considered (Table 1), it is apparent which of the two groups provide superior sport fishing to the public. The 18.5 percentage points separating the two satisfied angler categories for all waters represents as many as 32,000 "happier" anglers with Yellowstone native species waters as opposed to waters providing angling for non-native species.

Following the overview of native versus non-native species, a further breakdown can be made by individual species. Of the 83 waters for which information exists, 19 are classified as predominately brook trout waters, 38 are cutthroat waters, and 9 are rainbow waters. There are a series of 12 lakes and streams that have combinations of species: cutthroat and brook trout, grayling and either cutthroat or rainbow, cutthroat and rainbows, and cutthroat and lake trout. Lastly, there are three waters with lake trout and seven brown trout waters.

Table 2.

Species	Landing rate in fish per hour
1. Brook trout	2.152
2. Cutthroat trout	1.968
3. Rainbow trout	1.861
4. Cutthroat and Brook	1.144
5. Grayling and Cutthroat (or Rainbow)	1.114
6. Cutthroat and Rainbow	1.048
7. Cutthroat and Lake trout	0.843
8. Lake trout	0.594
9. Brown trout	0.338

When the landing rates of the nine species and combinations of species are compared (Table 2), the brook trout provides the single highest landing rate of any of the species or combination of species in Yellowstone. The brook trout are followed by the native cutthroat, the rainbow, four combinations of species, the lake trout, and lastly the brown trout. The difference between the highest landing rate and the lowest exceeds a six-fold divergence.

These same species and combinations of species are compared by percentage of successful anglers (anglers that catch one or more fish, Table 3). The combination of grayling and either cutthroat or rainbow trout provides the highest percentage of successful anglers. This species combination is followed by the rainbow, cutthroat and rainbow, cutthroat trout, brook trout, cutthroat and brook trout, lake trout, cutthroat and lake trout, and lastly the brown trout.

When percentage of fish caught that exceeded 12 inches in total length is contrasted (Table 4), no species comes close to the lake trout. It is followed by the combination of lake and cutthroat trout, the brown trout, the cutthroat, cutthroat and brook trout, rainbow, cutthroat and rainbow, grayling and either cutthroat or rainbow. The brook trout is last with only 2.2 percent of those

Table 3.

Species	Percentage of successful anglers
1. Grayling and Cutthroat (or Rainbow)	92.4
2. Rainbow trout	88.3
3. Cutthroat and Rainbow trout	87.8
4. Cutthroat trout	86.9
5. Brook trout	84.1
6. Cutthroat and Brook trout	77.1
7. Lake trout	72.8
8. Cutthroat and Lake trout	68.7
9. Brown trout	58.8

Table 4.

Species	Percentage of fish caught over 12 in. in length
1. Lake trout	74.8
2. Cutthroat and Lake trout	65.4
3. Brown trout	47.7
4. Cutthroat trout	45.0
5. Cutthroat and Brook trout	40.8
6. Rainbow trout	30.2
7. Cutthroat and Rainbow trout	27.4
8. Grayling and Cutthroat (or Rainbow)	25.9
9. Brook trout	2.2

caught exceeding 12 inches. There is a thirty four-fold difference between the brook and the lake trout and a twenty-fold difference between the brook trout and the native cutthroat.

Table 5.

Species sought	Percentage of anglers satisfied
1. Cutthroat trout	74.2
2. Cutthroat and Rainbow trout	67.5
3. Rainbow trout	64.8
4. Lake trout	60.7
5. Cutthroat and Lake trout	60.0
6. Grayling and Cutthroat (or Rainbow) trout	42.7
7. Brown trout	42.2
8. Cutthroat and Brook trout	40.2
9. Brook trout	40.0

The percentage of anglers that were generally satisfied with their fishing experience is more difficult to interpret (Table 5). The yes and no response to this question undoubtedly included elements inherent in the previous categories plus many more. There were a number of fishermen responses where particular anglers did not catch a fish and yet were satisfied with their angling experience. Conversely, there were also a number of anglers reporting that may have caught 30 or 40 trout in a given day, a fair number which may have exceeded 12 or even 14 inches, but nonetheless, were dissatisfied with their fishing experience. It is possible that satisfied anglers, making up nearly three-fourths of the total number fishing, may be at the upper limit of what is potentially possible in salmonid fisheries, considering the wide range in competence in the angling population.

It would appear that some species, perhaps the first five, provide significantly more satisfied anglers in Yellowstone Park than the last four (Table 5). The cutthroat, rainbow, and combination of the two species rank highest in this category because the group consistently ranks high in each of the other criteria. The lake trout is high on the scale primarily due to the size factor, although the landing rate on the species is higher than normally found in lake trout populations. The grayling, a species native in the Park, ranks sixth in angler satisfaction. It is largely extinct through its native range in the Park. The species is now found in numbers in only three alpine lakes that were originally barren. This modification of the original habitat of the species is thought to be responsible for its mediocre performance in the reported data.

The brown trout ranks low in the angler satisfaction category primarily because of its low catchability. The brook trout, which is last, is thought to have poor appeal due to the size factor.

If each of the quality fishing elements detailed in Tables 2 through 5 are compiled and given relative weight as indicated by the Yellowstone anglers interviewed as to what they thought a quality trip entailed, a single coefficient can be calculated. The method of compilation assumes that all (100 percent) of the anglers in the Park desire to have a satisfying angling experience; that well over a third thought that landing rates were the most important single element; and that the percentage of anglers who are successful is an equal prerequisite to that desired landing rate. Finally, less than 10 percent of the anglers interviewed thought that big fish were the most important element.

Weighing each factor in this general manner, though perhaps oversimplified, coefficients for each species can be calculated (Table 6). Lacking a term, the coefficient is called here the "Yellowstone Quality Fishing Coefficient".

Table 6.

Species	"Yellowstone Quality Fishing Coefficient"
1. Cutthroat trout	115.8
2. Rainbow trout	104.0
3. Cutthroat and Rainbow trout	98.3
4. Cutthroat and Lake trout	88.7
5. Lake trout	88.7
6. Brook trout	78.5
7. Grayling and Cutthroat or Rainbow trout	74.8
8. Cutthroat and Brook trout	71.1
9. Brown Trout	62.2

If this coefficient is realistic, it is apparent from the waters sampled that the native cutthroat trout is providing the best all-around sport fishing in Yellowstone Park. The exotic rainbow trout ranks second followed by waters where both cutthroat and rainbows (and their hybrids) predominate. Sequential ranking follows with cutthroat and lake trout, lake trout alone (both with the same coefficient); brook trout; grayling and either cutthroat or rainbow trout; cutthroat and brook trout; and, lastly, the brown trout.

It will be recalled that the Outdoor Recreation Resources Review Commission offered two solutions pertinent to salmonid management (King *et al* 1962): adding new waters and better management of existing waters. Regarding the former, it is suggested by the Yellowstone data that as new waters are created it might be possible to develop superior sport fisheries with the sport species already native to the drainage. It is not implied that the cutthroat trout would have the highest coefficient if it were introduced widely into waters where it is not native. World-wide shipments of cutthroat eggs (some 818 million) from Yellowstone Lake were made in the first half of this century. The general lack of success with the species outside of its historic range may be a good indication of this phenomena. It is proposed that native fishes, where they occur, are capable of providing superior sport fishing. It is noteworthy that in Yellowstone Park, where native cutthroat were helped over a falls that had previously excluded the species or planted into an adjacent watershed that had historically been barren, the cutthroat now provides the same quality of sport fishing as in those waters where it originally occured.

In regard to the second solution, that of better management of existing waters, these data further suggest that, if it were possible to transform or restore all of Yellowstone's waters now supporting exotic salmonids to their original condition, it would be possible to improve the quality of sport fishing. In relatively unaltered aquatic ecosystems, it may be highly presumptuous of man to think that he can improve on the biomass and population structure of native fishes that evolved over thousands of years.

As interest and concern regarding declining and threatened species, subspecies, and races of *Salmonidae* grows, there seems to be a tendency in some quarters to preserve relict populations as if they were museum pieces rather than as the logical tools for better management.

The motives cited earlier as the primary reasons for the widespread expansion of exotic fishes may be analyzed, based upon what has been learned from the 83 waters in Yellowstone Park. Did stocking exotic species initiate yields from barren waters? On some 34 waters for which there are data, exotic species, and most notably the rainbow trout, provide poor to excellent sport fishing. The data suggest, however, that had the range of the native cutthroat been expanded better yields would have been attained (yield in this paper refers to sustained recreational yields).

Did stocking exotic species maintain yields? On the Madison River, landing rates in the years maintenance stocking of exotic species was practiced were compared with recent years of "wild fish" management. It was concluded that landing rates in the fishery were not significantly different (Dean and Varley 1973). Maintenance stocking of native species in Yellowstone Lake and other waters was discontinued in the early 1950's. Presently recreational fishing in these waters is at least as good as fishing during the stocking era. From Tables 1 through 6, there is a suggestion that co-existing exotic and native species frequently provide less sport fishing quality than waters where either an exotic or a native species exists alone.

Did stocking exotic species increase or enhance yields? If it were assumed that the native species that have been replaced by exotics had similar sport fishing qualities as native populations present now, overall recreational yields have not been improved through the use of non-native trout.

Did stocking exotic species provide diversity, interest, and quality to sport fishing? Though a complex question that cannot be fully answered here, it may be pointed out that Yellowstone historically sustained three subspecies and/or races of cutthroat trout and a distinctive river-dwelling grayling. Popular accounts imply that the sport fishing qualities of each were somewhat different, and, indeed, a given form may vary considerably in individual waters throughout its range. Thus, it is suggested that diversity, interest, and quality were inherent in the historic and unaltered fishery of the Park. Subsequent exotic introductions have, therefore, merely provided the same diversity, interest, and quality presently found in essentially all other western waters – a unique diversity having been lost because of the introductions.

It is a matter of policy that in natural areas within the National Park System, native species are to receive preferential treatment with regard to preservation and restoration where this is feasible (USDI 1968). While this policy is defensible, it is gratifying that the preservation and restoration of native species in Yellowstone should provide recreational fishing that is generally superior to that offered by the exotic species that would ultimately be displaced through restoration.

REFERENCES CITED

Dean, J. L., and J. D. Varley. 1973. Annual Project Report (1972), Fishery Management Program, Yellowstone National Park. U.S. Fish and Wildlife Service. 84 p. (Processed).

Dean, J. L., and J. D. Varley. 1974. Annual Project Report (1973), Fishery Management Program, Yellowstone National Park. U.S. Fish and Wildlife Service. 170 p. (Processed).

King, W., *et al.* 1962. Sport fishing – today and tomorrow. ORRRC Study Report 7. U.S. Gov't. Printing Office, Washington, D.C. 84 p.

Northcote, T. G. 1970. Advances in management of fish in natural lakes of western North America. Pages 129-139 *in* N. G. Benson, ed. A century of fisheries in North America. Am. Fish. Soc. Spec. Publ. No. 7.

U.S. Dept. of the Interior, Bur. Sport Fish. and Wildlife, Committee on Rare and Endangered Wildlife Species. 1966. Rare and endangered fish and wildlife of the United States. Res. Pub. No. 34.

U.S. Dept. of the Interior, National Park Service. 1968. Administrative policies for natural areas of the National Park System. Revised ed. U.S. Gov't. Printing Office, Washington, D. C. 138 p.

ECOSYSTEM DETERIORATION UNDER MULTIPLE USE

By A. Starker Leopold

Department of Forestry and Conservation, University of California, Berkeley

I am increasingly convinced that fish and wildlife habitat in our western forest and range lands, both public and private, is undergoing a steady, chronic deterioration under existing patterns of multiple use. Livestock grazing in particular may be having cumulative ecologic ill-effects on the productivity of both lands and waters. Admittedly, my basis for this suspicion is more intuitive and subjective than proven; supporting data are fragmentary. I present the proposal as a hypothesis rather than a firm conclusion. I feel, however, that the hypothesis deserves the attention of conservation agencies and study by the scientific community. Let me present the case in the form of examples, drawn from my own experience.

Mule deer populations are declining steadily in all states west of the Great Plains. There must be some common denominator underlying this widespread phenomenon. Twenty five years ago I was involved in some intensive research on mule deer in California, and at the time we came up with firm conclusions regarding deer ecology. The gist of our findings, and those of many other investigators, was that deer tended to overpopulate their winter ranges and to damage their own winter food resource by overbrowsing. The obvious evidence was the periodic occurrence of starvation die-offs in severe winters. The solution seemed to be to reduce the herds by shooting some of the does, thereby maintaining a balance between deer and winter forage. Many states followed this formula, although some (like California) did not. But in all the western states, winter die-offs have become infrequent as the herds decline. Now the general consensus is that poor fawn production and survival is the underlying factor reducing deer numbers, not winter losses. Moreover, we seem to have good evidence drawn from the North Kings deer herd in the Sierra Nevada and other herds under intensive study that some nutritional deficiency in the does is leading to poor development of fetuses, producing weak or stillborn fawns. The public tends to blame the decrease of deer on past doe shooting or more currently on coyote predation. All the evidence suggests to me, however, that there has been widespread deterioration of the quality of deer forage on the spring and summer range and along the migratory routes, and persistent livestock grazing would appear to be a prime suspect in contributing to this effect. Admittedly, advance in plant succession with intensive forest practice and fire control has led to more closed canopy, but logging and wildfires would tend to counteract succession. Burns and cutover areas do not produce deer as they once did. I think that the ubiquitous cow is rendering subtle and cumulative effects on the soils and vegetation of western ranges, to the continuing detriment of deer herds.

I am currently engaged in preparing a book on the California Quail – its biology and management. Quail are decreasing steadily as are the deer. In agricultural valleys, the depletion of quail can be readily explained by loss of cover occasioned by ever-increasing intensity of agricultural use. But in the brushy and wooded foothills, which now constitute the final stronghold of the quail, cover is generally adequate, and the decrease in quail must relate in some way to reduction in available food in the form of seeds of weeds and broad leafed forbs. Persistent overgrazing by domestic livestock is quite clearly the primary cause of depletion of the quail food supply. In one locality in San Luis Obispo County, California, we have had the local quail population under continuous surveillance for 28 years, and local shifts in quail abundance can be positively traced to changes in grazing intensity. Again, as in the case of deer, the adverse effects of grazing are cumulative and chronic and affect the ecosystem as a whole.

Coming to a subject closer to our collective interests in this meeting, I am even more certain that the productivity of western trout streams is deteriorating under the continuous impact of multiple land use programs. Streams that were known to be highly productive in years past seem to have lost the capacity to produce and maintain high trout populations, even when the take is carefully regulated. Let me recount for you my experience with two parallel trout streams on the east slope of the Sierra Nevada near Truckee. In 1950, Paul R. Needham and I set out to find a location for a university field station where we could establish long-range studies of trout populations. We narrowed the search to two adjoining watersheds, Sagehen Creek and Prosser Creek. Both were superb small trout streams, suitable for the type of research Needham had in mind. The Sagehen Creek basin was wholly owned by the Forest Service, and by good fortune the grazing allotments were minimal – one band of sheep grazed across the basin on the way to and from the high country. No cattle grazing was permitted. Fortunately, we chose this site for our project in preference to Prosser Creek, where some private land in the mid-basin was subject to cattle grazing. Today, 25 years later, Sagehen Creek still meanders through grassy banks and is a favorite brown trout stream for dry fly enthusiasts. Prosser Creek, on the other hand, has been scoured by intermittent floods and runs shallowly over a broad cobbled streambed with few trout and few fishable holes. Both watersheds have sustained some logging; both were partially burned over by a wildfire in 1960. The only real difference has been the degree of grazing.

In some measure, I think that the type of stream degradation, illustrated so dramatically by Prosser Creek, is occurring on many or most western trout streams whose watersheds are subject to grazing and other forms of multiple exploitation. Considering grazing alone, there were 4.5 million cattle and 7 million sheep using the public domain in 1970, and perhaps that many animals again on private rangelands. I am quick to admit that all blame cannot be ascribed to the poor cow or sheep. Each of you surely has seen examples of the ruination of streams following wholesale clearcuts, extensive road building, damming and impoundment, sweeping wildfires, or subdivision for building. These forms of watershed abuse are obvious and deserving of attention. But the combination of uses, with grazing being the most insidious, is having cumulative effects on most western watersheds, and relatively little of our research is designed to measure or evaluate chronic habitat depletion.

There has been a great deal of excellent research on trout populations and trout streams. Most of it. however, has been short-term and directed at specific current problems. We tend to look at a stream as it is today, not as it was in the past. This is entirely parallel to our tendency to evaluate deer and quail ranges as they are, not as they were.

The topic assigned to me for discussion today is "Research Needs of an Ecosystem". I can suggest two ways in which chronic ecosystem depletion can be detected and measured:

1. **Comparative studies of streams in multiple use areas with streams in National Parks on Wilderness Areas subject to little or no development or land exploitation.** Considering this approach first, you are all aware of the remarkable response in fish size and standing crop achieved in Yellowstone Park by simple protective regulation. Can we measure the degree of response by protecting a fishery situated in a multiple use watershed? If so, I would predict a much smaller increase in size and number of fish. It will not be easy to find two comparable watersheds. But this approach is well worth attempting.

2. **Long-term studies in multiple use situations to measure deterioration over time.** This approach is far more tedious and more expensive because of the time element involved. Perhaps we could go back to streams studied intensively in years past and rerun measurements of trout populations, growth rates, production of food in stream bottoms and along banks, and other manifestations of productivity and ecosystem "health". By the same token we are now embarked in restudying the deer and quail ranges examined in the 1950's to detect changes in animal populations which by inference will point to basic changes in the supporting ecosystems.

In summary, I have a growing feeling that we have seriously underestimated the impact of grazing and other forms of land use on the capacity of wild lands to support wild animal populations, on land or in the water. Until we fully understand the impact of multiple use, we are in a poor position to make appropriate management decisions.

SYMPOSIUM SUMMARY

By Willis King

Before giving my summary, there is one item that I feel I must relate briefly. The list of endangered vertebrate fauna of the United States came out in May, 1974 with 30 species of fishes that are considered endangered. Twenty of those species are in the western states. This is surprising, because we would expect that conditions would be at least as good or better in the west than they are over the United States as a whole. This is not the case. Five of the species are trouts. There would be at least that many more trouts, if fishery taxonomists would finally straighten out some of the taxonomic problems we have with our trout, especially the cutthroats.

This situation indicates quite a lot to us. Its seriousness has been known to many aquatic biologists for some time. It is a result of the deterioration of aquatic habitats. Some of our more highly developed and sensitive aquatic organisms, including the trouts, are in serious trouble. We won't be having symposia on wild trout in primitive areas, unless their habitats are better maintained and preserved. This requires more attention than we have been able to give in our discussions this week. We cannot remain indifferent to such indications.

What I want to do in this Summary is attempt to bring into focus some of the things we have talked about. These may seem to be generalities, but are what we more or less agreed upon, and what was the focus of our discussions. I'm not going to refer to individual papers. I'm going to try to talk about ideas as they were presented by speakers.

One of the first things that was brought out was that we need wild areas to produce wild trout. This theme was present in our discussions on steelhead, Atlantic salmon, and on the resident trouts. Fish are a product of their environment, and cannot be separated from it. In the papers dealing with anadromous species, we were told that State, interstate, and Federal cooperation, even international cooperation, is necessary if we are to protect and restore these species.

Then, we found that fish are a whole lot like people, or people are a lot like fish; you can say it either way. They both need space; they both have GAS problems (General Adaptation Syndrome); they have their social order and life patterns. If we make much progress in understanding fish, the same as in understanding people, we have to understand their behavior.

There were few references to wild populations of trouts in reservoirs and tailwaters. There are some in lakes, but our speakers emphasized populations in streams. A large percent of water areas is thereby ruled out; at least fifty percent or more of our aquatic habitats.

The stocking of hatchery fish is generally adverse to natural fish populations, and the catch of wild fish may rise due to behavior patterns that are triggered by the stocking. Effects of stocking are usually short lived, and the end result on wild populations is often detrimental. Now, this doesn't mean that if there is a wild fish in a stream, that you shouldn't stock a hatchery fish. I don't think this was said or intended here.

We had some argument, but the majority agreed, that the maintenance of natural populations was more important in some waters than the level of angling produced. It is often more important to keep a species alive and to keep a type of angling alive, than how much angling is afforded or how many fish are caught. This is particularly important in management related to our National Parks, the National Wildlife Refuges, and to certain Federal, State, and private lands. We also agreed that restoration of a wild population to an area, where we believe conditions are favorable for it, is usually difficult, expensive and sometimes not possible. The biologists are not willing to concede that it can't be done, but they are quick to say that it will cost money and that all of the values that are represented in that area must be taken into account before we rush in with a restoration program.

We believe that wild trout areas should be identified and publicized. They may require special protection, but they don't require too much publicity. The fact that a relic trout population exists must be guarded. At the same time, to get support at the State or Federal level, you have to be able to make your case, but don't put a big sign on the newest highway, "The Last Ten Rocky Mountain Cutthroat Trout Are In This Stream."

We were shaken back a bit by Starker Leopold and some of the others who talked about management concepts. We have been taught that multiple use of lands and waters represents the highest public benefits. Public interest, you know, is a funny thing. You can warp it around to mean almost anything you want. I think we have learned here that we need to look at this concept of public interest, or multiple use, to be sure that it isn't a smoke screen. There are many areas where many uses are possible and are desirable. There are many other areas where one use must be paramount. This concept has been accepted when it comes to waterfowl management. We haven't quite got to this point yet where we are willing to say the same about fish. This is going to take effort on the part of anglers and fish managers to convince our public administrators and lawmakers, that fish and fishing may be the primary interest in some areas.

Dr. Leopold suggested that we go back and reevaluate some of our old survey data, to see where wild fish were found 20 to 30 years ago. In the first series of projects under Dingell Johnson (Federal Aid to the States in Fish Restoration), nearly every State had a fish survey project, to find out where their game fish were, what numbers, the condition of their streams and lakes. It's been twenty years since those projects were carried out. I hope some of them aren't still going, but one never knows. He suggested that biologists go back and see if they have any present day information for comparison. It would be well to repeat some of the earlier studies if there is a chance of restoring natural conditions and wild trout popoulations in your State.

We did agree in general on how to define a wild trout population. After hearing about a dozen definitions and writing them down, I have condensed them to a few words. "Wild trout are members of a naturally produced and maintained population, in a natural setting." Most of you agreed to this concept in your papers. I don't know how long it takes to establish a wild trout population. I won't define quality fishing, other than to say it is a highly personal matter.

On research needs, a few things came out, and this was one of the findings wanted from the Symposium. My notes includes three principal areas.

The first need was for an understanding of the genetic basis of trout characteristics and behavior. Some attention has been given to this, but apparently not enough. Fish managers still do not have a sufficiently sound basis for selecting the fish stocks that they want for specific purposes. In the past it has been pretty much a superficial selection process – and this may not be genetically sound. We need a better system for selecting stocks of fish to obtain the desired characteristics so that these may be passed to their offspring.

The second area of research needed was that we are not very sure of ourselves when it comes to interspecific relationships – such as rainbow-brook, or rainbow-cutthroat relationships. We need to understand the interspecific relationships that exist between those species and other trout or other fishes that may be in the same water. This is especially true where native fish are involved.

Thirdly, we don't know enough about the behavior of wild fish. We'vd studied the hatchery fish, perhaps as much as we need to. We know how to feed him, take care of him, and handle him, but we're not nearly as confident in our managing of wild fish populations.

The fishery biologists, the managers and the fishermen still have an opportunity to put more of these ideas into practice. It is going to take individual attention, and it is going to take sincere effort, at all levels. We do not want to be put in the position of doing too little, too late, since that has been the history of managing a great many of our natural resources. Let's not put it off.

Now, as our guides told us in Hawaii, "Hang loose!"

CONCLUDING STATEMENT

By Nathaniel P. Reed

Assistant Secretary of the Interior for Fish and Wildlife and Parks

Just before we got together this evening, I was handed a telegram. This one I think is important; it says, "Please convey my best wishes to the distinguished assemblage of anglers, biologists and trout managers; the future of wild trout well balanced with selective use of hatchery-raised trout is in your collective hands..." signed Rogers Morton, Secretary of Interior.

Superintendent Anderson, I know everyone in this room joins me in thanking you and your staff, the National Park Service members and their wives, who have made this Symposium such a great success. Jack and I have shared a great many moments in this park together, and one of the great qualities of this man is that he remembers the little things as well as the big things. Little things such as kindness to so many visitors and so many employees of this park, in spite of all the opposition of friends, foe and grizzly bears included. Jack Anderson is my man of all seasons. Thank you, Jack.

As you all know, Bill Luch is a fantastic character, and now you know he is one hell of a public speaker, and he is going to be a great President of Trout Unlimited. I can honestly say Bill, I can't think of a more perfect co-host. So, thank you and thank Trout Unlimited for making this Symposium happen.

This Symposium was organized by a dynamic trio: Frank Richardson, who took an occasional day off from his occupation, which, if you didn't know, is trout fishing. He is the only person I know in the Fish and Wildlife Service who would dare to charge me $20.00 to come to my own Symposium; Pete Van Gytenbeek, who we are just delighted to have here with us this evening; and John Peters, who officially represented the American Fisheries Society. Although Bill Luch and I take all of the bows and the kudos for our respective organizations, it is that dynamic trio and their secretaries who did all of the work. . . Thank you, gentlemen, from all of us.

A very special thanks goes to our TV crew – Vern Hennesay, Duane Turner, Don Tennet, and Burt Rounds. I've already observed some instant replays of the Symposium, and it indicates there were very few yawns and closed eyes, which must be some kind of a record.

I know you will join with me to thank with a giant applause John Amerman, Bob Jones, Dick Whipp, the kitchen crew and all of the young people of the Yellowstone Park Company who worked so hard to make you comfortable during your stay here in the Park.

And to you, Dr. King, whose dry wit, keen mind, and accurate watch has kept us in step and on time. Thank you, Willis, from all of us for setting a fast pace. I look forward to working on future symposia with you. One more round of applause for the discussion leaders and the panel members, including pinch-hitter Bill Helm. A tremendous amount of work went into those papers, and I think we all owe the speakers a great vote of thanks.

Now, as an afterthought, let me ask six of our visitors to stand, and we will give them applause. I would like to introduce to you this group, who because of the distance that they had to travel made a very special effort to be here. They are Ross Alexander, Fisheries Biologist, Nova Scotia; Rupert Andrews, Director of Sport Fish Division, Alaska Fish and Game; Harvey Andrusak, Regional Fisheries Biologist, British Columbia; Ron Johnson, Superintendent of Fisheries, Saskatchewan; Arthur Smith, Wildlife Biologist, Prince Edward Island; and Gerry Taylor Coordinator, Fish Habitat Improvement, British Columbia. Your presence has added an international flair to our discussions.

Fellow trout fishermen, we have had two days together discussing one of my favorite subjects, wild trout management. Back in the late winter of this year I announced that we would convene here in magnificent Yellowstone for this Symposium. Yellowstone in September, the crowds of midsummer gone, the frosted mountain peaks, a silhouetted grizzly on the horizon, the sound of bugling elk, the brilliant color of the aspens, and the rises of a great cutthroat – there is no other place to gather for such a meeting. With mixed feelings I now declare this Wild Trout Symposium to be concluded.

Socrates would have been pleased. Many have alluded to the problems that we face; remember Socrates for his strong belief was forced to take hemlock. I hope that his fate does not befall those of you who are brave enough to put forward new and innovative ideas. The ideas and concepts put forward at this meeting bear careful consideration. To accelerate the ideas and concepts put forward is important.

As most of you know, I take my trout fishing seriously. I have been involved both as an angler and as an administrator with trout. I have spent several years at it, really a lifetime, and many days have been here in Yellowstone. Since going to Washington, I've lost my innocence. I look back at those days before Washington as a time when the world was simpler and the problems of trout resources much easier to comprehend and solve. There really is nothing like a working day as field biologist or a day on a trout stream as an angler to give you that feeling about life, and there's nothing like being a Washington bureaucrat to help lose it. I haven't become disillusioned or cynical, actually, I'm an optimist; but my perspectives have changed since I became Assistant Secretary for Fish, Wildlife, and Parks.

You managers of wild trout fisheries shoulder a major responsibility to accelerate the development of an ethic which zones, if you please, wild trout waters from stocked waters. An ethic which incurs restrictions of tackle and kill, which are the very tools of development of that elusive term "quality sports".

Perhaps each of us would not agree on that term, the precise description of quality, but all of us know what poor quality is. No one who is involved with the organization of this Symposium thought that genuine instant miracles would occur. But what we hoped for has come true, this distinguished congregation of trout experts, perhaps the most impressive gathering of biologists, administrators, anglers, managers, and students, have assembled and rationally discussed problems and proposed solutions. We have communicated!

Trout Unlimited President Bull Luch and I thought it was **our** drawing power that brought you here, but perhaps the amenities of Yellowstone, September trout fishing, autumn colors, the sight and sound of rutting elk, had something to do with it. Whatever the reason, the outstanding attendence at this Symposium indicates the fascination of the subject. What we had hoped for most of all, that all of you, old and young in years, would use your minds hopefully unimprinted by traditional ethics which qualify trout fishing to killing ten fish or ten pounds, or the fish manager's obedience to the god of license sales at all costs.

We hope that you will leave Yellowstone refreshed, renewed, determined to face certain realities of the $12 barrel oil world in which we are living.

The age old policy of dumping hatchery fish off bridges into all fishable waters will be all to expensive to consider in a very short space of time. The quality of stocked trout, their genetics, their stamina, the waters where they will be stocked, their survivability, their ability to grow, their wildness, will be key factors in fish production in the future. Hatcheries programs, and this includes the Fish and Wildlife Service hatcheries, have been preoccupied in raising rapidly growing, oddly shaped, genetically tame candidates more suitable for canning than for fishing. Anglers supposedly want fighting fish, yet we grow nice safe gentle idiots who have little chance for survival in the waters into which they are released. Furthermore, most hatchery fish, like too many American goods, are programmed to self-destruct after two years. Pounds of fish per dollar expended has for too long been the Holy Grail, and I for one am tired of the same old stuff. By hook or by order I hope I will see the Fish and Wildlife Service take a leadership role in developing strains of fish which will survive, fish which may be difficult and even expensive to raise, but which are strong and healthy, a sporting quarry in a real world of angling.

If we are to use our collective minds, if we have courage, if we work together, we can preserve and enhance the wild trout fishery of North America. The blue ribbon trout water rivers of America need to be loved and revered. That is a goal worth working for.

Before we write the final chapter of our Symposium, I would share with you a passage from Robert Travers' book, *Trout Magic.* It is the testament of a fisherman, a wonderful philosophy: "I fish because I love to, because I love the environment in which trout are found which are invariably beautiful, and hate the environment where crowds of people are found which are invariably ugly. Because of all the television commercials, cocktail parties, and assorted social posturing, I thus escape. Because anywhere where most men seem to spend their lives doing things they hate, my fishing is at once an endless source of delight and an act of small rebellion. Because trout do not lie or cheat and cannot be bought or bribed or impressed by power, but respond only to quietude and humility and endless patience, because I suspect that men are going along this way for the last time, and I for one don't want to waste the trip, because mercifully, there are no telephones on trout waters, because only in the woods can I find solitude without loneliness, because bourbon out of an old tin cup always tastes better out there, because maybe one day I will catch a mermaid and finally not because I regard fishing as being so terribly important, but because I suspect that so many of the other concerns of men are equally unimportant and not nearly so much fun."

We will meet again. In the interim I challenge you to remember things that have been said here, to use these ideas and philosophy for the tough decisions that you make affecting the management of our wild trout resources.

Thank you for coming and for participating.

CONCLUDING STATEMENT

By Bill Luch

President, Trout Unlimited

I have thought long and hard about what I was going to say to you this evening, and I have something serious to say and also something on a light basis. Do I take it light first and then serious, or serious and then light? I am going to go light first and then serious because I don't want you to forget what I am saying in the serious vein by laughing afterwards.

First, I want to tell you a true story. You know that no serious fisherman ever lies and certainly a longshoreman fisherman like me never lies. On the east slope of Mt. Hood there is a small lake that, fortunately, the Fish and Game Commission never got to and so it has a wild trout population. This little lake provided a pretty nice fishing place; it wasn't well known. I used to go by it to stop and get water, packing in 6 or 8 miles bear hunting. On this particular trip something happened to me that was rather unique. I was bitten by a rattlesnake, and that was the last bear hunting trip I ever took. I figured if the animals didn't want me there, I wouldn't go back.

At the time, I was filling my water jugs on the banks of the little lake, and there was one man fishing with a device that you very seldom see on Pacific slopes, but eastern gentlemen, I am sure, have seen this before; perhaps those from the Mountain States have also. The guy had a big truck tire innertube with a pair of waders latched to it. He was standing in the waders, and he was fly fishing with only a part of him out of the water. Now this lake shelves off pretty fast to about 40 feet deep. While I was there, a car pulled up with what I am sure was one of the first cartop boats, a little plywood kind of tub. This guy got out of the car, stretched, looked out just as this gentleman in his wader innertube device pulled in a 15-inch trout. The guy, I'll say gentleman because he was fishing with flies and you know how that goes, released the trout, and this guy in the car went bonkers. He threw the boat off the car, pulled the fishing gear out, threw the oars out, pushed the boat in, put his boots on, and rowed out to this guy. Then he jumped up, pulled his boots up, and stepped over the side . . . which is as good a story about not going off half-cocked as I have ever heard.

During the term of this magnificent symposium, a couple of things have occurred to me that I think should be brought out. One that I think is important is that we all reflect on the fact that, at least in my knowledge, for the first time a sportsmen's organization has joined with the Federal government and put on something like this. It is unique, it is great, it needs to be fostered and continued. It needs to go from the Federal level to the State level and down to the county level. Another thing that really heartens me is the number of young people that are at this conference who paid their own freight to get down here, and that is exciting to me.

Now on the serious side, Father Wallsmith, who is the President of the University of Portland, made a remark one time to an audience like this. He said, "You know, friends, we are still like preachers. We come to our church on Sunday and we preach hell fire and brimstone to the wrong people. It is our friends that are here; we are talking about those who aren't here." That has happened here to some extent.

I would like to give you a very personal experience. I am going to use Frank Moore's name; some of you know Frank and some of you don't. He had the opportunity to get down to the Tetons to go fishing so he isn't here tonight. For four years the Northwest Steelheaders Council approached the Oregon Game Commission to protect portions of three streams that had significant wild trout populations. We did not ask that they take the fishermen off; we asked for a combination of gear and creel limit restrictions for four years. It wasn't until Frank Moore became a Commissioner that we got it by a 3 to 2 vote. We got only one portion of one stream; we lost the other stream. Do you know who shot it down the hardest? The biologists of the Oregon Game Commission—they destroyed us. I have never understood that; I don't understand it to this day, but I will tell you what happened.

We had a firestorm on our hands; we had every motel owner and greasy-spoon restaurant owner in the vicinity of these streams for miles around, Chamber of Commerce representatives, bankers, drugstore and hardware owners screaming bloody-murder not to protect these streams. We were some kind of freaks in their eyes, and we took the brunt for four years until Frank and Dan Callaghan got on that Commission and had the guts enough to swing one more vote over the objection of the staff.

No one has discussed here what is really going to happen when we go back, when you try to implement some of the things that you have heard here. That firestorm in Oregon will be minor as compared to some in your states. You are going to have everyone down on you until you have re-educated the public to something that you and your predecessors are responsible for, and that is the planting of catchable trout indiscriminately and the conviction of the average trout fisherman that he deserves and demands a limit every damn time he goes fishing. And where does it come from, fellows? Trout Unlimited didn't do it; the Federation of Fly Fishermen didn't do it; Cal-Trout didn't do it; none of the conservation organizations have done this; it has come out of and directly from the bureaus within the States and Federal government that have told the citizens for 35 to 40 years that it is their right to go out on the stream and bring home a limit of trout. And dammit, it is not their right to do so, not if we are going to preserve what we have very little of left. It is their right to go out on the stream, but it is not my right to take my wife and three children and come with 50 trout, 100 in possession. Now protect that resource, brother!

Now I want to ask you a question. How are you going to reverse 30 years of mistakes? We, Trout Unlimited, cannot do it. We can support you; we can beg you as we have done in the past. You are the only ones that can do it; you have the scientific knowledge, the scientific clout, and the background to get out there and put your butts on the line and say what has got to be done. We will be right there with you; we cannot do it alone; we are tired of pushing; we would like to tailgate for awhile. Further, we ask you to ask yourselves the next time you look in the mirror this question. "Do I have the courage to put my job and my career on the line, my well-being on the line, to do what I know is right?" That is a tough question, a damn tough question, but you have got to ask it.

Now, I am the last guy in the world to say that every stream should have wild trout in it. That would be foolish. There are streams that are going to continue as a put-and-take fishery; they won't support wild trout. But there are streams in every state represented here, and others, that if we are going to continue to allow to deteriorate, we are committing a crime not only against nature, but against ourselves. It is a damn tough hard question to answer, but I am begging you, I am pleading with you, go back and face the hatchery bureaucracy that many of you grew up in and tell them this far and no further on these streams. We'll be with you 100 percent.

Thank you very much.

TROUT UNLIMITED is a non-profit, national conservation organization dedicated to the protection of the cold water resource. If you would like more information about Trout Unlimited write to: Trout Unlimited, 4260 E. Evans Ave. Denver, Colorado 80222