PROCEEDINGS OF THE

36TH ANNUAL NORTHWEST FISH CULTURE CONFERENCE

TACOMA, WASHINGTON

DECEMBER 3, 4, 5, 1985

PROCEEDINGS

of the

Thirty-sixth Annual

N O R T H W E S T F I S H C U L T U R E C O N F E R E N C E

December 3 - December 5, 1985

Chairman

Henry E. Forner, Jr.
U. S. Fish and Wildlife Service
500 N.E. Multnomah St., Suite 1692
Portland, Oregon 97232

THE NORTHWEST FISH CULTURE CONFERENCE

Northwest Fish Culture Workshops are informal meetings for exchange of information and ideas concerning all areas of fish culture. Current progress reports of management practices and problems, new developments, and research studies are presented. Active discussion and constructive criticism are encouraged and furnish highlights of the conference. All persons interested in or associated with fish husbandry are invited to attend and to participate. Subject material is limited to topics that have direct application to fish culture.

The PROCEEDINGS contain unedited briefs or oral reports presented at each conference. Much of the material concerns progress of uncompleted studies or reports. THESE INFORMAL RECORDS ARE NOT TO BE INTERPRETED OR QUOTED AS A PUBLICATION.

TABLE OF CONTENTS

Remarks by William P. Horn, Assistant Secretary for Fish and Wildlife and Parks at the 36th Annual Pacific Northwest Fish Cultural Conference, Tacoma, Washington, December 3, 1985

It's a pleasure to be here today -- and a great honor. First, permit me to extend the regrets of Assistant Secretary Bill Horn. Bill very much wanted to meet with you, but an unforeseen conflict involving his duties as Chairman of the Great Lakes Fishery Commission meant Ann Arbor today instead of Tacoma. I've know and worked with Bill for a number of years and can attest, as can many of you who know him as well, that when he misses an important fishery-related conference it's not for lack of interest.

In any event, I'm very pleased to stand in for Bill today and share with you some of the ideas and observations he himself would have brought to you.

Let me begin with a history lesson of sorts. You and I, of course, are primarily products of a scientific educational backgroud -- indeed, one reason we probably chose to pursue the path of science is that we probably found the liberal arts with its emphasis on history a little too mundane. Well, history is a part of life as we all have come to understand. And I'm sure that each of you has a sense of some of the history of fish culture in this country, that the names Seth Green and Livingston Stone would indeed ring a bell.

But my lesson today is from recent history -- from approximately 1981 to the present. And what I'd like to do with your permission is to briefly outline Federal fishery policy -- as applied at the Department of the Interior -- during that time.

When the current Administration accepted its mandate in January of '81, there were many in the conservation and environmental community ready to proclaim doom in respect to conservation issues. Indeed, when the Federal budgets for Fiscal Years 1982 and 1983 became public, many in the conservation community perceived -- and quickly reported to the outside world -- that fishery budgets were being slashed, that the fishery program of the FWS was being gutted. They cited the proposed closure or transfer of Federal fish hatcheries as ample and sufficient evidence that all was lost for fishery resources at the Federal level. They predicted a future in which the professional fish culturist would have no role in the Federal sector. Well, as history has shown, and as congressional reports and administration testimony reveal, the intent was never to eliminate needed and legitimate Federal contributions and efforts, it was to allow them to be made in more efficient ways and become stronger in key, high-priority areas. Back in those days of easy allegations, perhaps it was understandable for some outside conservation groups to view a budget proposal that didn't include automatic increases as a drastic threat.

After all, the budget for many parts of Federal operations had long been on an upward spiral -- with little to indicate there had been corresponding increases in productivity for the public good, and that serious, long-standing problems in major fishery resources were being adequately addressed. But the dire consequences some predicted has failed to materialize. Instead, we find some very significant gains -- achievements that some would have regarded as fantasy, just a few brief years before.

Now history, as we all realize, is a study of balances -- balance of resources, wealth, and power. It would thus be imbalanced to say that all the recent achievements we have witnessed were solely the result of the Administration acting alone. We all know more about our system of Government than to accept as true such an assertion. These achievements resulted from ideas that came not only with the present Administration , but with the essential cooperation and support of the Congress, the public, and, of course, public servants like most of you who carry out the programs.

Accordingly, I believe our Federal fish propagation capability, viewed properly as a major tool of fishery resource management, is now on sounder footing than it has been in a long time.

Moreover, I believe that -- at least within the Interior Department -- we have stronger, more focused, and more effective fishery effort today than existed in 1981. Reflecting and serving as the basis for this belief is our statement of redefined responsibilities and role, issued earlier this year.

I'm sure each of you is familiar with this document. So I won't dwell on the specifics here today other than to note in passing what the Service believes to be its four key responsibilities in the fishery arena:

- To facilitate restoration of depleted, nationally significant fishery resources;

- To seek and provide for mitigation of fishery resource impairment due to Federal water-related development;

- To assist with management of fishery resources on Federal (primarily Service) and Indian lands; and

- To maintain a Federal leadership role in scientifically based management of National fishery resources.

Let me further point out that each of these is a shared responsibility, the discharge of which depends in varying but significant measure on the sustained performance of our fish propagation capability.

I call attention to these responsibilities to remind you -- and to remind myself -- that we all live and work with goals. Our goals are those espoused and articulated under policy statements. All too often we can get caught up in the day-to-day worries of our particular tasks and forget the big picture. At those times it's always useful and beneficial to remind ourselves that we're working in the right direction, making progress toward a goal. In the recent history of conservation in America, we have seen each Administration make its productive and positive mark. There has indeed been continuity. In my little history lesson today, I certainly didn't mean to detract from previous efforts. Rather, I wanted to bring to light the fact that positive efforts continue -- as the record amply attests.

As we review some of the more visible fishery topics of the day we can clearly see that much has been achieved. Let's look briefly at two of these: First, the U.S./Canada Salmon Interception Treaty. This significant accomplishment

was the result of long and, at times, very difficult negotiation. Altogether, nearly 15 years passed before a Treaty evolved. But today it is a reality. Today the Treaty offers very real hope for scientific resource management at the international level, with prospects of substantial user benefits for the two signatory countries.

As you are all aware, uncontrolled interceptions in the past have been a major problem contributing to both overfishing and its resulting social conflict. Our agreement with Canada will protect salmon while allowing each country to benefit from the salmonid resource it produces. The treaty ensures, to remind you, that the chinook salmon catch in waters off British Columbia and Southeast Alaska will be cut from 1984 levels by approximately 24%. In 1984, the catch was 1.5 million chinook. This year and next, the affected fisheries will reduce their take by 400,000 fish, and thus more chinook will return to Washington, Oregon and Idaho waters.

The Canadian troll catches of coho off Vancouver Island -- mostly fish of U.S. origin, -- will be cut back by half a million fish this year, and a like amount next. These decreased interceptions should go a long way to help restore the productivity of chronically depressed runs -- and at the same time, significantly improve the prospect for stabilized and balanced U.S. fisheries that depend on the coho.

One of the main strengths of the Treaty is that it will prevent overharvest. Both countries are formally committed to, in the words of the agreement, "Prevent over-fishing and provide for optimum production." The burden of conserving salmon stocks will be fairly shared; and the U.S. and Canada will cooperatively increase and carry out joint research on stocks of concern to both countries.

The need for the Treaty should remain foremost in our minds -- to protect and restore a splendid resource. And we would do well to remind ourselves of the value of that salmon resource. Salmon fishing and related industries contribute hundreds of millions of dollars annually to the U.S. Northwest alone. And each year Federal, State, Tribal, and private interests invest almost $87 million to propagate, manage, and protect salmon. Without the Treaty, much of the benefit of this investment would be reaped outside the region and the country. The Treaty represents protection of a long-term investment, too: more than $800 million for fish-passage and production facilities to mitigate damage to resources, important to the fishing industry and Indian tribes, caused by construction and operation of Columbia River hydroelectric facilities. The Northwest Power Planning Council, in fulfilling the Congressional mandate of the 1980 Northwest Power Act, plans to commit up to $750 million to restore Columbia River runs of salmon and steelhead. These are significant dollar amounts and the Treaty will help ensure that full and fair benefits will be returned to this region in the future.

Another program with great promise now and for the future is the Lower Snake River Compensation Plan (LSRCP).

Since 1978, as many of you know, an ambitious program has been underway to construct and operate major hatchery and trapping/release facilities to restore important runs of salmon and steelhead to the Snake River System.

Already hatcheries are having significant impact with near record steelhead returns, produced in part by LSRCP facilities. As additional facilities come on line, and as the production of the newly operational hatcheries makes its contribution, the 'compensation' intent of the LSRCP will be realized. If you are keeping score, 15 of the planned 21 hatcheries and trapping/release facilities are in operation. The remaining 6 are under construction and scheduled for completion by the end of 1988.

The Lower Snake plan represents a commitment -- and far more. It symbolizes the growing awareness that environmental concerns and considerations are no longer merely elective. The environmental component of any water development endeavor is not only right and a part of law -- it represents as well what the public knows is essential to long-term human well-being.

The achievement of environmental safeguards is an on-going process. The successes of recent years are impressive. They speak well for the effectiveness of cooperative intergovernmental and private efforts. But as fish culturists realize perhaps better than anyone -- water quality in the raceway is not an abstract notion subject to leisurely theoretical arguments and hypothetical debates. It's a matter of reality, of the here-and-now: Is this water good, wholesome, capable of sustaining fish life? Or is it tainted, unacceptable, and destructive to the hatchery and its fish?

As fish producers, our role in this scenario is quite clear: we need clean water. No if's, and's, but's. To secure the water quality required to culture fish, we are and must be effective advocates for the living resources the ensurance of whose productivity and maintenance is our predominant charge. The fish culturist, the field fishery biologist, the fishery resource administrator -- none of them can afford to operate as if in a vacuum. They must work cooperatively and responsibly with habitat specialists and participate in environmental protection efforts -- for the benefit of the resource and the public. Now, some would hear in this a call to activism and advocacy -- rather dicey pursuits for public servants. What I'm advocating is that all of us rededicate ourselves to the very pressing task at hand -- doing our part to secure a wholesome environment. When the assigned task is to produce x-number of fish, it is implicit that these be healthy creatures, destined for a liveable environment. Your task really does not end when hatchery screens are raised or when smolts are trucked off to release points. In a way, your higher calling -- task effective cooperation -- is just beginning.

Hatcheries do not stand alone, isolated from their environment. Neither can fish culturists. The hatchery and its professional staff are part of a dynamic and valuable ecology. They are part of that great web of interrelationships that seeks inexorably to restore and improve ecological balance to the environment. Our role is positive and productive; but we must remain mindful that hatchery production is not merely an end in itself, it's part of a larger process.

I am always eager to point out the important part that the Fish and Wildlife Service's production capability plays in the restoration of nationally significant fishery resources. Just briefly, I'd like to cite three examples:

On Chesapeake Bay, we have been actively cooperating with the States of Maryland and Virginia and with the EPA and Corps of Engineers to find ways

to halt the degradation of the Bay's great resources, and to help restore the striped bass for which the Bay is historically famous. I'm pleased to mention that this year marks our first attempt, as part of a 5-year program, to culture some of the Bay's wild strains of stripers in Service hatcheries. Currently, we are marking with coded-wire tags more than a quarter million phase-II stripers for release into the Bay, via their rivers of origin, to evaluate hatchery effectiveness in such a restoration effort. Six of our hatcheries took part this year and I'm quite proud of that involvement. But equally so, I'm encouraged by how well the various resource disclipines, representing a number of agencies, have been able to cooperate so effectively in this first-of-a-kind project.

With the Atlantic salmon, once again, we see that the role of the hatchery is essential. Our efforts in New England to restore to self-sustainability this magnificent fish to the Connecticut and Merrimack Rivers, and to augment their runs elsewhere, have been given a tremendous boost by our new facility on the White River in Vermont. Yet, so much more needs to be done -- on the international scene we continue to work for effective control of Atlantic salmon interceptions, lest our hatchery-produced investment wind up mainly a subsidy to foreign commercial interests. The restoration of the Atlantic salmon in New England rivers will serve to symbolize an important reconciliation between modern man and an ancient resource. It may signal to ourselves - in some small way - our maturing as a species.

A final example of the productive, integrated role of fish culture can be found in our Great Lakes effort. Working with the States and with Canada, we are helping to restore native populations of lake trout in Lake Ontario - this through a special project with the New York's Department of Environmental Conservation and Ontario's Ministry of Natural Resources. Elsewhere in the Great Lakes, our research, propagation, and lamprey control efforts are closely coordinated with States and Tribes in a long-term program to restore one of the world's great inland fishery resources -- the lake trout of the upper Great Lakes. With such a vast undertaking, progress can sometimes be slow in coming. The trout's premature removal must be tightly controlled, its habitat must be maintained at high quality, and its food supply must be tightly controlled, its habitat must be maintained at high quality, and its food supply must be guarded from stress. But, I am not discouraged; in fact, each year I see more reason for hope and for pressing forward. Our new hatchery at Iron River in Wisconsin is a visible sign of sustained commitment to the full and complete restoration of stocks of this great species.

Before concluding my remarks here today, I would like to return for a moment to my earlier theme: History, and Continuity. Hatcheries in this country began mid-way through the last century as a result of a perception -- and a correct one, at that -- that we were rapidly losing valuable fishery resources, that their productivity -- thought previously to be unlimited -- couldn't keep pace with mounting demand. The first fish culturists were private citizens, concerned citizens. Later this concern grew and states - such as Pennsylvania - became involved in fish culture to compensate for losses due in large part to uncontrolled use of the fishery resource, later also to impairment of the resource's habitat. Finally, the Congress of the United States established the U.S. Commission of Fish and Fisheries in 1871 -- and while among the Commission's initial answers to the loss of indigenous stocks

was the importation of carp -- its goals nonetheless were the same: to somehow help address depleted stocks and waters. Our pacific salmonid endeavors began in 1872, as you know, with salmon egg collecting on the McCloud River in California. The methods and perspective may have changed over the years, but in most areas, though occasionally modified, the basic goal has not. In the reorientation of its fishery-related mission, for instance, the Fish and Wildlife Service has changed the perspective of its fish-propagation purpose from primarily that of an end in itself to that of a means to an end: as its highest priority and wherever feasible, the rehabilitation of national fishery resources to optimum self-sustainability.

The thread in fish culture hasn't been "bigger-and-better" but in how quickly and effectively we correct our errors -- as a society, as a species. The history of U.S./Canadian fish culture, in and of itself as well as in the annals of American conservation is a notable one, I'm confident you will agree.

Many of you are aware, I'm sure, of the bill pending before Congress, H.R.3167, that would statutorily establish a National Fish Hatchery System. This proposed system would be composed of Federally owned or operated installations engaged in the propagation and distribution of fish. It would also include State and Tribal installations, but only to the extent that the fish produced help fulfill Federal objectives with Federal funds. The primary objectives of the system would be to provide fish for:

- Mitigating impacts of Federal projects;
- Restoring self-sustainable fishery resources determined to be depleted;
- Stocking waters to meet treaty obligations;
- Performing research and development in support of fish propagation; and
- Implementing recovery plans for threatened and endangered species.

As Assistant Secretary Horn has stated for the record before Congress, the Fish and Wildlife Service certainly agrees with the general philosophy and intent of this bill because -- among other things -- it recognizes the need for propagation of fish by the Federal Government and offers a coherent policy framework for administering that function; morever, it would provide for stable funding and require biologically sound plans for restoration and mitigation as the basis for Federal investment in fish production for those purposes.

No one can predict with certainty, of course, whether this bill or a similar measure can achieve swift passage. But the proposed legislation does indeed serve to re-emphasize Congressional interest in restoring misued, and/or compensating for irreparable damage to, natural fishery resources. Further, it underscores concern that the system proposed be as professional and efficient as possible, on behalf of the public interest and of the fishery resources it is intended to serve.

Fish culturists have already made many lasting contributions to North American society -- and to the health and well-being of our natural resources. Let me emphasize again that fish culture remains as timely and important today as it was more than a century ago. Its role is essentially unchanged -- to restore, to pay back, to replenish. The fish culturist may have been among the very first of our nation's conservationists, but today no longer stands alone. There are many different disciplines represented in the ranks of conservationists. Each of them working together, as they can and must, will help in that larger restoration goal -- securing, day-by-day, safer and more wholesome surroundings with abundant resources that our posterity may value and enjoy.

For each of you, I wish a most successful and rewarding conference.

Columbia River Fall Chinook Contribution

Robert Vreeland

National Marine Fisheries Service

In 1978 the National Marine Fisheries Service, Washington Department of Fisheries, Oregon Department of Fish and Wildlife and U.S. Fish and Wildlife Service began a study at hatcheries on the Columbia River rearing fall chinook. The purposes of the study are to 1) determine the contribution of fall chinook from individual hatcheries to the Pacific coast fisheries and 2) determine the proportion of the chinook catch in a fishery which comes from Columbia River hatcheries.

Coded wire tags were implanted in representative samples of fall chinook over four brood years, 1978-1981. From 18 to 20 rearing facilities participated in the study each year. During the study nearly 350 million fall chinook were released from Columbia River facilities of which nearly 14 million were tagged. From 3 to 4 million tagged fish were released each brood year.

Fall chinook contribute to the marine sport and commercial and Columbia River fisheries for up to four years after release. At this time no brood year has a complete set of estimated catch data for tagged fish for all possible catch years. Thus all results are preliminary and contribution estimates are minimums.

The 1978 brood fall chinook were caught primarily in the British Columbia and Washington marine fisheries. The percent distributions by fishery are 1%, 41%, 34%, 7% and 17% for the Alaska, British Columbia, Washington, Oregon and Columbia River fisheries respectively.

Comparisons of the average contributions of the 1978 and 1979 broods of fall chinook revile the contribution of the 1979 brood exceeds that of the 1978 brood, 3.6 to 2.7 fish per 1000 fish released respectively. This is despite the fact less catch data is available for the 1979 brood. Contributions by individual hatcheries have shown an even greater differences. For the 1978 brood, Spring Creek Hatchery had the greatest average contribution of 8.3 fish per 1000 fish released. Spring Creek was followed by Stayton Pond, Abernathy Bonneville and Big Creek at 6.5, 4.2, 2.9 and 2.6 fish per 1000 releases. The remainder of the hatcheries participating in the 1978 brood portion of the study contributed 2.0 or less fish to the Pacific coast fisheries per 1000 fish released. Spring Creek also had the greatest contribution for the 1979 brood at 12.8 fish per 1000 releases. Spring Creek was followed by Big Creek, Stayton Pond and Abernathy at 8.4, 6.7 and 4.7 respectively. The other hatcheries participating in the 1979 brood portion of the study had contributions of 3.0 or less per 1000 releases.

There are not only differences in contribution rates between broods and among hatcheries within broods, but there are differences among releases within a hatchery. The following table of four different release times and sizes at Spring Creek Hatchery illustrate this point.

Brood	Release Month	Catch/1000 Releases
1978	March	4.9
	April	16.1
	May	10.1
	August	.0
1979	March	9.0
	April	16.4
	May	19.6
	August	4.1

BPA's Contribution to the Artificially Reared Fish in the Columbia River Basin

Ronald Morinaka

I would like to present a brief overview of Bonneville Power Administration's (BPA) activities having to do with artificial production in the Columbia River Basin.

BPA initiated its funding of fishery research projects in 1978. With the passage of the Pacific Northwest Electric Power Planning and Conservation Act (Pacific Northwest Power Act) in 1980, BPA's Fish and Wildlife Program grew rather rapidly. The Act assigned to BPA responsibility to fund the protection, mitigation and enhancement of fish and wildlife resources effected by hydroelectric development and operation. Under the Act, the Northwest Power Planning Council (Council) was created. It also directed the Council to "promptly develop and adopt a program to protect, mitigate, and enhance fish and wildlife including related spawning grounds and habitat, the Columbia River and its tributaries." The Council used recommendations from the region's fish and wildlife interests to build its Columbia River Basin Fish and Wildlife Program (Program). This Program is being funded largely by BPA.

Under the Council's Program various sections deal with artificial production. The diversity of projects in this section range from building fish hatcheries such as the Cabinet Gorge Kokanee Hatchery on the Clark's Fork in Idaho and the Umatilla Steelhead Hatchery, to research on bacterial and viral vaccines.

Large capital projects are the most defined in the artificial program area. Facilities that are planned to be built are:

1. The Umatilla Steelhead Facility near Irrigon, Oregon, which will supply fish to rebuild the Umatilla Basin's fish runs.
2. The Yakima outplanting facility which will supply fish for Yakima restoration efforts.
3. The Colville Resident Fish Hatchery which will rear fish for resident fish programs in northeastern Washington, and
4. John Day Acclimation Ponds which are to increase the survival of fish reared and released from John Day Mitigation Facilities.

Cabinet Gorge Hatchery on Clark's Fork Idaho, and the Bonifer Springs Acclimation Ponds, on the Umatilla, are the only two facilities created, constructed, and operational under the Program, to date. By 1990, over $25 million will be spent to construct these facilities.

In addition to these capital projects, BPA has the responsibility to INCREASE HATCHERY EFFECTIVENESS. The rather all-encompassing area includes:

- Research and development of improved husbandry practices
- Research and development of improved rearing and release strategies,
- Stock indentification and assessment,
- Improved fish health protection, and,
- Smoltification research.

BPA is currently funding approximately 30 projects under or related to the Artificial Production at a cost of $5 million. Some of these are being presented here at this conference like yesterday's talk given by Bob Vreeland of National Marine Fisheries Service (NMFS). Copies of the Annual Reports from these projects can be obtained from BPA's Division of Fish and Wildlife.

A sample of past and ongoing projects are:

(1) Vaccine development for IHN and BKD
(2) Control of IHN by broodstock culling and antiviral drugs
(3) Evaluation of a pen rearing project for Bright Fall chinook
(4) Evaluation of a low-cost salmon production facility (CEDC)
(5) Stock indentification of Columbia River Basin salmon and steelhead
(6) Protection of wild, upriver salmon and steelhead by slipose clipping and Idaho hatchery salmon and steelhead, and
(7) Development of diets for enhanced survival

Future BPA interests in this Program area will depend on the objectives being developed by the Council and upon such amendments that may be made to the Program. At the moment, it appears safe to believe these will include:

(1) Increasing fish health monitoring,
(2) Evaluation and development of smolt indices, and
(3) Evaluation of the effects of integrating hatchery and wild fish.

These are priority areas that have been identifed by the various fisheries, agencies, and Tribes in the Basin. Our role will be to assist in the funding and implementation of these project areas through their procurement according to BPA regulations. BPA will also allocate these funds in a cost-effective and most technically expedient manner possible, and monitor the resulting progress of each project.

The ultimate goal of BPA's Artificial Production Program is to increase the survival of our Basin's hatchery fish.

SALMON FARMING AT THE CROSSROADS

Dan Romey - Metlakatla Indian Community
Metlakatla, Alaska

Introduction

In 1976, the Metlakatla Indian Community embarked on a self-determination salmon enhancement hatchery program. The prime mission was to raise and release all possible species of salmon so that the adults, when returning to the hatchery, would contribute to the common fishery of Alaska and provide a terminal harvest income for the Community. The operational scope was broadened in 1984 to include the "salmon farming" concepts (Ocean net pen rearing to market size).

Metlaktla is located in the Annette Island Reserve, on Annette Island approximately 20 statute miles south of Ketchikan, Alaska and 30 miles north of the Alaska-Canadian border. This area is a "cross-road" for salmon migration. Salmon returning south or east to their origin pass by Annette Island. They include Chinook from Oregon, Washington, Idaho, Canada and Alaska.

The Community's goal was the eventual completion of a 55 million egg/fry "no-frills" brute production station that could operate profitably and consistently with a minimum of cost, effort and complexity. Funding for constructing and operating such a hatchery was appropriated through Congress and administered by the Bureau of Indian Affairs.

Construction began in 1977, and a community native fish culturist training program implemented. However, delays ensued and in 1978 a makeshift hatchery to establish brood stocks was fabricated by the fish culturists. This was accomplished by using a discontinued Coast Guard fire station complex and other salvageable materials.

Egg-take traps were also established by the fish culturists on two Annette Island streams and the resulting Pink, Chum, and Coho raised at the improvised "Annette Hatchery". The fingerling were then released into Tamgas Creek at the site of the permanent hatchery so that the adult spawners would return to the facility.

Tamgas Creek Hatchery became operational September 1980. However, due to advanced establishment of brood stocks, hatchery construction and expansion has, by necessity, continued into 1985 in an attempt to keep pace with the station's increasing salmon production.

Basic Operation

The importance of two essentials for a successful hatchery operation is continually emphasized. These are high quality water and good nutrition administered under efficacious fish husbandry practices. Equipment, Diets and methodology of only current manufacture and known effectiveness are used.

Water System

The first of the two attributes, the basic Tamgas Creek Hatchery water supply, capable of delivering 30 cubic feet per second, is gravity-fed by a 1,000 surface acre lake system. The water is of the highest quality having 13 mg/L of dissolved oxygen, 6.5 pH, and no contaminates. The minimum flow is about 15 cubic feet per second, which occurs in mid-summer and mid-winter. A selective two-intake system allows water to be drawn from the surface or an 80'-deep hypolminion. This provides a modest range of temperature selection for either accelerating or retarding fish growth. By blending both intake sources, a moderate yearly water temperature range of about 4°c to 11.5°c is possible. A more detailed record of temperature is shown in Table 1.

This high water quality is accomplished by strictly maintaining a barrier weir that prevents all adult salmon from ascending Tamgas Creek into the lake system. Thus, no micro-orginisms are carried by returning adult spawners into the hatchery's water supply. There is no other competition for water use.

Incubation

Two types of egg incubators are employed.

The Heath vertical stacks are used for Chinook and Coho and the R-48 up-well type for Pink and Chum. All eggs are water-hardened in 2 mg/L Erythromycin and disinfected in 1:150 iodophore prior to entering the incubators. Because of this and maintaining high water clarity, very few problems are encountered in egg incubation. Chemical treatment of eggs for fungus is no longer necessary, and only cold water bacteria and Trichodina in fingerling require attention. These are controlled with 4% Tm-50 in the diet and 1:5,000 Formalin pond water treatment respectively. No substrate is used in the Heath vertical stacks on either Chinook or Coho. Interlox saddles are used on Pink and Chum in the up-well R-48s but tests are underway in 1985 to assess the difference in the substrate versus none on these species.

For egg clean-up and enumeration (shock and pick) a chart based on celsius temperature, is adhered to. This minimizes subjective errors and premature shocking of eggs. Figure 2. illustrates the general temperature areas of egg development for six species of salmon.

Ponding, Feeding

The second attribute to efficient operation is good nutrition. Because of tested and known satisfactory results, the Oregon moist diet is used on Chinook and Clarks dry on Coho and Chum. They are fed in accordance with the manufacturers chart.

When ready to receive feed, the swim-up fry are first "ponded" indoors in clean-up raceways and tanks. Up to three pounds of fry per cubic foot of pond water rearing space is possible because of high water quality.

Following clean-up and start of feeding, fry are transferred outdoors into any or all of sixteen 8' X 80' concrete raceways, two concrete 20' X 150' intermediate yearling ponds or a 120' X 350" elastomer-lined advanced rearing pond. The combined rearing capacity of these ponds is about 225,000 pounds of fish. This equates to about eight million smolt, 16 million fingerling or 60 million fry.

The hatchery's two 150' X 25' concrete adult capture and holding ponds enable the station to contain approximately 10,000 spawners at any one time. In case of heavy juvenile fish loads in spring and early summer, these ponds serve as short term fingerling or smolt rearing units.

Physical Plant

Tamgas Creek Hatchery has a 50' X 80' incubation building, up to date office, its own self-contained shop facility and is capable of accomplishing over 95% of any needed machinery or building maintenance. A coded wire tagging wet lab is located in the two-story main 40' X 80' shop/office building.

The laboratory is equipped with two CWT tagging stations with space for accomodating another two.

Fish Marking

About 10% of the Chinook and Coho are usually marked with the adipose fin clip and injected with the coded wire tag. However, due to the increase in production from 500,000 Chinook and Coho smolt in 1979 to eight million in 1984, the percentage of marked fish has been reduced to about 2% to keep within operation costs. Table 2. lists the species and number of fish raised and released at Tamgas Creek Hatchery from 1978 to 1986. The ultimate goal continues to be 55 million salmonoids. Of that number, 30 million are to be Pink, 15 million Chum, 6 million Coho and 4 million Chinook.

Marked Adult Recovery

The usual recovery areas of the Tamgas Creek Hatchery's marked Coho in the commercial fishery range from Icy Straights in Alaska, south to the Queen Charlotte Islands in Canada. Table 3. shows the percent distribution by port. As may be observed, the common Alaska Commercial fishery receives more Tamgas Creek Coho then Metlakatla. Thus, the community is making its contribution to the resource as planned.

Future Expansion

By December 1985, Tamgas Creek Hatchery had reached its 55 million egg incubation capacity but can still only rear about 8 million smolt. So, to further enhance fresh water smolt production, a natural 30-surface acre lake, having comparable water quality to Tamgas Lake, is being developed into a rearing complex. When completed in 1986 it will provide space for raising an additional eight million yearling salmonoid. Concurrently, a capital improvement expansion likewise underway is scheduled to provide sea-water net pens that will accomodate about 400,000 lbs of salmon smolt. The facility is also destined for rearing salmon for the fresh fish market (Mariculture) should conditions prove favorable.

Projecting that this will materialize on schedule, Tamgas Creek Hatchery should achieve its final goal and become financially self-sufficient in 1987.

TABLE 3 DISTRIBUTION OF TAMGAS CREEK HATCHERY MARKED COHO TURNED INTO COMMERICAL FISH PROCESSORS IN CANADA AND SOUTHEAST ALASKA

RECOVERY PORT	1981	1982	1983	1984
	PERCENT SEASON CATCH	PERCENT SEASON CATCH	PERCENT SEASON CATCH	PERCENT SEASON CATCH
PELICAN	2.7	4.0	8.1	4.8
SITKA	8.6	26.0	12.6	7.6
JUNEAU	0	2.0	0	0
PETERSBURG	2.2	10.0	20.5	22.2
KETCHIKAN	49.6	29.0	22.8	33.0
CRAIG	4.8	2.0	5.6	1.5
PORT ALEXANDER	3.2	5.0	1.9	0
METLAKATLA	24.6	15.0	24.7	25.7
EXCURSION INLET	0	1.0	0.9	1.3
HOONAH	0	3.0	0.6	0.5
PRINCE RUPERT (B.C.)	4.3	3.0	2.3	3.4
TOTAL	100%	100%	100%	100%

TAMGAS CREEK HATCHERY WATER

TABLE 1 AVERAGE YEARLY TEMPERATURES C°

MONTH	MEAN	MINIMUM	MAXIMUM
JANUARY	3.8	2.6	5.2
FEBURARY	4.2	3.0	5.4
MARCH	4.5	3.6	5.6
APRIL	5.2	4.0	6.2
MAY	8.3	6.4	10.2
JUNE	10.2	7.4	10.8
JULY	10.2	7.4	12.8
AUGUST	11.4	10.0	13.0
SEPTEMBER	11.2	9.6	12.8
OCTOBER	10.1	8.2	12.0
NOVEMBER	8.0	5.3	10.5
DECEMBER	5.0	3.3	7.0

TAMGAS CREEK HATCHERY

EGG HANDLING CHART

FIGURE 2

REV. 10/07/85

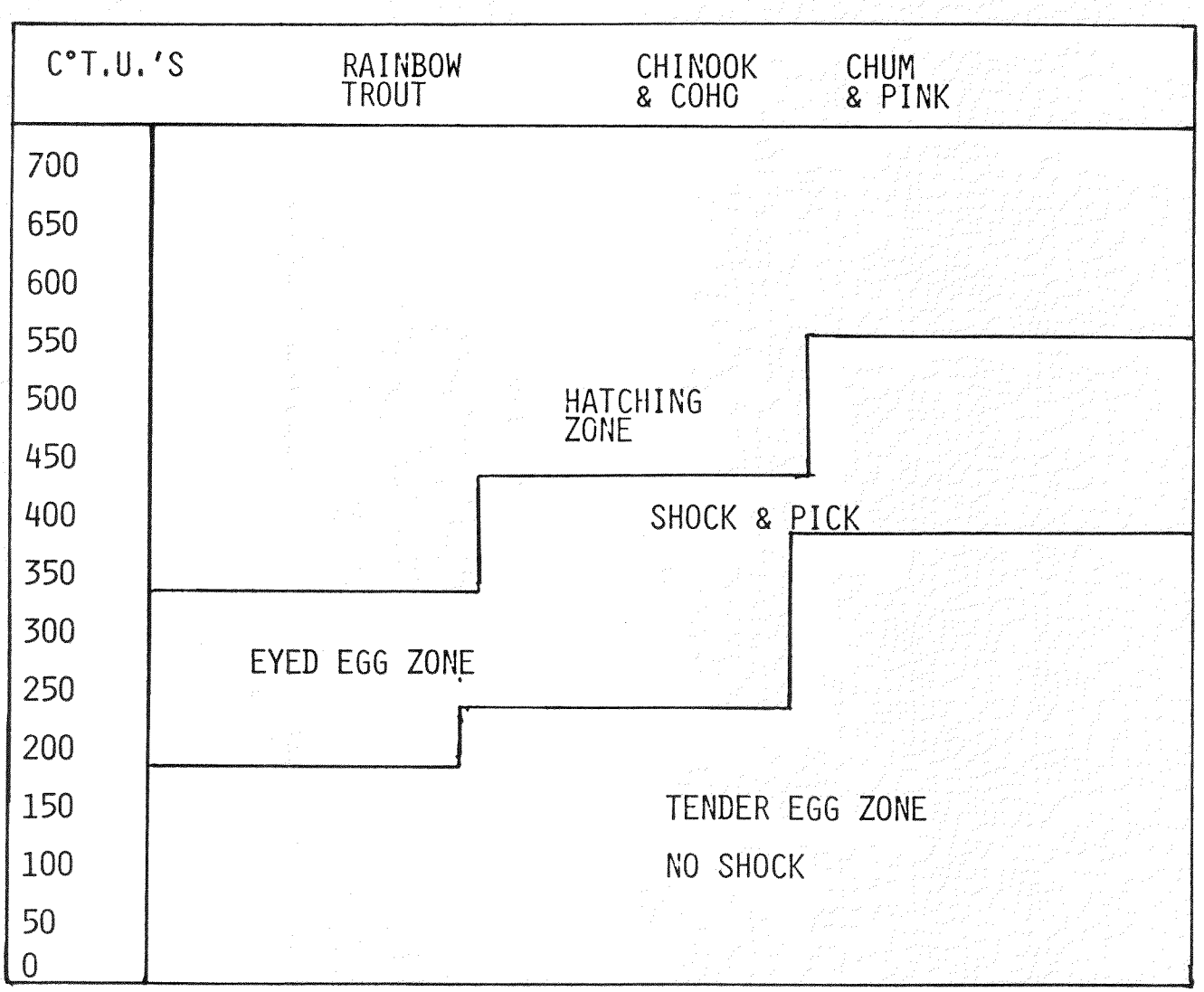


TABLE 2 SALMON RELEASES FROM TAMGAS CREEK HATCHERY
1978 THROUGH 1985

	THOUSANDS OF FISH					
YEAR	PINK	CHUM	COHO	KING (CHINOOK)	STEELHEAD	TOTAL
1978	(START OF HATCHERY PROGRAM, NO RELEASES THIS YEAR)					
1979	400.0	300.0	0	0	0	700.0
1980	110.0	560.0	46.0	0	0	716.0
1981	2,100.0	500.0	240.0	0	0	2,840.0
1982	4,700.0	340.0	341.0	0	11.0	5,392.0
1983	3,500.0	1,320.0	525.0	0	11.0	5,356.0
1984	2,700.0	2,000.0	500.0	50.0	12.0	5,262.0
1985	1,300.0	4,500.0	6,000.0	600.0	0	12,400.0
1986*	2,500.0	2,500.0	4,000.0	750.0	0	9,750.0

* STOCKS ON HAND FOR RELEASE IN 1986.

THE NEW WAY TO FISH CULTURE

Fred Norman
Fish Hatchery Manager
Puyallup Trout Hatchery
1416 14th St. SW
Puyallup, WA 98371

The first few months I had a computer a number of people asked the question - is a computer really necessary and do you use it that much? In the first few weeks, I wondered myself if I would ever get the hang of all the commands and was it that necessary. Today, it not only is worth the time learning but I have actually cut paperwork to a minimum. Don't get me wrong, the paperwork is still here but I don't have to handle as much.

Having been given an IBM-PC with a spreadsheet program and told to develop something has been a blessing in disguise for the hatchery. The spreadsheets name is Lotus 1-2-3.

Lotus is an integrated program with the ability to combine data analysis, information management and graphics in anyway your mind can think to do it.

Let me define a spreadsheet. In Lotus, it amounts to a piece of paper 56 feet long by 28 feet wide. Within this "piece of paper" are over 500,000 cells that can hold up to 9 digits in each one. Adding to this the mathematical hookups between cells you should be getting some idea as to the possibilities. Comparing this to a piece of 8 by 11 paper, it would take about 2500 pieces to match this size, and wouldn't you like to keep track of all of this.

With Lotus the task is easy to do and easy to learn, although with over 120 commands and 40 functions to learn it does take some study. One of the nice parts of most spread-sheet programs, they can be utilized while learning.

The first spreadsheet was an inventory worksheet of the hatchery ponds. When I made changes in the hatchery program, the worksheet would do the mathematical process for me. This has evolved into a massive worksheet that not only processes numbers, it also projects feed rates by water temperature, graphs the hatchery inventory by program need, graphs the density index for the ponds and writes all this information into weekly, monthly, and yearly production reports.

One other worksheet will "what if" the hatchery population as to pounds of feed needed for any period of time. It will project delta-1's needed for the best growth rate and will print out a feed schedule using that delta-1.

All this with a push of a couple of keys!

The next three pages are examples of the pond inventory program. The first page is the hatchery inventory, second page is a feed chart for the ponds and the third page is a typical feed projection for a group of fish using a 5 day feed period.

25-Nov-85	1	2	3	4	5	6	7	8	9	10	11	12	13
SPECIES	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow	Rainbow
LOT	1	3	3	3	3	3	3	3	3	3	3	3	1
PER/LB	11.1	31.5	20.9	20.7	34.5	23.3	32.7	59.0	17.1	12.7	17.4	21.1	11.1
BIOMASS	2,250	1,249	1,925	1,930	844	1,715	870	662	1,103	2,062	1,633	1,403	2,303
NUMBER	25,000	39,333	40,228	39,943	29,111	39,954	28,445	39,053	18,900	26,249	28,408	29,609	25,546
MORTALITY	0	97	43	43	46	51	61	600	73	15	54	44	11
TEMP (F)	50	50	50	50	50	50	50	50	50	50	50	50	50
%FED-CHART	1.4%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.7%	1.7%	1.7%	1.7%	2.0%	1.4%
% OF CHART	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
DAILY FEED	24	19	29	29	13	26	13	13	14	26	21	21	24
FEED SIZE	4	0	4	4	3	4	3	3	4	4	4	4	1/8
TIMES	1	1	1	1	1	1	1	1	1	1	1	1	1
PER	22.6	18.7	28.9	28.9	12.7	25.7	13.0	13.4	14.1	26.3	20.8	21.0	24.2

PONDS	14	15	16	17	18	19	20	21	22	23	24	25A	25B
SPECIES	Rainbow	Rainbow	Rainbow	Rainbow	W Sthd	W Sthd	W Sthd	Rainbow	Rainbow	Rainbow	Rainbow	W Sthd	xxx
LOT	1	1	1	3	9	9	9	3	3	1	1	9	0
PER/LB	10.2	17.7	11.1	60.0	22.3	35.7	25.5	25.7	34.9	17.0	34.0	12.5	0.0
BIOMASS	2,674	1,594	750	408	1,380	1,152	1,392	1,492	1,005	1,840	1,287	2,512	0
NUMBER	27,150	28,286	8,337	24,461	38,766	41,110	35,457	38,360	35,091	31,312	30,897	31,397	0
MORTALITY	479	309	263	21	0	22	16	18	8	185	151	0	0
TEMP (F)	50	50	50	50	50	50	50	50	50	50	50	50	50
%FED-CHART	1.4%	1.7%	1.4%	2.7%	2.0%	2.0%	2.0%	2.0%	2.0%	1.7%	2.0%	1.7%	1.0%
% OF CHART	75%	75%	75%	70%	70%	70%	70%	75%	75%	75%	75%	70%	70%
DAILY FEED	28	20	8	8	19	16	19	22	15	23	19	30	0
FEED SIZE	1/8	1/8	1/8	3	x	3	3	3	0	3	3	1/8	x
TIMES	1	1	1	4	4	4	4	4	4	4	4	4	4
PER	28.1	20.3	7.9	1.9	4.8	4.0	4.9	5.6	3.8	5.9	4.8	7.5	0.0

PONDS	25C	26A	26B	26C	27	28	29
SPECIES	XXX	Rainbow	Rainbow	Rainbow	xxx	XXX	RAINBOW
LOT	0	3	3	3	0	0	13
PER/LB	0.0	15.0	14.0	15.0	0.0	0.0	0.4
BIOMASS	0	1,363	723	1,337	0	0	6,754
NUMBER	0	20,448	10,117	20,057	0	0	2,769
MORTALITY	0	0	0	0	0	0	0
TEMP (F)	50	50	50	50	50	50	50
%FED- chart	1	1.7	1.7	1.7	1	1	1
% OF CHART	75%	75%	75%	75%	75%	70%	75%
DAILY FEED	0	17	9	17	0	0	51
FEED SIZE	0	4	4	4	0	0	10
TIMES	0	4	4	4	0	0	2
PER	0.0	4.3	2.3	4.3	0.0	0.0	25.3

50 (f)
10.0 (c)

25-Nov-85

	# totals	pd total	ave size	no.need	in hatch.		lot no.	chop ponds test	chop ponds control
LOT 1-	176,528	12,699	13.9	175,000	0	Rainbow Goldendale	3	2	10
LOT 2-	1,027,140	0	0.0	0	1,027,140	Rainbow South Tacoma		3	11
LOT 3-	507,766	21,721	23.4	460,000	0	Rainbow Spokane		4	12
LOT 4-	0	0	0.0	0	0			6	17
LOT 5-	0	0	0.0	0	0			7	21
LOT 6-	0	0	0.0	3,000	0	Rainbow Spokane		8	26 A,B,C
LOT 7-	0	0	0.0	0	0				
LOT 8-	0	0	0.0	0	0		1	14	13
LOT 9-	138,730	6,435	21.6	100,000	0	Win Sthd Chambers		16	15
LOT 10-	0	0	0.0	0	0			23	24
LOT 11-	0	0	0.0	0	0				
LOT 12-	0	0	0.0	0	0		9	19	20
LOT 13-	2,769	6,754	0.4	0	0	S Tac RB Brood			
LOT 14-	0	0	0.0	0	0		4	1	
LOT 15-	0	0	0.0	0	0				
LOT 16-	0	0	0.0	0	0				
totals-	1,852,933	47,609							

		Mon	Day	Year					
25-Nov-85	Pond 2	4	1	86 Ending date	3097 Total feed				enter
					$743 Feed Cost	¢.00/pd			0.24 <- price

Enter code number for species: 1 — 2 Enter condition factor
1 for rainbow — 1 for Idealized
2 for steelhead — 2 from past data

39,442 No. of fish

4 Daily Mortality

103.7 Current length - mm's

196 Ending length - mm's

92.3 mm's needed

127 Days of project

0.7267716 Delta L needed

0.7267716 Delta L wanted

1.1 Feed conversion

5 # of days in grow period

Enter Temp	Number of fish	Ending length	At max growth	Feed	feed ea day	Fish per pound	Pounds of fish	% Pond Density
51.2 30-Nov-85	39422	107	107	146.6	29.3	28.9	1363.6	0.65
51.2 05-Dec-85	39402	111	111	156.7	31.3	26.2	1506.1	0.70
51.2 10-Dec-85	39382	115	115	167.2	33.4	23.8	1658.1	0.74
51.2 15-Dec-85	39362	118	119	178.0	35.6	21.6	1820.0	0.79
51.2 20-Dec-85	39342	122	123	189.2	37.8	19.8	1992.0	0.84
51.2 25-Dec-85	39322	126	126	200.7	40.1	18.1	2174.4	0.89
51.2 30-Dec-85	39302	129	130	212.5	42.5	16.6	2367.6	0.94
51.2 04-Jan-86	39282	133	134	224.7	44.9	15.3	2571.9	0.99
51.2 09-Jan-86	39262	136	138	237.1	47.4	14.1	2787.5	1.05
51.2 14-Jan-86	39242	140	142	249.9	50.0	13.0	3014.7	1.10
51.2 19-Jan-86	39222	144	145	263.1	52.6	12.1	3253.9	1.16
51.2 24-Jan-86	39202	147	149	276.5	55.3	11.2	3505.3	1.22
51.2 29-Jan-86	39182	151	153	290.3	58.1	10.4	3769.2	1.28
51.2 03-Feb-86	39162	155	157	304.4	60.9	9.7	4046.0	1.34

FISH COUNTS 25-Nov-85

Pond Number	Pounds counted	Number Counted	Per Pound	Number of fish	Pounds to feed	Number of times	Length in mm's	Pond Factor
1	2.25	25	11.1	25,000	23.6	1	0	0.000
2	1	31.5	31.5	39,430	18.7	1	103.7	1.270
3	1	20.9	20.9	40,271	28.9	1	119.4	1.240
4	1	20.7	20.7	39,986	28.9	1	119	1.260
5	1	34.5	34.5	29,157	12.7	1	101.4	1.230
6	1	23.3	23.3	40,005	25.7	1	118.4	1.140
7	1	32.7	32.7	28,506	13.0	1	102	1.270
8	1	59	59.0	39,652	13.4	1	83.4	1.290
9	3.5	60	17.1	18,973	14.1	1	122.8	1.250
10	2.75	35	12.7	26,264	26.3	1	122.8	1.200
11	5	87	17.4	28,462	20.8	1	117.7	1.200
12	3.6	76	21.1	29,653	21.0	1	112.6	1.170
13	5.5	61	11.1	25,557	24.2	1	144.7	1.240
14	6.5	66	10.2	27,629	28.1	1	139.4	1.320
15	3.1	55	17.7	28,595	20.3	1	134.2	1.190
16	2.25	25	11.1	8,600	7.9	1	145.6	1.230
17	1	60	60.0	24,482	1.9	4	81.4	1.060
18	1	22.3	22.3	30,766	4.8	4	0	
19	1	35.7	35.7	41,132	4.0	4	103.7	1.080
20	4.2	107	25.5	35,473	4.9	4	115.9	1.100
21	2.8	72	25.7	38,378	5.6	4	82.7	
22	1	34.9	34.9	35,099	3.8	4	101.4	1.210
23	4.7	80	17.0	31,497	5.9	4	107.2	1.160
24	3	72	24.0	31,048	4.8	4	107.1	1.170
25A	2	25	12.5	31,397	7.5	4	0	
25B	0	0	0.0	0	0.0	4	0	
25C	0	0	0.0	0	0.0	0	0	
26A	1	15	15.0	20,448	4.3	4	121	1.190
26B	1	14	14.0	10,117	2.3	4	122.5	1.240
26C	1	15	15.0	20,057	4.3	4	119	1.230
27	0	0	0.0	0	0.0	0	0	
28	0	0	0.0	0	0.0	0	0	
29	1	0.41	0.4	2,769	25.3	2	0	

The Computerized Hatchery Optimization Porject (CHOP)

FIRST YEAR RESULTS (PHASE I)

by
Donald L. Chase
Fish Management Division
Washington Department of Game

ABSTRACT

Production of salmonid game fish under intensively managed conditions is a complex task. Management must define production goals of the aquacultural system. Production forecasting requires detailed records of fish production and good inventory techniques. Costs associated with producing fish are increasing while monetary returns are not.

Results from CHOP Phase I show that microcomputers and production programs are welcome productivity tools and do fit well within the hatchery environment. An average 20% food was saved, most production goals were met, and a 96% accuracy of predicting fish growth (length) was obtained.

INTRODUCTION

Production of salmonid game fish under intensively managed conditions is a complex task. "Intensive", in that a high degree of management is required, and "complex" in the way the production data are collected, stored, retrieved and evaluated. Fifty-six factors have been identified that can affect the productivity of raising salmonids (Klontz et al. 1979). These factors are interacting, dependent and independent, biotic and abiotic, and when operating together constitute a functional aquaculture system. All these factors can be grouped into the five components of raising salmonids, namely, fish, water, container, nutrition, and management. Such is their interrelationship that changing one factor of one component can bring about a series of changes through the entire system. The net effect of this cause and effect relationship is a change in the growth rate of the fish. The system remains in this state until another change is introduced (Klontz, 1982).

Management has the responsibility to control the various factors and their interactions in an aquacultural system to assure optimum production. To attain optimum production, production goals (i.e. product definition) must be defined. The product definition consists of setting criteria which define the goal(s) of the system. These criteria include the species of fish, quality of fish, size of fish to be produced, number of fish required, and the desired release date (Klontz 1982). Once the product definition is established, input variables and subsequent interactions of the aquacultural system such as growth rates, percent body weight to be fed, space and water requirements can be defined. This process of defining the system and management objectives is called production forecasting.

To adequately employ production forecasting, detailed records of fish production must be kept. Records of feed consumption, water flow, biomass in ponds, mortalities (including assessments of cause), water temperature, numbers of fish on hand, and maintenance and operations costs are necessary, not only for production forecasting, but for cost-effective operation of the aquaculture system.

METHODS

Four Washington Department of Game hatcheries, Aberdeen, Chelan, Puyallup, and Shelton, and two auxillary hatcheries, Beaver Creek and Skamania have been identified as participants in the Computerized Hatchery Optimization Project (CHOP). The hatcheries were selected from others by the following factors, (1) program size; (2) species produced; (3) location; and (4) hatchery manager interest. IBM Personal Computers and associated software were installed at each participating hatchery facility. Each microcomputer was installed with the followig hardware: 256K of RAM memory, two double-sided double-density 5 1/4" disk drives, a monochrome monitor, 80 column dot matrix printer, and a 300/1200 baud modem. Software included the Microsoft Disk Operating System (MS-DOS vers. 2.0), Lotus 1-2-3 spreadsheet, COMPACT (COMputer ACTivities) aquacultural software, and the K-Factor programs. Other software such as a word processor (PC-Write), database manager (PC-File), and communications (PC-Talk III) were added later as the manager and hatchery staff became more familiar with the computer.

CHOP was divided into three distinct "phases" (I, II and III) each associated with an aquacultural production year. There also existed a "Phase 0" which was considered the installation, and introduction period. Each phase is defined below:

1. CHOP Phase I, June, 1984 through June, 1985. During this phase a "sub-lot" of fish was created from a lot of fish. This sub-lot was then split into two (2) even groups, one group with "study" group, and the other "control" group. One rearing unit (i.e. trough, deep tank, circular pond, raceway, etc.) per study and control group was designated as being "on program" per hatchery. The "on-program" groups of fish were held from fry to scheduled release. Both groups of fish were fed commercially available diets that are presently being used at each hatchery. The control group was fed according to the hatchery manager's recommendations, whereas the study group was fed according to the computer program's recommendations. Both study and control groups were inventoried using the three methods described later, every 14 days. Information gathered from each inventory was entered into the computer.

   CHOP Phase I is designed to evaluate (and modify if necessary) the following: (1) the models used in growth projection; (2) the aquacultural production computer software; and (3) the hardware, support and training.

2. CHOP Phase II, June, 1985 through June, 1986. During this phase, half of all hatchery production will be considered the study group, and the remaining half as the control group. The study group will continue to be fed according to the computer program's recommendations. This phase is designed to evaluate the day-to-day operations and use of the computer in aquaculture.

3. CHOP Phase III, June, 1986 through June 1987. During this phase, if CHOP Phase II is a success, all of the hatchery production at the participating hatcheries will be done using the computer. Plans will be made for limited implementation at other WDG hatcheries.

RESULTS

The overall objective of CHOP is to determine the applicability of microcomputer production programs in "conservation" fish hatcheries. Since this objective is rather broad, several sub-objectives have been created to meet the main objective. Each objective (1-6) of CHOP is described, along with results to date.

Good inventory techniques are also necessary for good hatchery management. The two most common methods of growth assessment consist of estimating the number of fish per weight unit, or estimating the average length of fish in a population (Klontz 1982). This estimation of a population parameter is in all likelihood the most significant error in any aquacultural facility. Generally, less than 1% of the population is sampled, and the inventory data are expanded to represent the entire pond or hatchery. Inventory data can be used for estimating the number of fish or weight of a population, feeding calculations, carrying capacity calculations in rearing units, drug applications for disease control, and stocking of fish. Administrative uses of inventory data include preparation of annual reports, budgeting, feed ordering, estimation of production capabilities (rearing units or total hatchery production), and fish distribution (stocking) plans (Piper et al. 1982).

In addition to the management requirements, the costs associated with producing game fishes are increasing, while monetary returns (license fees and sales) are not. The cost of producing game fish for public sport fisheries is paid for by the public through a variety of ways (license sales, taxes on sales of sporting goods, and/or public taxes). In the state of Washington, the costs of producing salmonid game fish (trouts, chars) are paid by the public through hunting and fishing license sales and by mitigation or federal assistance. Washington Department of Game (WDG) data indicate that revenues from license sales have remained relatively unchanged for the last four years (Washington Department of Game 1983), however, the cost of producing salmonid game fish has increased.

Fish culture personnel have done remarkably well in the past in meeting production goals within financial limits, but this is becoming increasingly difficult to realize. Hatchery facilities often have been operating at, or exceeding, the limits of the aquacultural system to remain within the operating budget. This has often resulted in poor quality fish, high fish rearing costs, and/or reduced numbers of fish stocked. Therefore, in order to meet fish production demands and cost limitations, it is imperative that WDG hatcheries, and other conservation hatcheries, make the best possible use of their operating dollars and hatchery facilities.

Production forecasting is not a technique that is unique to aquaculture. The food animal production industry (beef, pork, poultry) have been using computerized production forecasting with success. Different models are used but the concepts are the same. In aquaculture, computerized production forecasting techniques are just beginning to be implemented, particularly in the private sector with catfish farming.

In summary, production forecasting integrates data on component parts of the system (i.e. fish, water, container, feed, and management) to determine how to best meet the production definition. In addition, production forecasting will allow the culturist to improve and/or reduce the variance of condition factors (length - weight relationship) of fish, and improve the documentation of all aspects of rearing and release of fish.

OVERALL DISCUSSION

From the above results it should be noted that the main objective of "the applicability of microcomputer production programs in conservation hatcheries" is a success. Expectations were either met or surpassed for all subobjectives. More work needs to be done in all areas.

CHOP Phase II will undoubtedly create larger and more various programs so that this work can be completed. CHOP Phase I should still be considered as an "educational" and "adjustment" year, rather than as a year for conclusion. The results do point towards an exciting upcoming year and perhaps even better results, but only after more work.

The only conclusion that can be made from this first year of CHOP is that microcomputers and production programs are welcome productivity tools and do fit well within the hatchery environment. Ask any CHOP hatchery manager if he is willing to "give up" his computer and you will get a resounding "NO". This in itself is an achievement.

Finally, I want to especially thank all of the CHOP hatchery managers (Bob Paulsen, Aberdeen hatchery; Denny Fryberger and Rick Stilwater, Chelan P.U.C. hatchery; Fred Norman Puyallup hatchery; and Larry Barger, Shelton hatchery), and their staffs for making this first year a success. Many fish were counted and weighed, many program "bugs" gave them problems, but they made it happen. I hope they keep up the good work and keep WDG Fish Management Division Hatcheries at the forefront in aquaculture. I also thank Fish Management Division and WDG Administration for keeping this project "alive".

DEGENERATIVE CHANGES IN KIDNEYS OF OVERRIPE, UNSPAWNED FEMALE TROUT

Beth MacConnell
Fish Technology Center
U.S. Fish & Wildlife Service
Bozeman, MT

This past summer we experienced chronic mortality in two-year-old female Colorado cutthroat trout. Since we had no need for the eggs, these fish had not been spawned. Mortality only occurred in unspawned, overripe females. Although bacterial gill disease was diagnosed and fish were treated, mortality in females persisted. A few fish were collected for histological examination. Degenerative changes were seen in the kidneys of these fish. Twenty moribund females were then sampled for hematocrit and plasma protein determination and histological examination.

Blood samples revealed elevated plasma protein and hematocrit levels. Plasma protein averaged 6.9 g/100 ml, with a range of 3.5-10.8 g/100 ml. Normal plasma protein levels are 2-6 g/100 ml. Hematocrits averaged 74%, with a range of 40-97%. Normal hematocrit levels in trout are 30-45%. Histological examination of tissue from moribund fish demonstrated severe pathological changes in kidney tubules resulting from apparent increased absorption of egg yolk protein in tubule epithelial cells. Similar changes were not seen in males.

Examination of kidneys from moribund unspawned, overripe female rainbow trout in transit from Idaho to California, submitted by Bob Toth, California Fish & Game, showed the same pathological changes. This points out the importance of stripping eggs from females even though they are not needed.

CONNOR LAKE CUTTHROAT TROUT PROGRAM

Peter Brown
Fisheries Branch
B.C. Ministry of Environment
Kootenay Trout Hatchery
Wardner, B.C. V0B 2J0

For the past 15 years, Connor Lake has provided almost all of the cutthroat trout eggs for the interior cutthroat stocking program in British Columbia. The lake system, located in southeastern B.C., is tributary to the Elk, then Kootenay, then Columbia Rivers. Although the system has three closely spaced lakes, only the largest lake contains sufficient numbers of fish to warrant our operation.

This relatively inaccessible lake, located at an elevation of 6,200 feet, was historically barren of fish. It was stocked only once, in 1950, with 50,000 cutthroat eggs from Kiakho Lake, the province's source of cutthroat eggs from 1923 to 1970. Connor Lake has since been self-sufficient in its reproduction of its trout population. The fish are described as westslope cutthroat (Salmo clarki lewisi) by McAllister et al. (1981).

The lake was first used as an egg collection site in 1970 and although it was operated on an annual basis from then until 1976 it has since been run only in alternate years. This is due to our fisheries managers' decision to stock cutthroat every second year in our high elevation, low productivity lakes. Although Connor Lake's population declined both in size and in numbers in the late 1970's and early 1980's, with the implementation of more strict fishing regulations both factors appear to be back to a more normal situation. The total annual spawning population is 1500 to 2000 fish. The adults are 3 to 4 years old at maturation, ranging from 29cm to 39cm with a few smaller precocious males. Females produce an average of 1100 eggs.

Egg collections have ranged from 176,000 to 665,000 in a season depending upon biologists' requests for fish. We now consider eyed egg losses in the range of 5% to be normal, a vast improvement over much higher losses experienced in the early years of the operation. Factors leading to this improvement include refinements to our spawning, transportation and incubation techniques.

Fertilized eggs are flown from the lake the same day they are collected. They are received, incubated, hatched and reared at the Kootenay Trout Hatchery. The eggs are incubated at 7°C to 8°C with hatching occurring in about 40 days. After being fed for 3 to 6 weeks on Silvercup salmon diets, the fry, now at 7000 to 2500 per Kg, are distributed into high elevation lakes, i.e. between 5000 and 8000 feet, and into some river systems. Between fifty and one hundred lakes and rivers are stocked with the fry and produce some excellent angling opportunities for those ambitious enough to travel to the mostly isolated areas.

Reference

McAllister, D.J., F.W. Allendorf, S.R. Phelps. 1981. An anlysis of the native and resident cutthroat trout (Salmo clarki) in the Bow, Kootenay-Columbia and Waterton River systems. 98 pp.

GENETICS OF FLESH COLOR IN CHINOOK SALMON

Gordon Berezay, Canada Department of Fisheries & Oceans

The flesh color of most fish is white, whereas the flesh of most Oncorhynchus and Salmon, range from a pale orangy white to red. The exception is the white fleshed chinook (O. tschwytscha) of British Columbia. The reddish pigmentation is due to deposition of carotenoids specifically the xanthophylls, which are carothenoids which have oxygen molecules in their structures. The storage of carotenoids in the muscle and even the skin and fins of the Salmonidae, is quite unique among fish and thus one would assume it must play a vital role in these species.

The carotenoids are fat soluble compounds synthesized by plants and vary in color from yellow and orange to red. Fish cannot synthesize carotenoids, but ingest them through their diet, especially crustaceans, such as shrimp and crabs. Because the carotenoids are fat soluble, they are lumped in the lipids.

In many fish they are a component of the chromatophores, which are the pigment containing or producing cells. These cells contain lipid droplets which have the pigment molecules bound up in them. The red stripe on rainbow trout and the coloration of Artic Char (the yellow and red) are produced by these cells. The coloration patterns are under nervous control in the fry and provide protective coloration patterns. In brook trout exposed to a light background and then exposed to a dark background, they move carotenoids from the flesh to the skin. This process is reversed when exposed back to a light background.

The sexual coloration of the adults is most likely under hormonal control and a secondary effect of carotenoid metabolism amd mobilization. In the spawning adults the coloration of the skin is due to the movement of the carotenoids from the muscle to skin, especially in the sockeye salmon. The Salmonids display various coloration patterns during spawning and this may be important in insuring proper specie identification when more then one species is spawning in the same area and at the same time and/or function in courtship.

The muscle, liver and the kidneys act as storage depots for the carotenes, and it appears that carotenes in the kidneys are important constituents in calcium absorption of saltwater adapted salmon.

I assume that the coloration patterns of spawning adults is a secondary benefit of carotenoid use by the Salomonidae, as the carotenoids are linked with very important metabolic roles, which are only now being defined. Beta carotene is the precursor for vitamin A, which is necessary for proper early organ, bone, integument, nervous system development and growth for many species of animals and it is found abundantly in salmon, thus I assume that it plays a similar role in early fry development. Provitamin A may be linked to the protective mucous coating of fish, and it is assumed that it functions as a stabilizing agent for the mucous by minimizing its breakdown. Recent biochemical studies indicate that the salmon have the ability to convert non-precursor vitamin A carotenes to the beta carotene precursor of vitamin A.

All salmoniods lay carotenes down in the egg yolk, which gives the egg its characteristic color. Carotenes are necessary for proper embryo development and increase growth and survival of young fry. In the adult, carotenes are necessary during gonad maturation to insure proper maturation and for egg quality. A carotene rich diet may be necessary to insure embryo survival and hatchability of the eggs. Other species have been found to suffer higher mortality rates during embryo development, if the female was reared on a low carotenoid diet and they had lower growth, maturation rates and fecundites, but this has not been carried out in salmon to date.

During the chum salmon freshwater migration, especially as gamete maturation reaches the final stages, astaxanthin is mobilized from muscle tissue and is found in the blood plasma and is laid down in the gonads and the skin. As well, astaxanthin is converted to several other carotenoids, which presumably play a role in the proper deposition of raw materials in the yolk.

PROPOSED METABLOIC PATHWAYS

ASTAXANTHIN

ADONIXANTHIN

B-CAROTENE VITAMIN A

ZEAXANTHIN

Astaxanthin is the xanthophyll in the flesh of the Salmonidae which gives the fish its red color. Other xanthophylls, such as lutein, give the flesh a yellowish coloration (the yellow color of chicken eggs is due to the high lutein concentration), and is found in many freshwater species. In fact there can be at least fourteen carotene/ xanthophylls present in the flesh of the Salmonidae, of which six are pigments. Zeaxanthin is a reduced form which has lost most of its oxygen molecules, and thus will give a pale or yellowish color to the flesh.

The coloration of the fishes muscle varies with the pigment that it receives in its diet. These may be laid down in the muscle directly, depending on the physical form that they are ingested as, and on genetic factors controlling the metabolism of the basic carotene/ xanthophyll and thus the final pigmentation of the flesh.

PROPOSED GENETICS OF FLESH COLOR

In B.C. the occurence of red and white fleshed chinook salmon has been recorded in the commercial fisheries for the past 20-30 years, as the fishermen have received a higher price/lb. for red fleshed chinook. These records indicate that there is a substantial portion of the chinook that are white fleshed (about 15-35% of the catch). It is also believed that there are no white fleshed chinook south of Canada, except some Puget Sound stocks, thus B.C. is the southern range of this stock. It has always been recognized that both red and white fleshed chinook are found in the main watersheds of B.C., the Fraser, Skeena and Nass Rivers, but the occurence in specific spawning populations was not well documented.

RIVER	% RED	% WHITE
NASS	78	22
SKEENA	87	13
FRASER	64	36

Godfrey proposed that the two flesh colored chinook were genetcally distinct, seperate races. Apart from flesh color he assumed that there was a spatial and temporal seperation of the spawning stocks in the Fraser system. He felt that the Harrison and lower Fraser River stocks were white fleshed and spawned in September through October, and that the upper Fraser and Thompson River stocks, were red fleshed and spawned in June and July. As well there was always a large population of white fleshed chinook caught off the west coast of Vancouver Island with a considerable degree of uniformity of numbers and timing from year to year.

Much of this data is from biological sampling of chinook caught in the index test fisheries for sockeye, thus the samples are small and may not truly representative. As well commercial records are not representative of specific populations.

With the advent of the Salmonid Enhancement Program (SEP), brood stock collection on many individual rivers has shown that in many rivers there are both white and red fleshed chinook spawning together, although the red population is generally dominant. Very few rivers have totally red fleshed stocks, as often there are some whites present.

This relatively new data would indicate that the white fleshed chinook is found throughout the spawning area of B.C. In general, this pattern of dominantly red fleshed chinook holds for most river systems in B.C., with the exception of the Harrison, Lillooet, the Kibella and Chuckwalla Rivers of Rivers Inlet and the Ecstall River which empties into the Skeena estuary. In fact the dominantly white fleshed stocks originate in rivers that have very limited freshwater rearing area, and it is most probable that the fry smolt in estuary.

The Eagle, Salmon and Shushwap Rivers of the Thompson drainage are totally red fleshed, as is Slim Creek, the Horsefly, Baezaeko Sebach, Willow and Swift Rivers of the Fraser River. River systems such as the Quesnel, MacGregor and Chilko of the Upper Fraser and the Atnarko River of the Central coast of B.C., have about 60% white fleshed and 40% red fleshed chinook. This is also true of the Kitsumalum River and possibly of the Morice River of the Skeena system. The white fleshed proportions on the Upper Fraser River are most likely biased, as the white fleshed chinook appear to enter the rivers earlier. Brood stock collection continues only until we reach our egg quotas, thus we are not sampling all of the red population. It is possible that the red proportion is as great or slightly greater than the white proportion.

% RED AND WHITE FLESHED CHINOOK,
OF VARIOUS B.C. STOCKS

RIVER	% RED	% WHITE
CARIBOO	76	24
QUESNEL	38	62
CHILKO	32	68
BLACKWATER	93	07
BAEZAEKO	86	14
NAZKO	97	03
BOWRON	97	03
WILLOW	100	
SEBACH	100	
SWIFT	100	
HARRISON		100
BIRKENHEAD		100
ECSTALL		100
CHUCKWALLA		100
KIBELLA		100

One of the mandates of SEP is to maintain the genetic integrity of the stocks and as it was believed that there was a race difference, we felt that we should cross red fleshed and white fleshed adults from the Quesnel River, separately. These two supposedly separate species spawn in the same area and their timing overlaps, thus are they genetically separate?

There are several characteristics of the adults that make them quite distinguishable. The color of the skin, flesh, eggs and the sperm are very different. Two short dives indicate that the white fleshed adults appear to pair together, separate from the red fleshed chinook. It is very easy to identify the two stocks underwater, thus it may be possible that pairing is done by visual cues.

It is proposed that the genetic uniqueness of the red fleshed and white fleshed chinook salmon, is a function of inheritance of an enzyme system which allows red fleshed chinook to lay the carotenoids down in the muscle tissue (Ruth Withler, PBS, Nanaimo) White fleshed chinook may have reduced the carotenoids and thus eliminated them or laid them down in another form, which is colorless.

Ruth has carried out three years rearing experiments of offspring of white and red fleshed parents, and proposes the following genetic loci, with two alleles each, and at least one red determing allele is necessary at each loci, for the deposition of the carotenoid pigment in the muscle.

AaBb = red flesh

aaBB = white flesh

It is possible for a W X W cross to produce red fleshed offspring

aaBb X Aabb = aaBb (W) :aAbb (W) :aabb (W) :aABb (R)

and for a R X R cross to produce white fleshed offspring.

AaBb X AaBb = AABB (R) :AaBb (R) :aAbB (R) :aabb (W)

Her study indicates that white fleshed chinook are predominant, as the RED:WHITE ratio is 1:1.1. Whether this genetic model holds for all mixed stocks is unknown. It does not answer the question of whether or not these chinook are genetically seperate stocks.

I carried out two dives on the river during spawning and it appears that the white fleshed adults spawn together as do the reds. As well it appears that the white fleshed chinook arrive at the spawning grounds a few days earlier than the red fleshed chinook. This may also be due to the possibility of selective spawning, by bringing in a partial temporal separation. The red color or lack of it, is very distinct underwater, thus the pairing of adults could be done by visual cues.

If there is actually selective or authoritative spawning, then I assume that there is some adaptive advantage for the two fleshed colored stocks to do so. It is possible that the genes controlling flesh color could be linked with other genes that give them an advantage when certain enviromental factors come into play or advantageous behavioral patterns are employed, to preserve the stocks.

Ken Pitre has proposed that the white fleshed fry smolt in the estuary. The totally white stocks occur in rivers, which have virtually no freshwater rearing areas and must smolt in brackish water, or at least utilize behavioral patterns that allow them to reach the smolting stage in the estuary. The up river white fleshed stocks may move downstream faster or more actively, than their red fleshed siblings, which may move down more passively. This behavior pattern would tend to moderate the utilization of the freshwater food supply and also moderate their impact on the estuary.

Circumstantial evidence for the different timing use of the estuary is that there is an influx of chinook fry into the Fraser River estuary in May-June and again in September. This behavior would also allow maximum use of the estuary as presumably the later arriving red fleshed fry would have it available to themselves.

Other observed differences between the white and red fleshed chinook which spawn upriver, are observed in their timing of entering freshwater. The Birkenhead River, which is tributary to the Lilloet Harrison system, is a totally white stock, and is taken in the food fishery in February. As well the percentage of white fleshed chinook captured in the Fraser River test fishery does not explain the numbers that are found spawning. The test fishery begins in early April, thus the white chinook must be entering before the red fleshed chinook.

I feel that these bits of information should be studied more fully as there are enough different factors present to indicate that the white and red fleshed chinook, may be genetically different or at least they may utilize very different behavioral patterns.

THE INCIDENCE OF APPARENT STRAYING AMONG CHUM SALMON STOCKS REARED AT SNOOTLI CREEK HATCHERY, BRITISH COLUMBIA

Presented by:
E.W. Britton
Department of Fisheries & Oceans
1090 W. Pender St.
Vancouver, B.C.

Maturing chum salmon may stray to non-natal streams. For enhanced stocks, the degree of apparent straying may be affected by enhancement strategy. Snootli Creek Hatchery, located on a tributary of the Bella Coola River, on the central coast of B.C., serves as a central enhancement facility for several local stocks of chum salmon. Broodstock is captured at weirs located on each river. Eggs and fry are cultured as discrete stocks and, after a variable period of rearing at the hatchery, are released back into the natal stream. Recovery data for fin-clipped groups are summarized. From 10 brood year - stock combinations, 78-100% of each brood returned as four year olds. Straying among 4 year olds was 42.3% (standard error, 8.5). Straying to rivers outside the Bella Coola River system accounted for 20% of total apparent straying, equivalent to 6.4% of estimated hatchery escapement. Of strays captured within the Bella Coola River system, 82% were captured in tributary streams downstream of the release streams and 18% were captured upstream. Apparent straying was negatively correlated with increased size of the juvenile chum at time of release (linear regression). Straying as reported here is calculated from chum captured in weirs. It is documented that salmon have successfully located and spawned in natal streams having previously acsended other streams during the course of migration. Apparent straying to systems with weirs therefore, may be higher than the degree of straying under natural conditions.

THE USE OF HORMONES IN SALMON BROOD STOCK MANAGEMENT

Martin S. Fitzpatrick and Carl B. Schreck
Oregon Cooperative Fishery Research Unit
Oregon State University
Corvallis, Oregon 97331

Hormones can be used in hatchery situations for various purposes, including the acceleration of maturation in brood stock. The following scenarios may provide a need for acceleration of maturation:

1. Avoidance or prespawning mortality--this may be a major concern for management of hatchery populations of chinook salmon;

2. Enhancement of the growth potential of offspring, i.e. allow a slightly longer rearing time;

3. Synchronization of egg stripping;

4. Maturation induction of uncooperative animals.

Hormones control many aspects of reproduction in fishes, such as growth and development of the eggs and sperm, color of the skin, and behavior. Steroid hormones directly affect the development of the eggs and sperm; however, steroid hormone secretion is controlled by gonadotropic hormone (GtH) secreted from the pituitary gland and GtH release is controlled by releasing hormones such as luteinizing hormone-releasing hormone (LH-RH) from the hypothalamus. The application of exogenous hormones can accelerate maturation. By treating a fish with an analog of LH-RH (LH-RHa--the analog is used because it is superactive), we can artificially stimulate the secretion of GtH, which will cause the release of the steroids necessary for the completion of sexual maturation.

The following equipment is necessary for a maturation-acceleration program: LH-RHa (available from many vendors); sterile saline; syringes or an ovijector; needles; anesthetic; and 95% ethanol. The LH-RHa is dissolved in sterile saline (we recommend a dose of about 2.0 pg/kg body weight) and this solution is then delivered into the abdominal cavity of the fish with either syringes or ovijectors. The fish is first anesthetized and then injected--it is critical that the needle be inserted at an angle that does not puncture the eggs mass. The point of injection is generally between the vent in and the pelvic fins. After each injection, the needle should be swabbed with 95% ethanol. The injection procedure is usually repeated 2-3 days later to maximize the effect of the hormone. The cost associated with the materials required for a maturation-acceleration program is about $0.50 per fish (cost will vary dependent on number of fish treated and dose used).

Working with coho salmon in 1982, we found that within 13 days of injection, between 84% and 91% of the females receiving two injections spaced 3 days apart had ovulated compared to 45% of the saline-injected controls (Fitzpatrick et al. 1984, Aquaculture 43: 67-73). This past fall (1985),

the treatment was used on a production basis at a hatchery. Within 18 days, 62% of the coho had ovulated wheras only 19% of saline-injected controls had ovulated. This year we also treated chinook salmon and found that 62% of the LH-RHa-treated females had ovulated within 13 days compared to 27% of uninjected females. In general, salmonids appear to be sensitive to treatment with LH-RHa at about 4 weeks before normal spawning time.

There are limitations to treating fish with LH-RHa:

1. There appears to be a decrease in the average viability of eggs in hormone-treated fish. This does not appear to be a "general" phenomenon, i.e. the egg viabilities from the whole population do not drop; rather, there are a few females that produce eggs of extremely low viability which is sufficient to lower the average viability of the whole population. This effect may actually be independent of the hormone treatment but related more to the ability to judge that a fish is ready to be spawned.

2. Disease transfer can take place unless precautions are taken to sterilize the needle after each injection.

3. There are limits to how far a female can be advanced. In our best result to date, coho salmon were advanced on average by 24 days.

4. There appears to be a "time-window" of sensitivity--unless fish are sensitive to LH-RHa, spawning will not be advanced. In 1984, we studied the effect of timing of injection. Coho salmon which were treated on 16 October did not respond on average any better than saline-injected controls. However, if we injected females from the same original population one week later, we accelerated maturation.

In summary, LH-RHa can be used effectively and economically to accelerate maturation in salmon; however, experiments should be set up to determine the best time to inject, most effective dose, and number of injections.

EVALUATION OF A METHOD FOR INCUBATING EGGS IN A MOIST INCUBATOR

Matt Foy - Canada Department of Fisheries & Oceans

Fish culturists have long recognized that salmonid eggs are tolerant of long periods of exposure to the air if they remain cool and moist. For example, a common method for transporting eyed eggs is by means of an insulated, waterless container in which a moist environment is maintained by the damp gauze or other water-saturated material. A film of water covers the eggs, which prevents desiccation and enables transfer of oxygen and metabolic waste products. An occasional rinse is necessary to remove accumulated waste products if transport time is lengthy. The concept of the moist incubator is based on this principle.

Simply described, the incubator is a water-tight box containing eggs in shallow, perforated trays. Controlled by an automatic timer, it fills with water and immediately drains at 4 - 8 hour intervals. Just prior to hatching, eggs are transferred to a conventional incubator to satisfy the requirement of alevins for total immersion.

Two variations of the moist incubator were assessed using 1984 brood chum and chinook eggs. At the Bella Bella C.E.D.P. Project, a single-pass, gravity-supply system was installed. At the Fort Babine C.E.D.P. Project, a 150 l capacity re-use system, utilizing a bilge pump powered by a 12-volt rechargeable battery, was installed. Clinoptilolite and charcoal filters were incorporated into the re-use system to remove metabolites.

The survival rate of 50,000 chum eggs to the advanced-eyed stage was 97.5% for the moist incubator at Bella Bella. Comparative results for control groups in Atkins and Heath-type incubators were 96.6% and 96.7% respectively. At Fort Babine, the survival rate of 17,000 chinook eggs to the advanced-eyed stage was 94.5%. No controls were conducted at the latter project site.

If further evaluation indicates that the moist incubation technique is feasible, it may have special application in situations where:

- advancing or retarding the rate of embryonic development is desirable. Since small volumes of water are involved, the energy cost of regulating water temperature is minimal.

- silting problems associated with fall-water freshets are a deterrent to operating a conventional incubation system.

- hatchery facilities are at a remote location and it is an advantage to incubate eggs off-station for reasons of cost, convenience or security.

- therapeutic chemical treatment of eggs over an extended time period is desirable, but too costly in the case of conventional incubators.

EFFECTS OF BACK-PACK ELECTROSHOCKERS ON INCUBATING CHUM SALMON EGGS

The increasing use of back-pack electroshockers to capture brood stock prompted a study to determine the effects of pulsed direct current on salmon eggs incubating in spawning gravel, although it is known that eggs and sperm are viable when obtained by this brood stock capture method.

In January 1983, four small bucket incubators, fed by low-conductivity 10°C ground water were installed at Inch Creek Hatchery to test the effects of electroshocking at various stages of larval development. Approximately 1300 eggs were planted in each incubator and covered with 25 cm of gravel. Eggs and sperm were pooled prior to fertilization and planting. Flow was maintained at 1.5 U.S. gpm in each incubator. Electroshocker output was 850 volts, 0.15 amps, 72 Hz, 4.8 ms, 10 sec. duration, 127.5 watts. Eggs were examined at 350 ATU's. Results were the following:

Shock Treatment	No.Eggs	No.Dead	% Mortality
Control (unshocked)	1,333	107	8.0
2 hrs. after fert.	1,281	137	10.7
90 ATU	1,383	893	64.6
280 ATU	1,312	86	6.6

The experiment was repeated with 12 bucket incubators in January, 1984. There were 3 treatment groups and 4 replicates of each treatment. All other procedures were the same as in the previous experiment. Results were the following:

Shock Treatment	No. Eggs	No. Dead	% Mortality	
			$\bar{X}$	Range
Controls	5,253	254	4.8	3.7-6.0
21 ATU	5,349	1,487	27.8	12.8-46.6
100 ATU	5,463	1,927	35.3	22.4-49.0

Analysis of dead eggs from the 100 ATU groups indicated 20% survived to the eyed stage. Seventy percent of these were found to have abnormalities: micro-opthalmia, club-tail, or very small bodies.

Conclusions:

1. Sensitivity to electrical shock appears to be related to stage of larval development, as is the case for mechanical shock.
2. Although the experiments do not represent conditions under which electroshockers would be used in the field, results indicate that a potential hazard to salmonids eggs exists if the equipment is used near spawning redds.

Dropout Disease and Diet in Spring Chinook Salmon

J.N. Rowan[1] and J.E. Holway
34288 S.E. Rainbow Road
Estacada, Oregon 97023

[1]Present Address: Lahontan National Fish Hatchery
620 Highway 395
Gardnerville, NV 89410

Introduction

Historically, dropout disease has caused a 15-20% mortality loss in Spring Chinook Salmon (Oncorhynchus tshawytscha) fed OMP at Eagle Creek National Fish Hatchery, Oregon. Observed dropout symptoms generally match those described by Wood (1979). The fish begin feeding normally but stop feeding at about 1.13 g/fish (400 fish/pound), become pinheaded, experience clubbing of the gills, and finally succumb.

Dropout investigations were initiated at Eagle Creek in 1978 in an attempt to find a method of controlling the syndrome. These studies were based on the assumption that the disease was not genetically predetermined. The early work systematically eliminated many possible causes including: timing and length of feed size transitions, changes in flow velocity and water temperature, and handling stress. Further work with different diets led to a production scale diet study in 1983. The results of this test indicated that the incidence of dropout was related to the type of diet fed. Highest losses were associated with the dry diets (Abernathy Dry and Silver Cup Salmon Feed) while of the moist diets those fish fed OMP experienced greater incidence of dropout than those fed BioDiet. Little or no dropout was observed in the groups fed liver. Losses were mitigated in both of the dry diets as well as in OMP when liver was used as a recovery agent or diet supplement. These results suggested that the syndrome can be prevented or reversed with liver and that BioDiet can be used to control dropout mortality. The 1983 test also suggested that subtle differences in nutrition, texture, or palatability, shared by both BioDiet and liver (and to a lesser extent, OMP), are advantageous in keeping fish on feed. Moreover, the results of the early studies combined

with the feed test seemed to indicate that dropout was a result of either a basic feed rejection or a nutritional problem.

With the preliminary work done, two additional years of study were undertaken to determine the role of diet in dropout mortality. The work was performed on two different brood years of fish. The first year's study (Year I) was designed primarily to more carefully relate the incidence of dropout disease to diets with varying physical characteristics. The experiment was also conducted to verify whether the disease could be controlled or reversed through dietary regimentation. In the second year (Year II), an attempt was made at relating the incidence of the disease to diets with varying nutritional compositions. The overriding objectives were to clearly characterize the disease and to demonstrate a cause of the problem.

Materials and Methods

Each year, approximately 250,000 Willamette strain Chinook (SCS) were incubated and hatched in Heath trays at temperatures ranging from 0-12^{o} C (32-54^{o} F). The 1983 brood year was obtained from the Clackamas Hatchery, Oregon, while the 1984 brood year was spawned at Eagle Creek NFH. Swimup fry were placed in fiberglass tanks and initially fed at 800-900^{o} C TU's from hatching. Tank volumes averaged 2.6m^{3} (93 ft^{3}), and equalized tank flows ranged from 114 liters per minute (lpm) (30 gpm) initially to 197 lpm (52 gpm) at the end. Water from Eagle Creek has an average pH of 7.3, 14 ppm alkalinity (as CaCO3), 20 ppm total hardness, 6.9 ppm calcium, and .74 ppm magnesium. Water was continuously recycled through a clinoptilolite biofilter system (Horsch and Holway, 1983) with 10-15% make up water added daily. The average water temperature was 8.9^{o} C (49^{o} F).

Methods: Year I

The dietary regimentation is shown in Figure 1. Triplicate treatments of BioDiet, OMP, and Abernathy Dry feed were fed. Feed rations were based on a hatchery constant (Holway, 1976) and corrected for percent dry matter (Table 1). Generally, feed size transitions occurred gradually over a seven day period. Particle size determination was based on fish size (Table 2).

All fish were fed their initial diets until a number of dropout related symptoms were observed at which time the recovery diets of either liver or BioDiet were fed. Dropout symptoms included: pinheading, weakness, low gastro-intestinal tract content, poor gill condition, changes in feeding behavior, decreased growth, low condition factor (Piper et al., 1982), and/or increased mortalities.

Results: Year I

Weak pinheads appeared at 250 TU's from the first feed in all diets. These pinheads tended to be less than 49.0 mm (1.93 inches) in length. The number of pinheads (Table 3) was higher in replicates exhibiting the least growth (Table 4). Overall, 50% of all pinheads examined had clubbed gills and empty gastro-intestinal tracts as described by Wood (1979). Of the three replicates carried to conclusion, only 14% of the BioDiet dropouts, 27% of the OMP dropouts, and 29% of the Abernathy Dry dropout fish exhibited both empty guts and clubbed gills.

Mortalities began at 560 TU's and were lower in the moist diets and in those tanks recovered with liver or BioDiet than in the dry diets or unrecovered replicates. Actual losses were measured to be 0.71% in BioDiet, 6.33% in OMP, and 14.72% in Abernathy Dry tanks (Figures 2-5).

Because of production constraints and recovery diets, recorded losses were lower than potentially possible if the syndrome were allowed to run its course. The best estimate of potential losses were from observations made on samples and condition factors. Potential losses might have been as high as 5% of the BioDiet fish, 23% of the OMP fish, and 53% of the Abernathy Dry fish if the experiment were continued uninterrupted.

Methods: Year II

Duplicate tanks of BioDiet, BioMoist Grower (BioDiet without preservatives), OMP, OMP plus fresh ground beef liver (OMP/L), and OMP supplemented with extra vitamin A, B_2, C, pantothenic acid, and Na as salt (OMP-S) were maintained. All diets were fed from the beginning except OMP-S whose replicates were fed OMP starter mash initially and then switched to 1/32" OMP-S (OMP-S mash was unavailable). Feed rations were based on hatchery constants (Holway, 1976) and corrected for moisture content (Table 1). Particle size determination was based on fish size (Table 2). Additional adjustments were required for the OMP/L diet treatments where fresh liver was fed at 20% of the full OMP allotment five days per week. On those days, only 92% of the total OMP level was presented to the OMP/L tanks so that equal amounts of dry matter could be fed to every treatment.

Results: Year II

Characteristic symptoms of dropout disease began to appear at about 250 TU's from first feed. Emaciated, pinheaded fish with white pectoral fins were observed to swim weakly near the tail screens. Few of these dropout fish exceeded 50 mm (1.97 inches) in length, and nearly all of

them had a low condition factor (K = $56x10^{-7}$ to $73x10^{-7}$) compared to healthier fish in the same replicate (K = $82x10^{-7}$ to $89x10^{-7}$). Growth data for the treatments are shown in Table 5. None of the dropout pinheads in the BioDiet or BioMoist treatments exhibited both clubbed gills and empty gastro-intestinal tracts but 33% of the OMP/L, 66% of the OMP-S, and 80% of the OMP treatment's pinheads did manifest both symptoms. Mortalities began at about 500 TU's and were generally higher in the OMP than in the OMP-S or OMP/L treatments (see Figures 6 - 10). Actual mortalities reached 0.24% in the BioDiet, 0.15% in the BioMoist, 0.99% in the OMP/L, 1.59% in the OMP-S and 3.44% in the OMP treatments. Final losses could not be evaluated due to production constraints. However, potential losses, though lower then historical averages, might have been as high as 2-6% in the OMP treatment, 2-3% in the OMP-S treatment, 2-4% in the OMP/L treatment, and less than 1% in the BioDiet or BioMoist treatments.

It should be noted that laboratory analyses of 1/32" and 3/64" OMP and OMP-S pellets indicated that there was no significant difference between OMP and OMP-S with respect to the concentration of supplements added to OMP-S feed. It is doubtful that these analyses reflect natural degradation. Rather, it is thought that the feed was improperly prepared at the manu facturer's level. Therefore, the results listed for OMP-S replicates may not be related to the supplementation.

Conclusions

Symptoms of dropout disease appeared at about 250 TU's from first feed, while death did not occur until 500-600 TU's. Characteristic symptoms varied through time and included: weakness, lethargy, pinheaded Shape, low condition factor (Where the K-factor is about 20 x 10^{-7} less than

that of normal fish), opaque pectoral fins, length less than 55.0 mm, some clubbed gills and/or empty gastro-intestinal tracts. These symptoms were similar to those described by Wood (1979) except not all dropout fish had both clubbed gills and empty gastro-intestinal tracts.

The syndrome appeared to begin very early in the fish's life cycle since pinheads first develop about the time of the first feed size change and were never much longer than 55.0 mm. The fish began feeding and growing but did not continue to do so for long. The increase in mortalities and other symptoms were delayed manifestations of the disease. It seems clear that the problem is related to the type of diet fed in the very early stages of feeding. The most important feeds were the starter and possibly the first pellet size feeds.

Dropout disease occurred regardless of the type of diet fed with the possible exception of liver. Moist diets such as OMP or BioDiet, experienced lower losses than their dry diet counterparts, Abernathy Dry and Silver Cup Salmon Feed. Lower mortality levels, were associated with diets that produced better growth. However, while the liver fed in Year I was associated with poor growth, it was a very effective recovery diet. In contrast, BioDiet was a moderately successful recovery diet but a better preventive diet. In Year I, losses to dropout were lower and growth was generally better in BioDiet than in any of the other replicates. This trend repeated itself in Year II where the incidence of dropout was significantly higher ($P < 0.05$) in the OMP tanks than in the BioMoist or BioDiet tanks. In addition losses were higher ($P < 0.1$) in the OMP treatments than in the OMP/L or OMP-S treatments. There was little difference in growth or mortality between the OMP/L and OMP-S groups.

Discussion

On a production scale, dropout disease can be controlled satisfactorily by feeding BioDiet or BioMoist Grower feeds from the swim-up to the fingerling stage of SCS development. Losses of up to 5% might be expected but the advantages of good growth far outweigh the benefits of feeding supplemental liver where growth is very poor. Furthermore either liver is inadequate as a supplemental preventive agent, or it must be fed at a rate greater than 20% of the OMP allotment to be effective as in Year I. After the danger of dropout has passed, other feeds that are, perhaps, less expensive may be fed which will provide all the growth required at the hatchery level. Work at Carson NFH, Washington (John Davis, 1985. Personal Communication) has determined that losses will be lowest if the diet is changed after their fish have reached 500/lb. Moreover, beginning SCS on a dry diet, such as Abernathy Dry, or Silver Cup Salmon feed offers no survival or growth advantages with respect to dropout disease.

The causes of dropout are unclear. Several possibilites are nutritional deficiency in the feeds, physiological inability of the fish to use nutrients as provided, feed palatability, and fish preference. There is also some speculation that dropout is related to yolk depletion in fry which leaves the fish deficient in nutrition before transition to external feeds is complete. Dropout disease may actually be a combination of these and other factors. Further experimentation will be required to confirm our results and to explore other possible causes of the disease.

Acknowledgements

We thank Dr. H.G. Ketola, Tunison Laboratory of Fish Nutrition, Cortland, N.Y., for his efforts and aid in the collection and analysis of data; Mr. C.E. Smith, Bozeman, NFH, Bozeman, MT., for histological work; Dr. D.W. Johnson, Iowa State University, Ames, IA; and Mr. A. DeJesus, VA Medical Center, Hampton, VA, for technical assistance. Special thanks are due to the entire staff of Eagle Creek NFH.

Literature Cited

Holway, J.E. 1967. Transferring Modern Advance in Trout Coho Salmon Culture. Proceedings of the Northwest Fish Culture Conference. p. 86-91.

Horsch, C.M., and J.E. Holway. 1983. Use of Clinoptilolite in Salmon Rearing. Zeo-Agriculture: Use of Natural Zeolites in Agriculture and Aquaculture.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish Hatchery Management. Washington, D.C. U.S. Dept. of the Interior, Fish and Wildlife Service.

Wood J.W. 1968. Diseases of Pacific Salmon: Their Prevention and Treatment. State of Washington: Dept. of Fisheries, Hatchery Division.

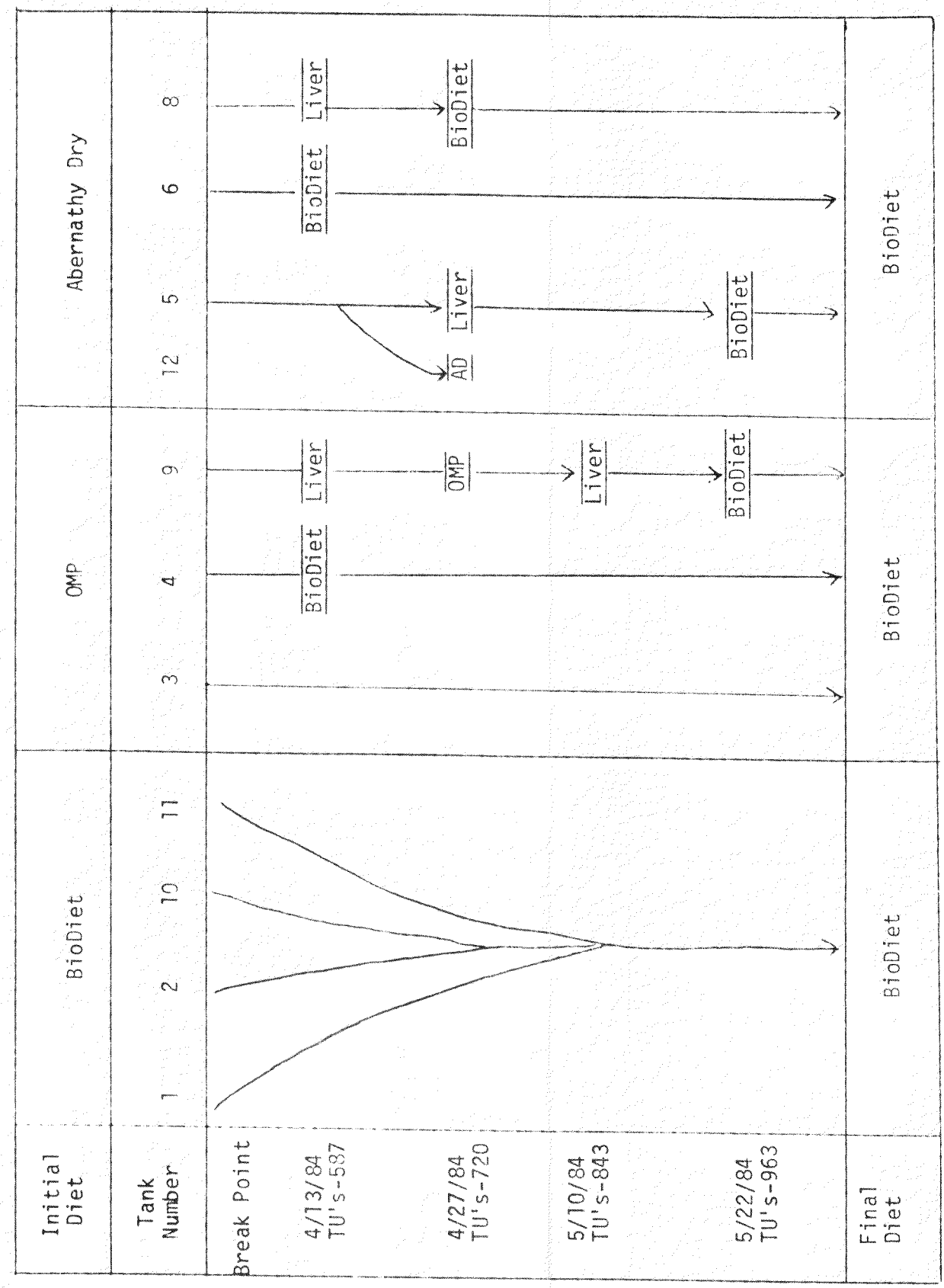


Figure 1. Dietary regimentations including: initial diet per tank, dates of recovery diet alterations (break point) and TU's. Note 1010 fish were isolated out of tank 5 (4/22/84) and maintained on Abernathy Dry. (Year I).

Table 1. Percent dry matter per diet and corresponding correction factors for feed level determination in Year I and II.

Diet	Description	% Dry Matter	Correction Factor
1	BioDiet	79	1.00
2	OMP	71	1.11
3	Abernathy Dry	93	0.85

Table 2. Relationship between fish size and feed size in Year I and Year II.

Diet	Particle Size	Fish Size (g/fish) Year I	Year II
Abernathy Dry	Starter Mash	First - 0.49	First - 0.49
or	1/32" Pellet	0.49 - 0.91	0.49 - 0.91
OMP	3/64" Pellet	0.91 - 1.81	0.91 - 1.81
BioDiet	Starter #2	First - 0.49	First - 0.49
or	Starter #3	0.49 - 0.91	0.49 - 0.83
BioMoist	Grower 1.0mm	0.91 - 1.01	0.83 - 1.81
Grower	Grower 1.3mm	1.01 - 1.81	1.81 -
	Grower 1.5mm	1.81	

Table 3. Dropout mortalities as a percentage of the total per tank in the individual diet treatments in Year I.

Diet (tank)	% Mortality (dropout)	Recovery Diet
BioDiet		
1	1.18	(-)
2	0.71	(-)
10	0.60	(-)
11	0.89	(-)
OMP		
3	6.33	(-)
4	2.39	BioDiet
9	0.31	Liver/OMP/Liver
Abernathy Dry		
5	1.86	(-)/Liver
6	4.35	BioDiet
8	0.43	Liver
12	14.72	(-)

(-): No recovery diet was fed to the replicate.

Table 4. Mean and standard deviation of the number of grams/fish based on bi-weekly quarter sample results taken on dates shown at given accumulation of TU's. Notation is made where diets were altered for recovery purposes. (Year I).

Tank	(Diet/Recovery Diet)	Date	2/28/84	3/13/84	4/10/84	5/21/84
		TU's	161	299	560	963
1	(Bio)		.457±.043	.741±.030	1.457±.117	2.971±.293
2	(Bio)		.479±.006	.682±.010	1.289±0	2.763±.005
10	(Bio)		.501±.038	.710±0	1.451±.018	3.228±0
11	(Bio)		.470±0	.704±.017	1.491±0	3.292±.039
3	(OMP)		.459±.041	.676±.003	1.130	1.859±.201
4	(OMP/Bio)		.470±.014	.648±.023	1.087±.084	2.245±.140
9	(OMP/Liver)		.454±0	.643±.012	1.094±0	1.960±0
5	(Ad/Liver)		.464±.008	.682±.003	.986±.018	1.640±0
6	(Ad/Bio)		.461±.001	.661±0	.882±0	2.110±.134
8	(AD/Liver)		.494±.061	.661±.029	.892±.020	1.768±0
12	(AD)		<---------	See Tank 5	--------->	1.458±.160

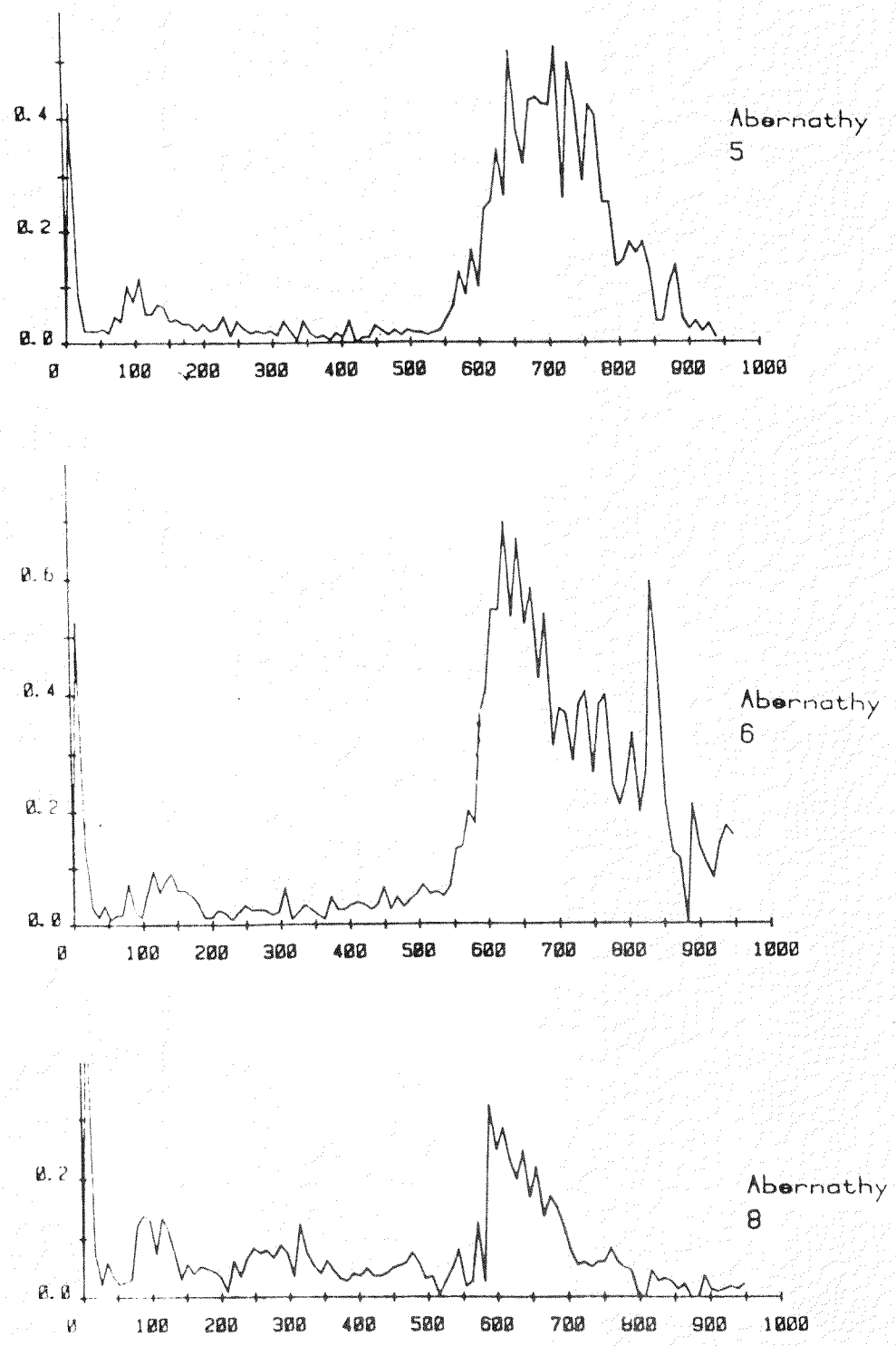


Figure 2. % daily mortality vs TU's for Abernathy tanks 5,6, and 8. Dropout mortalities began at about 560 TU's, 1st feed size change on March 13 at 300 TU's, 2nd change on March 27 at 450 TU's. Tank 5 switched to liver on April 27 at 700 TU's. Tank 6 switched to BioDiet and tank 8 to liver on April 13 at 600 TU's. Tank 8 switched to BioDiet on April 27 at 700 TU's. (Year I)

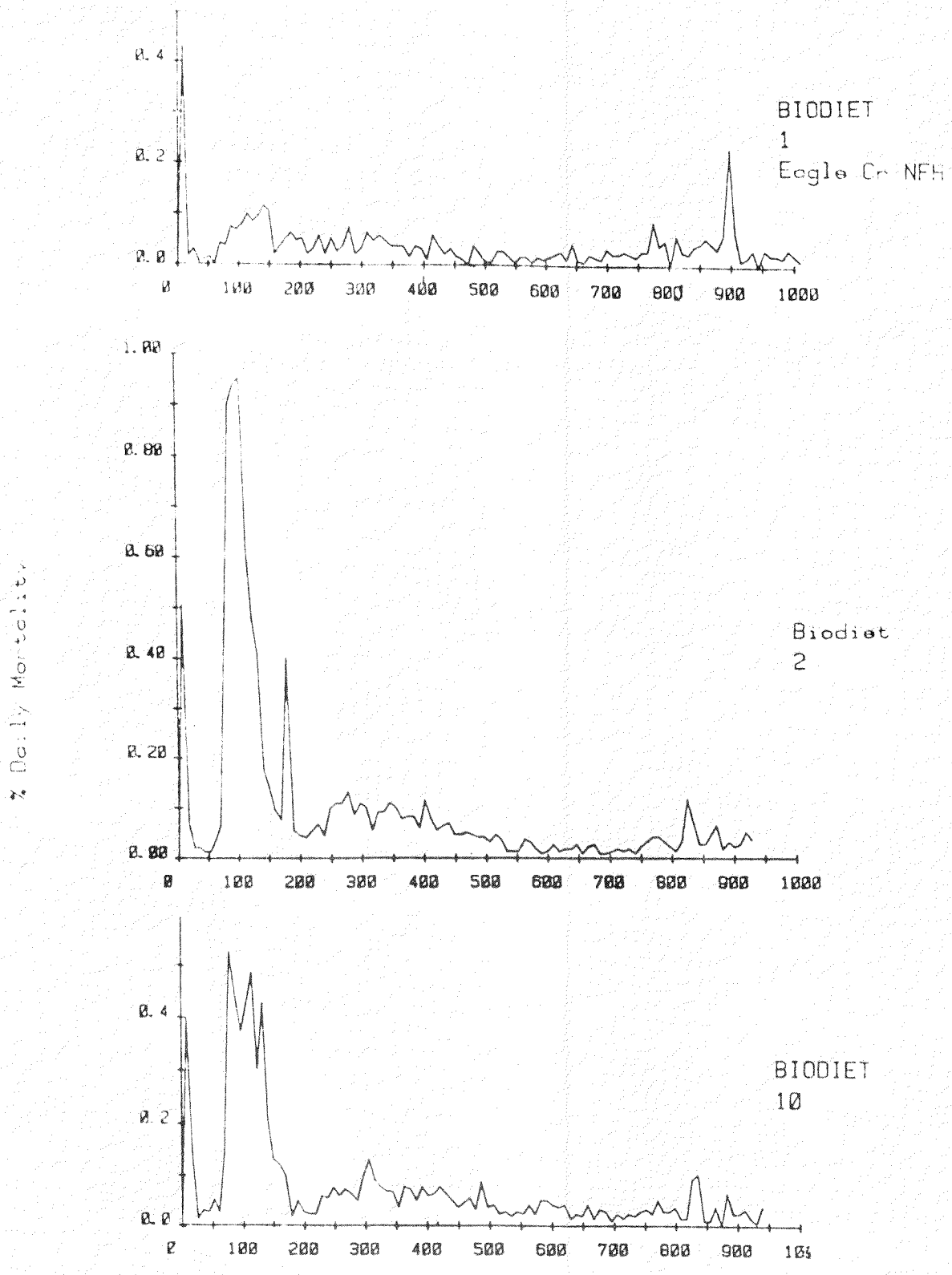


Figure 3. daily mortality vs TU's for BioDiet tanks 1,2, and 10. High initial mortalities due to fungal infection. 1st feed size change March 7 at 300 TU's, 2nd change March 27 at 450 TU's, 3rd change April 7, 4th on May 9. (Year 1)

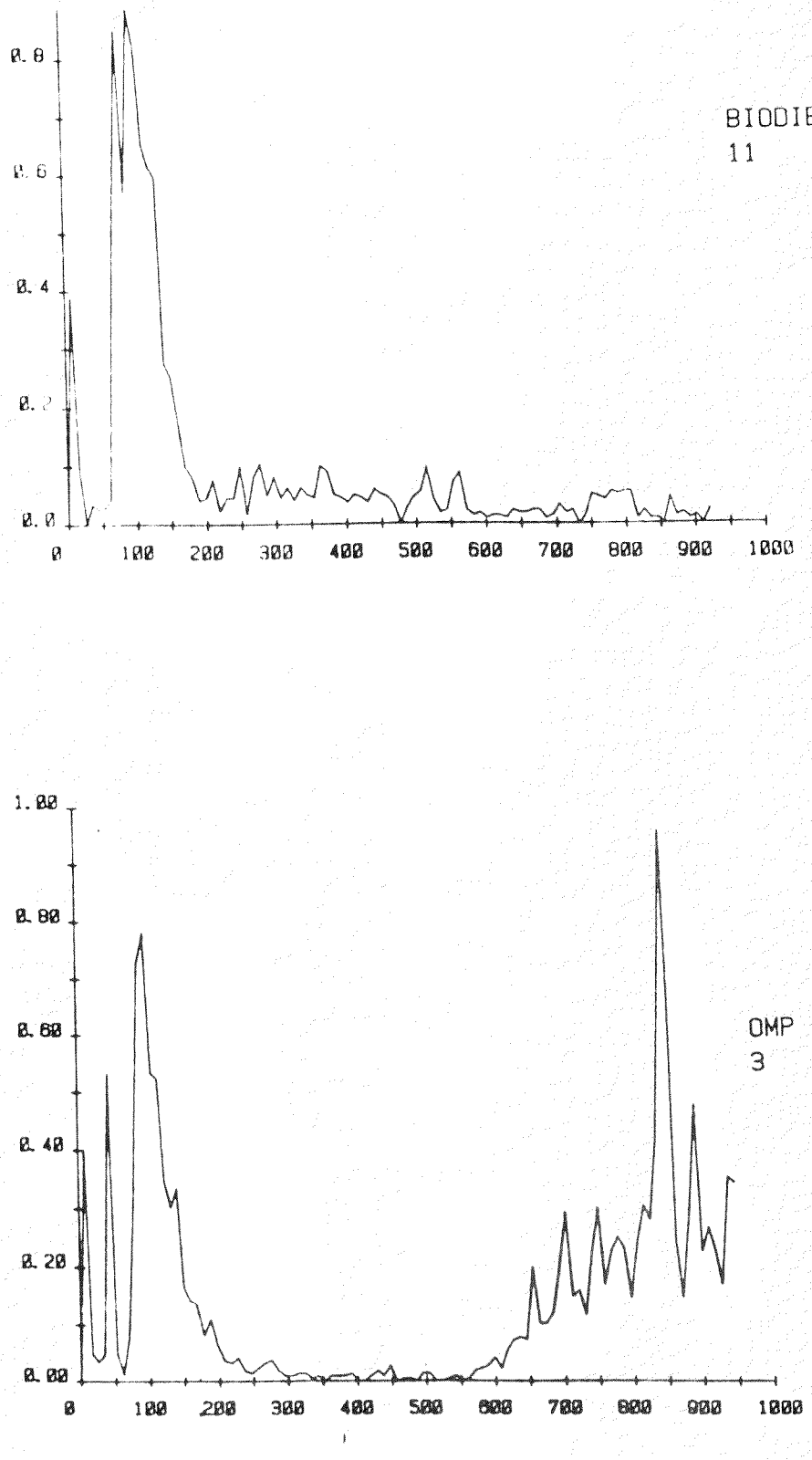


Figure 4. % daily mortality vs TU's for BioDiet tank 11 and OMP tank 3. Tank 11 feed size changes correspond with other BioDiet tanks. Tank 3 dropout mortalities began at about 600 TU's. 1st feed size change March 13 at 300 TU's, 2nd change March 27 at 450 TU's. High initial loss due to fungal infection. (Year I)

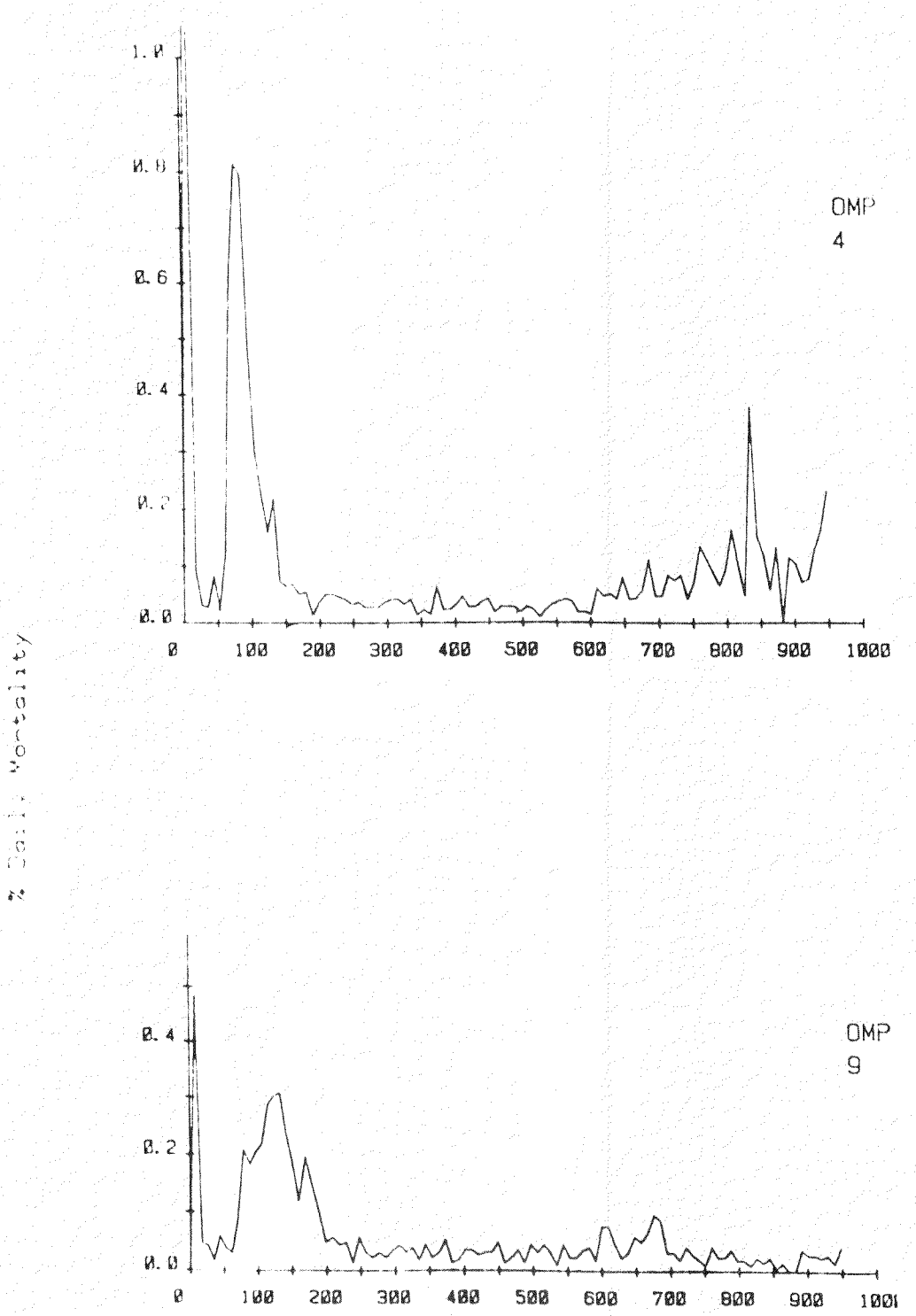


Figure 5. % daily mortality vs TU's for OMP tank 4 and 9. Feed size changes on March 13, March 27. Tank 4 switched to BioDiet April 13 (600 TU's). Tank 9 switched to liver April 13, switched back to OMP April 27 (700 TU's), switched back to liver May 10 (850 TU's), switched to BioDiet May 22 (950 TU's). High initial losses due to fungal infection. (Year I)

Table 5. Mean and standard deviation of the number of grams per fish based on bi-monthly samples of head, mid, and tail sections of the tanks shown. (Year II).

	Date	2/28/85	3/15/85	4/15/85	4/30/85
	TU's	137.4	265.1	553.1	684.8
Diet	Tank				
BioDiet	1	.476±0	1.453±.067	1.683±.095	1.957±.055
	10	.452±.008	1.537±.015	1.680±.026	1.987±.045
BioMoist	4	.445±.046	1.443±.040	1.870±.130	2.167±.102
	8	.454±.013	1.480±.036	1.800±.031	2.207±.042
OMP	6	.450±.017	1.700±.020	1.247±.188	1.670±.435
	12	.439±.002	1.697±.106	1.457±.230	1.663±.254
OMP/L	2	.466±.034	1.70±.010	1.370±.106	1.537±.224
	9	.441±.007	1.703±.030	1.237±0	1.360±.151
OMP-S	5	.432±0	1.683±.021	1.477±0	1.863±.350
	11	.439±0	1.697±.106	1.427±0	1.667±.404

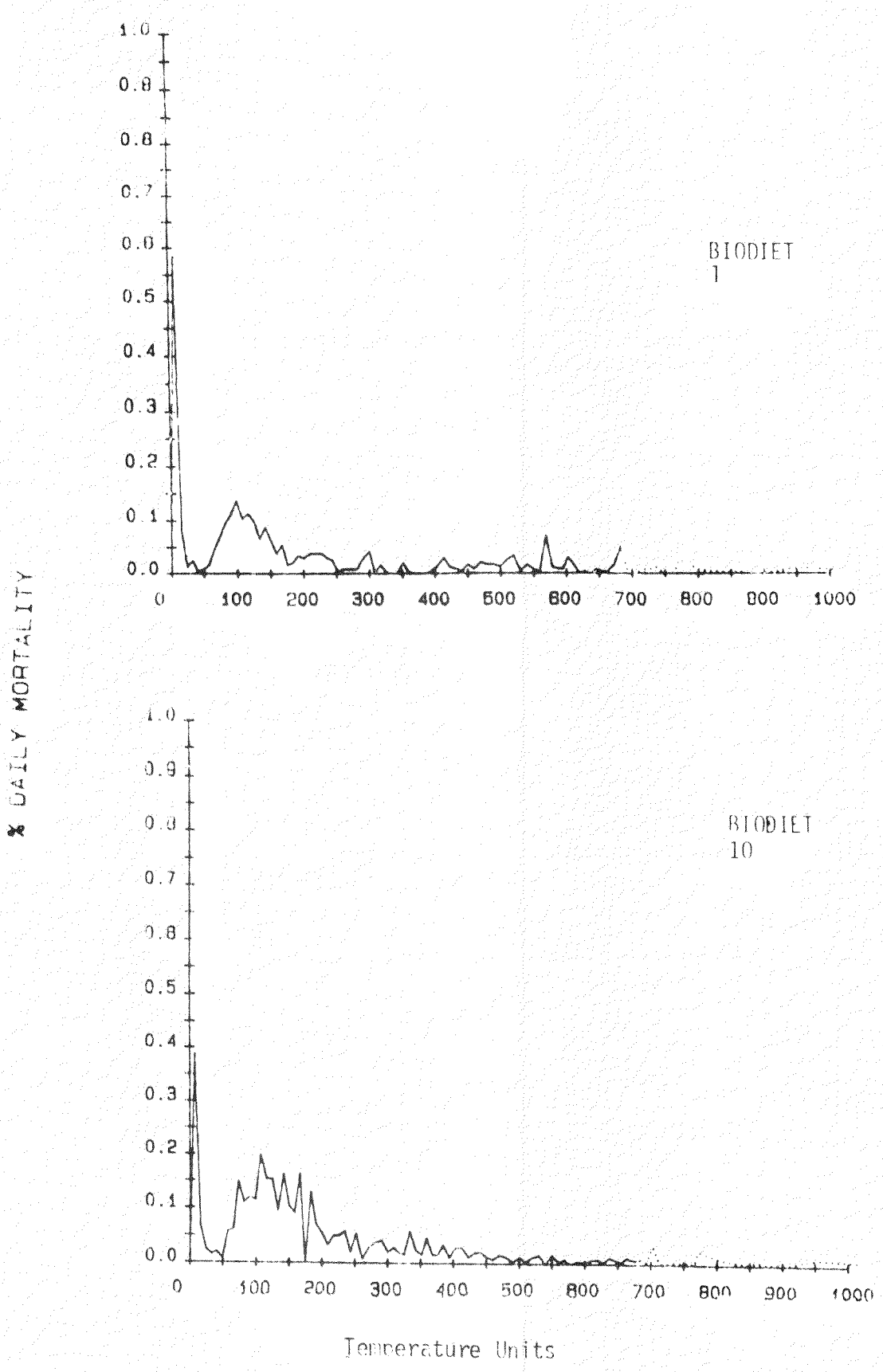


Figure 6. % daily mortality vs TU's for BioDiet tank 1 and 10. First feed size change on March 4 at 171 TU's; second change on March 26 at 363 TU's; third switch on April 18 at 582 TU's; last change on Anril 29 at 676 TU's. Diet changed to BioMoist on April 30 at 685 TU's for production reasons. High initial losses due to a fungal infection.

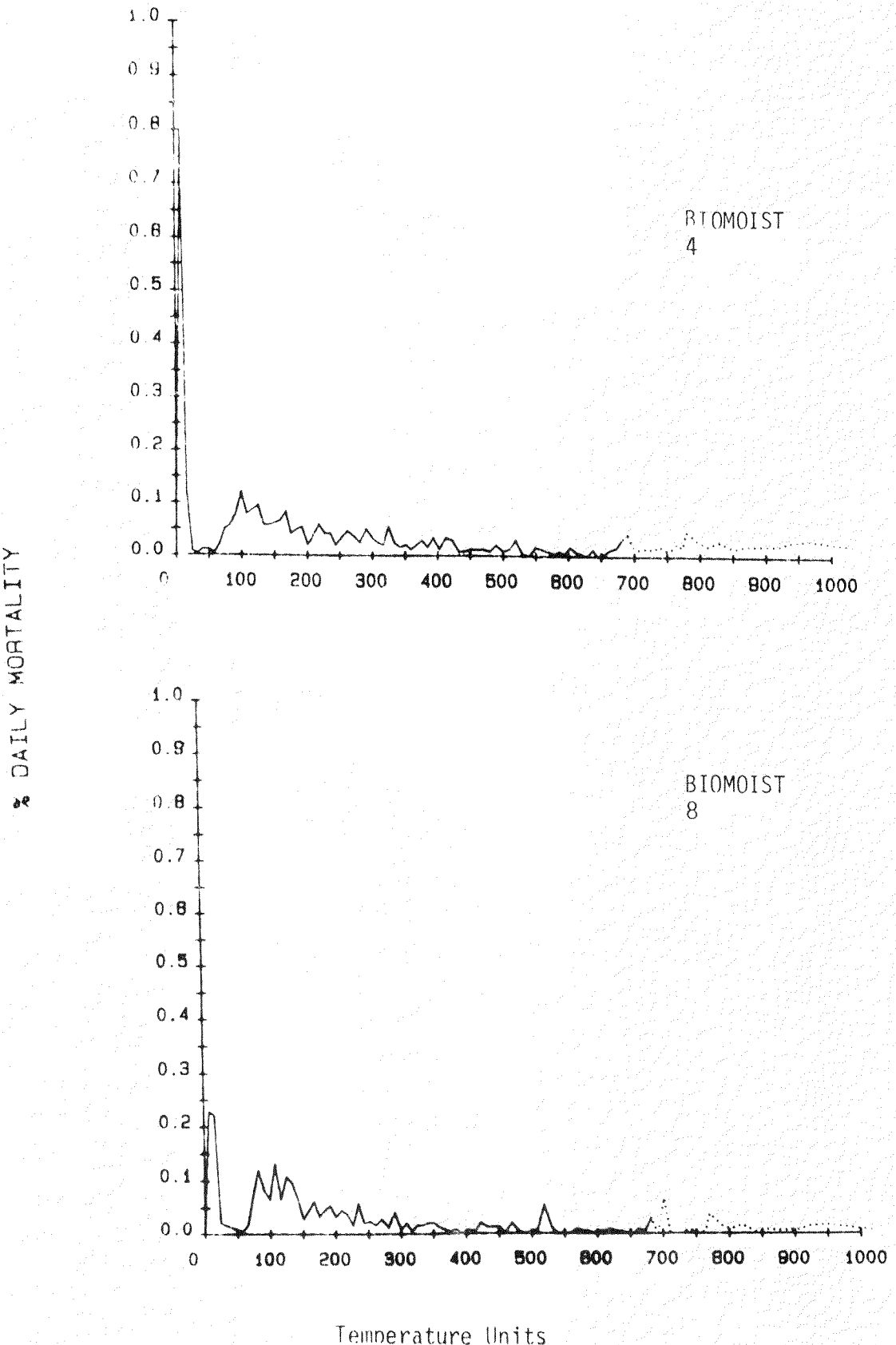


Figure 7. % daily mortality vs TU's for BioMoist tanks 4 and 8. Feed changes at 171, 363, 582 and 676 TU's. High initial losses due to a fungal infection.

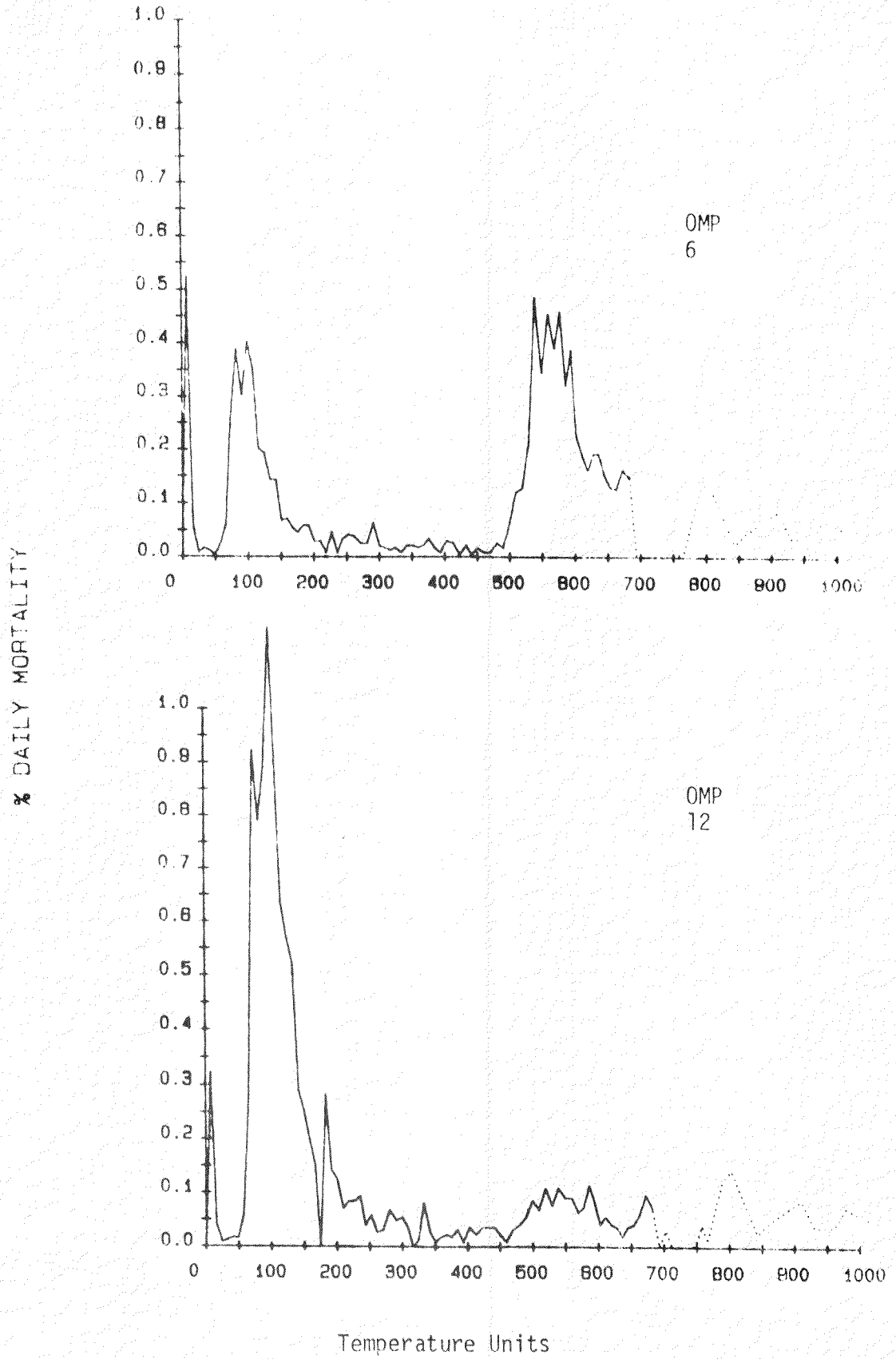


Figure 8. % daily mortality vs TU's for OMP tanks 6 and 12. First feed change on March 4 at 171 TU's; next size change on March 26 at 363 TU's. Diet changed to BioMoist on May 9 at 768 TU's for production reasons. Dropout mortalities begin around 460 TU's. High initial losses due to a fungal infection.

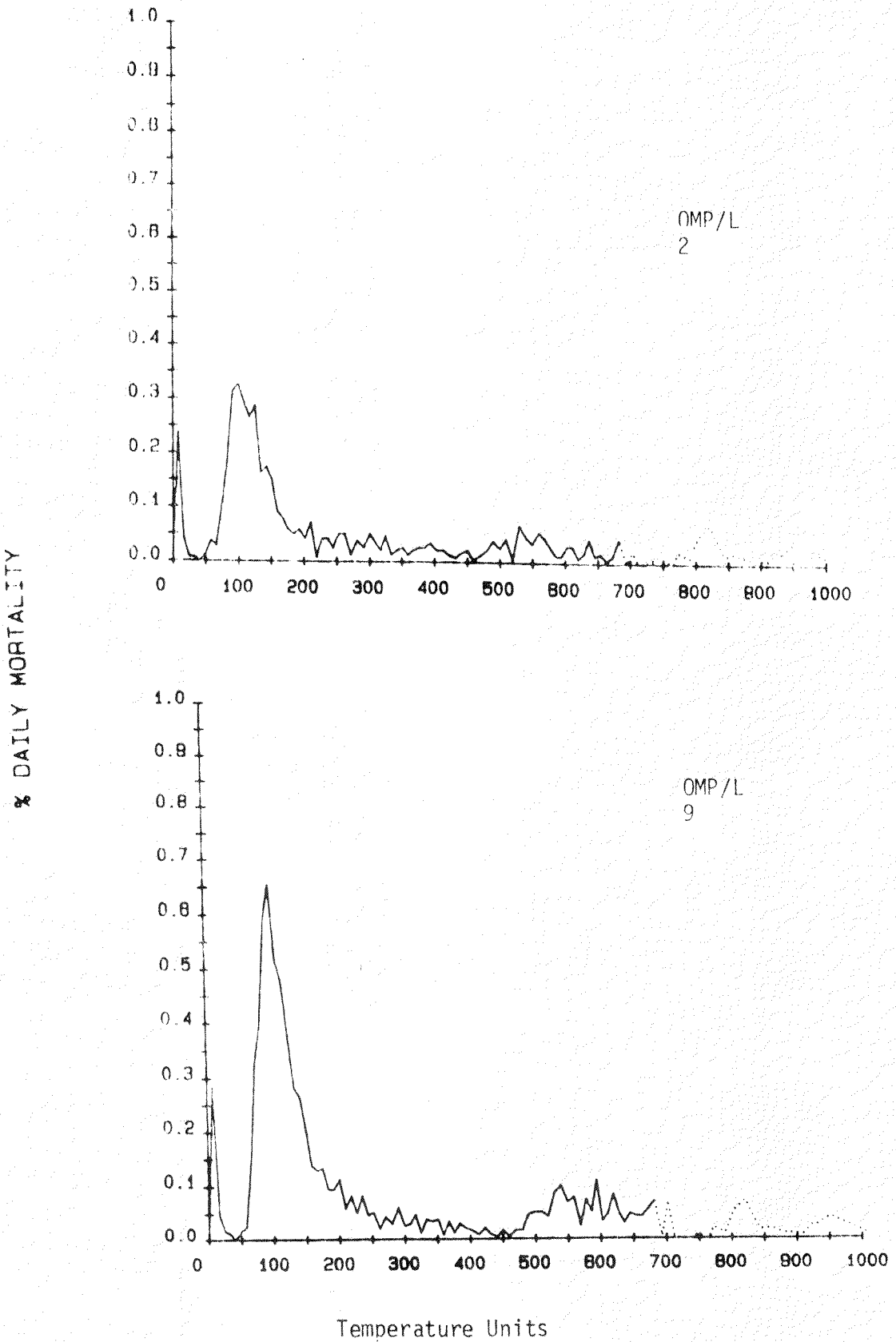


Figure 9. % daily mortality vs TU's for OMP/L tanks 2 and 9. Feed size change at 171 TU's and 363 TU's. Diet changed to BioMoist at 768 TU's. Dropout losses begin around 500 TU's. High initial losses due to fungal infection.

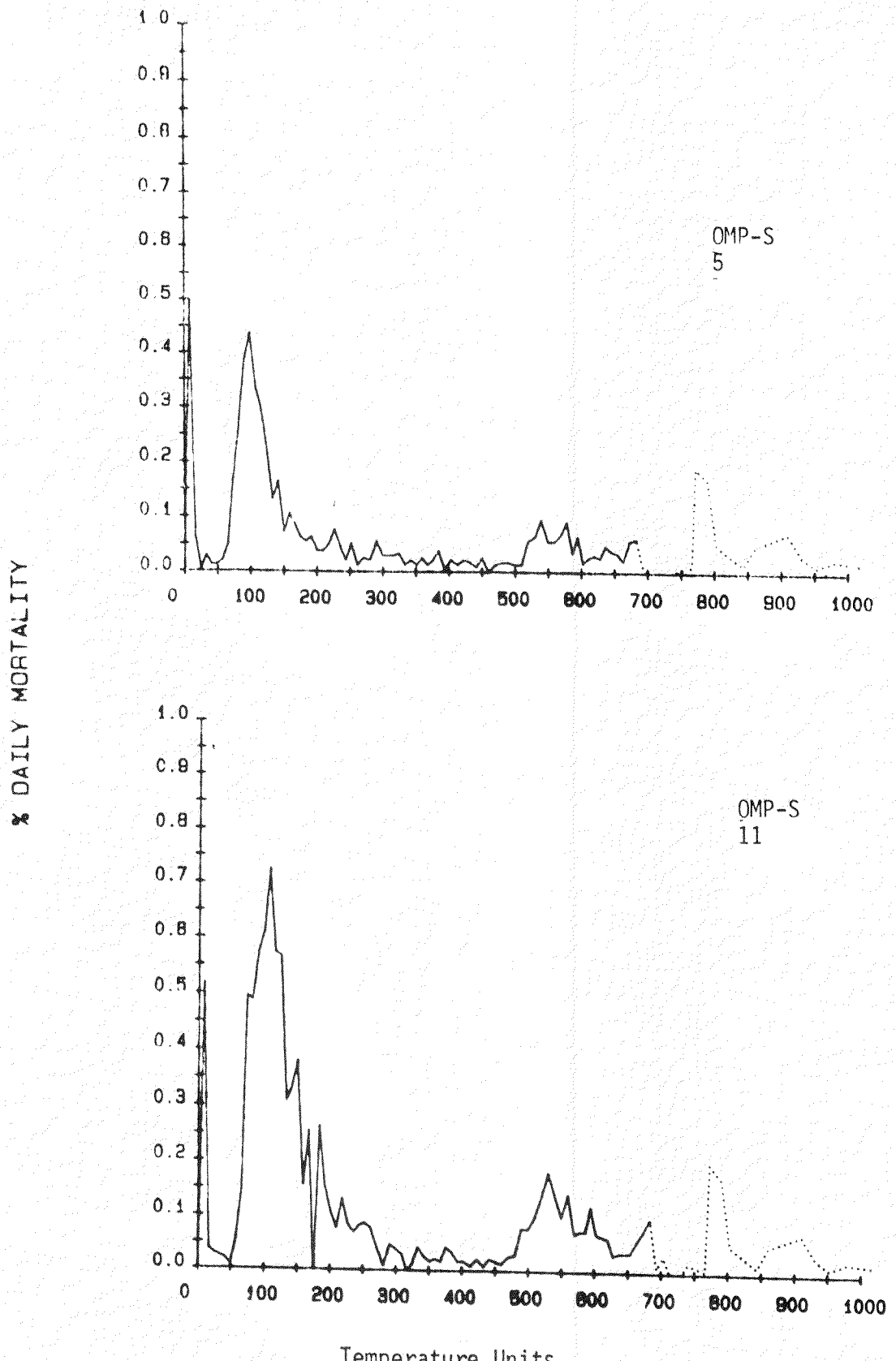


Figure 10. % daily mortality vs TU's for OMP-S tanks 5 and 11. Feed size changes at 171 TU's and 363 TU's. Diet changed to BioMoist at 768 TU's. Dropout losses begin around 500 TU's. High initial losses due to a fungal infection.

A PROGRESS REPORT ON THE EFFECTS OF DIET ON SMOLTING INDICES

by

L.G. Fowler
U.S. Fish and Wildlife Service
Abernathy Salmon Culture Technology Center
1440 Abernathy Road, Longview, Washington 98632

Juvenile chinook salmon (Oncorhynchus tshawytscha) were fed isonitrogenous dry diets supplemented with either tuna oil or beef tallow at varying levels for an 18-week period. The resulting total lipid content (wet weight basis) of the diets were 7, 13, and 19 percent. Growth rates, gill Na-K adenosine triphosphatase activity (ATPase), and plasma thyroxine concentrations (T_4) were monitored. Additionally, groups of control fish and those that had been subjected to a simulated downstream migration period (exercised and starved) were given a 24-hour sea water challenge and blood sodium levels determined.

Fish fed diets containing tuna oil grew at faster rates than comparable lots fed beef tallow, with those receiving the highest level of fish oil attaining the largest size. Fast growing fish (groups fed medium and high levels of fish oil) attained a peak in gill ATPase activity about two weeks sooner than slower growing fish. Analyses indicated that fish size was a major contributor to ATPase activity. Plasma T_4 concentrations were significantly higher in fish fed diets containing beef tallow (medium and high levels) than in any of the other groups of fish. Fish size did not appear to influence these results. The simulated downstream migration resulted in a T_4 surge in all groups of fish which had not previously shown an increase. Plasma sodium concentrations appeared to be influenced by diet with groups of fish fed beef tallow showing somewhat better ability to regulate plasma sodium after a 24-hour exposure to saltwater.

VITAMIN C INTAKE AND RESISTANCE TO *Vibrio anguillarum*

John E. Halver and Oliver Navarre, University of Washington

Dan Mulcahy, U.S. Fish and Wildlife Service, Seattle, Washington

Rainbow trout (*Salmo gairdneri*) fingerlings (av wt 1gm) were fed purified diets containing 0, 100, 500, 1000, or 2000mg of ascorbic acid per kg of dry diet for 28 weeks. Replicate lots were reared at water temperature range of 10-15°C (50-59°F). After 18 weeks on test representative fish from each lot were challenged with pathogenic *Vibrio anguillarum* (strain NCMB6) to measure susceptability and/or resistance to the pathogen. Two types of challenge were used: (1) peritoneal injection, or (2) bath immersion of measured concentration of pathogen. Survival was directly related to supplemental level of ascorbic acid in the dietary treatment. A second test was conducted with immunized fish and indicated the primary defense was not by humoral antibody synthesis in rainbow trout at this stage of development. A secondary defense system by cell mediated immunity or by non-specific factors was dependant upon ascorbic acid intake for rapid defense against this pathogen. After ten weeks post immunization, however, high levels of ascorbic acid dietary intake promoted late humoral antibody activity, and enhanced survival of fish fed higher than recommended requirements for vitamin C(100mg/kg dry diet).

Conclusions indicate ascorbic acid intake has a direct affect upon resistance of rainbow trout to *Vibrio anguillarum* under these experimental conditions. Immune protection system acts quickly after antigen challenge and appears dependant upon ascorbate intake. The humoral antibody immune system has a longer inductive phase and is also affected by ascorbate level of the diet. It is also characterized by a higher mean titre and persistant high titre at high ascorbate dietary treatments measured at 10-12 weeks after immunization. Higher than maximum growth recommended requirements for vitamin C are needed for maximum protection of rainbow trout against Vibrio.

KIDNEY LESIONS IN DWORSHAK STEELHEAD FRY - NUTRITION RELATED?

Charlie E. Smith
Fish Technology Center
U.S. Fish & Wildlife Service
Bozeman, MT

A study was conducted at the Dworshak National Fish Hatchery to test the effect of ozone as a disinfectant against IHN virus. As part of the study steelhead trout (STT) fry, held in ozone-treated and untreated water, were examined histologically to determine if there was sufficient residual ozone in the water to cause pathological changes in tissues; also to confirm whether or not mortality in fry held in certain tanks was or was not due to IHN virus disease.

In addition to finding pathological changes typical of IHN virus disease and an atypical bacterial gill disease in a few fish, 55/140 (39%) STT fry from both the ozone-treated and untreated water revealed degenerative changes in kidneys. Changes consisted of accumulation of protein (hyaline droplet degeneration) and fluid (hydropic degeneration) in kidney tubule epithelia. Often cells were so swollen as to occlude tubule lumens. Protein was also found in tubule lumens, phagocytic cells in blood forming tissue around tubules and occasionally in liver cells. Affected fry were smaller than unaffected fry. Such degenerative changes resulted from proteinurea and proteinemia and may be caused by feeding fry, still with ample yolk, high protein feeds too early in their development and thus overloading their systems with protein.

OPTIMUM INITIAL FEEDING DATES FOR STEELHEAD AT NIAGARA SPRINGS HATCHERY

Steve E. Dillon

Idaho Dept. of Fish and Game
Niagara Springs Hatchery
Wendell, Idaho

INTRODUCTION

The art of steelhead culture is a complicated one. There are many laws of nature that govern its success. To more fully understand these laws, and thereby master the art, it becomes necessary to continually search for methods and procedures that will harmonize with the nature of the species rather than to try to force success by convenient methods based on limited knowledge. In an attempt to accomplish this objective the following project was initiated to test one hypothesis: Size diversity and subsequent loses of A-strain steelhead reared from a given lot of eggs can be reduced by delaying feeding until a high percent of the sac-fry are swimming up.

PROBLEM

Historically, wide spread size diversity of same aged fish has occurred in steelhead reared at the Niagara Springs hatchery. Although a very high percentage of fry in any given lot hatch within 24 hours of each other, the percentage of "leaders" and "laggers" usually increases as the growing cycle progresses. Swim-up is not as dramatically defined as the hatching stage of development. Therefore, it is easily judged prematurely. Hence, feeding can be initiated prematurely. In addition, hatchery reared steelhead exhibit a highly competitive social behavior, and competition for food and space is critical. Once the less aggressive fish fall behind the others, the situation compounds itself and widens the gap. This opens the door to subsequent cannibalism and drop-out which are also characteristic problems in steelhead culture. Eventually, many of those dropouts that are not eaten weaken and die. Of the remainder that survive until released, few, if any, will return as adults (Wagner et al. 1963).

In the early years of operation grading was used to alleviate this problem but was eventually abandoned because of increased occurrence of disease. It was felt at the time that the added stress associated with grading was causing more trouble than it was preventing. During the mid 1970's viral diseases became so critical that handling of fish was reduced to an absolute minimum. This essentially put Niagara Springs back to where it started with the size variance dilemma.

OBJECTIVE

A common practice in Idaho hatcheries has been to initiate feeding as soon as possible to give the fry a better start. The result has often been substantial mortality of the later hatched sac-fry that remain on the vat floors. This has been due to suffocation and other related gill problems caused by waste, feed, and fungus build-up, and by damage from brushes during vat cleaning necessitated by feeding. Experimentation with these causes of mortality has been conducted with kokanee, rainbow, kamloop, brown, and brook trout at the Eagle and Nampa hatcheries. The main emphasis of this research was to eliminate, or at least reduce, these losses. In each case it was found that early feeding was not necessary, and that it was, in fact, detrimental to those fish that were not yet swimming. By deferring feeding until a high percentage of the sac-fry were swimming up it gave the later sac-fry a chance to catch up in development to the point that they could compete for food. Also, they were able to avoid the problems of suffocation, etc., associated with early feeding. A side benefit of these studies was a more uniform size in fingerling and subcatchables. A considerable amount of work has been done to determine when various salmonids first take feed (Piper et al. 1982). However, little information is available on the subject for salmon or steelhead. This promoted an initial feeding date study of steelhead at Niagara Springs. The purpose of the study was to determine an optimum initial feeding date for steelhead to reduce early losses of sac-fry and later losses resulting from excess variance in size.

RESEARCH DATA

Guidelines

Approval was received for an allotment of 200,000 eggs for the study. They were divided into two study groups of 100,000 eggs each. A control group of 100,000 eggs was selected from the regular allotment. They were incubated and hatched according to normal hatchery procedure in water 58° F. in temperature in separate upwelling incubators which spilled into six foot circular vats. Water flow was set at five gallons per minute and increased on an individual basis as oxygen demand dictated. Information on hatching, swim-up, button-up, mortality, and initial feeding dates was collected.

Each group was allowed to swim out of the incubators at will. First swim-up occurred eight days after hatching in all groups, but it was not until twelve days that the full onset of swim-up began (Figure #1). Growth was checked by sample counts on May 31 and again by sample counting and weighing on June 12 when they were moved outside. Vat cleaning began with feeding, and mortality was recorded daily from that point on. Feed was calculated by the hatchery constant method according to a hatchery constant of 10 and an average daily length increase of .026 inches which is in the five year average for steelhead at this station.

In anticipation of a final inspection prior to release in the spring, both study groups and the control group were returned to their original lots when moved to outside ponds. These lots were held separate throughout the remainder of the rearing cycle. The study groups combined comprised approximately 73% of their total lot.

Control Group

The control group consisted of 104,940 eggs. Total hatch was achieved on May 4. Feed was first presented at 13 days after hatching on May 17 at approximately 50% swim-up. This was in accordance with the timing used in all other lots incubated this year. By June 12 when the fish were moved outside they had grown .445 inches in length. The average daily length increase was .017 inches. Mortality at that point was 1,682 fish.

Study Group #1

The first study group of 103,752 eggs hatched on May 4. Feeding was deferred 18 days after hatching at which time an estimated 90% had reached swim-up. On June 12 when they were inventoried and moved outside it was determined they had grown .341 inches. The average length increase was .016 inches per day. Mortality was 1,205 fish.

Study Group #2

The second study group, comprised of 104,280 eggs, also hatched on May 4. Initially, it was intended that they should be fed at 90% button-up but due to the gaunt appearance of the "leaders" (approximately 15%) it was decided to discontinue this portion of the study at 19 days. On May 23, feeding began. Upon inventorying it was noted that this group grew .297 inches in length, an average of .015 inches per day, and mortality totaled 1,370 fish.

Final Inspection

In March length frequencies were collected on both the study group and control group lots just prior to their release. Three hundred smolts from each lot were measured and recorded. Sample lengths from the study group lot ranged from 110 to 290 millimeters. Mean length was 200 millimeters. Of the samples taken from the control group lot the range was 100 to 280 millimeters, and the mean length was 190 millimeters (Figure #3).

COMPARISON

Growth Rate

Growth rate was essentially the same in all three groups. In each case the fry showed a vigorous feeding response when feed was first presented. They did not, however, feed at the prescribed rate on the first day as other trout have done in previous studies. It was not until the third day that they ate a full ration as prescribed by the hatchery constant method of feed calculation. For this reason the short time period in which the length data was collected the growth data is insufficient and misleading.

Mortality

The mortality record clearly shows that, to a point, deferred initial feeding reduces early losses of steelhead fry (Figure #2). Even though the second study group was discontinued earlier than planned, information is sufficient for strong support.

Length Frequencies

Other research has indicated that releases of hatchery reared smolts less than 170 millimeters in length show a high rate of residualism during downstream migration (Wagner et al. 1963, and Chrisp and Bjornn 1978). Further, the occurrence and proportionate increase of residualism of hatchery reared smolts larger than 240 millimeters is also evident in downstream migration (Chrisp and Bjornn 1978, and Partridge 1985).

By comparing the length frequencies of both lots one can see a similarity in ranges and mean lengths, but the major difference is in frequencey of lengths between 170 and 240 millimeters. Of the smolts measured in the study group lot 91% fell within the desirable limits of 170 millimeters to 240 millimeters in length. The control group lot showed 78% within those same desirable limits.

CONCLUSION

These facts suggest the following. Deferred initial feeding of steelhead fry provides more uniformity in size by allowing a higher percentage of fry to begin feeding at the same time. This gives rise to reduced early drop-out, reduced opportunity for cannibalism, and a potential for a higher rate of downstream migration of smolts. Although the results of this study appear conclusive, it must be noted that there are many factors which affect stratification in size of fish reared under hatchery conditions. Therefore, two conclusions have been drawn. First, deferred initial feeding of steelhead does reduce early losses of sac-fry. And, second, deferred initial feeding of steelhead does reduce size diversity. It is recommended that deferred initial feeding be instituted at Niagara Springs with the stipulation that collection of pertinent data continue in order to more fully substantiate the results of this study. It is further recommended that other potential factors effecting size diversity be researched to further improve the operation and maximize the cost efficiency of this station.

LITERATURE CITED

Chrisp, E.Y. and T.C. Bjornn, 1978. Parr-smolt transformation and and seaward migration of wild and hatchery steelhead trout in Idaho. Forest, Wildlife, and Range Experiment Station. Final Report, Project F-49-12, Salmon and Steelhead Investigation. Moscow, Idaho.

Partridge, Fred E., 1985. Effects of steelhead trout smolt size on residualism and adult return rates. U.S. Fish and Wildlife Service, Lower Snake River Fish and Wildlife Compensation Plan. Contract No. 14-16-001-83065 (1983 segment).

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard, 1982. Nutrition and feeding. Pages 208-262 in R. G. Piper, editor-in-chief. Fish Hatchery Management. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C.

Wagner, H.H., R.L. Wallace, and H. J. Campbell, 1963. The seaward migration and return of hatchery-reared steelhead trout, Salmo gairdneri (Richardson) in the Alsea River, Oregon. Transactions of the American Fisheries Society 92:202-210.

Figure #1: Daily accumulated percentage of total swim-up of steelhead sac-fry.

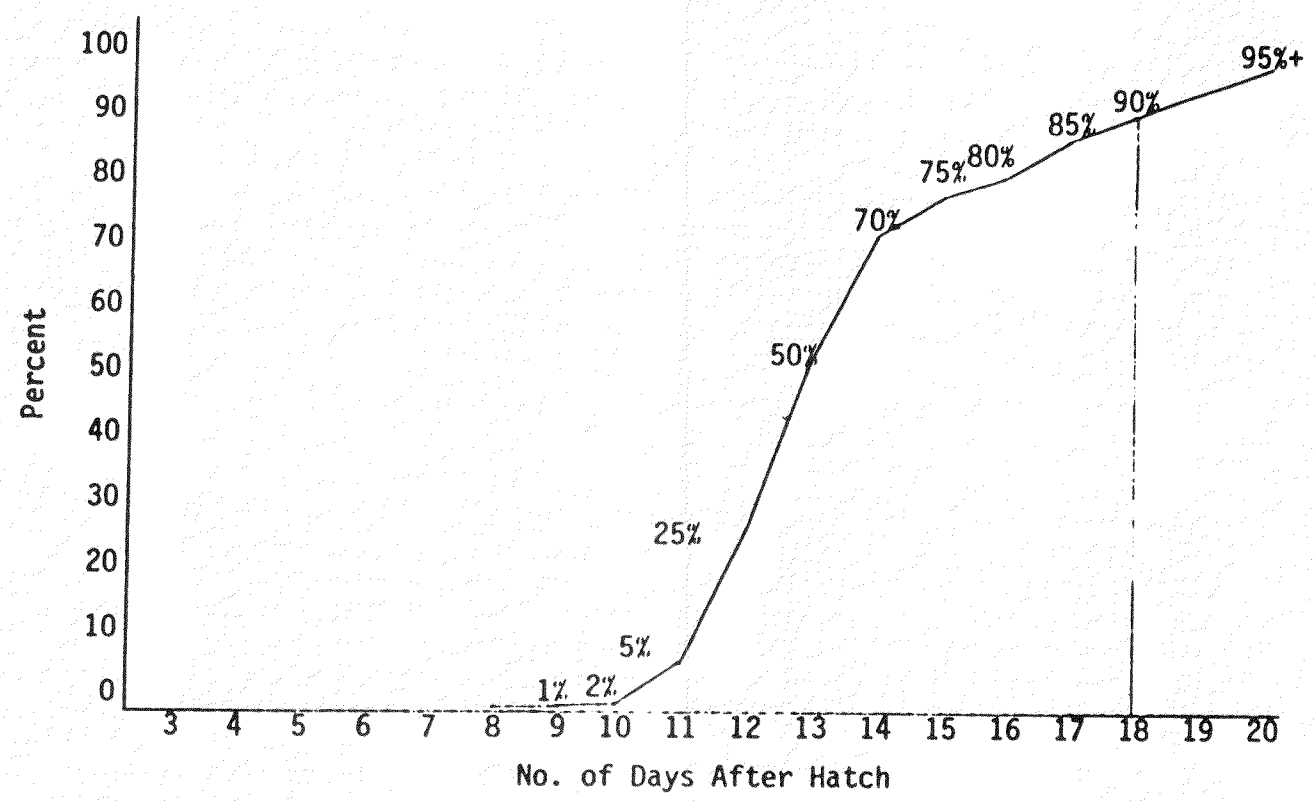


Figure #2: Mortality of steelhead sac-fry from hatch (May 4) to ponding (June 12).

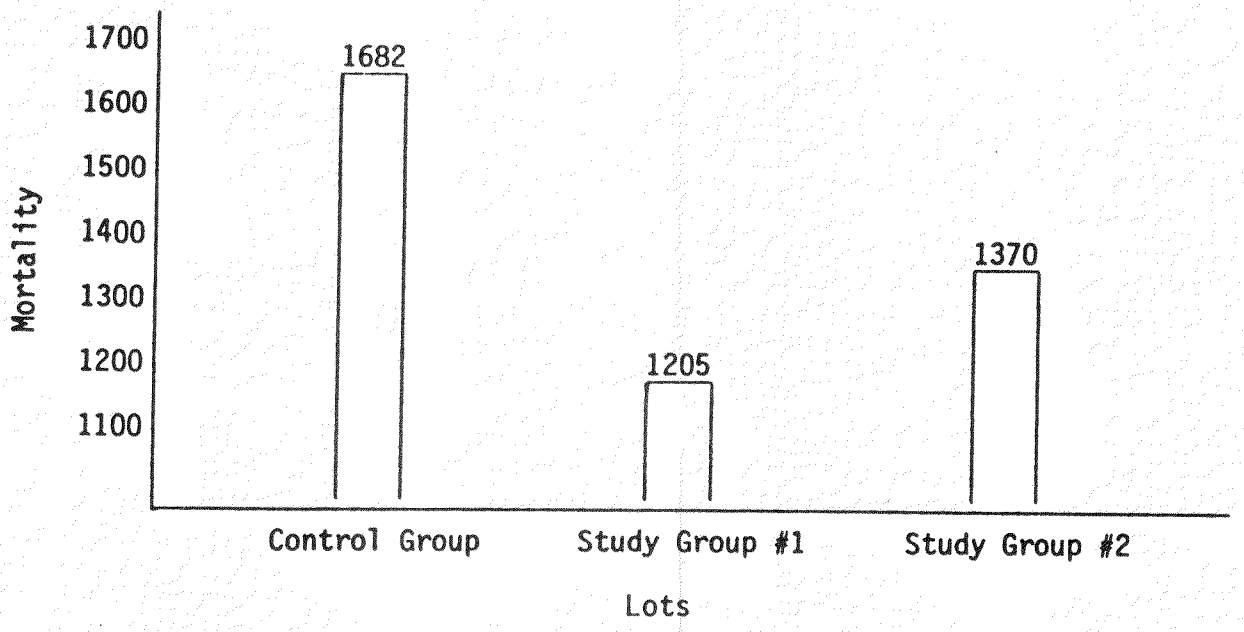
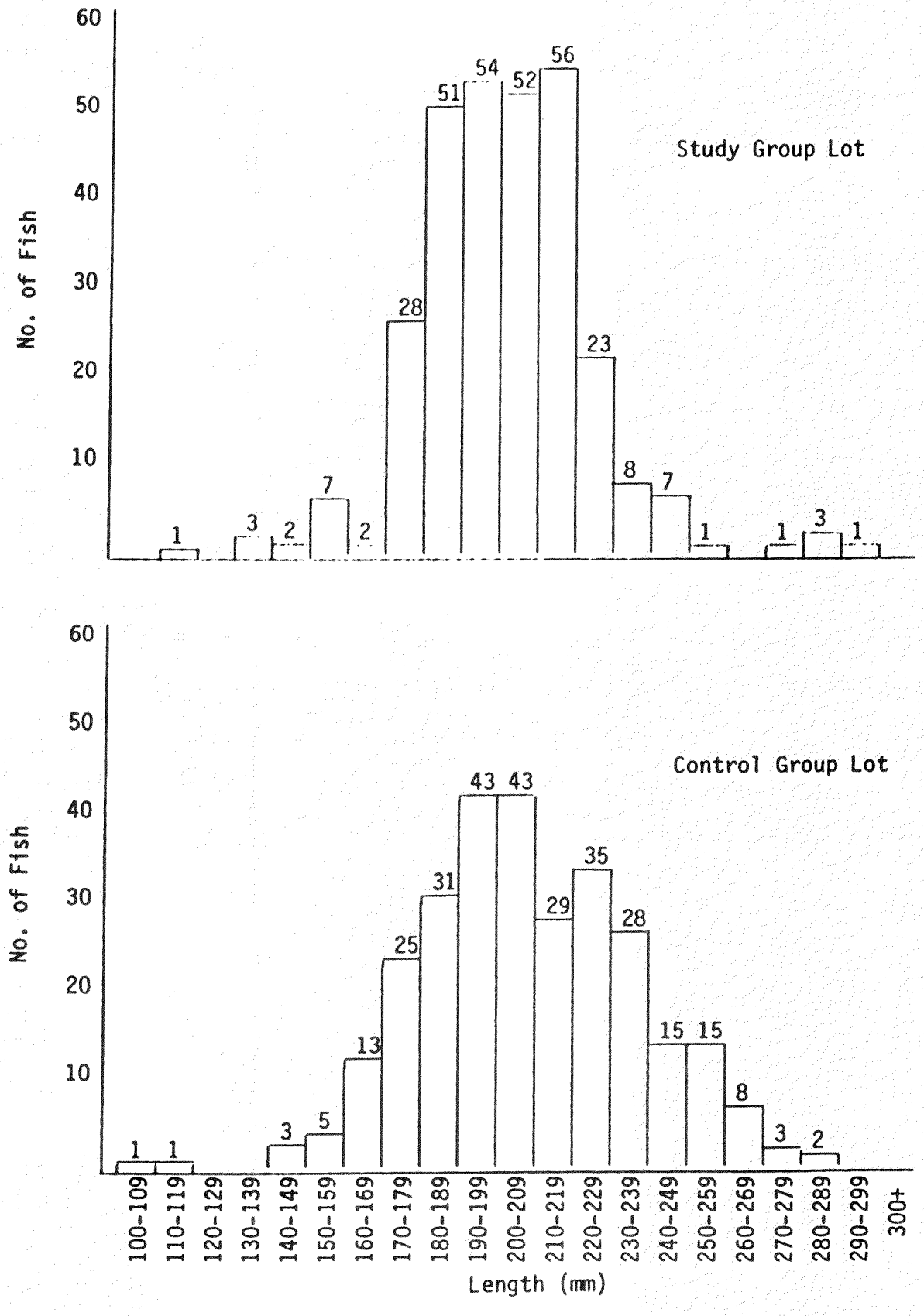


Figure #3: Comparison of length frequencies from control and study group lots of steelhead smolts at release.



A HISTOLOGIC LOOK AT CODED-WIRE TAGGED CHUM SALMON

by

John Morrison
U.S. Fish and Wildlife Service
Abernathy Salmon Culture Technology Center
1440 Abernathy Road, Longview, Washington 98632

The coded-wire tag (CWT) has been successfully used during the past 20+ years to specifically identify various experimental groups and populations of pacific salmon and steelhead. In recent years the need to tag increasing numbers of fingerling, fry and emergent migrating salmonids has provoked the development of the 1/2 length CWT. Claims of successfully tagging fish as small as 1800/lb have been made, yet it is generally accepted that 1/2 tagging is most satisfactory when fish are in the 600/lb size or larger.

When desired tag placement (medically in the snout, forward of the eyes) is accomplished, minor tissue damage is observed histologically. However, in small fish (chum salmon 1/2 tagged at 700/lb), if tag implantation is off center and into the olfactory bulb area, substantial mainstem olfactory nerve damage can and does occur.

LIVING WITH WHIRLING DISEASE: NOTES ON ITS EXTENDED RANGE IN CALIFORNIA

Christopher M. Horsch
U.S. Fish & Wildlife Service
Coleman Fish Health Center
Route 1, Box 2105
Anderson, Ca 96007

Introduction

In mid-February 1985, the myxosporidean, Myxobolus sp., was found in Rainbow Trout (Salmo Gairdneri) at Darrah Springs State Fish Hatchery, approximately 10 miles up stream from Coleman National Fish Hatchery. This parasite of nervous tissue which closely resembles Myxosoma cerebralis (causastive agent of Salmonid Whirling Disease), was originally diagnosed as such. An extensive monitoring program was therefore begun at Coleman to determine if an infectious cycle had been established in the Coleman canal (main water supply for Coleman NFH).

Approximately 75% (based on 90%, 5 fish pools) of the 1984 Brood Year steelhead were found to harbour spores of Myxobolus sp.. Of the spore samples collected from these fish, 5% were of similar morphology, i.e. size, shape, absence of iodinophilus vacuole, to M. cerebralis spores. Histologic examination revealed some spores of this type in association with cartilage destruction. However, no confirmation could be given by National Fish Health Research Lab, Leetown, using the F.A.T. procedure. Hence these fish were released as scheduled in March 1985.

1984 BROOD YEAR

Release of this year class was accomplished during February and March of 1985. Approximately 75% were released directly from Coleman into Battle Creek. The remaining 25% (200,000) were part of a Time-Size-Site of release study and were coded-wire-tagged. 50% were released at the Coleman site; 50% were released just below Red Bluff Diversion Dam on the Sacramento River.

In early May, several of these coded-wire-tagged fish were collected by trawling near the Delta area (in the vicinity of Sacramento) and sent to Coleman FHC for processing. Further collections were made via the sport fishery during July and August in the vicinity of Red Bluff Diversion Dam. All samples were found to harbour spores of M. cerebralis. Sufficient numbers of spores were recovered to have confirmatory serologic tests run (this was not done, however due to having received confirmation by this time on samples from 1985 BY at Coleman). These fish will return as adults in the Fall of 1986.

1985 BROOD YEAR

First-feeding fry were put into hatchery rearing tanks in mid-March 1985. These fish got off to a very good start due largely to the efforts of hatchery crew through egg disinfection, tank cleaning, and prophylactic parasite treatments. Mortality was very light (less than 0.1%) throughout the first 4 months. Mortality was regularly examined for clinical signs of Whirling Disease. None were ever seen.

Visual examinations of this lot were made daily beginning one month post ponding. The first tissue examination was accomplished at 2 months post ponding. Samples were collected from all representative egg takes. All were negative for spores of M. cerebralis.

In late May, all early egg takes were moved to outside raceways. Daily visual examinations were continued. Whirling and "black-tail" characteristic of Whirling Disease, were first observed in early June. Some skeletal deformities were noted but none were indicative of Whirling Disease alone. Combined, all clinical signs of Whirling Disease were observed in less than 0.1% of this lot.

Once these clinical signs were observed, sampling was intensified. 150 fish from each rearing unit at least 3 months post ponding were taken for examination. All samples consisted of whole heads (defleshed). Samples were processed using the Plankton-Centrifuge/Trypsanization method. Sub-samples were fixed in Bouin's solution and forwarded to Abernathy Salmon Cultural Technology Center for histologic examination. Sampling continued as each group of fish reached 3 months post ponding.

All groups were found to harbour spores of M. cerebralis. Average spore numbers per 5 fish pool were 300,000 (3 months post ponding). Serologic confirmation was accomplished by Maria Markiw of the National Fish Health Research Lab, Leetown. Histologic confirmation was accomplished by John Morrison of Abernathy Salmon Cultural Technology Center, Longview, Washington.

FWS FISH HEALTH PROTECTION POLICY

The Fish and Wildlife Fish Health Protection Policy (1984) has thus far been followed both in intent and by the letter. The following were steps taken as prescribed in the FWS FHPP:

> Immediately upon receiving confirmation of M. cerebralis in the fingerling steelhead at Coleman NFH, measures were taken to quarentine the facility. All mortalities have been removed quickly and disposed of either by burial or incineration. Utmost care has been taken to insure that fish do not "escape" from the facility. A coordination meeting was held with representatives of California Department of Fish & Game and US Fish & Wildlife Service (Coleman, FAO Red Bluff, R.O., and Fish Health Center). The situation was evaluated in light of current knowledge of the organism and its extended range in California waters. Plans were made and initiated to (1) increase "wild fish" monitoring throughout Battle Creek watershed: (2) use sentinal fish at key locations throughout the drainage; (3) continue quarantine; (4) intensify sampling of late run FCS fingerlings (currently negative); (5) sample all raceways individually to ascertain percent infection.

HATCHERY SURVEY RESULTS (MID-AUGUST 1985)

150 fish were collected and processed from each raceway. Samples were examined as 5 fish pools. All samples were positive for M. cerebralis. Individual fish samples were then examined. Nearly 75% of 60 fish were positive for M. cerebralis.

During coded-wire-tagging of these fish in October, 50,000 fish were individually examined for clinical signs of Whirling Disease. Only 12 fish (0.01%) showed any skeletal deformities, none of which are indicative of Whirling Disease alone.

WATERSHED SURVEY RESULTS (AUGUST/SEPTEMBER 1985)

In excess of 500 wild trout have thus far been collected and examined from 16 different locations on the Battle Creek drainage and surrounding Sacramento River. The following is a listing of those sample sites and the number of fish examined from each:

1. Darrah Springs SFH effluent 10 RBT
2. NF Battle CR at Volta Power House 30 RBT
3. NF Battle CR at Wildcat Diversion 33 RBT
4. NF Battle CR at Wildcat RD 30 RBT
5. Digger CR at Manton RD 30 RBT
6. Digger CR at Bristol-Benton Canal 52 RBT, 1 BNT
7. SF Battle CR at South Power House 52 RBT, 1 BNT
8. Main Stem Battle CR at Coleman Power House 27 RBT
9. Main Stem Battle Cr above Coleman NFH Dam 5 RBT
10. Coleman Canal at Coleman NFH Diversion 60 RBT
11. Sacramento River above mouth of Battle CR 100 RBT/STT
12. Sacramento River above RBDD 9 STT (Coleman NFH origin)
13. SF Battle CR below South Power House 60 RBT
14. SF Battle CR below Inskip Power House 25 RBT
15. Sacramento River at Mill Creek 20 RBT/STT
16. Commercial Trout Hatchery on Ripley CR - SF Battle CR at South Power House 30 RBT

In addition to the Coleman NFH, six sample locations yielded fish carrying spores of M. cerebralis. No fish with clinical signs of Whirling disease were observed at any location. The following is a listing of the locations and relative abundance of spores per sample:

Number of Fish	Location	Clinical Signs	Number Spores Per 5 Fish Pool (3 months post ponding)
60	Coleman Canal	--	300,000
27	Main Stem Battle CR	--	50,000
5	Main Stem Battle CR	--	50,000
121	SF Battle CR @ SPH	--	50,000
60	SF Battle CR below SPH	--	300,000
20	Sac. River below RBDD	--	300,000

The focus of infectivity is a native trout population in the vicinity of the South Power House on SF Battle Creek. It is still undetermined how infectivity became established at this location. All samples taken below this point on SF Battle Creek as well as Main Stem Battle Creek have been positive for M. cerebralis.

SUMMARY

Based on histopathology of 1984 BY steelhead at Coleman and collection of M. cerebralis spores from sport caught steelhead in the Sacramento River, it is safe to assume that these fish were in fact carrying M. cerebralis at the time of their release in February and March. It is also evident from visual external examinations of large numbers of BY 1984 as well as BY 1985 steelhead that the incidence of "DISEASE" was extremely low (less than 0.1%). Clinical signs were completely absent in wild trout.

M. cerebralis is well established in the Battle Creek drainage, and due to the inadvertant release of the infected 1984 BY fish, it may now be establishing itself in the Sacramento River above Red Bluff Diversion Dam. It has been found in 46 other locations throughout California, encompassing 13 major river systems, nine of which drain to the Pacific Ocean. One Federal, one State and four Commercial facilities are involved. Measures to control its spread by CDF&G have proved ineffective as the majority of findings are in wild trout populations with no hatchery involvement.

It is clear from this survey and others by CDF&G that erradication of M. cerebralis from California would involve erradication of the majority of the fisheries, predominantly wild trout, in the State.

Known Distribution of Whirling Disease
In California (1-October-85)

Trinity River

Main Stream - below confluence South Fork

Streams Tributary to Sacramento R.

*Battle Cr. (near Coleman NFH)
Deer Cr. Junct. S.R. #32 and 89
*Springs at Mt. Lassen Trout egg taking station pvt. Deer Cr. Drainage (Black Forest Lodge)
Cold Springs (Mt. Lassen Trout)

Sacramento River

Main Stem vicinity Coleman NFH-Steelhead

Feather Drainage

N.F. Feather at Rock Cr.
East Branch N.F. Feather
Sucker Run Cr. (S. F. Feather)
Flea Valley Cr. (N.F. Feather)

Bear Drainage

Wolf Cr. (Camp Far West Reservoir)

*Lahontan Drainage

Topaz L.
Walker R.
Carson R.
Upper Truckee R.
Lower Truckee R.
Taylor Cr.
Meeks Cr.
**Marletta L. (Nevada)
Prosser Cr.
Sagehen Cr.
Donner Cr.
Squaw Cr.
Donner L.

American Drainage

S.F. American at Kyburz

Mokelumne Drainage

N.F. Mokelumne at Salt Springs Reservoir & Tiger Cr.
Mill Cr.
*M.F. Mokelumne - Kemoo Trout pvt.
Forest Cr.
*Licking Fork - Blue Mt. Trout pvt.
S. F. Mokelumne
Main Stem Mokelumne R. at Electra

Calaveras Drainage

N.F. Calaveras R.
San Antonio Cr.

Stainslaus Drainage

Angeles Cr.

San Lorenzo Drainage

Main Stem San Lorenzo R.
*Bean Cr.
Zayante Cr.
Newell Cr.
Loch Lomond L.

Drainages Direct to Pacific Ocean

*Garrapata Cr. (Monterey Co.)
Big Cr. (Santa Cruz Co.)

Owens River Drainage

Oak Cr.
Goodale Cr.
Crowley L.
*Mt. Whitney SFH
Division Creek

*Confirmed by USF & WLS or clinical disease symptons
**Drains into California waters

Internal Fungus Controlled by Delaying Initiation of Feeding

Steve Roberts
Washington Department of Game
1421 Anne Avenue
East Wenatchee, WA 98801

A 5 to 20% mortality has been observed in newly feeding rainbow fry at numerous Washington Department of Game hatcheries. An internal fungus, Saprolegnia sp. is the cause of the mortality. Three experiments were conducted at two hatcheries, Omak and Spokane to test the delaying of initiation of feeding in efforts to control the internal fungus. Duplicate groups of fish were first fed at 0, 3, 7, 11, and 15 days following first observation of swimup. Delaying intial feeding to 7, 11, or 15 days post swimup markedly reduced internal fungus mortality. Fish size was only reduced in the test groups first fed at 15 days post swimup. Water temperatures for the experiments were 51 F. Recommendations on the timing of first feeding for rainbow fry to control internal fungus based on water temperature were generated. Feeding should commence at 170 temperature units after swimup was first observed.

ABSTRACT

Operation of the Ozone Pilot System at

Dworshak National Fish Hatchery

David E. Owsley, P.E.

Environmental Engineer

U.S. Fish and Wildlife Service

Two distinct water treatments were tested in the study. Both sources originated from the North Fork of the Clearwater River, the hatchery's water supply. North Fork water was pumped to Mechanical Building II and heated from 40°F. to 54°F. Later in the study when the river temperature met rearing requirements, heating was terminated. The water from Mechanical Building II went to Mechanical Building I where it was divided. The ozone system received 600 gpm and the control received 600 gpm. Water to the control group passed through packed columms prior to entering the incubators and rearing tanks. Water to the ozone group entered a contact chamber first. Here it was ozonated for 10 minutes, and passed through packed columns into a pump sump. It was then pumped into two modified bioreactors for detention. From the detention tanks, water flowed to the test groups of incubators and rearing tanks. The ozone rearing tanks and incubators were plumbed with packed columns. Ozone appears to be a means of controlling the IHN virus at Dworshak National Fish Hatchery in the early rearing stages.

INTRODUCTION

Dworshak National Fish Hatchery has experienced high losses of steelhead trout in the nursery rearing stage since 1982. These losses are attributed to a pathogenic virus called infectious hematopoietic necrosis (IHN). The virus was identified in the hatchery in 1982 when 48% of the production fish were lost in the nursery building.

In 1983, the hatchery suffered a 98% loss in the nursery building. The high loss occurred with a modified broodstock culling program. Production goals were met by early rearing of fry at Kooskia National Fish Hatchery. Eyed eggs were transplanted from Dworshak to Kooskia to be hatched and then reared on well water. The fish were transported back to Dworshak at approximately 250 fish per pound (2 inches). These fish had a low incidence of IHN losses after returning to Dworshak.

In 1983, a group of test fish broke with the virus while being reared on single-pass water treated by ultraviolet lights. The parent fish were originally tested to be IHN negative. This led hatchery personnel to believe that the water supply, as well as the adult fish, was a source. Based upon work done by Wedemeyer in 1978, a decision to test ozone was made with a pilot study beginning in 1984. After 5 months of continuous failures in the equipment, the study was terminated with no results (Owsley, 1984).

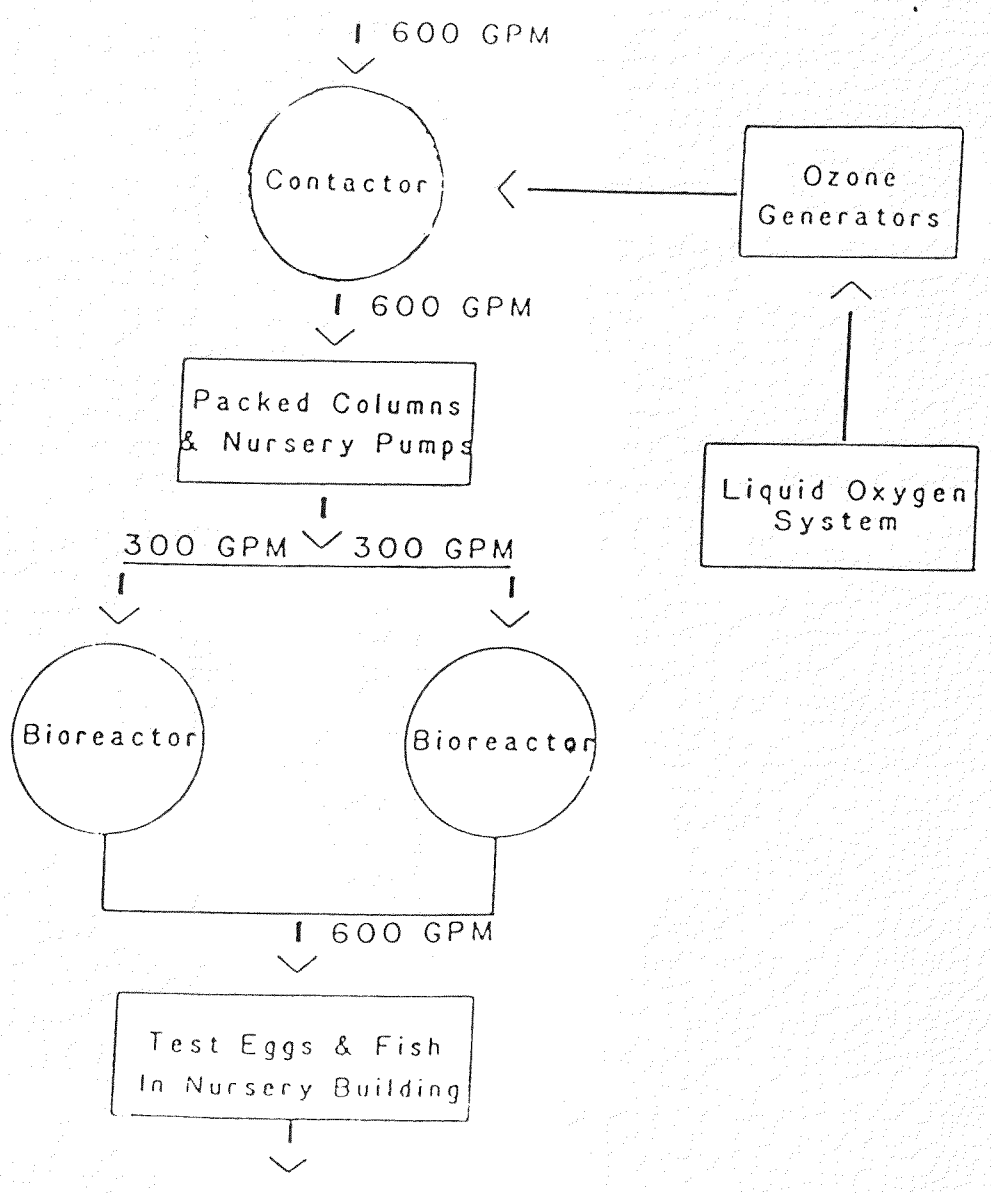
The 1984 production year started with a full-scale broodstock culling program. This program suffered a 70% loss in the nursery building. Kooskia received culled eggs and remained free of losses. The broodstock culling plan was initiated by Dr. Mulcahy from the National Fishery Research Center in Seattle, Washington.

After the early rearing losses at Dworshak in 1984, another problem arose for the Clearwater steelhead. A new anadromous fish hatchery, to be located across the river from Dworshak, was under design and would use the same water supply. At this time, a joint study by the Idaho Department of Fish and Game, U.S. Army Corps of Engineers, and the Fish and Wildlife Service began to find a safe, reliable water sterilization system. Ozone was to be investigated and a study group toured the existing ozone plants in the Northwest. James M. Montgomery, Consulting Engineers, was to provide professional services on designing, installing, and assisting in operation of an ozone water sterilization system at Dworshak on a test basis. The study was set for 6 months and was to preclude design of the new Clearwater hatchery.

II. OZONE STUDY

The ozone test was designed to treat 600 gpm of raw water. The water supply was to have a 10 minute contact time with ozone and leave the contractor with a minimum of 0.10 ppm ozone residual. The design residual was 0.20 ppm of ozone. The ozonated water was then degassed by packed columns and held in a detention tank for a safe level of less than 0.002 for rearing fish (see ozone schematic).

OZONE SYSTEM SCHEMATIC



The control group also received 600 gpm of raw water. The water was treated by packed columns for nitrogen gas removal.

Both the control and ozone group consisted of 16 nursery tanks plus egg jars and single female incubators (bucket and colander). Loadings and densities were to be the same in each group. Eggs from a single female were divided equally among each group. Three different egg takes from the run were entered into the study.

III. PROCESS DESCRIPTION

Two distinct water treatments were tested in the study. Both sources originated from the North Fork of the Clearwater River, the hatchery's water supply. North Fork water was pumped to Mechanical Building II and heated from 40°F. to 54°F. Later in the study when the river temperature met rearing requirements, heating was terminated. The water from Mechanical Building II went to Mechanical Building I where it was divided. The ozone system received 600 gpm and the control received 600 gpm. Water to the control group passed through packed columns prior to entering the incubators and rearing tanks. Water to the ozone group entered a contact chamber first. Here it was ozonated for 10 minutes, and passed through packed columns into a pump sump. It was then pumped into two modified bioreactors for detention. From the detention tanks, water flowed to the test groups of incubators and rearing tanks. The ozone rearing tanks and incubators were plumbed with packed columns (see Process Schematic).

Green eggs in both groups were placed in bucket and colander incubators for the culling procedure. Once the eggs were determined to be from IHN negative parents, the eyed eggs were hatched in egg jars. The bucket and colander incubators did not have packed columns, but the egg jars did in the control. The purpose of the packed column was to remove nitrogen gas from the heated water supply.

Both the control and the ozone study groups were operated on single-pass operation.

IV. EQUIPMENT

The ozone generators were supplied by Emery Industries, Inc. Each generator supplied 10 pounds per day of ozone using a compressed air system. Each generator was capable of supplying the required ozone treatment at the design flow. The generators were wired so that if one failed, the other would pick up automatically. (See design criteria).

An 8-inch pneumatic solenoid valve was installed on the incoming water supply line. In case of a power failure or failure of both generators, this valve would automatically close, although it had to be opened manually once it closed. This protected the system from getting a flow of raw water into the system when the generators were inoperable.

Two Ozone Research and Equipment Company ozone analyzers were used in the system. One monitored the production gas from the generators; other, the off gas from the ozone contactor.

DNFH OZONE PILOT PLANT DESIGN CRITERIA

Description	Unit	Value	Notes
Capacity Design			
Flow	gpm mgd	600 0.864	As per RFP available from DNFH No recycle
Ozone Generator			
Output	lbs/day	7.21	As per RFP
Air Flow	scfm	7 - 14	Variable
Concentration	%	1 - 1.8	Variable
Ozone Contactor			
Number	No.	1	Circular SS tank
Concentration	mg/l	1	
Detention time at Design Flow	min.	10	
Contactor Dimension	ft	dia = 8½, h = 16	
Average Water Depth	ft	13.7	To be set
Volume	ft^3 gal	780 6,000	
Post Ozone Detention At Design Flow			
Piping	min.	1.5	8" 16", 12'
Pump Well	min.	6.8	10' x 9' x 6'
1 Bio Reactor	min.	36.2	Assumed dia. = 14' x h = 18'
2 Bio Reactor	min.	36.2	
TOTAL DETENTION	min.	80.7	

The ozone contactor consisted of a 6000 gallon stainless steel tank. Contact time consisted of 10 minutes. No froth skimmer was included in the design. An air stone diffuser system was used to introduce the ozone into the contactor.

A Series 4000 dissolved ozone analyzer was installed in the outlet pipe from the contactor. This was a membrane electrode sensor furnished by Ultamet Instruments, Inc. A chart recorder was installed by hatchery personnel for a continuous monitoring system.

A liquid oxygen system was used during the study instead of compressors. The liquid oxygen was supplied from a local dealer on a 24-hour basis. The pressure-regulated liquid oxygen manifold was operated off 2 banks of 3 bottles of oxygen on an automatic switchover basis. All oxygen equipment was on a rental agreement.

The ozonated water from the contactor was deozonated using packed columns, which were located at the pump sump. Two 24-inch diameter columns, 5 feet in height filled with 4-1/2 feet of 1-1/2 inch biorings removed most of the residual ozone.

Once through the packed columns, water was pumped to two existing bioreactors for detention time. The pump sump and bioreactors are part of the existing nursery reuse system. The bioreactors were cleaned and the sand media was removed for this study. Each bioreactor offered a 36 minute detention prior for the ozonated water.

A backup oxygen system consisted of an oxygen cylinder that could provide approximately 2 hours of operation in an emergency situation.

A backup pump system consisted of a 400 gpm pump wired to emergency power that could supply the fish a source of water for a minimum of 1 hour from the detention tanks.

Sump pumps were from the nursery reuse system and had to be restricted to deliver 600 gpm flow. Two pumps were wired for the 600 gpm flow and a third was plumbed to handle any overflow problems.

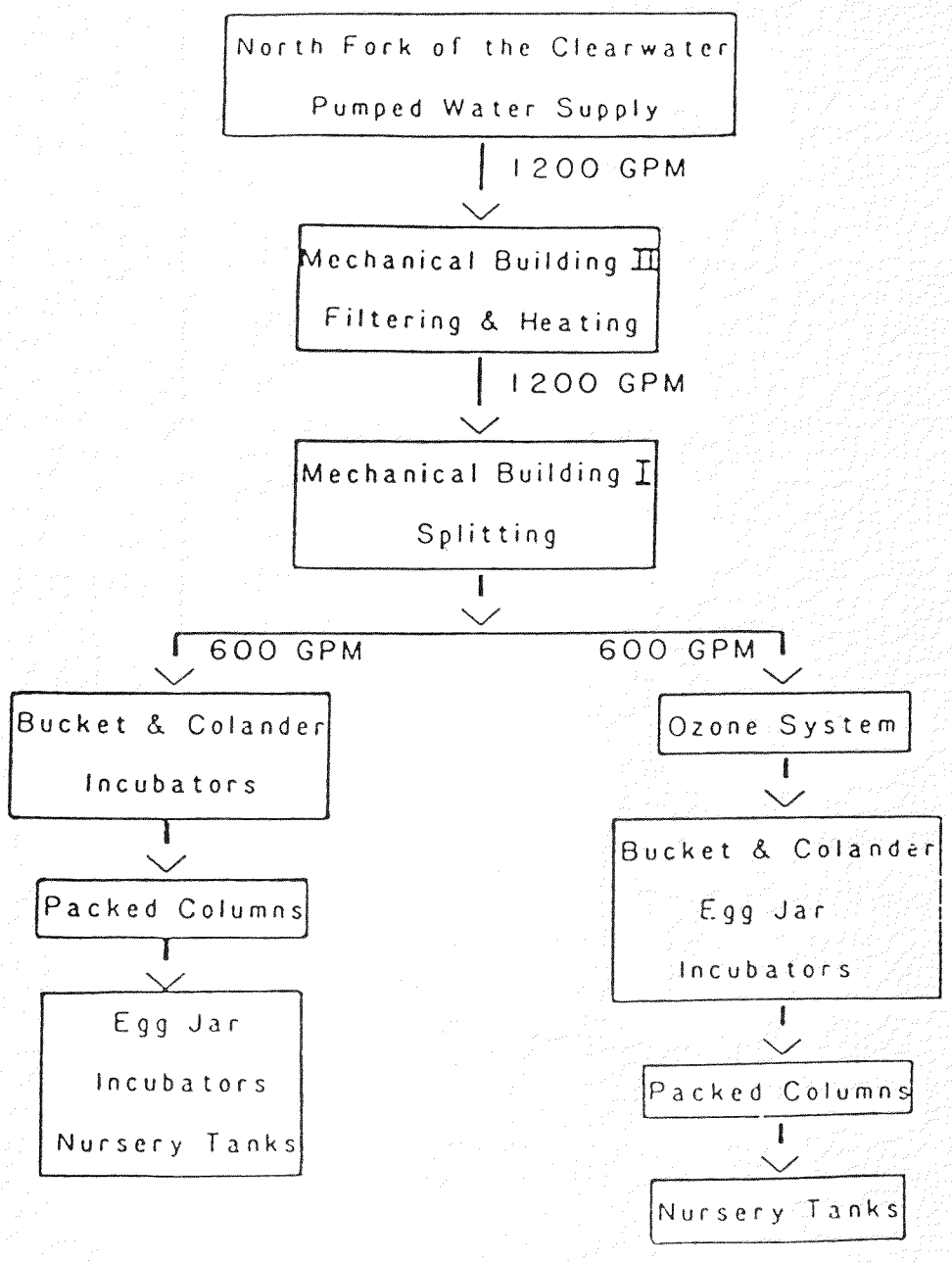
Generators were housed in a pre-fab metal building. An exhaust fan that would remove all the air contents of the building in less than 3 minutes was installed.

A telephone dialer alarm system, installed to accept any alarms from the generators, notified key personnel.

V. START UP

The ozone pilot work began in December, 1984 with the contractor starting construction and installation. The equipment for the study was designed to be utilized with the existing nursery reuse system.

PROCESS SCHEMATIC



The ozone generators, which arrived in January 1985 by special delivery, were in very poor shape. The system was filled with water to check out the piping and equipment. Emery Co. representatives checked and repaired the damaged generators. They presented a 1 day session on the operation and maintenance of the generators.

February and March 1985 were spent operating the generators and getting the system fine-tuned. On March 26, eggs from take 9 (230,000) were added to the system and the study began.

VI. MONITORING

Monitoring ozone study consisted of daily analysis of the ozone in the water at four locations. (See ozone system sampling).

1. Contactor out
2. Pump sump - in and out
3. Bioreactors - in and out
4. Nursery building - fish in and out - eggs in and out

The water analysis procedure was a modified DPD (N,N-diethyl-p-phenylene-diamine) spectrophotometric method for ozone residual. Standard curves were developed using ozone standards of 1.0 ppm, 0.5 ppm and zero from Hach Chemical Company. The standard curve was checked using chlorine standards of 1.0 ppm, 0.5 ppm, zero and corrected by a factor of 0.6.

Total bacteria samples using the Millipore technique were taken weekly at the same locations.

Oxygen, nitrogen gas and BOD_5 samples were taken routinely in the nursery building.

VII. OPERATION

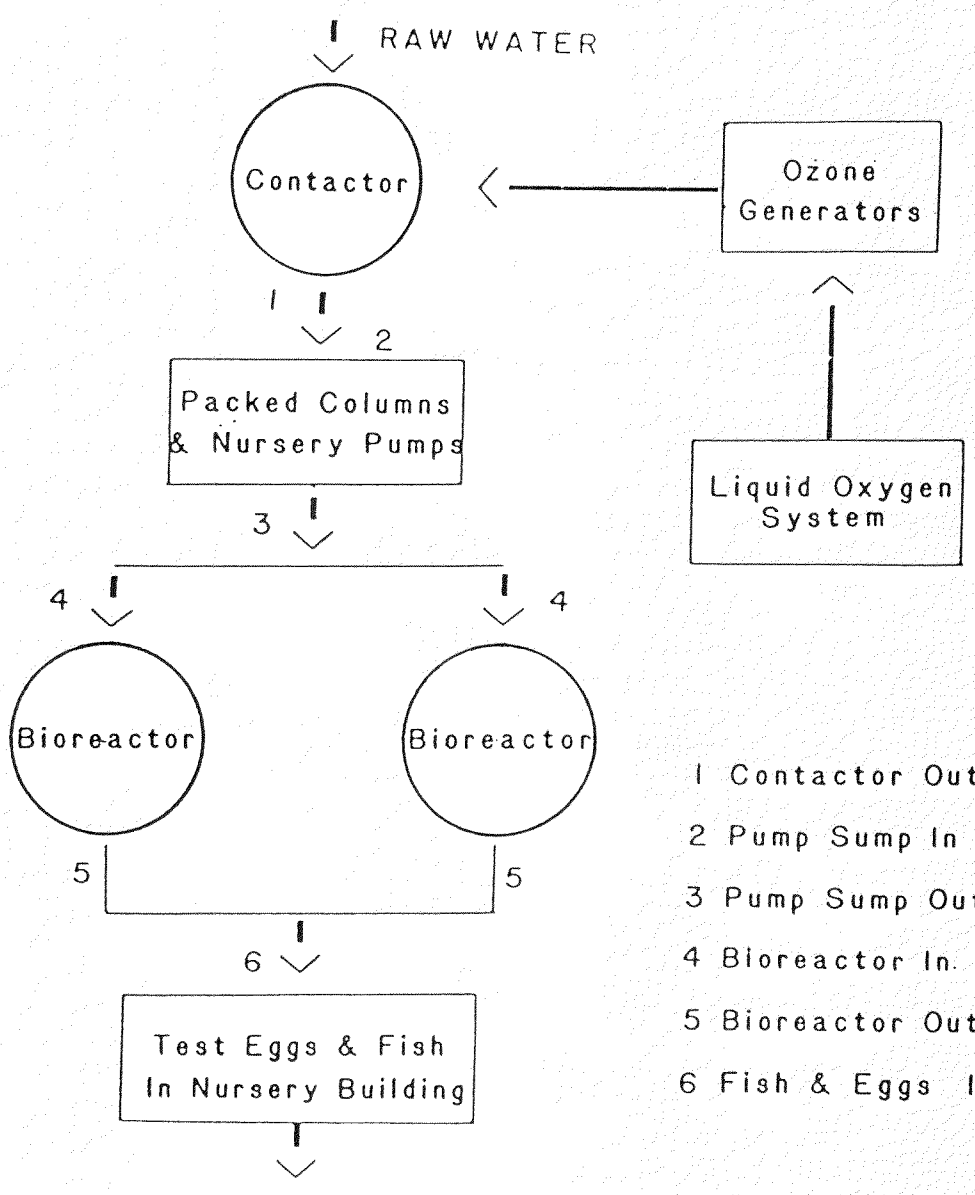
The ozone generators were received damaged and some of the later operational problems may be a direct reflection from the shipping. Some of the operational and design concerns are summarized below:

A. OZONE LEAKS

1. Inside of the building where the ozone generators were placed was always a source of ozone. The ozone was mainly leaking from the rear of the generators. Emery Co. representatives indicated that the shields should be sealed with silicone the first time that the generators were opened for maintenance work. A two-speed exhaust fan was not adequate to remove all the ozone from the building.

2. The ozone contactor was installed without an ozone destruction unit because of costs. A vent with an exhaust fan was supposed to remove the off-gas ozone into the atmosphere. Due to wind currents in the immediate area, the ozone was common odor in the area. Ozone gas was also very noticeable around the pump sump area. This was probably due to the stripping effect of the packed columns.

OZONE SYSTEM SAMPLING



1 Contactor Out

2 Pump Sump In

3 Pump Sump Out

4 Bioreactor In.

5 Bioreactor Out

6 Fish & Eggs In

B. OPERATIONAL DAMAGE

1. Because of ozone leaks, it was assumed that the "O" rings in the oxygen flow meters were destroyed. These rings were supposed to be manufactured for an ozone environment.

2. The solenoid valves for the oxygen supply system failed at the end of the study, and it was assumed that ozone destroyed the membrane in these valves.

3. The rubber coating on an electric heater cord was destroyed during the duration of the study. Effects of ozone on rubber is well documented.

4. The "O" rings in the membrane ozone electrode were destroyed during the course of operation. These rings were exposed on a continuous basis to the ozone residual in the water.

C. POWER OUTAGES

There was a total of nine power outages during the ozone study. Eight can be attributed to an energy contract that coincided with the ozone study at the hatchery. The other outage was an annual outage scheduled by Clearwater Power Company.

D. LIQUID OXYGEN SYSTEM (LOX)

The original thought of using liquid oxygen was justified from an operational and economical standpoint. Neither assumption proved valid during the study. Costs of liquid oxygen exceeded the study estimate. The reliability of the equipment also failed during the study. Problems with the oxygen regulator plagued the study for several weeks. High pressure from the oxygen system resulted in a broken flow meter. On several occasions, the regulator did not switch resulting in a low ozone residual in the water supply (less than 0.10 ppm was considered low).

E. BACKUP SYSTEMS

1. Compressed oxygen cylinder was incorporated for an emergency oxygen supply source to the generators. The system was used on two occasions. The first was a test of the system. The second was a period when work was being performed on the faulty regulator. Both operations were successful in maintaining the ozone study.

2. A backup pump system was designed to give the nursery facility approximately 1 hour of down time in case of a failure in the generators. The system was successfully tested, but never used during the course of the study.

F. DETENTION TANKS

Two bioreactors were emptied and cleaned for detention chambers. Each bioreactor was designed to give 36.2 minutes detention time for ozone residual decay. A temperature problem early in the study forced the use of only one bioreactor for the study. Ozone decay in the bioreactors was marginal whether one or two bioreactors was in operation.

G. FROTH REMOVAL

Because the design incorporated an existing system, no removal of froth was incorporated into the study. Early rearing, namely in the egg jar stage, showed high concentrations of froth in the nursery tanks. The froth disappeared once egg jars were removed from the tanks. A substantial amount of froth was always present in the pump sump. It is to be expected that a likely amount would be in the contact chamber. There was no visible means of checking the contact chamber.

H. ALARMS

Hatchery personnel responded to 21 alarms during non-working hours. This does not include alarms during normal working hours and days.

VIII. SUMMARY AND CONCLUSIONS

Ozone appears to be a means of controlling the IHN virus at Dworshak National Fish Hatchery in the early rearing stages. Eleven of the fourteen control tanks were destroyed due to the virus. None of the fourteen ozone tanks were destroyed. IHN was found in the ozone fish, but did not cause severe mortality. It is assumed the virus in the ozone tanks came from the fish rather than the water.

Ozone is a manageable method of disinfecting a hatchery water supply. Equipment reliability is imperative and safety cannot be over emphasized.

Further studies using IHN positive eggs needs to be done. Plans for such a study are presently being done.

The Effect of Ozone Water Disinfection on the Control of IHN at Dworshak National Fish Hatchery

by

Greg Pratschner

To test the efficacy of ozone water disinfection on the control of infectious hematopoietic necrosis (IHN) epizootics in steelhead (Salmo gairdneri), three incubation and early rearing experiments were conducted between March and August 5, 1985 at the Dworshak National Fish Hatchery (Idaho).

The individual egg lots from $\leq$ 10, IHN-free females were evenly divided between two rearing tanks. Half were incubated and reared in tanks supplied with ozone-treated river water (test tanks) and half were incubated and reared identically in tanks supplied with untreated river water (controls). The experiments, representing three distinct egg takes or spawning days, were replicated in 28 total nursery tanks (14 test:14 control).

Nearly 20 times more steelhead were lost to IHN reared in control tanks. The results, within the constraints of these experiments, imply that ozone may efficiently prevent high losses in the very early life history of Dworshak reared steelhead.

OZONE EXPERIMENT SUMMARY

	EXPERIMENT					
	A		B		C	
	O_3	CONT	O_3	CONT	O_3	CONT
SPAWNING DATE	MAR 26		APR 16		APR 30	
SPAWNING PAIRS	100		50		50	
EGG LOTS CULLED	2		1		36	
TANKS INVOLVED	8	8	4	4	2	2
AVERAGE FISH/TANK(K)	29.1	37.2	30.5	32.9	23.0	21.5
IHN MORTALITY(K)	0.7	91.2	4.3	25.0	0	0
NO. TANKS WITH IHN	4	8	1	3	0	0
PERCENT LOSS TO IHN	0.3	30.62	3.52	18.95	0	0

Steelhead Broodstock Culling Techniques

by

Robert J. Austin

U. S. Fish and Wildlife Service
Dworshak National Fish Hatchery
P. O. Box 18
Ahsahka, Idaho 83520

In an attempt to reduce early rearing losses of steelhead to infectious hematopoietic necrosis (IHN) virus, a management program of intensive fish health sampling and selection of virus free eggs was implemented at Dworshak during 1985. Using "aseptic" technique during spawning, male and female gametes were collected individually and paired one-to-one. Egg lots were water hardened in iodophore (100mg/l) and incubated in discrete colanders at 53-54°F. Samples of spleen from males and ovarian fluid from females were collected and assayed for IHN virus by standard cell culture tehniques. At 8 days post-fertilization, known positive egg lots were mechanically culled. At eye-up, virus free eggs were picked, enumerated and transferred to Heath trays for final incubation. Assuming culling was complete and no vertical transmission of virus occurred, only IHN clean egg lots were reared in Dworshak's production program.

IHNV TRANSMISSION - A STUDY OF IHNV CARRIER STATE IN SOCKEYE SALMON

Lori J. LeVander, Kathleen Hopper, Kevin H. Amos, WDF

ABSTRACT

Sixty adult sockeye salmon were trapped at the U. S. Government Locks (salt water, fresh water interface) and transported to the U.S.F.W.S. lab at Sandpoint. They were held in 20 containers of pathogen-free dechlorinated city water (Cedar River watershed). They were spawned and sampled for presence of IHNV.

Sixty adult sockeye were also trapped at the locks and transferred to Seward Park Hatchery. They were held in Lake Washington water (Cedar River watershed). They were spawned and sampled for IHNV. The eggs are being incubated in Lake Washington water.

Our results showed no virus present in either test group - Seward Park or Sandpoint. Natural spawning sockeye in the Cedar River have a 98% to 100% incidence of IHNV.

The Use of Ozone to Eradicate *Ceratomyxa Shasta* at the Cowlitz Trout Hatchery

by

Jack Tipping
Washington Game Department

Abstract

A pilot scale ozone system was installed at the Cowlitz trout hatchery to control infections of *Ceratomyxa shasta*. It was found CT values (minutes of retention x ozone residual at contact) of 1.0 and greater were sufficient to remove *C. shasta* while those less than 1.0 generally were not. Residual toxicity did not appear to be a problem for fish at less than .010 mg/l. Residuals were greatly reduced by turbidity. A experiment on summer steelhead reared to term is in progress and appears to offer promising results.

Introduction

The myxosporidian protozoan *Ceratomyxa shasta* has infected and caused serious fish loss at the Cowlitz trout hatchery, a Tacoma City Light mitigation facility, since it began operation in 1967. Since 1980, fingerling to smolt survival has averaged 37.5% and since 1983 when several rearing pond improvements were made, fingerling to smolt survival has averaged about 50% (Tipping et al. 1985). *C. shasta* is believed responsible for most of this mortality. There is no known cure for this disease which is usually managed for by avoidance of infective water. However, the Cowlitz trout hatchery obtains nearly all of its 55 cfs from infectious river water and the mitigation program calls for about 1.3 million smolt size fish to be produced annually.

A pilot scale ozone system was installed in 1984 to determine if *C. shasta* could be controlled at a favorable benefit/cost ratio (Tipping and Kral 1985). Ozone technology has been utilized in waste water treatment and in drinking water purification but has been tested little in fish hatcheries. Also, although tests have been done on *C. shasta* with chlorine and ultraviolet, no one has attempted to use ozone to control it. Due to the great capitol costs of ozone equipment, it was important to determine minimum effective dose and retention time requirements. With the large volume of water used at Cowlitz, a required dosage of 2 mg/l versus 1 mg/l would result in many thousands of additional dollars in equipment. Retention time requirements could also greatly affect costs if a vessel to retain a large volume of water needs to be constructed.

Another important parameter to be determined was the amount of ozone residual fish could be exposed to without causing mortality since this would affect degassing requirements.

Methods

Ozone System

An OREC (Ozone Research and Equipment Company) model SP38-AR generator was used to provide ozone to a system (Figure 1) designed by Chuan Vu, Tacoma City Light engineer. The ozonator is capable of producing about 900 grams (2 lbs) of ozone per day.

A compressor provided air to the ozone generator at a predetermined rate as desired from 20 to 40 standard cubic feet per hour. The ozonator was operated at 15 psi generator pressure and ozone production was adjusted with a powerstat dial in combination with air flow volume.

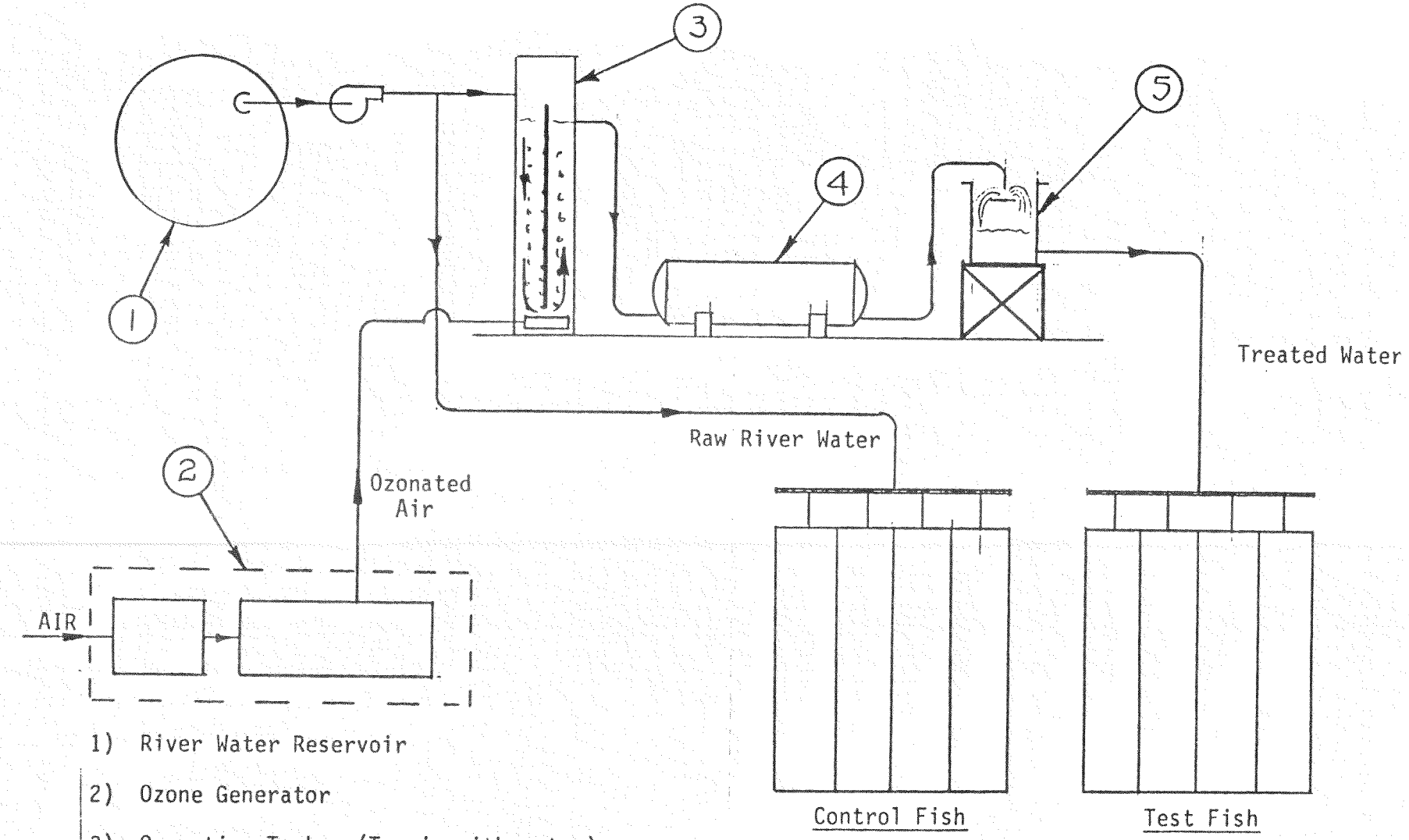
Ozone left the generator through a 1.2 cm teflon tube and was delivered to the contact chamber via airstones where it mixed with raw river water. Ozonated water could then be passed into a retention tank if desired, and then into a degassing chamber, 91 cm in diameter and 2.4 m tall. This tank was filled with 5.1 cm diameter bio-rings and a fan pushed air into the tank bottom. Water then passed into four hatchery troughs or a small raceway (1.2 m x 12.2 m). Controls consisted of four hatchery troughs or another small raceway which recieved a similar amount of raw river water .

Experimental Design

In 1984, groups of approximately 200 fish each were held in separate test and control troughs for seven consecutive days for each ozone dosage tested. In 1985, two groups of 100 fish were exposed to treated and untreated water for four days at each dosage and retention time tested.

After exposure, fish were placed in C. shasta free well water (10.0 C° in 1984). In 1985, half of the groups, with the exception of those on August 6 and 10 , were placed in heated well water (15.5-16.7 C°) and the others in unheated water (12.2 C°). Medicated (TM50) OMP feed was fed to fish throughout the experiment and feed was occaisionally mixed with epsom salts to reduce Hexamitus infections. Fish were occasionally treated with a formalin drip to reduce external parasites.

Species of fish used in the dosage and retention time experiments was Twin Lakes Cutthroat, a high mountain lake



1) River Water Reservoir
2) Ozone Generator
3) Ozonation Tank - (To mix with water)
4) Retention Tank
5) De-Ozonation/Tank - (To remove ozone residual)

Figure 1. PILOT DISINFECTION SYSTEM
COWLITZ TROUT HATCHERY

strain previously found to be quite susceptible to C. shasta. Size of fish varied from 1200 to 200 per pound.

Mortalities were picked daily and examined for C. shasta or frozen for later examination. A slide smear was made from the lower intestine and examined under 100X magnification until trophozoites or spores were identified, or for a period of five minutes. Fish were held in well water for a period of between 60 and 130 days until mortalities from C. shasta had long passed.

In a second phase of the experiment in 1985, one group each of 2500 summer steelhead @ 60 /lb was continuously exposed on 24 August to either 85 gpm ozonated or raw river water in the small raceways mentioned previously. Mortality rates are being monitored and growth, condition, and feed conversion will be determined when the fish are released in May, 1986. This part of the experiment should help in determining a benefit/cost anaylsis since results should somewhat represent production fish.

Bacteria counts

Bacteria plate counts of raw and ozonated water were also made to determine ozone effectiveness. The membrane filter procedure for total coliforms was conducted similar to Jensen (1983). Briefly, a volume of water was filtered through a 45 micron membrane filter which was placed in a petri dish containing MF-endo medium and a medium pad. This was placed in an incubator at 35 C^{o} for 24 hours. All colonies were counted and extrapolated for volume of water used.

Monitoring Ozone in Air

An OREC model DM 110 ozone monitor was used to determine amount of ozone in air being delivered to the contact chamber. The monitor indicated amount of ozone per standard cubic liter and was converted to mg/l by multiplying by the constant .9286. Total mg/l ozone applied to the water was then determined by measuring amount of water being treated.

Water Chemistry

Turbidity was monitored with a Hach Surface Scatter Turbidimeter 5 continous flow turbidity meter and measured in NTU. Turbidity was checked at least weekly.

Water temperature was monitored several times a week and pH was checked on occasion. Specific conductivity was taken from USGS records.

Ozone in Water

A modification of the DPD (N, N-diethyl-p-phenylene-diamine) spectrophotometric method of ozone residual was used to determine small ozone residuals in water. Standard curves with the spectrophotometer were developed from chroline standards corrected by a factor of .6. A Hach kit model OZ-2 ozone test kit was used for samples greater than .3 mg/l.

Results

Ozone and C. shasta

Results of the 1984 tests showed an application dose of about .6 mg/l with a retention time of 28.6 minutes was effective in removing the infective stage of C. shasta (Table 1). Dosages less than this which were tried failed. The CT value obtained by multiplying the ozone residual sampled immediately after contact times the minutes of contact and retention time indicated 1.89 and 4.83 were effective but .63 and .43 were not. It should be noted bacteria kill was over 99 percent at the ozone dosages which proved effective for C. shasta. Only C. shasta positive mortalities are listed although others occurred.

In 1985, results of tests showed CT values of .97 and greater were effective and those .77 or less were ineffective, although those CT values resulting in 99+ percent bacteria kills had only a small amount of C. shasta escape. It was hoped a 99+ percent bacteria kill would eliminate all C. shasta at all retention times. However, the tests conducted on August 6 and August 10 showed with similar application dosages and residuals at contact, not all C. shasta was removed with a shorter contact/retention time.

Time to death from C. shasta was influenced by incubation temperatures after exposure as also found by Udey et al.(1975). Fish held in 1984 had a mortality range of 34 to 100 days incubated at 10 C° while in 1985 at 12.2 C, range was 38 to 75 days and at 16 C range was 24 to 38 days. For example, fish exposed on August 4, 1985 had an average of 30.4 days until death at 16 C while those incubated at 12.2 C had an average of 56.9 days until death (Figure 2).

There also appears to be a peak infectious time. In 1984, assuming greater numbers of infectious units hasten time to death, peak infectious time was in late August. In 1985, infection was readily obtained from fish live boxed through mid-September but was found at greatly reduced levels after September even though river temperatures remained at 11.1 C° through October.

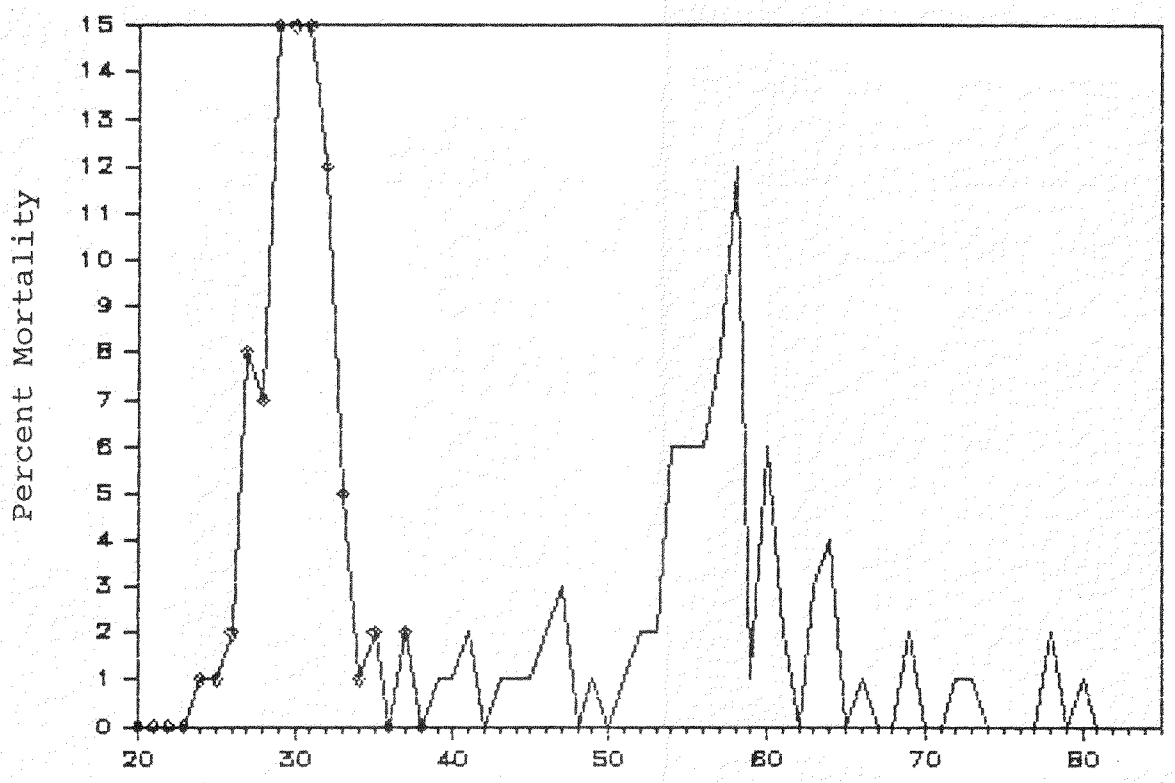
Table 1. C. shasta mortality at various ozone dosages.

Date	Mean O-3 Dose	Flow	Turbidity (NTU)	Minutes Retained	Mean Bact kill (%)	Mean O-3 @CC	Ceratomyxa morts (%) Raw Warm(1)	Raw Cool	Ozonated Warm	Ozonated Cool	C*T(2)
1984 Data											
8-28	.59	40gpm	1.1	28.6	99.12	.066		90		0	1.89*
9-7	.19	40gpm	1.1	28.6	87.13	.015		81		95	0.43
9-13	.82	40gpm	1.1	28.6	99.89	.169		81.5		0	4.83*
9-20	.82	40gpm	1.1	28.6	99.89	.169		81.9		0	4.83*
9-29	.35	40gpm	1.1	28.6	94.76	.022		—		82.7	0.63
1985 Data											
7-16	.75	40gpm	2.3	28.6	98.16	.034	28	25	0	0	0.97*
7-19	.68	40gpm	2.3	12.5	97.55	.037	68	37	2	2	0.46
7-23	1.00	75gpm	2.3	6.6	99.85	.079	69	36	1	1	0.52
7-27	.53	75gpm	2.3	6.6	98.90	.024	56	71	30	27	0.16
7-31	.62	75gpm	2.3	15.3	98.94	.023	77	80	70	62	0.35
8-4	.37	75gpm	2.3	15.3	64.20	.012	90	88	86	81	0.18
8-6	.78	50gpm	2.3	22.9	99.14	.077		100 86		0 0	1.76*
8-10	.76	50gpm	2.3	10.0	99.65	.077		91 99		3 7	0.77
9-3(3)	.86	85gpm	2.3	5.9	99.69	.103		90		3.3	0.61
9-13(3)	.86	85gpm	2.3	5.9	99.70	.108		100		0	0.64*

(1) Incubation temperature
(2) C*T = ozone residual after contact * retention time
* = Successful in removing C. shasta
(3) = Live boxed in raceways

Ozone Residual Toxicity

Toxicity problems with ozone residual was encountered when fish @ 400-500 /lb were exposed to .010-.020 mg/l on a continuous basis in 1984. Some mortality was observed 13 days later and ceased when ozone residual was reduced to .007 mg/l. In 1985, residual ozone amounts ranged up to .010 when entering the hatchery trough with no apparent mortality problems. Summer steelhead @ 30-60/lb have been exposed to residuals entering a small raceway ranging between .008 and .017 mg/l for about 14 weeks at this time with no apparent problems.



—— Unheated Incubation (12.2 C) ◊ Heated Incubation (16.6 C)

Figure 2. Incubation temperature vs C. shasta mortality.

Turbidity Effects on Ozone

Ozone effectiveness is influenced by organic and inorganic demand in the water. Turbidity increases ozone demand and decreases residual ozone levels available for pathogens. For example, in 1984 turbidity was about 1.1 NTU and an applied ozone dose of .59 mg/l resulted in a residual of .066 mg/l

whereas in 1985 with a turbidity of 2.3, an applied dose of .62 mg/l showed a residual of .023 mg/l.

Turbidity increased in October, 1985 due to heavy rains. The residual generated by the same ozone dose at various turbidity levels changed considerably (Table 2). Obviously, the less demand in the water, the less ozone required to do the job.

Table 2.Effects of turbidity on ozone residual @ same dose.

Turbidity (NTU)	Ozone at Contact chamber
3.5	.150
3.7	.080
4.0	.075
4.4	.050
4.8	.027

Ozone Experiment on Summer Steelhead

The experiment on summer steelhead in the second phase of 1985 is incomplete at this time. However, to date mortality has been 36 in the raw river water side and 8 in the ozonated side. It should be noted that mortality in production fish from C. shasta continues throughout the rearing term so mortality totals are expected to change considerably. Raw river fish appear to be less healthy and many appear ready to drop out. Size of fish at the end of November was 17.6 grams in the raw side and 31.3 grams in the ozonated side. Feed consumed in November was five and 70 pounds in the raw and ozonated side, respectively.

Mortality will be less severe for the raw river group than production fish because they were not exposed to infective water until late August, about two months later than usual. Additionally, mortality in the ozonated group may be larger than expected because the CT value fish were exposed to was only .61 until early October when it was changed to 1.3 after results from August 10 were discovered. To date, C. shasta has not been found in fish from the ozonated side although live box tests of Twin Lakes Cutthroat indicated it was present in low levels prior to October.

Because of prior stock history, Cowlitz steelhead have developed a resistance to C. shasta. It is when infective units overwhelm the immune system that mortality results. C. shasta was first found in raw river water fish on September 26 and other pathogens present include Hexamitus, Costia, and Trichodina. Only Hexamitus has been found in the ozonated group so far.

Equipment Reliability and Electricity Costs

The equipment has shown a fair amount of reliability. Several problems were initially encountered in 1984 with the compressor rattling switches off. A few alarms for high and low cooling water pressure on the generator have been sounded but were fixed with an external relief valve. The ozone monitor for determining amount of ozone in air has had the most problems. In 1984, the monitor malfunctioned and had to be sent back to the manufacturer and in 1985, a leak developed inside the machine causing serious corrosion and failure.

Electricity costs to operate the ozone generator and compressor to make about .8 lbs (363 g) of ozone per day was about $.65, based on $.0265/kwhr.

Discussion

Ozone appears to offer a viable solution to the mortality problems caused by C. shasta at the Cowlitz hatchery. A residual level of .10 with ten minutes of contact/retention time appears to be sufficient to destroy it . A bacteria kill of 99+ percent will kill most of the C. shasta.

Because C. shasta is not transmitted directly from fish to fish and Cowlitz steelhead have some resistance to the disease , a water treatment plant should do quite well in controlling it. Temporary equipment breakdowns will not result in large epizootics. Ozone should also reduce mortality from other pathogens. However, once present, other pathogens could spread.

IHN virus has caused epizootics at the Cowlitz trout hatchery in previous years. The ozone system should reduce chances of outbreaks of IHN caused by horizontal transmission since Wedemeyer et al. (1978) was able to kill IHN with a residual of .01 mg/l and a retention time of 30 seconds for a CT of .005.

If results indicate a substantial savings of fish in the second phase of the 1985 experiment, it will be recommended a system be installed to treat about 20 cfs at the hatchery. This will be enough water to hold the hatchery program until sometime in November when waters cool and C. shasta is known to be less infective. Also, river water frequently becomes turbid in December requiring greatly increased ozone application which would reduce the benefit: cost ratio. Average summer and fall turbidity should be similar to 1984 levels since an upstream reservoir was drafted down in 1985. It appears the system would require about 75 lbs of ozone and $50 electricity costs per day.

Engineers will recognize a challenge in designing the most economical ozone system at any hatchery because of tradeoffs in dosage, retention and degassing. A system could have longer retention to offset dosage requirements but may require building of an large tank to hold water. Large ozone dosages reduce the need for retention but increase degassing requirements.

Literature Cited

Jensen, N. 1983. Membrane filter procedure for the fecal coliform test. Wash. St. Dept. of Ecology.

Tipping, J., R. Rathvon, and S. Moore. 1985. A summary of rearing pond improvements attempted at the Cowlitz trout hatchery from 1980 to 1985. Wash. Game Dept.

Tipping, J. and K. Kral. 1985. Evaluation of a pilot ozone system to control Ceratomyxa shasta at the Cowlitz trout hatchery. Progress report. Wash. Game Dept. #85-18.

Udey, L.R., J.L. Fryer, and K.S. Pilcher. 1975. Relation of water temperature to ceratomyxosis in rainbow trout and coho salmon. J. Res. Bd. Can. 32:1545-1551.

Wedemeyer,G.A., N.C.Nelson, and C.A.Smith.1978. Survival of the salmon viruses IHN and IPN in ozonated, chlorinated, and untreated waters. J. Fish. Res. Bd. Can. 35:875-879.

VIRAL DISEASES OF CULTURED SALMONID FISHES OF THE PACIFIC RIM

James R. Winton
Department of Microbiology
Oregon State University
Corvallis, Oregon USA 97331

ABSTRACT

This paper reviews information about the isolation, propagation, morphology, pathogenicity, host range and geographic distribution of the known viruses of salmonid fishes cultured in countries of the Pacific rim. Eight viruses have been isolated in cell culture and at least partially characterized while three others have been observed by electron microscopy. The viruses that have been characterized are: infectious pancreatic necrosis virus (IPNV), infectious hematopoietic necrosis virus (IHNV), Oncorhynchus masou virus (OMV), nerka virus in Towada lake, Akita and Aomori prefecture (NeVTA), yamame tumor virus (YTV), Herpesvirus salmonis (HSV), chum salmon virus (CSV) and a chinook salmon paramyxovirus (CSP). The viruses observed by electron microscopy are: erythrocytic necrosis virus (ENV), intraerythrocytic necrosis virus (INV) and a salmonid anemia virus (SAV). Among these viruses are a birnavirus (IPNV), a rhabdovirus (IHNV), four herpesviruses (HSV, OMV, NeVTA and YTV), a reovirus (CSV), a paramyxovirus (CSP), an iridovirus (ENV) and two unclassified agents that resemble togaviruses (INV and SAV).

Experimentally, several of these viruses can infect a wide range of salmonid fishes while others appear to have strong host specificity. Rainbow trout (Salmo gairdneri) including the anadromous form, the steelhead, have been reported to be infected with IPNV, IHNV, HSV, INV and ENV. Chinook salmon (Oncorhynchus tshawyshcha) are hosts for IPNV, IHNV, CSP, ENV and SAV while IPNV, ENV and SAV have been observed in coho salmon (O. kisutch). The sockeye salmon (O. nerka) and its landlocked form, the kokanee, have been found to harbor IHNV, NeVTA and ENV. Chum salmon (O. keta) are hosts for CSV, IPNV, IHNV and ENV while IPNV, IHNV and ENV have been observed in pink salmon (O. gorbuscha). The masou salmon (O. masou) and its landlocked form, the yamame, have been infected with OMV, YTV, and IHNV. Amago trout (O. rhodurus) has been reported to be a host for IPNV.

Chile has reported IPNV. In the United States IPNV, IHNV, HSV, INV, SAV and CSP have been observed while workers in Canada have documented IHNV, IPNV and ENV. In Japan, salmonids have been found with IPNV, IHNV, CSV, OMV, YTV, NeVTA and ENV. A report from Korea indicates IPNV is present in that country while fish in Taiwan have been found to contain IPNV and IHNV.

Because viral diseases are untreatable, avoidance is the only control measure. The shipment of virus-infected fish and eggs has caused the introduction of many fish viruses into countries where they did not previously exist. The importance of a disease control policy is stressed. Vaccines are being developed against fish viruses and their future and potential applications are discussed.

PROLIFERATIVE KIDNEY DISEASE (PKD) IN SALMONID FISH IN CALIFORNIA

R. P. Hendrick,[1] M.L. Kent,[1] J.S. Foott[1] and D. Manzer[2]

[1] Aquaculture and Fisheries Program
Department of Medicine
School of Veterinary Medicine
University of California
Davis, California 95616

[2] State of California
Department of Fish and Game
Fish Disease Laboratory
2111 Nimbus Road
Rancho Cordova, California 95670

Proliferative kidney disease (PKD) among salmonid fish has been detected at eight fish-rearing sites in California. The primary species involved are under-yearling king salmon (Oncorhynchus tshawytscha) and rainbow and steelhead trout (Salmo gairdneri). Coho salmon (O. kisutch) were involved in one outbreak in 1983 at Mad River Hatchery. With the single exception of Hot Creek Hatchery, a spring-fed water supply, all locations utilize either rivers or reservoirs as water sources. Most outbreaks of PKD have occurred at water temperatures of 15C or above and mortalities have ranged from approximately 5% or less to 95% (cumulative). King salmon seem to be most vulnerable and display great numbers of parasites during early stages of infection. Most epizootics are associated with primary or secondary pathogens and these have included, Ichthyophthirius, Flexibacter, Ceratomyxa, Aeromonas salmonicida and gill bacteria.

The disease is seasonal at most locations, being most prominent in mid summer to early fall. At one study site, this was found to be more a function of abundance of the infective stage of the parasite than water temperature. Through monthly exposures of sentinel rainbow trout, we were able to determine that the infective stage first appears in April peaks in June and then disappears in November. These studies further indicated that fish exposed at 10C can contract PKD if transferred to 15C water for development of the disease.

Fish recovered from PKD are resistant to infection upon second exposure to the infective stage, while yearlings of the same size and age readily contract the disease. Control of PKD by water treatment using filtration and ultraviolet light shows some promise.

THE SEQUENTIAL DEVELOPMENT OF THE PKX MYXOSPOREAN IN SALMONID FISHES

Michael L. Kent and Ronald P. Hedrick
Aquaculture and Fisheries Program
Department of Medicine, School of Veterinary Medicine
University of Californa, Davis
Davis, California 95616

Although the protozoan (PKX) that causes proliferative kidney disease (PKD) has previously been considered an amoeba or a haplosporidan, our recent studies indicate that it belongs most appropriately to the phylum Myxozoa. Fish exposed to water containing the infectious stage of PKX exhibited parasites after 3 wk. The following week typical PKX organisms were prevalent in the kidney interstitium and by 5-6 wk the interstitial nephritis that is typical of PKD was evident. As the disease progressed, PKX organisms migrated to the kidney tubules and released their internal daughter cells into the lumen. Intraluminal sporoblasts, consisting of up to six cells, formed within the released daughter cells. Many sporoblasts organized into spores with two spherical polar capsules. Although the intraluminal spores persisted for several months after the interstitial form of PKX and associated inflammation had subsided, they did not completely develop because they remained within the eveloping cell and did not form valves. These myxosporean spores have been found in fish from all PKD epizootics that we have examined. These include two locations on Vancouver Island, B.C., Canada, Quinault Lake in Washington, the Hagerman State Hatchery in Idaho and all locations in California. Similar myxosporeans have been detected in brown trout Salmo trutta and Atlantic salmon S. salar in Europe.

Although the precise taxonomic status of the PKX myxosporean has not been determined because only immature spores have been found in salmonids, its development is reminiscent of the genus Sphaerospora. In surveys of non-salmonids from PKD enzootic waters, have been observed immature spores similar to those of PKX and mature Sphaerospora spores in the renal tubules of tui chub Gila bicolor and stickleback Gasterosteus aculeatus. Studies are underway to determine the association of these parasites with PKX and the role of non-salmonids as reservoir hosts.

QUALITY IMPROVEMENT

Volitional Coho Releases

Andy Appleby
Washington Department of Fisheries

Introduction

The Washington Department of Fisheries has been actively involved in evaluating electronic fish counting hardware for several years. During this time, accuracy has increased to + or - 4% of hand-counted groups under volitional release conditions. This capability has allowed the evaluation of volitional release studies.

In 1985, a 3-year study began at four WDF Columbia River hatcheries using electronic counters in conjunction with volitional releases of yearling coho.

General Principles

A great deal of work has been done on anadromous species to determine the best criteria for migratory readiness. Decreases in condition factors, elevated levels of gill (Na+K) -ATPase and plasma thryoxine levels have all been associated with seaward migration and preparedness for oceanic existence (Wagner 1968; Zaugg and McLain 1972; Dickoff 1978; Folmar and Dickhoff 1980). The best criteria is believed to be volitional migratory behavior (Brannon 1982).

The Oregon Department of Fish and Wildlife has conducted volitional migration studies using steelhead (Ewing 1984) during 1981 and 1982. Results showed changes in the common indices of parr-smolt transformation were not coincident with active migrating behavior.

The Washington Department of Fisheries study allows the fish to determine their readiness to migrate, thus taking the burden off culturists, biologists and programmers to determine optimum release times, and hopefully, maximize survivals.

Study Specifics

Four hatcheries were chosen for participation in this study; Grays River, Kalama Falls, Elokmin and Klickitat. Grays River and Kalama Falls were used because coho are normally released from several identical ponds, thus providing a control group for survival comparisons. One pond at Grays River and Kalama Falls was released on a specific day according to program requirements. The study ponds had a FC-3 electronic fish counter (Northwest Marine Technology) installed on April 19th and releases commenced immediately. Each pond at Grays River contained approximately 75,000 fish represented by six tag codes (3 replicates in each pond).

Kalama Falls ponds contained approximately 170,000 fish each, represented by four tag codes (2 replicates in each pond).

Elokomin and Klickitat hatcheries were chosen because they release large numbers (over 1 million) of coho from a single pond, and could continue to release fish for an extended period of time (8-12 weeks).

Results

Grays River

Almost one-half of the volitional release pond left the night of April 22 (Fig. 1), about one week before the scheduled release for the control pond. These fish were observed actively migrating down the west fork of the Grays River after release. The only other peak in migration occurred on April 27, five days following the major outmigration. Peak outmigration averaged 1,500 fish/hr April 22.

Kalama Falls

The outmigration pattern at Kalama Falls was distinctly different from Grays River (Fig. 2). The first peak in outmigration occurred on April 21. The highest one-day average was 654 fish/hr on that date. Subsequent peaks in activity were seen at 3-6 day intervals (average 4.6 days).

Elokomin

This station proved more interesting for analysis. The large numbers of fish and the longer release period gives a more representative picture of migration response at this hatchery (Fig. 3).

Peaks in outmigration occurred every 3-11 days ($x = 9.2$) between April 3 and May 27, but were closer together ($x = 4.5$ days) between April 23 and May 17. The highest hourly average was 6,042 fish/hr on May 27.

Klickitat

Peaks at Klickitat occurred at 5-10 day intervals, building over 2-4 days, then decreasing over 2-4 days, the time frame between peaks of activity averaged 11.2 days (range 6-23 days) (Fig. 4). The highest hourly average was 2,292 fish/hr on May 18.

Discussion

Fish at all stations could return into the pond after exiting. The design of the outlet structures provided a small forebay for fish to hold in before moving over dam boards or into the sump and down the pond drain. Despite this, very few fish returned to the ponds. Counts of less than 50 fish per day moving back into the pond were common and support the notion that fish which passed through the counter were showing a desire to move downstream.

The average size of actively migrating fish was larger than the average size fish remaining in the pond. This trend was similar for all groups at all stations.

When data from Klickitat and Elokomin are overlaid, some similarity becomes evident (Fig. 5).

Period of activity are clearly cyclic and are taking place at both stations close to the same date. The forces which drive these peaks of migration are not well understood.

Lunar periodicity has been correlated with coho fry downstream migration (Mason, 1975). The same study could not find any significant correlation between coho smolt migration and moon phases, however. The single highest nightly count of smolts were captured on the full moon, but peaks also occurred during the new moon (Mason, 1975).

Klickitat's and Elokomin's data show periods of low outmigration at full and new moon phases and peaks occurring on or about the first and last quarters. The variable pattern of cloud cover at night undoubtedly modified lunar intensity and duration as seen by the fish. No data were collected regarding this during 1985.

Minimum size thresholds may also explain the cyclic nature of outmigrations. The fish remaining were fed as usual and as segments of the population reached a minimum size, they began migration. This assumption is clouded by the fact that while average size of fish remaining in the pond was smaller, individual fish were larger than the average outmigration.

Day vs. nights counts during 1985 releases could not be accurately calculated due to the arbitrary criteria for delinating day from night. Even with the eight-hour limiation for the day count, it was common for the day total to be equal to or higher than the 16-hour night (Fig. 6).

What the data clearly shows is: when fish are actively migrating they move well during the day and night. When fish are not migrating, they show little activity at either time.

References

Brannon, E., Feldmann, C. 1982. University of Washington zero-age coho salmon smolt production. Aquaculture. 28 (1982). 195-200

Dickhoff, W.W., Folmar, L.C. 1978. Changes in plasma thyroxine during smoltification of coho salmon, Oncorhynchus kisutch. Gen. Comp. Endocrionl., 36:229-232.

Ewing, R.D., Evenson M.D. 1984. Indices of parr-smolt transformation in juvenile steelhead trout (Salmo gairdneri) undergoing volitional releases at Cole Rivers hatchery, Oregon. Aquaculture, 40 (1984) 209-221.

Folmar, L.C. and Dickoff, W.W. 1980. The parr-smolt transformation (smoltification) and seawater adaptation in salmonids. A review of selected literature. Aquaculture, 21:1-37.

Mason, J.C. 1975. Seaward movement of juvenile fishes, including lunar periodicity in the movement of coho salmon fry. J.Fish. Res. Board Can., 32:2543-2547.

Wagner, H.H. 1968. Effect of stocking time on survival of steelhead trout, Salmo gairdneri, in Oregon. Trans. Am. Fish. Soc., 97:374-379.

Zaugg, W.S. and McLain, L. R. 1972. Changes in gill adenosine triphosphatase activity associated with parr-smolt transformation in steelhead trout, coho and spring chinook salmon. J. Fish. Res. Board, Can., 29:167-171.

Elokomin's pond contained approximately 1.2 million fish represented by two tag codes. Klickitat's pond contained about 1.7 million coho, also represented by two tag codes. Releases began at both hatcheries the first week of April.

Coho at all facilities were spawned, incubated, hatched, tagged, and reared using standard practices for those hatcheries. The only difference occurred at release.

Numbers of outmigrants were recorded at each facility at 8:00 a.m. and 4:30 p.m. daily. The 4:30 p.m. total was considered the "day count", the 8:00 a.m. total was considered the "night count".

Sampling outmigrants for length and weight during peak outmigrations occurred at all stations. Sampling outmigrants for presence of AD+CWT fish was conducted at Elokomin and Klickitat hatcheries throughout the release period.

Specific release information is summarized in Table. 1.

Table 1. Release information.

	Size at Release	Total Release	Number of Tags	Tag Code	Stock
Klickitat			22,462	63/30/31	
4/8-6/13/85	13 f/lb	1,163,035	22,461	63/30/30	"S"
Elokomin			25,618	63/32/53	
4/3-5/27/85	18 f/lb	1,703,000	26,149	63/32/54	"S"
Kalama Falls Volitional Release Pond			51,340	63/31/57	
4/19-5/20/85	17 f/lb	169,200	51,214	63/31/56	"N"
Kalama Falls Control Pond			50,886	63/32/32	
5/9/85	17 f/lb	167,114	51,014	63/32/33	"N"
Grays River Volitional Release Pond			24,274	63/32/60	
			24,695	63/32/61	
4/19-5/13/85	16 f/lb	74,542	24,678	63/32/59	"S"
Grays River Control Pond			23,941	63/31/01	
			24,599	63/32/62	
4/30/85	16 f/lb	73,760	24,579	63/32/63	"S"

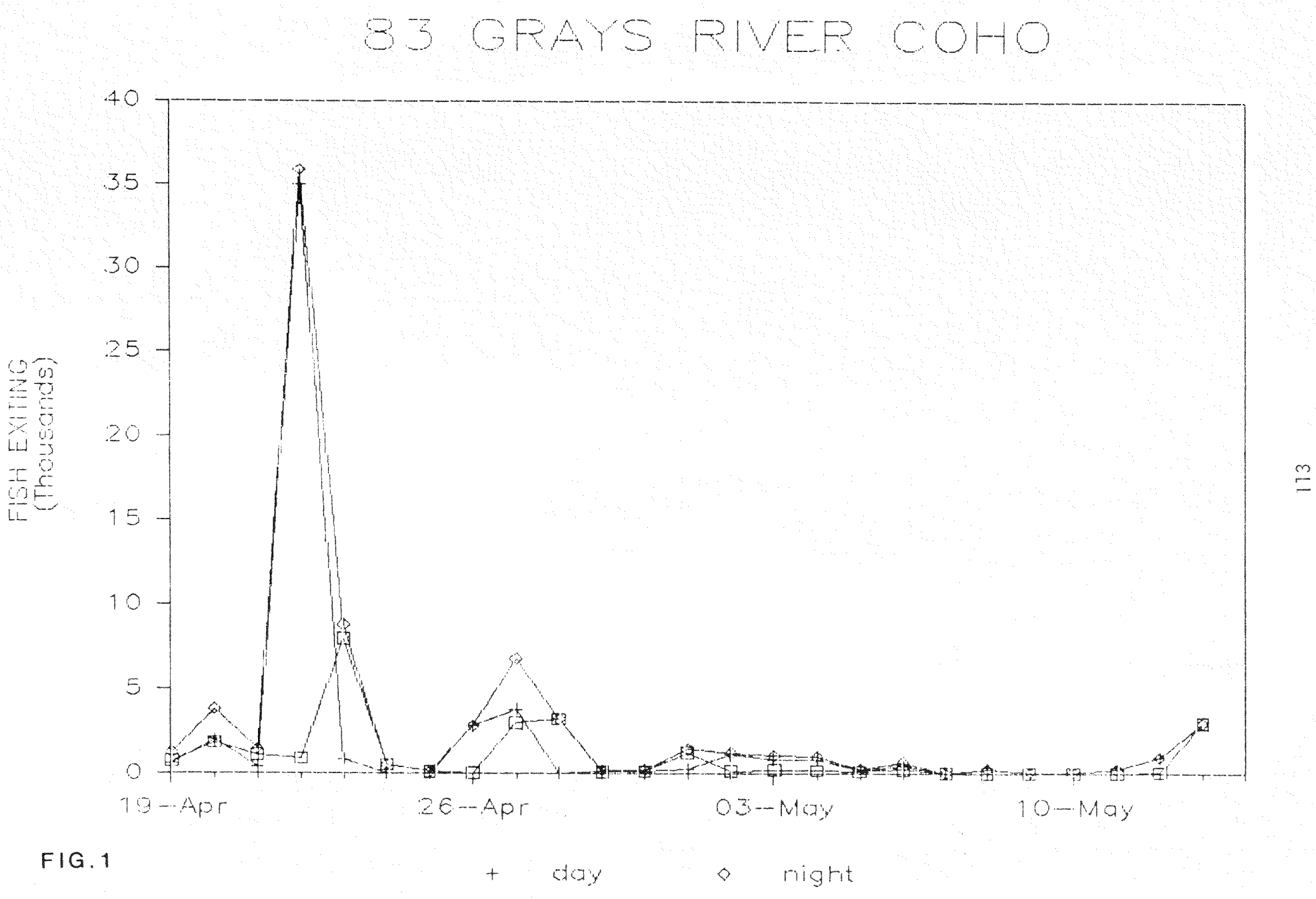

83 GRAYS RIVER COHO
FISH EXITING
(Thousands)
40
35
30
25
20
15
10
5
0
19--Apr
26--Apr
03--May
10--May
+ day
◇ night

FIG. 1

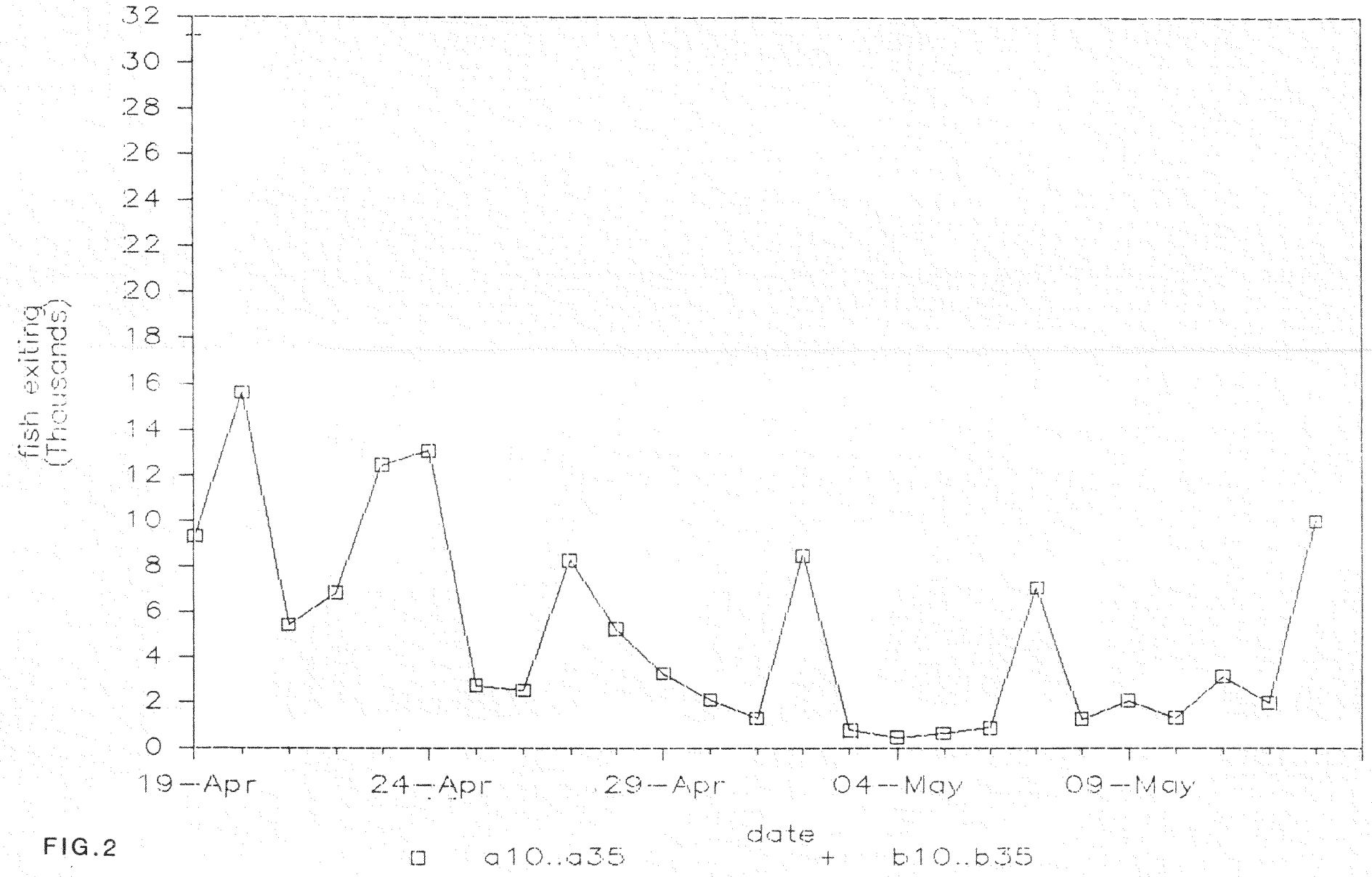

83 KALAMA FALLS COHO
fish exiting (Thousands)
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
19--Apr
24--Apr
29--Apr
04--May
09--May
date
a10..a35
b10..b35

FIG.2

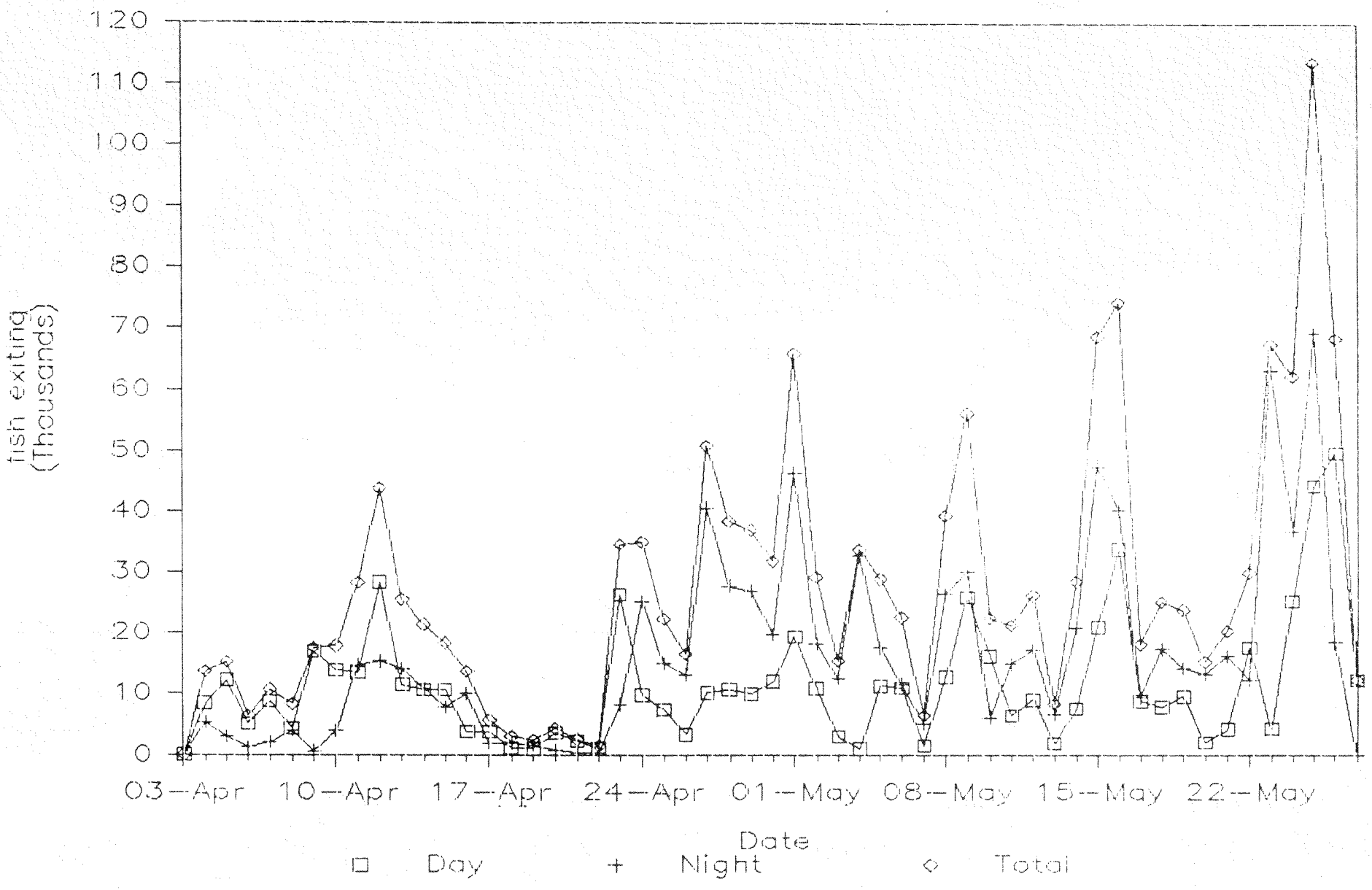

83 Elokomin Coho
fish exiting (Thousands)
120
110
100
90
80
70
60
50
40
30
20
10
0
03—Apr
10—Apr
17—Apr
24—Apr
01—May
08—May
15—May
22—May
Date
Day
Night
Total

FIG.3

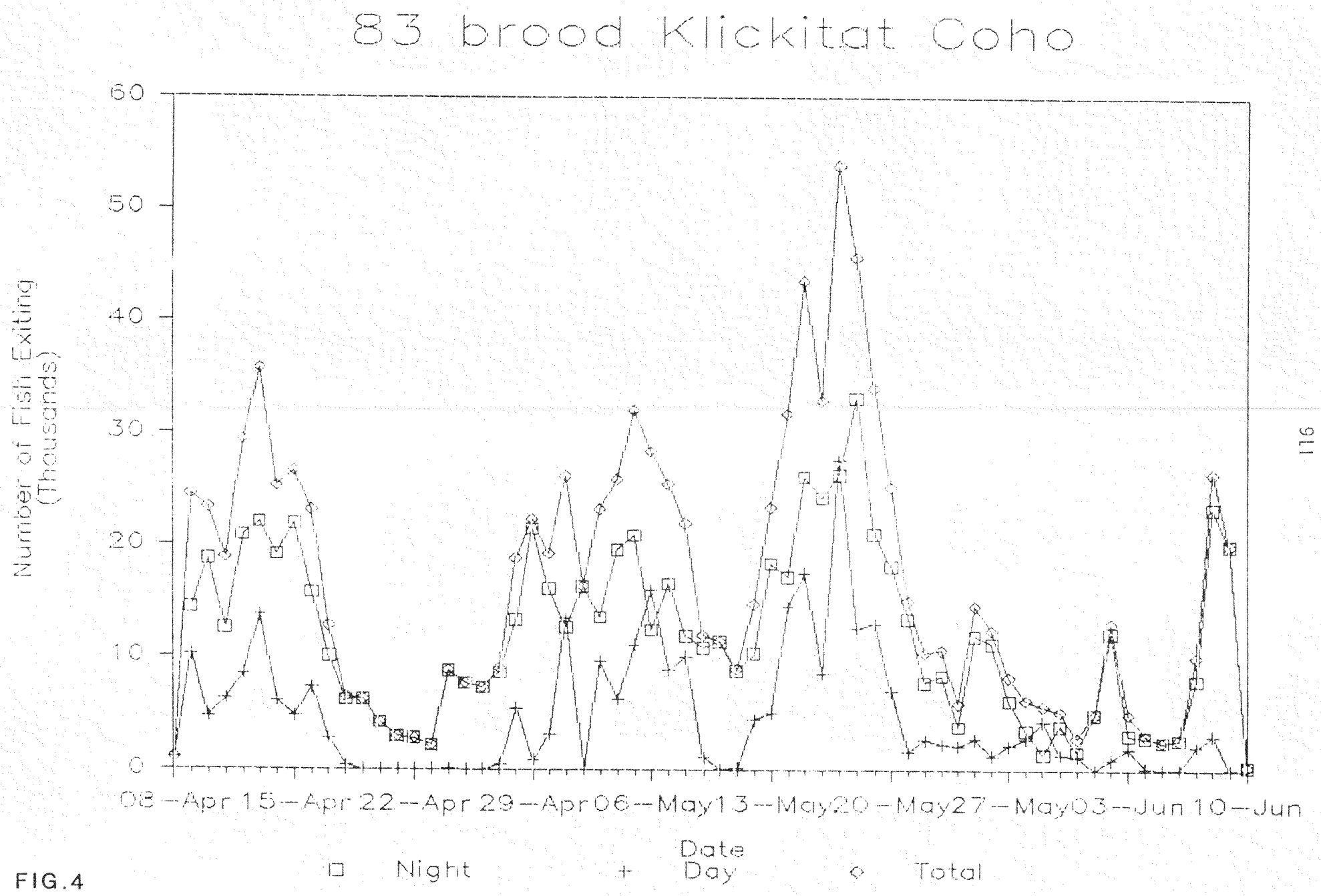

83 brood Klickitat Coho
Number of Fish Exiting (Thousands)
60
50
40
30
20
10
0
08 --Apr 15 --Apr 22 --Apr 29 --Apr 06 --May 13 --May 20 --May 27 --May 03 --Jun 10 --Jun
Date
Night
Day
Total

FIG.4

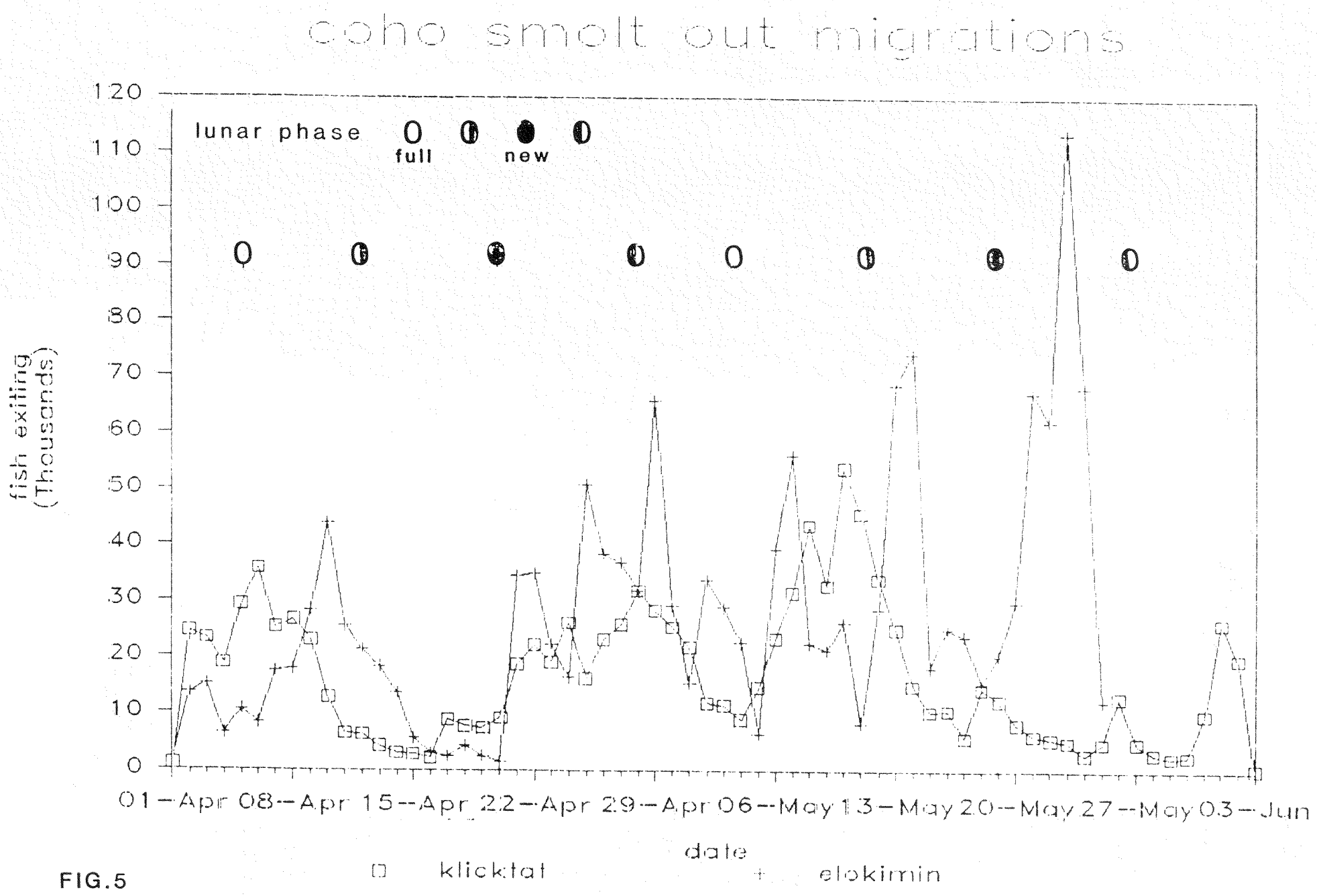

coho smolt out migrations
lunar phase
full
new
120
110
100
90
80
70
60
50
40
30
20
10
0
fish exiting (Thousands)
01-Apr 08-Apr 15-Apr 22-Apr 29-Apr 06-May 13-May 20-May 27-May 03-Jun
date
klicktat
elokimin

FIG.5

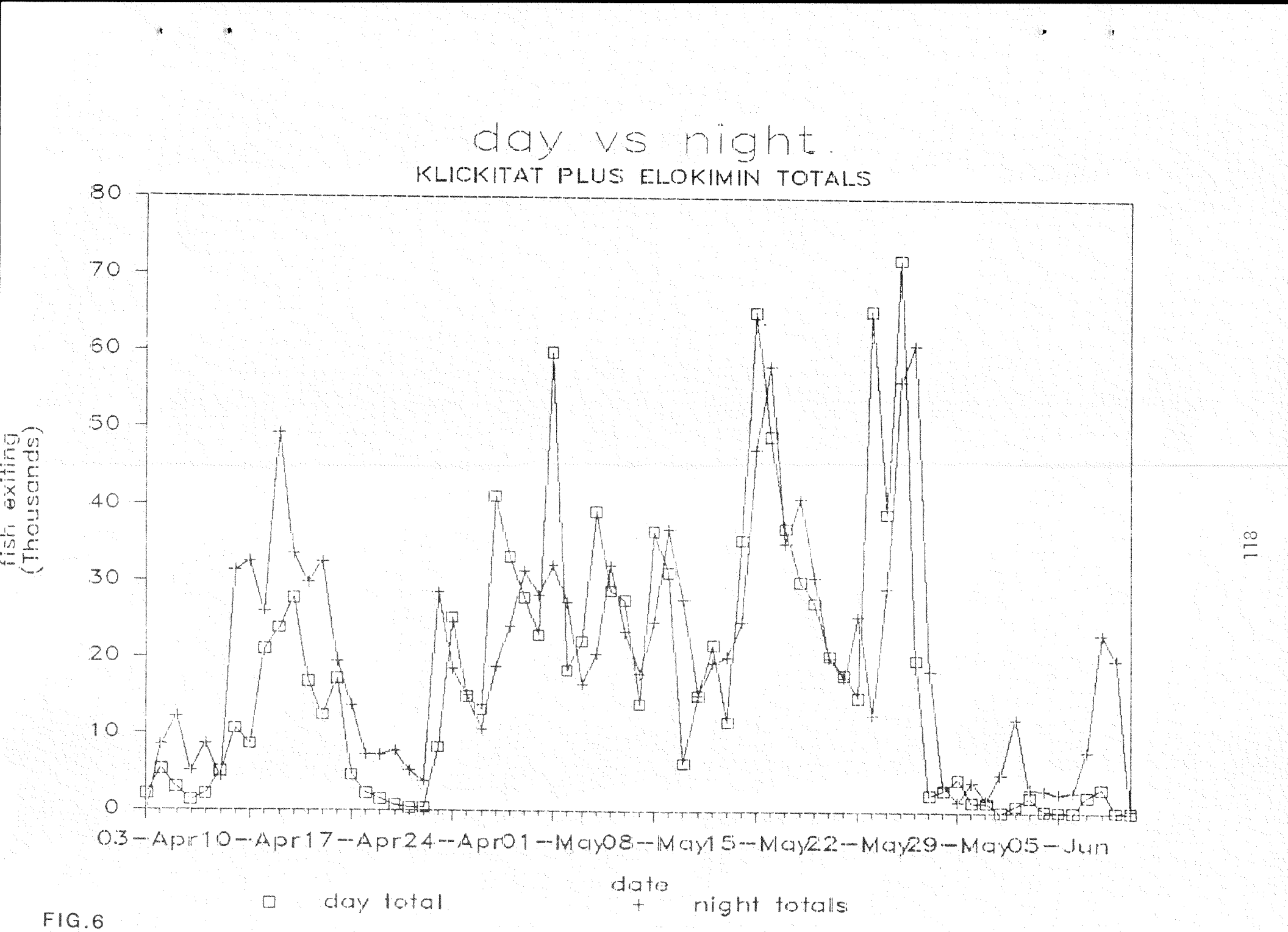

day vs night.
KLICKITAT PLUS ELOKIMIN TOTALS
80
70
60
50
40
30
20
10
0
fish exiting
(Thousands)
03-Apr10-Apr17-Apr24-Apr01-May08-May15-May22-May29-May05-Jun
date
day total
night totals

FIG.6

COHO SMOLT OUT MIGRATIONS %

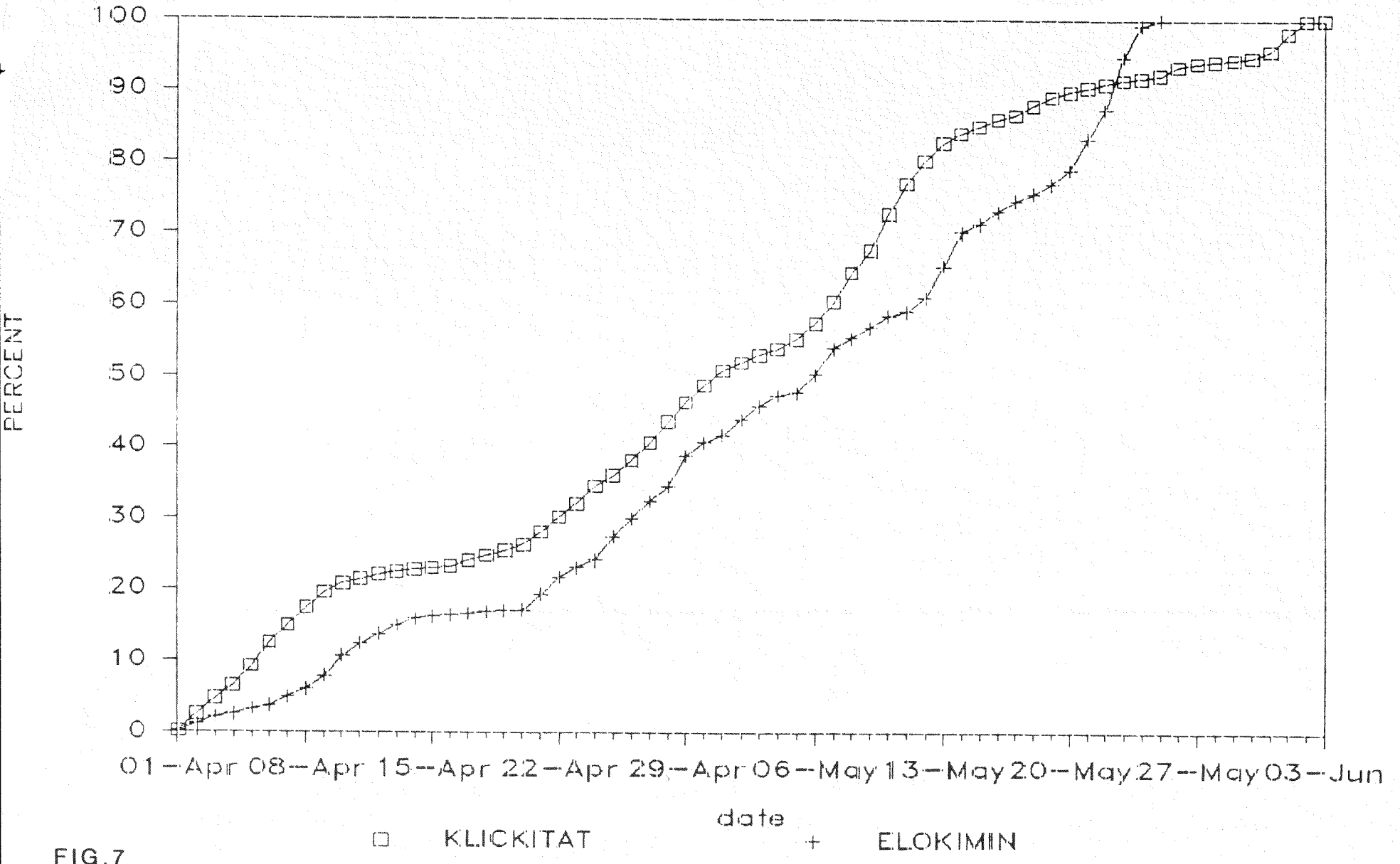


FIG.7

THE USE OF ADVANCED PHOTOPERIOD TO INDUCE EARLY SMOLTIFICATION OF YEARLING COHO SALMON

By

Richard Schneider
Washington Department of Fisheries

In general, Washington Department of Fisheries salmon hatcheries strive for a mid-May release of their yearling coho salmon (O. kisutch). At many hatcheries, this is a critical time of increasing water temperature and pond loadings. Rapidly growing chinook and coho fry can stretch the limits of a hatchery's water supply by mid-April. The water and pond space taken up by yearling coho is often coveted by many hatchery managers, leading to requests for permission to release these fish early. Sometimes the situation demands that they be released early, but an attempt is always made to achieve as late a release time as possible.

The choice of mid-May as a release goal is a compromise between the previously mentioned water-reared constraints and size and time of release studies that have shown increasing adult returns from May, June and even July releases (Seidel and Mathews 1977; Schneider and Foster 1981; Bilton et al. 1984). Although many factors are involved in this survival increase, one explanation is the rising percentage of smolts in a pond as spring approaches summer. Research has shown that highly smolted coho salmon migrate rapidly and adapt to seawater readily. At the hatchery level, this process is monitored by changes in growth rate, body coloration, increasing migratory activity and decreasing condition factors. Other biochemical factors have been identified, such as gill Na+K+ATPase, which increases concurrently with smolt appearance, migratory behavior and other indicators of smoltification (Zaugg 1982a).

Observations of coho salmon in WDF hatchery ponds has found smolt numbers to rise from as low as zero percent in late March to nearly 100% by the middle of May. The environmental cue that appears to synchronize this development is increasing day length as the summer solstice nears. Research has shown that manipulating photoperiod during the rearing of juvenile salmonids can affect the rate and time of smoltification (Clark et al., 1978; Ericksson and Lundquist 1982). In recent studies, the ability of coho salmon to regulate sodium has been enhanced by photoperiod advancement when certain size and growth rate conditions were met (Brauer 1982).

The hatchery chosen for this study (Willapa Hatchery, Lebam, WA) is forced annually to release a portion of its yearling coho near the beginning of April to make room for rapidly growing chinook and coho fry whose pond space needs have exceeded available water supplies. Past observations of these "early" released yearlings have shown low numbers of morphological smolts at the time of release. Preliminary tag recoveries from these groups also shows survival to be significantly less than for groups released on normal May release dates. The goal of this study was to use artificial lighting to induce a pond of yearling coho to achieve a high level of smoltification one month earlier than would occur under natural day length.

DISCUSSION

Normal progression of the smoltification process can be inferred from data taken from the two natural photoperiod groups. The transitional stage fish began showing up as a small percentage of the pond in early February. By the middle of March, almost all fish had reached the transitional stage. Shortly after this, smolted fish began appearing in the pond, condition factors began to fall and gill Na+K+ATPase levels began to rise. Under normal conditions, the percentage of smolts increases rather rapidly during the month of April and peaks sometime in May. Water temperature will affect the rate at which this process moves, but the underlying mediator is increasing photoperiod prior to the summer solstice (Clarke et al., 1978; Ericksson and Lundquist 1982).

The goal of this study was to accelerate the attainment of a high level of smoltification by using an advanced photoperiod. The results of this study show that a 90% rate of smoltification was reached in the advanced photoperiod treatment pond almost one month before a similar level was reached under natural day length (Fig. 4).

Size and time of release studies have shown increased survival of yearling coho salmon released in May, June and July compared to earlier time periods. This study has shown that the onset of some physiological changes associated with smoltification can be moved forward by advancing photoperiod cues. Post-release catch and escapement of this treatment group will show whether these advanced smolt characteristics can be transformed into improved survival. Improved survival of early release groups will give some hatcheries flexibility to maintain high levels of production without sacrificing coho smolt quality. If successful, this technique may have a wider application by allowing hatcheries to simulate June or July releases without actually holding fish to these times.

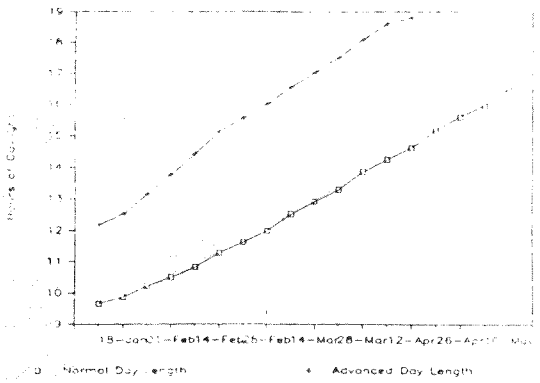


Fig.1. Daylength of Treatment vs Control

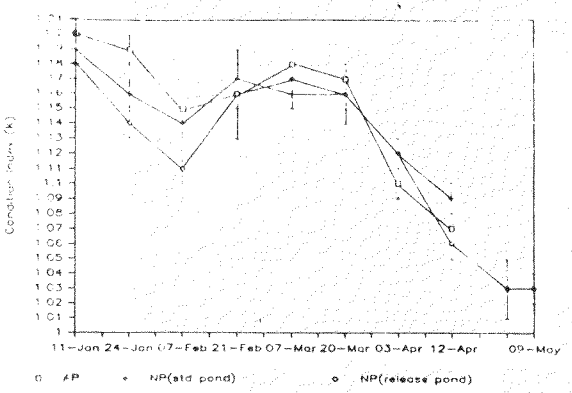


Fig.2. Condition Index. (Mean + 95% C.I.)

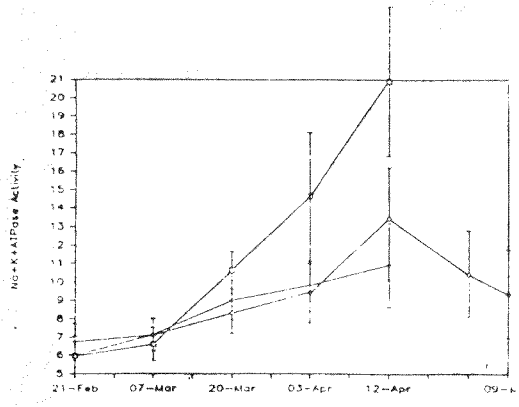


Fig.3. Gill Na+K+ATPase. (Mean + C.I.)

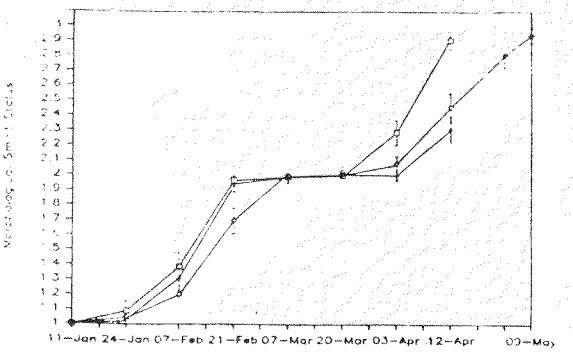


Fig.4. Smolt Status (MSS). (Mean + C.I.)

SALMON SPAWNING COUNTERBALANCE

David L. Rieben
Oregon Department of Fish and Wildlife
Big Creek Hatchery

During my years as a fish culturist, I have never seen or heard of an aide, of any kind, for holding female chinook salmon while removing eggs, other than a two-man method. Each season at Big Creek Hatchery made me progressively more aware of the need to counter a portion of the weight of the carcass while holding it up to remove the eggs. I had envisioned a method but thought it would be too cumbersome. This year I decided it was certainly worth a try. It took about three trys to get the size and shape of the hook assembly that I wanted. The results were very well worth the effort.

The hook aseembly is made of 39 inches of one-half inch water pipe bent in a manner as shown in the sketch. The handle is on a one-half inch rod inside the pipe. This allows it to rotate so the spawner can more readily hook and unhook the fish.

This hook assembly has a lightweight rope attached at the top. The rope goes up through a pulley directly overhead, and then along the ceiling to another pulley attached by the wall of the spawning shed. It then attaches to a plastic jug filled with about ten pounds of rock. Weight can be added by filling the jug with water. The jug goes up and down as the hook assembly is raised up and down. The first pulley mentioned above is mounted on a horizontal rod which is bolted to the ceiling. This allows more freedom of movement from side to side as the spawner works his way across a rack of fish.

When set up for use the counterweight is near the floor and the hook assembly at shoulder height.

To use the device, proceed as follows:

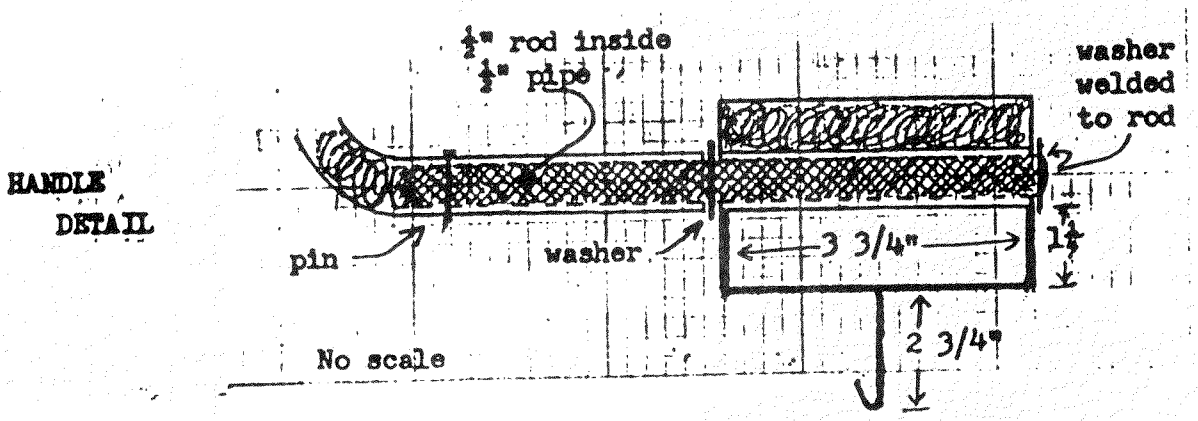
Pull the handle down and rotate the hook back, then push it under the gill plate and lift. Obviously it depends on the weight of the fish how much lift is needed on the handle to lift the fish from the rack. After the eggs are removed, the carcass is normally removed from the hook by lifting with the free hand inside the body cavity. You can also remove it by simply twisting the hook.

On a few small females it is necessary to hold down slightly, but with the vast majority, the counterweight will hold 70-80% of the weight.

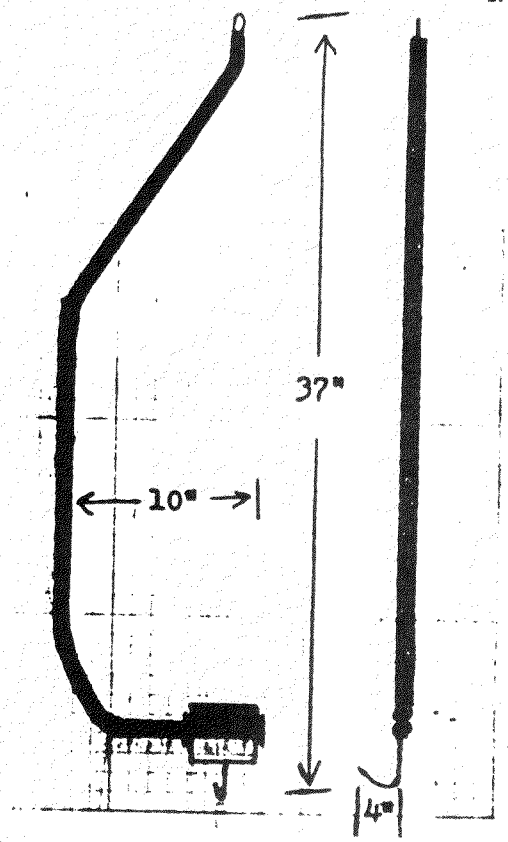
This device has accomplished its objective of greatly reducing the back strain of the egg taker. Due to lowered fatigue, productivity is increased. It also keeps fingers from being cut on the gill rakers as was often common when using a gloved hand under the gill cover.

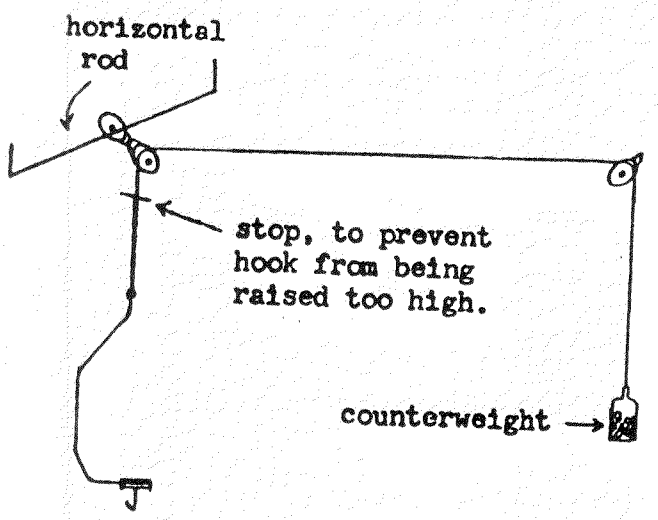
The sketch shows a hook for a right handed person. A left handed person would probably want a hook pointed in the opposite direction.

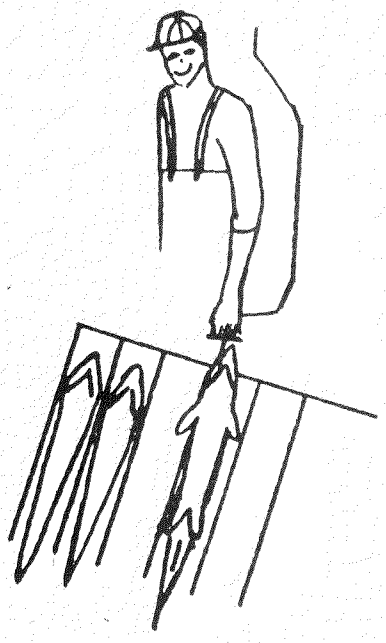
For picking up males we use a hook by itself (without the counter-weight). For two years that is what we used for the females. Prior to that we just used a cloth gloved hand under the gill cover.

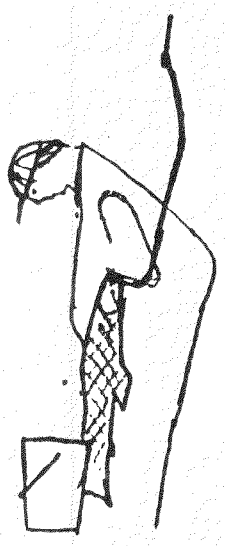


No scale


37"
10"
4"


horizontal rod
stop, to prevent hook from being raised too high.
counterweight





RACEWAY AND POND PREDATOR NETTING

Stanley C. Woody, Hatchery Manager
Washington State Department of Game
Beaver Creek Hatchery
Cathlamet, Washington

Beaver Creek Hatchery is located 40 miles from the mouth of the Columbia River and 4 miles up the Elochoman River which flows into the Columbia east of Cathlamet, Washington. This hatchery, like so many others in the northwest, has been plagued with bird predation. Blue Herons, Seagulls and Mergansers frequently visit the hatchery looking for a free meal. All around the ponds were completely inundated with bird droppings and many of the dead fish that were picked off showed bill marks on their bodies. Every Fall inventory of our ponds showed astonishing losses that were accountable. Even though we know there was a ground animal predation we figured the majority of the fish losses were coming from the Blue Herons and the Seagulls. We tried various non-lethal means to control the birds such as cracker shells, zom guns, bird alarms, electric shock devices, etc., but nothing seemed to deter them for any length of time.

We decided that the only way to control bird predation effectively was to deny them access to the ponds. This meant a net structure covering the entire raceways and rearing pond area had to be constructed.

We purchased blueberry netting, cable, polyline, galvanized pipe and various hardware items to do the job. First we dug holes around the entire one-acre pond and set two-inch pipe two and a half feet into the ground with concrete so we could have something to anchor the cable to. Then the cable was run through the eyebolts in the pipe, pulled tight and secured with cable clamps. From this cable we could cross line it at several spaces the length of the pond, again securing these cables with cable clamps. In order to keep the center of the netting from sagging, twelve-foot lengths of 2-inch pipe were anchored in concrete at four evenly spaced intervals in the center of the pond. On one side of the pond four boat winches were welded to two-inch pipe and set in concrete. Aircraft control cable from the winches was attached to the center cable after it was strung through a chain link welded near the top of the pipes. This allows the center of the netting to be raised or lowered by cranking the four winches. Next, six panels of netting 16 feet wide and 725 feet long were cut and attached together by poly twine. The netting panels were then pulled over the cables and attached with plastic conduit ties.

Raceways: After the rearing pond was covered we started work covering 20 raceways with a total area of 22,000 square feet. We purchased eight twenty-one foot lengths of schedule forty galvanized pipe, eight inches in diameter. We welded steel caps on one end which was to serve as the top so water could not enter the inside of the pipe. We obtained the services of P.U.D.'s equipment and manpower to dig the holes and set the pipe. The pipe was set in five foot holes with concrete which made a solid base for the wire to be pulled to maximum tightness. We welded two half links of chain at the top and one at the bottom to string our wire through. Rachet type wire

tighteners were installed inline and tightened to near maximum which is 700 pounds tensile strength rating of the wire. We strung two wires at the top to hold the top netting and the top of the side netting; then strung one at the bottom to hold the side netting. We used four-inch blueberry netting, securing it to the wire with polyline. The top netting was kept from sagging by stringing the wire back and forth from the perimeter wires. Several rachet-type wire tighteners were installed in various areas of the wire and pulled to maximum tightness to keep the net from sagging. On two sides of the netting S hooks were used to hold it to the wire so it could be raised up to facilitate loading and unloading of the raceways. There are two access points at each side of the netting to enter the enclosed area.

The total cost of all materials and rental equipment was $4533.41 to cover both areas. All labor was supplied by the hatchery crew and it was accomplished along with other routine work.

The idea of covering ponds is not new. We collected a lot of ideas from observing other hatcheries and incorporating some of our own ideas.

Evaluation: We have completed our first inventory of our fish program this Fall and it looks like we have reduced our fish losses up to 15% on some ponds over the entire three-specie program. Since the netting was not designed to keep out ground predators it appears that we can credit most of the remaining unknown loss to otter, mink, etc. After we have completed an entire year with the netting installed we should have a better idea just how effective this was to reduce unknown losses.

Summary: There are some improvements that could be made, such as stronger netting material which would be more beneficial when a bird flies into it. They now can easily break the strands of netting if they fly into it. In addition to this, in country where there is a heavy snow accumulation it could cause the netting some severe damage.

This pond netting may not be the entire answer, but it has kept the birds out of the pond areas while complying with non-lethal control measures.

Vendor sources for material:

HI-TEN FENCE AND TRELLIS SUPPLY, P. O. Box 44714, Tacoma, WA 98444

REDDEN NET COMPANY, 2626 Harbor Loop, Bellingham, WA 98225

CONSOLIDATED ELECTRICAL DISTRIBUTORS, 1154 12th Avenue, Longview, WA 98632

CASCADE LOGGER SUPPLY, 1550 Industrial Way, Longview, WA 98632

INTERNET, INC., 2730 Nevada Avenue, North New Hope, MN 55427, Longview, WA 98632

A Time Saving Egg Treatment System from the Iron River NFH

Stephen M. Pastor

Eagle Creek National Fish Hatchery

34286 SE Rainbow Rd.

Estacada, OR 97023

The routine treatment of salmonid eggs to control the growth of fungus can be a time consuming process. The Iron River National Fish Hatchery in northern Wisconsin began production of lake trout (Salvelinus namaycush) in 1983. The standard small scale approach for treating eggs was adopted. This method consists of measuring water flows in stacks of hatching trays, then applying formalin from "chicken waterers" with a hole drilled in the outer edge of the base to provide a constant flow of liquid.

Since Iron River is a broodstock hatchery supplying eggs to other hatcheries it has a total of sixty stacks of trays. Measuring water flows and measuring formalin for this number of stacks would take hours. Serveral time saving methods were developed and/or adapted by the hatchery staff.

Flow indicating devices were placed on top of each stack of eggs. These devices consisted of translucent dish pans with a hole drilled in the bottom. The height at which the desired water flow backed up in the dish pans was marked. Reduced flow was indicated when the water height was below the marked line, and too much flow was indicated by a water level above the mark. Adjustments to the desired flow could easily be made. Experience at the Eagle Creek National Fish Hatchery in Estacada, OR, indicates that one gallon plastic milk jugs are both more practical and less expensive than plastic dish pans.

The ability to treat all stacks simultaneously rather than seperately was seen as the next time saver. Formalin could be pumped directly into

water flowing into the stacks. In order to achieve the correct concentration, however, total water flow had to be determined. Although flows to individual stacks could be assessed at a glance, the use of three head troughs to supply water to the stacks posed a problem. Overflow from each of the three troughs flowed into standpipes accessible only with a stepladder. A method of measuring this overflow was needed to determine total water flow.

Overflow water was diverted from the standpipe drains into "flow measuring columns", and then into a floor drain. The columns consist of a plate of plexiglass sandwiched between two pieces of three inch pipe. A hole in the plexiglass restricts water flow through the pipe. There is a positive relationship between the height of water in the column and the amount of water flowing through the pipe. A sight gauge of clear tubing was attached to the column and flow rates corresponding to various heights were marked. Overflow water in all three head troughs could now be measured by glancing at the flow measuring columns, and flows to individual stacks could be set by using the measuring pans.

Formalin was pumped into the incoming water supply by a fixed speed peristaltic pump. The amount of liquid pumped during a fifteen minute period was determined, and a corresponding mark was made on the treatment container. The amount of formalin needed for a treatment was added to the container and water was added to make up the volume which would be pumped in fifteen minutes. Although a timer was used to shut off the pump, use of a stock volume provided a failsafe endpoint to the pumping of chemical.

Several interesting features were planned for the never completed treatment container. Formalin would be pumped into the treatment container directly from a fiftyfive gallon drum. Although this would eliminate an opportunity to measure chemical volume, it would reduce exposure to toxic

fumes since the container would be vented outside of the work area. Formalin volume would be assessed by reading fluid level and volume on a sight tube attached to the treatment container. A small diameter pipe attached to the bottom of a large diameter pipe would allow measurement of small amounts of formalin, yet allow a large quantity of water to be added to create the volume to be pumped in fifteen minutes. This arrangement provides a great deal of flexibility with a fixed speed pump.

ENUMERATION AND ISOLATION OF FISH AND HUMAN PATHOGENS FROM THE OREGON MOIST PELLET

Cheryl Moffitt-Westover, Oregon State University

Enumeration and isolation of bacteria, including fish and human pathogens, from the Oregon Moist Pellet (OMP) and the diet's ingredients are being examined. A comparison of the products resulting from a recently remodeled fish hydrolysate pasteurization process is being made with diets produced by the old system. Previously hydrolysate and final product had bacterial counts which averaged 5.5×10^8 and 4.8×10^7/gram respectively, whereas the new product has $<1.0 \times 10^4$ to 3.1×10^6 and 9.1×10^5/gram; a reduction of bacterial counts by more than two logs. Two isolations of Yersinia ruckeri serotype II and two of Salmonella sp. have been made from the fish hydrolysate which comprises 30% of the finished product. In addition, two Salmonella sp. were identified from OMP samples produced prior to installation of the new equipment. Neither of the pathogens have been isolated from the new equipment. A total of 24 samples is currently being tested for selected pathogens.

THE USE OF ANDROGENS FOR THE PRODUCTION OF STERILE RAINBOW TROUT FOR MARICULTURE

Igor I. Solar and Edward M. Donaldson.

West Vancouver Laboratory, Fisheries Research Branch
Department of Fisheries and Oceans,
4160 Marine Drive, West Vancouver, B.C. V7V 1N6 Canada

ABSTRACT

The immersion of rainbow trout alevins in a solution of 100 or 400 µg/l 17α-methyltestosterone followed by oral administration of the androgen to fry for periods of 60 or 90 days at a dose of 25 mg/kg diet produced 100% sterile fish at the time of sampling, immediately after the end of the treatments. Variable numbers of sterile, semi-sterile and female fish were produced with dietary treatment of methyltestosterone or testosterone or with combinations of immersion (500 µg/l) and dietary testosterone at doses ranging from 250 to 2500 mg/kg diet.

This study shows that immersion treatment prior to the oral administration of the steroid 17α-methyltestosterone results in effective inhibition of gonadal differentiation and prevents sexual maturation to a greater extent than dietary treatment alone.

INTRODUCTION

The development of a technique for the effective sterilization of rainbow trout has great potential value for the mariculture of this species. The precocious maturation of the stocks, particularly males, has detrimental effects on growth, survival in sea water and

marketability of the fish. Specifically, the management applications of culturing sterile stocks are:

a) preventing the production of early maturing males;

b) maximizing growth by diverting energy, otherwise used in gonadal development, into flesh;

c) permitting year round harvesting by maintaining silver bright quality;

d) eliminating losses associated with sexual maturation in seawater.

At the West Vancouver Laboratory, we have been investigating the use of steroid hormones for the control of sexual differentiation and sterilization of salmonids including rainbow trout (Donaldson and Hunter, 1982; Hunter and Donaldson, 1983; Solar et al., 1984, 1985).

This report describes preliminary results obtained using the synthetic hormone, 17α-methyltestosterone (MT) and the naturally-occurring androgen testosterone (T) in combinations of immersion and feeding treatments.

MATERIALS AND METHODS

The gametes were obtained from three year old Spring Valley rainbow trout cultured in sea-pens at the Pacific Biological Station, Nanaimo, B.C. The eggs were fertilized, divided into groups of approximately 200, placed in plexiglass chambers with 1 mm plastic mesh top and bottom (Goetz et al., 1979), and incubated in Heath trays (Heath Techna Corp.) at temperatures ranging from 6.5 to 9.0°C.

On days 3 and 10 after 100% hatch the chambers containing the yolk-sac alevins were immersed for two hours in 5 liter polyvinylchloride (PVC) boxes containing a solution of either 17α-

methyltestosterone or testosterone (Sigma Chemical Co., St. Louis, MO), Table I. After each immersion treatment the chambers were returned to the incubators until alevin swim-up.

Following swim-up the fry were transferred to 50 liter tanks supplied with aerated well water (10 ± 1°C). Starting at day 24 post-hatch the fry were fed small amounts of untreated diet (OMP) to initiate feeding. Then starting 30 days post-hatch the fry were fed the hormone treated diets (MT or T) for 60 or 90 days at the doses shown in Table I. Additional groups received dietary treatment only and others no treatment at all.

At the end of the treatments approximately 30 fish from each replicate group were randomly sampled, killed with a lethal dose of 2-phenoxy-ethanol (Syndel Laboratories, B.C.), weighed and measured. Whole body cross sections (3-5 mm thick) were cut at a point just caudal to the pectoral fins and placed in Bouin's fixative. Sex and gonadal condition were determined by histological analysis.

RESULTS

Normal 1:1 male:female ratios were found in the control fish examined at the end of the treatments. The experimental groups, however, showed substantial variation from the normal ratio (Table I). At the time of first sampling (60 days), the highest percentages (100%) of sterile fish (gonads devoid of germinal elements) were observed in the groups submitted to combined immersion and dietary treatments with MT and in the group receiving combined immersion and the lowest dietary treatment with testosterone. At the second sampling (90 days) a decrease in the proportion of sterile fish was found in all the groups

treated with immersion and/or dietary testosterone. Concurrently, the percentage of fish with gonads containing developing oocytes increased in the same groups. The fish treated with MT, immersion and dietary treatments, however, remained consistent (100% sterile) at both sampling times.

The growth (Table II) and survival of the treated groups were not significantly different from controls except for the groups fed the highest dose of testosterone which had the lowest average weight and the highest mortality.

DISCUSSION

The results of this study show that exposure of rainbow trout alevins to the combined effect of immersion and oral androgen treatment, specifically 17α-methyltestosterone, inhibits gonadal development and gametogenesis, under experimental conditions.

Earlier investigators have reported the variable effects of MT on the gonads of rainbow trout. Jalabert et al. (1975) produced 12% steriles and 12% hermaphrodites using 15 to 60 µg/g MT in the diet. Johnstone et al. (1978), using 2-hour immersions at the eyed-egg and alevin stages followed by 3 mg/kg MT in the diet for 90 days, reported 17% fish with gonads composed of hypertrophied and sterile connective tissue. Harbin et al. (1980) incorporated methyltestosterone in the diet of rainbow trout at a dose of 30 mg/kg diet for 110 days. Histological examination of the gonads showed increased vascularization and connective tissue infiltration. In our own studies (Solar et al. 1984, 1985) we have reported close to 80% sterile domestic trout produced by oral treatment with MT at a dose of 25 mg/kg for 60 days.

The remaining fish showed localized areas of spermatogonia among extensive areas of connective tissue. Subsequent observations by disection of 2 to 3 year old treated trout from these studies has revealed lobular testicular development including portions of ovarian tissue.

The presence of fish with intersex (hermaphroditic) gonads and the paradoxical increase of female rainbow trout following prolonged treatment with high doses of androgens has been discussed in previous reports (Solar et al. 1984, 1985). This is a phenomenon which has also been observed in the amphibia and other species of teleosts. The feedback inhibition of androgen biosynthesis or aromatization of exogenous androgen into estrogens, have been hypothesized as possible mechanisms to explain the androgen-induced feminization.

The current study is the first to report complete androgen induced sterility in the rainbow trout. This result has been achieved by treating the trout at the alevin stage prior to the 25 mg MT oral treatment which was used in our earlier studies (Solar et al., 1984, 1985). The sterilization observed appeared to be complete (absence of germinal elements in the gonads) when fish were sampled after 60 or 90 days of treatment. Follow-up observations on 2 year old fish, (by which time male fish would normally reach sexual maturity) have shown promising results. A sample of the fish taken two weeks before this conference (Nov. 12, 1985) showed no sexual maturation among 13 treated fish (stringlike gonads which could not be removed by dissection) while a sample of the controls (15 fish) produced 6 females and 9 males, 3 of which had large, fully mature (running) testes. These results suggest

that the sterile condition remains in effect during long term rearing or substantially reduces or delays sexual maturation.

REFERENCES

Donaldson, E.M., and Hunter, G.A., 1982. Sex control in fish with particular reference to salmonids. In: W.S. Hoar Symposium, Fish Reproduction: Behavior and Endocrinology. Can. J. Fish. Aquat. Sci. 39: 99-110.

Goetz, F.W., Donaldson, E.M., Hunter, G.A., and Dye, H.M. 1979. Effects of estradiol-17β and 17αmethyltestosterone on gonadal differentiation in the coho salmon, Oncorhynchus kisutch. Aquaculture. 17: 267-278.

Harbin, R., Whitehead, C., Bromage, N.R., Smart, G., Johnstone, R., and Simpson, T., 1980. Sterilization and other effects of methyltestosterone in the rainbow trout. J. Endocrinol., 87: 66-68 (Abstr.).

Hunter, G.A., and Donaldson, E.M., 1983. Hormonal sex control and its application to fish culture. In: Fish Physiology, (W.S. Hoar, D.J. Randall and E.M. Donaldson, eds.). Vol. IX, Part B, Behavior and Fertility Control, Chap. 5. p. 223-303. Academic Press.

Jalabert, B., Billard, R., and Chevassus, B., 1975. Preliminary experiments on sex control in trout: Production of sterile fishes and simultaneous self-fertilizable hermaphodites. Ann. Biol. Anim. Bioch. Biophys., 15: 19-28.

Johnstone, R., Simpson, T.H., and Youngson, A.F., 1978. Sex reversal in salmonid culture. Aquaculture, 13: 115-134.

Solar, I.I., Donaldson, E.M., and Hunter, G.A., 1984. Optimization of treatment regimes for controlled sex differentiation and sterilization in wild rainbow trout (Salmo gairdneri Richardson) by oral administration of 17α-methyltestosterone. Aquaculture. 42: 129-139.

Solar, I.I., and Donaldson, E.M., 1985. Studies on genetic and hormonal sex control in domesticated rainbow trout. II. Use of methyltestosterone for masculinization and sterilization in cultured rainbow trout. Can. Tech. Rep. Fish. Aquat. Sci. No. 1380. 9 p.

TABLE I - Effect of immersion and oral administration of 17α-methyltestosterone (MT) and testosterone (T) on the gonadal morphology of cultured rainbow trout (Salmo gairdneri Richardson).

Group No.	Hormonal treatment		Number	Gonadal morphology %		
	Immersion µg/l	Dietary mg/kg	60 D/90 D	60 Days/90 Days		
				♀	♂-♂ST (1)	ST (1)
1	100 MT	25 MT	47/58	0.0/0.0	0.0/0.0	100.0/100.0
2	400 MT	25 MT	50/49	0.0/0.0	0.0/0.0	100.0/100.0
3	-	25 MT	68/50	1.5/8.3	16.0/8.3	82.5/83.3
4	-	250 T	27/26	18.5/30.8	7.4/3.8	74.1/65.4
5	500 T	250 T	26/25	0.0/16.0	0.0/0.0	100.0/84.0
6	-	1250 T	26/21	7.7/14.3	0.0/0.0	92.3/85.7
7	500 T	1250 T	31/27	6.4/18.5	0.0/0.0	93.5/81.5
8	-	2500 T	23/10	4.3/20.0	0.0/0.0	95.6/80.0
9	500 T	2500 T	34/31	5.9/45.0	0.0/0.0	94.1/54.8
10	-	-	50/47	54.0/44.7	46.0/55.3	0.0/0.0

(1) ♂ST = partially sterile; ST - sterile

TABLE II - Growth data of rainbow trout treated with methyltestosterone (MT) or testosterone (T) for 60 or 90 days. Mean ± SD.

Androgen treatment		D 90 (60 days treatment)		D 120 (90 days treatment)	
Immersion µg/l	Dietary mg/kg	LN cm	wt g	LN cm	wt g
100 MT	25 MT	5.1 ± 0.3	1.6 ± 0.3	6.4 ± 0.3	3.2 ± 0.7
400 MT	25 MT	4.9 ± 0.4	1.4 ± 0.4	5.9 ± 0.6	2.5 ± 0.7
0	25 MT	5.0 ± 0.4	1.6 ± 0.4	6.2 ± 0.7	3.0 ± 1.0
0	250 T	4.9 ± 0.4	1.4 ± 0.4	6.0 ± 0.3	2.4 ± 0.4
500 T	250 T	5.1 ± 0.3	1.7 ± 0.3	6.0 ± 0.6	2.7 ± 0.8
0	1250 T	4.8 ± 0.4	1.5 ± 0.5	6.0 ± 0.7	2.8 ± 1.0
500 T	1250 T	4.8 ± 0.4	1.4 ± 0.4	6.0 ± 0.7	2.9 ± 1.1
0	2500 T	4.3 ± 0.6	1.0 ± 0.5	6.0 ± 0.8	2.9 ± 1.0
500 T	2500 T	4.5 ± 0.5	1.1 ± 0.4	5.6 ± 0.8	2.3 ± 1.0
0	0	5.0 ± 0.4	1.5 ± 0.4	6.1 ± 0.5	2.6 ± 0.9

D = days post-hatch (age) at time of sampling.

CULTURE TRAILS WITH WHITE STURGEON (ACIPENSER TRANSMONTANUS) IN 58° F SPRING WATER

MAX J. WOOLLEY & ROBERT A BUSCH

CLEAR SPRINGS TROUT CO., BUHL, IDAHO

The Columbia River Basin Fish and Wildlife Program provides for the protection, mitigation, and enhancement of resident fish populations. Section 801 notes White Sturgeon (Acipenser Transmontanus) as a species of interest while sections 804 (e) (3) and 804 (3) (8) seek to determine the potential for their artifical propagation.

High economic value of sturgeon meat, caviar, and fingerlings for the aquarium trade, has prompted private aquaculture firms to also take active interest in sturgeon culture.

Four day old white sturgeon sac-fry were obtained and monitored for growth and survival in 58° F spring water over a 60 day period. Groups were also subjected to experimental culture systems, culture techniques, feeding regimens, and disease management techniques. Growth experiments showed faster gain in groups reared in spring water warmed to 64° F, however groups reared in 58° F spring water showed more consistent even growth among all individuals. Survival experiments showed a significant advantage to sturgeon reared in 58° F water.

SUMMARY OF EXPERIENCE RELATED TO A TOXIC ALGAL BLOOM

by A. J. Solmie and R. O. Kennedy

Resume

The experimental fish farm at the Pacific Biological Station in Nanaimo has been operating for 12 years. The objective of the farm has been to assess the biological and physical parameters necessary for netpen rearing of salmonids and rainbow trout in salt water.

This paper summarizes our observations of a particularly damaging algal bloom which first occurred in 1973 and nearly every subsequent year. From water samples phytoplankton of the Chaetoceros ssp. genus was diagnosed as the causative agent for severe losses of sockeye salmon stocks in 1973 and 1974. The diatom Chaetoceros convolutus being the damaging species while Chaetoceros decipiens and Chaetoceros debilis were also found in water samples at the fish farm.

Chaetoceros convolutus occurs along the Pacific Coast from southern California to Alaska with specific regions being considered as hot spots. Chaetoceros convolutus is unicellular but forms in "chain-like" ribbons. Each cell has four setae which are armed with siliceous barbed spicules or spines. It has been demonstrated that it is the spines or spicules which actually kill the fish (Bell, Griffioen and Kennedy 1975).

The literature states that blooms form in layers and are unpredictable in density and occurrence. The reason for this is that not only one but several conditions must be met to trigger a bloom. The prime conditions being the proper amount of nutrients, water clarity, light intensity and turbulence of the water. Blooms can vary in depth from 1 meter to over 30 meters depending on location.

Methods and Procedures

At the fish farm a daily physical monitoring program is carried out. The observations carried out for the first 9 years were water temperatures at 1/2 meter and 4 meters depths along with salinities at both levels; wave height, wind direction and speed; water clarity with a 30 cm secchi disk; type of suspension; rainfall; barometric readings, light intensity and air temperature. We later reduced these observations to water temperatures and salinities at .5 meters and 4 meters depths; water clarity, type of suspension, and barometric observations.

Obtaining water samples

Water samples are obtained at 1 meter with a bucket and rope from which a 2 litre sample is taken and organisms preserved by adding 2% formalin by volume. Samples collected at depths were collected with a Van Dorn bottle when one was available or by suspending a 4 litre bottle on a rope then releasing the stopper at the desired depth.

Filtration

After agitating the sample to obtain an even suspension, a subsample of the contents was taken to obtain a known volume (1000 mL, 500 mL or 250 mL volumes are convenient for converting to cells/litre after a count is completed). If the water is turbid, use smaller subsamples (i.e. 250 mL). Filtration is achieved using a Millipore Suction Filtration system and a 2 litre modified Erlemery flask. Because the Chaetoceros cells are relatively large use up to 8 u Millipore filter paper.

Counting

After filtering is complete rinse the sample from the filter paper with a squirt bottle (distilled H_2O) into a 2 inch Petri dish with a E.R. Bogush measuring slide grid underneath. These were then plated onto a stereoscopie microscone. Under 500X magnification identify the Chaetoceros cells. Because they occur in chains count the cell bodies in each chain (at the end of a bloom dead cells form floating clumps which are still damaging to fish and should be included in the count). Because cells counts during a bloom can reach over 20,000 cells/litre the grid allows you to count part of the total cells in the Petri dish (for convenience 1/2, 1/4 or 1/8 then count the cells times 2, 4, or 8 respectively gives cells per subsample. If your subsample was 500 mL or 250 mL then cells per subsample times 2 or 4 respectively = cells per litre.

Observations

Our observations have shown that the fish are killed during a bloom by the spicules becoming lodged in the gills either causing hemorrhaging or by a mucous buildup from irritation of the gill lamellae which causes suffocation. The fish at this stage of distress show signs of gasping as if there is oxygen deficiency. They will often be seen hanging in the corners of the netpen or lined up facing the current coming through the side of a netpen. Fish of all sizes are affected with sockeye and rainbow trout being the most vulnerable.

A summary of yearly occurrences, extent of bloom, physical conditions and mortalities are shown in Table 1.

From observations at our site we know that we can expect blooms to occur in the fall and occasionally during August. The fall blooms usually occur for a 2-4 week period with a minor and major peak. The major peak signifies the end of the bloom (Figure 1). The bloom ending with senescence or a change in water caused by a strong S.E. wind. During blooms we have calm or light N.W. wind conditions. The August blooms are of short duration but very damaging probably because of high water temperature and lock of mussel (Mytilus edulis) fouling on the netpens.

Water samples collected at various depths show that our blooms occur from the surface to the bottom of the water column with the highest cell counts coming from 1-10 meters. Our pens are 4 meters deep. Samples collected progressively distant from our farm show that we are in the centre of a hot spot (Tables 2 and 3).

Table 4 illustrates the effect of two types of fouling and at what degree of fouling where we may achieve some protection. Algal fouling and medium fouling by mussels appear to offer very little protection and in fact may act as a trap for Chaetoceros convolutus when fish have been excited. Water clarity monitoring and cell counts have shown that a netpen heavily fouled with mussels will give a significant degree of protection. When fish are fed in this type of situation cell counts increase considerably.

Conclusion

From our observations and statements in the literature we feel that site selection is the key to protection from algal blooms. If one is faced with algal blooms the following suggestions would assist in managing around Chaetoceros convolutus or other damaging blooms:

1. Set up a detailed water sampling program to determine what algal blooms affect you and to what extent. Is there a correlation between blooms:

2. Monitor the physical parameters as they will warn when a bloom is beginning (for example, decreasing visibility).

3. Monitor fish behavior daily and more closely when a bloom begins.

4. Do not feed your fish or excite them during a bloom.

5. If you have a narrow layering effect can you circulate water from depth to lessen the intensity. This may be done by current including pumps or by an airlift system.

6. Consider the option of mussel fouled netpens but be aware that this is also heavy work when netpens can be changed.

References

1. Marine phytoplankton production, distribution and species composition in Pendrell and Hotham Sounds, British Columbia by John G. Stockner and David D. Cliff.

2. Phytoplankton ecology of the Strait of Georgia, British Columbia by J.G. Stockner, D. D. Cliff and K. R. S. Shortreed.

3. Mortalities of pen reared salmon associated with blooms of marine algae by G. R. Bell, W. Griffionen and O. Kennedy.

4. Marine plankton diatoms of the west coast of North America by E. E. Cupp.

Table 1. Summary of C. convolutus and percent mortalities.

Year	Duration of bloom	Peak	Average temp.	Secchi readings	Cells per litre	Species					
						Sockeye	Coho	Chinook	Pink	Chum	RBT
1973	Sept. 12-Oct. 9	-	12.7	-	-	18	-	-	N.A.	N.A.	N.A.
1974	Oct. 24-Nov. 5	Oct. 16	14.7	-	8360	37	+	-	N.A.	-	N.A.
1975	Sept. 18-Oct. 25	Oct. 16	12.1	7.0	6660	-	1	-	-	-	N.A.
1976	No bloom	-	-	-	-	-	-	-	-	-	-
1977	Aug. 19-25	Aug. 20	18.9	3.0	8000	60-100	43	37	18	15	N.A.
1978	Oct. 2-23	Oct. 16	11.7	7.0	28800	-	+	+	+	+	N.A.
1979	July 24-Oct. 10	Aug. 2	18.0	3.5	3600	-	+	+	-	-	3
1979		Oct. 2	14.1	3.5	2800	-	-	-	-	-	-
1980	Oct. 1-30	Oct. 24	12.5	6.0	23000	N.A.	5	7.7	N.A.	N.A.	N.A.
1981	No bloom	-	-	-	-	-	-	-	-	-	-
1982	Insignificant bloom	Oct. 16	13.3	-	100	-	-	-	-	-	-
1983	Aug. 12-15	Aug. 12	18.5	5.2	1300	N.A.	.8	2.5	N.A.	N.A.	33
1984	Oct. 1-8	Oct. 2	14.1	5.0	3000	N.A.	-	-	N.A.	N.A.	N.A.
1985	Aug. 26-Sept. 3		17.1	6.0	250	N.A.	-	-	N.A.	N.A.	N.A.

1973 crop of chinook and coho harvested June 1974.

N.A. = Not Applicable.

+ = Losses less than .05.

- = Losses not defined.

Table 2. Layering effect of Chaetoceros convolutus.

Year	Date	Surface	1 meter	2.5 m	3.5 m	8 m	9 m	12 m	15 m	25 m
1974	Oct. 29	3680					3040			2180
	Nov. 7	620								680
1977	Aug. 23	8100	10100	13400	32000				15000	
	Aug. 24	3000	3700	10200	32200				15200	
1983	Aug. 13	1350		1350						
	Aug. 14	850		750						
1984	Oct. 4	1000			4000	3000				
	Oct. 5	2500			3500	4000		3000		

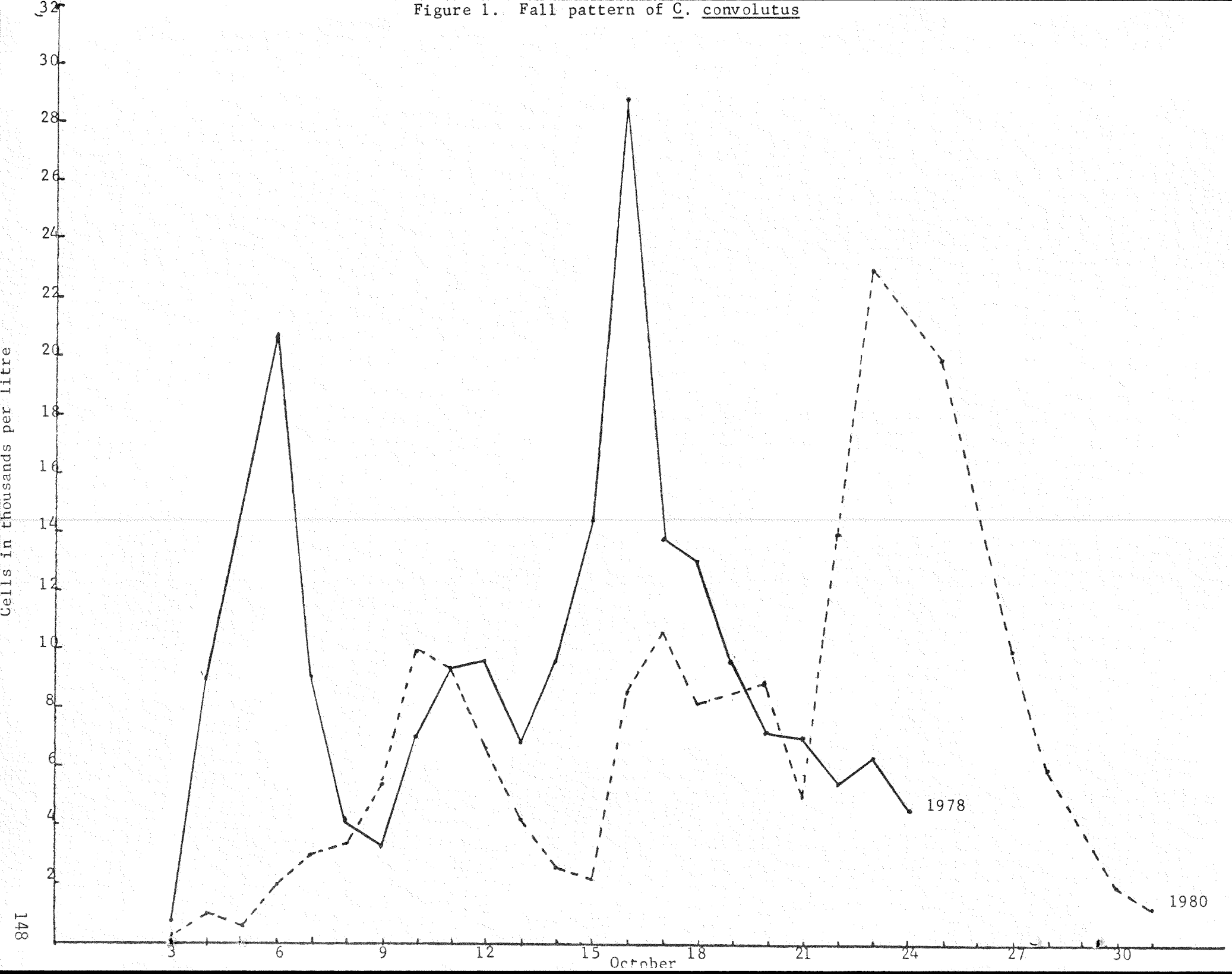
Table 3. Chaetoceros convolutus sampling at the fish farm and surrounding area.

Date	Fish Farm	Near Fish Farm	South Side Brandon Island	Jessie Island	Descanso Bay	Locke Bay	Northumberland Channel	Jacks Point	Eggus Point	Snake Island	Hammond Bay
1978											
Oct. 3	800										
4	9376	8640			5824	3712	2816	1952			
6	24220		7360	8960					5376	3804	4416
16	28800		Farm at False Creek				No Chaetoceros				

Table 4. Effect of net fouling on C. convolutus concentrations.

Year	Date	Moderate algal	Moderate mussel	Heavy mussel	Outside of netpens
1978	Oct. 4		8800		13000
	5		1800		1200
	17		13600		13700
	18		15500		13100
	19		17600		9920
	20		9400		7500
	21	7200	5400		
	22	5500	4000		
	23		2000		6400
	24	2700	1900		
1984	Oct. 3	1000	500	200	3000
				500	after feeding

Figure 1. Fall pattern of C. convolutus



Dan Adkins
Fish Culturist
WA Dept. of Game

Dr. George H. Allen
Aquaculture Project Dir.
City of Arcata, CA 95521

Andy Appleby
Salmon Culture Division
WA Dept. of Fisheries
902 E. Union
Olympia, WA 98501

Michael D. Shirley
Bellingham Vo-Tech School
Marine Occupations Student
P O Box 696
Bellingham, WA 98227

Bruce Bachen
NSRAA
103 Monastery St.
Sitka, AK 99835

Gary Baker, Hatch Supt.
Idaho Fish & Game
American Falls Hatchery
American Falls, ID 83211

Patricia A. Baker
WA Dept. of Fisheries
Minter Creek
E. 281 Coulter Cr. Rd.
Belfair, WA 98528

Dan C. Barrett, Mgr.
OR Dept. Fish & Wildlife
Roaring River Fish Hatchery
42255 Fish Hatchery Dr.
Scio, Oregon 97374

Bob Becker
NE Region Liberations Coord.
OR Dept. Fish & Wildlife
201 20th
La Grande, OR 97850

Wendy Beeghley
Fisheries Technician
NW Indian Fisheries Comm.
6730 Martin Way E.
Olympia, WA 98506

Christopher Beggs
Asst. Stock Enhancement Off.
Puntledge River Hatchery
Box 3111
Courtenay, B.C. Canada
V9N 5N3

Larry L. Barger
Hatchery Manager
WA Dept. of Game
Shelton Trout Hatchery
W. 7570 Eells Hill Rd.
Shelton, WA 98584

Art Brown
Fish Culturist I
Dept. of Game
12404 SE Evergreen Hwy.
Vancouver, WA 98684

Bob Bugert
Fish Biologist III
WA Dept. of Fisheries
P O Box 474
Waitsburg, WA 99361

John Campbell
Astoria High School
690 17th St.
Astoria, OR 97103

Richard Carmichael
OR Dept. Fish & Wildlife
Badgley Hall, EOSC
LaGrande, OR 97850

David Celli
Assistant Manager
Dept. of Fisheries & Oceans
Box 477
Blackendale, B.C. VON 1HO

Gordon Conway, Manager
Shuswap Falls Hatchery
P O Box 819
Lumby, B.C. V0E 2G0

Robin E. Crisler
Assistant Manager
OR Dept. Fish & Wildlife
Elk River Hatchery
95183 Elk River Rd.
Port Orford, OR 97465

Mark DeCew
WA Dept. of Fisheries
P O Box 149
Salkum, WA 98582

Larry Dimmick
Asst. Mgr. Bonneville Hatchery
OR Dept. Fish & Wildlife
Star Rt. B, Box 10
Cascade Locks, OR 97014

Doug Dixon
Naval Architect
Marco Seattle
2300 W Commodore Way
Seattle, WA 98199

Glen Dixon
Assist Manager
Dept. Fisheries & Oceans
Box 61, Dewdney, B.C.
V0M 1H0

David Ewart, Fish Culturist
Quinsam Hatchery
Canadian Dept.Fish. & Oceans
Campbell River, B.C.V9W 5C1

David C.R.Ford
Fish Culturist II
WA Dept. of Fisheries
Lewis River Salmon Hatchery
4404 Lewis River Road
Woodland, WA 98674

E. Royce Gunter, Jr.
Fish Hatchery Mgr. II
CA Dept. Fish & Game
Warm Springs Hatchery
3246 Skaggs Spring Rd.
Geyserville, CA 95441

Don Haerling, FC 1
WA Dept. of Fisheries
Cowlitz Salmon Hatchery
2284 Spencer Rd.
Salkum, WA 98582

Bob Hager
WA Dept. of Fisheries
Salmon Culture Division
Room 11g, Gen. Admin. Bldg.
Olympia, WA 98504

Robert Haines
Fish Culturist
Seastar Resource Corp.
General Delivery
Edmont, BC V0N 1N0

Bill Halloran
S.S.R.A.A.
1649 Tongass Ave.
Ketchikan, AK 99901

Dave Harding
Dept. Fisheries & Oceans
1090 W. Pender St.
Vancouver, BC
Canada V6E 2P1

Jim Harvey
McKenzie Fish Hatchery
OR Dept. Fish & Wildlife
43847 Gregg Dr.
Leaburg, OR 97489

Greg Haw
WA Dept. of Fisheres
Cowlitz Salmon Hatchery
2284 Spencer Rd.
Sackum, WA 98582

Alan Hemmingsen
OR Dept. Fish & Wildlife
Oregon State University
303 Extension Hall
Corvallis, OR 97331

Thomas C. Herbst, Mgr.
OR Dept. Fish & Wildlife
Willamette Hatchery
76389 Fish Hatchery Rd.
Oakridge, OR 97463

Raymond L. Hill, Mgr.
OR Dept. Fish & Wildlife
Irrigon Hatchery
P O Box 573
Irrigon, OR 97844

Szczepan Wolski, Mgr.
Clearwater River Hatchery
R R 2, Box 2142
Clearwater, BC
Canada V0E 1N0

John G. Hoskins
OR Dept. Fish & Wildlife
Leaburg Hatchery
90700 Fish Hatchery Rd.
Leaburg, OR 97489

Dail Hurdlow
N.S.R.A.A.
Box 2606
Sitka, AK 99835

Bill Hutchinson
Fish Hatchery Supv.
ID Dept. Fish & Game
3806 S. Powerline Rd.
Nampa, ID 83651

Ken Isaksson
WA Dept. of Game
Cowlitz Trout Hatchery
1182-C Spencer Rd.
Winlock, WA 98596

Dennis Issaac
Fish Identifications
OR Dept. Fish & Wildlife

Terry F. Jones, Mgr.
OR Dept. Fish & Wildlife
Marion Forks Hatchery
Star Route, Box 71
Idanha, OR 97350

Michael Kent
Battelle Northwest
439 W. Sequim Bay Rd.
Sequim, WA 92182

Bryan Kenworthy
Fishery Biologist
Olympia FAO
2625 Parkmont Lane, Bldg A
Olympia, WA 98502

Curt Kerns
Assoc. Prof., Fisheries
Univ. of Alaska, Juneau
11120 Glacier Hwy.
Juneau, AK 99801

Jay S. Kidder
Engineer/Biologist
R.W. Beck
2121 4th Ave.
Seattle, WA 98121

Bob Kirby
Fish Biologist I
WA Dept. of Fisheries
Salmon Culture Division
Olympia, WA 98501

Eldon E. Korpela, Retired
Astoria High School
Aquaculture Teacher
Rt 3, Box 255
Astoria, OR 97103

Kathryn Kostow
Biologist

Duncan K. Law
OR State University
250 36th St.
Astoria, OR 97103

Steven Leask
BIA
Tamgas Hatchery

James Lee
Asst. Mgr. Cowlitz Hat.
WA Dept. of Game
1182 D Spencer Rd.
Winlock, WA 98596

Michael Leitz
S.S.R.A.A.
1649 Tongass
Ketchikan, AK 99901

Lori LeVander
Fish Biolgist II
WA Dept. of Fisheries
18210 NE 103rd CT.
Redmond, WA 98052

Steven Lock
BioMed Research Lab.
1115 E. Pike St.
Seattle, WA 98122

Doug Loucks
Klickitat Salmon Hatchery
WA Dept. of Fisheries
Rt 2, Box 90
Glenwood, WA 98619

Tom Lichatowich
1010 S. Elm
Canby, OR 97013

Otto Lynn
Field Rep.
Rangen Inc.
Buhl, ID 83316

Marge McBride
Quinault Indian Nation
P O Box 189
Taholah, WA 98587

Colin Mackinnon, SEP
Fisheries, Canada
1090 W. Pender
Vancouver, BC
Canada V6E 2P1

William L. Mahone, Sr.
Makah Fisheries Mgr.
P O Box 343
Neah Bay, WA 98357

Gene Middaugh
Fish Hatchery Manager
OR Dept. Fish & Wildlife
43182 N. River Dr.
Sweet Home, OR 97386

Lee Miesbauer
Associate
Andersen,Bjornstad,Kane,Jacobs
220 West Harrison
Seattle, WA 98119

George F. Nandor, Mgr.
Fall Creek Hatchery
OR Dept. Fish & Wildlife
Star Rt. 2, Box 1292
Alsea, OR 97324

Douglas C. Neisz
Fisheries Student
Mt. Hood Community College
2950 NE 23rd, #108
Gresham, OR 97030

Terry Nosho
Washington Sea Grant
Univ. of Washington
Seattle, WA 98105

Tony Novotny
NMFS
2725 Montlake Blvd. E.
Seattle, WA 98112

Bill Nyara
OR Dept. Fish & Wildlife
Siletz Hatchery Manager
12916 Logsden Rd.
Blodgett, OR 97326

Gordon Ochs
Industrial Plastics
680 S. 28th St.
Washougal, WA 98671

Steve Pastor, Asst. Mgr.
US Fish & Wildlife
Eagle Creek NFH
34288 SE Rainbow Rd.
Estacada, OR 97023

Donald L. Peterson
WA Dept. of Fisheries
Cowlitz Hatchery Mgr. I
2284 Spencer Rd.
Salkum, WA 98582

Vincent Piel, Jr.
Fisheries Tech.
Yakima Indian Nation
P O Box 34
White Swan, WA 98952

Jeffrey D. Preston
Mt.Hood Community College
2950 NE 23rd #5
Gresham, OR 97030

Chris Randolph
Wildlife Biologist
WA Dept. of Game
5405 NE Hazel Dell Ave.
Vancouver, WA 98663

Jack Rensel
Wilner-Rensel Associates
712 North 34th St.
Seattle, WA 98103

Tim Richardson, Student
Bellingham Vo-Tech
15093 Marine Dr.
White Rock, B.C.
Canada V4B 1C5

Bobbie Riggle
Fish Culturist I
Cowlitz River Salmon Hatchery
WA Dept. of Fisheries
2284 Spencer Rd.
Salkum, WA 98582

Randy Robart
OR Dept. Fish & Wildlife
P O Box 15
Madras, OR 97741

James A. Robinson
Asst. Hatchery Manager
OR Dept. Fish & Wildlife
HC 60, Box 10
Idleyld Pk, OR 97447

Dennis Roley
WA Dept. of Fisheries
University of Washington
M-2 Fisheries Ctr., WH-10
Seattle, WA 98195

Michael A. Rolfe
Cowlitz Trout Hatchery
WA Dept. of Game
1182 E. Spencer Rd.
Winlock, WA 98596

Jim Schettler
Design Engineer
Andersen,Bjornstad,Kane,Jacobs
220 W. Harrison
Seattle, WA 98119

Carl Schreck
OR Coop Fish Research Unit
Oregon State University
Corvallis, OR 97330

Larry Schroder, Manager
Coulter Creek Hatchery
WD Dept. of Fisheries
E. 4th Coulter Cr. Rd.
Belfair, WA 98528

Mark L. Schuck
WA Dept. of Game
411 South First St.
Dayton, WA 99328

Dick Schwab
Rangen, Inc.
Box 706
Buhl, ID 83316

Bruce P. Snyder
Fishery Biologist
Station Manager
Big Beef Creek
9744 Manley Rd., NW
Bremerton, WA 98312

Robert A. Sohler
Fish & Wildlife Tech III
OR Dept. Fish & Wildlife
76389 Fish Hatchery Rd.
Oakridge, OR 97463

Al Solmie
Fish Farm Manager
Dept. Fisheries & Oceans
Pacific Biological Station
Nanaimo, B.C.
Canada V9R 5K6

Janice Rowan
Fishery Biologist
710 Highway 395
Gardnerville, NV 89410

Trent Stickell
Hatchery Manager
OR Dept. Fish & Wildlife
Star Rt. B., Box 12
Cascade Locks, OR 97014

Mike Stoddard
Hatchery Superintendent
Star Rt., Box 330
Grace, ID 83241

Mike Stratton
Hatchery Prod. Coord.
OR Dept. Fish & Wildlife
1916 SE 20th
Portland, OR 97214

Bruce Suzumoto
Vice President
Prince William Sound
Aquaculture Corp.
P O Box 1110
Cordova, AK 99574

Paul Tappel
Civil Engineer
R. W. Beck & Associates
2121 Fourth Ave.
Seattle, WA 98121

Guy Toedtemeier
WA Dept.of Fisheries
Fish Culturist I
Minter Creek Salmon Hatchery
12615 124th Ave., Ct. KPN
Gig Harbor, WA 98335

Mark Tollfeldt
S.S.R.A.A.
1649 Tongass
Ketchikan, AK 99901

Bill Townsend, Mgr.
Trout Lodge, Inc.
Box 11
McMillin, WA 98352

Ray Volk, Asst. Mgr.
Robertson Creek Hatchery
Box 1118
Port Alberni, B.C.
Canada V9Y 7L3

Keith Warren
Salmon Culturist
CEDC Fisheries Project
250 36th St.
Astoria, OR 97103

Richard Westgard
W.S.D.F.
M-2-Fisheries Center
University of Washington
Seattle, WA 98905

Robert D. Wheeling Jr.
Fisheries Student
Mt. Hood Comm. College
3522 NE 17th Apt. D-6
Gresham, OR 97030

Herbert M. Whitish
Coded Wire Tag Tech.
6730 Martin Way
Olympia, WA 98506

Josette Wier, Student
Malaspina College
Box 43
Nanaimo, B.C.
Canada V9R 5K4

Lloyd Wilbur
Hatchery Technician
Skokomish Tribe
N. 541 Tribal Center Rd.
Shelton, WA 98584

Garrett Winkel
Malaspina College Student
1361 Stewart Ave.
Nanaimo, B.C.
Canada V9S 4E2

Bo Woronowicz
Regional Sales Manager
Protect-A-Cover, Inc.
8420 196th St. S.W.
Edmonds, WA 98020

Rita Zamluk
Malaspina College Student
1260 Galerno Road
Campbell River, B.C.
Canada V9W 1J6

James Winton
Oregon State University
Marine Science Center
Newport, OR 97366

COMMERCIAL DISPLAYS

ABKJ, Inc., Consulting Engineers
220 West Harrison
Seattle, WA 98119
(206) 285-1185

Aqua Health
Rt. 3, Box 299
Buhl, ID 83316

Argent Laboratories
8702 152nd N.E.
Redmond, WA 98052
(206) 885-3777

BioProducts
P. O. Box 429
Warrenton, OR 97144
(503) 861-2256

Bio Sonics
4520 Union Bay Place N.E.
Seattle, WA 98105
(206) 527-0905

Common Sensing
7595 Finch Road N.E.
Bainbridge Island, WA 98110
(206) 842-4873

EMA Marketing, Inc.
5065 S.W. Nash Ave.
Corvallis, OR 97333
(503) 758-1555

J. L. Eager, Inc.
P. O. Box 476
N. Salt Lake, UT 84054
(801) 292-9017

F.A.L. Products
P. O. Box 9037
4540 S. Adams
Tacoma, WA 98409
(206) 475-5772
1-800-851-1510

Industrial Plastics
680 S. 28th St.
Washougal, WA 98671
(206) 835-2129

Jensorter
18934 Riverwoods Dr.
Bend, OR 97144
(503) 389-3591

Landa Inc.
4920 N.E. 122nd Ave.
Portland, OR 97230
(503) 255-5980 ext. 345
1-800-547-8672

Marco Seattle
2300 W. Commodore Way
Seattle, WA 98199
(206) 285-3200

Muckleshoot Indian Tribe
34900 212th Ave. S.E.
Auburn, WA 98002
(206) 939-7738

N.W. Marine Technology, Inc.
Shaw Island, WA 98286
(206) 468-3375

Protect - A - Cover
8420 196th St. S.W.
Edmonds, WA 98020
(206) 775-6658

Reiff Fiberglass Co.
Rt. 4, Box 183
Walla Walla, WA 99362
(509) 525-1081

Silver Cup Feeds
Murray Elevators
P. O. Box 7428
Murray, UT 84107-0428
(801) 596-3528
1-800-521-9092

VMG Industries, Inc.
858 Grand Ave.
Grand Junction, CO 81501
(303) 242-8623

DOOR PRIZES

NORTHWEST FISH CULTURE WORKSHOP

December 3, 4, & 5, 1985

#740	Bob Smith	NMFS	Lead line
#760	Tim Schamber	ODFW	Lead line
#803	Don Peterson	WDF	Lead line
#685	Steve Roberts	WDG	Lead line
#791	Chris Gibson	Sea Farm of Norway	10 lb. test
#789	Tom Scribner	Yakima Nation	10 lb. test
#698	Max Wooley	Clear Springs Trout	Rod & reel
#772	Fred Norman	WDG	Night at motel & brunch
#625	Bobby Bivans	ODFW	Lead line
#736	Ivan Harvard	WDG	Lead line
#688	Bob Kirby	WDF	Lead line
#780	Dan Barrett	ODFW	Lead line
#813	Randy Robart	ODFW	Lead line
#839	James Graybill	Mt. Hood CC	Monofilament
#754	George Nandor	ODFW	Monofilament
#763	Loren Dingwall	WDG	Beer stine
#830	Kevin Amos	WDF	Little Chief Smoker
#666	Don Peterson	Admin. Envir B.C.	Lead line
#755	Bill Nyara	ODFW	Lead line
#714	Jim Gearheard	WDG	Lead line
#774	Robert Sohler	ODFW	Monofilament
#649	Jerry Fisher	ODFW	Monofilament
#653	Earl Steele	Bellingham VO-Tech	Fly line
#770	Ray Sheldon	ODFW	Beer stine
#707	Robert Haines	Sea Star Research BC	$25 gift certificate
#749	James Gibson	Skagit System	Fenwick Rod

DOOR PRIZE DONATORS

Ashaway Line Co.
Ashaway, RI 02804

Cortland Line Co., Inc.
Cortland, N.Y. 13045

Best Western
Executive Inn
Tacoma, WA

Fenwick
Westminister, CA

Fred Meyer Shopping Centers
P. O. Box 42121
Portland, OR 97242

Larry's Sport Center
Oregon City Shopping Center
Oregon City, OR

Luhr-Jensen & Sons, Inc.
400 Portway Ave.
Hood River, OR 97031

Pabst Brewing Company
P. O. Box 947
Olympia, WA 98507

ANNUAL NORTHWEST FISH CULTURE CONFERENCES

HISTORICAL RECORD

Year	Location	Host Agency	Chairman
1950	Portland, Oregon	U.S. Fish & Wildlife Service	Perry, T.
1951	Wenatchee, Washington	U.S. Fish & Wildlife Service	Burrows, R.
1952	Seattle, Washington	Washington Dept. of Fisheries	Ellis, B.
1953	Portland, Oregon	Oregon Fish Commission	Cleaver, F.
1954	Seattle, Washington	U.S. Fish & Wildlife Service	Rucker, R.
1955	Portland, Oregon	Oregon Game Commission	Rayner, J.
1956	Seattle, Washington	Washington Dept. of Game	Millenbach, C.
1957	Portland, Oregon	U.S. Fish & Wildlife Service	Johnson, H.
1958	Seattle, Washington	Washington Dept. of Fisheries	Ellis, R.
1959	Portland, Oregon	Oregon Fish Commission	Jeffries, E.
1960	Olympia, Washington	Washington Dept. of Game	Johansen, J.
1961	Portland, Oregon	Oregon Game Commission	Jensen, C.
1962	Longview, Washington	U.S. Fish & Wildlife Service	Burrows, R.
1963	Olympia, Washington	Washington Dept. of Fisheries	Ellis, B.
1964	Corvallis, Oregon	Oregon State University	Fryer, J.
1965	Portland, Oregon	U.S. Fish & Wildlife Service	Halver, J.
1966	Portland, Oregon	Oregon Fish Commission	Hublou, W.
1967	Seattle, Washington	University of Washington	Donaldson, L.
1968	Boise, Idaho	Idaho Fish & Game Department	Cuplin, P.
1969	Olympia, Washington	Washington Dept. of Game	Johansen, J.
1970	Portland, Oregon	Oregon Game Commission	Jensen, C.
1971	Portland, Oregon	U.S Fish & Wildlife Service	Smith, M.
1972	Seattle-Tacoma, WA	Washington Dept. of Fisheries	Noble, R.
1973	Wemme, Oregon	Oregon Fish Commission	Jeffries, E.
1974	Seattle, Washington	University of Washington	Salo-Brannon
1975	Newport, Oregon	Oregon State University	Donaldson, J.
1976	Twin Falls, Idaho	University of Idaho	Klontz, B.
1977	Olympia, Washington	Washington Dept. of Game	Morrow, J.
1978	Vancouver, Washington	U.S. Fish & Wildlife Service	Leith, D.
1979	Portland, Oregon	Oregon Dept. of Fish & Wildlife	Jeffries, E.
1980	Courtenay, B.C.	Fisheries & Oceans	Sandercock, K.
1981	Tumwater, Washington	Washington Dept. of Fisheries	Ashcraft, W.
1982	Portland, Oregon	National Marine Fisheries Service	Wold, E.
1983	Moscow, Idaho	Idaho Fish & Game & University of Idaho	Parrish, E. & Klontz, G.
1984	Kennewick, Washington	Washington Dept. of Game	Gearheard, J.
1985	Tacoma, Washington	U.S. Fish & Wildlife Service	Forner, E.
1986	Springfield, Oregon	Oregon Dept. of Fish & Wildlife	Schultz, M.