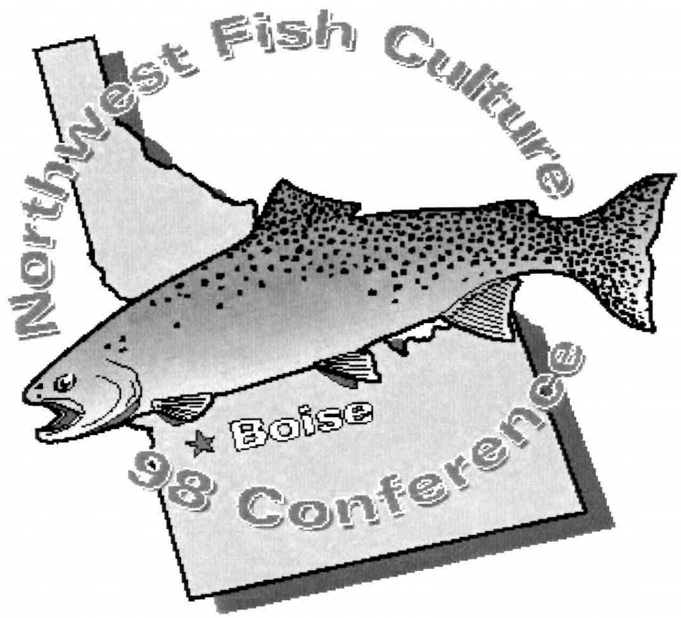
49th Annual Pacific Northwest Fish Culture Conference



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PROCEEDINGS

OF THE

FORTY-NINTH

PACIFIC NORTHWEST

FISH CULTURE

CONFERENCE

DECEMBER 1-3, 1998

GROVE HOTEL
BOISE, IDAHO

CO-CHAIRMEN
TOM ROGERS and TOM FREW
IDAHO DEPARTMENT OF FISH AND GAME

49^{th} Annual Pacific Northwest Fish Culture Conference

Preface

The Annual Pacific Northwest Fish Culture Conference is an informal meeting by and among fish culturists, for the exchange of information and ideas about all aspects of fish culture. These conferences are hosted on a rotating basis by the various fisheries agencies and entities in the Pacific Northwest. The subject matter is generally limited to topics that have direct application to fish culture, although many times the subjects' spill over to management and research themes, which are intimately entwined with the science of fish culture. The meeting is also utilized to renew old friendships, begin new ones, and develop personal contacts between those of common interest. All persons interested in fish husbandry are invited to attend and to actively participate.

The theme of **"Making Fishing Better,"** constitutes an agency perspective this year, allowing some insight into the area of sport fishing. Agencies and commercial hatcheries allow tremendous numbers of the public to enjoy the angling experience. As evidence of the popularity of sport fishing, Idaho devotes a great deal of effort in this endeavor. In the past, this conference has been an inspiration to many fish culturists to strive to improve fish culture techniques and ultimately improve the quality of the fish, which are produced. We suspect this inspirational history will continue through this 49^{th} conference and beyond.

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Door Prizes:	Rick Alsager, Tom Tighe
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Session Chairs:	Keith Johnson, Doug Young, Joe Chapman, Gene McPherson

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KEYNOTE ADDRESS: MAKING FISHING BETTER WITH CULTURED FISH.......OR NOT?

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Abstract

State fisheries agencies are mandated to protect and perpetuate fish resources and to provide fishing. Cultured fish play a direct role in providing fishing, supporting over 80 percent the lake and reservoir trout fisheries in Idaho and a major portion of the total recreational trout fishing in most Northwest states. Cultured salmonids play other beneficial roles in education, angler recruitment, and absorbing and segmenting consumptive fishing effort. Fish culture has played a major role in attempts to restore wild stocks, with several notable successes. The benefits of sustaining and attempting to restore fisheries with cultured fish are not without cost, however. The financial cost is substantial, with 43 percent of Idaho's discretionary budget going toward culturing resident salmonids. Much attention has been focused recently on suggested direct negative impacts of cultured and introduced fish on imperiled wild stocks. The greatest cost, however, is the created public and political perception that fish culture is a cure all, and an acceptable alternative to addressing habitat problems. Despite past sins and perception to the contrary, most current uses of cultured trout in streams are driven by habitat conditions. In Idaho, only three percent of stream miles are stocked with cultured trout, and eighty percent of those have little or no potential for natural trout production. Historical advancements and past measures of culture success have focused on the culture product. Increasingly, culturists are and need to continue working with management and research looking at how the culture product is used and how it can play an even greater role in making fishing better in the Northwest.

Introduction

State fisheries agencies are mandated to protect and perpetuate fish resources and to provide fishing. Cultured fish play a direct role in providing fishing, supporting over 80 percent the lake and reservoir trout fisheries in Idaho and a major portion of the total recreational trout fishing in most Northwest states. Cultured salmonids play other beneficial roles in education, angler recruitment, and absorbing and segmenting consumptive fishing effort. Fish culture has played a major role in attempts to restore wild stocks, with several notable successes. The benefits of sustaining and attempting to restore fisheries with cultured fish are not without cost, however. The financial cost is substantial, with 43 percent of Idaho's discretionary budget goes toward culturing resident salmonids. Much attention has been focused recently on suggested direct negative impacts of cultured and introduced fish on imperiled wild stocks. The greatest cost, however, is the created public and political perception that fish culture is an acceptable alternative to addressing habitat problems. Despite past sins and perception to the contrary, most current uses of cultured trout in streams are driven by habitat conditions. In Idaho, only three percent of stream miles are stocked with cultured trout, and eighty percent of those have little or no potential for natural trout production. Historical advancements and past measures of culture success have focused on the culture product. Increasingly, culturists are and need to continue working with management and research looking at how the culture product is used and how it can play an even greater role in making fishing better without reinforcing the misconception that hatcheries are a cure-all.

State fish and game agencies are charged first and foremost with preserving and perpetuating fish resources for future generations. Other agencies and institutions have that same obligation or interest. But key to understanding states' perspectives on the use of cultured fish is the rest of our mandate . . . "for fishing". Providing fishing requires that fish resources be managed, not just preserved. Inherent in managing fisheries is that potential risks, costs, and benefits of management actions be continually weighed.

Considerable attention has been focused in recent years on the effects of cultured fish on wild stocks and wild stock fisheries. Conferences such as "Uses and Effects of Cultured Fish in Aquatic Ecosystems" and "Wild Trout and Planted Trout – Balancing the Scale", popular and peer reviewed articles, various Endangered Species Act related documents, and mitigation research projects have examined the role of cultured fish in fisheries management. I would like to offer some state agency perspectives on the benefits and costs of using cultured fish to make fishing better.

Making Fishing Better

The states' use of cultured trout originated in a perceived need to supplement natural populations as a means of preserving and perpetuating them, or to enhance the productivity of a fishery. In time, state fisheries managers learned that many of these efforts merely contributed to the decline of wild trout stocks if the initial habitat or harvest problems were not addressed. Currently, cultured trout have little role in supplementing wild trout populations as a fisheries enhancement tool by itself.

Cultured salmonids have and still do play an important, but minor, role in restoration of wild stocks where habitat problems are corrected and cultured fish from captive brood stock are used for supplementation or reintroduction. In this capacity cultured salmonids have played a successful role in the restoration of wild stocks to the point where they could support fisheries – the greenback cutthroat in New Mexico and Colorado, the Apache trout in Arizona, and the Bonneville cutthroat in Utah being recent examples.

The primary manner in which cultured trout make fishing better is in providing trout fisheries where none would otherwise exist. In states across the west, a major portion of existing trout fisheries are dependant on cultured trout. Oregon estimates that 80% of all trout harvested in that state come from a hatchery. All of Nevada's significant trout fisheries are hatchery supported. In Idaho, cultured trout are used to support fisheries primarily as 3 to 9-inch put-grow-and-take fish in lakes and reservoirs and as "catchable" sized fish in small lakes, ponds, and streams.

Streams

In Idaho, and in most western states, the angler's preferred fishing is for trout in streams (Reid 1988). In Idaho, 30% of the annual angling effort is so directed. The role of cultured trout in managing stream trout fisheries varies considerably between states. Montana, under a wild trout policy and blessed with an abundance of high quality streams, stocks very few cultured trout in streams. By contrast, Nevada has essentially no significant trout fisheries that could support themselves without cultured fish. Idaho currently stocks 857 miles of streams with "catchable" trout. Based on the Northwest Rivers Inventory habitat classification of Idaho streams (Nellis and Allen 1986) and Idaho's Section 319 water quality assessment, at least 80% of those stream miles have limited or no potential to provide fisheries without cultured fish. One-fourth of Idaho's "catchable" production is stocked in streams.

Lakes and Reservoirs

Lakes and reservoirs support a major portion of trout fishing effort in the west. In more arid western states, lakes and reservoirs may support 85% or more of the fishing effort (Jim Curran, Nevada Fish and Wildlife, personal communication). Even in northwestern states with greater stream resources, lakes and reservoirs may support half or more of the trout fishing effort. In Idaho, 48% of licensed anglers fished lakes and reservoirs for trout, and 28% of the state's total fishing effort was directed at trout in lakes and reservoirs (Reid 1988).

Few lakes and reservoirs have wild trout populations that could support trout fisheries. Of Idaho's 186 major public fishing lakes and reservoirs which have trout fisheries, only 13 (8%) have trout fisheries supported by wild stocks alone; another 17 (10%) are potentially capable of supporting trout fisheries with wild trout. One hundred thirty-three (82%) provide sport fisheries for trout dependant on the use of culture fish. Overall, three-fourths of Idaho's "catchable" production and essentially all of the fry and fingerling trout production is stocked in lakes, ponds, and reservoirs.

Other Roles

In addition to these direct roles, cultured trout have several indirect roles, which benefit fishing. Cultured trout have been used extensively for educational purposes and to help students and adults learn about the need for clean gravel and good water quality. Over 300,000 people per year view hatchery trout and incubating trout eggs in a living stream display a the Morrison-Knudsen Nature Center, operated by the Idaho Department of Fish and Game in Boise. They have been used effectively by schools in adopted streams to learn and draw attention to the importance of habitat protection and restoration.

Put and take hatchery trout programs recruit anglers. These anglers then become important constituents in support of policies and legislation to improve water quality and minimum stream flows. Over 58,000 angler hours are expended in a put-and-take fishery on an 11-mile reach of the Boise River in Boise (Reid and Mabbot 1987). During the winter of 1992-1993, when the Bureau of Reclamation cut flows to less than half of the previously agreed to 150 cfs minimum flow, the Department publicized that trout stockings were being terminated because of low flows. Numerous television and newspaper reports and editorials were run on the need to provide adequate flows for fish. As a result, a bill to allow the conversion from consumptive to non-consumptive in-stream water rights was introduced in the Idaho Legislature. The bill did not pass, but its introduction reflects the potential influence that participants in an urban stocked-trout fishery can have on environmental legislation.

Hatchery trout fisheries also play an important role in absorbing consumptive pressure which might otherwise be directed to wild trout fisheries. As referenced earlier, the most preferred trout fishing by Idaho anglers is in streams, and 50% of 8,515 anglers surveyed statewide by Reid (1988) indicated they would not continue to fish their favorite stream if they could not keep some trout.

Providing hatchery trout fisheries in proximity to wild trout fisheries effectively segments consumptive and non-consumptive effort and absorbs consumptive demand for stream trout fishing. Elle (1993) evaluated the wild trout population and fishery for the first year following adoption of a two-fish wild trout limit on the South Fork Payette River in Idaho. While there was no recent data for comparison, he found nearly identical effort in the two trout area as an adjacent six-trout area which was stocked and designated as put-and-take (59h/acre vs. 55 h/acre). Yet exploitation of wild trout over 10 in was only 5% in the two-trout zone and 44% in the six trout hatchery zone.

Rohrer (1991) took a census of the fishery in the Middle Fork Boise River during 1988 when hatchery trout were being stocked over an entire 40-mile reach. He repeated the census two years after eliminating hatchery plants in the upper portion and concentrating all stocking in the lower 11 miles, where habitat was less suitable for wild trout and access was easier. At the same time a quality regulation of two trout, non under 14-in, was placed on the upper reach. Estimated total effort during 1990 was nearly identical to that estimated in 1988 (8,680 h vs. 8,727). The distribution of effort changed markedly, however. Effort in the lower reach comprised 62% of the total effort in 1988 and 90% in 1990, after all hatchery stocking had been moved to that area. Having the hatchery trout fishery available not only provided a consumptive fishery, but increased angler acceptance of restrictive wild trout regulations.

Development of put-and-take ponds adjacent to several rivers and streams that have historically been stocked has resulted in more fish making it to the angler's creel and public acceptance of wild trout management on those rivers and streams.

Risks/Costs of Using cultured Fish

These aforementioned uses of cultured trout have had irrefutable benefits in making fishing better. The use of cultured salmonids has not been without cost, however. Most attention has focused on the potential detrimental biological effects of stocking cultured salmonids with wild stocks (e.g., White 1992). I believe that indirect negative effects of using cultured fish overshadow any direct biological impacts that the fish themselves have on wild stocks.

One obvious indirect impact is the monetary cost. Not counting capital costs, Mauser (1994) estimated the Department's average cost of rearing, transporting, and stocking put-and-take trout was $.62. Even at Idaho's current goal of a minimum 40% return, each fish in the anglers' creel would cost $1.50, one-tenth the cost of an annual license. The Department currently spends 43% of its discretionary (license and Sport Fish Restoration Act) funds generated from fishing on hatchery-related programs for resident fish.

A second adverse effect of using hatchery fish is reinforcement of misconceptions that harvest is independent of the production capacity of natural systems, and that socking is an acceptable substitute for harvest restraint. Of Idaho's wild trout fisheries, roughly one-third have a trout biomass of less than 15 lb/acre, and only one third exceed 50 lb/acre (Elle 1993). While put-and-take stream fisheries can easily be managed for higher yield, this use of cultured fish can undermine efforts to manage wild trout fisheries within natural production capabilities.

The greatest adverse effect associated with using hatchery fish is reinforcement of the misconception that socking is an acceptable alternative to habitat protection or restoration. Fish and game agencies across the country have historically responded to declining fisheries due to habitat degradation with hatchery supplementation of the fishery. While hatcheries may play an important role in some fisheries restoration efforts, these uses of stocking and insufficient information and education on habitat and harvest-related limitations on fisheries have given the public the message for decades that hatcheries can fix all fisheries problems.

These misconceptions have stemmed not from the culture but the use of hatchery fish. Major changes are occurring, however. From historically stocking essentially every stream that was reachable by vehicle, Idaho dropped to 2000 stream miles stocked in 1985. In their 1991-1995 Fish Management Plan, the Department adopted a policy of managing only for wild trout where habitat is capable of supporting an acceptable fishery (guideline of 0.3 fish/h catch rate for trout greater than 8 in). By 1993 the miles of streams stocked had dropped to less than 900 of Idaho's 26,000 stream miles. Numbers of "catchable" trout stocked in streams dropped from nearly one million to 658,000.

To measure angler attitudes about the role of hatcheries in fisheries management, I sent a post card questionnaire to 200 licensed anglers in each of Idaho's seven administrative regions. Names were selected at random from the state's license database. The questionnaire asked anglers to allocate the $15 they spent on a fishing license among six major fisheries-related programs. The 506 anglers who returned questionnaires allocated 32% of their license money to stocking, compared to 21% on habitat protection and enhancement, 14% on enforcement, 13% on access, only 7% on surveys and research, 4% on information and education, and 10% on "other".

It is no wonder that developers propose, and much of the general public finds it acceptable, to use hatcheries as mitigation for damming rivers, changing flows, and otherwise altering habitat important to wild stocks. When hatchery mitigation is less expensive than avoiding habitat impacts, the pressure from development interests and public acceptance of hatcheries result in major challenges to fisheries managers to maintain habitat conditions and perpetuate wild stocks.

Summary

The use of culture fish does make fishing better. The use of cultured fish directly make fishing better by providing fishing where none would otherwise exist and they indirectly make fishing for wild stocks better by their use in education, recruitment of anglers and resource advocates, and diversion of consumptive fishing effort. The use of cultured fish to make fishing better has not been without cost, the greatest being public misconceptions that have been created on their appropriate uses.

Because stocking fish is one of the relatively few quantifiable, tangible, and easily measured accomplishments of state fisheries agencies, it has often been the first thing held up to the public in media contacts, agency annual reports, and other accounting of agency accomplishments to enhance fishing. In so doing, fisheries agencies have reinforced a major misconception that stocking solves most fishery problems and undermines support for sound management of wild stocks and their habitat.

Efforts to enhance fish culture have focused on production of their product, with success measured using units of numbers, size, pounds, condition, and time available. Major strides have been made in the efficiency of culture practices and the quality of the culture product. Increasingly, culturists are and need to continue working with managers and researchers in efforts to enhance what cultured fish accomplish. In that arena, responsibilities and successes are shared between culture and management. The challenge to both is to measure and communicate success-using units such as hours of angling supported, angling satisfaction, and cost to the creel rather than numbers or pounds of fish planted.

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Session I

Making Fishing Better!

Session Chair:

Joe Chapman
(Idaho Department of Fish and Game)

UTAH'S URBAN FISHERY IN THE HIGH UINTAS

by

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Abstract

Utah's High Uintas have always been known for their beautiful, pristine, backcountry lakes. Considered far from the city and way up in the mountains, away from the rat race of urbanization. However with the State of Utah's booming growth and network of fast speed highways, the Uintas are now just a little over an hours drive from most of the Wasatch front. The roadside lakes have now become an "Urban Family Fishery". Most of the lakes and rivers along the Mirror Lake Highway are now stocked once or twice a week with catchable size fish. The once out of the way Uintas, in certain areas, have become a put and take fishery with many families pouring into these fishing holes. The Uintas are second only to Strawberry Res. as the most fished area in the state during July and August. The area has become a very important economic and recreational area without any sign of ever letting up. The roadside lakes along the Mirror Lake Highway are now the Urban Fishery of Utah's High Uintas.

Introduction

The name of my paper is "Utah's Urban Fishery in the High Uintas". What is an urban fishery? Maybe you picture Andy and his boy Opie walking along with their fishing poles over their shoulders and a bucket of worms, walking down the road to the fishing hole at the edge of Mayberry to do some fishing. I often picture a small pond in the center of a developed sub-division where the local kids can ride their bikes down to the pond and fish and swim all day. Here the kids would set around and dunk/ nightcrawlers and swim when it got too hot or if the fishing wasn't good. The stocking truck would come by once a week to put in a few net full of pan size fish that was suppose to last till the next weeks stocking. The boys would take turns calling the nearby hatchery to see if they could sneak any information on what day they were going to be stocking the pond so they could be there first. Sometimes we have to rethink what an urban fishery has become in today's fast pass society with two household incomes and sport utility vehicles in front of each home. Its a hurry, hurry, hurry society with a "drive-up" mentality or "what's in it for me" attitude. This "drive-up" mentality has now gone to fishing along Utah's Mirror Lake Highway, where fast, easy access and convenience to the roadside lakes have made some lakes in the High Uintas an urban fishery for sure.

The Uinta Mountains

The Uinta Mountains of northeastern Utah are unique in that they are the highest mountain range in Utah and the only major range of mountains in the contiguous United States to lie in an east and west direction. This is a country of snow-capped mountains, large alpine basins dotted with lakes, steep rocky slopes, green meadows and tall trees. Four of Utah's major rivers, the Duchesne, Provo, Weber and Bear, originate in the snowfields of these mountains. There are well over 1,000 natural lakes in the Uinta Mountains and more than 650 of these support populations of game fish.

Located in the center of this pristine, beautiful backcountry paradise is the Mirror Lake Highway, Utah's urban fishery in the high Uintas. This Scenic Byway is located an hours drive to the east from most of the Wasatch front and Utah's most populated area, with well over a million people. This beautiful highway has

26 developed campgrounds, 12 major trail heads to the back country, and 12 roadside lakes and rivers for the drive-up recreationalist, plus many other undeveloped camping spots along the road. Some of theses lakes have handicap access around the whole lake. This area has intense public pressure during the summer months of June, July, August and September. Congress has even initiated a user fee to those using the highway to help keep up with the increased usage and demand on the resource.

This area once considered far from the city and way up in the mountains, away from the rat race of urbanization has now become "Utah's Urban Fishery in the High Uintas".

With Utah's booming economy came a booming population growth especially along the Wasatch front and its surrounding bedroom communities. This booming population brought increased demand on all the natural resources, especially the small urban fisheries which in turn overflowed out into the nearby Mirror Lake Highway and its roadside lakes and rivers. Utah's urban fishing opportunities are very limited, especially close to the Wasatch front due to new development, protected water sheds for culinary use, and with Utah being the second driest state in the nation. The once out of the way Uintas, along the Mirror Lake Highway, has now become a put and take fishery with many families pouring into these fishing holes without any sign of letting up.

History

The Mirror Lake Highway, which cuts through the middle of the Uintas, use to be a one lane, rough jeep trail that took hours to travel in the best of condition. The roadside lakes were stocked with a truck once a year and horse back was used to stock the back country lakes with mostly cutthroats, brook and grayling. This was all done using milk cans strapped on the sides of packhorses with gunnysacks tied around the top. The jostling of the water in the cans caused by the horses walking kept it aerated enough to keep the small fish alive. On long trips fresh water was added to the milk cans once or twice during the trip.

The back country lakes are now aerial stocked with a fixed wing airplane, what use to take months to stock on horse back can now be done in hours with a higher percent survival.

The roadside lakes and rivers are now stocked once or twice a week with a truck instead of once a year and the pressure is so high that even that is not enough to meet the demand. The old jeep trail is now a 55 mph highway and an hours drive from the Wasatch front. Families flock to area to get out of the heat and freeway construction, brought about by the 2002 Olympics, to do a little camping and fishing and to get out of the city.

Stocking

The lakes and rivers along the Mirror Lake Highway are stocked weekly and most even being stocked twice a week with catchable rainbow trout and catchable albino rainbow trout. The waters along the highway receive over 102,000 ten-inch catchables in a three-month period, which is equal to over 36,000 lbs. of fish. The number of fish averages 278 fish/acre of surface water or 99 lbs. of fish / acre of surface water annually. Strawberry Reservoir, the #1 fishery in the state receives 4.5 lbs. of fish / acre as a comparison.

The albino rainbow trout is an urban fish if there ever was one and is used for that purpose. The albino rainbow is a true albino and is stocked at a 3 to 1 ratio in most of the roadside lakes and rivers. The albino was originally brought into the state for research purposes but the public interest in this unique fish has made it a favorite in urban fisheries such as the Mirror Lake Highway. It serves a dual purpose in being stocked in these heavy fish waters; it gives an added variety in the urban creel that most people desire and it is a marker to show the public that the waters are being stocked and there are fish in the water. There are only three lakes along the highway that are not stocked with albinos and we get more complaints on those three lakes as not being stocked than the others are combined. Not everyone is a good fisherman and so if a fisherman can't catch a fish it means that there are no fish in the water but when you add 25% albinos and they can see the fish then the fisherman can see that we have done our part and its up to him to catch them.

The fishing regulations in this area allows a daily bag limit of 8 fish per angler which puts an added pressure on the hatchery program to stock this many lbs. of fish. This is one area that needs to be addressed to cut the bag limit back, which will give more fishing opportunity for the general public. Most of the public has the "catch my limit" mentality and the limit can be lowered to save more fish for others, take pressure of the hatcheries, and still allow more people to "catch my limit" attitude.

Surveys and Study

The increased fishing pressure and demand on fish has dramatically increased over the last few years. Not only state wide but especially in the Uintas and along the Mirror Lake Hwy. An angler survey done in 1995 had some very interesting results:

In the months of July, August and September the Uinta Mountains were the second heaviest fished area in the state, just behind Strawberry Resiovior, the #1 water in the state. This means that more people came to the Uintas to fish than Flaming Gorge, Lake Powell, Utah Lake, Bear Lake, Fish Lake and Willard Bay during the summer months. These are Utah's most popular fished waters. And it is only slightly behind Strawberry and Lake Powell for the entire year and the Uintas are covered with snow seven month of the year. In a 1996 study by the American Sportfishing Association, sport fishing in Utah brought in over 336 million dollars to the state's economy. And the Uintas as a whole brought in over 28 million since it is so heavily fished and you can see the economic and recreational impact it has on Utah's fisheries program as well as to the local and State's economy.

Conclusion

So what is an urban fishery, especially in today's fast pace society? Yes, its still Andy and Opie walking down the road to the edge of Mayberry , after work, to catch some fish with the other neighbor kids who are there on their bikes. But it is also the roadside lakes of the High Uintas with its frequently stocked catchables. Why is there a need for family fisheries? We are loosing a generation of fisherman and unless we provide this type of urban fishing we are going to loose fishing all together. The special interest groups with their special regulations and hidden agendas aren't going to cut it when it comes to paying the bills and getting the fish out into the waters for the public. Without this strong base of everyday people to support hatcheries and the put and take programs, the natural reproduction isn't or can't take the type of pressure we receive in these urban type fisheries. They are our "bread and butter" when it comes to the state's fishing programs. And why should we call the Mirror Lake Highway in the High Uintas an urban fishery? Because of Utah's dramatic development and growth, the Uintas have become that "just out of town" fishing hole and as growth continues to increase and spread, it will be even more important to keep these Urban Fisheries in the High Uintas of Utah.

"A FISHERMAN'S DREAM" CREATING NEW FISHING OPPORTUNITIES

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Abstract

In this day and age of growing concerns to protect native species of salmon and trout in Idaho, waters open for general catch and keep fisheries are dwindling. Regulations necessary to protect these precious native species severely restrict the sportsman's ability to find waters open for general limit fishing in some areas of the state. In these waters regulating fishing methods have also created a situation where regional fisheries managers have needed to eliminate or greatly reduce stocking of Idaho's hatchery reared rainbow trout. At the same time managers are trying to supply opportunities for sportsman to catch fish for the skillet. This has brought us into a realm of using creative ideas to meet everyone's concerns for the native species while still providing adequate fishing opportunity for the keep'em and eat'em fisherman. Mr. McGehee's presentation gives an account of the creation of a fisherman's dream, a new place to catch a whopper.

Introduction

In this day and age of growing concerns to protect native species of salmon and trout in Idaho, waters open for general catch and keep fisheries are dwindling. Regulations necessary to protect these precious native species severely restrict the sportsman's ability to find waters open for general limit fishing in some areas of the state. In these waters regulating fishing methods have also created a situation where regional fisheries managers have needed to eliminate or greatly reduce stocking of Idaho's hatchery reared rainbow trout. At the same time managers are trying to supply opportunities for sportsman to catch fish for the skillet. This has brought us into a realm of using creative ideas to meet everyone's concerns for the native species while still providing adequate fishing opportunity for the keep'em and eat'em fisherman.

This exact situation came to play in my personal life in the spring of 1995. My parents were visiting for a few days and wanted to go fishing in the Red River area of central Idaho. At the time general fishing season was not open and the streams and rivers were closed to fishing. My mother was a catch'em and eat'em fisherman so she was not interested in a catch and release fishery of any kind . We found that the only place open to fishing in the area was a dredge pond twenty miles from Red River which had been planted with rainbows by Idaho Department of Fish and Game.

We had a great time fishing and we caught several nice fish for the frying pan. As the weeks went by I thought of the fun we had fishing and how limited that type of fishing opportunity was in certain areas. The fishing trip with my family gave me the idea of creating new fishing opportunities for year round fishing.

After sketching a crude drawing of a fishing pond that could be located in an abandoned portion of our chinook rearing facility at Red River, I began showing it to other department personnel, management teams, other agencies, contractors and businesses in our area. During the initial organizing time I explained the project to anyone who would pause long enough to listen. Everyone who heard the plan liked it and felt it was a worthwhile project. People were especially interested when hearing that the project was to be organized as a community volunteers effort. They also agreed that relying on dwindling state funds would make the success of a project like this very unlikely. Those we contacted felt "A community effort" was the project's only hope for success.

In October of 1995 my mother passed away before I was able to show her the drawing of the new fishing pond. The memories of our last fishing trip together fueled my desire to proceed with the idea of creating new fishing opportunities for Idaho sportsman. Over the next year and a half I discussed the project with many people but could not seem to get anything to take shape. My crude drawing just didn't seem to carry enough weight to get anyone involved. During a telephone discussion on an engineering project with Kevin Neilsen of CH2M Hill I mentioned the fishing pond project and problems with its progress. He really liked the idea and felt his firm could help me out by providing an artist concept drawing and hydraulic engineering. The drawing was great so I took it to the first business to attempt to get over our initial hurdle. We needed equipment to dig a really big hole in the ground. I visited with Keith Church of Hahn supply in Lewiston, Idaho. Hahn Supply operates a rental business and a trackhoe just happened to be in their inventory of equipment. Keith liked the idea of the project and could actually see the reality of the final project from the new drawing. He volunteered the use of their trackhoe, which turned out to be the straw that broke the camels back in getting construction going. The project then started off on a snowball effect and quickly took shape.

The next two months were very exciting. Every business we approached, with the drawing and an explanation of the project plus the fact that we actually had equipment to construct the pond and a starting date, jumped at the opportunity to be involved. At the end of the project it was very rewarding to see the job complete but it was even more rewarding to see the list of partners and the details of their contributions. An unexpected bonus came when Cal Groen, Clearwater Regional Supervisor for Idaho Department of Fish and Game, announced in a regional staff meeting that the pond would be named "Karolyn's Pond" in memory of my mother.

On June 6,1998 a fisherman's dream had finally come true. It began with a kids fishing tournament followed by a dedication ribbon cutting ceremony marking the official completion of "Karolyn's Pond". Fifty seven children participated in the opening day kids fishing tournament. They caught a total of 171 fish that day.

This new fishing opportunity has been an outstanding hit with the public. From June 6 to September 30,1998 our staff recorded at least 1,123 fisherman took advantage of Idaho's newest put and take fishery. The finished pond includes a parking lot, a gravel base trail and a fully accessible handicap pier. The remaining portion of the abandoned rearing pond was converted into a wetlands complete with pothole ponds for waterfowl. Partners in construction of Karolyn's pond came from three different agencies and twelve private companies. The following list shows each member of our construction team and their donation. The dollar value of the contributions totaled $23,700. The Karolyn's pond project was even on the World Wide Web. CH2MHILL prepared a news feature on their home page showing pictures of the dedication ceremony and kid's fishing tournament accompanied with a write up of the history on this community effort.

CONTRIBUTORS TO THE CONSTRUCTION OF KAROLYN'S POND

Business	Representative	Item Donated
CH2MHill	Kelvin Anderson Gale Burley, Brandi Wilson	Artist concept drawings and hydraulic profile.
U.S. Forest Srvc. Red River Ranger Dist.	John Bisbee	Set aside land on special use permit & construction of road bed on top of dike.
Hahn Supply	Keith Church	Insurance &transport of trackhoe
Western Power Equipment	Lamont Johnson	Trackhoe
Grassland West	Randy Gilmore Brad Styner	Grass seed
Valeria Yost Western Art	Valeria Yost	Art work for welcome sign
Lower Snake River Comp.	Ed Crateau	Employee wages & backhoe use
Idaho Co. Road Dept.	John Diltz	Transport gravel
Clearwater Constr.	Mark Vaffiotis	Core drilling
Pepsi	Kent Hollingsworth	Entry sign
Potlatch Corp.	Charlie Pottenger Ed Hogan	Supply pipeline and fittings
Orofino Builders	Steve Crockett	Handicap pier
Nicks Welding	Larry Moore	Handrail
Idaho Fish & Game	Ernie Yost Jerry McGehee	Construction & Design Fund Raising & Design
Habitat Improvement Plan	Miles Benker	Native trees & shrubs

Construction of Karolyn's Pond was fully funded by donations. Contributions for the construction of this fishing opportunity totaled $23,700.

"CATCHABLE TROUT = TROPHY TROUT"

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Abstract

About 500 "trophy" (2 to 10 pound) fish were stocked at 15 different sites in the Clearwater Region in Idaho. The goal of the program is to provide large trout in put-and-take fisheries. Cost of the program to the budget is minimal. Fish are removed from the settling pond using cast nets, dip nets or hook-and-line. Removal of the fish, without disturbing the bottom sediment, has not disrupted our effluent monitoring requirements.

Introduction

Waters managed for put-and-take fisheries often lack the opportunity to catch large fish. Put-and-take fisheries manage catch rates by stocking numerous fish at a relatively small size, i.e. 9 to 10 inches. The cost prohibits rearing the same number of fish to a large size, therefore, creating a trade off between the numbers and size. Providing a trophy element for the put-and-take angler increases their satisfaction.

Purpose

The purpose of this paper is to explain a Clearwater Hatchery program that provides a trophy element to put-and-take fisheries without reducing numbers of fish and at virtually no extra cost.

Over the past five years, about 3,200 rainbow trout (2 -10 pounds each) have been collected from raceway tailraces and settling pond and stocked in Idaho's Region 2 waters. Fish are collected from the tailrace and settling pond by cast net and hook-and-line fishing.

Fish escaping from hatchery rearing containers can create a nuisance with discharge permits. Removing fish from the settling ponds helps alleviate permit problems. Fish recovery methods do not disrupt effluent that has settled to the bottom.

Using those fish has a tremendous benefit to the angler and to the image of the Idaho Department of Fish and Game. For example, a Delaware angler wrote to the Regional Manager telling of their twelve-year-old son's experience in his catch of a lifetime, when he hauled in a six-pound fish from a half-acre pond. Other stories of trophy fish have created enough notoriety that the local newspaper, The Lewiston Tribune, wrote a two-page article of the Clearwater Hatchery put-and-take trophy trout program.

We created criteria for stocking these trophy rainbows, which include; 1) high exploitation, 2) popular fishing areas, i.e. high visibility, 3) fishing derbies. Not only is it important for these fish to be caught, but equally as important is for other anglers to see them. The excitement that their trophy trout create is worth a little extra effort!

PROVIDING AN URBAN FISHERY IN BOISE, IDAHO

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Abstract

The goal of providing a quality fishery for the general public is an ongoing challenge. Providing a quality fishery in an urban environment adds a few more variables to contend with. Water quality and water temperatures are always factors to consider when planting fish. However, in the urban setting, many other factors may influence the ability to maintain certain sections of the fishery. Throughout downtown Boise, the Department of Fish and Game plants the Boise River and several local ponds. Many of these ponds have been modified from old rock quarry pits to provide a fishery not otherwise available. With the addition of more commercial and housing developments, access to the Boise River and these ponds is becoming more limited. Along with the restrictions brought about by increasing development and ever growing populations comes increasing angler demand for easy, local fishing access. With the addition of dams on rivers to aid with flood control and irrigation needs, comes the problem of dealing with fluctuating water flows. Planting may need to be postponed depending on the amount of water being discharged from these dams.

During 1997, Nampa Hatchery, the primary source of hatchery fish for the Southwest part of the state, planted 42,500 fish in the Boise River and 92,000 fish in 10 local ponds. Wilson Springs Ponds, a complex of 5 man-made ponds in Nampa, Idaho, is an excellent example of a well-used urban fishery. A creel survey conducted by Department biologists from July 1, 1993, through June 30, 1994, showed an exploitation rate of 90.6% in the two largest ponds. A creel survey was also conducted on the Boise River from March 1, 1994 through February 28, 1995. A total of 35,215 rainbow trout were planted during the survey period. Total catch (kept + released) was estimated at 68 %. This estimate included wild and hatchery fish due to misidentification by the volunteers who conducted the survey. In 1987, another survey reported an 81% return. These surveys show an abundance of the angler hours are spent in the immediate area and that the return rates are providing an efficient fishery for these anglers. Urban fisheries also give the Department of Fish and Game an excellent opportunity to educate the public about fishing. Department personnel take part in seminars offered to the public during Free Fishing Day throughout the state. This effort is aimed more towards the public that does not normally take part in fishing. These local fisheries also provide an opportunity to groups such as the Disabled Veterans, and handicapped access areas are provided on most of the ponds.

Goals and Objectives

The goal of providing a quality fishery for the general public is an ongoing challenge. Many variables are present and the Department needs to remain flexible in order to meet these challenges. The Treasure Valley area currently has a population of approximately 363,000 people. An annual growth rate averaging 2% in the last two years significantly increases the number of anglers. Existing urban fisheries programs are characterized by very high fishing pressures and harvest rates. The goals of the Department are to provide a diversity of fishing opportunities to these anglers and at the same time make it an enjoyable experience that will actually encourage more people to start fishing. Stocking frequency and species catchability are two components to consider (Alcorn 1981). Urban fisheries affect a large portion of the angling public. By 1991, 70% of anglers 16 years and older lived in urban areas (Schramm and Edwards 1994). Studies show that most of the anglers that urban fisheries target are more interested in catching "fish for the pan". They would rather catch six 10-inch fish than catch two 14-inch fish. They are, for the most part, harvest oriented and want to catch more fish. Keeping regulations simple also helps to make the fishing experience more pleasant. Most of the anglers in the urban setting don't really care about "Special Regulations" and creating larger fish. Most anglers don't really care if they catch a 10-inch fish or a 14-inch fish. The Department has to take into account all of the desires of the public they are trying to please and the variables in the urban environment to create a successful urban fishery.

Accessibility is probably one of the most constantly changing and difficult variables to keep up with. A well-managed fishery that is only accessible to a small percentage of the anglers is not an efficient utilization of hatchery produced trout. Hatchery produced trout account for a very large percentage of the fish that are caught on the Boise River, therefore, considering the cost, we must be sure to take advantage and place these trout in the most accessible locations for the anglers.

Another factor in providing a quality fishery is water quality. Many different groups are interested in how the water resource is managed. Anglers, farmers, and recreational users all have interests in how the Boise River is managed and manipulated. Water quality also includes dealing with warmer water temperatures throughout the late summer months. There are also a series of dams on the Boise River that affect water quality. These dams are used for flood control and irrigation that vary the flows of the river dictating when and where fish can be planted. They also provide a convenient semi-urban fishery for bass, crappie, perch, bluegill, etc., and a water recreation source.

Cost is also a major consideration. Developing a fishery is one thing, maintaining it is another. The expenses involved in creating an urban fishery will be wasted if the funds are not carried through year to year. Creating an urban fishery that makes fishing accessible for the entire family, within a few miles of home, will entice many more people to purchase a fishing license while at the same time promote the sport of fishing.

Another goal of the Department is to try to increase angler interest at any time possible. Easily accessible fishing opportunities provide an excellent opportunity for an angler to get a friend or family member interested in the sport of fishing. There are many ways to promote fishing and the urban fishery is one of the best ways.

Achieving Our Goals

Accessibility is probably one of the areas of most concern at this time. With a population of approximately 363,000 people in 1998, and the addition of more commercial and housing developments, access to the Boise River is becoming more limited. The Department has actively sought to acquire ownership of or easement to private ponds. Several of the ponds around Boise are old rock quarry pits and have been established as urban fishing ponds. These ponds provide an extremely accessible, nearby fishing opportunity to the people of Boise. Nampa Hatchery planted 92,000 catchable trout in 10 ponds in 1997. This accounted for approximately 17 % of the hatchery's catchable production. Several of these ponds are in downtown Boise. All are within a few minutes drive from anywhere in Boise. One example of how well used these ponds are is Wilson Springs Ponds. A complex of 5 man-made ponds in Nampa made exclusively for fishing. These ponds consist of one trophy catch-and –release pond, two catch-and-release bass and bluegill ponds, and two two-fish limit ponds. A one-year creel survey during 1993-94, conducted by the Department, showed a total catch rate of 90.6% in the two two-fish limit ponds. A total of 12,747 catchable rainbows were planted in the two ponds. Of these, 11,555 fish were estimated to have been harvested. This survey showed that the 2,965 anglers interviewed spent a total of 64,217 hours. These anglers made 39,397 fishing trips (Allen et al., in press).

The Boise greenbelt, a paved pathway that follows the river throughout downtown Boise, gives easy access to several of the larger "Put-and –Take" ponds that are planted. Several of these ponds also have handicapped accessible docks. Most of the length of the greenbelt offers excellent access to the Boise River. A creel survey was conducted on the Boise River from Glenwood Ave. to Barber Park from March 1, 1994 through February 28, 1995. A total of 35,215 rainbow trout were planted during the study period. Total catch (kept + released) of hatchery planted fish was estimated at 27%. This survey conducted by volunteers, had some possible misidentification of wild/hatchery fish, which we feel, underestimated the total return estimates of the hatchery trout. In 1987 another survey reported an 81% return (Allen et al., 1998). The Departments goal for total return is 40% by number or 100 % by weight (Pittman et al., 1996). These surveys show that anglers are, by far, exceeding the goal for returns on this 17km stretch of the Boise River. In another creel survey of the South Fork of the Boise River, not necessarily "urban", hatchery trout accounted for 80% of the fish checked in creels, but the overall return total creel rate was only 21% (Pittman et al., 1996). This survey shows that most anglers are catching hatchery trout but that they need to be catching more of them. This demonstrates that the Department is not getting its "monies worth" from the trout planted in this section. The goal is to get fish on the hook and the South Fork survey shows that these hatchery trout are not being utilized in the most efficient manner.

As far as accessibility for planting fish, sites are becoming extremely limited. Several of our plant sites are being developed and this requires the Department to cooperate with the city to maintain some areas to approach the river. There are several bridges that allow access, however there are times of the year when low water flows do not allow these sites to be utilized. The Boise Parks and Recreation Department allow the Fish and Game Department to drive stocking trucks onto the Greenbelt. This allows several of the larger ponds to be planted however some of the river sites are not accessible off of the greenbelt.

How the water is managed is also a concern to many different groups of people. A series of dams are upriver from Boise. These dams are used for flood control and therefore can change the flow of the river throughout Boise. Flood control takes precedence over fishing and may at times, usually in early spring when waters are running high, prevent stocking the river. When these reservoirs become to full, it is necessary to spill at an increased rate, usually at or just above flood stage. This is not usually a serious concern as far as fish planting as the water is also too high and dangerous to fish at this time. Water flows in the Boise River are controlled nevertheless and are necessary to plan around for stocking schedules.

Water quality for most of the Boise River is not an issue. However, below Glenwood Ave., the Boise River has its first sewer treatment plant. Water quality begins to deteriorate downstream from this point. Many of the irrigation drains also run back into the Boise River. Low summer flows and poor water quality is a problem from Star to the mouth of the Boise River downstream. This area of the Boise River is not very densely populated and is not planted with hatchery trout. The "urban" section of the Boise River has very good water quality and temperatures are always at a suitable level for planting trout. This allows for planting to continue throughout the season and maintains the angler's interest. Water flows remain the limiting factor for planting hatchery trout.

The Boise River is also a haven for many swimmers and rafters during the hot summer months. The most popular stretch of the river for rafters is also the most popular stretch for the anglers. This is occasionally a little frustrating to the angler who watches the plant truck release several hundred trout only to have to compete for access to them by hundreds of river floaters and rafters. Most of the time the two groups work it out and everyone enjoys their time on the river.

The cost of producing hatchery trout is something to consider. In 1997, Nampa Hatchery produced 556,718 catchable trout weighing 188,208 lbs. The total cost to produce and transport these fish was $407,000. This equals about $0.057/inch (Alsager et al. 1997). With funding being decreased from year to year, we need to assure that the hatchery product is utilized to the maximum extent possible. This does not mean that we should only plant catchable trout in urban areas, but that we need to try to put as many of these fish in front of as many of the anglers as possible.

The cost of maintaining the urban fishery can be split among many different agencies. The city parks and recreation departments can be responsible for building and maintaining fishing accesses such as docks, walkways, etc. State water quality agencies can be in charge of monitoring and improving water quality. Once the initial cost of establishing the fishery is invested, the public will provide incoming funds through increased license purchases. This will help offset the cost of hatchery produced trout. The U.S.F.W.S. reported anglers spent $23.50 per day of fishing in Idaho. Angler expenditures from fishing the Boise River from Glenwood Bridge to Barber Park are estimated to be $1,270,974 annually (Allen et al., 1998).

Increasing the angler's interest can be accomplished in a number of ways. The first of which is to educate the public. Various events and programs are available to the public. Free Fishing Day is a nationwide event that promotes fishing by allowing anyone to fish on that day without a license. This is an excellent opportunity to provide families, kids, and single parents to expose themselves and others to fishing. Many fishing clinics are available and offer free equipment use and advice on how to use it. Nampa hatchery opens its settling pond to fishing and allows kids to fish from 8 am to 12pm then it is open to anyone from 12pm until 5pm. All the needed equipment is provided. Hundreds of families show up and many are "first time fishermen". Department personnel are present and assist with the fishing. This is truly a good experience for all involved. Many other clinics are conducted at the other ponds throughout Boise.

Educating the public can be done on a more passive route also. Many pamphlets, brochures, and fishing guides describe the various fishing locations and give helpful information that may end up giving someone a very successful fishing trip. This may also include just answering a few questions.

A very popular way to increase the interest can be observed on the days when surplus steelhead is transported to Boise for planting in the Boise River. On these trips, approximately 200 steelhead are transported from Oxbow Hatchery in Hells Canyon to the Boise River. Anglers are standing in line to see these large fish placed in their favorite fishing holes. Besides generating extra funds through the sales of steelhead permits, it is an excellent opportunity to expose the public to a type of fish that many would never have the opportunity to fish for. It is truly amazing to see someone catch a steelhead in downtown Boise. A site many will never forget.

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Session II

Pathology/Disease

Session Chair:

Dr. Keith Johnson
(Idaho Department of Fish and Game)

ADAPTIVE DISEASE MANAGEMENT STRATEGIES FOR THE ENDANGERED POPULATION OF KOOTENAI RIVER WHITE STURGEON *Acipenser transmontanus*

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Abstract

For the endangered Kootenai River white sturgeon population, conservation aquaculture was identified as a prudent and necessary recovery tool due to its biological status and the demonstrated uncertainties of other recovery efforts. Conservation aquaculture programs need to address the potential impacts on the genetic variability, artificial selection, and effects of disease on the native population prior to development and implementation of the program. Available scientific information should be used to develop management strategies that minimize the transmission of disease from cultured fish to native fish and the potential severity of disease in the native population. The white sturgeon iridovirus (WSIV) is the most prevalent viral pathogen of white sturgeon relative to its distribution and frequency of occurrence and may be endemic to wild white sturgeon populations throughout the Pacific Northwest. This case study illustrates the importance of conservation aquaculture programs in certain fishery situations. In addition, we show how management strategies must remain flexible and adapt to the current available scientific information to provide maximum benefits. Management of the Kootenai River white sturgeon population represents a model cooperative effort of professional fisheries scientists from private industry, academia and provincial, federal and state governmental agencies, and Indian Tribes. This cooperation is essential and a prerequisite for successful achievement of the program goals. Cooperation is also necessary for adaptation of management strategies, as new information becomes available.

Introduction

The white sturgeon (*Acipenser transmontanus* Richardson) population in the Kootenai River was listed as endangered on September 6, 1994 (59 FR 45989) under the authority of the Endangered Species Act of 1973. The Kootenai River population is one of several land-locked populations of white sturgeon found in the Pacific Northwest. Their distribution extends from Kootenai Falls, Montana, located 50 river kilometers below Libby Dam, downstream through Kootenay Lake to Cora Linn Dam on the lower west arm of Kootenay Lake, B.C. A natural barrier at Bonnington Falls downstream of Kootenay lake has isolated the white sturgeon in the Kootenai River from other white sturgeon in the Columbia River since the last glacial age approximately 10,000 years ago (Northcote 1973). The population was listed as endangered due to two decades of nearly undetectable recruitment, declining population size, and habitat loss and degradation (U.S. Department of Interior, Fish and Wildlife Service 1996). The last substantial year-class was naturally produced in 1974.

Operation of Libby Dam impounded the Kootenai River near Libby, Montana, forming Lake Koocanusa. Construction and operation of Libby Dam has drastically altered the hydrograph, thermograph, and downstream nutrient loading rates in the Kootenai River (Apperson and Anders 1991). This may have reduced the natural recruitment. Research has confirmed natural spawning in five of the past six years. However, natural recruitment has been undetectable since 1974. In 1995, the population of adult white sturgeon in the Kootenai River was estimated to be 1,469 individuals (Paragamian et al. 1996). Natural recruitment was estimated to be approximately 1% of the population since nine years of sampling recovered only 16 white sturgeon less than 22 years of age (Paragamian et al. 1995). Because white sturgeons do not mature until about age 20, the equivalent of one full generation in the white sturgeon life cycle had been lost.

The Kootenai River White Sturgeon Technical Committee was formed by the U.S. and Canadian regional agencies and the Kootenai Tribe in June 1992 to address the concerns of the future viability of the species. The committee was unable to negotiate a Conservation Agreement among the various agencies. The agreement was to implement strategies to prevent the extinction of the Kootenai River white sturgeon. Subsequently, the fish was listed as endangered in 1994. In 1995, a recovery team was convened by the U.S. Fish and Wildlife Service (USFWS). The team was to develop a plan outlining needed strategies for the initial recovery of the species. Because the species range is transboundary, the recovery team included members with technical expertise from the U.S. Fish and Wildlife Service; the Kootenai Tribe of Idaho; Idaho Department of Fish and Game; Montana Fish, Wildlife and Parks; U.S. Army Corps of Engineers; Bonneville Power Administration; British Columbia Ministry of Environment, Land, and Parks Fisheries Division; and the Canadian Department of Fisheries and Oceans (Table 1). They concluded that the recovery of the species was contingent upon the re-establishment of natural recruitment, minimizing additional loss of genetic variability and mitigating habitat impacts, primarily those caused by the construction and operation of Libby Dam. Therefore, the recovery strategy addressed these concerns through three priority actions: 1) augment flows of the Kootenai River to enhance natural reproduction; 2) implement a conservation aquaculture program, i.e., artificial propagation and release, to prevent extinction; and 3) re-establish suitable habitat conditions, to increase the changes of white sturgeon survival beyond the egg/larval stage (U.S. Department of Interior, Fish and Wildlife Service 1996).

The conservation aquaculture program had started in 1991 to address experimental questions but had yet to be implemented. Every year since 1991, with the exception of 1994, progeny from wild broodstock were successfully produced and reared in the Kootenai Tribal Hatchery, home to the conservation aquaculture program. While efforts to restore natural reproduction (augmented discharge during the spawning period in 1991-1995) stimulated natural spawning, these effects did not appear to restore natural recruitment in the population (Paragamian and Kruse 1996). In the short term, supplementation of the population via artificial propagation (using wild broodstock), culture and release of juvenile white sturgeon appeared to be the most viable option for preventing extinction of this unique species. The program was to address several concerns about the use of supplementation regarding genetic variability and the potential to introduce disease into the wild population. This case study describes how the issue of introduced disease was addressed.

Summary and Conclusions

Conservation aquaculture was identified as a prudent and necessary recovery tool for endangered Kootenai River white sturgeon. The biological status of the species and the demonstrated uncertainties of other recovery efforts justified the use of conservation aquaculture. Conservation aquaculture programs need to address the potential impacts on the genetic variability, artificial selection, and effects of disease on the native population prior to development and implementation of the program. Management strategies should be based on the available scientific information to minimize the transmission of disease from cultured fish to native fish and the potential severity of disease in the native population. It is essential that these strategies be flexible and designed to incorporate new scientific information on a continual basis.

One of the primary concerns of any artificial propagation program is the potential introduction and transmission of pathogens in both cultured and native populations. Generally, predictions of the potential disease impacts in natural populations have been extrapolated from observations of disease conditions in cultured fish. However, these predictions may not be directly applicable to wild populations since conditions associated with aquaculture (e.g. increased densities, suboptimal water quality) often promote the clinical manifestation of infection. The high-density conditions that can occur in culture facilities can also promote progressive and relatively rapid disease transmission among captive populations.

Conceptually, infection and disease are separate phenomena although these events are often mistakenly considered in the same context. Simply, infection, defined as invasion of a host by a pathogenic agent, is a more common event although both infection and disease depend on the interaction of various factors including (1) the health and immunological status of the host; (2) the dose and virulence of the pathogen; and (3) the environmental conditions that affect the host and the pathogen (LaPatra 1998). In contrast, disease is defined as the condition that results in morbidity and, possibly, mortality in the individual host or population as a consequence of infection. The extent and severity of disease is also a function of these various factors. Adverse environmental factors include temperature and conditions that may increase stress in fish populations such as inadequate water flows and increased densities. Conditions that promote or exacerbate disease are generally more prevalent and pronounced in aquaculture facilities than in wild populations. Increased densities are not only conducive to disease but also promote the rapid and progressive transmission of infection throughout the population. However, the increased incidence and severity of disease in aquaculture for any pathogen is generally due to adaptation of pathogens over time that can become endemic to a species (LaPatra 1997). This is important for viral pathogens that have a restricted host-specificity such as the white sturgeon iridovirus (WSIV). For example, experimental exposures of WSIV to chinook salmon *Oncorhynchus tshawytscha*, channel catfish *Ictalurus punctatus* and striped bass *Morone saxatilis* indicated their resistance to infection, but lake sturgeon *Acipenser fulvescens* suffered a mild form of the disease (Hedrick et al. 1992). An increased incidence of morbidity and mortality within the host population would result in extinction of the host species and its endemic pathogen. Therefore, asymptomatic infection may be widely distributed throughout wild populations without clinical manifestation of disease that may subsequently occur in aquaculture situations due to aquaculture-specific stressors. Clinical disease that results in sickness and/or death is more easily diagnosed than asymptomatic infections or subclinical disease that may require more sophisticated diagnostic tests or procedures. Regardless, the isolation or presence of a pathogen does not indicate a disease event. However, identification of a pathogen in otherwise healthy fish populations should be followed by review and appropriate alteration of husbandry and management practices to prevent possible future disease events. Changes in these practices may simply be the alteration or management of specific environmental conditions such as the maintenance of decreased culture densities or increased water flows necessary to minimize or prevent potential future disease events in the population (LaPatra 1997). This preventative measure may also apply to wild populations and is underscored by the recent decline in the Kootenai River white sturgeon population as a result of changes in the physical and biological parameters of the river ecosystem following construction of the Libby Dam.

As previously mentioned, WSIV is the most prevalent viral pathogen of white sturgeon relative to its distribution and frequency of occurrence and may be endemic to wild white sturgeon populations throughout the Pacific Northwest. The latter assumption is based on observations that wild sturgeon used as broodstock were the source of WSIV in progeny of these broodstock and that clinical manifestation of disease in these progeny was due to adverse environmental conditions (LaPatra et al. 1994; LaPatra et al. 1996a). In 1992, juvenile Kootenai River white sturgeon were destroyed and movement of surviving fish was severely restricted following diagnosis of WSIV in this group of fish. These juvenile fish were invaluable due to the progressive decline in the natural population and the failure to reestablish natural recruitment in the population with augmentation of water flows in the Kootenai River. This response was probably not necessary based on the available scientific information that infection may be a natural phenomenon within the wild population. In 1995, four families of progeny from wild Kootenai River adults resulted in the production of greater than 2,000 2-year-old fish. In 1997, the disease testing protocol developed for this program was conducted prior to release of the fish that resulted in the diagnosis of asymptomatic WSIV infection in three of the four families. Two of the families were tagged and released due to the absence of disease in one family and the decision that WSIV was endemic in the wild population based on the available scientific information. Previous studies also indicated that the culture of sturgeon at low densities with minimum stress could prevent disease and minimize infection (LaPatra et al. 1994; LaPatra et al. 1996a). This strategy was successfully employed for the remaining two families that were subsequently tagged and released in October 1997.

Intervention to stabilize the population and the continual adaptation of management strategies to achieve this objective were partially the result of the uncertain status of the wild Kootenai River white sturgeon population. However, development of the management strategies was also influenced by the relevant scientific information that became available during implementation of the Kootenai River white sturgeon conservation aquaculture program. This case study illustrates the importance of conservation aquaculture programs in certain situations and the necessity that the management strategies remain flexible and adapt to the current available scientific information for maximum benefits. Continued efforts are in progress to understand the ecology and natural history of WSIV in white sturgeon. Such information would undoubtedly be applicable to future white sturgeon management. The successful development and use of nonlethal sampling procedures for detection of WSIV infection will also permit the future examination of tagged fish released from the Kootenai Hatchery and wild-caught sturgeon broodstock. Hatchery renovations have also been initiated to minimize the adverse conditions associated with artificial rearing and prevent or minimize infectious disease events associated with these adverse conditions. Finally, surveillance strategies that are more sensitive and specific for the detection of these pathogens need to be developed and used in conservation aquaculture programs and management of the population as appropriate.

Restoration of an entire population that has been severely altered for decades and that inhabits a large floodplain ecosystem such as the Kootenai River system requires long-term, multiagency cooperation and commitment. Management of the Kootenai River white sturgeon population represents a model cooperative effort of professional fisheries scientists of various disciplines from private industry, academia and provincial, federal and state government agencies including Indian Tribal agencies (Table 1). This cooperation is a necessary prerequisite for the successful achievement of the program goals and continual modification and adaptation of management strategies as new information becomes available. Furthermore, this cooperative effort also illustrates that effective management of entire populations is best achieved by the interdisciplinary cooperation of various fisheries professionals. This interdisciplinary cooperation reflects a current trend in the fisheries profession that replaces the more traditional approach of various professionals working in isolation on separate aspects of the same problem. Obviously, the latter approach is less effective and therefore less desirable for the management of populations especially threatened or endangered populations such as the Kootenai River white sturgeon.

Table 1. Professional fisheries scientists of various affiliations involved in the Kootenai River white sturgeon cooperative effort.

Name	Agency	Specialty
Susan Ireland	Kootenai Tribe of Idaho, Bonners Ferry, Idaho	Fisheries Biologist / Manager
Scott LaPatra	Clear Springs Foods, Inc., Buhl, Idaho	Fish Health Specialist
Joseph Groff	School of Veterinary Medicine, University of California, Davis, California	Fish Health Specialist / Veterinarian
Robert Hallock	U.S. Fish and Wildlife Service, Spokane, Washington	Fisheries Manager
Stephen Duke	U.S. Fish and Wildlife Service, Boise, Idaho	Recovery Team Leader
John Morrison	U.S. Fish and Wildlife Service, Olympia, Washington	Fish Health Specialist
Kathy Clemens	U.S. Fish and Wildlife Service, Ahsahka, Idaho	Fish Health Specialist
Larry Lockard	U.S. Fish and Wildlife Service, Kalispell, Montana	Fisheries Biologist
Jay Hammond	B.C. Ministry of Environment, Land, and Parks, Nelson, British Columbia	Fisheries Manager
Sally Goldes	B.C. Ministry of Environment, Land, and Parks, Nanaimo, British Columbia	Fish Health Specialist
Gordon Ennis	Canada Department of Fisheries and Oceans, Vancouver, British Columbia	Fisheries Manager
Dorothy Keiser	Canada Department of Fisheries and Oceans, Nanaimo, British Columbia	Fish Health Specialist
Ned Horner	Idaho Department of Fish and Game, Coeur d'Alene, Idaho	Regional Fisheries Manager
Keith Johnson	Idaho Department of Fish and Game, Eagle, Idaho	Fish Health Specialist
Vaughn Paragamian	Idaho Department of Fish and Game, Coeur d'Alene, Idaho	Fisheries Research Biologist
Jim Peterson	Montana Fish, Wildlife and Parks, Helena, Montana	Fish Health Specialist
Brian Marotz	Montana Fish, Wildlife and Parks, Kalispell, Montana	Fisheries Research Biologist
Paul Anders	University of Idaho, Aquaculture Research Institute, Moscow, Idaho	Fisheries Research Biologist
Rick Westerhof	National Marine Fisheries Service; formerly of Bonneville Power Administration, Portland, Oregon	Fisheries Biologist
Scott Bettin	Bonneville Power Administration, Portland, Oregon	Fisheries Biologist-HydroIntegration
Jeff Laufle	U.S. Army Corps of Engineers, Seattle, Washington	Fisheries Biologist

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EPIDEMIOLOGY OF VIRAL INFECTIONS IN WHITE STURGEON FROM THE PACIFIC NORTHWEST

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Abstract

White sturgeon Acipenser transmontanus are susceptible to a variety of viral, bacterial, and fungal diseases. The viruses that have currently been reported include the white sturgeon iridovirus (WSIV), white sturgeon herpesvirus-1 (WSHV-1), white sturgeon herpesvirus-2 (WSHV-2), and the white sturgeon adenovirus (WSAV). Previously, these viruses have only been identified in cultured populations. However, these cultured fish were all spawned from wild white sturgeon broodstock. A survey of lower Columbia River juvenile (<1-year old) wild white sturgeon was conducted in the fall of 1994, 1996, and 1997. Fish were collected by standard methods and either nonlethally sampled and released or held in captivity using virus-free water supplies. Captive sturgeon with morbidity and mortality were sampled for virus isolation and histological examination. In 1994, a virus identical to WSHV-2 was isolated. Two previously undescribed viruses were detected in 1996. Additionally, an adeno-like virus similar to the enteric adenovirus previously described in white sturgeon from California was isolated in cell culture. A WSIV infection in wild white sturgeon from the Columbia River was also diagnosed in 1997.

Introduction

The white sturgeon iridovirus (WSIV) is the most prevalent viral pathogen of white sturgeon relative to its distribution and frequency of occurrence. This agent was first detected in cultured white sturgeon from California in 1988 (Hedrick et al. 1990). The virus has an affinity for epithelial tissue including the integument, gills, oropharynx, and olfactory epithelium. Infection results in cytomegaly with subsequent cellular degeneration and necrosis and is often associated with epithelial hyperplasia. Mortality as high as 95% is assumed to be due to anorexia and disruption of normal physiological processes including respiratory and osmoregulatory functions. Secondary infections are common and the disease appears to be most severe in sturgeon younger than 1 year. The original description of WSIV disease occurred in hatchery-raised sturgeon and the virus was assumed to originate from wild sturgeon adults collected from the Sacramento River and held for use as broodstock. Pathognomonic signs of this disease have been observed in archival histological material from progeny of the first artificially spawned wild stocks beginning as early as 1983 (Hedrick et al. 1992). Previous investigations have also reported the presence of WSIV in cultured white sturgeon from the lower Columbia River in Oregon, the Snake River in southern Idaho, and the Kootenai River in northern Idaho (LaPatra et al. 1994). These observations suggest that WSIV may occur in wild sturgeon and may be present in many Pacific northwest populations due to the long life span of the species, migratory patterns of the species, and continuity of the river systems.

Serious losses of cultured sturgeon less than 10 cm in length have also been associated with WSHV-1 (Hedrick et al. 1991). Although the virus has only been documented in California, WSHV-1 may be present in other river basins which contain native populations of white sturgeon. However, histological examination of tissue samples collected from wild white sturgeon adults and juveniles in California, Idaho, and Oregon did not indicate prior infection with WSHV-1 (LaPatra et al. 1994).

The initial isolation of WHSV-2 was from captive white sturgeon broodstock. This same virus has also been isolated from dermal lesions of subadult white sturgeon (Watson et al. 1995). Economic losses in California aquaculture operations due to this virus may be greater than any other known white sturgeon virus. Although vertical transmission of other fish herpesviruses has been demonstrated, there is currently no direct evidence that the gametes of sexually mature sturgeon are involved in transmission of WSHV-2. Egg-associated transmission, however, may explain the occurrence of WSHV-2 infections among sturgeon reared in single-pass well-water due to the apparent absence of other sources of infection. Therefore, it is important for hatchery and fishery management personnel to determine the natural reservoirs of infection and the prevalence of WSHV-2 in native sturgeon populations.

Unlike the other white sturgeon viruses, the white sturgeon adenovirus (WSAV) may be an incidental finding that does not result in disease. The virus was initially observed in 1985 but has not been detected since 1986 (Hedrick et al. 1985). This may be the result of viral surveillance programs that have primarily focused on the more virulent and economically important pathogens such as WSIV and WSHV.

Epidemiological Surveys

1994: Sturgeon were collected to obtain information about the prevalence of these viruses in native populations as part of an Oregon Department of Fish and Wildlife (ODFW) study. Trawls for sturgeon were conducted in the Columbia River downstream from the Bonneville Dam. Histological specimens were collected nonlethally from 90 sturgeon that were 16-37 cm in fork length. Approximately 10-20% of these animals were estimated to be 4-6 months old. Microscopic examination of integument samples revealed possible WSIV infection in one fish although this was not confirmed. However, WHSV-2 was isolated from a group of these wild white sturgeon that died during captivity at the ODFW Clackamas Laboratory although these fish were maintained in pathogen-free water.

1996: In September, 55 wild juvenile white sturgeon (mean fork length, 153 mm) were collected from above (N=20) and below (N=35) the Bonneville Dam on the lower Columbia River and held in pathogen-free water at a research facility in Cook, Washington to screen for viral agents. Tissue samples including integument, gills, liver, kidney and spleen were collected from mortalities and moribund fish for viral isolation and histological examination. Three different viruses were isolated which were further characterized by transmission electron-microscopy. One virus isolated in cell culture exhibited non-enveloped icosahedral particles approximately 70 nm in diameter with an electron dense core of approximately 55 nm that was confined to the nucleus of infected cells. These characteristics were consistent with an adeno-like virus. Another virus was observed in the liver, gill, spleen, and kidney that resulted in distinct histological changes including enlargement of affected cells with margination of the nuclear chromatin that significantly increased the nuclear to cytoplasmic ratio. Ultrastructurally, the affected cells had dissolution of the nuclear chromatin. These viral particles were also non-enveloped and exhibited a hexagonal profile with a diameter of 55-65 nm consistent with a papova-like virus. A third virus was detected after prolonged incubation in cell culture at 18^{o}C. These particles were very pleomorphic in shape and were initially thought to be WSIV. However, the average diameter was 350-360 nm whereas the diameter for WSIV was previously reported to be 250-260 nm (Hedrick et al. 1990).

1997: A total of 35 juvenile white sturgeon (mean length, 289 mm) were collected from two different locations in the Columbia River; 15 from the Dalles Reservoir (between the Dalles and John Day Dams) and 20 from the John Day Reservoir (between the John Day and McNary Dams). Unlike the 1996 investigation, many of these fish were likely yearlings instead of young of the year fish. These fish were transported and held separately in virus-free water at a research facility in Abernathy, Washington. Initially, four fish died following transfer to the facility that was most likely due to handling associated with capture and transport. However, morbidity and mortality was negligible in the remaining sturgeon. The fish were euthanized and sampled after 3-4 months in captivity. No replicating agents were detected by cell culture. However, histological examination revealed enlarged, amphophilic to basophilic, epithelial cells of the gills and integument that are pathognomonic for WSIV infection in 11% (4/35) of the sturgeon. The intensity of infection was very mild and not associated with clinical disease. Additionally, 14% (5/35) of the sturgeon had histological changes consistent with an early WSIV infection. The majority of these affected fish were collected from the Dalles Reservoir which is downstream from the John Day Reservoir.

Discussion

Artificial propagation of fish has facilitated the isolation and identification of pathogens and other microorganisms that have evolved with their hosts in natural environments. Intensive culture magnifies the impact of pathogens and other microorganisms but does not create the association or effect. In contrast, studies to determine the distribution of these organisms in free-ranging fish have been limited, and the potential impacts of disease in these populations have generally been inferred from the knowledge and experience obtained from intensive culture.

Four viruses have been reported from cultured white sturgeon that include the white sturgeon iridovirus (WSIV), white sturgeon herpesvirus-1 (WSHV-1), white sturgeon herpesvirus-2 (WSHV-2), and the white sturgeon adenovirus (WSAV). Although the initial reports of these viral agents involved cultured sturgeon, these cultured fish were all spawned from wild white sturgeon broodstock. The results of this survey confirm the presence of WSIV, WSHV-2, and presumably WSAV in wild juvenile white sturgeon. Additionally, the two previously undescribed viruses isolated from wild juvenile white sturgeon indicates an association of other viral agents with wild populations that may potentially be pathogenic in cultured populations. Furthermore, this information provides credible evidence that these viral agents may be enzootic in Pacific northwest sturgeon populations due to the long life span of the species, migratory patterns, and continuity of the river systems. Recently, an iridovirus similar to WSIV was also detected in Russian sturgeon *Acipenser guldenstadi* from northern Europe (Adkison et al. 1998) suggesting that WSIV is not species-specific and may have a larger natural range than previously recognized.

Diagnostic tests currently available for these agents lack sensitivity and are limited to viral isolation and histological examination of tissues (LaPatra et al. accepted). This has precluded further investigations to evaluate the distribution and potential effects of these viruses on white sturgeon populations. A potential tool for enhancing the detection of organisms associated with free-ranging populations of fish is the utilization of "stress" associated with captivity similar to the techniques used in salmonids to detect infection with *Aeromonas salmonicida*. Fish that are asymptomatically infected but otherwise "healthy" and not stressed are generally immunocompetent that restricts or prevents the clinical manifestation of a subclinical infection. However, wild fish transferred to an artificial environment become stressed that may result in inanition followed by morbidity and mortality often due to infectious agents. For example, the sturgeon collected in 1994 (fork length, 150-200 mm) and 1996 (mean fork length, 153 mm) were smaller and apparently younger than those collected in 1997 (mean fork length, 289). Clinical disease did not occur in the latter fish and only a mild asymptomatic WSIV infection was observed in 11% of the animals after 3-4 months of not feeding and dewatering 2 times per day for 7 days. In contrast, clinical disease occurred in the smaller fish collected in 1994 and 1996 that was confirmed by isolation of WSHV-2 and with histological evidence of a more severe papova-like virus infection. These observations suggest that life stage and condition of fish in association with the extent and severity of the stressor(s) are important factors in the manifestation of clinical disease.

A more complete understanding of the epidemiology of infectious agents as a result of disease investigations in cultured populations has been invaluable in the management of these populations. However, it is understood that these pathogens are a normal component of natural aquatic ecosystems whereas intensive culture only magnifies the effects of these microorganisms in the host but does not create the relationship. Although the epidemiology of disease and the associated causal agents in cultured fish have been well documented, the relationship and distribution of pathogens in wild fish populations needs further investigation. White sturgeon in the lower Columbia River provide an excellent population for these studies since there has been no enhancement, mitigation or conservation aquaculture programs that would affect the distribution of these potential pathogens within the population. Additionally, these are well managed and reproductively stable wild populations that support excellent sport and commercial fisheries. However, several pathogenic and previously undescribed viruses appear to be associated with these populations although there is currently no evidence that these agents have had a deleterious effect on the populations. Future studies will continue to survey wild sturgeon from different areas to further characterize these viruses.

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BACTERIAL KIDNEY DISEASE AND EFFORTS TOWARD CONTROL IN THE OREGON CHINOOK CAPTIVE BROODSTOCK PROGRAM

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Abstract

A captive broodstock program for the Grande Ronde River basin spring chinook salmon listed under the Endangered Species Act was begun in 1995. Prophylactic treatments for bacterial kidney disease (BKD) were designed into the project at its outset. Logistical and toxicological problems with the treatments soon resulted in decisions to suspend them. Losses to BKD ensued and combinations of the therapy using erythromycin injections and feeding of aquamycin were employed to control the losses. Most recently, appropriate aquamycin was not available for prophylactic treatments and erythromycin fish pills were used. Treatment efficacy is impossible to assess because proper control groups are lacking. Control of BKD and treatments based on sound science are considered critical to the future of this program.

Introduction

In the summer of 1995, the Oregon Department of Fish and Wildlife initiated a captive broodstock program using natural stocks of spring chinook salmon from three Grande Ronde River basin streams in northeastern Oregon. This effort is designed to "reduce the risk of extinction" in stocks from the upper Grande Ronde River, the Lostine River, and Catherine Creek. The program is authorized by the National Marine Fisheries Service under the Endangered Species Act. It is co-managed with the Confederated Tribes of the Umatilla Indian Reservation and the Nez Perce Tribe. Operations are funded by the Bonneville Power Administration (the complete details of the program can be found in: Statement of Work, Grande Ronde Basin Spring Chinook Captive Broodstock Program, Richard W. Carmichael, Oregon Department of Fish and Wildlife, September 1998). The goal is to collect 500 summer parr from each of these streams each year and raise them to mature adults in captivity. The initial months of rearing occur at Lookingglass Hatchery in freshwater until the fish smolt. Upon smolting (May) during their first year in captivity, one-third of each stock are taken to Manchester Marine Laboratory on Puget Sound in the state of Washington for seawater rearing, and the other two-thirds are taken to Bonneville Hatchery in Oregon for freshwater rearing. They are all spawned at Bonneville upon reaching maturity, and their progeny are reared in a conventional hatchery production program at Lookingglass Hatchery for release as smolts back into the stream of parental origin.

There were many uncertainties anticipated in this program, and the impact that bacterial kidney disease (BKD) might have been one of those uncertainties. This paper discusses bacterial kidney disease and efforts toward controlling it in the Oregon chinook captive broodstock program. First, the occurrence of the disease will be discussed in the context of BKD-related mortality and clinical infection rates in spawned adults. Second, prophylactic and therapeutic antibiotic treatments are presented. Third, an intraperitoneal injection procedure for juveniles that was implemented in 1998 is outlined.

Occurrence of Bacterial Kidney Disease in Mortality and Spawned Adults

Bacterial kidney disease mortality, defined by fish that died with gross clinical signs or high enzyme-linked immunosorbent (ELISA) values ($\geq$1.000 OD units), is shown in Table 1. It is reported as the percent of mortalities with BKD among the total number of fish collected. In the '94 brood year stocks, the first onset of BKD was in the Grande Ronde River stock at Lookingglass Hatchery during the first eight months after capture. Overall BKD mortality has also been the highest in the Grande Ronde stock at 49.1%. In November of 1997, BKD mortality began in the Lostine River stock at Bonneville. Total mortality has been 20.0% in that stock. The Catherine Creek stock has been the least impacted by BKD with an overall mortality of 7.2%. All '94 brood year BKD mortality has occurred in freshwater at Lookingglass and Bonneville; none has occurred at the Manchester Marine Laboratory.

Table 1. The total number of mortalities with clinical BKD and BKD mortalities as the percentage of total fish collected in the Oregon chinook captive broodstock program for the '94 and '95 brood years. These are the Catherine Creek (CC), Lostine River (LR) and Grande Ronde River (GR) stocks. The fish are held at Lookingglass Hatchery during their first eight months after capture. Two-thirds of each stock are then taken to Bonneville Hatchery and one-third to Manchester Marine Laboratory for rearing to adulthood. No Grande Ronde River '94 brood year fish were taken to Manchester and no Grande Ronde River '95 brood year fish were collected for captive broodstock.

	CC94	LR94	GR94	CC95	LR95
	Total Number of Fish Collected				
	498	499	110	500	481
Location/Year	Number of Mortalities with Clinical BKD				
Lookingglass 1995	1	0	5		
Lookingglass 1996				0	0
Bonneville 1996	19	15	15		
Bonneville 1997	6	9	14	14	5
Bonneville 1998	10	76	20	41	47
Manchester 1996	0	0			
Manchester 1997	0	0		0	0
Manchester 1998	0	0		2	9
% of mortalities with clinical BKD (number per the total collected)	7.2	20.0	49.1	11.4	12.7

Only the Catherine Creek and Lostine River '95 brood year parr were retained for captive broodstock in the summer of 1996. None of these died of BKD during their first months at Lookingglass. In contrast to BKD incidences in '94 brood year stocks, there has been some BKD mortality in '95 brood year fish in seawater at Manchester Marine Laboratory occurring since June of 1998. In terms of percentage, however, the BKD loss remains much lower at Manchester (3.6% at Manchester and 17.0% at Bonneville). It is important to understand that beginning with the '95 brood year, natural and accelerated-growth regimens were applied at Lookingglass Hatchery during their first year using water temperature manipulation. Only natural-growth fish are taken to Manchester and fish from both growth regimens are taken to Bonneville. The mortality at Bonneville beginning with '95 brood year fish, therefore, needs to be analyzed according to growth regimen in order to make valid comparisons to Manchester where all fish are on the natural growth profile. Overall BKD mortality for '95 brood year fish at both Manchester and Bonneville is 12.7% for the Lostine River stock and 11.4% for the Catherine Creek fish.

The percentage of '94 brood year spawned adults with clinical BKD has followed a pattern similar to the juvenile mortality by stock, although it is less in the spawned fish (Table 2). In the Grande Ronde '94 brood year spawned fish, 41.7% have had BKD. For the Lostine River stock, this value is 11.6% and for the Grande Ronde stock it is 4.4%. In '95 brood year fish, which includes 195 males and only one spawned female, 16.0% of the Lostine River stock and 1.3% of the Grande Ronde stock have had clinical BKD. Data analysis concerning the BKD incidence in spawned fish reared in seawater at Manchester and freshwater at Bonneville is ongoing, as is the BKD mortality in fish reared under the accelerated and normal-growth temperature profiles at Bonneville.

Table 2. The proportion and percentage of clinical BKD in Oregon chinook captive broodstock spawned adults for the '94 and '95 brood years. These are the Catherine Creek (CC), Lostine River (LR) and Grande Ronde River (GR) stocks. No Grande Ronde River '95 brood year fish were collected for captive broodstock. Two-thirds of each stock are taken to Bonneville Hatchery and one-third to Manchester Marine Laboratory for rearing to adulthood, although no Grande Ronde River '94 brood year fish were taken to Manchester. Upon sorting at Manchester, all maturing fish are taken to Bonneville for completion of maturation and spawning in freshwater.

	CC94	LR94	GR94	CC95	LR95
Year spawned/Sex	Proportion of Spawned Adults with Clinical BKD				
1996 Male	4/10	6/10	2/6		
1997 Male	2/71	2/74	7/13		
1998 Male	1/34	2/21	0/1	1/77	19/118
1998 Female	1/68	7/41	1/4		0/1
% of spawned adults with clinical BKD	4.4	11.6	41.7	1.3	16.0

Prophylactic and Therapeutic Treatments for Bacterial Kidney Disease

Prophylactic treatments with oral aquamycin every four months after capture were designed into the program at the outset with the expectation that some infection by *Renibacterium salmoninarum,* the BKD organism, would be present in these natural populations. This expectation was based on data obtained in previous years showing that infection was known to occur in natural juvenile spring chinook salmon in the Lostine River and Catherine Creek. It was hoped that this systematic four-month frequency of antibiotic therapy might prevent clinical levels of infection and significant mortality from occurring. It was also hoped it might prevent or limit the need for additional treatments that would complicate the program and potentially require additional handling of the fish. Prophylaxis with aquamycin was intended to be carried out at the recommended INAD dosage and duration of 100 mg/Kg body weight per day for 28 consecutive days, respectively.

The first aquamycin prophylactic feeding was programmed to be administered at Lookingglass Hatchery during October of each year, following capture of the parr earlier in the summer. This was in fact done for the brood years of 1994, '95 and '96. October was selected in order to adapt the fish to eating an artificial diet in the first few weeks after their capture while at the same time obtaining some initial growth before feeding medicated feed, which is less desirable to fish in terms of taste. October was also chosen because water temperatures are sufficiently high so that the fish take enough feed to receive the therapeutic level of antibiotic before water temperatures are adjusted downward in November to mimic natural conditions. Even under this scenario, growth was inhibited, and maximizing growth is considered crucial to the program goals.

Difficulties with the prophylatic protocols arose in the first year. Requirements to handle, tag, transport and perform other manipulations with the fish made the every-four-month treatment regimen impossible. In part, this was because the required 14-day detoxification period following a treatment resulted in a 42 day no-handling scenario. Then, mortalities occurred in three different aquamycin treatments, and the basic premise of the aquamycin prophylaxis became highly suspect and has since been the subject of ongoing concern. Presumptively, these mortalities were due to antibiotic toxicity. Decisions were made to suspend the four-month prophylaxis and only treat the fish if BKD losses indicated therapy was needed. Bacterial kidney disease losses rose within the ensuing months and dorsal sinus erythromycin injections were adopted for many treatment applications because the high BKD mortality demanded a more aggressive therapy than feeding prophylaxis could provide. Because of the presumed toxicity events, however, injections with erythromycin were begun at a conservative dosage of 10 mg antibiotic/Kg body-weight of fish. Mortality to BKD continued at a high rate at Bonneville, so the injection dosage was increased incrementally to 15 and 20 mg/Kg by using small test groups (five or ten fish) of each stock and brood year at both Manchester and Bonneville. Using this approach, it took several weeks to get all stocks and brood years to the 20 mg/Kg treatment level. In the meantime, BKD mortality continued at a high rate in some stocks. No evidence of erythromycin toxicity was identified at any time during this process.

Other adaptive measures have been taken to mediate the ongoing problem of erythromycin toxicity during medicated feeding regimens. One is to simply terminate medicated feeding if nearly 21 total days of medication has been achieved. Another has been to change to an every-other-day sequence of medicated feed, with no feed of any kind on alternate days, until 28 total days of medication was attained (Christine Moffitt personal communication). This method has been effective with no known resulting toxicity mortality.

For recently planned aquamycin treatments of '96 brood year stocks at Bonneville and Manchester, medicated feed of the appropriate size and drug concentration was not available. To facilitate treatment, John Morrison (USFWS) generously provided the project with erythromycin fish pills which were administered under prescriptions. These pills were mixed with normal feed pellets and broadcast to the fish using typical feeding procedures. These were given for 21 days with no associated mortality. At both Manchester and Bonneville, however, a few fish displayed "red-heads" and light coloration thought to be associated with feeding the pills (Carlin McAuley and Scott Lusted personal communications).

Erythromycin Injection of 97 Brood Year Parr

In conjunction with the collection of the '97 brood year parr in the summer of 1998, injections of erythromycin were given to the fish upon their arrival at Lookingglass Hatchery in lieu of the October aquamycin feeding given to the previous three brood years. The use of injections rather than feeding is designed to remedy the growth inhibition resulting from the use of medicated feed in October while still providing an acceptable level of prophylaxis for BKD.

Upon arrival at Lookingglass, each fish was anesthetized, weighed to the nearest 0.1 g, and given an intraperitoneal injection of erythromycin at a dosage of 20 mg/Kg body weight before being placed into a Canadian trough for the duration of its rearing in freshwater at Lookingglass. Injections were done with sterile 0.5 cc tuberculin syringes with an attached 29-gauge needle. Separate syringes were used for each fish. The individual injecting the fish called out the dosage from a dosage chart made specifically for this purpose, then another individual verified the dosage before the fish was injected. This protocol required diluting Gallimycin-200 (injectable erythromycin containing 200 mg erythromycin/mL) down to 2.5 or 5.0 mg/mL, making manageable volumes for injecting fish in the 1-10 g range. The diluent for

Gallimycin was a formulation containing glacial acetic acid (16.4%) and absolute alcohol (83.6%), kindly provided by Craig Banner of the ODFW Fish Pathology group. Freshly diluted antibiotic was made aseptically each Monday on the week that fish were collected.

One-hundred sixty-seven surrogates (non-ESA listed parr collected from Lookingglass Creek) and 500 fish each from Catherine Creek, the Lostine and the upper Grande Ronde rivers were given this injection without any known deleterious effects. Unfortunately, however, because there were no other treatments given to cohorts, the efficacy (or lack thereof) of this treatment cannot be scientifically assessed. The only means to assess the efficacy of this treatment lies in the long-term outcome of bacterial kidney disease and levels of *R. salmoninarum* antigen measured in the kidneys of those '97 brood year fish that survive to spawn. Attempting to make year-to-year comparisons within a stock is not a valid approach to making this assessment. A recommendation was made to the Oregon Chinook Captive Broodstock Technical Oversight Team that surrogates be used in a pilot group study to control BKD as soon as possible to compare the efficacy of a single injection to a standard aquamycin feeding in fish of similar size. Whether or not this proposal is carried out, the relative efficacy of the single injections will likely become apparent at some future date. One '97 brood year Catherine Creek fish died with clinical BKD on September 19, 1998, one month after it was injected with erythromycin. Another died of BKD on November 9, 1998. There have been no other '97 brood year BKD mortalities. The fish are scheduled for a standard aquamycin feeding beginning in February of 1999.

Summary

Bacterial kidney disease has the potential to be a serious impediment to fulfilling the goals of the Oregon chinook captive broodstock program. Significant BKD mortality has occurred in the '94 brood year fish. These losses are reported as numbers of dead fish, but how the losses might affect the diversity in the gene pool from these populations may not be accounted for in simple numbers. Susceptibility and resistance to BKD has been shown to have a genetic component (reviewed by Fryer and Lannan 1993) and certain genetic types may be eliminated from these captive populations by BKD. One important goal of the program is to maximize genetic diversity from within these populations, so losses to BKD could be significantly reducing that diversity. In the '94 brood year, the population of fish captured was reduced by 20% in the Lostine River fish and 49% in the Grande Ronde River fish before a female was ever spawned. Indeed, of 110 Grande Ronde parr collected in 1995, only four females were spawned as four-year-old adults in 1998, and one of these had clinical BKD. Loss to BKD in '95 brood year fish is at 12% and only one female was spawned in 1998. These '95 brood year fish must survive another 9-10 months before the major portion of the females are expected to mature.

The second impact that BKD may have on captive populations is the occurrence of BKD in the progeny of the spawned females with moderate and high infection levels. Maternal transmission of the bacterium is well documented (Evelyn et al. 1984) and experience in artificial propagation programs has shown that clinical disease can be expected to occur in the progeny from infected females. Low density rearing, aggressive prophylactic treatments, and limited handling will be needed on the juveniles to minimize the impacts of BKD, which will pose a threat throughout the entire life of these progeny.

To date, BKD has been far more prevalent in fish reared at Bonneville in fresh well water than in fish at Manchester reared in seawater treated with ultraviolet light. This is based solely on the incidence of mortality for two brood years. Further insight into the effects of seawater rearing versus freshwater on *R. salmoninarum* infection rates and levels will be provided by an evaluation of spawned fish reared under each environment. Using the ELISA, infection profiles will be obtained to provide data for this important analysis. If this program is to continue beyond its currently projected five-year duration, consideration should be given to taking a larger portion of the fish to Manchester each year. This evaluation, of course, will also need to take into account other performance measures being made on the seawater versus freshwater reared cohorts.

Events that have occurred in the program related to medication for BKD include: 1) poor palatability of medicated feed resulting in growth retardation and reduced drug efficacy, 2) mortality, presumably resulting from a toxic reaction to erythromycin, with the Lostine River stock appearing to show a higher sensitivity than the other two stocks, 3) the inability to obtain appropriate medicated feed at times, and 4) limited medication options that have scientific documentation. Where BKD is concerned, the program has evolved to a point where it must balance the need to treat the infection, how, when and what to treat it with, and whether or not the treatment will be effective and safe. Most, if not all, of these treatments are unproven in the life stages of fish being treated and at the frequencies that medication are being given. Resolution to the medication unknowns and better control of BKD are unquestionably needed for this captive broodstock program. In some ways, the array and diversity of adaptive prophylactic and therapeutic strategies used thus far have confounded the uncertainties in the project rather than helped to resolve them. A systematic and scientific approach to treatments is needed to evaluate their effectiveness in order for the most prudent course of action to be taken when adaptive strategies are required.

Acknowledgments

Many individuals from several agencies and groups participate in the Oregon captive broodstock program in various ways and we acknowledge their contributions. Particular contributions to the fish health component of the program were made by Carlin McAuley (NMFS), Willie Noll (ODFW), Leslie Smith (ODFW), Nadine Hurtado (ODFW), Terry Kreps (ODFW retired), Rich Holt (ODFW) and Bryant Spellman (ODFW). The fish culture professionals at Lookingglass Hatchery, Bonneville Hatchery and Manchester Marine Laboratory are obviously the key personnel to administering medications and taking care of the day-to-day health and welfare of the fish. Funding for the fish health activities is provided by the Bonneville Power Administration. Kassandra Brown (ODFW) provided very valuable editorial assistance.

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Session III

Hatchery Practices

Session Chair:

Doug Young
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AN EASIER WAY TO MEET GENETIC SPAWNING GUIDELINES

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Abstract

Genetic spawning guidelines for Pacific salmon usually recommend 1:1 mating of males and females. Review of spawning practices in Pacific Northwest salmon hatcheries reveals that many programs have not adopted 1:1 spawning. Undoubtedly, logistical difficulties have made 1:1 spawning difficult or impractical for many progams. Here, we suggest a practical approach to using sets of factorial matings (for example, each of five females mated with each of five males). This approach allows sets of eggs to be pooled before fertilization. This makes egg-taking and transportation easier than 1:1 spawnings because eggs from individual females do not have to be kept separate. It also provides a greater genetic advantatge than 1:1 spawnings, which will keep your geneticist smiling.

Introduction

Genetic spawning guidelines are designed to conserve genetic diversity. Unfortunately, they may not always be very practical. For example, genetic spawning guidelines for Pacific salmon usually recommend 1:1 mating of males and females with the caveat that milt from males should not be pooled (Hershberger and Iwamoto 1981, Kapuscinski 1993). The practical consequences of this are that eggs from individual males and females must be kept separate. The inherent logistical difficulties of collecting, transporting, or fertilizing individual collections of eggs and milt have undoubtedly made 1:1 spawning difficult or impractical for many programs. Not surprisingly, review of spawning practices in Pacific Northwest salmon hatcheries reveals that many programs have not adopted 1:1 spawning. In this presentation, we suggest an alternative approach to meeting the intent of genetic guidelines that does not have some of the logistical difficulties of 1:1 matings.

The intent of 1:1 spawning is to minimize the potential inbreeding and loss of genetic information in a population. Geneticists estimate this potential by the effective breeding numbers of the population (N_e). Technically, a population may have different effective breeding numbers to describe the potential for inbreeding or loss of genetic information by genetic drift (Crow and Denniston 1988). Genetic drift is the random genetic change that occurs because not all the genetic information in a population can be passed on through a few individuals. Either way, however, the larger the effective breeding number is the less the potential for inbreeding or loss of genetic information. The effective breeding number is almost ways less than the actual numbers of spawners, but the actual number depends on a variety of factors. These include the total number of spawners, sex ratio, mating system, and variation in the number of offspring that survive to reproduce from different families (Falconer 1996, Caballero 1994).

Spawning practices that ignore the critical factors influencing effective breeding number can inadvertently increase the potential for inbreeding and loss of genetic information (Gharrett and Shirley 1985, Withler 1988). It is possible, however, to take advantage of some of these critical factors to increase the effective breeding number. One way of increasing the effective breeding number over that of 1:1 matings is to use factorial matings. Factorial matings are where the gametes from a set of individuals are divided and fertilized so that every female is mated to every male (Figure 1). Factorial matings increase the effective breeding number for genetic drift without increasing inbreeding. The amount that the effective breeding number increases from factorial matings can vary, but computer simulations indicate that even 2 x 2 factorial matings can be beneficial (Busack in prep).

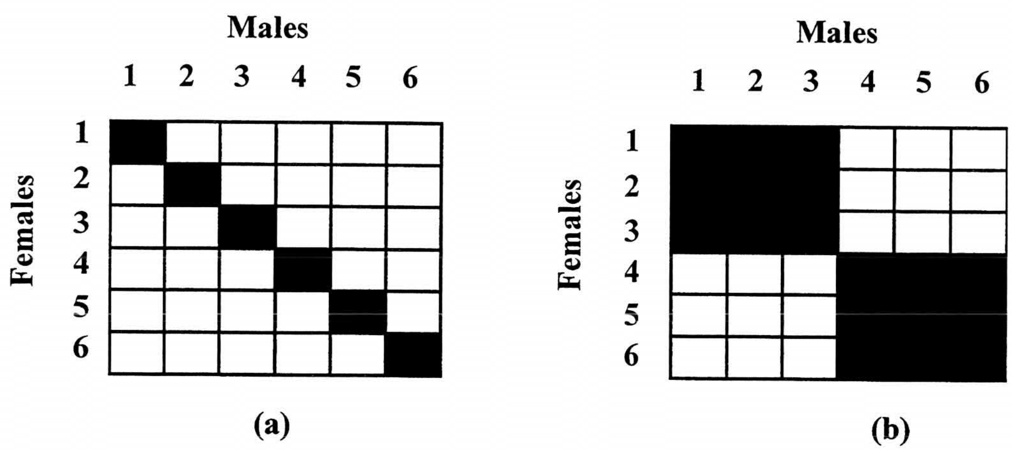

Figure 1. Mating schemes. In paired 1:1 matings (a), all the eggs from a single female are fertilized by a single male. In a semi-factorial mating (b), equal lots of eggs from each of three females have been mated to three males to make two 3 x 3 factorial matings. In a full factorial mating (not shown), every female would be crossed with every male.

The Method

Factorial matings are used most often in situations where the number of spawners is small enough to allow the eggs and milt to be divided into equal lots and fertilized as illustrated in Figure 1. The same effect is possible, however, by pooling the eggs from a group of females, mixing them thoroughly, and then dividing them up into a number of separate, equal lots for fertilization. The number of lots is equal to the number of females that were originally pooled. The main steps are described below.

1. Collect eggs from 2-10 females into a common container. The number of females used determines the size of that factorial mating. For example, if eggs from five females were pooled, they will be fertilized with milt from five males in a 5 x 5 cross.

2. Collect milt from individual males in separate containers.

3. Prior to fertilization, rinse the pooled eggs in an isotonic solution of 13.68 g/l of $NaHCO_3$. This is a critical step. By suspending the pooled eggs in solution, it is possible to mix the eggs gently and thoroughly. Thorough mixing is essential for this is to be an effective factorial cross. In addition, rinsing the eggs in the buffered solution can significantly increase fertilization (Wilcox et al. 1984).

4. Pour off the excess $NaHCO_3$.

5. Divide the pooled eggs into equal lots in separate containers. The number of containers will be equal to the number of females that were pooled.

6. Fertilize each lot with the milt from a different male.

Conclusions

The ability to use pooled eggs is the main practical advantage that this method has over 1:1 matings. The increase in effective breeding size is the main genetic advantage. In large production facilities that have traditionally pooled eggs and sperm, this technique could potentially increase effective breeding size 2-3 fold.

These benefits do come at some cost in labor. In trial runs at the Nisqually Indian Tribe's Clear Creek Hatchery, we estimated that it would take three hatchery biologists an additional 70 minutes to collect and fertilize one-half million eggs during a day. Although this is a significant increase in effort, it is not an impractical. Where logistical reasons, such as the need to pool eggs, make 1:1 spawning impractical, this approach to factorial mating may be a viable alternative.

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EFFECTS OF PHOTOPERIOD MANIPULATION ON PRECOCIAL BEHAVIOR OF IDAHO SUMMER STEELHEAD SMOLTS

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ABSTRACT

In spring of 1996, it was noted that we had high levels of precocial development of steelhead male smolts in some raceways. It was observed to be nearest one yard light at the intake end of production raceways. The following year, most of the raceways were checked and the raceways nearest the offending yard light had the highest incidence. In 1997, the yard light was removed and the incidence of precocial smolts dropped from as high as 25% to nearly zero percent. The position of the yard lights in relation to the raceways appears to have a direct bearing on this behavior.

DISCUSSION

In February of 1996, while pit tagging various lots of summer steelhead presmolts, one raceway had nearly 25% precocial smolts detected. This fish lot showed about 50% less survival to collection facilities on Lower Snake Dams than the other tagged groups.

The year that we noticed the problem (1996), we had installed racks at the mid-point of the raceways (100 feet) to keep the fish from congregating at one end or the other and wasting feed. Our raceways are fed by a traveling bridge with 16 raceways fed at a time. The fish near the yard light (GE Lucalox LU 150/55) could no longer travel through 200 feet of raceways and were probably more influenced by the yard light.

In the spring of 1997, a check on precocial smolts over several raceways showed highest incidence near one yard light located at the head end of several raceways. Raceways farther away from the yard light showed decreasing incidence.

The offending yard light was turned off in preparation for the brood year 1997 production cycle. These fish were checked in March of 1998 and sampled raceways ranged between 0 and 1.3% precocial development. (Figure 1 and 2.)

Yard lights at the tail end of raceways have not been turned off. The bottom raceway sections are much deeper and get less light. It appears to be yard lights at the head end of raceways shining directly into their line of vision that causes the problem.

Figure 1. 1997 Check Percent Precocial

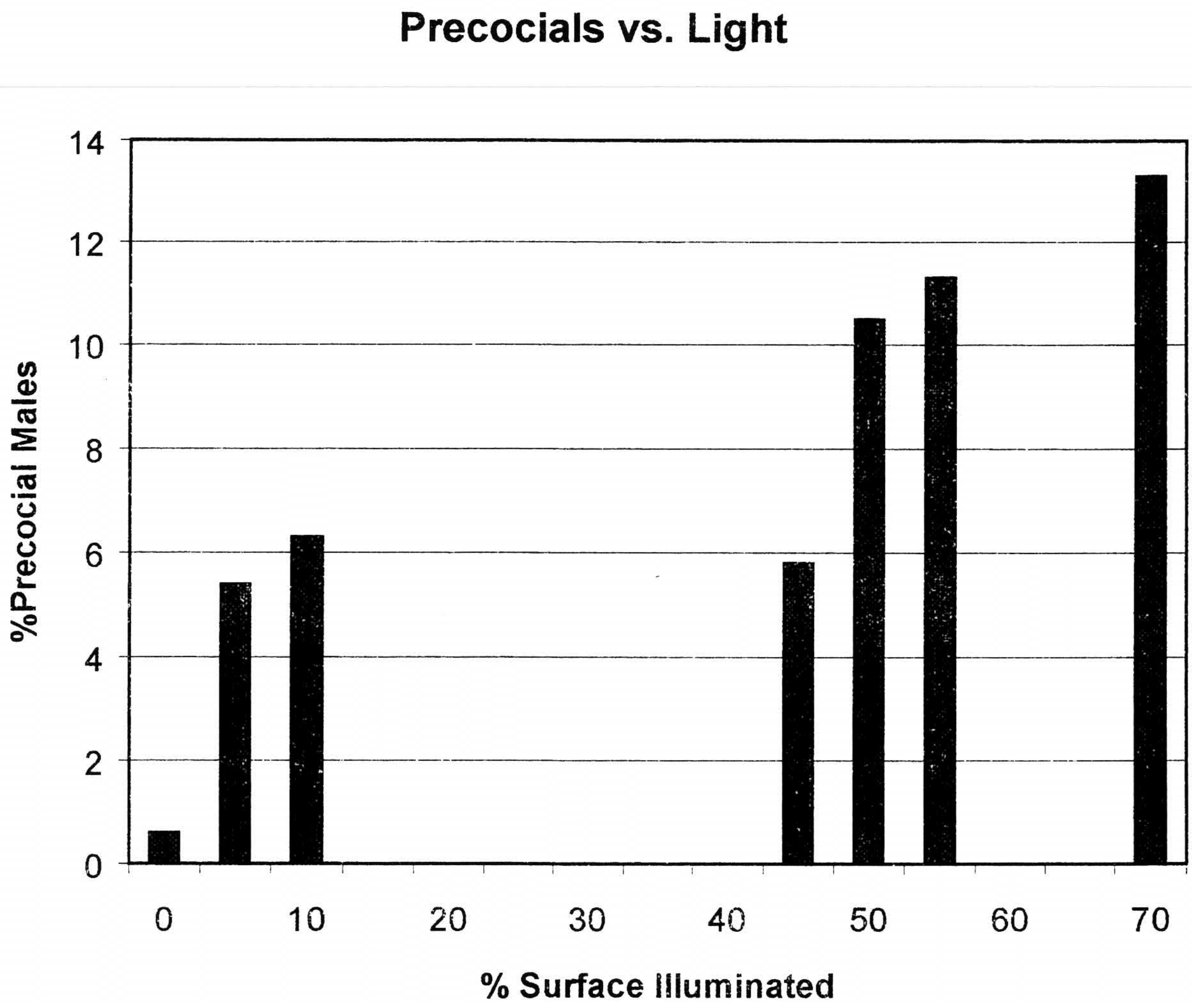
Yard Light No Yard Light

16 W	13.3%		15 E	1.3%
15 W	11.3%		11 E	0.0%
14 W	5.8%		7 E	0.0%
10 W	5.5%		5 E	0.0%
5 W	0.0%		2 E	0.6%
2 W	0.0%		1 E	0.6%

Porch Light

Figure 2. 1998 Check and Summary

Raceway	1996	1997	1998	Raceway	1996	1997	1998
16 W	25%	13.3%	0.0%	16 E			
15 W		11.3%		15 E		1.3%	
14 W		5.8%	0.0%	14 E			
13 W				13 E			0.6%
12 W				12 E			0.0%
11 W				11 E		0.0%	
10 W		5.5%		10 E			
9 W				9 E			
8 W			0.6%	8 E			
7 W				7 E		0.0%	0.0%
6 W				6 E			
5 W		0.0%		5 E		0.0%	
4 W				4 E			
3 W				3 E			
2 W		0.0%		2 E		0.6%	
1 W				1 E		0.6%	1.3%


Precocials vs. Light
%Precocial Males
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
% Surface Illuminated

CLE ELUM SUPPLEMENTATION AND RESEARCH FACILITY

Dan Barrett, Complex Manager
Charles Strom, Assistant Manager
Virgil Lewis, Fish Culturist

Abstract

On May 1, 1997 the Complex Manager reported in for duty at the Cle Elum Research station, at a time when this facility was still under construction. The only items furnished to this new facility were two pads of paper and two pencils. The station was officially turned over the Yakama Indian Nation on August 1, 1997. A crew of seven full time employees, consisting of one complex manager, two assistant manager trainees, two fish culturist IV's, one office assistant, and one night watchman, operate the Cle Elum Hatchery. As the acclimation sites for this station come online for operation, others will have employment opportunities here.

The first Spring Chinook adult salmon was received on May 30, 1997 and adult transfer continued until the 18th of September. A total of 105 males and 253 females were trapped at the Roza collection facility and delivered to the Cle Elum Hatchery. Mark Johnston and crew did an excellent job in determining the sex of the fish as a 95% accuracy rate was recorded. The fish were treated with formalin to control fungus during the holding period. The first treatment was on June 2 with a concentration of 1:8000 ppm, and as the adult holding period continued the concentration of formalin increased. On June 25 the treatment was increased to 1:7000 ppm, and on July 21 it was bumped to its maximum concentration of 1:6000 ppm. The treatments lasted until the start of spawning. The pre-spawning adult mortality rate was 9.3%, for the five-month holding period.

Spawning began on September 3 and continued for a nine-week period. During the spawning period research support involved staff from the YIN, WDFW, and USFWS, along with assistance from other volunteers/helpers. After egg mass was recorded, each female had their eggs divided into three equal components. Each component was then fertilized with sperm from one of three different males to maximize genetic diversity. All fertilized components were re-combined and then placed in iso-buckets for incubation. Once the eggs reached the eyed stage, they were to be shocked, accounted for, randomized into treatment pairs and then placed into vertical incubators for the remainder of the incubation period.

Water temperature was controlled for each group of eggs taken from the nine week spawning period, allowing the later lots of eggs to catch up in development with the first lots of eggs (decrease water temps for early egg take and increase water temp for later egg take). This, in compliance with facility planning, allowed all fish to be ponded in a one-week period around April 15, 1998. 534,200 eggs were taken during the spawning period. Upon reaching the eyed stage, the eggs were shocked; the dead eggs removed while the remaining good eggs were hand counted. The actual egg take was 502,181 eggs, with 93% (466,071) reaching the eyed stage. The crew split the eggs into control and treatment ponds after having finished counting the good eggs. Each pond has half of the female egg lots into each of two groups (control and treatment), to avoid a potential bias if any female should have bad eggs. A total of 10 ponds where utilized for the 97 brood, five ponds for the control and the other five for the experimental treatment.

All ponds where covered with bird netting for protection from avian predation. The control ponds will be reared following conventional hatchery methods. The experimental ponds have a camouflage bottom and sides, midwater structure (fir trees), and floating covers to mimic natural conditions. Food delivery to the experimental ponds is brought about by under water feeders.

We utilized many different resources for the construction of items needed to carry out facility operations. Some of the items adapted for use during the spawning and rearing processes included camouflage netting, bread carts, rubber gasket materials and cable tensioners. Barney Tulee, a screener for Federal Surplus items, acquired these items. A good assortment of tools aided to provide a strong base in the construction and adaptive management of all materials used for the project.

A 40-minute slide presentation will be given with three speakers and a question period.

MAINTAINING GENETIC DIVERSITY IN EAST FORK SALMON RIVER CHINOOK SALMON USING A SPAWNING MATRIX.

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Abstract

Chinook salmon (Oncorhynchus tshawytscha) from the East Fork of the Salmon River are listed as a threatened population. Wild parr from the 1994 cohort were collected and held in captivity by the Idaho Department of Fish and Game and the National Marine Fisheries Service to be released as mature adults in the fall of 1998 under a captive rearing evaluation program. However, concerns regarding the volitional spawning success of the captively reared fish resulted in all 31 maturing adults from the 1994 cohort being held for captive spawning. Fin tissue from maturing adults and samples of cryopreserved milt from available 3 year-old males that matured in 1997 were analyzed for genetic differences using mitochondrial and nuclear DNA markers. Mitochondrial haplotypes and nuclear genotypes were identified in the maturing fish and used to construct a spawning matrix. Crosses were prioritized for outcrossing similar maternal lineages followed by outcrossing similar nuclear genotypes. Assigning a numerical value to each genetic type allowed crosses to be prioritized as females matured. The crosses performed using the matrix reconstitute two genotypes in the F_1 *absent from either the live parental female or male component, maintain the same frequency of less common genotypes within the population, and avoid further losses of diversity in the* F_1 *generation due to genetic drift.*

EFFICACY OF ALKA-SELTZER AS A FISH ANESTHETIC

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Abstract

Currently, only tricaine methanesulfonate (MS-222) and carbon dioxide have been approved by the U.S. Food and Drug Administration for use as anesthetics among food fishes. Unlike MS-222, carbon dioxide is available in many forms and has the added advantage of no Aclearance@ or withdrawal period before treated fish can be harvested as food. One form, carbonic acid, has been found to be an effective anesthetic for rainbow trout, Oncorhynchus mykiss (Gelwicks et al. 1998). We examined the efficacy of using Alka-Seltzer Gold7 tablets to generate carbonic acid as an anesthetic for juvenile chinook O. tshawytscha and coho salmon O. kisutch. Two Alka-Seltzer treatments were used: 0.58 g/L and 2.93 g/L, with 0.0 g/L as the control. For each species, four groups of five randomly selected fish (13-14 months post-fertilization) were tested per treatment (chinook length range, 103-166 mm; coho length range, 105-175 mm) in a 45 L container. Following as much as a 15 min period to induce anesthesia, fish were fin-clipped (simulating a possible handling scenario in a field or lab study) and then transferred to a 200 L tank for recovery and monitoring (72 h) for mortality and effects of treatment. Water temperature, pH, dissolved oxygen and alkalinity were measured before and after fish were treated. Regardless of the Alka Seltzer treatment level (0.58 g/L or 2.93 g/L), only one fish died (0.58 g/L treatment) in our experiment. No mortalities occurred among control fish, despite clipping fins with no anesthesia. The highest concentration (2.93 g/L Alka Seltzer) anesthetized all test fish within 2.16 min. The lowest treatment concentration (0.58 g/L) required up to 15 min to induce an anesthetic effect in spring chinook, and nearly 10 min to anesthetize all coho salmon. This study demonstrates the potential usefulness of a commercially available, pre-packaged, easily transportable product for anesthetizing juvenile salmonid fishes. Its use may be particularly meaningful in fishery field studies where released fish can be caught by fishers or predators to the extent that other anesthetics (e.g. MS-222) cannot be used. These preliminary data are the basis for more extensive studies now underway.

Introduction

Various types of fish anesthetics have been used and evaluated by fishery biologists over the past several decades. These have included tricaine methanesulfonate (MS-222; Schoettger and Julin 1967), carbon dioxide (CO_2; Fish 1943), sodium bicarbonate ($NaHCO_3$; Booke et al. 1978), oil of clove (Taylor and Roberts In Press), and others.

The compounds used as fish anesthetics have various advantages and disadvantages. One of the most frequently used and approved fish anesthetics is MS-222, commonly sold under the name Finquel7 (Argent Corporation). MS-222 is registered by the U.S. Environmental Protection Agency and the Food and Drug

Administration (FDA) and is capable of anesthetizing fish rapidly (Meyer et al. 1976). However, MS-222 requires a 21 d waiting period before test specimens can be released into areas where they may be caught and consumed by humans. CO_2 and $NaHCO_3$ are very inexpensive anesthetics, but death can occur from oxygen deprivation if doses are too high (Booke et al. 1978). In addition, the use of CO_2 gas (bubbled into tanks of water) is known to induce anaesthesia, but the required equipment is not very portable in field environments. Oil of clove is a natural substance but is not yet approved for use as a fish anesthetic by the FDA.

Commercially available Alka Seltzer7 compounds contain $NaHCO_3$, a known source of CO_2. Consequently, we evaluated the potential of Alka Seltzer as a low-cost, easy-to-transport anesthetic for fish in hatchery and field settings. In addition, the product is intended for human consumption. One of us (BJ) had conducted preliminary tests of the anesthetic properties of Alka Seltzer (aspirinated) on juvenile spring chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout (*O. mykiss*), and non-aspirinated Alka Seltzer on steelhead trout (*O. mykiss*) in California. In the study described here, we evaluated non-aspirinated Alka Seltzer as a potential anesthetic for juvenile chinook and coho salmon (*O. kisutch*). The results presented here are considered preliminary and provide a foundation for more detailed evaluations.

Methods

Origin and characteristics of test fish.-- All tests were conducted on spring chinook and coho salmon. The spring chinook were hatched from eggs obtained from Carson National Fish Hatchery, Washington. The coho were hatched from eggs obtained from Big Creek State Hatchery, Oregon. All fish were acclimated to the treatment temperature (see below) and were not fed for 48 h prior to each test. At time of study, the spring chinook juveniles averaged 127.9 mm in fork length (range, 103-166), 24.3 g in weight (range, 12.6-49.9), and age was 14 months (post-fertilization). The coho juveniles averaged 136.6 mm fork length (range 105-175), 31.2 g in weight (range, 13.0-61.0), and were 13 months of age, post-fertilization.

Test conditions.-- Treatment equipment consisted of circular plastic containers (41.9 cm in diameter) that held 45 L of water. A flowing Awater bath@ was established around each container to maintain a treatment temperature of 13^{O} C. All tests were conducted with well water (pH 7.9; total alkalinity 82-86 mg/L; total hardness 95 mg/L). Two Alka Seltzer treatments were used for each species: 0.58 g/L (one tablet per 3.78 L well water) and 2.93 g/L (five tablets per 3.78 L), as well as a control consisting of 0 g/L Alka Seltzer. Next, a partial fin clip (scissor clip) was made on each fish including controls to simulate handling in a field or hatchery environment. Only Alka Seltzer Gold7 (no aspirin or added medication) was used in our tests. Each tablet (weight; 2.2 g) contained 958 mg of heat-treated $NaHCO_3$, 832 mg of citric acid, and 312 mg of potassium bicarbonate, as reported by the manufacturer. Treatment concentrations and measured water quality parameters during the study are presented in Table 1.

Table 1.-- Water quality parameters (means) at start and end (15 min-treatment) of each Alka Seltzer Gold7 treatment on juvenile spring chinook and coho salmon at Abernathy Technology Center, Washington. (Temperature was 13^{O} C for all treatments.)

Species	Alka Seltzer (g/L)	pH Start	pH End	Oxygen (ppm) Start	Oxygen (ppm) End	Total Alkalinity (mg/L) Start	Total Alkalinity (mg/L) End
Chinook	0	7.90	7.90	9.80	9.48	83.35	83.22
	0.58	6.40	6.40	9.75	9.50	213.08	215.95
	2.93	6.18	6.20	8.93	8.78	668.50	695.25
Coho	0	7.90	7.85	9.70	9.35	83.00	83.70
	0.58	6.35	6.40	9.80	9.53	198.83	217.55
	2.93	6.13	6.15	9.57	9.30	677.00	730.25

Four replicates of five fish each from both species (collected at random) were tested at each of the two treatment levels and the control (20 fish per treatment per species). Water temperature, pH, dissolved O_2, and alkalinity were measured after Alka Seltzer was added and became dissolved in each test container. These data were also recorded after 15 min of treatment. For each treatment, five fish were transferred randomly by dip net from the stock tank to the treatment container. The times required for the first and fifth fish to lose equilibrium (and remain on tank bottom) were recorded for each treatment. After fins were clipped as described above, all fish (including controls) were then transferred by net to a recovery tank containing only well water. The recovery times were recorded for the first and fifth fish to regain equilibrium. Mortality was monitored for 72 h following each test.

Results and Discussion

Regardless of the Alka Seltzer treatment level (0.58 g/L or 2.93 g/L), only one mortality was observed in our evaluation (This fish died about 2 hours after treatment). Also, there were no mortalities among our control fish, despite fin clipping without anesthetization. Table 2 presents anesthetic induction and recovery times for all fish by treatment level. The greatest treatment concentration (2.93 g/L Alka Seltzer Gold) induced anesthesia among all test fish in just over 2 min. The lowest treatment concentration (0.58 g/L) required up to 15 min to induce an anesthetic effect in spring chinook, and up to nearly 10 min to anesthetize a coho salmon juvenile.

Table 2.-- Mean induction and recovery times (min) ± SE (ranges in parentheses) for spring chinook and coho salmon anesthetized with Alka Seltzer Gold7 at levels up to 0.58 and 2.93 g/L. (For each species and treatment level, four replicates of five fish each were used. Induction and recovery times were monitored up to 15 min).

Species	Alka Seltzer g/L	N	Deaths	Induction Time (min)		Recovery Time (min)	
				1st Fish	5th Fish	1st Fish	5th Fish
	0	20	0	-	-	-	-
Chinook	0.58	20	1	3.98 ± 0.59 (2.51 - 5.38)	13.07 ± 1.93 (7.28 - 15.00)	0.29 ± 0.11 (0.03 - 0.50)	5.59 ± 3.17 (1.08 - 15.00)
	2.93	20	0	1.15 ± 0.04 (1.08 - 1.21)	1.86 ± 0.10 (1.68 - 2.13)	1.82 ± 0.08 (1.68 - 1.98)	2.58 ± 0.18 (2.03 - 2.86)
	0	20	0	-	-	-	-
Coho	0.58	20	0	4.06 ± 0.53 (3.06 - 5.10)	8.35 ± 0.89 (5.76 - 9.78)	0.96 ± 0.31 (0.61 - 1.91)	7.38 ± 2.27 (3.83 - 13.83)
	2.93	20	0	1.26 ± 0.12 (0.98 - 1.56)	2.04 ± 0.06 (1.93 - 2.16)	1.39 ± 0.32 (1.01 - 2.36)	3.06 ± 0.64 (1.88 - 4.38)

Although somewhat preliminary, our results demonstrate the potential usefulness of a commercially available, easily transportable product for anesthetizing juvenile salmonid fishes. Its use may be particularly meaningful in fishery field studies conducted in remote areas. Alka Seltzer may be equally useful in studies where released fish may be caught by fishers or predators, and where other compounds (e.g. MS-222) cannot be used because of required Aclearance times@.

An observation of interest is that fish at the high Alka Seltzer dosage (2.93g/L) actually recovered more quickly than those exposed to 0.58g/L (Table 2). The chinook treated at 2.93g/L recovered in less than 3 min, in the coho in just over 4 min, where as some of the fish treated at the low dosage (0.58g/L) required over 13 min to recovery. Fish struggled more at the low treatment level than those exposed to the high level, as evidenced by the longer induction times at low verses high treatment levels. Consequently, recovery from low-level Alka Seltzer treatment may have been prolonged by an exhaustion effect.

In a study of rainbow trout, Gilderhaus and Marking (1987) demonstrated that 60 mg/L of MS-222 was an effective anesthetic level. At an estimated price of $75 per 100g MS-222, this equates to 4.5 cents to treat 1 L of water at 60 mg/L. At the 2.93 g/L dosage of Alka Seltzer, the comparable cost is 18 cents per L treated. Thus, Alka Seltzer may not be as cost-effective as alternative anesthetics, however its benefits include the lack of a required Awithdrawal@ period, its availability as an approved substance for human use on an Aover-the-counter@ basis, and its pre-packaging and portability. Additional study is planned with other species and life stages of fish.

Acknowledgement

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INFLUENCE OF REARING CONDITIONS AND DIET TYPE ON FIN EROSION

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Abstract

Fish with eroded fins which are stocked into waters may not be aesthetically pleasing to anglers, may have impaired survival, and may be prone to bacterial infections. It has been demonstrated that fin erosion may be derived from nutritional imbalances in feeds and environmental conditions inherent to hatcheries. Specifically it has been shown that raceways which contained cobble covered bottoms contributed to less fin erosion among rainbow trout (Onchorhynchus mykiss) and that steelhead trout fed a krill-based diet had better fin condition compared to fish fed a fish meal-based diet. For this study a total of six concrete raceways were fitted with a false floor which comprised a layer of gravel supported by perforated aluminum under which a drainage system lay, and six raceways were left untreated. Within the series of false floor raceways three were fed a control diet (ctrl/ff) and three were fed a krill-based test diet (test/ff). For the untreated raceways three were fed a control diet (ctrl/rw) and three were fed a krill-based test diet (test/rw). The hatchery performance of fish was significantly influenced by raceway and feed type. Final weights, feed conversion, and specific growth rate ranked in order of performance were as follows: test/rw > test/ff > ctrl/rw > ctrl/ff. For final weights and specific growth rate there were significant diet and raceway effects, and for feed conversion there was a significant diet effect. Fish in the false floor raceways did not grow as quickly and had final weights that averaged a few grams less than those for control raceways. Relative fin length measurements also revealed dietary and substrate effects. By week seven, fish in the false floor raceways had significantly longer dorsal, caudal, anal, ventral and pectoral fins than fish in concrete bottom raceways; the test diet also resulted in significantly longer fins for all but the ventral fins. By the conclusion of the study (week 17), all fins measured, except the caudal, were significantly longer for fish on the test diet than the control diet. All fins of fish in the false floor raceways were significantly longer than those of counterparts in the concrete-bottomed raceways. Significant diet x substrate interactions were noted for all fins except the dorsal, indicating that fin condition was best when using the test diet and false floor raceways. Health Condition Profile information also indicated significant diet and raceway effects. Mesenteric fat levels (ranked from 0, no fat, to 4, pyloric caeca covered) were significantly better on week 11 for the test/rw (2.8), test/ff (2.7), and control/rw treatments (2.5) compared to the control/ff fish (1.8). By week 17, test/rw fish had significantly better fat scores (3.2) than ctrl/ff fish (2.7) and ctrl/rw fish (2.9); test/ff treatment had an intermediate score (3.1). For week 11, mean fin index values (possible range from 0, no erosion, to 2, erosion with hemorrhaging) were best for the test/ff fish (0.1), followed by test/rw (0.2), ctrl/ff (0.4), and ctrl/rw (0.5), and by week 17, fin index scores were significantly better the test/ff fish (0.4) followed by ctrl/ff (0.6), test/rw (0.8), and ctrl/rw (1.1). Both types of treatments analyzed, cobbled substrates with a false floor, and krill-based feeds, had significant impacts on fish performance and fin conditions. In most cases the best results obtained were with fish raised in raceways with a cobble substrate and fed the krill-based diet.

Introduction

Fin erosion can be a common occurrence among fish raised in modern, large-scale culture operations. Fish with eroded fins which are stocked into waters may not be aesthetically pleasing to anglers, may have impaired survival, and may be more prone to bacterial infections. It has been demonstrated that fin erosion may be derived from aggression between fish, stocking densities, nutritional imbalances in feeds, or environmental factors inherent to a hatchery. In work conducted previously at the Fisheries Experiment Station (FES), Logan, UT, Bosakowski and Wagner (1995) demonstrated that rainbow trout (*Onchorhynchus mykiss*) and cutthroat trout (*Onchorhynchus clarki* Utah) raised in concrete raceways which contained a layer of cobble as substrate exhibited significantly less fin erosion than their counterparts raised in concrete bottomed raceways. An earlier inventory of Utah state hatcheries found that better fin condition was associated with fish which were raised in raceways and ponds that contained natural bottoms of mud or cobble (Bosakowski and Wagner 1994). Nutritional imbalances in fish feeds has also been implicated as a possible source of fin erosion. Lellis and Barrows (1997) demonstrated that steelhead trout fed a krill-based diet exhibited improved fin condition compared to fish fed a fish meal-based diet. They theorized that the krill-based diet, which contained naturally higher levels of copper, in some way improved the process of collagen formation in fin rays than the fish meal-based diet, which contained higher levels of iron, calcium and phosphorus. The purpose of this study was to test the hypothesis that raceway substrate (cobble vs. concrete) and dietary components improved the fin condition of rainbow trout.

Materials and Methods

Rainbow trout (*Onchorhynchus mykiss*) of the Sand Creek strain were raised indoors at the FES, Logan, UT, from swim-up for five weeks during which they were fed either a control diet or a test diet. After the five weeks on their respective diets (0.9 g/fish) the fish were moved outside into concrete raceways of the following dimensions: width = 1.1 m , depth = 0.6 m, width = 6.0 m. A total of six raceways were fitted with a false floor which was comprised of a layer of gravel supported by perforated aluminum under which a drainage system laid. The remaining six raceways were left untreated. For the series of false floor raceways three were fed the control diet (ctrl/ff) and three were fed the test diet (test/ff). For the untreated raceways three were fed the control diet (ctrl/rw) and three were fed the test diet (test/rw). The fish were stocked at densities of 1,200 fish per raceway.

The fish were hand fed either the control diet which was formulated to match a standard trout grower diet with fish meal as the primary protein source, or the test diet which contained krill meal as the primary protein source along with supplemental minerals thought to improve fin condition. Diets were made at the U. S. Fish and Wildlife Service's Bozeman Fish Technology Center, Bozeman, MT. At the beginning of the study fish were fed a ration that was 4.2% of the fish body weight, and by the end this ration was adjusted to 2.5%. Fish were inventoried monthly for weight gain. Fin measurements were made at the onset of the study, and then on weeks 7, 11, and 17. Fin measurements were used to calculate fin index values after Kindschi (1987). Necropsies were performed according to the Health Condition Profile (HCP) by Goede and Barton (1990) on ten fish per raceway (30 total per treatment) on weeks 11 and 17.

The flow indices used for the study ranged from 0.1 at the beginning to 0.4 by the end of the 17 week outside segment of the study. Density indices ranged from 0.2 to 0.5, but in general whenever the density index reached 0.4, it was lowered by adjusting the crowding screen. Water was supplied to the raceways by a well which had the following qualities: temperature = 13 EC, oxygen = 7.2 mg/l, alkalinity = 235 mg/l, hardness = 222 mg/l, pH = 7.2. Supplemental oxygen was supplied to the well water via liquid oxygen injected into sealed packed columns which fed into a common head box. Final water quality measurements showed all parameters within acceptable ranges for good trout growth. Dissolved oxygen concentrations were significantly lower, however, at the raceway tails for false floor treatments, 5.5 mg/l, compared to 6.5 mg/l for the control raceways by the end of the study.

Results

The hatchery performance of the fish was significantly influenced by raceway and feed type. Final weights, feed conversion (FCR), and specific growth rate (SGR) ranked in order of performance were as follows: test/rw > test/ff > ctrl/rw > ctrl/ff (Table 1). For final weights and SGR there were significant diet and raceway effects, and for FCR there was a significant raceway effect. For each of the above parameters there were no significant diet x raceway effects. No significant differences were found between the treatments with respect to mortalities which averaged 2.2%.

Comparisons of relative fin lengths also revealed significant dietary and raceway effects. The initial fin measurements taken five weeks after first feeding indicated those fish on the test diet had better dorsal and pectoral fins than the control fish (Figure 1). By week seven, fish in the false floor raceways had significantly longer fins than fish in concrete bottom raceways; the test diet also resulted in longer fins for all but the ventral fins. Significant diet x raceway effects were also found for caudal and ventral fins. Measurements made on week 11 also revealed significantly better fins among fish in false floor raceways compared to concrete raceways, and better dorsal, anal, and pectoral fins for fish fed the test diet compared to the control diet. Significant diet x raceway effects were also found for caudal and ventral fins. By the conclusion of the study (week 17), all fins measured, with the exception of the caudal, were significantly longer for fish on the test diet than the control diet (Figure 1). All fins of fish in the false floor raceways were significantly longer than those of counterparts in the concrete-bottomed raceways. Significant diet x raceway interactions were evident for all fins except the dorsal.

Health Condition Profile information also indicated significant diet and raceway effects. Mesentery fat levels (ranked from 0, no fat, to 4, pyloric caeca covered) were significantly better for the test/rw (2.8), test/ff (2.7), and control/rw treatments (2.5) compared to the control/ff fish (1.8). By week 17, test/rw fish had significantly better fat scores (3.2) than ctrl/ff fish (2.7) and ctrl/rw fish (2.9); test/ff treatment had an intermediate score (3.1). For week 11, mean fin index values (possible range from 0, no erosion, to 2, erosion with hemorrhaging) were best for the test/ff fish (0.1), followed by test/rw (0.2), ctrl/ff (0.4), and ctrl/rw (0.5). By week 17, fin index scores were significantly better the test/ff fish (0.4) followed by ctrl/ff (0.6), test/rw (0.8), and ctrl/rw (1.1).

In this study, for hatchery performance and fin condition, both test diet and substrate had a significant impact. Growth and fat accretion were best for the test/rw treatment and this may be, at least in part, a result of the false floor design. The design appeared to serve the function of allowing detritus to filter down through the cobble and out of the raceway via the drainage system. But there were several problems associated with the design. First, it did not allow for a true plug flow through the raceway because incoming water was being filtered out through the cobble and drainage system the entire length of the raceway. This was shown in the lower DO readings at the raceway tails which were 5.5 mg/l for the false floor raceways compared to 6.5 mg/l for the concrete-bottomed raceways. Second, the presence of the cobble may have prevented fish from eating feed that had settled to the raceway bottoms. Within the test and control dietary groups, final weights, feed conversions, and growth rates were better for those fish in concrete-bottomed raceways compared to false floor raceways. These differences in fish performance with respect to raceway type were arguably offset by the quality of fins obtained. By the end of the study fish fed the test diet in false floor raceways exhibited superior fin condition, however with the exception of the dorsal fin, fish fed the control diet in false floor raceways exhibited similar fin condition. Fish fed the test diet in concrete-bottomed raceways did have slightly better fins than those fed the control diet in concrete-bottomed raceways, although the differences were not as dramatic. For both cases, cobble as a raceway substrate and the use of the fin erosion test diet, the overall condition of the fins was improved which lead to higher quality fish, and possibly a better product for the resource.

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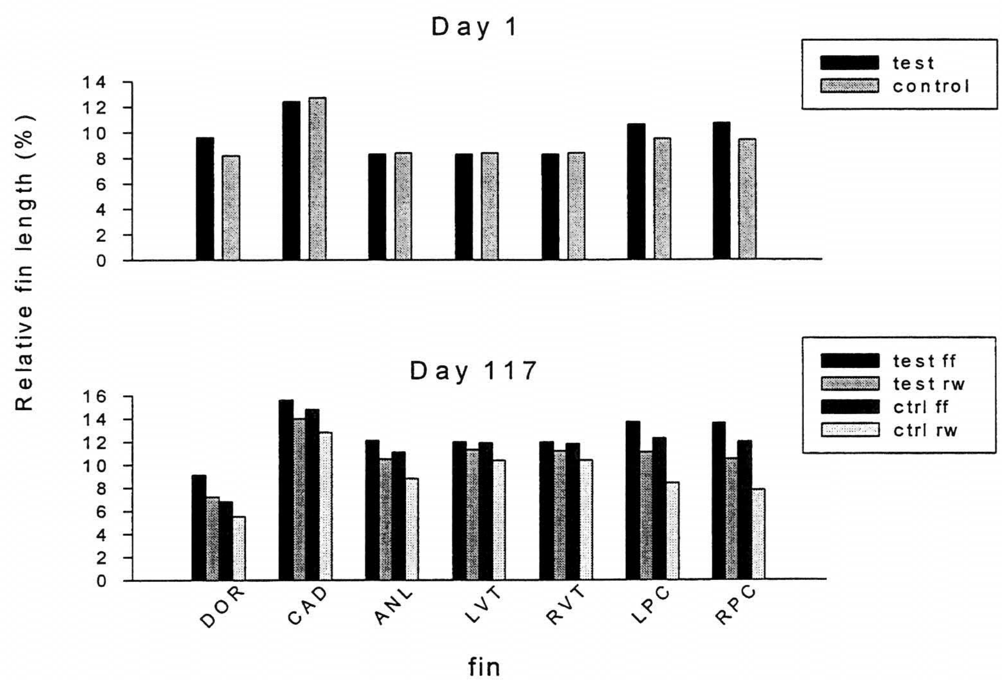
Table 1. Hatchery performance of rainbow trout fed a test diet and raised in untreated raceways (test rw) or raceways with false floors (test ff). And fish fed a control diet and raised in untreated raceways (ctrl rw) or raceways with false floors (ctrl ff). Values are means (" s.d.) of three replicate raceways of fish.

Diet/treatment	Final weights	FCR[1]	SGR[2]	Mortality (%)
Test/raceway	22.0 ± 0.5	0.84 ± 0.02	1.76 ± 0.01	2.3 ± 0.3
Test/false floor	20.7 ± 0.8	0.86 ± 0.03	1.72 ± 0.02	2.1 ± 0.2
Control/raceway	19.4 ± 0.9	0.89 ± 0.03	1.70 ± 0.03	2.1 ± 0.1
Control/ false floor	18.0 ± 0.8	0.91 ± 0.03	1.66 ± 0.02	2.2 ± 0.5
P > F Diet	0.00	0.03	0.00	0.93
Raceway	0.03	0.29	0.03	0.62
Diet X RW	0.96	0.81	0.84	0.51

[1] FCR = total g feed/total g weight gain

[2] SGR = ((ln final weight - ln initial weight)/length of study in days)*100

Figure 1.Comparison of relative fin length (% of total length) of rainbow trout fed a test diet and raised in untreated raceways (test rw) or raceways with false floors (test ff). And fish fed a control diet and raised in untreated raceways (ctrl rw) or raceways with false floors (ctrl ff). Day numbers indicate time of study in outdoor raceways. Fin abbreviations are DOR = dorsal, CAD = caudal, ANL = anal, LVT = left ventral, RVT = right ventral, LPC = left pectoral, and RPC = right pectoral.



PROGRESSIVE CULTURE OF COHO SALMON AT WILLARD NATIONAL FISH HATCHERY

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Introduction

Little White Salmon/Willard National Fish Hatchery Complex is located in Cook, Washington on the Little White Salmon River a tributary of the Columbia River approximately 270 km from the Pacific Ocean. Returning adult coho salmon are spawned at the Little White Salmon NFH brood facility where green eggs are incubated. Once eyed eggs develop they are transferred to Willard NFH which is located five miles upstream from its parent facility. Willard NFH is one of two federal coho salmon hatcheries above Bonneville Dam on the Columbia River. I along with three other employees work to produce 2.5 million coho salmon smolts for release. Bacterial coldwater disease, steatitis (sunburn), phoma herbarum, and gas supersaturation are the primary problems facing the coho salmon which we rear. These fish health concerns prompted us to implement projects to alleviate high fish mortalities and improve overall fish health. Packed columns have been installed to reduce the total gas pressure from our well water system and an initial feed study will be monitored to inhibit phoma herbarum.

Egg Incubation Study

Typically, eyed coho salmon eggs are transferred from Little White Salmon NFH to Willard NFH in burlap cloth set in wire baskets. The eggs are then enumerated and placed in Heath incubation trays. Each tray averages 4,600 eyed eggs. We attempted to imitate the natural spawning environment by incubating the eggs in neoprene matting. Results indicate that there was no significant difference in the survival of eggs with neoprene matting and those without. We also implemented two types of egg jars to incubate eyed eggs. Each jar was loaded with 40,000 eyed coho salmon eggs. Incoming water was forced through a perforated metal screen which allowed the eggs to rotate in the jar. Results from this study indicate that eyed eggs survived at a higher rate in heath trays as compared to egg jars. Bacterial coldwater disease analysis for both studies is inconclusive.

Baffles In Nursery Tanks

We have fifty-two nursery tanks at Willard. After initial hand feeding all tanks are feed by Northstar automatic feeders. We installed baffles in an attempt to reduce the labor involved in cleaning tanks and provide fish with a comfortable rearing environment. Four baffles and five baffles were used in respective tanks. Results indicate that five baffles per tank and water flow greater than 30 gpm are effective for cleaning nursery tanks. The size of the tank effluent screen was also a limiting factor.

Sunburn Prevention Study

Currently, we have fifty uncovered raceways at Willard. Coho salmon fry are transferred from tanks to raceways on May 15th each year. As early as ten days after transfer, fry develop white lesions on their dorsal tissue. This is commonly known as steatitis. In order to inhibit steatitis we utilized styrofoam sheets of insulation. Six 2' x 8' sheets were placed on the water=s surface of each raceway. Results indicate that the covers were effective in reducing the incidence of sunburn, but did not entirely eliminate tissue damage. The data that we collected revealed that fish in the covered raceways contracted sunburn at half the rate of fish in uncovered raceways.

Coho Salmon Condition Factor Analysis

We also monitored the coho salmon condition factor for an eleven month period. We found that the condition factor did not change for three months (December thru February). During this period it is obvious that the fish did not convert the fish food to growth. This winter we will conduct a reduced feed rations study from December thru February to determine if fish will attain the target size of 15 fish per pound at time of release.

Future Projects

Raceway covers are currently being designed by our regional engineer. A diet study is being monitored to inhibit steatitis, and five baffles per nursery tank are being revisited in order to reduce fish stress during nursery rearing. Finally, packed columns have been installed to reduce the total gas pressure in our well water system.

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EFFECTS OF A MODIFIED FEEDING STRATEGY ON GROWTH AND SMOLTIFICATION OF SUMMER STEELHEAD (*ONCORHYNCHUS MYKISS*) AT DWORSHAK NATIONAL FISH HATCHERY

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Abstract

A modified feeding program for steelhead (Oncorhynchus mykiss) was designed to promote smoltification in small fish, and to reduce production of larger fish that residualize. The growth rate of juvenile steelhead was manipulated during rearing to achieve a specific growth rate of < 0.5 (by weight) or < 0.2 (by length) in December and January, and a significant increase in growth rate between February and April. Specific growth rates and feed amounts from ten previous years were used to calculate the rations necessary to produce desired specific growth rates. Rations were reduced during winter months to levels comparable to that used in years characterized by smaller fish at release and subsequent higher adult returns. A reduction in growth was seen after one month in the fish fed reduced rations, as evidenced by significantly lower mean lengths and weights in January through March ($P < 0.05$) than in controls. Mean condition factors were also significantly lower ($P < 0.05$) from December through February in the reduced ration fish than in controls. The desired reduction in specific growth rate was not achieved until January. With conversion to production rations in February, the fish that had been on reduced rations quickly compensated and achieved the same mean length and weight in March and April as production fish. The decrease in condition factor between March and the time of release in April was observed in both groups when gill Na^+, K^+-ATPase levels were similar. After transfer to seawater, there was no difference in length, weight, condition factor, or mortality between the groups, and both groups had achieved the same level of smoltification as measured by gill Na^+, K^+-ATPase (23 mol $P_i \cdot$ mg protein$^{-1} \cdot h^{-1}$) after 1 month. Hatchery production records provided the information necessary to achieve a growth pattern similar to wild fish by reducing feed amounts, and to produce fish comparable in size and condition at release to fish on full production rations. Water temperature, weight inventories, and ration records from the specific hatchery stock should be considered when designing modified feeding programs.

Introduction

Steelhead (*Oncorhynchus mykiss*) from Dworshak National Fish Hatchery (DNFH) are characterized by a wide length frequency distribution at the time of release. A consequence of the wide size distribution is the production of three groups of fish: small fish that do not migrate, functional smolts, and large fish that residualize and may compete with wild stocks. Efforts to achieve size-at-release requirements, the use of demand feeders, and warm water temperatures may all contribute to an increase in the size range. Many alternative feeding strategies have been developed to counter growth patterns common to steelhead production facilities. The results of earlier studies strongly suggest that the time of year, holding temperature, and the stock of fish may influence the outcome of feeding trials. Reductions of feed to 50% of normal rations, regardless if fed continously or intermittently, were found to reduce weight gain and to control the production of large fish that might residualize (Smith 1987). The effects of reduced continuous or intermittent feedings were compared for steelhead held at 15 ^{o}C to determine the effects on growth rates and size variation (Klontz et al. 1991). All reductions in ration achieved reductions in both length and weight gain, but size variation did not change. Kindschi (1988) found that when rations were reduced, continuously fed fish had greater size variation than fish fed intermittently on a reduced diet. Steelhead also may exhibit compensatory growth after periods of starvation, which allows them to achieve the same growth as control fish after a return to normal ration levels (Dobson and Holmes 1984). Therefore, growth may be reduced by a decrease in ration, size variation may be reduced by intermittent feeding, and compensatory growth allows for accelerated growth when fish are returned to normal rations. We applied these observations to our study.

Our objectives were to (a) increase the number of fish that migrate by promoting smoltification in smaller fish, (b) reduce the number of large fish, and (c) to reduce the length frequency distribution. Rations were reduced during winter months to achieve a growth pattern modeled after growth in wild fish, which involves a reduction in growth rate during the winter months followed by accelerated growth immediately before migration, or in the case of hatchery fish, before release. Our study differs from other steelhead production studies in that we used the DNFH monthly inventory records from the past ten years to design the modified feeding schedule based on growth rates for specific months. Mean lengths, weights, and rations were documented for each month of the years 1987 through 1997, and specific growth rates and g feed · g fish^{-1} were calculated. The minimum specific growth rate (in length and weight) determined for DNFH steelhead over the past ten years was selected, and the ration amounts consumed during periods of minimal growth were chosen as the desired amount. The stock- and site-specific design allowed us to reference specific growth patterns of DNFH steelhead, and to test the design on a production level for future hatchery applications.

Methods

Fish from a single spawning take of steelhead at DNFH (brood year 1997) were used for the experimental population. The treatment and control groups were duplicated for a total of 4 ponds with the same stocking density. Fish were reared under routine hatchery conditions until November 26, 1997. Fish were fed Nelson's Silver Cup steelhead diet. Specific growth rate by both length and weight was calculated for the production group from the past ten years (Tables 1 and 2), and the minimum growth rates for the stock were determined. 1989 and 1996 were used as reference years.

The rations for December were selected to achieve a target growth rate approximately half of that seen in most other years. The two ponds designated for modified feeding were put on rations calculated as 0.25 g feed · g fish^{-1} · month^{-1} based on estimated weight of fish from the previous inventory. Fish were fed one-third of the calculated weekly ration three times a week (Monday, Wednesday, and Friday) when demand feeders were loaded. On February 10, production-level rations were resumed for fish in treatment groups.

Table 1. Specific growth rate calculated from the change in fork length (mm) per day of Dworshak National Fish Hatchery System II steelhead from 1987 to 1998.

Brood Year	Release Year	DEC	JAN	FEB	MAR
1987	1988	1.032	1.295	0.303	-0.096
1988	1989	**0.526**	**0.558**	**0.447**	**0.195**
1989	1990	1.548	1.266	1.207	0.796
1990	1991	1.292	1.489	1.191	0.719
1991	1992	1.563	1.318	0.937	0.759
1992	1993	0.594	0.614	0.808	0.586
1993	1994	0.638	1.705	1.410	1.112
1994	1995	1.427	0.717	0.735	0.325
1995	1996	**0.610**	**0.705**	**0.935**	**0.414**
1996	1997	1.072	0.695	0.163	0.212
1997	1998	**0.848**	**0.744**	**0.897**	**0.809**

Table 2. Specific growth rate calculated from the change in weight (g) per day for Dworshak National Fish Hatchery System II steelhead from 1987 to 1998.

BY	RY	DEC	JAN	FEB	MAR
1987	1988	0.427	0.453	0.037	0.072
1988	1989	**0.075**	**0.250**	**0.200**	**0.111**
1989	1990	0.501	0.435	0.405	0.251
1990	1991	0.425	0.500	0.399	0.225
1991	1992	0.525	0.434	0.314	0.255
1992	1993	0.192	0.203	0.274	0.196
1993	1994	0.227	0.559	0.478	0.371
1994	1995	0.475	0.224	0.247	0.108
1995	1996	**0.305**	**0.143**	**0.323**	**0.124**
1996	1997	0.363	0.228	0.050	0.066
1997	1998	**0.282**	**0.260**	**0.299**	**0.257**

Table 3. Grams of feed per gram fish for Dworshak National Fish Hatchery System II steelhead from 1987 to 1998.

BY	RY	DEC	JAN	FEB	MAR
1987	1988	0.36	0.33	0.2	0.11
1988	1989	**0.27**	**0.22**	**0.18**	**0.15**
1989	1990	0.57	0.44	0.36	0.57
1990	1991	0.43	0.43	0.38	0.32
1991	1992	0.47	0.47	0.38	0.28
1992	1993	0.31	0.21	0.31	0.19
1993	1994	0.28	0.38	0.5	0.47
1994	1995	0.31	0.47	0.21	0.35
1995	1996	**0.27**	**0.38**	**0.28**	**0.36**
1996	1997	0.32	0.21	0.08	0.08
1997	1998	**0.27**	**0.23**	**0.23**	**0.26**

Three inventory methods were used during the experiment. Monthly inventory summaries were provided by DNFH and were used to determine specific growth rates and feeding rates. The Idaho Fishery Resource Office took monthly length and weight inventories of 100 fish per group, and complete tank inventories were conducted monthly at Marrowstone Marine Station, where fish were held in seawater. Physiological sampling of 20 fish per group was conducted at the time fish were returned to full rations, at 1-month intervals until the time of release, and at 1 and 3 months after transfer to seawater. Length and weight data was analyzed using both the 100-fish inventories and the 20-fish physiological samples, which were compared to test for method bias. Results are presented based on monthly inventories until January, after which both inventory and physiological sample results were available. Statistical analysis of the difference between treatment and control groups was conducted on both inventory and physiological data.

Physiological measurements included length (mm), weight (g), specific growth rate, gill sodium, potassium-activated adenosine triphosphatase (Na^+, K^+-ATPase) (µmol $P_i \cdot$ mg protein$^{-1} \cdot h^{-1}$), mucus lysozyme (µg $\cdot mL^{-1}$), and total body fat analysis for comparison among the groups. Mucus lysozyme and total body fat analysis results are not available at this time. Gill Na^+, K^+-activated ATPase was assayed by the method of Schrock et al. (1994), and mucus lysozyme was determined by a microassay plate method adaptation of Litwack's (1955) turbidimetric assay. Statistical analysis was performed using t-tests (SAS version 6.0).

Results

A statistically significant difference between the mean fork lengths of treatment and control fish was seen one month after the reduced feed rations began ($P < 0.05$) (Figure 1), as measured by the 100-fish inventory in January. The significant difference persisted in February as measured by both inventory methods, and in March in inventory fish. During the first month after conversion to production demand feeding, the mean specific growth rate was much higher in the modified feed group than controls (Figure 2). Compensatory growth in treatment fish continued until release time in late April, when the mean lengths were no longer significantly different between the control and treatment groups. Specific growth rates for the modified feed treatment fish were higher for the first two months in seawater, but the difference was not significant. Changes in mean weight followed a similar pattern to that of fork length. A significant difference in weight between the modified feed fish and the controls was seen in January and February ($P < 0.05$), and the difference persisted in March (Figure 3). Increased specific growth rates (by weight) in the treatment group compensated for the temporary reduction in rations (Figure 4) as seen by the higher specific growth rates from February through the date of release in late April. During holding in seawater, the specific growth rate of the modified treatment group remained higher than in controls for the first 2 months.

A significant difference in condition factor (Figure 5) between treatment and control groups at the onset of the experiment was not seen in the November inventory results. Soon after treatment fish were placed on the modified feed schedule in late November, a significant difference in condition was seen between the groups ($P < 0.05$), and the difference persisted until March. At the time of release, the difference between treatment groups as measured by the inventory data was negligible. Mean condition factor of the modified feed group, calculated from the final physiology sample before release, was significantly different than that of the control group (Figure 5). Both treatment and control fish showed the characteristic reduction in condition factor seen during smoltification between March and time of release in April, although the timing of the decrease was different, and discrepancies were apparent between the inventory and physiology results. A significant difference in condition factor in seawater was present only in the July inventory results, after a disease episode resulted in mortality. Gill Na^+, K^+-ATPase activities were monitored beginning February 12, 1998 (Figure6) .No significant differences in ATPase activity between treatment and control groups were found during the study. In both groups, ATPase values remained low in fresh water, but increased dramatically after transfer to seawater on April 25 (mean = 5 on April 22; mean = 23 on June 1).

Discussion

Significant differences in length and weight existed between control fish and fish fed a reduced, intermittent diet. The difference occurred soon after fish were placed on the modified feeding schedule, and the difference persisted until fish were returned to production demand feeding. Hatchery personnel indicated that the demand feeders were emptied on the day they were filled, resulting in 1-day fasting periods on Tuesdays and Thursdays, and 2-day fasts on the weekends, which are short compared to a previous study that found fish reach a non-feeding mode after extended periods of fasting (Smith 1987). Klontz et al. (1991) found no difference in rates of growth between fish fed on continuous or intermittent schedules, and we were surprised at the reduction in growth that was achieved after recalculation of actual feeding rates of both treatment and control fish from the amount of feed fed and inventory weights of the fish. When the feed rate of the entire production system was recalculated for the study period, it was found to be 0.27 and 0.23 g feed $\cdot$ g fish^{-1} during December and January, respectively. These rates were low compared to other years (Table 3), and at the minimum levels we had selected (1989 and 1996). Recalculation of the modified ration level with inventory weights revealed that rates were 0.26 and 0.19 for December and January, respectively, rates not much different than control fish. Fish from the spawning take used for the experiment were larger than System II production fish based on the DNFH monthly inventory summaries. We did not achieve the reduction in ration of 50% compared to the production fish that would be necessary to achieve a significant reduction in growth based on a previous study (Smith 1987). The estimation of the target feed rate from the previous ten years' records did not anticipate the low feeding rate of the production group as a whole, and the small difference in feeding rates between the experimental groups was evidenced by few differences in physiological performance.

Condition factor did not prove to be a good indicator of smolt development because interpretation of results was confused by the simultaneous decrease of condition factor in control fish during normal smolt development and the decrease in condition factor in fish while on reduced rations (Figure 5). After the return to full rations, the fish initially increased in condition factor, then exhibited the decrease in condition factor

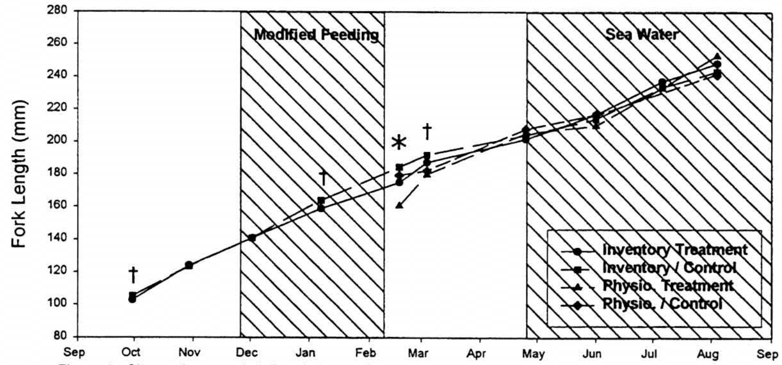

Figure 1. Change in mean fork length (mm) of steelhead reared under a modified feed program (treatment) and on regular production feeding schedule (control) at Dworshak National Fish Hatchery, 1997-1998. († = significant difference ($P < 0.05$) between treatment and control for 100-fish inventory, * = significant difference ($P < 0.05$) between treatment and control for both 100-fish inventory and physiological samples.)

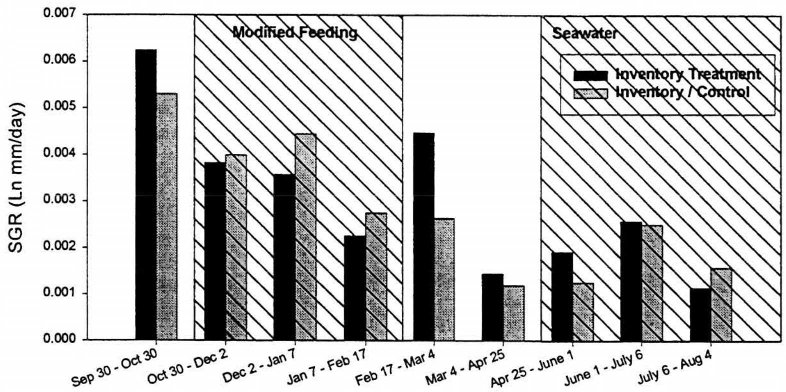

Figure 2. Specific growth rates (Ln mm/day) of steelhead reared under a modified feed program (treatment) and on a regular production schedule (control) at Dworshak National Fish Hatchery, 1997-1998.

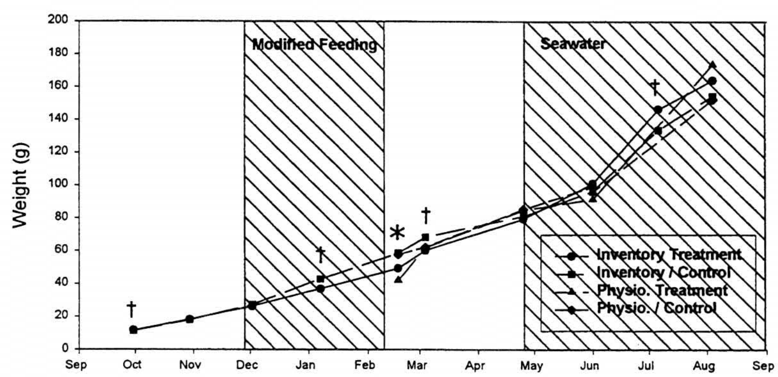

Figure 3. Change in mean weight (g) of steelhead reared under a modified feed program (treatment) and on regular production feeding schedule (control) at Dworshak National Fish Hatchery, 1997-1998. († = significant difference ($P < 0.05$) between treatment and control for 100-fish inventory, * = significant difference ($P < 0.05$) between treatment and control for both 100-fish inventory and physiological samples.)

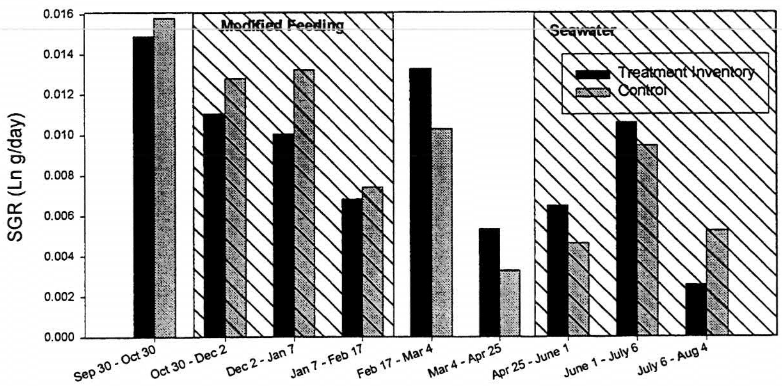

Figure 4. Specific growth rates (Ln g/day) of steelhead reared under a modified feed program (treatment) and on a normal production feed schedule (control) at Dworshak National Fish Hatchery, 1997-1998.

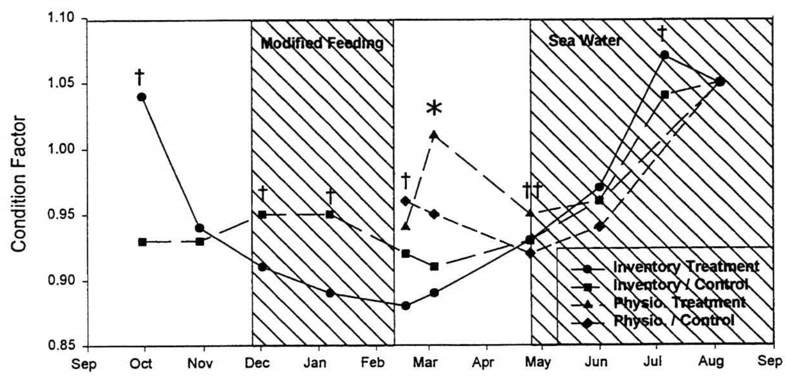

Figure 5. Change in mean condition factor of steelhead reared under a modified feed program (treatment) and on regular production feeding schedule (control) at Dworshak National Fish Hatchery, 1997-1998. († = significant difference ($P < 0.05$) for 100-fish inventory, †† = significant difference ($P < 0.05$) for physiological sampled fish, * = significant difference ($P < 0.05$) for both 100-fish inventory and physiological sampled fish.)

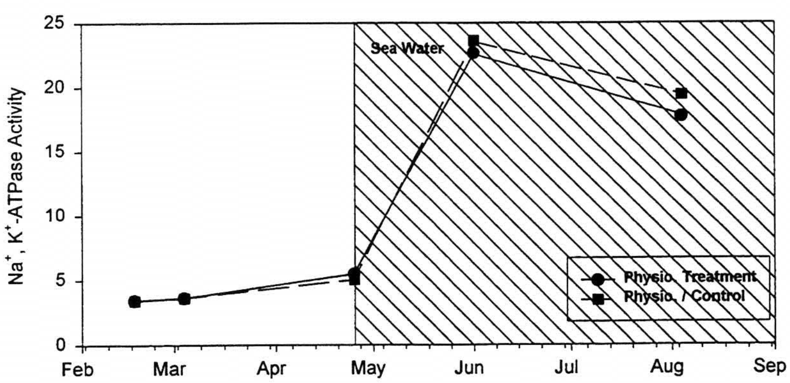

Figure 6. Change in mean Na^+, K^+-ATPase activity (μmol $P_i \cdot$ mg protein $^{-1} \cdot h^{-1}$) of steelhead reared under a modified feed program (treatment) and on regular production feeding schedule (control) at Dworshak National Fish Hatchery, 1997-1998.

associated with smoltification immediately before release, suggesting that the period of compensatory growth was immediate and short. In the results calculated from the 100-fish inventories, condition factor in modified feed fish was still increasing, probably a result of compensatory growth. Discrepancies between results calculated from the inventory and the physiology samples may be explained by differences in sample size and the level of variation among individuals. By all measurements, reduced ration fish were the same size at release as the control fish, and showed the same acclimation, growth rate and smolt development after transfer to seawater.

Two objectives of the study that were not achieved were the reduction in the length frequency distribution of the release groups, and the rearing of smaller fish. The compensatory growth seen in the modified feeding schedule fish allowed them to reach the same size at release as control fish; and performance in seawater was similar, as measured by growth rates and gill ATPase. A greater reduction in ration may be recalculated using the past year's experience combined with the hatchery records. Results of the 100-fish control inventory we used to monitor production growth did not alert us to the reduced feeding rate of the System II production group as a whole. Future trials will reduce feeding rates substantially below what the stock records suggest, but the intermittent feeding schedule will continue. We will continue to evaluate discrepancies between different sampling methods and sample sizes to eliminate the differences in results we saw between methods. The desired pattern of growth was achieved in our study, with reduced growth in December and January, and accelerated (compensatory) growth immediately before release. Controls and fish fed the modified reduced ration on an intermittent feeding schedule demonstrated similar migration and seawater performance.

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EFFECTS OF A MODIFIED FEEDING STRATEGY ON PIT-TAG INTERROGATIONS AND MIGRATION TIMES OF SUMMER STEELHEAD (*ONCORHYNCHUS MYKISS*) AT DWORSHAK NATIONAL FISH HATCHERY

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Abstract

A modified feeding program was designed to promote smoltification in small fish, and to reduce production of larger fish that residualize. The growth rate of juvenile steelhead (Oncorhynchus mykiss) was manipulated during rearing to achieve a specific growth rate of < 0.5 (by weight) or < 0.2 (by length) in December and January, and a significant increase in growth rate between February and April. PIT-tags were used to compare interrogation rates and migration times of small (≤199 mm) and large (>199 mm) steelhead smolts between treatment and control groups. Of particular interest was whether the accelerated growth treatment would result in significantly better performance for smaller sized fish. Smolts in the treatment group had a significantly (P<0.05) faster mean migration time to Lower Granite Dam than those in the control group, but no significant differences were observed between large or small smolts either between or within groups. Overall, the control group had a higher interrogation rate than the treatment group, 81% vs. 77%, respectively. In the treatment group, the larger smolts had a higher interrogation rate than the smaller smolts, 79% vs. 75%, respectively. In the control group, both the large and small smolts were interrogated at 81%. Gill ATPase increased markedly after smolts were released. However, there were no significant differences in mean gill ATPase between small and large smolts in either the treatment or control group.

Introduction

Wide length frequency distributions are a common characteristic of juvenile steelhead at Dworshak NFH. Lengths often range from 80 to 240 mm (total length) by the time they are released as smolts. Research conducted by the Idaho Fishery Resource Office and Dworshak NFH indicates that a high proportion, as many as 25%, of the steelhead that are less than 170 mm at the time of release may not be migrating downriver to the ocean (Bigelow 1995; Bigelow 1997). This does not conform to the Biological Opinion from the National Marine Fisheries Service (NMFS) on Hatchery Operations for 1996-1999 that calls for hatchery steelhead to be released between 170-220 mm (TL) in order to minimize residualization. The Draft Snake River Salmon Recovery Plan (SRSRP) recognizes that Steelhead larger than 170 mm experience more complete parr-smolt transformation and are therefore more likely to actively migrate . Of particular concern is the potential interaction of residual steelhead with sensitive species such as the endangered Snake

River fall chinook, spring and summer chinook, or the threatened wild Snake River steelhead. Interactions include displacement, competition for food, and behavioral effects (Viola and Schuck 1995; McMichael *et al.* 1997). .

At Dworshak NFH in 1997 -1998, we reduced feed in the winter and increased feed in the spring in an attempt to increase the growth rate of summer steelhead during the period of smoltification. An increase in growth in the spring is a major indicator of smoltification and it is recognized that, physiologically, the period of rapid growth is an integral component of smolt development (Wedemeyer 1996). Some reports indicate that growth rate at the time of smoltification may be more critical in the parr-smolt transformation process than the absolute amount of growth that occurs (Whitesel 1991). The overall goal of this project was to increase the proportion of smaller sized steelhead at Dworshak NFH that successfully smolt and migrate to the ocean by manipulating growth rate during smoltification prior to release at the hatchery. This paper presents data that compares the migration rates, survival rates, and smolt development of small smolts ($\leq$199 mm) and large smolts (>199 mm) between treatment and control groups after being released from the hatchery.

Methods

Two replicate treatment and control groups of summer steelhead were set up in outside Burrows ponds at Dworshak NFH in the summer of 1997. The treatment consisted of an altered feeding schedule designed to achieve a specific growth rate of < 0.5 (by weight) or < 0.2 (by length) in December and January, and a significant increase in growth rate between February and April.. Two weeks prior to release, 200 fish above and below 199 mm (FL) were PIT tagged from one treatment pond and one control pond. Data on PIT-tag interrogations at Lower Granite, Little Goose, and Lower Monumental dams on the Lower Snake River and from McNary Dam on the Columbia River were retrieved from PTAGIS.

Mean migration times to Lower Granite Dam for small smolts and large smolts were compared between the treatment and control groups using two-sample t-tests (Wilkinson 1990). The total number of unique PIT-tag interrogations at Lower Granite, Little Goose, Lower Monumental, and McNary dams was used as a minimum estimate of survival to Lower Granite Dam. Cumulative interrogations for 10 mm length groups in both the treatment and control groups were determined and compared statistically using a chi-square test for differences in probabilities (Conover 1971).

Smolts were recollected at Little Goose Dam during the first two weeks of May after release using the National Marine Fisheries Service s interrogation-by-code facilities. PIT-tag numbers were recorded and a small segment of gill filament was sampled from the first gill arch on the left side of all smolts collected to measure gill ATPase levels. Mean gill ATP-ase and migration time to Little Goose Dam for small and large smolts in both treatment and control groups were compared using two-sample t-tests (Wilkinson 1990).

Results

Mean migration time for the treatment group to Lower Granite Dam was significantly ($P < 0.05$) faster than for the control group. However, comparisons between small and large smolts within groups and between small and large smolts between groups revealed no significant difference. Migration times to Lower Granite Dam ranged from 4.6 to 6.1 days (Table 1).

No significant differences in interrogation rates were observed for any of the comparisons made. The control group was interrogated at a higher rate than the treatment group, 81% vs. 77%, respectively (Table 2). Smaller smolts generally had a lower interrogation rate than larger smolts, in both the treatment and control groups. Within 10 mm length groups, the control group usually had a higher rate of interrogation than the treatment group (Figure 1).

Differences in mean gill ATPase between small and large smolts were not significant for either the treatment or control groups prior to release. Mean gill ATPase values ranged from 4.4 to 5.7 for small and large smolts in both the treatment and control groups (Table 3). At Little Goose Dam, mean gill ATPase values for small and large smolts for both treatment and control groups increased to 14 (Table 4). Mean migration time to Little Goose Dam ranged from 7 to 8 days.

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Table 1. Mean migration time of small (≤ 199 mm) and large (> 199 mm) steelhead smolts that were PIT-tagged, released, and detected at Lower Granite Dam for the accelerated growth treatment and control groups at Dworshak NFH in 1998.

Treatment	Mean Migration Time (Days)		
	Small Smolts	Large Smolts	Combined
Accelerated Growth	4.6	5.2	4.9
Control	6.1	5.1	5.6

Table 2. Number of small ($\leq$ 199 mm) and large (> 199 mm) steelhead smolts that were PIT-tagged, released, and detected at downriver dams for the accelerated growth treatment and control groups release from Dworshak NFH in 1998.

Treatment	Small Smolts			Large Smolts			Total		
	Marked	Detected	Percent	Marked	Detected	Percent	Marked	Detected	Percent
Accelerated Growth	199	149	74.9	201	159	79.1	400	308	77.0
Growth Control	200	162	81.0	200	162	81.0	400	324	81.0

Table 3. Mean gill ATPase of small ($\leq$ 199 mm) and large (> 199 mm) steelhead smolts for the accelerated growth treatment and control groups prior to release from Dworshak NFH in 1998.

Treatment	Mean Gill ATPase		
	Small Smolts	Large Smolts	Combined
Accelerated Growth	5.0	5.5	5.4
Control	4.4	5.7	5.2

Table 4. Mean gill ATPase and mean migration time for PIT-tagged steelhead smolts collected at Little Goose Dam on the lower Snake River

			ATPase				Migration Time		
Experimental Group	Size	N	Mean	Std. Dev.	Min.	Max	Mean	Std. Dev.	Min.
Treatment	Small	17	14	4	8	22	8	5	5
	Large	19	14	5	5	27	7	3	6
Control	Small	12	14	5	6	24	8	4	5
	Large	17	14	4	8	23	7	3	6

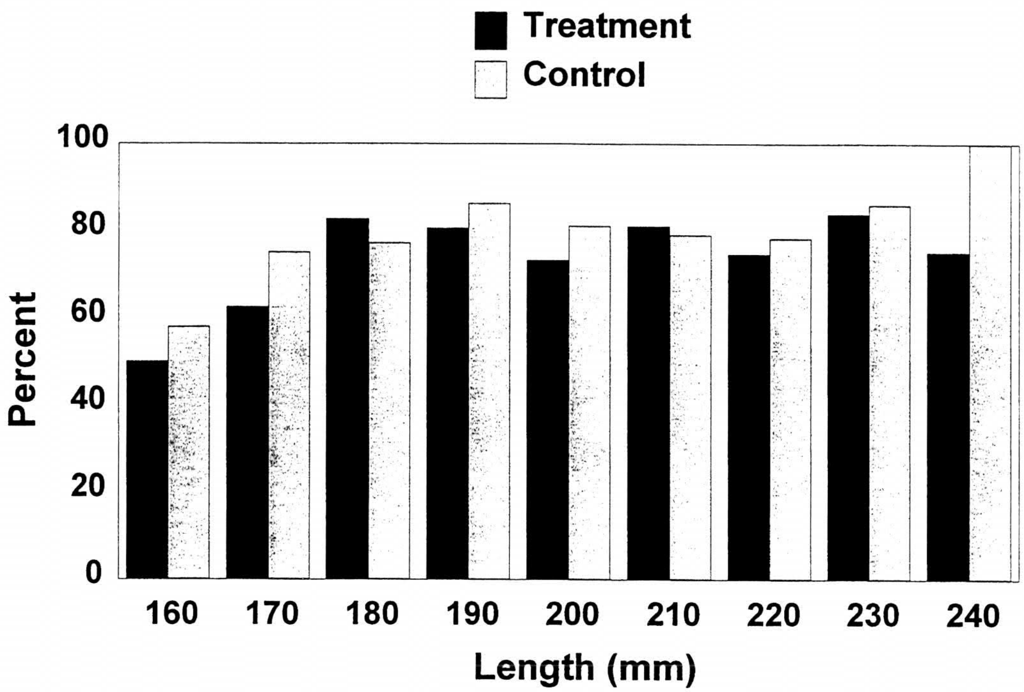

Figure 1. Percent of smolts interrogated at Lower Granite, Little Goose, Lower Monumental, and McNary dams for 10 mm length groups in the treatment and control groups.

Session IV

Fish Culture and Fish Management

Session Chair:

Gene McPherson
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A NUTRITIONAL APPROACH TO REDUCING PHOSPHORUS AND NITROGEN EXCRETION OF FARMED RAINBOW TROUT

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Abstract

In the interest of maintaining and improving stream water quality, the aquaculture industry is currently making efforts to minimize the amount of phosphorous, nitrogen and organic waste in aquaculture effluent. As all waste discharged in fish farm effluent is originally derived from the feed fed to the fish, one practical way to accomplish this is through changes in formulation of the diets fed the fish. We investigated the effect of two variables, percent dietary fishmeal and percent dietary lipid, on phosphorus and nitrogen retention and excretion, specific growth rate, feed conversion ratio, final carcass lipid content and sensory characteristics of fillets of rainbow trout. In the first experiment, dietary treatments included two levels of dietary fishmeal (50% and 20%) and three levels of dietary lipid (17%, 24% and 31%). The reduction in fishmeal content from 50% to 20% (corresponding to a reduction in dietary phosphorus from 1.4% to 0.8%) resulted in an increase in phosphorus retention from about 30% to 50%, and reduced phosphorus excretion (mg/kg gain) by more than 50%. Nitrogen retention increased and nitrogen excretion decreased as dietary lipid increased from 17% to 31%. Specific growth rate increased and feed conversion ratio improved as dietary lipid increased from 17% to 31%, but specific growth rate and feed conversion ratio were unaffected by the level of dietary fishmeal. Final carcass lipid content increased as dietary lipid increased. A 14 member sensory panel could distinguish a difference in sensory characteristics between fillets of trout fed diets containing the highest and lowest lipid levels, but sensory panelists could not distinguish differences between trout fillets fed the intermediate lipid diets and the high lipid or low lipid diets. Level of fishmeal had no effect on sensory characteristics. The adjustment of diet composition of fish feeds has strong potential to improve aquaculture effluent water quality.

COLOR MARKING OF JUVENILE AND ADULT SALMON

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Abstract

Fisheries research in the Umatilla River has required the use of marked fish to identify juvenile and adult salmonids. We used color marks on juvenile salmon as a tool in outmigration monitoring and tested these marks on adult salmon as a potential tool for managing stocks. Marks were an aqueous fluorescent pigment encapsulated in latex microspheres (photonic marks; NEW WEST Technologies, Santa Rosa, CA) or a silicon-based elastomer (visible implant or VI- jet marks; Northwest Marine Technology, Shaw Island, WA). Juvenile chinook and coho salmon and steelhead (65-265 mm FL) were marked to assess trapping efficiency, to indicate PIT-tagged fish, and as a secondary mark to test survival; marks were applied in all fins. Adult chinook salmon (710-956 mm FL) were test marked on the pectoral girdle, base of the dorsal fin, and the pectoral fin. Marks on juveniles and adults were applied subcutaneously using a needle-less injector powered with pressurized CO_2. Both mark types were visible with the naked eye under ambient light. We tested seven colors on juveniles and two colors on adults and evaluated marks and marking technique based on mark quality, ease of application, mark retention and detection, mark and equipment cost, and logistical problems and requirements.

For juvenile fish, the proportion of good marks ranged from 15-91% dependent on color and location. Color discrimination was difficult between yellow-based and red-based colors. Marks were retained up to 60 d. Mark cost was higher for yearling steelhead ($0.15/mark) than smaller subyearling chinook salmon ($0.08/mark) because a higher paint dosage was required. Marking speed averaged 550 fish/h during mass marking. Caudal and dorsal fins were easier to mark in most cases than pelvic or pectoral fins. Marking problems included splitting of fins and accidental injection into the fish's body.

For adult fish, marking the pectoral girdle was easier and produced a better mark (70% good) than marking the pectoral fin or base of the dorsal fin. Pink marks were easier to detect than yellow marks which blended with the natural colors of the fish. Marks were retained up to 56 d. Mark rate was 1 fish/30 s at a cost of $0.25/mark.

For both juvenile and adult fish, mark quality was dependent on the angle of the injector and its proximity to the fin or body and the experience of the marker; anesthetic was required for marking all fish. We found no difference in the mark quality or application between photonic or VI-jet marks. During mass marking, equipment malfunctions and clogging of the injector nozzle were common problems. The injector required continual maintenance with frequent use. Cost of the injector and associated equipment was about $2000 per unit. Cost of marking solution was $800/L for photonic marks and $400/L for VI-jet marks. Injector parts and cleaning solutions were expensive and difficult to obtain outside the vendor.

In summary, we found color marking with a CO_2 injector to be a viable alternative to other types of marks (brands, syringe or Panjet marks) for both juvenile and adult salmonids. Given the limitations with the marking equipment, this marking technique was efficient, provided a good visual mark, and was safe for fish. The potential for other applications exists, but further studies are needed on mark retention and predation effects on juvenile fish.

Introduction

Fisheries research in the Umatilla River has required the use of marked fish as a tool in outmigration monitoring of juvenile salmonids. Marked fish were necessary to identify fish from different experimental rearing strategies at Umatilla Hatchery and to conduct trap efficiency tests or secondary survival tests. In previous years, we used freeze brands, syringe color marks, or Panjet color marks on fish. Although the syringe and Panjet marks were an improvement over freeze brands because of easier logistics and application, they were still not easily detected on the ventral surface of the fish. In 1997 and 1998, we tested the use of a different color mark and marking technique that promised to produce a visible mark that was quickly and easily applied to large numbers of fish. We also tested color marks on adult spring chinook salmon as a potential tool for broodstock identification or to replace other short-term marks. We tested eight colors on juvenile fish (yellow, red, pink, purple, blue, orange, green, and dark yellow) and two colors on adult fish (pink and yellow). Our objectives were to evaluate the marks and marking technique based on mark quality, ease of application, mark retention and detection, mark and equipment cost, logistical problems and requirements, and safety.

Methods

The new type of mark (photonic mark) was applied using a polymethylmethacrylate fluorescent pigment encapsulated in latex microspheres (5-8 μm diameter microspheres) developed by New West Technologies, Santa Rosa, CA. We also used another acrylic latex microsphere solution (visible implant or VI-jet mark) developed by Northwest Marine Technology, Shaw Island, WA with the same characteristics as the photonic mark. Both types of marks were visible to the naked eye under ambient light. Marks on juvenile and adult fish were applied subcutaneously using a needle-less injector (BMX1000 system; New West Technologies) powered with filtered and pressurized CO_2 (600 psi). The injector unit was comprised of an injector head with nozzle and power unit. The marking solution was drawn into the injector head from a separate bottle connected by a siphon tube. All fish were anesthetized with methanesulfonate (MS-222) prior to marking. The dosage amount (0.05-1.0 ml) was regulated by gaging blades on the power unit, with incremental adjustments of 0.05 ml.

Adult spring chinook salmon (710-956 mm FL) being held for broodstock were test-marked on the fleshy joint at the base of the pectoral fin (pectoral girdle), base of the dorsal fin, and on the pectoral fin. Earlier trial marking on a dead chinook salmon indicated that marks in these areas were easier to apply and produced an immediate and repeatable mark. Two people were required to mark each adult fish; one person stabilized the fish while the other person applied the mark. Two 0.15-ml injections were applied for each mark. Each of 30 fish was marked in the three target locations on the right side of the fish; 26 were marked with yellow and 4 were marked with pink. Fish were held from 30 to 56 d after marking. Mark quality was checked by a single evaluator immediately after the fish was spawned. We categorized the marks as "good" if marks were clearly visible and bright, "fair" if marks were visible but slightly faded, "poor" if marks were light and small, and "none" if no mark was visible. A secondary mark (opercle punch) indicated the fish was color marked.

Juvenile salmon (65-265 mm FL) were marked by one person on the caudal, anal, ventral, and dorsal fins by holding the fish underwater and positioning the fin against a white ceramic tile; the tile provided a solid backing for the fin. The marking gun was positioned at an angle to force the paint into several fin rays. One 0.10-ml injection was applied for each mark. Marks were categorized as "good" if two or three rays were clearly marked; "fair" if one ray was visibly marked, or "poor" if the mark was small and not clearly visible. On known-marked fish, the absence of a visible mark was also noted. Good and fair marks combined produced a readable mark, whereas unreadable marks were those that were poor or lost.

The underwater marking method was used after experimental marking at Sandy Hatchery indicated that overspray from airborne particles could cause respiratory irritation (Mallette et al. 1998). In 1997, yearling spring and fall chinook salmon, subyearling fall chinook salmon, and summer steelhead were photonic marked to distinguish different hatchery rearing strategies. In 1998, the same species of fish were marked with photonic and VI-jet marks to assess trapping efficiency and indicate PIT-tagged fish during outmigration monitoring. Examination of fish for mark quality ranged from several days to several weeks after marking but prior to release, and from several days to several weeks after release. Mark quality was checked by various evaluators.

Results

Adult Fish

Of the 26 adult fish marked with yellow photonic paint, 65% of the marks in the pectoral girdle were good quality and 35% were fair; in the pectoral fin, 31% were fair, 23% were poor, and 46% had no mark; in the base of the dorsal fin, 4% were fair, 23% were poor, and 73% had no mark. Of the 4 fish marked with pink photonic paint, 100% of the marks in the pectoral girdle were good quality; in the pectoral fin, 75% were poor quality, and 25% had no mark; in the dorsal fin base, 50% were fair and 50% were of poor quality. Marking in the pectoral girdle was relatively easy and did not require a high level of accuracy to produce a good mark. However, it was more difficult to consistently apply a good mark to the pectoral fin ray and at the base of the dorsal fin. Accuracy was important and the angle of the marking gun relative to the fin was crucial in injecting the mark into the fin rays. Movement of live fish increased the difficulty of holding the marking gun at the correct angle. When marking at the base of the dorsal fin, moving the gun only a small distance from the preferred location at the fleshy base produced a poor mark.

Color choice was important for detection, depending on the development of the adult fish. Pink was easily detected while yellow was difficult to detect because it blended with the natural colors of the skin as the fish approached spawning and skin deterioration proceeded. Chinook salmon retained photonic marks up to 56 d and we suspect that the marks would be visible for much longer.

The time required to handle and mark each fish in three locations was about 30 s, although marking time varied for each fish as some fish recovered from the anesthetic rapidly and were difficult to handle. We estimated a cost of $0.25 per mark. At times, air bubbles entered the siphon tube making the marking system inoperable until it was reprimed. The design could be improved by attaching the paint bottle directly to the marking gun to eliminate loss of priming. Although marking required the fish to be sedated, the method is non-invasive and easy to apply, particularly to the pectoral girdle. Moreover, identification of paint marks requires little experience by the observer. Even though fish in our study were dead when examined for marks, we believe that identification would be possible for fish that are mildly sedated.

Juvenile Fish

In 1997, quality of photonic marks on the anal fins of juvenile fish 24-96 h after marking varied by species and mark color. Readable marks on coho salmon (96% yellow), yearling fall chinook salmon (82% red, 93% orange), and subyearling fall chinook salmon (91% orange, 84% pink, 80% blue) were comprised mostly of good quality marks (50-63%). A higher proportion of pink, orange, and blue marks on subyearling fall chinook salmon were not detected (4-9%) compared to other species (0.3-2%). Seventy-five percent of the dark green marks on yearling spring chinook salmon were readable, of which

34% were good quality and 41% were fair. This was the first group of fish marked and inexperience may have affected mark quality. Readable marks on summer steelhead (82-88%) were mostly fair (70% orange, 77% red, 80% dark yellow) and poor marks ranged from 12% (dark yellow) to 18% (orange).

When recaptured in the lower river from several days to several weeks after release, percent detection of marked fish released ranged from 0.6-1.2% (due to low trapping efficiencies). However, the yellow mark on coho salmon was detected in only 0.1% of the marked fish, and the dark yellow mark on summer steelhead was only 0.06% detected. No orange- or red-marked summer steelhead were detected at the trap site.

In 1998, juvenile salmon that were PIT tagged were also given a photonic or VI-jet mark in the anal fin to indicate the fish had a tag. At the time of marking, greater than 98% of all marked fish had readable marks (good + fair quality). Summer steelhead marked with purple, red, and dark yellow and held for 36 d after marking and those marked with yellow, pink, orange, and green and held for 44 d after marking maintained the same high percentage of readable marks. Unreadable marks ranged from 0% (pink) to 2.4% (orange). The proportion of unreadable marks was higher for yearling spring chinook salmon held 55 d after marking (1.2% pink, 2.4% green, 4% yellow) and subyearling fall chinook salmon held 31 d (5% pink, 7% yellow and green). At recapture approximately 40-60 d after marking, readable marks were observed at proportions greater than 80% for all color marks released, except yellow on spring chinook salmon which was not detected.

When we used various colors and fins for trap efficiency marks, the most readable colors and best marking locations (> 80% good quality) were red (pectoral fin) and purple (caudal fin). The least readable (> 20% poor quality) were red and orange on the caudal fin. Pectoral and pelvic fins were harder to mark than anal, dorsal, and caudal fins because of their tendency to fold under the fish. It was also difficult to distinguish yellow from dark yellow from green marks, and pink from red from purple marks if there was no basis for comparison. Some red marks could be confused with bloody fins.

For juvenile fish, mark quality was dependent on the angle of the injector and its proximity to the fin or body, and the experience of the marker. We found no difference in the mark quality or application between photonic or VI-jet marks. Applying the mark required certain considerations to prevent marking problems. The marking medium needed to be frequently agitated to keep it in solution. Otherwise, the injector head would clog, requiring disassembly and flushing with distilled water. It was also important to ensure air was not entrapped in the siphon tube when changing colors or nearing the end of a solution mixture; loss of prime in the injector head and damage to interior parts would result. The fins of smaller fish (subyearling salmon) tended to split when CO_2 pressure was at 600 psi; reducing the pressure to 500 psi kept the fin intact. Injecting the solution too close to the body at times resulted in accidental penetration through the skin into the fish's body. Marking speed averaged 550 fish/h during mass marking, but was reduced with malfunction of marking equipment.

Marks costs for marking juvenile fish were based on the cost of a liter of photonic solution ($800/L). We marked considerably less fish per liter of solution than the vendor originally stipulated. Mark cost was higher for yearling steelhead ($0.15/mark) than smaller subyearling chinook salmon ($0.08/mark) because a higher dosage was required. For yearling chinook salmon, mark cost was $0.10/mark. Cost would be considerably reduced using the VI-jet solution ($560/L) which was sold as a concentrate and diluted by 50% prior to use. The cost of the BMX1000 system (power unit, injector head, and nozzle) was $1,665. Each gas regulator for dispensing CO_2 was $194 and the gas line was $125. Total approximate cost for each marking unit, excluding the cost of bottled CO_2, was near $2,000. For our work we used six units which was necessary during intensive hatchery marking. Other incidental costs included cleaning fluid, replacement parts, and maintenance kits, all obtained from the vendor (New West Technologies).

Maintenance was high on the marking guns, especially with frequent use. Internal O-rings deteriorated rapidly, requiring regular changing. The valve core in the trigger mechanism would also deteriorate and need replacing. At times, the clutch on the power unit would not engage the plunger of the injector head properly, causing a misfiring. Lubrication was important, especially in the damp environment in which the equipment was used. During intensive marking, one person was required to maintain and repair the marking equipment and ensure that markers were using the equipment correctly.

Summary and Future Application

We found color marking with a CO_2 injector to be a viable alternative to other types of marks (brands, syringe, Panjet marks) for both juvenile and adult salmonids. Given the limitations with the marking equipment, this marking technique was efficient, provided a good visual mark, and was safe for fish. Color marking of adult and juvenile salmon has application to fish culture, management, and research studies. However, further studies are needed on mark retention and effects on vulnerability to predation of juvenile fish.

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BASIC BIOCHEMICAL RESEARCH APPLIED TO ACHIEVING SALMONID VITALITY

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Abstract:

Just as the focus for humans has shifted from treatment-centered practice toward preventive medicine, so has my approach concentrated on the understanding of robust health in fish—particularly the necessary nutritional needs. For the past couple of decades, I have been measuring the levels of certain micro-nutrients in rainbow trout, coho, chinook and Atlantic salmon. In laboratory experiments we have shown evidence of improvement in the immune-response system when diets are enhanced with selenium, vitamin E and C. To date I have measured micro-nutrient loss in salmonids when they are under various forms of stress, e.g. physical and chemical. The loss of micro-nutrients has been shown to decrease the efficiency of the immune- response system.

In conjunction with Dr. Jim Congleton of the University of Idaho, I have been comparing the difference in micro-nutrient levels of hatchery and wild smolts in the Snake/Columbia River system with the aim of increasing the return rates.

In preliminary studies with culturists in British Columbia, we have found that when broodstock diets are enhanced with the micro-nutrient selenium, it is transferred and reflected in the eggs. We also found that selenium levels in hatchery eggs were lower than the wild eggs, in the same proportion as we found in smolts and returning adults of earlier studies.

Past and present research will be drawn upon to illustrate this approach. Possible remedies will be offered to help ensure better health for cultured fish.

Introduction:

As a medically trained biochemist, I gravitated toward a quest for understanding the basic reasons for disease problems in the fish culturing industry. My early days at the School of Fisheries were devoted to studying effects of stress in salmon at fish ladders. Later, my focus included water chemistry. The study of water chemistry is a very complex one in itself. I felt that in order to determine what a fish needs for good health the first step would be to study the fish's total environment. Secondly, we would need to consider additives to water – both man's and nature's. Thirdly, we should analyze the biochemical interactions which result. My current research involves the combination of all my past experience: water quality, total environment, food, basic biochemistry and the effects of stress on the health of fish.

A Working Hypothesis:

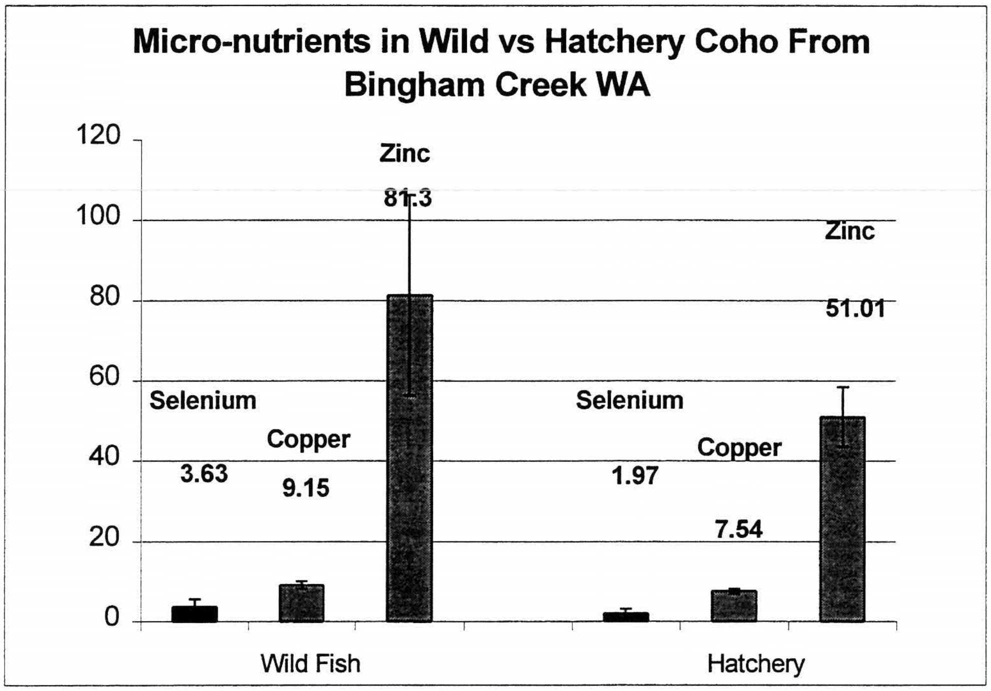
My hypothesis may be stated as follows: Hatchery-rearing and aquaculture conditions are known to be stressful to fish (Wedemeyer 1972, 1976; Strange et al., Strange et al.,1977; 1988, Barton et al., 1980; Pickering et al., 1982; Davis and Parker 1983; and Felton et al., 1989). There is nothing harmful about stress—in fact it is a necessary function of normal life. However, as the length of time increases, stressful states can become <u>dis</u>tressful states, leading to tension. Prolonged states of distress are ultimately manifested in biochemical malfunctioning, illness, and/or death. As with humans, the important goal is an optimal coordination between stress and relaxation. In addition to the normal pattern for resting/activity cycles, nature has endowed the animal kingdom with another coping mechanism for sudden response - a very potent and spontaneous adrenal system. This system is designed to give the organism a high energy boost in order to escape predators or undesirable situations. In order to gain the energy needed for a given emergency, the adrenal system will place very stringent demands upon certain biochemical functions. Then to regenerate when the emergency has ended, the adrenal system is designed to return to the resting state, not to remain in an elevated state. However, for a fish reared in a hatchery environment, or crowded into a truck, a return to a resting state may be prevented. Therefore, the adrenal system may well become fatigued, causing a build up of the by-products known as cortico-steroids. With this unnatural demand on the adrenal system, there is an abnormal biochemical demand to metabolize these cortico-steroids, which are commonly used by technicians as indicators of stress.

My hypothesis is that prolonged demand on the adrenal system will result in its being less responsive, hence less dependable as a measure of induced stress. Data which supports this hypothesis was shown in a study by Salonius and Iwama (1991, 1993). They demonstrated significantly fewer cortico-steroids found in hatchery-reared coho and chinook when compared to their wild counterparts. A similar condition in humans has been labeled "chronic fatigue syndrome" or "CFS" (Barker et al., 1994). If unchanged in humans, this condition leads to an array of diseases and illnesses with only one commonality, that of prolonged "stress". The manifestations of stress and their relationships to disease are far from being completely understood. However my interest concerns the role of nutrition in preparing fish to meet the demands of stress and not only to survive, but to thrive.

News media today include reports of human health issues involving supplements of selenium, vitamins E and C – all micro-nutrients—the loss of which appears to be associated with prolonged stress. Although these micro-nutrients are small, as the name "micro" implies, their role in the biochemistry of an organism is quite remarkable. They act as the messengers, or catalysts, that cause change – just as the tiny match, when struck, can ignite a huge fire.

Progress To Date:

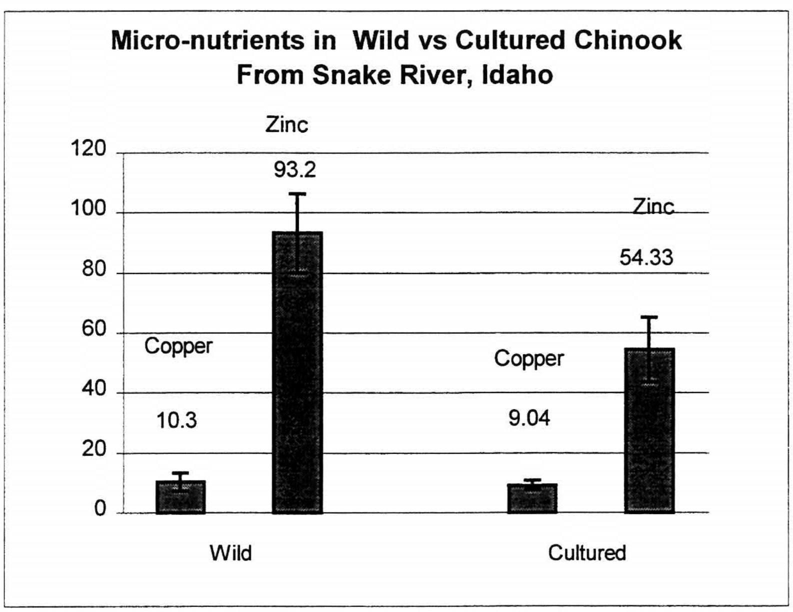
First it was necessary to establish a micro-nutrient profile of a healthy fish. But, where to find an unstressed fish? My basic assumption was to use wild fish from a pristine environment. Comparisons were made between wild and hatchery-reared cohos from both the weir and the hatchery at Bingham Creek, WA. Here we could compare smolts of the same specie. Figure 1 (below) demonstrates what we found in terms of three of the key micro-nutrients in the immune-system.



(Felton et al., 1990, 1994) (Conc. as microgram/gram dry weight)

Figure 1

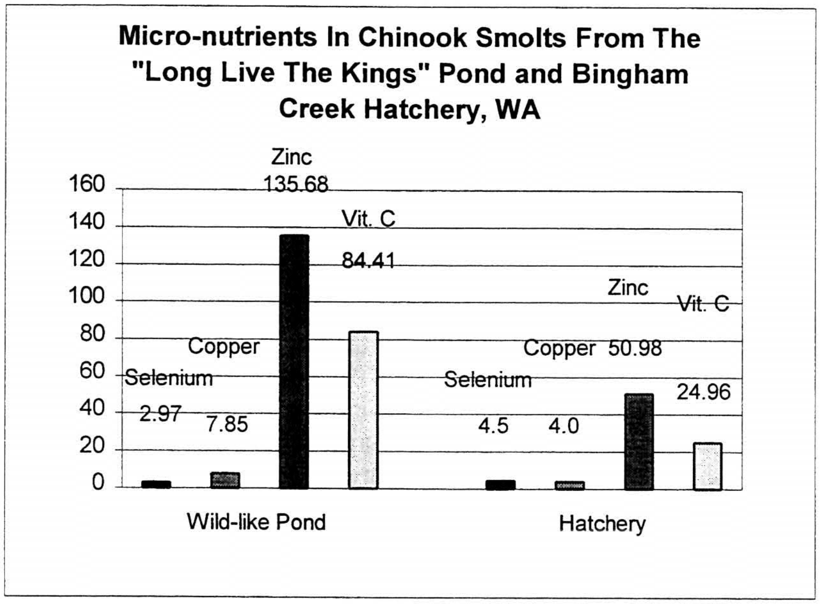
You will note that figure 2 illustrates a similar finding for zinc in chinook from Idaho's Snake River.



(Felton and Congleton, 1998) (Conc. as microgram/gram dry weight)

Figure 2

We are not sure why the copper levels are similar between the wild and hatchery fish as shown in figure 2. But we know that there have been copper tailings found in some of the tributaries of the Snake River (a situation not found in western Washington State
(Woodward et al., 1994).

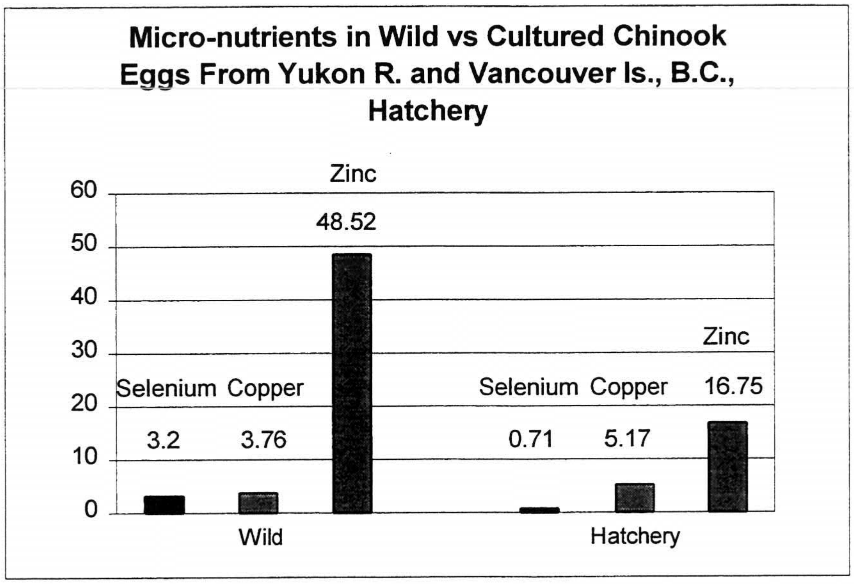


(Felton et al., in publication 1998) (Conc. as microgram/gram dry weight)

Figure 3

To measure differences in habitat, studies were carried out on pond-reared chinook. In figure 3 comparisons are shown with a conventional hatchery raceway. These findings seem to indicate that a pond produces smolts that are more wild-like than those reared in raceways. It is interesting to note that these comparisons between wild-like and hatchery chinook replicate the findings in figure 1 between wild and hatchery coho measurements of zinc and copper.

Provocative research is being conducted with Jason Mann of Ewos, Canada, concerning the transfer of micro-nutrients in broodstock and egg survival. Figure 4 will present preliminary data on the baseline levels in wild chinook eggs as compared to the hatchery broodstock eggs.



(Felton and Mann, unpublished data, 1998) (Conc. as microgram/gram wet weight)

Figure 4

As these charts indicate, we are establishing a baseline standard of micro-nutrients in wild species and comparing cultured specimens with that standard. It is an approach that Dr. Thomas R. Dawber initiated in 1949 in his medical study of 5,209 normal citizens, about 50% of the Framingham, Mass., population 30 – 62 years of age. These were not patients who were ill. From yearly tests, he followed the progress of well-ness, publishing his findings in Journals of Medicine which are used by physicians world wide.

In our on going research we have begun to establish a diagnostic indicator of health in fish – a biochemical test that can be applied to measure how a habitat is affecting the well-being of salmon, thereby giving scientific data to the predictability of survival.

This diagnostic test can also be applied to other attempts to increase return rates, such as water quality improvement. Our ultimate goal is to know what proportion of micro-nutrient supplements are optimal for fish in their rearing and transportation cycles. By providing the best feed, habitat and water quality, we hope not only to reduce the need for costly treatments of antibiotics but also to prepare salmonids to overcome their many life stresses with their immune-response systems still in sound condition.

Acknowledgments:

I would like to express my appreciation to my wife Helen Martin Felton for her expert editorial advice and her devoted interest in this important project; to Ms Barbara Cairns, James Youngren and Robert Endicott of the " Long Live The Kings " organization, Seattle, WA, to Steve Schroder and Jim Congleton of Washington State F & W Department and U.S. F & W Cooperative, University of Idaho respectively and to Jason Mann, Ewos of Canada.

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ENVIRONMENTAL COMPLIANCE AT FISH HATCHERIES

Gary D. Kollman

Abstract

The day to day operations occurring at fish rearing and research facilities require the storage and handling of hazardous chemicals. These chemicals are used for biological purposes, or for some facilities, hazardous materials are used in exogenous industrial activities (e.g. motor vehicle maintenance) which are vital to the function of the facility. Fish hatcheries must comply with all local, state, and federal environmental laws just like any other industrial facility; although, in some cases agricultural exemptions exist for certain regulations. Environmental and safety and health regulatory compliance for hatcheries can be divided into 14 separate categories. Each category represents a plethora of applicable environmental regulations. These regulations affect such processes as on-site burning, storage and use of hazardous chemicals, construction activities, biological research, pathogen reduction, and grounds maintenance. An external comprehensive multimedia environmental compliance audit can be an excellent and obligatory tool used to identify those areas of fish hatchery operation which may require corrective actions to fix environmental problems. This proactive assessment tool may prevent fiscal losses by prevention of decreased production via hatchery contamination, by eliminating regulatory agency fines, and by decreasing the propensity of work-related accidents. Recent comprehensive environmental audits of fish hatcheries have revealed a large volume of various types of environmental problems. The most common problems are associated with noncompliance with health and safety regulations, incorrect storage and use of hazardous materials, improper wastewater discharge, and deficient storage tanks.

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Assessment Approach And Objective

The primary objective of the environmental compliance assessment process is to identify operations and activities at the Fish Hatchery that may cause adverse impacts to public health and the environment. Specifically, the environmental assessment is intended to evaluate the status of ongoing or unresolved enforcement actions, assess the storage and handling of chemicals and wastes, ensure that personnel maintaining the facility are adequately trained, and evaluate compliance with an Environmental Assessment Manual which is used as a guide to the auditor. The manual organizes environmental regulations into various common topics of compliance.

In accordance with applicable requirements, an assessment is organized under 13 major environmental protocol categories. A supplemental category (Protocol 14 - Environmental Health and Safety Management) is usually added to evaluate compliance with industrial hygiene standards and health and safety procedures. A description of each environmental category and the assessment objectives for each category is presented in Table 1.

Table 1
Environmental Compliance Protocols And Objectives

Protocol Number	Protocol Description	Assessment Objectives
1	Air Emissions Management	Evaluate compliance with all applicable regulations associated with air pollution emissions from stationary and mobile sources.
2	Cultural Resources Management	Evaluate compliance with all plans and programs for the protection and management of cultural resources, including historic and prehistoric properties.
3	Hazardous Materials Management	Assess the storage and handling of chemicals and the spill contingency and response requirements related to hazardous materials. Verify that fish hatchery personnel are adequately trained and familiar with hazardous material handling and emergency response procedures.
4	Hazardous Waste Management	Assess the storage and handling of chemicals and the spill contingency and response requirements related to hazardous wastes. Verify that fish hatchery personnel are adequately trained and familiar with hazardous waste handling and emergency response procedures.
5	Natural Resource Management	Evaluate compliance with all permits, plans, and programs for the protection of natural resources and endangered and threatened species.
6	Other Environmental Issues	Evaluate compliance with appropriate regulations concerning the National Environmental Policy Act (NEPA) process, environmental noise, the Installation Restoration Program (IRP), pollution prevention, and program management.
7	Pesticide Management	Assess the storage and handling of pesticides and the spill contingency and response requirements related to pesticides.
8	Petroleum, Oil, and Lubricant Management	Assess the storage, handling, and disposal of petroleum based products and the spill contingency and response requirements related to petroleum products. Verify that fish hatchery personnel are adequately trained and familiar with applicable handling, spill prevention, and emergency response procedures.
9	Solid Waste Management	Evaluate the collection, storage, disposal, and resource recovery of solid wastes generated at the fish hatchery.
10	Storage Tank Management	Review essential regulatory items concerning underground storage tanks (USTs) and aboveground storage tanks (ASTs), including tank emissions, structural concerns, monitoring, and recordkeeping requirements.
11	Toxic Substances Management	Assess the management of toxic materials, including asbestos, lead based paint, radon, and PCBs.
12	Wastewater Management	Evaluate the regulations, responsibilities, and compliance requirements associated with wastewater and stormwater discharge at the fish hatchery.
13	Water Quality Management	Evaluate compliance with all rules, regulations, and requirements associated with quality of the potable water supply system.
14	Environmental Health and Safety Management	Evaluate compliance with industrial hygiene standards and the fish hatchery Health and Safety Program.

To provide a thorough environmental assessment of the Fish Hatchery, the environmental compliance assessment includes a comprehensive records review and facility reconnaissance survey. The following activities are performed during an assessment:

- Review of available facility records, permits, and regulatory correspondence;
- Review of data collected from previous investigations, assessments, monitoring plans, and corrective action programs;
- Review of aerial photographs and maps;
- Inspection/reconnaissance of the fish hatchery to ensure facility compliance with appropriate regulations;
- Interviews with key, responsible personnel familiar with fish hatchery operations and activities.

Information collected from the facility reconnaissance survey and records review is compared to applicable federal, state, and local regulations to evaluate items of potential environmental concern. The key regulations that serve as references during an assessment include the following:

- The Environmental Assessment and Management (TEAM) Guide, developed by the Department of Defense, 1995;
- Code of Federal Regulations;
- State Administrative Rules; and
- Uniform Fire Code

Non-compliance findings are documented on Environmental Compliance Assessment Individual Finding Sheets. In accordance with applicable requirements, incidents of non-compliance are divided into two reportable categories: Significant and Major. Significant findings are defined as a situation that requires immediate attention, and poses or is highly likely to pose, a direct and immediate threat to human health, safety, the environment, or the mission. Major findings are defined as a situation that requires action, but not necessarily immediate action, and may pose a threat to human health, safety, or the environment if uncorrected. Minor findings (mostly administrative in nature) are noted and verbally transmitted to responsible personnel during the assessment outbrief.

Based on the findings, recommended corrective actions are subsequently developed for each finding. Recommended actions include information on implementability, budget, and responsible party. Exhibit 1 provides a typical example of a Finding Sheet.

Exhibit 1

Environmental Assessment Individual Finding Sheet

Protocol 3 - Hazardous Materials Management
Finding No. 1

FACILITY: Fish Hatchery DATE: March 18, 1998

BUILDING/LOCATION: Laboratory and Pesticide Storage Room.

FINDING: Major

DESCRIPTION OF FINDING: 1) Flammable materials are being stored next to hydrochloric and acetic acid in the laboratory; and 2) Flammables are being stored next to pesticides in the Pesticide Storage Room. Examples of this finding are shown in Figure 3.

CRITERIA: Incompatible materials in storage and incompatible materials in use shall be separated. Reactive compounds should not be stored adjacent to flammable materials.

REGULATORY OR TEAM GUIDELINE CITATION:
Uniform Fire Code (1994) 8001.9.8

CORRECTIVE ACTION(S):

1. Immediately segregate the acids and flammable materials.
2. Store the flammable materials in the flammable storage cabinet.
3. Purchase a corrosive storage cabinet for acid storage.

APPROXIMATE COST TO IMPLEMENT CORRECTIVE ACTION(S):

1) Up to two person-hours for staff to separate incompatible materials and check Material Safety Data Sheets (MSDSs).

2) Up to $1,000 for purchase of a Corrosive Storage Cabinet.

Common Findings At Fish Hatcheries

Based on environmental audits at over fifty government fish hatcheries, the following is a list of the most common environmental compliance deficiencies observed at fish hatcheries:

- Improper Open Burning
- Inadequate Underground Storage Tanks
- Minimal Safety and Health Programs
- Improper Storage of Flammable Materials
- Improper Processing of Used Oil

- Improper Transportation of Hazardous Materials
- Improper Designation and Storage of Hazardous Waste
- Unsafe Delivery of Chlorine, Ozone, and/or Formalin
- Improper Storage of Formalin and Chlorine
- Improper Storage of Pesticides
- Improper and/or Nonpermitted Wastewater Discharge
- Inadequate Labeling of Hazardous Materials
- Inadequate Training for Staff
- Improper Recordkeeping for Environmental Records.

Each of these findings may result in staff injury, regulatory agency fines, hatchery contamination, or public relations problems.

Conclusion

Compliance with applicable environmental and safety and health laws results in fish hatcheries being more productive and safer facilities. Given that the purpose of fish hatcheries and fish research facilities is to increase environmental quality, it is unfortunate and ironic that serious environmental concerns exist at many of these facilities. By performing professional environmental audits, these facilities can take a proactive stance at assuring effective fish production, preventing public relations problems, decreasing liabilities, and assuring a safe workplace for employees. Environmental auditing is a proven, cost-effective means to assure effective hatchery management.

References

1) Code of Federal Regulations, Office of the Federal Register National Archives and Records Administration.

2) Environmental Assessment and Management (TEAM) Guide, developed by the Department of Defense, 1995.

3) Oregon Administrative Rules.

4) Washington Administrative Code

5) Various confidential environmental audit reports prepared by Tetra Tech, Inc. 1997, 1998.

6) International Fire Code Institute. Uniform Fire Code, 1998.

BIANNAUL SPAWNING BEHAVIOR IN THREE STRAINS OF RAINBOW TROUT

Daniel Abeyta
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Wesley Orr

Presented By
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Abstract

Kincaid (1983), Katsumi (1984), and Parke (1995) reported biannual (twice annually) spawning in rainbow trout.
Biannual spawning has also been documented in three strains of rainbow trout at the Ennis National Fish Hatchery. Documentation was confirmed by fin clipping and physical separation of biannual spawners for up to 3 years. Secondary spawns take place 5 to 6 months after the primary spawn. Egg survival to the eyed stage is reduced in secondary spawns. The percentage of fish spawning biannually in each year class is not consistent year to year. Questions are raised about the cause of biannual spawning, and possible advantages or disadvantages of this anomaly.

Introduction

Kincaid (1983) reported observing biannual spawning behavior in fall-spawning rainbow trout (Onchorynchus mykiss) in 1976. Through selection, the frequency of fish exhibiting biannual spawning behavior increased to 96.9, 86.5 and 93.0% of the fish spawning at 2.0, 2.5 and 3.0 years respectively. Additionally, Katsumi et al. (1984) reported a strain of rainbow trout breeding twice a year in Japan with 62.3% and 95.2% of the fish ovulating in the summer and winter breeding seasons respectively. Likewise, Parke and Burns (1995) reported twice per year spawning activity at two hatcheries in Alberta, Canada. However, in general, there appears to be relatively very little information on this anomaly.

Six strains of rainbow trout at the Ennis National Fish Hatchery (NFH) exhibit a primary spawn. Three of these strains also exhibit a secondary spawn about 6 months later (Table 1). The percentage of fish exhibiting biannual spawning varies but is similar to that reported by either Katsumi or Kincaid. The variation is probably because sorting was conducted at random, rather than regular time intervals. Similarly, egg viability (% eyed) in the secondary spawn is comparable to that achieved in the primary spawn for individual weeks. The initial discovery of biannual spawning activity occurred June 1994 in the McConaughy and Eagle Lake strains. The initial detection of biannual spawning in the Erwin strain occurred May 1996, however, it was suspected earlier as overripe eggs were frequent between May and June during first sort from 1985 to 1997.

Ennis NFH is located 12 miles southwest of Ennis, Montana. The hatchery consists of 36 outside raceways and an additional 36 tanks in the main hatchery building. The newly constructed broodstock technology building contains 48 circular tanks. Approximately one-half of the outside raceways are partially covered with Hanson Weatherport structures over the raceways. The covered section provides shelter for hatchery personnel during inclement weather conditions as well as offering shade and protection for the fish. The hatchery has an abundant year round water supply which flows at 15,000 gallons per minute (gpm) from two springs located approximately 1/4 mile north of the hatchery. The dissolved oxygen is typically 8.1 to 8.3 parts per million (ppm). The water temperature is a constant 54 degrees Fahrenheit. The pH ranges from 7.8 to 8.0 . Nitrogen gas levels have been reduced to approximately 102% with the installation of open, packed columns. Biannual spawning at Ennis NFH is discussed below.

Biannuals	*Primary Spawn*	*Second Spawn*	*Annuals*	*Spawn Time*
Erwin	July-August	December	Arlee	Oct.-Dec.
McConaughy	Dec.-Feb.	June	Fish Lake	Feb.-Mar.
Eagle Lake	Dec.-Feb.	June	Shasta	Dec.-Feb

Table 1: Ennis NFH Rainbow Trout Strains

Biannual Spawning History

At Ennis NFH, rainbow trout normally mature and spawn for the first time at two years of age. Males are typically stocked for recreational fishing after first spawning. Most of the females maturing at 2 years old are kept and spawned again at three years of age. Occasionally, some females are kept to four and five years of age. The following is a description of the extent of the documented biannual spawning history for each strain and how biannual spawning compares to the primary spawn.

MCCONAUGHY RAINBOW TROUT

About 85% of McConaughy strain RBT spawn as 2 year olds, and 99% spawn as three year olds. Normal spawning time for McConaughy strain RBT is December, January and February.

MCD92

During December 1993 and January 1994 about 79% of lot MCD92 spawned for the first time. Average eye up was 86%. On 6/29/94, at about age 22, ovulation occurred again in 21% of these fish, but many of the females were overripe when spawned, and eye up was only 47% **(fig.1)**. These biannual spawners were fin clipped for identification and returned to the original lot. From 12/6/94 to 2/14/95, all of them spawned again as 3 year olds. Average eye up was 81%. These fin clipped fish were moved into a separate raceway. From 6/12 to 7/11/95 50% of them spawned again. Most of these fish were grossly overripe which probably accounts for the average eye up of 15% . Between 12/13/95 and 2/14/96, 93% of these same fish spawned again with an average eye up of 84%. It was confirmed by fin clipping that these fish spawned at age 2, 22, 3, 32, and 4 years of age!

MCD93

Two year old McConaughy strain rainbow trout were spawned for the first time in December 1994. Six months later in June 1995, 36 % of the females were noticed to be ripe during routine sample counting. These ripe fish were spawned and yielded a 59% eye up. These fish were also fin clipped before mixing them back into the original lot. Of the fin clipped females, 100% spawned again as 3 year olds from 12/13/95 to 2/20/96 with an average percent eye up of 85%. These fish were held and spawned again at age 32, and 4 before being stocked out.

MCD96

In July 1998, during routine sample counting, 28 ovulating females were separated from the main lot. These fish will be monitored for the biannual spawning trait.

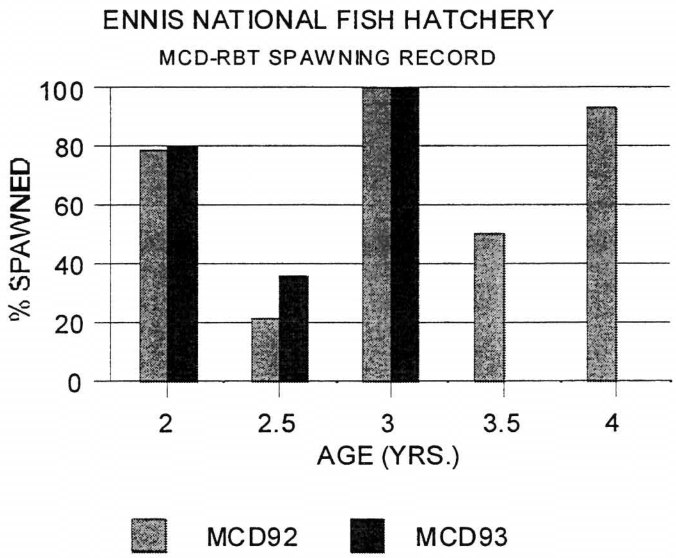

FIGURE 1. Spawning record of McConaughy rainbow trout

EAGLE LAKE RAINBOW TROUT

About 80% of Eagle Lake strain RBT spawn as 2 year olds, and 95% spawn as three year olds. Normal spawning time for Eagle Lake strain RBT is December, January and February.

ELW92

This lot first spawned from 11/30/93 to 2/1/94 as 2 year olds. On 6/29/94, 7% of these fish spawned again as 2.5 year olds with an average eye up of only 21% **(fig.2)**. Poor egg survival among the mid year spawners probably resulted from over ripe eggs. Biannual spawners were fin clipped and moved to a separate raceway for observation. Between 11/29/95 and 2/15/96, 100% of these fish spawned as 3 year olds, and eye up was 83%. From 6/15 to 8/15/96, 82% of these fish spawned again at 32 years of age yielding an average eye up of 50%. And finally, from 12/19/96 to 2/20/97, 85% of these fin clipped fish spawned for the 5th time at age 4 with an average eye up of 79%.

ELW93

Two year old Eagle Lake rainbow trout spawned for the first time in December 1994. About 81% spawned and average eye up was 87%. Five months later in June 1995 several ripe females were discovered during routine sample counting. From June until August 8, 17% of this age group had spawned again with an average eye up of 44%. These ripe fish were marked by fin clipping, and mixed back with the original lot. Ninety three percent spawned again from 12/19/95 to 2/20/96. Average eye up was 84%. These same fish were documented spawning for a 4th, and 5th time at 32 and 4 years of age before being stocked out.

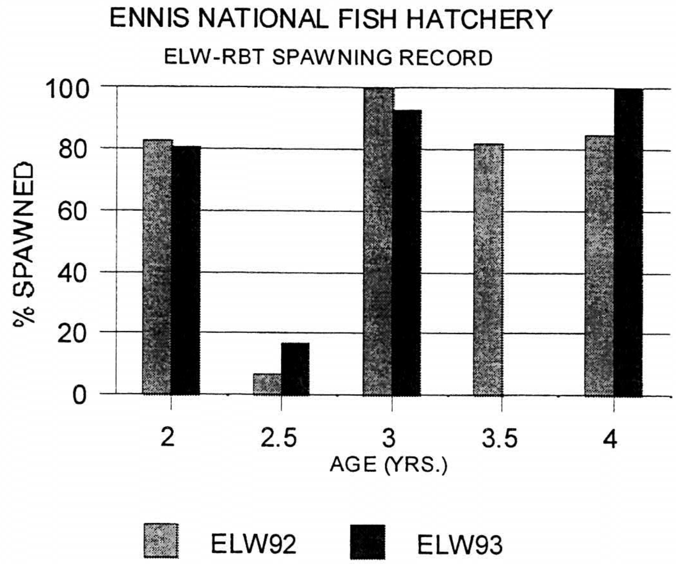

FIGURE 2. Spawning record of Eagle Lake rainbow trout

<u>ERWIN STRAIN RAINBOW TROUT</u>
The normal spawning season for the Erwin strain is July and August. However, from 1985 to 1997, Erwin strain rainbows were spawned over a 3 to 5 month period. Every year a number of these fish had overripe eggs at first sort. It was noted the percent of fish sorted with bad eggs did not increase significantly whether the fish were sorted in early May or in June. In other words, they were reaching final maturation sometime earlier than May!

<u>ERD93</u>
These fish spawned for the first time during the summer of 95 as 2 year olds **(fig.3).** When this lot was sorted at 2 years old on May 7, 1996, 114 fish out of 700 (16%) had overripe eggs (characterized by white, soft, broken, and bull s-eye eggs). The bad eggs were stripped out and those 114 fish were separated from the rest of the lot. Spawning records show that from 8/1 to 9/25, viable eggs were taken from 96 (84%) of these 114 fish. In October, the unspawned females in this lot were sorted and most of them had over ripe eggs.

<u>ERD94</u>
These fish spawned for the first time from 6/11 to 9/25/96 as two year old fish. On March 26, 1997, the lot was sorted for ripeness. Of 800 females, 195 (24%) contained overripe eggs which were stripped out. These 195 fish were held separately from the rest of the group. From 6/10 to 9/16/97, a total of 147 (89%) females spawned, and 20 fish were in stages of final maturation when the test was terminated on 9/16/97. Average eye up was 76%. The original lot of ERD94 females were spawned during the same time period. Of those fish, 96% spawned and the average eye up was 83%.

<u>ERD95</u>
On 12/30/97, during routine sample counting, ripe fish were detected in 2 year old Erwin strain rainbow trout. On 12/31 the entire lot was sorted and 245 ripe females were separated from the lot. On January 2,

1998 these females were spawned. ERD96 males were used to fertilize the eggs (this was the first time Erwin strain males have been observed spermiating this time of year). There were 23 fish with normal appearing eggs and 222 fish with over ripe eggs. Egg survival to the eyed stage was 25%. These fish were moved to a separate raceway so their future spawning behavior could be examined in detail. Ninetysix percent of the 245 females spawned again at 3 years during 5/26/98 to 8/18/98 with an average eye-up of 81.40%.

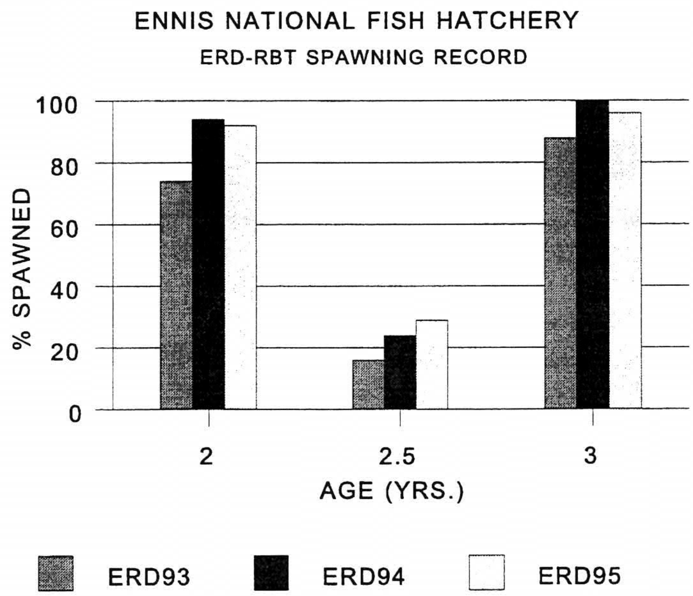

FIGURE 3. Spawning record of Erwin rainbow trout

Potential Causes

There are several hypothesized explanations for biannual spawning. Constant water temperature, feed amount, hormones or other chemicals in feed or water, body size and composition, and photoperiod to mention a few. However, because of the fact that other rainbow trout strains exposed to identical environmental and physical conditions at Ennis NFH do not show signs of spawning twice annually a better explanation is possibly a genetic influence. A rare allele found only in the three biannual strains at Ennis NFH could be one explanation. Kincaid s (1983) research on biannual spawning using rainbow trout strongly supports this hypothesis. After 3 selection cycles, Kincaid found that 84% of the females, and 43% of the males, expressed the biannual spawning trait. Likewise, Katsumi s (1984) investigations suggest a genetic basis for explaining the cause. In his findings rainbow trout were spawning twice/year in three different laboratories under natural photoperiod conditions and at varying water temperatures. These findings certainly do not rule out potential contributing factors such as feed type/amount, photoperiod, body size and composition, and/or constant water temperature. It may well be a combination of the above factors interacting together that initiates this peculiarity. Additional research will be required to more fully understand the cause(s) of this phenomenon.

Management Implications

There are some advantages in having populations of biannual spawning rainbow trout. Egg availability in March, April, and May, when eggs are normally not available, would provide increased long and short term planning flexibility for hatchery managers. Reduced broodstock requirement would result in reduced maintenance which for some hatcheries may be another advantage. From a commercial fish culture perspective, biannual spawning would result in increased production which in turn would increase profits. Some disadvantages might be reduced somatic growth, smaller eggs, lower percentage of spawners, and a lower percent eye up. Consistency in egg quality (% eyed) needs to be achieved before biannual spawning in rainbow trout can be used as an effective management tool.

Direction of Ennis NFH

On January 2, 1998 hatchery personnel spawned 23 ERD 95 females and these eggs were fertilized with milt from ERD 96 males. These fish are believed to be biannual spawning rainbow trout since the primary spawning period for the Erwin strain is July and August. Some of these eggs were hatched out. Ennis NFH currently has 580 of these 11 month old fish on hand. The plan is to continue to keep these fish separate from the main lot and spawn them at two years of age. If the offspring of these known biannual rainbow trout are biannual spawners themselves we ll have relatively strong evidence that biannual spawning is genetically controlled. However, we are planning on having some genetic analyses conducted on these fish to strengthen our findings. Additionally, 28 MCD 96 females have been set apart from the main lot to conduct similar studies. These fish were observed to be ovulating while conducting routine sample counts in July 1998.

Conclusions

1) Initial research suggests biannual spawning appears to be genetically controlled, however further testing needs to be completed for confirmation.

2) Regular sorting intervals must be initiated to better understand why egg viability and percentage of lot spawning is lower in biannual spawners.

3) Biannual spawning rainbow trout would have both advantages and disadvantages for management implications.

4) Further investigations must be conducted to understand why a higher percentage of females than males are biannual spawners.

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THE POWER AND EASE OF THE CODED-WIRE TAG RETRIEVAL AND ANALYSIS SYSTEM

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Abstract

The Coded-Wire Tag Retrieval and Analysis System (CRAS) is a free publicly-available computer program developed by the Northwest Indian Fisheries Commission. It offers a variety of reports on coastwide hatchery production and coded-wire tag (CWT) studies. CRAS is available only through the NWIFC home page at www.nwifc.wa.gov.

CRAS is powerful. It offers a variety of reports on all coastwide salmon and steelhead hatchery releases, and reports on all coho and chinook CWT recoveries, which have ever been reported to the Pacific States Marine Fisheries Commission (PSMFC). These include nearly 90,000 individual releases since 1958, and over 3 million coho and chinook recovery records. CWT recovery records are available in either raw format, or summarized by area and fishery. CWT recovery reports include: (1) CWT Summary Report (which displays general information on a CWT group's release, recoveries, and survival); (2) Freshwater Recovery Report (which displays all freshwater recoveries by site and gear type); and (3) Fishery Recovery Report (which displays all coho or chinook recoveries in a user-specified fishery(ies) and recovery time period(s)).

CRAS is easy to use. Users are able to request releases of interest through a criteria input screen, and CRAS then generates a list of all corresponding releases. For example, a user may wish to find out all brood year 1980 to 1985 coho and chinook released into the Skagit River. This would be accomplished by simply entering those species, brood years, and location, and the resultant list of releases could then be displayed through reports that summarize the information by user-selected variables (e.g., by release year, hatchery and species). Recoveries from CWT studies can easily be analyzed the same way.

CRAS is the only coastwide database to offer this array of features and reports. Its power and ease of use make it useful to fishery managers, hatchery planners, and researchers everywhere.

Introduction

The Coded-Wire Tag Retrieval and Analysis System (CRAS) is a free publicly available computer program developed by the Northwest Indian Fisheries Commission (NWIFC). It offers a variety of reports on coastwide hatchery production and coded-wire tag (CWT) studies. CRAS is available only through the NWIFC home page at www.nwifc.wa.gov.

CRAS is powerful. It includes all coastwide release and recovery data which have ever been reported to the Pacific States Marine Fisheries Commission (PSMFC). This includes nearly 90,000 individual releases since 1958, and over 3 million coho and chinook recovery records. The PSMFC data are summarized in several useful ways:

- codes are replaced by English names
- release and recovery numbers can be summed
- individual recovery locations are summarized by fishery (Table 1). These fisheries can be grouped by the user, too.
- lists of releases or CWT study groups can be generated at a number of levels: Domain (e.g., California), Region (e.g., Northern California), Basin (e.g., Klamath/Trinity Rivers), or Hatchery (e.g., Trinity River Hatchery).

Table 1. CRAS Fisheries

Fishery Number	Fishery Name	Fishery Number	Fishery Name
1	Southeast Alaska Troll	15	Georgia Strait/Johnstone Strait Net
2	Southeast Alaska Net	16	Fraser River Net
3	Southeast Alaska Sport	17	Strait of Juan de Fuca Net (Canadian Area 20)
4	North British Columbia Troll	18	WA Area 4, 4B Troll
5	Central British Columbia Troll	19	WA Area 4 Sport
6	North/Central British Columbia Sport	20	WA Area 3 Troll
7	North British Columbia Net	21	WA Area 3 Sport
8	Central British Columbia Net	22	WA Area 2 Troll
9	NW Vancouver Island Troll	23	WA Area 2 Sport
10	SW Vancouver Island Troll	24	WA Area 1 Troll
11	West Coast Vancouver Island Sport	25	WA Area 1 Sport
12	West Coast Vancouver Island Net	26	WA North Coast Net
13	Georgia Strait/Juan de Fuca Strait/Johnstone Strait Troll	27	Grays Harbor Net
14	Georgia Strait/Juan de Fuca Strait/Johnstone Strait Sport	28	Willapa Bay Net
29	Buoy 10 Sport	63	WA Area 10 Sport
30	Tillamook Troll	64	WA Area 11 Sport
31	Tillamook Sport	65	WA Area 10 Net
32	Newport Troll	66	WA Area 10A Net
33	Newport Sport	67	WA Area 10B Net
34	Coos Bay Troll	68	WA Area 10E Net
35	Coos Bay Sport	69	WA Area 11 Net
36	Brookings Troll	70	WA Area 11A Net
37	Brookings Sport	71	WA Area 12 Sport
38	Crescent City Troll	72	WA Area 12, 12B, 12C, 12D Net
39	Crescent City Sport	73	WA Area 12A Net
40	Eureka Troll	74	WA Area 13 Sport
41	Eureka Sport	75	WA Area 13 Net
42	Fort Bragg Troll	76	WA Area 13A Net
43	Fort Bragg Sport	77	WA Area 13C Net
44	Southern California Troll	78	WA Area 13D Net
45	Southern California Sport	79	WA Area 13E-K Net
46	WA Area 7 Sport	80	Freshwater Sport
47	WA Area 7, 7A Net	81	Freshwater Net
48	WA Area 7B, 7C, 7E Net	82	Juvenile Catch
49	WA Area 7D Net	83	High Seas Catch
50	WA Area 5, 6, 6C, 7, 7A Troll	84	Escapement
51	WA Area 5 Sport	85	Alaska Cost Recovery
52	WA Area 6 Sport	86	Gear and Location Unknown
53	WA Areas 4B, 5, 6, 6A, 6C Net	87	Canada General-Troll
54	WA Area 6D Net	88	Oregon General-Troll
55	WA Area 8 Sport	89	Oregon-Calif General-Troll
56	WA Area 8 Net	90	California General-Troll
57	WA Area 8-2 Sport	91	Alaska-Unknown or Mixed Gear
58	WA Area 8A Net	92	Oregon-Unknown or Mixed Gear
59	WA Area 8D Net	93	Columbia R-Unknown or Mixed Gear
60	WA Area 9 Sport	94	California-Unknown or Mixed Gear
61	WA Areas 6B, 9 Net	95	Washington General-Net
62	WA Area 9A Net		

CRAS is easy to use. Users can easily input a description of the releases of interest by using the CRAS criteria input screen. CRAS then automatically generates a list of all corresponding releases. For example, a user may wish to learn about all brood year 1980 to 1985 coho and chinook salmon released into the Skagit River. This would be accomplished by simply entering those species, brood years, and location. The resultant list of releases or CWT groups could then be displayed through several reports.

The reports in CRAS are of three main types: 1) Hatchery Production, 2) Recoveries by CWT, and 3) Recoveries by Fishery.

Hatchery Production Reports

CRAS has two hatchery production reports: (1) Short Release Report, which displays one line per release record (Figure 1); and (2) Release Summary Report, which summarizes release numbers by user-specified variables, such as release year, brood year, species, agency and/or hatchery (Figure 2).

Figure 1. CRAS Short Release Report

Short Release Report

Hatchery	Brood Year	Run Type	Specie	Stock		Release Dates First	Last	Release Stage	Size (g)	Total # Released	Kilograms Released	Release Site	Release Identifier
EDUCKET CR HATCH	1988		Coho	HOKO R	19.0148	05/10/89	05/10/89	Fingerling	1.00	15,760	16	UNNAMED WAATCH TRIB	114198900129
EDUCKET CR HATCH	1988		Coho	HOKO R	19.0148	05110/89	05/11/89	Fingerling	1.00	54,689	55	WAATCH RIVER	!14198900130
EDUCKET CR HATCH	1988		Coho	QUINAULT R	21.0398	04/10/90	04/11/90	Smolt	32.40	48,655	1,576	EDUCKET CREEK	052259

Figure 2. CRAS Release Summary Report

Release Summary By Release Year, Species

Release Year 1989

Species Coho

Hatchery	Spec	Run	BrYr	Stock	First Dt	Last Dt	Rel Stage	Tot # Rel	Lbs Rel	Release Site	# Tagged	Release Code
EDUCKET CR HATCHERY	coho		1988	HOKO R19.0148	05/10/89	05/10/89	Fingerling	15,760	35	UNNAMED WAATCH TRIB		114198900129
EDUCKET CR HATCHERY	coho		1988	HOKO R19.0148	05/10/89	05/11/89	Fingerling	54,689	121	WAATCH RIVER		114198900130
					Species Subtotals:			70,449	156			
					Release Year Subtotals:			70,449	156			

Release Year 1990

Species Coho

Hatchery	Spec	Run	BrYr	Stock	First Dt	Last Dt	Rel Stage	Tot # Rel	Lbs Rel	Release Site	# Tagged	Release Code
EDUCKET CR HATCHERY	coho		1988	QUINAULT R	04/10/90	04/11/90	Smolt	48,655	3,475	EDUCKET CREEK	47,936	052259
					Species Subtotals:			48,655	3,475			
					Release Year Subtotal:			48.655	3,475			

CWT Recovery Reports

CWT recovery reports include: (1) CWT Summary Report, which displays general information on a CWT group's release, recoveries, and survival (Figure 3); (2) Recovery Distribution Report, which summarizes recoveries by fishery (Figure 4); (3) Freshwater Recovery Report, which displays all freshwater recoveries by site and gear type (Figure 5); and (4) Survival and Contribution Rates Report, which provides a short summary of each tag code's recovery statistics (Figure 6).

Figure 3. CRAS CWT Report

CWT SUMMARY REPORT

RELEASE SUMMARY

Tag Code: 630731
Brood Year: 1989
Species: Chinook
Hatchery Name: SAMISH HATCHERY
Releasing Agency: Washington Dept. Fish and Wildlife
Release Stage: Fingerling
First Release Date: 5/25/90
Last Release Date: 5/25/90
 # Tagged: 202,682
 # Ad Onlys: 3,631
 # Unmarked: 744,187

Run: Fall
Release Site: FRIDAY CREEK
Stock: SAMISH (FRIDAY CR)
Hatchery/Wild: Hatchery
Type of Tag: Embedded Replicate
Avg Weight (g): 4.7

RECOVERY SUMMARY (ALL AGES)

Recovery Location	Number of Obs. Recoveries	Number of Est. Recoveries	Percent of Total Recoveries
Alaska	0	0.0	0%
British Columbia	35	149.2	31%
Washington	52	211.8	44%
Oregon	1	3.2	1%
California	0	0.0	0%
Escapement + Freshwater Catch	112	120.5	25%
Total Recoveries	200	484.7	100%

Estimated Minimum Survival Rate: 0.0023914

Estimated Recoveries by Age:

	Total		**Fishery**		**Escapement**	
	Number	**%**	**Number**	**%**	**Number**	**%**
<= Age 2	8.6	2%	2.6	1%	6.0	5%
Age 3	219.8	45%	174.7	47%	45.1	40%
Age 4	249.8	52%	188.4	51%	61.4	55%
Age 5	4.0	1%	4.0	1%	0.0	0%
>= Age 6	2.5	1%	2.5	1%	0.0	0%

Figure 4. CRAS Recovery Distribution Report.

CWT RECOVERY DISTRIBUTION REPORT

Tag Code:630731

Brood Year: 1989
Age: 4
Species: Chinook
Hatchery Name: SAMISH HATCHERY
Releasing Agency: Washington Dept. Fish and Wildlife
Release Stage: Fingerling
First Release Date: 5/25/90
Last Release Date: 5/25/90
 # Tagged: 202,682
 # Ad Onlys: 3,631
 # Unmarked: 744,187

Run: Fall
Release Site: FRIDAY CREEK
Stock: SAMISH (FRIDAY CR)
Avg Weight (9): 4.7
Type of Tag: Embedded Replicate
Total # of Expanded Recoveries: 249.8
Total # of Expanded Fishery Recoveries: 188.4

Recovery Location	Number of Obs. Recoveries	Number of Est. Recoveries	% of Total Recoveries
NW Vancouver Island Troll	4	15.1	6.0%
SW Vancouver Island Troll	2	8.9	3.6%
West Coast Vancouver Island Sport	2	21.5	8.6%
Georgia/Juan de Fuca/Johnstone Str. Troll	1	3.2	1.3%
Georgia/Juan de Fuca/Johnstone Str. Sport	8	29.7	11.9%
WA Areas 4 and 4B Troll (Cape Flattery)	4	20.6	8.2%
WA Area 3 Troll (Quileute)	1	1.1	0.4%
WA Area 7 Sport	3	12.9	5.2%
Nooksack/Samish Net (WA Areas 7B, 7C, 7E)	9	56.4	22.6%
Juan de Fuca Troll (WA Areas 5, 6,6C, 7,7A)	1	1.6	0.6%
WA Area 5 Sport	1	9.5	3.8%
WA Area 6 Sport	1	5.0	2.0%
WA Area 9 Sport (Discovery-Admiralty)	1	2.9	1.2%
Freshwater Escapement	59	61.4	24.6%

Figure 5. CRAS Freshwater Recovery Report

Freshwater Recovery Report

Tag Code: 634025
Species: Chinook
Hatchery: SAMISH HATCHERY
Releasing Agency: Washington Dept. Fish and Wildlife
Release Stage: Fingerling

Brood Year: 1990
Run: Fall
Release Site: FRIDAY CREEK
Stock: SAMISH (FRIDAY CR)

Return Year	PSC Fishery	Site	# Observed	# Estimated
1992	Hatchery	SAMISH HATCHERY	37	37.72
1993	Hatchery	SAMISH HATCHERY	159	165.38
	Spawning Ground	R-COWICHAN RIVER	1	
		SAMISH R 03.0005	2	7.18
1994	Hatchery	H-CAPILANO RIVER	1	1.00
		KENDALL CR HAT	1	1.00
		SAMISH HATCHERY	123	124.23
	Spawning Ground	SAMISH R 03.0005	2	8.64
1995	Hatchery	SAMISH HATCHERY	14	14.00

Figure 6. CRAS Survival and Contribution Rate Report

Survival and Contribution Rate Report

SPECIES: Coho

Assigned Group Code	Tag Code	Hatchery Name	Release Site	BrYr	CWTs Released	Expanded Fishery Contribution Rate	Total Expanded Escapement Rate	Expanded Recovery Rate
1	212411	ELLIOTT BAY NET PENS	ELLIOTT BAY	1992	45,567	0.0305	0.0003	0.0308
	212540	ELLIOTT BAY NET PENS	ELLIOTT BAY	1993	42,691	0.0315	0.0006	0.0321
					MEAN	**0.0310**	**0.0005**	**0.0314**
2	634354	SOOS CREEK HATCHERY	BIG SOOS CREEK	1990	45,696	0.0180	0.0073	0.0252
	634801	SOOS CREEK HATCHERY	BIG SOOS CREEK	1991	46,421	0.0631	0.0367	0.0998
	634802	SOOS CREEK HATCHERY	BIG SOOS CREEK	1991	45,153	0.0611	0.0349	0.0960
	634954	SOOS CREEK HATCHERY	BIG SOOS CREEK	1992	44,166	0.0318	0.0027	0.0344
	635452	SOOS CREEK HATCHERY	BIG SOOS CREEK	1993	44,909	0.0140	0.0054	0.0194
					MEAN	**0.0376**	**0.0174**	**0.0550**

Fishery Recovery Report

The CRAS Fishery Recovery Report displays all coho or chinook recoveries in a user-specified fishery(ies) and recovery time period(s) (Figure 7).

Figure 7. CRAS Fishery Recovery Report

Fishery Recovery Report

Fishery Group Area 11 Sport
Species: Chinook

Strata		BY	Tag Code	Release Site	Hatchery	Stock	Observed	E"mated
Jan	1993	1987	534202	SOUTH SOUND NET PENS	SOUTH SOUND NET PENS	DESCHUTES R 13.0028	1	3.4
	1993	1989	630849	SUND ROCK NET PENS	SUND ROCK HATCHERY	FINCH CR 16.0222	1	3.4
	1993	1989	635916	FINCH CREEK	HOODSPORT HATCHERY	BIG QUILCENE 17.0012	1	3.4
	1993	1990	633929	CHAMBERS CREEK	GARRISON HATCHERY	GARRISON SPRINGS STK	1	3.4
Feb	1993	1987	634704	HUPP SPRINGS REARING	HUPP SPRINGS REARING	WHITE R 10.0031	1	3.0
	1993	1989	630455	SOUTH SOUND NET PENS	SOUTH SOUND NET PENS	DESCHUTES R 13.0028	1	3.0
	1993	1989	631125	ICY CREEK	ICY CR HATCHERY	BIG SOOS CR 09.0072	1	3.0
	1993	1989	633926	CAPITOL LAKE	CAPITOL LAKE REARING	BIG SOOS CR 09.0072	1	3.0
	1993	1989	635642	HUPP SPRINGS REARING	HUPP SPRINGS REARING	WHITE R 10.0031	2	6.0
	1993	1989	635638	SUND ROCK NET PENS	SUND ROCK HATCHERY	FINCH CR 16.0222	2	6.0
	1993	1990	021548	CHEHALIS RIVER	H-CHEHALIS RIVER	S-HARRISON RIVER	1	3.0
	1993	1990	211833	KALAMA CREEK	KALAMA CR HATCHERY	MCALLISTER CR I 1.0324	1	3.0
	1993	1990	633929	CHAMBERS CREEK	GARRISON HATCHERY	GARRISON SPRINGS STK	1	3.0
Mar	1993	1989	633926	CAPITOL LAKE	CAPITOL LAKE REARING	BIG SOOS CR 09.0072	3	7.2
	1993	1989	635542	HUPP SPRINGS REARING	HUPP SPRINGS REARING	WHITE R IO.OG31	1	2.4
	1993	1989	635637	SUND ROCK NET PENS	SUND ROCK HATCHERY	FINCH CR 16.0222	1	2.4
	1993	1990	212026	STILLAGUAMISH RIVER	STILLAGUAMISH HATCH	STILLAGUAAMSH R -NF	1	2.4
	1993	1990	212044	WHITE RIVER	WHITE RIVER HATCHERY	WHITE R 10.0031	1	2.4
	1993	1990	634521	ZITTEL'S MARINA PENS	SOUTH SOUND NET PENS	DESCHUTES R 13.0028	1	2.4
Apr	1993	1989	630847	SUND ROCK NET PENS	SUND ROCK HATCHERY	FINCH CR 16.0222	1	1.2
	1993	1989	631419	FOX ISLAND PENS - EC	FOX ISLAND HATCHERY	BIG SOOS CR 09.0072	2	2.4
	1993	1989	633926	CAPITOL LAKE	CAPITOL LAKE REARING	BIG SOOS CR 09.0072	2	2.4
	1993	1989	635542	HUPP SPRINGS REARING	HUPP SPRINGS REARING	WHITE R 10.0031	1	1.2
	1993	1990	211833	KALAMA CREEK	KALAMA CR HATCHERY	MCALLISTER CR 11.0324	1	1.2
	1993	1990	212026	STILLAGUAMISH RIVER	STILLAGUAMISH HATCH	STILLAGUAMISH R -NF	1	1.2
	1993	1990	633954	SOUTH SOUND NET PENS	SOUTH SOUND NET PENS	DESCHUTES R 13.0028	1	1.2
	1993	1990	634008	SOUTH SOUND NET PENS	SOUTH SOUND NET PENS	DESCHUTES R 13.0028	1	1.2
	1993	1990	634304	FOX ISLAND PENS - EC	FOX ISLAND HATCHERY	DESCHUTES R 13.0028	1	1.2

CRAS is the only coastwide database to offer this array of features and reports. Its power and ease of use make it useful to fishery managers, hatchery planners, and researchers everywhere.

SPECIALIZED TROUT STRAIN DEVELOPMENT IN BRITISH COLUMBIA

Tim Yesaki,
British Columbia,
Ministry of Fisheries, Fish Culture Sectionb

The British Columbia, Ministry of Fisheries, Fish Culture Section stocking program stocks over eleven hundred lakes and streams with approximately eleven million trout and anadromous trout each year. The BC Fisheries stocking program supports 25 % of the five hundred million dollar freshwater fishing industry in British Columbia.

Seven species and over thirty stocks of trout, char and kokanee are reared in five major provincial hatcheries located in Abbotsford, Bull River (Cranbrook), Clearwater, Duncan and Summerland. The BC Fisheries hatchery program utilizes wild and semi-wild brood stocks, rather than domestic strains, for 95% of its production.

BC Fisheries has developed a number of different specialized strains of trout in an attempt to increase performance (growth and survival to creel) and production efficiencies:

- **Coarse fish strains:**
  In 1997, BC Fisheries produced over 1.5 million rainbow trout from two strains (Blackwater; Tzenzaicut) that have co-evolved with high densities of non-salmonids. These fish are stocked into lakes where competition from non-salmonids (e.g. suckers, shiners) have historically prevented the establishment of successful fisheries. When stocked into a system containing non-salmonids, these two coarse fish strains outperform rainbow trout from a monoculture system.

- **Alkaline tolerant strains:**
  BC has a number of very productive, alkaline lakes. In the past, millions of fish have been stocked into these waters without successful establishment of fisheries. BC Fisheries is developing a broodstock from a large alkaline (pH 9.4) lake in the interior of BC. When stocked into an alkaline lake, our studies to date show that these alkaline tolerant fish outperform rainbow from non-alkaline systems.

- **All-female triploid rainbow trout:**
  BC Fisheries has three pure strains of all-female rainbow trout. XX male lines are maintained in hatchery or in managed brood lakes. All-female triploid rainbow trout are stocked into systems that are managed as trophy fisheries (reduced creel limits). Regular rainbow trout will mature at 3-4 years of age. Our studies to date indicate, in limited harvest systems, 6-8 year old all-female triploid rainbow trout will remain silver and immature.

- **All-female triploid brook trout:**
  In October 1998, BC Fisheries will produce 100% all-female triploid brook trout for stocking purposes. In the previous two years, all of our production brook trout have been triploid only. We have observed spawning behaviour in 0+ and 1+ triploid brook trout males. BC Fisheries has committed to all-female triploid production to avoid the losses to early maturation in males and to prevent impacts on native fish species.

Data from post-stocking evaluations of the coarse fish, alkaline tolerant and all-female triploid rainbow trout strains will be presented. Details on all-female triploid brook trout production will also be presented.

EVALUATIONS OF BROODSTOCK PERFORMANCE INCLUDING NATURAL REPRODUCTIVE SUCCESS FOR NON-LOCAL AND LOCAL WILD BROODSTOCK HATCHERY STEELHEAD STOCKS IN THE KALAMA RIVER, WASHINGTON

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Abstract

Studies of hatchery and wild steelhead have been conducted on the Kalama River since the mid-1970s. Primary research objectives for those studies were to compare the natural reproductive success of non-locally derived hatchery stocks to that of the indigenous wild stocks. Genetic tagging with electrophoretically detectable allozyme variants was used in the first two phases of study to estimate the reproductive contributions of hatchery summer-run and hatchery winter-run steelhead spawning naturally in the Kalama. Natural production by wild summer and winter steelhead was found to be substantially higher than that of the hatchery stocks. The survival differential was increasingly pronounced at successive (subyearling, smolt, and adult) life history stages of the offspring. These differences are believed to reflect (in part) genetic differences between the wild stocks and the transplanted hatchery stocks. Both non-local stock source and domestication selection likely play a role in the poor performance of these stocks in the wild. Continued natural spawning by those non-local stocks poses both genetic and ecological risks to wild steelhead in the Kalama and elsewhere in southwest Washington. Accordingly, adults from the genetically dissimilar hatchery stocks are no longer permitted access to the principal spawning areas in the Kalama upstream of a barrier falls and trap. Moreover, a new phase of research was initiated to evaluate performances and wild stock conservation merits of hatchery-reared fish spawned from wild Kalama steelhead brood stock. In-hatchery performance and adult return rates of fish spawned from wild winter-run will be compared to that of the non-local hatchery stock reared at the same facility for the 1998-2000 hatchery brood years. A more intensive study of summer-run wild broodstock performance will evaluate in-hatchery performance and adult returns rates of the 1999-2001 broods as well as the natural reproductive success of returning hatchery-reared adults compared to their wild counterparts.

Introduction

Studies of the life history and genetic attributes and ecological interactions of hatchery and wild steelhead have been conducted on the Kalama River since the mid-1970s. A primary focus of the research objectives for those studies was to compare the natural reproductive success of the non-locally derived hatchery stocks to that of the indigenous wild stocks. Genetic tagging with electrophoretically detectable allozyme variants was used in the first two major phases of study to estimate the reproductive contributions of hatchery summer-run and hatchery winter-run steelhead spawning naturally in the Kalama. A study comparing the reproductive success of hatchery and wild summer-run was conducted in the Kalama from the mid-1970s through the mid-1980s. Findings from that work were reported in two publications, one covering natural production to the smolt stage (Chilcote et al. 1986) and one to the returning adults stage (Leider et al. 1990). A parallel study, this time on Kalama hatchery and wild winter-run steelhead, was conducted from the mid-1980s through the mid-1990s. A manuscript is currently in preparation that will focus on the winter-run findings, but also include some reanalysis of summer-run data. A third major phase of research was initiated this year to assess the natural reproductive success of hatchery-reared fish spawned from wild Kalama steelhead parents (local wild broodstock).

This paper will review and revisit the initial summer-run work, compare and contrast that to findings from the winter-run work, discuss management implications of those works regarding wild stock conservation, and describe the objectives and general approach for the new phase of research on wild broodstock.

Study Area and Stock Backgrounds

The Kalama River is a medium sized tributary of the lower Columbia River. It drains about 530 square kilometers of land as it flows approximately 72 km from its source in the southwest foothills of Mt. St. Helens to its mouth at river km 118 of the Columbia.

The hatchery steelhead planted in the Kalama have been almost exclusively outplanted from two facilities located a few tributaries upstream or downstream of the Kalama within the lower Columbia basin. Beaver Creek Hatchery (BCH) on the Elochoman River (Figure 1) has been the traditional source of the hatchery winter steelhead plants in the Kalama. Origins of the BCH winter-run stock include fish from Chambers Creek Hatchery (south Puget Sound), Cowlitz Hatchery, and the Washougal River (Crawford 1979). Skamania Hatchery (SKH) on the Washougal River has been the source of the hatchery summer-run plants. Origins of the SKH summer-run stock were primarily fish from the Washougal and Klickitat rivers (Crawford 1979). Thus these hatchery stocks have non-local and mixed-stock origins relative to wild Kalama steelhead. Nevertheless, their reproductive success is of key steelhead management interest since these are the stocks that have been outplanted into most of the lower Columbia tributaries throughout southwest Washington since the late 1950s.

The focus area of study is that portion of the Kalama basin between the Kalama Falls Hatchery (KFH; river km 17) and the upper Kalama Falls (river km 59), which is a total barrier to upstream migration. Based on flight surveys, the vast majority of steelhead spawning takes place in this portion of the basin, and the fishway and trap adjacent to the partial barrier falls at KFH is the access site for all sampling of upstream migrating adults. Sampling of downstream migrant smolts was also conducted at a trap site adjacent to KFH.

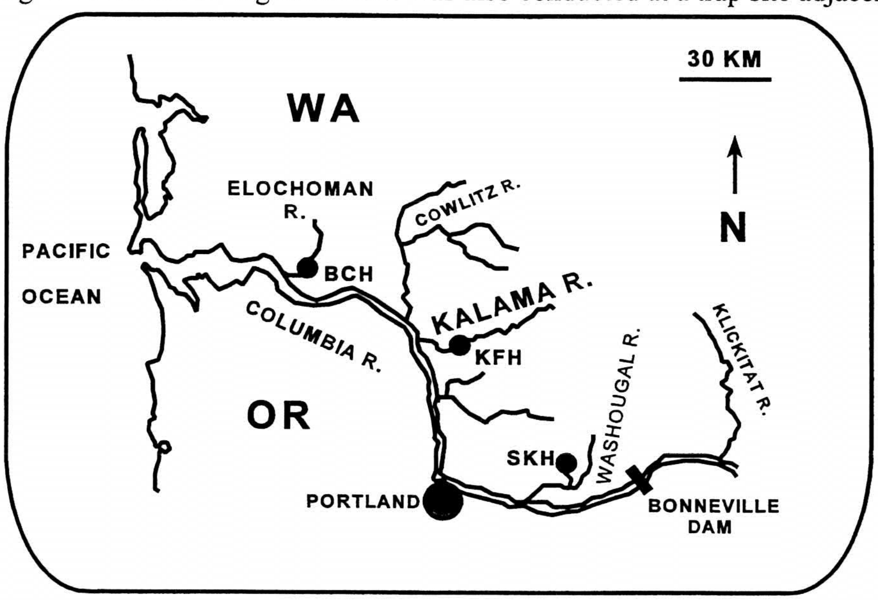

Figure 1. Location of the Kalama River and selected Washington hatchery sites in the Lower Columbia basin (see text).

Summer-run and winter-run steelhead are both indigenous to the Kalama River, and recent analysis of genetic profiles of allozyme loci indicate that the wild stocks are still genetically distinct from the hatchery stocks. Nevertheless, Skamania hatchery summer-run had been stocked in the Kalama for 20 years prior to initiation of the summer-run study, and Beaver Creek winter-run were stocked for 30 years prior to initiation of the winter-run study. It is therefore important to note that "wild" as used here refers to steelhead that were naturally spawned and reared. It is recognized that some of the "wild" fish may be the offspring or descendants of successfully spawning hatchery fish. However, this was the only practical working definition, since partitioning the population into "native" and "naturally spawned hatchery" components was not possible.

Hatchery Summer-run Study

A genetic marking approach was used that enabled us to quantify the proportion of naturally spawned steelhead in the Kalama that could be attributed to hatchery or wild parents, which is the basis for our comparison of the reproductive success of hatchery and wild fish. The G3PDH-1 enzyme locus was chosen as the summer-run genetic marker locus, having a common allele (A) and a variant allele (B). The B allele was historically rare in wild Kalama steelhead, but less rare in the Skamania hatchery summer-run stock. This facilitated the use of selective breeding to increase the frequency of the B allele in the hatchery fish. Figure 2 illustrates how selective breeding was used to alter the Skamania stock G3PDH-1 make-up from one predominated by fish having two copies of the A allele (type AA) to one in which all fish had at least one copy of the B allele. This was done by using only type BB male spawners, randomly bred with females of all types. The resulting progeny formed 100% of the hatchery summer steelhead planted in the Kalama River for four consecutive years. Sampling of returning adults from those smolt plants confirmed a much higher frequency of the B allele (nearly 0.5) in the hatchery summer-run (HS) adults than in wild Kalama summer-run (WS) adults (B < 0.1; Figure 3). This is what enabled estimation of the proportion of naturally spawned offspring that were attributable to hatchery or wild parents. Natural production dominated by either hatchery or wild spawners would result in a B frequency in the offspring being similar to that of their HS or WS parents, respectively. More equal production by hatchery and wild summer-run would result in offspring B frequencies intermediate to that of the HS and WS parents.

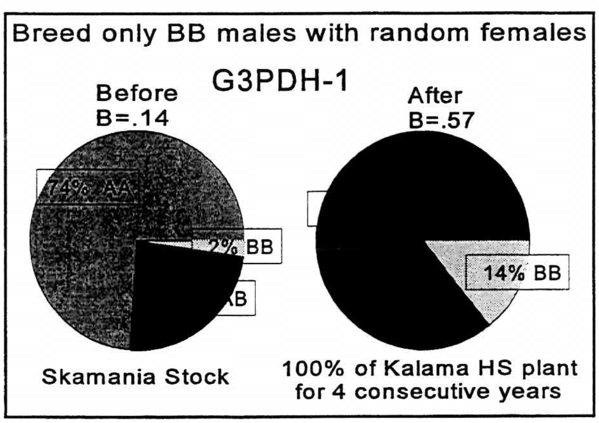

Figure 2. Genetic marking approach for hatchery summer-run.

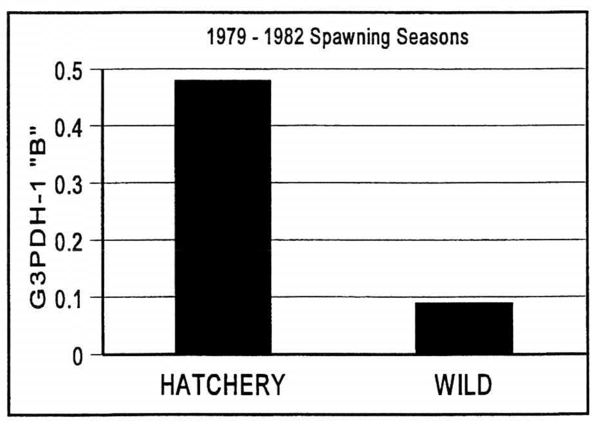

Figure 3. Genetic marker frequency in summer-run spawners.

In addition to genetic mark data, a key piece of information needed to compare natural reproductive success on a spawner-per-spawner basis is the relative abundance of the hatchery and wild spawners. Among the summer-run spawners, hatchery fish were much more abundant, their numbers ranging from 3 to 5 times that of wild summer-run spawners. Analysis of genetic mark frequencies in three stages of offspring sampled showed that the hatchery fish were indeed contributing to natural production, though generally not at levels commensurate with their numerical dominance on the spawning grounds. On average, hatchery adults contributed to the production of 65% of the fry, 50% of the smolts, and 40% of the returning adult offspring from the four study brood years (1979-1982), with a considerable (about 2-fold) range among years. After taking parental spawner numbers into account, the relative reproductive success of the hatchery fish was determined to be (on average) 95% of that of wild spawners at the fry stage of their offspring, 30% at the smolt stage, and 15% of that of wild fish at the returning adult stage. Again, there was substantial variation among brood years, particularly at the juvenile stages.

The absolute value of these results differ somewhat from those previously published, due to methodological refinements. Qualitatively, however, the findings are the same: hatchery fish were generally less successful at natural reproduction that wild fish, and the relative production and survival of their offspring decreased at successive life stages. Most significantly, the hatchery spawners produced less than 1/5 as many returning adult offspring as did wild spawners, on a spawner-per-spawner basis.

Hatchery Winter-run Study

A slightly different genetic marking approach was used to compare the natural reproductive success of hatchery and wild winter-run steelhead in the Kalama River. In this case, the SOD-1 enzyme locus was chosen as the marker locus, again with a common allele (A) and a variant allele (B). At this locus the B allele was much less rare in both the hatchery and wild stocks than was the case for the summer-run marker. Figure 4 depicts the genotype composition in the hatchery population before and after selective breeding in which only males and females having two copies of the B allele were used for spawning (except that 9 AB x BB crosses were used one year in addition to 20 BB x BB crosses). The resultant progeny were almost exclusively type BB and formed 100% of the hatchery winter-run smolts stocked in the Kalama for three consecutive years. The frequency of the genetic marker allele averaged nearly 0.8 in returning adult hatchery winter-run vs. about 0.35 in wild winter-run sampled in the 1989-1991 spawning seasons (Figure 5).

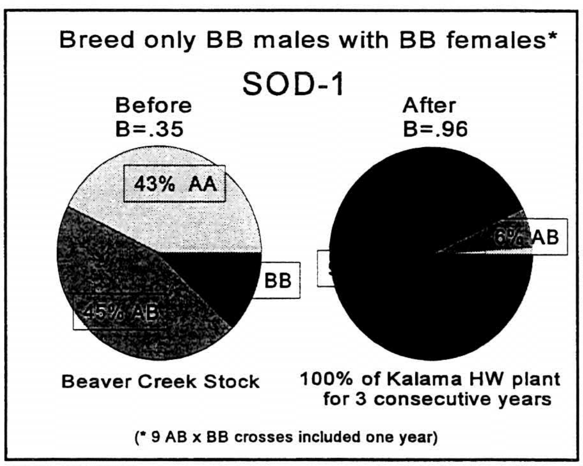

Figure 4. Genetic marking approach for hatchery winter-run.

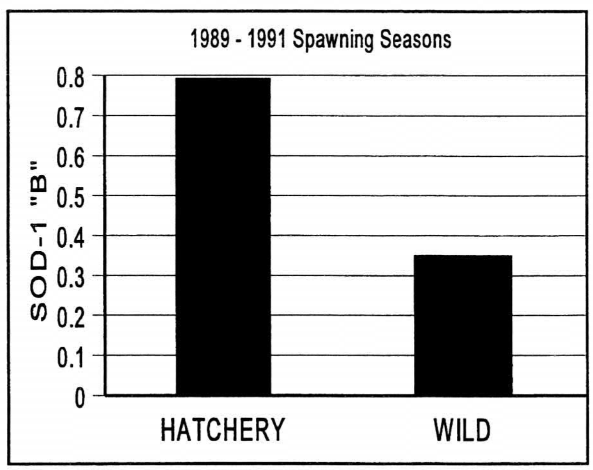

Figure 5. Genetic marker frequency in winter-run spawners.

In sharp contrast to what was observed for summer-run, hatchery winter-run spawners were generally less abundant than their wild counterparts. The number of hatchery fish ranged from equal to one-half that of the wild fish. Hatchery winter-run did contribute to natural production, but generally not at levels commensurate with their relative spawner abundance (as was seen for summer-run). Hatchery winter-run produced on average

25% of the fry, 35% of the smolts, and 5% of the adult offspring (again, with considerable variation among years). For two of the three brood years natural production by hatchery winter-run was effectively zero (0 and 1% point estimates), though it should be noted that estimates between 0 and 5% are not statistically different. On average, the reproductive success of the hatchery winter-run was estimated to be 60% of that of wild fish at the fry stage, 125% at the smolt stage (owing to a substantially higher estimate (280%) for the first brood year than for the other two years (33-62%)), and 8% at the returning adult stage. So, as was seen for the summer-run, the relative reproductive success of hatchery winter-run was generally (though not always) lower than that of wild winter-run, and was decidedly lower at the adult stage than at the juvenile stages.

Summary and Implications

Natural production by the non-local hatchery summer and winter steelhead was found to be substantially lower than that of the wild Kalama stocks. The survival differential was increasingly pronounced at successive (subyearling, smolt, and adult) life history stages of the offspring. These differences are believed to reflect (in part) genetic differences between the wild stocks and the transplanted hatchery stocks. Both non-local stock source and domestication selection likely play a role in the poor performance of these stocks in the wild.

However, both summer and winter-run hatchery spawners contributed biologically significant levels of production to the juvenile offspring stages. It seems likely that some of the production of juveniles (especially smolts) by hatchery spawners could displace production by wild spawners to the extent that density dependent factors limit total production.

Perhaps most importantly, continued natural spawning by the non-local hatchery stocks poses a genetic risks to wild steelhead in the Kalama (and elsewhere in southwest Washington), through their potential to interbreed with wild fish. Studies on the spawn timing of steelhead in the Kalama (Leider et al. 1984) suggest that the potential for interbreeding is highest for the summer-run, due to the large number of hatchery spawners and a moderate degree of overlap of their spawn timing with that of wild summer-run. Though there is less potential for interbreeding between hatchery and wild winter-run (lower numbers of hatchery spawners and less temporal overlap), a given increment of interbreeding could have greater impact due to the lower reproductive success of the hatchery winter-run spawning in the wild.

In response to these risks, adults from the genetically dissimilar hatchery stocks are no longer permitted access to the principal spawning and rearing areas in the Kalama, upstream of the barrier falls and fishway trap at the Kalama Falls Hatchery. Unfortunately, the option to block upstream passage of returning hatchery adults is not available in most streams. Yet Washington's Wild Salmonid Policy, issues surrounding ESA listings, and just plain prudent wild stock management all demand that reductions in the degree of natural spawning of the non-local hatchery stocks must occur throughout SW Washington (and elsewhere in the state). A solution that has been increasingly offered in recent years is to switch to the use of local wild broodstock sources for production of hatchery fish, both for harvest augmentation and for supplementation of natural production to rebuild wild populations. However, the jury is still out on just how successful that option may be and what risks it may hold. The need to understand those risks has prompted the Kalama Research Team to engage in a new phase of research to assess the performance of wild broodstock hatchery steelhead on the Kalama River.

Future Research: Wild Broodstock Assessment

Two studies were initiated this year to evaluate the performance and wild stock conservation merits of hatchery-reared steelhead spawned from wild Kalama broodstock. In-hatchery performance and adult return rates of fish spawned from wild winter-run will be compared to that of the non-local hatchery stock reared at the same facility for the 1998-2000 hatchery brood years. A more intensive and long-term study of summer-run wild broodstock performance will evaluate in-hatchery performance and adult returns rates of the 1999-2001 broods, as well as the natural reproductive success of returning hatchery-reared adults compared to their naturally spawned and reared counterparts. Wild Kalama summer-run are now being held for spawning this winter. Their offspring, the first of three experimental broods, will be released as one-year smolts in 2000. Returning adults will be tissue sampled for determination of DNA profiles (along with returning wild adults) beginning in 2002. DNA tissue sample will then also be collected from their naturally produced offspring (smolts and adults), with the intent to classify their origins as either from HxH, HxW, or WxW spawner crosses. The genetic identification tool to be employed is pedigree analysis of genetic profiles at multiple, hypervariable microsatellite DNA loci. A pilot analysis is in the works to identify appropriate msDNA loci, and the degree of variation in those loci, in wild Kalama steelhead and resident rainbow trout.

While this new phase of research is ambitious and presents many logistical, technological, and financial challenges, it also has the potential to produce some very badly needed information about the performance and hatchery-wild interaction implications of the use of local wild broodstocks.

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MARINE SURVIVAL OF OPIA HATCHERY COHO SALMON RELATED TO MARINE TEMPERATURES

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Abstract

Observed year to year and decadal variability in coastal coho salmon adult returns cannot be explained by any land or water use changes over at the last 30 years. Documented changes in climate and especially ocean conditions can explain observed variability in coastal coho salmon return rates. Estimates of Oregon Production Index Area (OPIA) coho hatchery smolt survival rates show decade-scale trends that correspond to decade-scale trends in sea surface temperatures and biological productivity in the California Current. These hatchery smolt survival rates are the best available indicator of natural marine survival rates for coastal coho salmon. Declines in biological productivity in the California Current since 1976 can explain most of the declines observed in OPIA coho hatchery marine survival rates. Recent advances in large data set management have allowed the condensation of sea surface temperatures for the northeast Pacific Ocean. These results show the same decade-scale temperature trends from California to Alaska (with latitude differences) since at least 1945. These results help explain many Pacific Northwest salmon productivity trends.

Introduction

The importance of inland climate and ocean conditions on salmon survival and run cycles has been poorly understood but a growing awareness of ocean and climate cycles helps shed light on our local coho, chinook, steelhead and searun cutthroat problems of late. This is most clear in coastal coho salmon. Coho salmon catch from California to southern Washington (the Oregon Production Index Area, OPIA) increased modestly with the startup of the ocean troll fleet in the early 1920-era and then gradually declined to low levels in the early 1940-era. Coho catch was low but stable from then to 1960 when the catch dramatically climbed to a new record high by the mid 1970s. Coho catch has declined since then, very dramatically in the early 1990s. See Figure 1. The decline in coho catch is what most people understand as the salmon crisis in the Pacific Northwest. The catch decline and parallel spawner run declines is what prompted the National Marine Fisheries Service to list the California and Southern Oregon coho stocks under the Endangered Species Act. There was no salmon crisis during the 1940 to 1960 low catch period. The high abundance of coho salmon in the late 1960s and early 1970s created economic expectations that were part of the coho salmon problem that subsequently developed.

The increase in coastal coho catch from 1960 through 1975 can be explained by the development of good hatchery practices, expanded hatchery production, and perhaps most important very favorable ocean conditions. Hatcheries supplied up to 80 percent of the coho catch during this period. What caused the dramatic coho catch decline since then and the declines in spawner runs? Hatchery production actually increased slightly in the late 1970s and then remained fairly constant. Hatchery practices generally steadily improved. Forestry and agriculture land use practices and wastewater treatment steadily improved in the region. Catch should have increased or at least continued at the high mid 1970s level but instead it progressively declined. Spawner runs were a virtual disaster in the early 1990s. Why? The answer can only be a combination of inland climate and related ocean conditions.

Climate

People from the Pacific Northwest are very aware that they were in an almost continuous drought, a warm and dry cycle, from the mid 1970s through 1992. The years 1977, 1978, 1981 were notable drought years and from 1987 to 1992 were the second driest in recorded California history (Nash 1993). Warm and dry inland climate adversely affects salmon stream habitat. Stream elevations are lower, pools are shallower, side channels are often dry, transported sediment tends to be deposited, salmon habitat on aerial and volume bases are significantly lower, and stream temperatures are significantly warmer. The warmer stream conditions generally favor freshwater predators of juvenile salmon and they must eat more when the waters are warmer. Warm and dry inland climate results in significantly lower freshwater survival for juvenile salmon (all species) and for adult spring chinook salmon. And similar adverse low flow and temperature effects adversely affect the estuary survival of outmigrating salmon smolts. The adverse temperature effect is clearly evident in Klamath River records (Richert and Olson 1993), as is the lowered flow/reduced available habitat effect (Bureau of Reclamation records). In combination the warmer temperature and lowered hydraulic flows must have adversely affected the relatively small Klamath River estuary as well. Similar low flow and elevated temperature impacts occurred in the Sacramento River and in the Rogue River in Oregon (USGS Internet records) and the combined warmer temperatures and lowered flows must have adversely affected estuary conditions in those two systems as in the Klamath River. All coastal California and Oregon streams and estuaries must have been adversely affected by these warm and dry conditions extant from 1976 to 1993.

Beginning in 1993, the drought period appeared to be ending and remarkable chinook salmon rebounds were seen in the Sacramento, Klamath and Rogue Rivers in 1995 and 1996. The 1995 Klamath River fall chinook run was 200,000 adults with 150,000 natural spawners. The natural spawner goal is 97,000 adults, a level not seen since the 1960s. So the 1995 Klamath run was phenomenal. And the 1995 Rogue River runs reached levels not seen since the mid 1980s. The southern chinook rebound cannot be answered by improved freshwater conditions related to inland climate alone. And they cannot be linked to any significant land or water use changes because there weren't any in California or Oregon. And finally the majority of these southern chinook salmon were hatchery fish which were sheltered from the potential effects of land and water uses

Ocean Effects

Inland climate effects are not separated from ocean effects as the atmosphere and the ocean are very interconnected; one cannot separate them for many physical observations. The surface temperature of the northeast Pacific Ocean gradually began to increase in 1970 and there was a major change in the northeast Pacific Ocean current patterns in 1976 (Bernal and McGowan 1981; Chelton, Bernal and McGowan 1982; McLain 1984; Pearcy 1992; Graham 1995; Barry et al. 1995; and Roemmich and McGowan 1995).

California Current Productivity Declines

As the northeast Pacific Ocean has warmed in the last two decades, there have been invertebrate species shifts (for example southern species are moving northward in the intertidal zone, Barry et al. 1995). Phytoplankton and zooplankton production in the California Current (the marine home of our coastal coho and southern chinook salmon) have been decreasing as waters have warmed, the California Current has slowed and weakened, stratification has increased, upwelling has decreased, and nutrients have been more and more limited. The nutrient limitation has resulted in significantly lowered primary and secondary productivity in the California Current critical for plan area coho salmon. See the above citations in this paragraph plus the excellent recent article by McGowan et al. (1998). Marine birds and mammals have been seriously impacted as well and many marine fish and invertebrate species have shifted their distribution northward (ibid). Murre seabirds have been adversely affected. They have declined drastically since the late 1970s (Takekawa et al. 1990, Pryne 1994). And macrozooplankton, Murres, baitfish, and oysters are not the only marine species to have been adversely affected in our ocean waters. Oregon pink shrimp, English sole, petrale sole and other fish catches have been similarly adversely affected.

Zooplankton Food Base Decline

Zooplankton production has declined over 70% in the past two decades in the California Current, with similar declines in larval fish biomass (McGowan et al. 1998). Roemmich and McGowan (1995) calculated up to an 80% reduction in zooplankton biomass since the mid 1970-era. Per classical ecological theory (Odum 1959), a 70% decline in zooplankton production results in a 70% reduction in predators dependent on zooplankton directly and in their food chain (such as coho salmon) while an 80% reduction would result in a food supply that could only support 20% of the prior predator biomass (such as coho salmon). These ocean changes (and others discussed below) have measurably impacted the marine survival and growth of both coastal coho and southern chinook salmon. Preferred prey for juvenile coho salmon in the California Current have declined in abundance and in their diet over the last 20 years (McGowan et al. 1998).

Marine Survival Estimates

The adverse marine conditions are most notable in coastal coho salmon. We do not have direct measurements or estimates of marine survival for wild salmon populations at this time. The best indicator of marine survival is derived from hatchery coho return and catch data (available from mini-OPI packet data from LeFleur, WDFW, 1998). For the period from 1965 to 1975, the average coho marine survival was 6.7%; from 1976 to 1990, the average coho marine survival was 3.2%; from 1991 to 1997 the average marine survival was only 1.2% (Figure 2). Applying classic food chain dynamics theory, a 70% reduction in the coho salmon food base, should result in a predicted coho salmon marine survival rate of 2%. An 80% food base reduction results in a predicted coho salmon marine survival rate of 1.7%. The observed empirical average marine survival rate from 1991 to 1997 was 1.2% (compared to the 6.7% average from 1965 - 1975). The observed survival rate (1.2%) was less than predicted (1.7 to 2%) but very close based on a reduced food supply alone. A change in the predator population, such as a shift northward in the distribution of Pacific mackerel which was also observed, could easily account for the additional coho salmon survival decline.

Kaczynski (1994) derived the minimum marine survival for coastal coho salmon needed to at least maintain their population level (no increase or decrease). This was done by an application of the net replacement rate (Birch 1948, Caughley 1967). At equilibrium when the net replacement rate is one, one adult female is replaced by an adult daughter in the course of one generation. In salmon population dynamics, adult returns are the best index of productivity. The minimum marine survival for coastal coho salmon is 2.7%. Coho marine survival was so poor in 1976, 1983, 1984, 1986, 1989, 1991, 1992, 1993, 1994, 1995, 1996, and 1997 (smolt entry years) that coastal coho salmon populations probably would have declined naturally even if there were no salmon fishing seasons based on hatchery survival estimates as indicators of wild coho marine survival (all under 2.7% in those years). The net replacement rates in these years was less than one. The marine survival estimates are reasonable and they have a high correlation with the jack salmon index used to set salmon fishing seasons (86% of the variation is explained, Figure 3).

The marine survival estimates also have a high correlation to the Willapa Bay oyster condition index (degree of oyster meat inside an oyster shell). See Figure 4. California and Oregon coho salmon do not eat Willapa Bay oysters. Common adverse marine factors are affecting both Willapa Bay oyster plumpness and coastal coho salmon marine survival: namely warmer marine temperatures, stronger stratification, reduced nutrient availability, and consequently lowered primary productivity (and then lowered secondary productivity for the coho salmon). And the body size of coastal coho salmon has been adversely affected as well. From 1970 to 1975, the average weight of troll-caught coho salmon was 8.2 pounds, while from 1976 to 1991, the average weight was only 6.2 pounds (dressed weight corrected to whole weight in September from PFMC annual catch data records). Reduced body size in salmon means less eggs per female. So the net replacement rates of coastal coho salmon have been further adversely affected beyond just the reduced marine survival.

Climate/Ocean Cycles

So we have had a triple negative effect: adverse inland freshwater survival, estuary survival, and ocean survival all related to natural environmental variability since 1976. Two alternate hypotheses can explain these inland climate and ocean effects. The first hypothesis is "simple" 20 to 40 year linked ocean and climate cycles. Fisheries scientists have discovered similar cycles going back over 200 years in California Current bottom sediment core samples. The cycles are reflected in changes in abundance in the scales of Pacific herring, saury, hake, sardine and northern anchovy in distinct sediment layers (Smith 1978). All five species fluctuated in unison in these cycles. Nickelson (1986) continued the observation on the abundance changes in northern anchovy and showed that its trend corresponded with coho salmon abundance. Nickelson showed that coho had their highest marine survival in years that had the coolest ocean waters and the highest upwelling. Figure 5 shows the decade-scale sea surface temperatures in the near-shore ocean off Coos Bay, Oregon and the very significant warming trend apparent there since 1976. Figure 6 shows the upwelling cycle and the significant downward trend in upwelling since the mid 1970s.

El Nino events compound the adverse decadal increasing warm water effect (Jacobs et al. 1994, McGowan et al. 1998) and during El Nino events we see a significant increase in warm water predators such as Pacific mackerel. Figure 7 shows decadescale patterns in the Southern Oscillation Index, an index of El Nino events in the northeast Pacific Ocean. El Nino events occur when the oscillation index is negative and the strength of the EL Nino increases as the index gets more negative. In a sense, we were in an almost constant El Nino from 1976 to present. Macrozooplankton production has decreased some 70 to 80% in the California Current (80 % in Roemmich and McGowan 1995, 70% in McGowan et al. 1998) in the period from 1976, baitfish are significantly lowered in abundance (Nickelson 1986), and seabirds have been adversely affected as well. The California Murre (Auk seabird) has declined over 50% in abundance and the Washington Murre population has declined over 80% because of adverse marine conditions (Takekawa et al. 1990, Pryne 1994). The seabirds in the Southern California Bight declined 90% in this 20-year period (McGowan et al. 1998). These adverse impacts have resulted because of the decade -scale changes in the California Current exacerbated by El Nino events. Interestingly when we have warm - dry inland climate and warm - poor ocean conditions in California, Alaska has a warmer more productive ocean effect. The Alaska Current became stronger in 1976 and more stratified since then. Alaskan waters are more light limited for primary production (compared to more nutrient limited for the California Current). The increased stratification in the Alaskan Current has resulted in increased primary and secondary production (McGowan et al. 1998). And Alaska has had increasing salmon survival since 1976 and record salmon catches in the last several years. They had poor salmon survival and poor catches from the 1950s to mid 1970s when we had better ocean conditions, a stronger California Current with less stratification and more available nutrients for primary production, higher zooplankton production, and better marine growth and survival for coho salmon.

There is some evidence that changes in the southern portion of the California Current began in 1994. Upwelling markedly improved and ocean waters were cool all the way to Mexico. Southern chinook salmon were caught off Mexico in 1995 and 1996, both good ocean years for southern chinook stocks with a greatly increased ocean pasture area. This shift in the southern portion of the California Current helps explain the southern chinook stock rebound. Inland climate and ocean conditions were both advantageous for these southern chinook year classes. There is some evidence that Southern Oregon and Northern California coho salmon also began to exhibit increased survival relative to Northern Oregon coho salmon. And we appeared to be moving into a cool wet inland climate cycle beginning in 1995.

What Is Primarily Limiting Coastal Coho Salmon Populations?

Many northwest fish biologists assume that freshwater stream conditions are limiting coho salmon production. This assumption was also implicit in the listing of this ESU by the National Marine Fisheries Service (NMFS) and in the designation of critical habitat by NMFS. More recently NMFS (1998) now acknowledges that adverse inland climate and ocean conditions are at least partly responsible for observed population declines of salmon. And the above discussion demonstrates this for coastal coho salmon. When one examines observed year to year differences in adult returns (the most traditional population parameter used to evaluate population responses in salmon and the population parameter that integrates the often more highly variable lifestage survivals) over the last few decades, one cannot account for observed adult return variability year to year by any significant changes in freshwater habitats.

The most constant lifestage habitat for salmonids in the Pacific Northwest (except urban and suburban watersheds especially in Puget Sound) over the past thirty years has been the freshwater spawning and rearing areas. And if anything these freshwater salmon habitats have been gradually improving in quality over-the landscape over the last three decades. This has to be true with the advent and then continuous improvements of state and federal forest management practices, agricultural conservation practices, wastewater treatment advances, etc. Freshwater habitat variability cannot explain the high variability observed in returning adult salmon counts over at least the last three decades. And the limited historical records indicate great year to year variability in adult returns before extensive forest utilization began. Further, one observes the same general year to year variability patterns in undeveloped as well as managed watersheds. And, especially, freshwater habitat variability cannot explain the recent two-decade coastal coho salmon run declines that precipitated the NMFS concern and ESA action. In contrast, adverse inland climate and ocean variability can explain much of the observed variability in adult returns over the last thirty years and the recent productivity declines.

Broad Northeast Pacific Ocean Decadal Trends

Recent advances in computer data base management (EarthInfo Comprehensive Ocean - Atmosphere Data Set - COADS Global Marine Database Version 1998) have made sea surface temperature (SST) information for the northeast Pacific Ocean more readily available for analysis. Summaries of annual SST data (weighted average values) are presented here for five selected locations: off mid to northern California, Oregon/Washington coasts, Vancouver Island, southeast Alaska, and the Gulf of Alaska. These locations were selected as representing portions of the northeast Pacific Ocean available for portions of the marine residence of various Pacific salmon populations. Figure 8 presents annual SST trends at these nearshore and Gulf of Alaska locations for the period of record 1950 through 1995. These data include all available empirical SST records (49,029 monthly summarized records for these selected locations). Weighted average values were derived for months and then years for these locations. Available records were irregular in occurrence and simple averages could have distorted annual average values toward more heavily sampled seasons. Irregularities in the frequencies of sampling locations (not random or stratified) could still bias annual trend results somewhat.

The SST trends are revealing and do help us in understanding salmon adult return trends. First, distinct temperature latitude differences are apparent for the selected locations (Figure 8). Latitude differences were anticipated and the distinction in the derived data sets was reassuring. Second, two distinct decade - scale temperature trends are evident for all five selected locations. Third, the decade - scale temperature trends are the same (are highly correlated) for all five locations, California to Alaska. There was a warming and then cooling trend from 1950 to about 1970 and then an almost constant warming trend to the present. There was a mid 1980-era cool node within the second warming trend. The magnitude of the two temperature trends varied somewhat from location to location. The two decade - scale trends for mid to northern California for example are less distinct than for the other locations and the trends off Vancouver Island are more pronounced.

The correlation of the decade - scale trends helps explain the synchrony of steelhead runs over vast geographic areas reported by Cooper and Johnson (WDW 1992) and chinook runs reported by several authors. The California results clearly show marine temperature constraints for the southern edge of salmon ranges and why upwelling is so critical for southern salmon stocks. And these temperature trend data show how the warm ocean problem has progressively marched northward over the years first affecting California, then Oregon and Washington, and then British Columbia.

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Figure 1

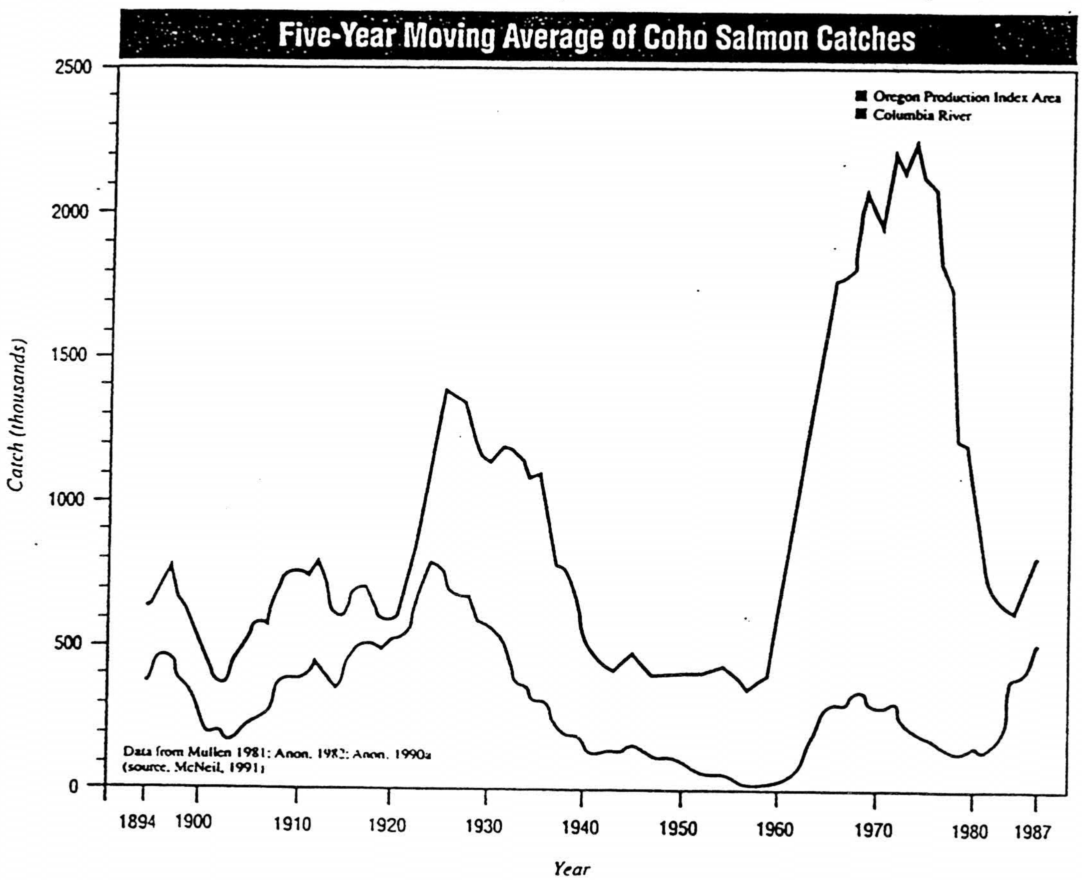
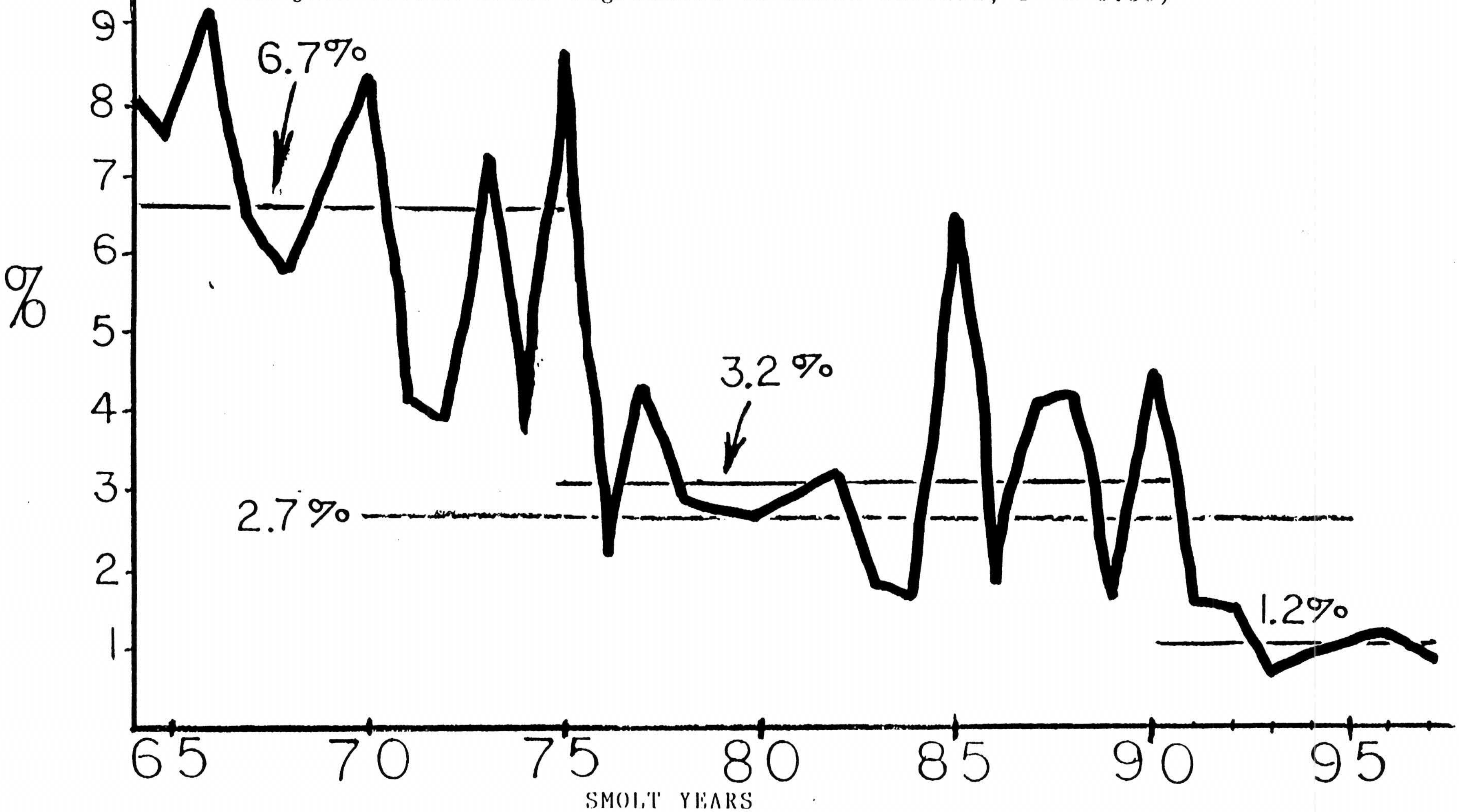

Five-Year Moving Average of Coho Salmon Catches
Oregon Production Index Area
Columbia River
Catch (thousands)
2500
2000
1500
1000
500
0
Data from Mullen 1981; Anon. 1982; Anon. 1990a
(source, McNeil, 1991)
1894
1900
1910
1920
1930
1940
1950
1960
1970
1980
1987
Year

FIGURE 2.

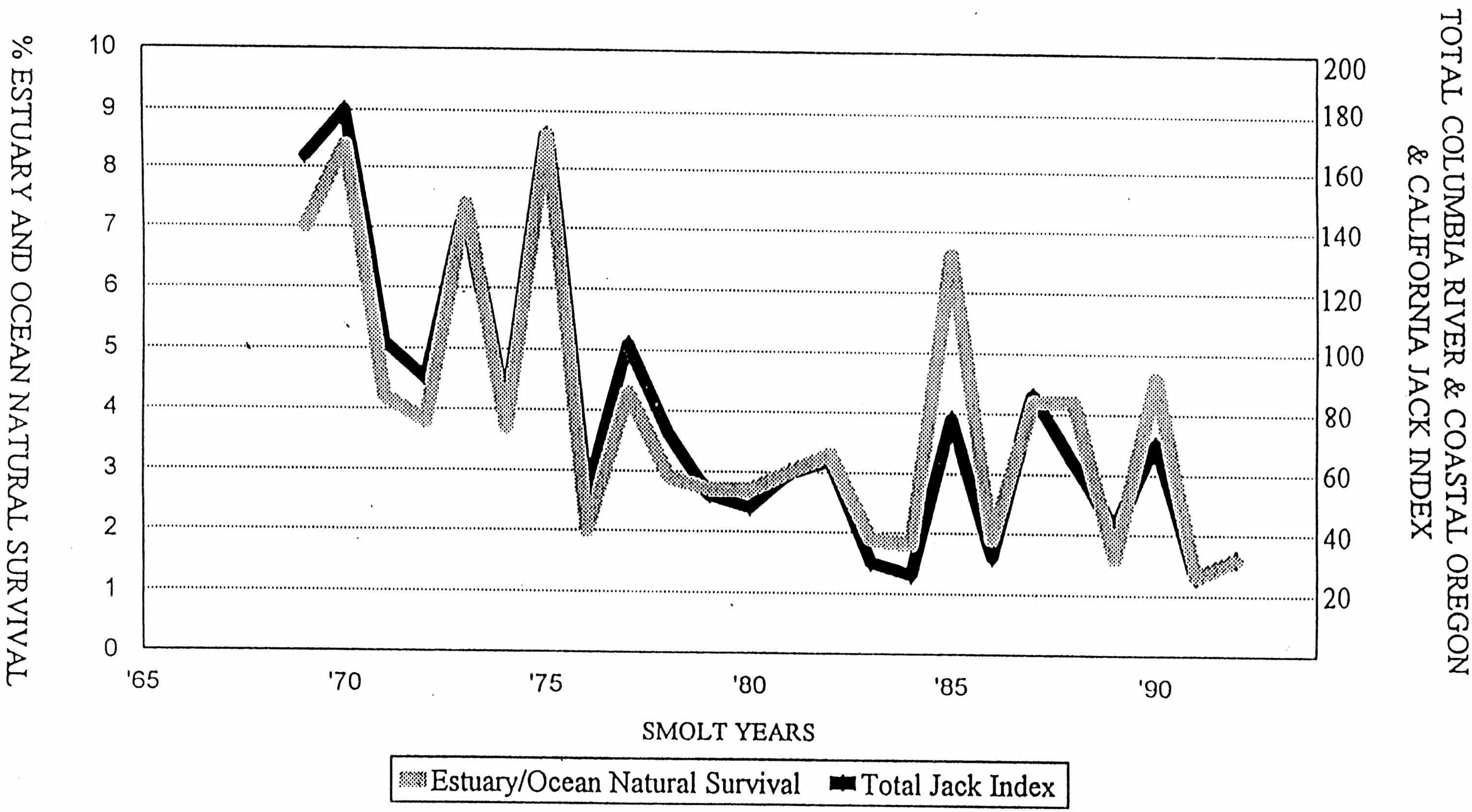
COHO SALMON MARINE SURVIVAL FOR THE OREGON PRODUCTION INDEX AREA
___ BASED ON HATCHERY ESTIMATES FOR THE STATED SMOLT YEARS ___

(Sources: Nickelson 1994, WDFW 1998; estimates for 1991—1997 via jack return index regression to smolt survial, $r^2 = 0.86$)



Notes: horizontal lines are averages for those years. 2.7% is estimated minimum survival needed to maintain population.

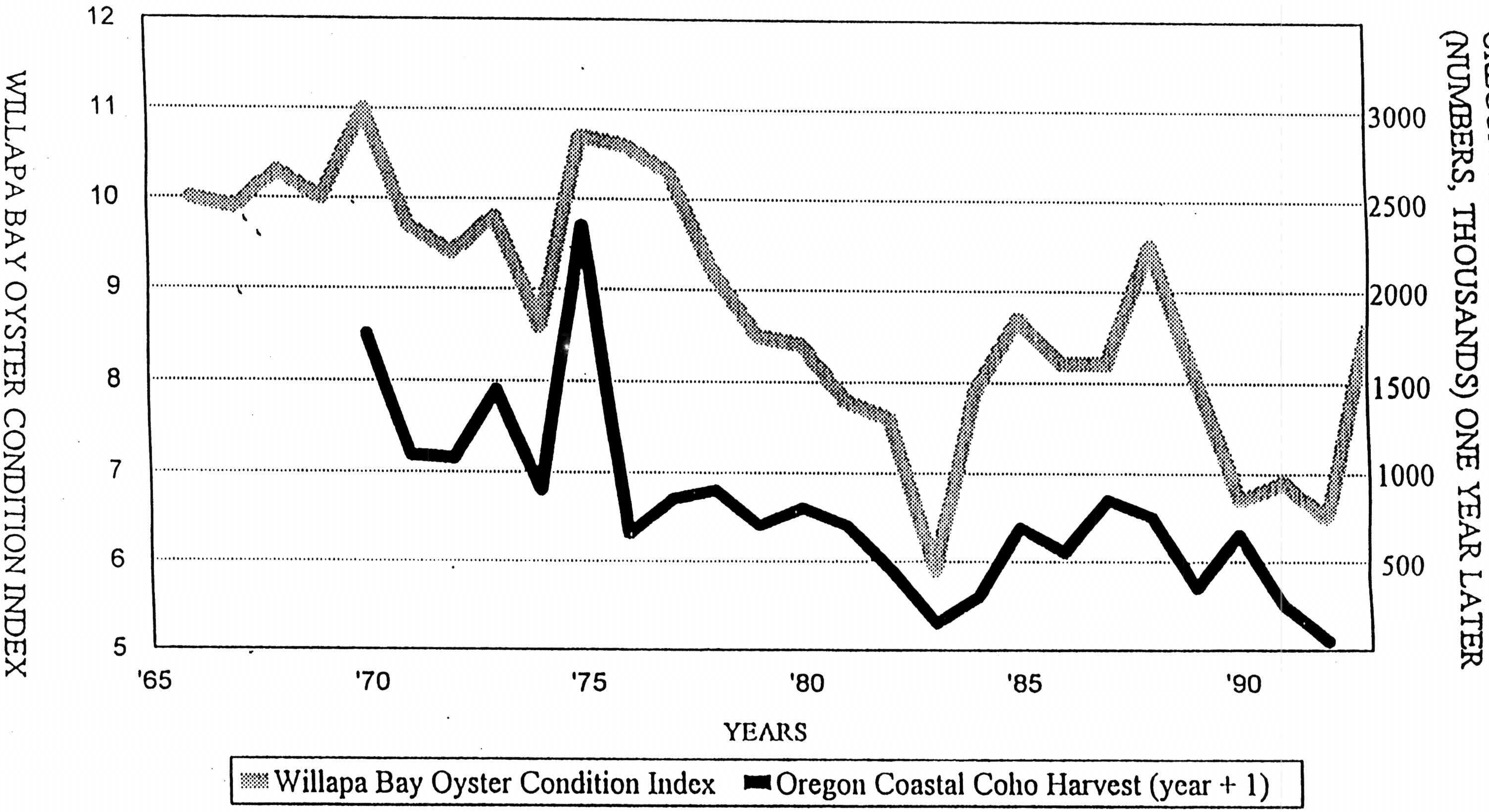
Figure 3 . ESTUARY/OCEAN NATURAL SURVIVAL ESTIMATES (FROM HATCHERY FISH) AND TOTAL JACK INDEX VALUES FOR THE SAME SMOLT YEARS (TWO INDEPENDENT ESTIMATES)



Correlation $r_2 = 0.856$

Sources: See Fig. 1 for marine survival estimates; LeFleur (WDFW) 1994 for jack index values (mini OPI packet).

Figure 4. WILLAPA BAY OYSTER CONDITION INDEX AND OREGON COAST HARVEST OF COHO SALMON CALIFORNIA CURRENT EFFECT



Sources - PFMC 1991, 1984; Bodenmiller 1994; WDFW 1994

FIGURE 5. NEARSHORE ANNUAL SEA SURFACE TEMPERATURES OFF CHARLESTON, OREGON (3 YEAR MOVING AVERAGE). HORIZONTAL LINES ARE AVERAGES FOR THOSE YEARS. SOURCES: ODFW 1995, NOAA 1998.

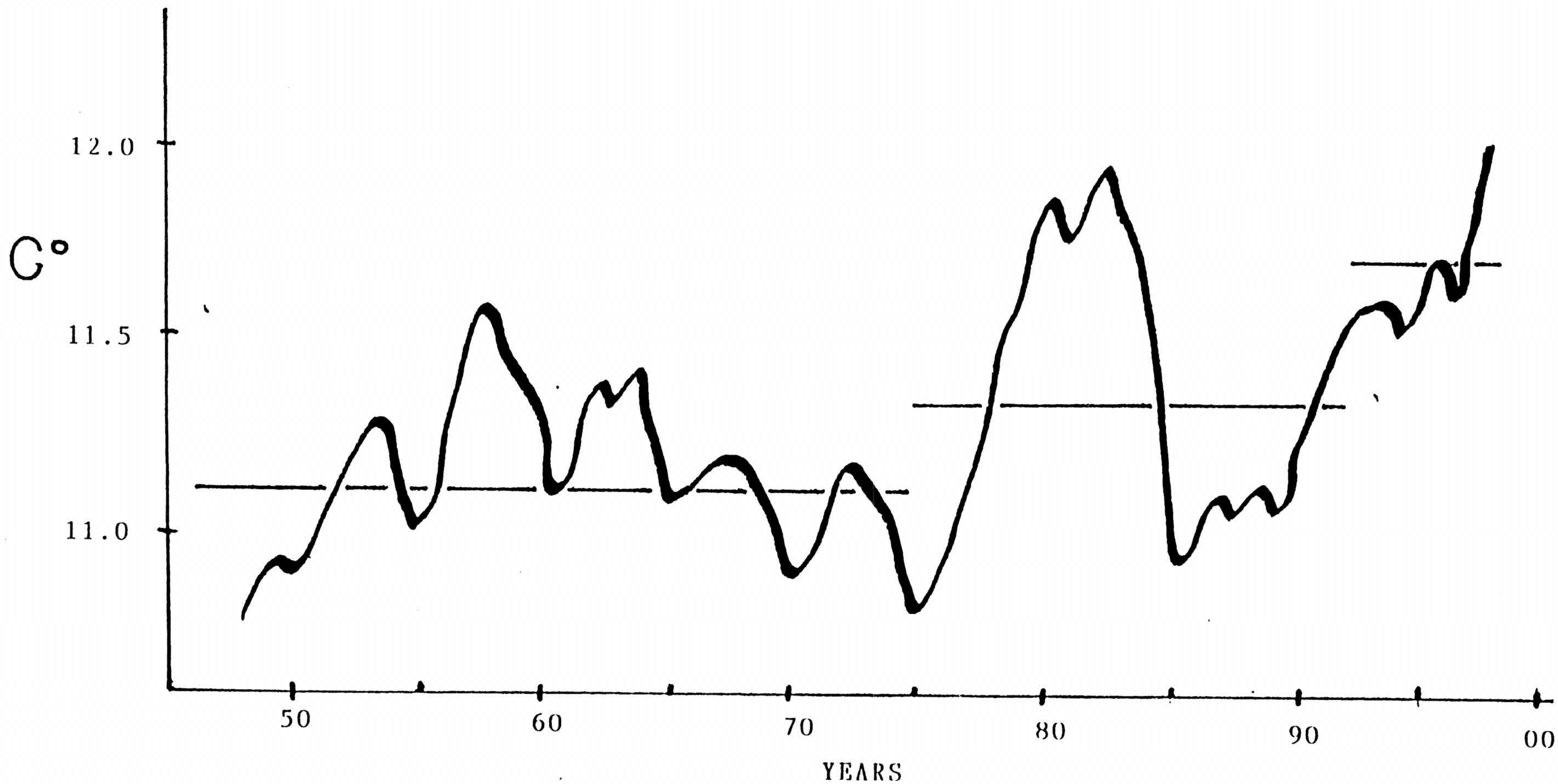
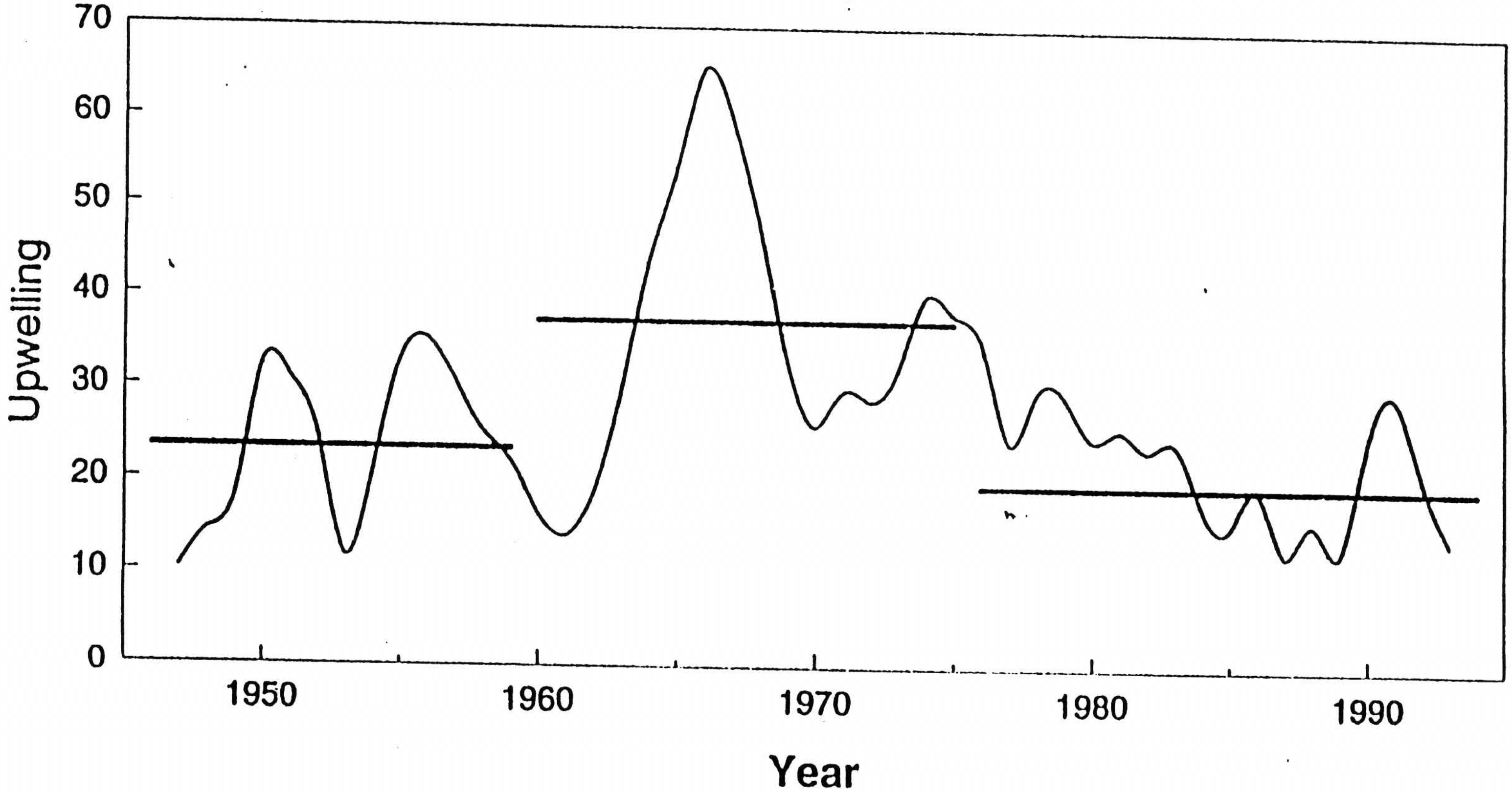


Figure 6.

Bakun Upwelling Index 45° N Latitude

April - June 1946-1994

3-year moving average with mean values for 1946-59, 1960-75, and 1976-94



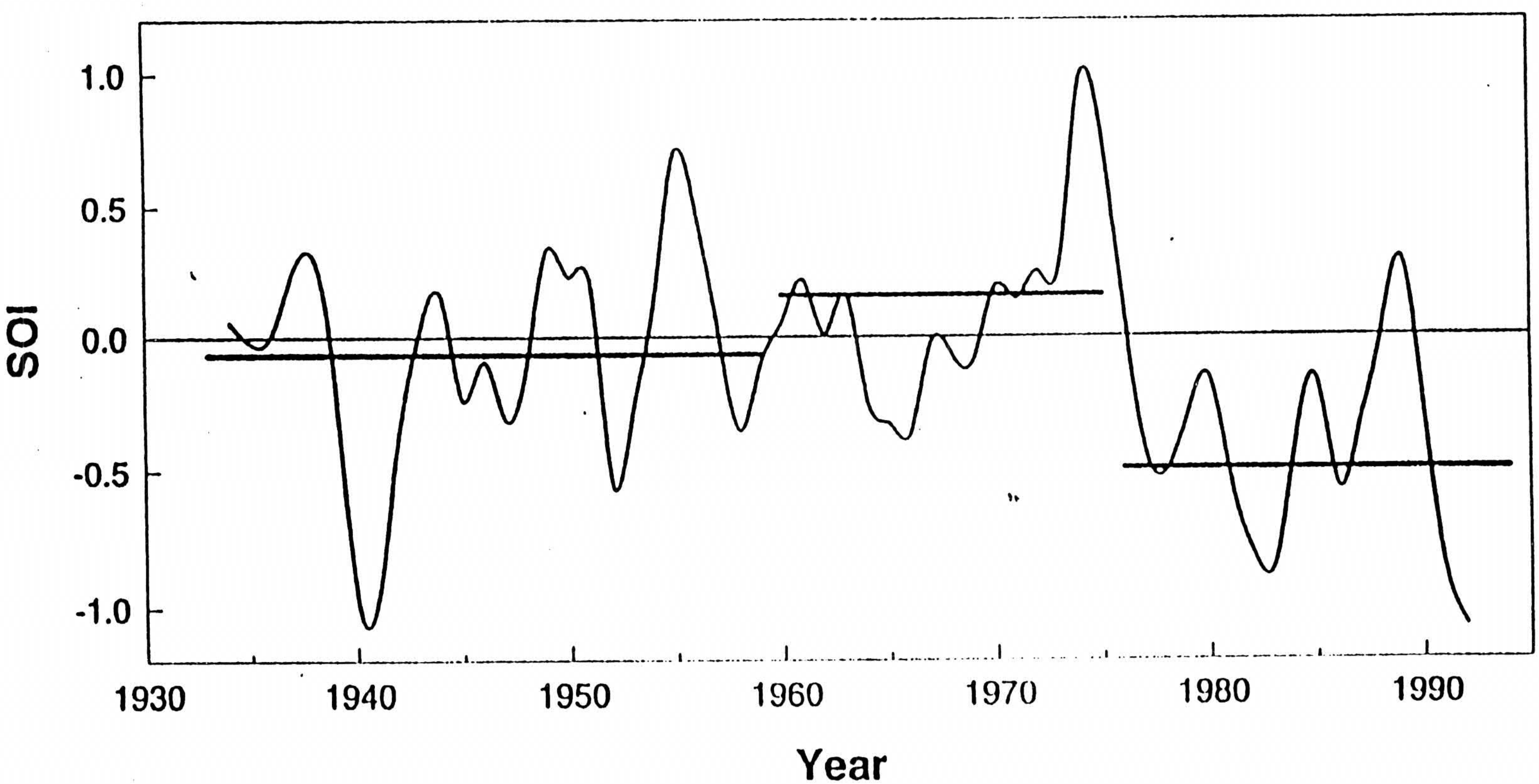
Source: ODFW 1995

Figure 7.

Southern Oscillation Index

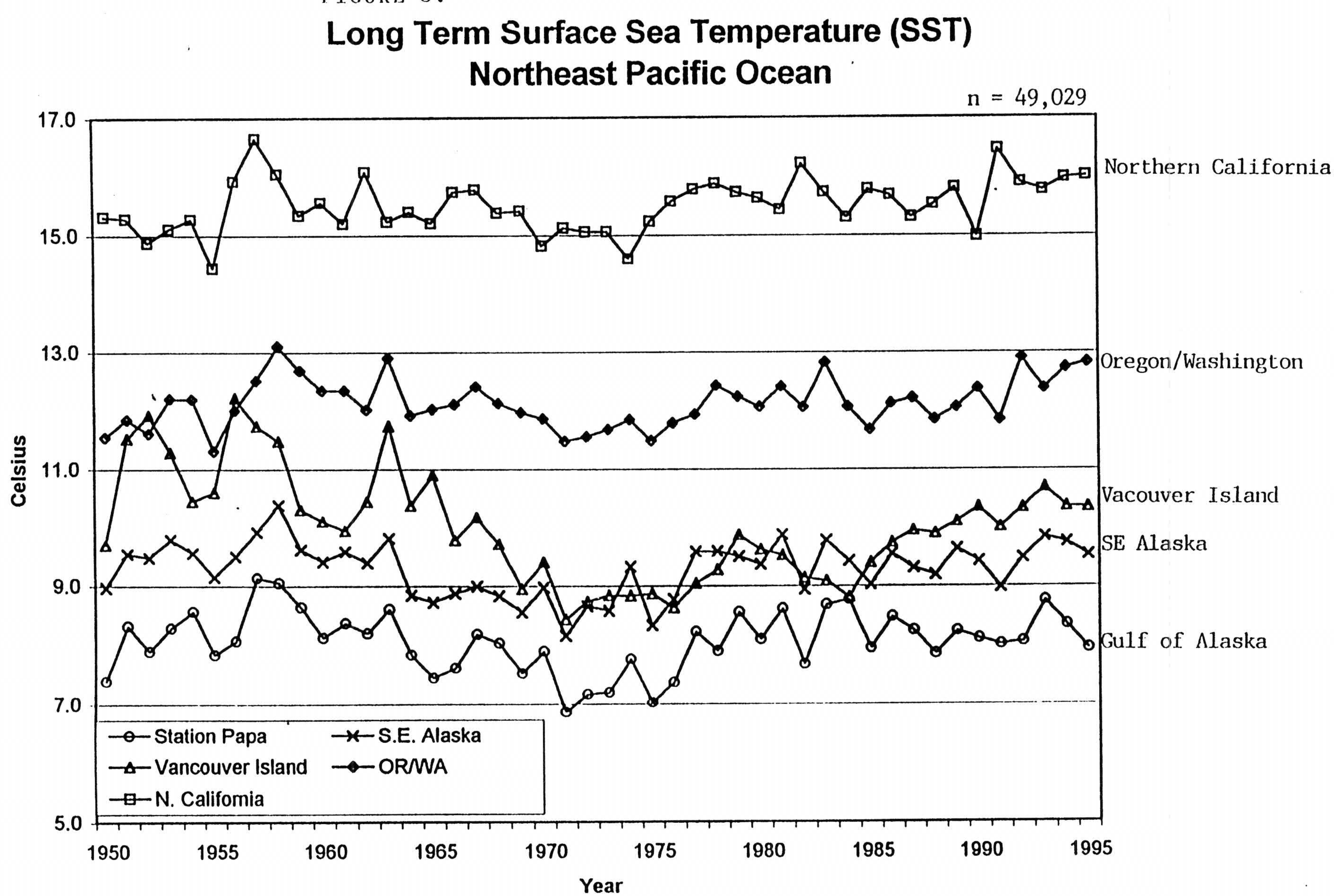
1930-1993

3-year moving average with mean values for 1933-59, 1960-75, and 1976-93



Source: ODFW 1995

FIGURE 8.



Long Term Surface Sea Temperature (SST)
Northeast Pacific Ocean
n = 49,029
Celsius
17.0
15.0
13.0
11.0
9.0
7.0
5.0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year
Northern California
Oregon/Washington
Vacouver Island
SE Alaska
Gulf of Alaska
Station Papa
S.E. Alaska
Vancouver Island
OR/WA
N. California

FIGURE 9.

Long Term Surface Sea Temperature (SST)
Northern California

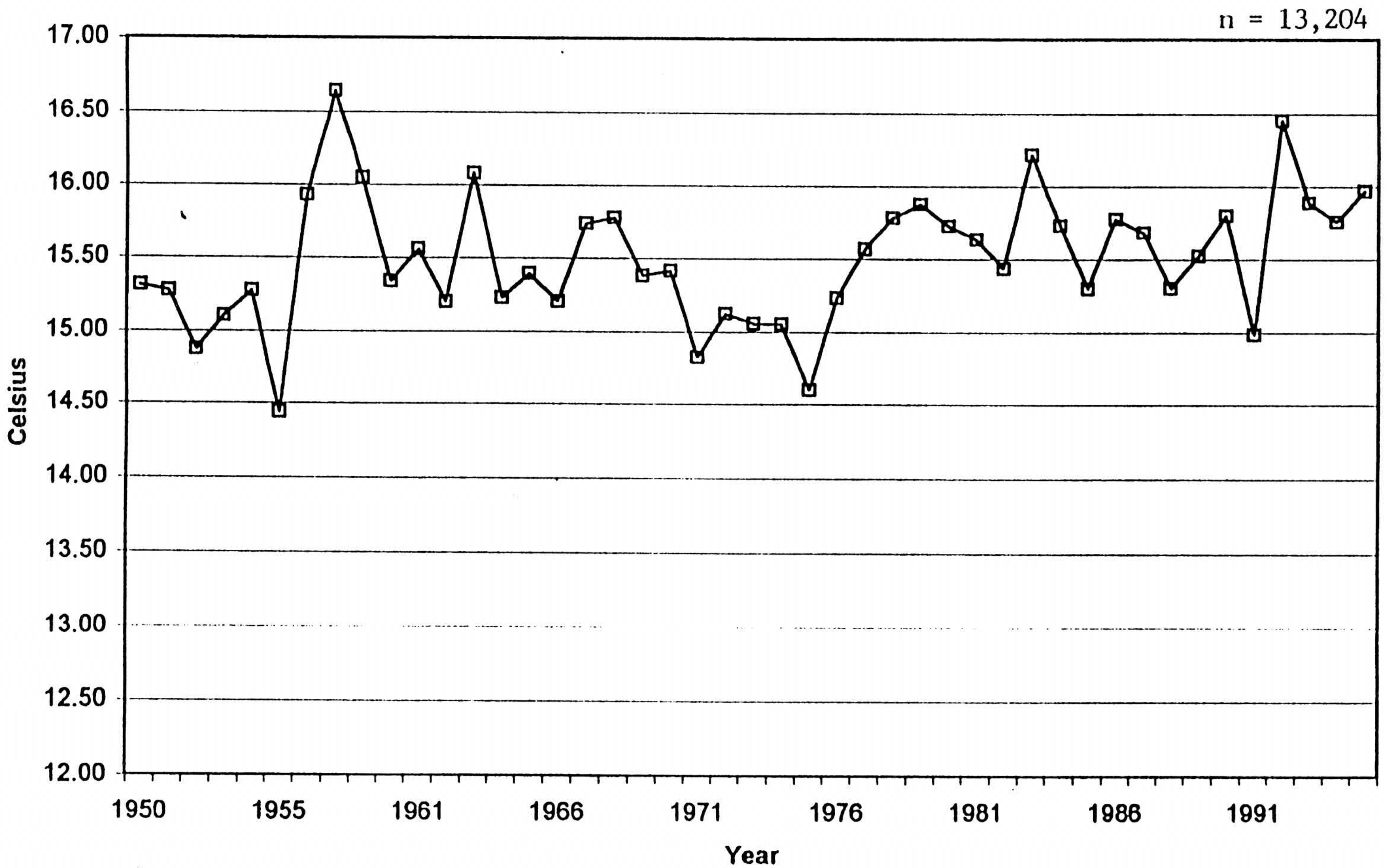
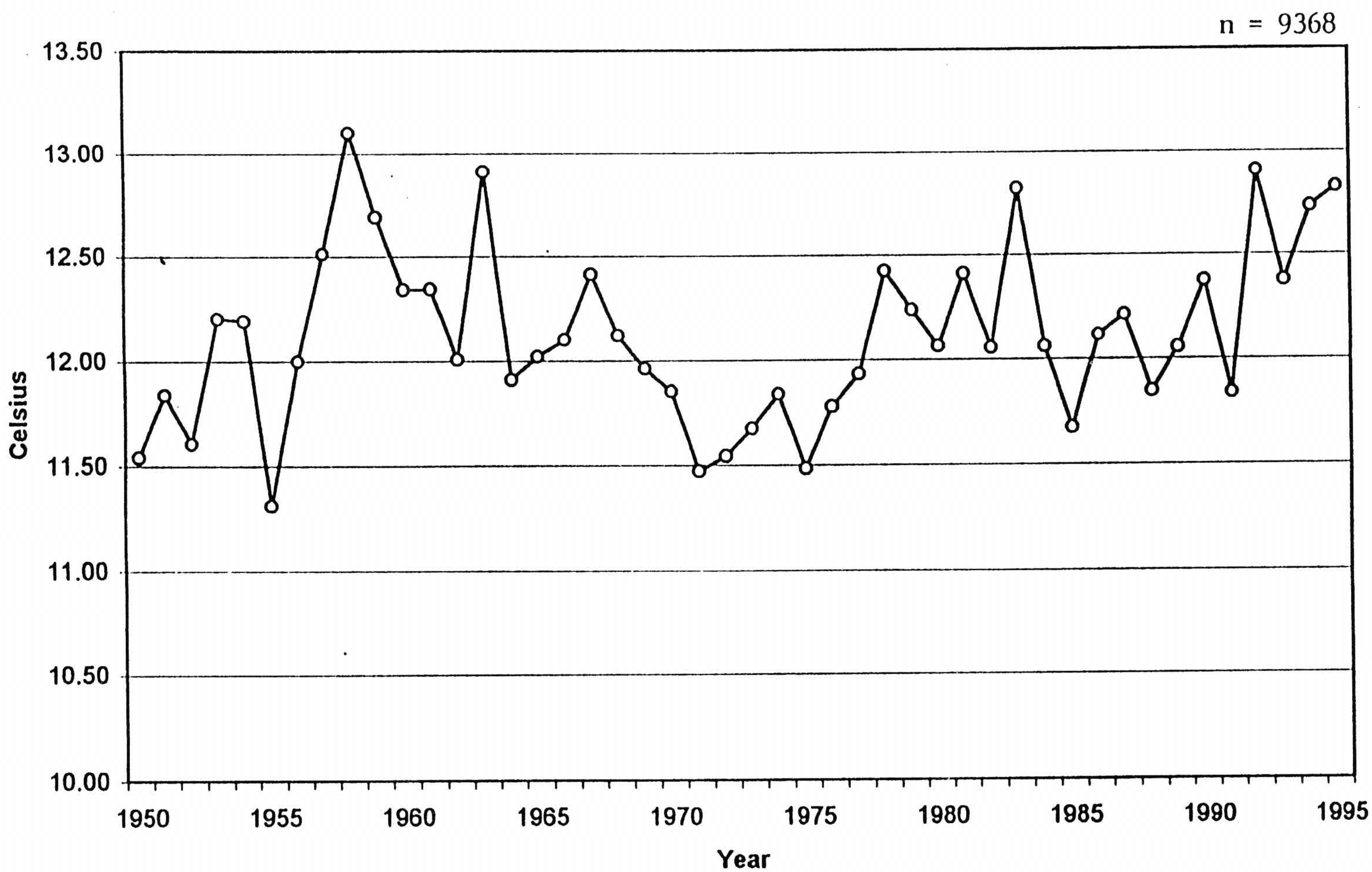


FIGURE 10.

Long Term Surface Sea Temperature (SST)
Coastal Oregon and Washington



DISTRIBUTION AND RECENT MANAGEMENT OF INTRODUCED FISHES IN IDAHO

Bill G. Hutchinson
State Fishery Manager
and
Sharon Clark
Technical Records Specialist
Idaho Department of Fish and Game

Abstract

Past introductions of exotic species, purposeful, and accidental have established successful fisheries in Idaho, sometimes at the expense of native stocks. The Idaho Department of Fish and Game (Department) records, since 1913, documents over 1.2 ***BILLION*** *non-native fish of 48 different species stocked in Idaho. Recently, the Department has protected native species through restrictive regulations, reduced stocking rates, use of sterile fish, extensive marking programs, and in some cases elimination of non-native fish releases. Conservation agencies are faced with a real dilemma in that they are to preserve and protect native species, yet must provide recreational fishing opportunities for their constituents, sometimes in conflict with those native species.*

Introduction

In the late 1800s, Idaho's pioneers from the east and midwest, longing for the kinds of fish they were used to catching, began shipping fish by railroad and stage lines for release into Idaho's lakes and rivers. Bass, crappie, perch, and brook trout were some of the first exotic game fish to arrive, with carp introduced as a potential food fish. Since that time, over 1.2 BILLION non-native fish of 48 different species have been stocked throughout all of Idaho's major drainage's to provide for recreational fisheries.

Introduced strains of rainbow trout were by far the most numerous and widely distributed fish released into Idaho waters. Nearly 585 million non-native rainbows (59%) have been released as documented by the Department records since 1913. In the past thirty years alone, over a half BILLION non-native fish have been stocked in Idaho's waters to provide recreational fishing. However, with increased emphasis for native species, degraded habitats, and increasing hatchery costs the numbers of stocked fish have been declining in Idaho since 1990 (Figure 1).

In 1975, the Department adopted in its 15-year policy plan, and again reiterated, in its 1996-2000 Fishery Management Plan, a policy that wild native salmonids would be given priority consideration in all management decisions.

As a result of that policy direction, the Department has been taking steps to protect its wild native fishes. Since 1970, the Department has protected native species through restrictive regulations and protective habitat requirements. Catch-and-release regulations have been effective in protecting native fish (westslope cutthroat) from overharvest in unproductive waters, restoring overharvested populations, providing quality and trophy fisheries, and redirecting consumptive angling efforts to other waters as well as providing "blue ribbon" fisheries for some introduced species. Where quality habitat has been maintained, restrictive regulations have been effective. The Department is also putting more emphasis on developing urban fishing ponds and concentrating non-native fish stocking in altered habitats (i.e., lakes and reservoirs) no longer capable of sustaining native fishes.

Idaho has 26,000 miles of fishable streams and over 3,500 lakes and reservoirs in which the Department manages fish and wildlife resources. There are 42 species of game fish now found in Idaho, of which, 13 are native species. The Department annually stocks approximately three million catchable size rainbow trout and over 14 million fingerlings. Hatchery programs are expensive and the majority of our releases are concentrated in waters with altered habitats (i.e., lakes, reservoirs, and ponds) and in areas with high concentrations of anglers (i.e., campgrounds and urban waters) thus maximizing the return-to-creel and the cost/benefit ratio. Except for some high mountain lakes, waters within designated wilderness areas are not stocked with exotic species and have been established as refugia for wild native populations.

Recent actions by the Department require any species introduction into a drainage that does not currently have that species must undergo the review process adopted by the American Fisheries Society for introductions of aquatic species. This process ensures that any species considered for introduction is prohibited until potential impacts on habitat alteration, trophic alteration, spatial alteration, gene pool deterioration, and disease introduction are assessed.

The Department has altered many fish stocking programs with introduced species in response to listing of native fish as threatened or endangered under the Endangered Species Act (ESA). For example, in some waters all stocked fish must be marked to distinguish them from wild native species. Size and or bag limit restrictions have also been lifted to favor listed species. Numbers of fish stocked have been reduced and release locations changed to minimize impacts on native fishes. Under our ESA permits, the Department is required to monitor impacts on listed fish from these releases and have found that our stocking program has negligible impacts of native stocks.

Idaho has implemented an extensive fish health-monitoring program to prevent the spread of diseases from hatchery fish to wild populations. Hatcheries are inspected regularly to assess the disease status of their fish prior to release, and diseased fish are not released while undergoing an epizootic. Of great concern is the impact pathogens released from wild fish residing in or above hatchery water supplies have on hatchery populations. It has been well documented that wild fish infect hatchery fish. Idaho is working hard to minimize impacts of diseases on both wild and hatchery fish.

Protecting genetic integrity of native fishes is critical in Idaho's fishery program. Of the 26,000 miles of fishable streams, the Department currently stocks less than 800 miles with hatchery fish. And in areas containing native populations, the Department has begun using sterile fish to provide supplemented recreational fisheries and minimize genetic impacts to wild stocks.

Hybridization has been identified as a real problem in certain waters. Introduced rainbow trout breeding with native cutthroat, and brook trout breeding with native bull trout, have been documented, but the long-term impacts are unknown at this time. The Department is currently taking steps to reduce or eliminate hybridization through physical removal programs (i.e., gillnetting, multipass-electrofishing) and also stocking sterile fish in areas that have native populations. Although sterile fish are more expensive to produce, we believe it is a small cost when managing fisheries with native fish populations. The introduced species, which has had the most widespread impact to Idaho's native fisheries, is the brook trout. They were widely distributed, are very prolific and adaptable to both lake and stream habitats.

Idaho's most notorious exotic species introduction was the introduction of mysis shrimp into large lakes in the northern part of the state. Mysis were introduced in Priest Lake to provide enhanced forage for an introduced species (kokanee), but resulted in the establishment of a classic predator trap through the increased survival of another introduced species, lake trout. This large lake trout population has adversely impacted the native cutthroat and bull trout stocks. In Upper Priest Lake, the Department has begun an experimental program to physically remove lake trout through gillnetting in hopes of enhancing cutthroat and bull trout. This has shown to be an effective way to remove lake trout while protecting native species, but is very costly and because of continued movement of fish from Priest Lake may not achieve the desired results.

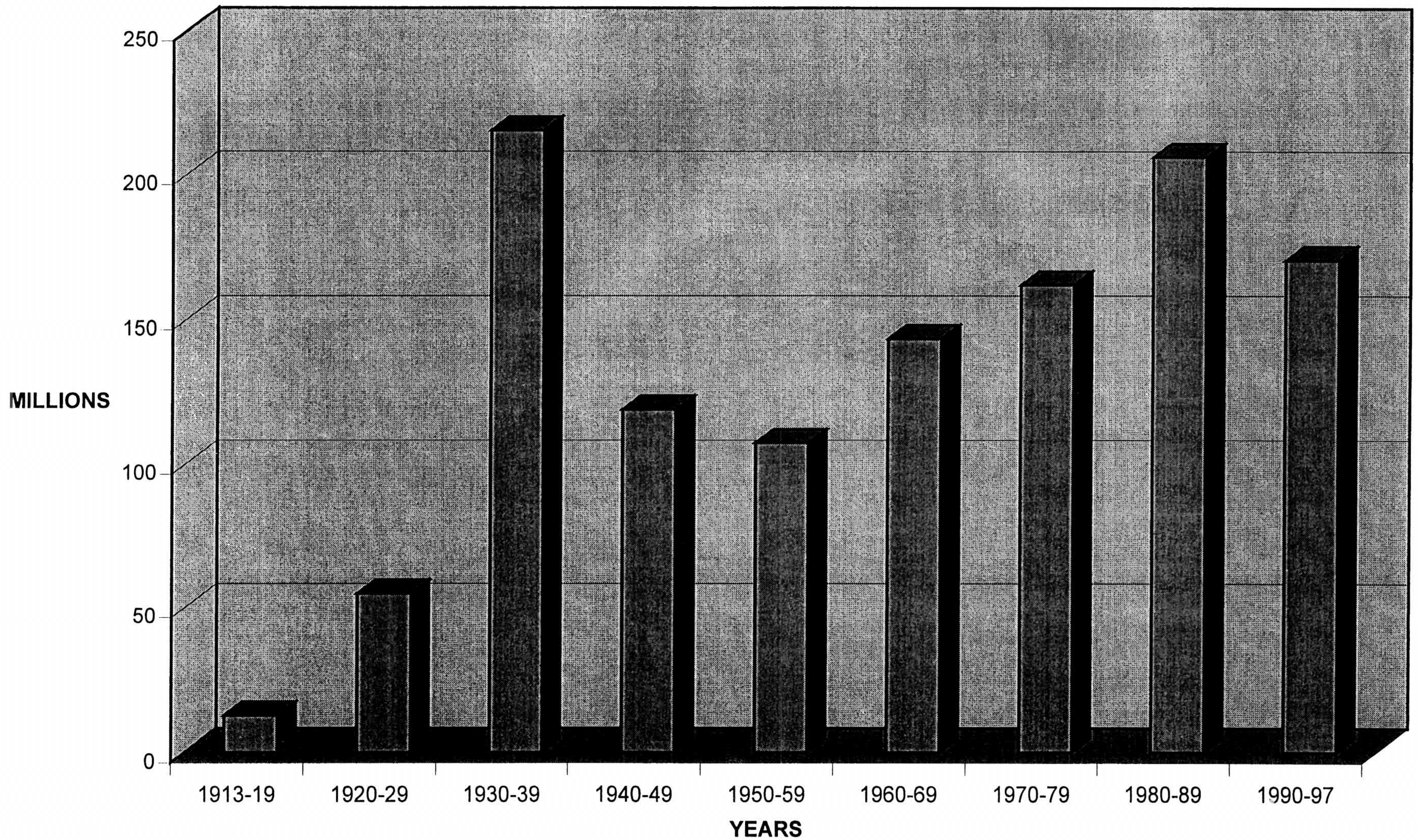
Conservation agencies typically introduce fish for what they can provide in the way of recreational fisheries, not what they can do for the ecosystem. In Idaho, like most all states, it is illegal to introduce fish into public waters without a permit from the Department. However, illegal fish introductions by the public and escapees from fish culture facilities pose a real threat for future unwanted introductions. Overnight airfreight, easy accessibility to out-of-state commercial fish hatcheries, and an impossible enforcement situation has the potential for future disasters on native species.

Introduction of non-native fish during the past twenty years has caused concern with conservation agencies relative to the protection of wild native species. Past introductions, purposeful and accidental, of exotic species have established successful fisheries, sometimes at the expense of native stocks. In Idaho, an example of a successful, from a recreational fisheries point of view, yet illegal introduction is the northern pike into the chain lakes of North Idaho. Disgruntled fishermen took matters into their own hands when the Department would not yield to their requests of establishing pike and walleye fisheries. This illegal introduction established a thriving, trophy pike fishery at the expense of a native cutthroat population.

Conservation agency managers must ensure that decisions about future introductions are based upon sound ecological evidence and the potential impacts are properly evaluated. One thing for sure, once non-native fish are established they are sometimes very difficult if not impossible to eradicate, not only from an economic standpoint but also from a social or political view.

Stocking hatchery fish, both native and non-native, is merely a tool fish managers use to provide recreational fisheries or restore native populations. Like many tools, there is a right and wrong way to use them. We do not propose to eliminate the tool, but simply apply our acquired knowledge to use it correctly. Conservation agencies are faced with a real dilemma in that they are mandated to preserve and protect threatened and endangered species as well as perpetuating fishery resources for their constituents, often in conflict with each other.

IDAHO HISTORICAL FISH STOCKING



EVALUATION OF THE INFLUENCE OF DIET AND DEMAND FEEDING ON FISH PERFORMANCE AND PHOSPHORUS DISCHARGE

Ronney E. Arndt, Eric J. Wagner[1],Charles R. Bobo, Patrick A. Brown,
Ronald L. Roubidoux, M. Douglas Routledge,and Quentin A. Bradwisch
Fisheries Experiment Station, Logan, Utah 84321

Three separate studies were conducted to determine the influence of diet type (floating feed, low phosphorus feed, standard sinking feed) and feeding method (hand vs demand) on the hatchery performance of rainbow Oncorhynchus mykiss and cutthroat trout O. clarki utah. In the first study, a production-scale evaluation of a low phosphorus fish feed was conducted at three of Utah's state hatcheries. At the Mantua, Loa, and Midway hatcheries, rainbow trout were fed either a standard grower diet (control) or a low phosphorus (low-P) diet. Fish fed the low-P diet grew better than the control group at the Loa and Midway hatcheries, but at Mantua the opposite was true. Total weight gain, specific growth rates, and feed conversion ratios were better for the low-P groups at Loa and Midway, while at Mantua weight gain and feed conversions were better for the control group. At all three hatcheries there was some variability among indices measured by the Health Condition Profile, but no trends suggesting that low phosphorus diets compromised fish health. Fish fed the low-P diet at Midway, which has hard water, revealed a reduction in lithic deposits of the kidney and psuedobranch. Total P discharges measured at the raceway tails showed a reduction of 38% at Mantua, 27% at Loa, and 25% at Midway with fish fed the low-P diet compared to the control diet. The average feed cost was $US 0.76/kg fish for low-P feed and $ 0.74/kg fish for the control diet.

In the second study, rainbow trout were fed one of four commercial (Silvercup) diets: floating trout (TF), steelhead (SF), sinking low-P (LP), or salmon (S) formulations. Fish fed the SF diet had consistently better final weights, total weight gain, specific growth rates, and feed conversion ratios compared to the LP or TF treatments. Feed cost per kg fish produced was not influenced by diet type and averaged US$ 0.61. Diet type did not influence the health of the fish nor did it significantly influence the degree of fin erosion exhibited by the fish. Midway through the study, total phosphorus discharge was considerably higher for the SF and LP fish, 65 and 60 mg P/day/kg fish respectively, compared to 36 and 31 mg P/day/kg fish for the TF and S treatments respectively. By the end of the study, the LP fish had higher total phosphorus in raceway effluent, 76 mg P/day/kg fish, compared to 44 and 42 mg P/day/kg fish for the TF and SF fish respectively.

In the third study there were two separate feeding trials, one for cutthroat trout, and the other for rainbow trout. Each specie was fed an extruded floating feed either by hand or a demand feeder, or a sinking pelletized feed. For both feeding trials, measurements of the total phosphorus in raceway effluent revealed a trend of increasing phosporus concentration ranked by treatments as follows: floating feed by hand < floating feed by demand feeder < sinking feed by hand. Final mean weights of cutthroat trout were not significantly different. However, fish fed the floating feed via a demand feeder had significantly better feed conversions, 0.69, than the fish fed the floating feed by hand, 0.85, or the sinking feed by hand, 0.83. Rainbow trout fed the floating feed via a demand feeder had significantly larger final weights, 74.4 g/fish, compared to 63.8 g/fish for the floating feed by hand treatment, or 58.8 g/fish for the sinking feed by hand treatment. Feed costs per kg fish produced were not significantly different between treatments within a given trial and averaged US $0.83 for the cutthroat and $0.76 for the rainbow.

It appears that the use of either low-P or floating feeds fed by hand may be a good way to reduce phosphorus discharges from hatcheries while still maintaining fish production at a reasonable cost.

[1]Presenter

HATCHERY OUTREACH
PANEL DISCUSSION

TOM FREW
(Idaho Department of Fish and Game)

ABSTRACTS FOR HATCHERY OUTREACH PANEL DISCUSSION

"WE'VE BUILT THEM, PEOPLE ARE COMING, NOW LET'S MAXIMIZE OUR OUTREACH POTENTIAL"

Session Chair, Judith M. Maule, Outreach Specialist
U.S. Fish and Wildlife Service, Region 1
911 NE 11th Avenue
Portland, OR 97232

Abstract

Fish hatcheries are the land base for Federal, State and Tribal Fisheries Programs and, as such, they provide a unique and powerful opportunity for relaying information to a variety of audiences. Hatcheries are often the most visible local contact point for our agencies with educators, students and business owners, and other community members in rural and urban areas. People come to hatcheries to enjoy the beautiful locations, see fish, and learn more about how our agencies are working to restore valuable fisheries. How can we find the time, talent and money needed to educate people about the value of our Fisheries Programs? What are the messages we can send people home with that will help to support our work on behalf of natural resources?

"KEEP THE SALMON COMING HOME"

Steve Bell, Executive Director
Friends of Issaquah Salmon Hatchery (FISH)
125 Sunset Way,
Issaquah, WA 98027

Abstract

"Keep the Salmon Coming Home" is the motto of the Friends of Issaquah Salmon Hatchery, aka FISH. The Issaquah Hatchery in Washington State was slated for closure in 1993. Four million dollars and a lot of great volunteers later, Issaquah Hatchery is poised to be one of the state's most visited educational highlights. FISH Executive Director, Steve Bell, has been finding ways to add value to the state's investment for three years and the state has responded by funding needed improvements like new salmon viewing windows in the fish ladder, a new well water supply for weak stock recovery, and a new bridge for school kids to view spawning salmon. How did Issaquah go from shut down to wide open?

"RECIPE FOR HATCHERY OUTREACH PROGRAMS FEATURING CULTURAL AND NATURAL HISTORY THEMES"

Susan Sawyer, Information and Education Specialist
U.S. Fish and Wildlife Service
Dworshak National Fish Hatchery Complex
P.O. Box 18, State Highway 7
Ahsahka, ID 83520-0018

Abstract

Spice up your basic hatchery outreach menu by adding a side of cultural resource interpretation and mixing in a dash of natural history. Broaden existing or create new partnerships with Tribes, communities, schools, and other agencies for a complete and balanced diet of public programs to keep visitors coming back for more.

"REINFORCING THE MESSAGE: HATCHERIES ARE WHERE THE ACTION IS"

Bonnie Long, Aquatic Education Program Manager
Washington Department of Fish and Wildlife
600 Capital Way, N
Olympia, WA 98501-1091

Abstract

The State of Washington is working on a variety of educational projects at their state hatcheries including kiosk signs and generic environmental learning centers. Visitors will truly "get the message" when they visit a Washington State hatchery!

"NO VISITORS ALLOWED: OUTREACH CHALLENGES AT A RESEARCH HATCHERY"

Dan Barrett, Manager
Cle Elum Fish Hatchery
P. O. Box 836
Cle Elum, WA 98922

Abstract

How do you tell the public about your fisheries program when they can't walk around your hatchery? Outreach strategies the Cle Elum Fish Hatchery may provide some helpful suggestions for hatcheries where the public cannot get up close to the fish or talk with the staff at the hatchery. Visitors can connect with the importance of the work you are doing while keeping their distance from hatchery operations.

"EDUCATION, A KEY TO SUCCESS"

John Gahl, Chief, Information and Education
Idaho Department of Fish and Game
600 S. Walnut, P.O. Box 25
Boise, ID 83707

Abstract

Education is the key to the future of hunting and fishing. An organized, planned approach to education will ensure that responsible behavior is the end result. Not all of our publics will become hunters or anglers, yet, we will need their support. How does the work we do at our hatcheries fit into that educational goal and what are the objectives that we need to establish? The "educational pyramid" needs to be our focus.

COMMERCIAL EXHIBITORS

Company	Representative	Telephone	Fax	E-mail
Argent Chemical Lab	Dr. Eliot Lieberman			
BioOregon	Russ Farmer/ Walter Kost	503-861-2256	503-861-3701	
Christensen Net Works Inc	Scott Christensen	360-384-1446	360-384—1446	
Common Sensing	Brian D'Aoust	208-266-1541	208-266-1428	comsen@dmmi.net
EMA-Engineered Products Division	T.R. Gregg	541-929-3225	541-929-2274	greggr@peak.org
EWOS Canada Ltd.	Paula Galllowày	250-286-8361	250-286-0788	
Familian Northwest	Victor Clemens	360-835-2129		
Harper Brush Dist, Inc..	Ken Taylor	425-255-2074	425-235-6709	
Intermountain Weighing Systems, Inc	Tom Bradley/ Chrstine Bradley	208-362-3667	208-362-5085	tomlbs@aol.com
J.L. Eagar, Inc,	Stan Bell	801-292-9017	801-295-7569	
Jensorter	Greg/Cathy Jensen	541-389-3591	541-389-0050	jensorter@transport.com
Magic Valley Heli-Arc	Louie/Linda Owens	208-733—0503	208-733-0544	
MariSource/ Flex-a-lite Consolidated, Inc..	Eddy Willingham Rainer Willingham	253-922-2700	253-922-0226	flex@flex-a-lite.com
Moore-Clark	Ron Malnor/ Steve Boggio	604-325-0302 425-744-4500	604-325-2884 425-744-6619	
Nelson & Sons, Inc../ Silver Cup Fish Feed	Chris Nelson/ Jerry Zinn	800-521-9092	801-266-7126	silvercup@xmission.com
Point Four Systems, Inc.	Rob Barratt	604-936-9936	604-936-9937	
PRA Manufacturing Ltd	Wayne Gorrie	250-754-4844	250-754-9848	prammfg@island.net
Rangen, Inc.	Jerri Fulllerton	208-534-6421	208-543-4698	rangenff@magicllink.com
The Mallory Co.	Steve Gauthier	360-636-5750	360-577-4244	info@mmalloryco.com
Water Management Technologies, Inc.	Terry McCarthy	225-775-0026	225-755-0995	
VMG Industries, Inc.	Bruce Marshall	970-242-8623	970-243-3563	
Warren Water Broom Mfg. Co.	Dell Warren	503-458-6694		

Door Prize List

Prize	Donors
Pistol Case	Outdoor Outlet, Challis, ID
Fishing Cap	Terry's Sports, Challis, ID
Screwdriver Set	Jensen Oil, Challis, ID
Screwdriver Set	Kimble Oil, Challis, ID
BL Fly Rod & Reel Case	Bagmaker, Boise, ID
3 cases of wine	Idaho Wine Comm, Boise, ID
Christmas Wine Gift Box	Pintler Cellers, Nampa, ID
Christmas Wine Gift Boxes	Ste. Chapelle, Marsing, ID
10 cases of potatoes	Simplots, Caldwell, ID
10 hats	Simplots, Caldwell, ID
Fishing Rods	Sportsman's Loft, Nampa, ID
Sweat Shirts	IDFG Nature Center, Boise, ID
Print & Stamp	IDFG, Boise, ID
Print	Idaho Wildlife Foundation, Boise, ID
Sockeye Print	4-Sockeye, Nampa, ID
Print Framing	Baker's Custom Framing, Nampa, ID
Rifle & Fishing Rod	MariSource, Milton, WA
Sporting Goods	Sunset Sports Center, Boise, ID
Sporting Goods	Black Sheep Sporting Goods, Boise, ID
Sporting Goods	Intermountain Outdoor Sports, Meridian, ID
Sporting Goods	D&B Supply, Meridian, ID
$40 Gift Certificate	Les Schwab, Boise, ID
Case of Oil	Les Schwab, Nampa, ID
$20 Gift Certificate	Table Rock Brewery, Boise, ID
Outboard Oil	Century Boatland, Twin Falls, ID
Goose Call Kit	Honker's Supreme, Twin Falls, ID
North Face Shirt	Elevation Sports, Twin Falls, ID
Fartless Pinto Beans	Made In Idaho, Twin Falls, ID
Video & book on Barbecue	A Happy Camper, Twin Falls, ID
Inflatable Camping Chair	Koppel's Browzeville, Twin Falls, ID
Fishing Idaho Book	Rainbow Fly Shop, Twin falls, ID
Multi-tool w/case	Ridlely's Home Center, Jerome, ID
Gerber Knife	Bunn's, Wendell, ID
Knife Set	Hub City Building, Wendell, ID
Multi-screwdriver	Greg Terminal Co, Gooding, ID
Drill Bit Set	Volco, Gooding, ID
Antique Model Tractor & Bank	John Deere, Wendell, ID
Daypack, flashlight set	Rangens Feed Co, Buhl, ID

STAINLESS STEEL COFFEE MUG	RANGENS FEED CO, BUHL, ID
FIVE NICE KNIVES	BIOOREGON, WARRENTON, OR
SPORTING GOODS	MOORE-CLARK, EDMONDS, WA
HEAVY COAT	SILVER CUP, MURRAY, UT
SWEAT SHIRTS	SILVER CUP, MURRAY, UT
MISC PRIZES	EAGAR, INC., N. SALT LAKE, UT
MISC PRIZES	IDAHO POWER CO., BOISE, ID
MISC PRIZES	AQUAHEALTH
GOURMET FOOD BASKET	ARGENT, REDMOND, WA
ELECTRIC FLASHING LURE	RIVERSIDE SPORT SHOP, OROFINO, ID
KHAKI T-SHIRT	D&B SUPPLY, LEWISTON, ID
TOY 4X4 PICKUP	NAPA AUTO PARTS, OROFINO, ID
CAMOUFLAGE BASEBALL CAP	NAPA AUTO PARTS, OROFINO, ID
FILSON BASEBALL CAP	OLIVES AUTO PARTS, OROFINO, ID
"BIG MO" ELK CALL	WILD BILL'S SPORTS, OROFINO, ID
24 QUART COOLER	ACE HOME CENTER, OROFINO, ID
6 EA ENGRAVED KNIVES	OROFINO BUILDERS SUPPLY, OROFINO, ID
$50 GIFT CERTIFICATE	LES SCHWAB, OROFINO, ID
WILDLIFE ORIGINAL ART PIECE	VALLERIA'S WILDLIFE & WESTERN ART, OROFINO, ID
CARHARTT BASEBALL CAP	CORRAL WEST RANCHWEAR, LEWISTON, ID
ATLANTIC SALMON FLIES BOOK	TWIN RIVER ANGLERS, LEWISTON, ID
DUFFLE BAG	ARMY/NAVY STORE, LEWISTON, ID
SNAKE BITE/BEE STING KIT	ARMY/NAVY STORE, LEWISTON, ID
3 EA DESK SETS	BLACKSHEEP SPORTING GOODS, LEWISTON, ID

NORTHWEST FISH CULTURE CONFERENCE
HISTORICAL RECORD

YEAR	LOCATION	HOST AGENCY	CHAIRMAN
1950	PORTLAND, OR	U.S. FISH AND WILDLIFE SERVICE	TED PERRY
1951	WENATCHEE, WA	U.S. FISH AND WILDLIFE SERVICE	ROGER BURROWS
1952	SEATTLE, WA	WASHINGTON DEPT. OF FISHERIES	BUD ELLIS
1953	PORTLAND, OR	FISH COMMISSION OF OREGON	FRED CLEAVER
1954	SEATTLE, WA	U.S. FISH AND WILDLIFE SERVICE	BOB RUCKER
1955	PORTLAND, OR	OREGON GAME COMMISSION	JOHN RAYNER
1956	SEATTLE, WA	WASHINGTON DEPT. OF GAME	CLIFF MILLENBACH
1957	PORTLAND, OR	U.S. FISH AND WILDLIFE SERVICE	HARLAN JOHNSON
1958	SEATTLE, WA	WASHINGTON DEPT. OF FISHERIES	BUD ELLIS
1959	PORTLAND, OR	FISH COMMISSION OF OREGON	ERNIE JEFFRIES
1960	OLYMPIA, WA	WASHINGTON DEPT. OF GAME	JOHN JOHANSEN
1961	PORTLAND, OR	OREGON GAME COMMISSION	CHRIS JENSEN
1962	LONGVIEW, WA	U.S. FISH AND WILDLIFE SERVICE	ROGER BURROWS
1963	OLYMPIA, WA	WASHINGTON DEPT. OF FISHERIES	BUD ELLIS
1964	CORVALLIS, OR	OREGON STATE UNIVERSITY	JOHN FRYER
1965	PORTLAND, OR	U.S. FISH AND WILDLIFE SERVICE	JOHN HALVER
1966	PORTLAND, OR	FISH COMMISSION OF OREGON	WALLY HUBLOU
1967	SEATTLE, WA	UNIVERSITY OF WASHINGTON	LOREN DONALDSON
1968	BOISE, ID	IDAHO DEPT. OF FISH AND GAME	PAUL CUPLIN
1969	OLYMPIA, WA	WASHINGTON DEPT. OF GAME	JOHN JOHANSEN
1970	PORTLAND, OR	OREGON GAME COMMISSION	CHRIS JENSEN
1971	PORTLAND, OR	U.S. FISH AND WILDLIFE SERVICE	MARV SMITH
1972	SEATTLE, WA	WASHINGTON DEPT. OF FISHERIES	DICK NOBLE
1973	WEMME, OR	OREGON FISH COMMISSION	ERNIE JEFFRIES

NORTHWEST FISH CULTURE CONFERENCE
HISTORICAL RECORD

YEAR	LOCATION	HOST AGENCY	CHAIRMAN
1974	SEATTLE, WA	UNIVERSITY OF WASHINGTON	ERNIE SALO
1975	OTTER CREST, OR	OREGON STATE UNIVERSITY	JACK DONALDSON
1976	TWIN FALLS, ID	UNIVERSITY OF IDAHO	BILL KLONTZ
1977	OLYMPIA, WA	WASHINGTON DEPT. OF GAME	JIM MORROW
1978	VANCOUVER, WA	U.S. FISH AND WILDLIFE SERVICE	DAVE LEITH
1979	PORTLAND, OR	OREGON DEPT OF FISH & WILDLIFE	ERNIE JEFFRIES
1980	COURTENAY, B.C.	FISHERIES & OCEANS, CANADA	KEITH SANDERCOCK
1981	OLYMPIA, WA	WASHINGTON DEPT. OF FISHERIES	WILL ASHCRAFT
1982	GLENEDEN BEACH, OR	NATIONAL MARINE FISHERIES SERVICE	EINAR WOLD
1983	MOSCOW, ID	UNIVERSITY OF IDAHO & IDAHO DEPT. OF FISH AND GAME	BILL KLONTZ & EVAN PARRISH
1984	KENNEWICK, WA	WASHINGTON DEPT. OF GAME	JIM GEARHEARD
1985	TACOMA, WA	U.S. FISH AND WILDLIFE SERVICE	ED FORNER
1986	EUGENE, OR	OREGON DEPT OF FISH & WILDLIFE	CHRIS CHRISTENSEN
1987	TACOMA, WA	WASHINGTON DEPT. OF FISHERIES	WILL ASHCRAFT
1988	RICHMOND, B.C.	B.C. MINISTRY OF ENVIRONMENT	DON PETERSON & PETER BROWN
1989	GLENEDEN BEACH, OR	NATIONAL MARINE FISHERIES SERVICE	RZ SMITH
1990	BOISE, ID	IDAHO DEPT. OF FISH AND GAME	BILL HUTCHINSON
1991	REDDING, CA	CALIFORNIA DEPT OF FISH & GAME	KEN HASHAGEN
1992	WENATCHEE, WA	WASHINGTON DEPT. OF WILDLIFE & ALASKA DEPT. OF FISH AND GAME	JOHN KERWIN & IRV BROCK
1993	SPOKANE, WA	U.S. FISH AND WILDLIFE SERVICE	ED FORNER
1994	SUNRIVER, OR	OREGON DEPT OF FISH & WILDLIFE	RICH BERRY

NORTHWEST FISH CULTURE CONFERENCE
HISTORICAL RECORD

YEAR	LOCATION	HOST AGENCY	CHAIRMAN
1995	FIFE, WA	WASHINGTON DEPT. OF FISH & WILDLIFE	LARRY PECK
1996	VICTORIA, B.C.	B.C. MINISTRY OF ENVIRONMENT, LANDS, AND PARKS & DEPT. OF FISHERIES AND OCEANS CANADA	DON PETERSON & GREG BONNELL
1997	GLENEDEN BEACH, OR	NATIONAL MARINE FISHERIES SERVICE	RZ SMITH
1998	BOISE, ID	IDAHO DEPT. OF FISH AND GAME	TOM ROGERS & TOM FREW
1999	SEATTLE, WA	U.S. FISH AND WILDLIFE SERVICE	RAY BRUNSON
2000	TO BE ANNOUNCED		