1993 SOCKEYE CULTURE WORKSHOP

ALASKA DEPARTMENT OF FISH & GAME
DIVISION OF COMMERCIAL FISHERIES
MANAGEMENT AND DEVELOPMENT

Proceedings of the 1993 Alaska Sockeye Salmon Workshop

Kenai Princess Lodge
Cooper Landing, Alaska
November 2-3, 1993

The Alaska Sockeye Salmon Workshop is an informal meeting for the exchange of information and ideas concerning all areas of sockeye culture.

These proceedings are a combination of the unedited reports and materials made available by the speakers and narrative reconstructed from notes taken by Jana Geesin, Joan Thomas and Keith Pratt. Much of the material concerns progress of incompleted studies or projects. However, the intent is to disseminate information as rapidly as possible. **These informal records are not to be interpreted or quoted as a publication. Any reference to these contents should be approved by the author (s) and cited as a personal communication.**

Chairman's Remarks

Close to 100 people attended and participated in the Sockeye Workshop held at the Kenai Princess Lodge, Cooper Landing, Alaska on November 2 and 3, 1993. People came from all over the State of Alaska, Washington, Oregon and British Columbia.

I would like to thank all who attended, those that made presentations, panelists, our panel moderator and those that allowed me to use their notes from the meeting.

One of the workshop goals was to schedule a number of presentations meant to fuel an open panel discussion at the end of the day. As expected, the discussion was active and lively with a good exchange of information and ideas. Hopefully, we can all learn not only from each other's successes, but also from the set backs as well.

What further promoted discussions at the end of the day were the accommodations at the lodge. It was an easy place for people to meet and network.

Thanks to the staff at Trail Lakes Hatchery for providing tours of their facility before and after the workshop.

The cost of the meeting room, coffee service, and the printing and mailing of the Proceedings was provided for by the registration collected.

1993 SOCKEYE WORKSHOP
FINAL AGENDA

November 2

8:00	Coffee, registration
8:20	Welcome, announcements - Terry Ellison
8:30	Keynote address, John Burke
9:00	Workshop format and agenda changes - Terry Ellison
9:10	Statewide summary of losses due to IHNV in Alaska Sockeye Hatcheries in 1993 - Jill Follett
10:00	Break
10:20	Snettisham Hatchery's experience with IHNV in 1993 - Butch Cobb
10:40	Pillar Creek Hatchery's experience with IHNV in 1993 - Chris Clevenger
11:00	Kitoi Bay Hatchery's experience with IHNV in 1993 - Tim Joyce
11:20	Trail Lakes Hatchery's experience with IHNV in 1993 - Jeff Hetrick
11:40	Main Bay Hatchery's experience with IHNV in 1993 - Eric Prestegard
12:00 - 1:15	Lunch
1:15	IHNV in Harding River Chinook Salmon - Bob Zorich
1:40	Detection of IHNV in returning sockeye (pre-spawners) in saltwater - Garth Traxler
2:00	An overview of sockeye hatchery production in Alaska since 1974 - Steve McGee
2:20	Review of sockeye policies and procedures - Ted Meyers
2:40	Break
3:00	Open forum/panel discussion; moderator - Bob Burkett
4:50	Announcements - Terry Ellison
5:00 - 7:00	Dinner Break
7:00 - 9:00	Videos of sockeye eggtakes (hatchery and field) shown in conference room

November 3

8:00	Coffee, registration, announcements - Ellison
8:30	Overview of sockeye fry transports - Carol Coyle
9:00	Evaluation of stocking densities in sockeye nursery lakes - Gary Kyle

9:30	Survivals of stocked fry to the smolt stage at Crescent Lake - Scott Kelly
10:00	Break
10:20	Freshwater net pen rearing and smolt produced at English Bay Lakes - Mark Schollenberger
10:50	Sockeye salmon smolt production and zooplankton response from the stocking of Sweetheart Lake in Southeast Alaska - Rich Yanusz
11:15	The Baker Lake sockeye project - Gary Sprague
11:45	Update on the Cedar River sockeye project - Rand Little, Joan Thomas
12:30 - 1:30	Lunch
1:30	Survivals of fry to smolt in lake stocking projects in southeast Alaska - Mike Haddix
1:50	The Spiridon Lake sockeye project - Steve Honnold
2:10	Update of the Lake Wenatchee sockeye project - Joan Thomas
2:20	Virginia Lake sockeye enhancement project - Tim Zadina
2:40	Redfish lake sockeye salmon captive broodstock program - Tom Flagg, Keith Johnson & Jeff Gislason
3:00	Break
3:20	1992 & 1993 evaluation of zero age adult sockeye returns - Mark Tollfeldt
3:40	Adult survivals of smolts reared in fresh water versus saltwater - Jerry Taylor
4:00	A summary of smolt to adult survivals from various experimental groups released from Main Bay Hatchery - John Burke
4:35	Question and answer period
4:55	Final wrap up - Terry Ellison
5:00	End of Workshop

Introduction of Keynote Speaker

It's my privilege this morning to present to you our keynote speaker and a good friend, Dr. John Burke.

Most of you either know Dr. Burke or have at least met him at some time, but what many of you probably don't know is that the first degree he earned was a B.A. in Philosophy from San Jose State in California. Fortunately for us involved in fisheries, he didn't stay in California or in the field of Philosophy.

He moved North and continued his education at the University of Washington, where he received a M.S. degree in 1977 and a Ph.D. in 1982 in Fisheries Biology. The primary focus of these degrees was centered around diseases of sockeye salmon in Alaska. Most of the field work was done in the Bristol Bay area and on Kodiak Island. This research was supported, in part, by the Alaska Department of Fish and Game.

John began working for the Alaska Department of Fish and Game in 1980 as a fish pathologist/virologist traveling throughout the state. During this period is when he initially met many of us here today.

Then from 1983 to 1990 he worked at Main Bay Hatchery in Prince William Sound. First as the Assistant Hatchery Manger and then as the Hatchery Manager. It was mainly through John's vision and hard work that this facility was converted in 1987 from a large production chum salmon hatchery to the first ever yearling sockeye salmon smolt production facility. Tomorrow,he will be reporting on some very interesting results from those first years of sockeye smolt production at Main Bay.

The past three years, Dr. Burke has been the FRED Division Regional Supervisor in Southeast Alaska, responsible for managing the activities of the personnel in that region, including four hatcheries and three area biology offices.

Beginning November 16, 1993 he will be the Deputy Director of the Sport Fish Division.

To state once again what I said in the beginning; it is my privilege to present to you our keynote speaker and a good friend, Dr. John Burke.

Metaphysics, Sockeye and a Virus

by

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(This paper was paraphrased from the author's notes and recollection and Terry Ellison's recollection. JB March 1994)

Metaphysics has come to be known as the branch of philosophy that systematically investigates first causes and the nature of ultimate reality, and as such, is a part of how each of us perceives the world we live in; a part of our overall knowledge (Terry Ellison 1994). Or, the attempt to conceive the world as a whole by means of thought, has been developed, from the first, by the union and conflict of two very different human impulses, the one urging men toward mysticism, and the other urging them toward science (Bertrand Russel). Or, metaphysics, how we come to *know* things.

What is knowledge? Most of us have access to all the external data of our world, how do these data get assembled so that we come to know something. What does it mean to ***know*** things.

Let's go back to your first year at the university in Humanities 101, when you read Plato for the first time; the allegory of the cave. You are seated in a large cave. There is a bonfire somewhere behind you. Between the bonfire and where you sit there are a number of somewhat vague objects. The objects cast shadows on the wall before you. These shadows are forms of different objects: a horse, a chair, a bird, a boat, a tree, etc. The shadows are not precise, they do not have color or other special descriptive detail; but as we come to recognize the shadow we somehow *know* the objects it represents. As an example different horses that we identify may have long or short hair; be short and rotund or tall and lean, or black, brown or spotted; regardless, we recognize each animal as a horse.

Plato's students asked him about other concepts like justice, equality, or honor. He could not easily explain how one understood all of these things as they represented a set of more abstract forms. He told the students there was a single highest form, beauty; and that once a person was able to know beauty, that person somehow understood all of the other forms. They asked him how someone gets to this point and he told them that some people were simply lucky. But, back to the forms on the wall. Today we would probably call these patterns ***paradigms***.

We all need paradigms. If we did not have the ability to quickly recognize and interpret the vast amount of data we encounter each waking minute, we would be immobilized by sensory gridlock and probably institutionalized. Everyday input is sorted and filed for you by your paradigms. It is important to note that each of us has our own set of paradigms; they are subjective by nature. In fact some psychologists have designed systems to characterize people in distinct groups by the way they assemble knowledge with their paradigms. This is one of the things making each of us unique.

Our paradigms are necessary, but at the same time they can limit out ability to learn. As each of us grows older we get more and more comfortable with and confident about our paradigms. And, perhaps each of us gets a little lazy. How many truly new objects or thoughts did you really embrace yesterday? Was it easier to slightly twist yesterday's input a little so that it fit the paradigms you already had, rather than adding a new paradigm or two. Extending this thinking a little, it is quite possible that the motive driving much of scientific research is the simple justification of the validity of each scientist's already formed paradigms; not finding something new. Or in the words of Paul Simon, "a man hears what he wants to hear and disregards the rest. . ."

This may seem trite, only a line from an old 60's ballad. But, let's look at some examples before quickly dismissing the thought. Years ago I was a fourth grade teacher. In the mid 1960's some educators and psychologists started looking at what we were doing to our children in the traditional classroom. A book titled, *Learning to Fail,* (I regret I do not have the citation) was published at that time revealing some disturbing findings. The work concluded we were teaching children that failure was an acceptable and inevitable part of everyday life. The thing I most remember from the book was one of the case studies.

With the end of the school year every teacher wrote a fairly long evaluation of each pupil they had instructed. These files grew as they were passed to each subsequent teacher until the pupil graduated from high school. The first thing a teacher did before school started in the fall was to study the files of their perspective students. In the case study, the files of a number of very similar students were manipulated. The students were randomly labeled "slow", "bright", "troublemaker", etc.. When the study was completed, by and large each student had performed (in the eyes of the present teacher) as the manipulated file had predicted. The deliberately manipulated teacher's perception of the student had eventually manifested in the student's behavior. Of course this was not true in every case of teacher or student, but it was true in most cases.

Let's bring this a little closer to home. Several years ago a memo and a copy of a publication was circulated through the department by the genetics staff. If my memory serves correctly, the paper was Russian. Several geneticists had examined a stock of fish that had been enhanced for a short time a number of years ago. The modern geneticists could find no evidence of the introduced fish in the genetic makeup of the present stock. The implied interpretation of this work was that it might be wise to look at our enhancement programs as they may have little if any impact on the stocks or fisheries we try to enhance. We might be spending a lot of money and effort and accomplishing very little. My perspective was very different. Enhancement activities have recently been criticized a great deal for altering the genetic nature of wild stocks. From the perspective of a person involved in large enhancement programs, these findings were positive and provided some assurance that enhancement activities need not irrevocably harm the genetic nature of the naturally produced fish. What each of us saw simply depended on the perspective from which we interpreted the same information.

We have talked only briefly about paradigms; but let's leave it here for now and talk about Sockeye.

Where did you meet your first sockeye?

In the 1950's through the mid 1960's (at least) there was a legendary steelhead river in Northern California, known only to some. The Mattole River is below Eureka and Ferndale at the end of a road that travels through the "lost coast" of northern California. The river once held a run of large steelhead (and still may). On an early morning in 1966 I left Weaverville for the 3 hour drive with my fishing partner headed for the Mattole. It was in the early spring, cold and clear. There was black ice on the road. I had a pair of waders that were given to me by the school principal where I was teaching. The waders were size 9. I usually wear a 12. I do remember trying to get my feet into the waders that morning. Taking them off in the evening was even more interesting. We quickly went down to the river, near where it flowed into the sea. There were a few others there before us.

There was a river fog. Ice formed in the rod guides on the first several casts. My partner quickly caught a 12 pound fish and buried it under the gravel by the stream bank, refrigerating his catch. Moving downstream to the next run we came across an older fisherman. He wore a military surplus costume common in those times. He was hunkered back on his heels smoking a cigarette. He had made a little pool beside the river with some large stones. There was a 3 or 4 pound fish in the pool. The fish didn't look like a steelhead. I asked what it was. He looked up over his cigarette and said "blueback". It was obvious he was not going to say much more, and there were fish to catch downriver.

The day warmed with the sun. There was another lesson that spring day so many years ago. It had to do with a paradigm. Fishing for steelhead in heavy water with 4 pound test line, very light weights, and a flatfish; I did not hook a fish.

Back in Weaverville, I began to wonder about the "blueback". The only reference book I had with colloquial names for fish listed the synonyms, "red salmon", "red", or "sockeye". Years later my old fishing partner assured me that it was probably a small steelhead. He thinks some of the locals around Eureka called these fish "bluebacks". And, a sockeye should not have been in the Mattole; nonetheless, I chose to think that this was my first.

Sockeye are certainly unique, as is each of the other species of Pacific salmon. Sockeye do not easily fit stereotypes. I was told at the university that they are always associated with lakes and that adults spawn only in a tributary to the lake or the lake outlet, that fry rear in the lake for a year, and that smolt went to sea and return after 2 or 3 years as adult fish. Many of you have dispelled this paradigm. Sockeye are perhaps most unique from other salmon in their ability to adapt. They simply fit into the environment where they can. Sockeye exist as anadromous fish from the lower flood plain reaches and backwaters of large rivers without associated lakes to high mountain lakes where they have become resident freshwater dwellers.

Why sockeye? They are valuable to the commercial fishery. Many people consider sockeye the best tasting salmon. They are interesting. Some people simply like the red fish.

Main Bay Hatchery. The single thing that was most responsible for holding back yearling sockeye smolt propagation was a universal paradigm among fish culturists and pathologists; if you reared sockeye for any extended period in a hatchery environment, the fish would certainly become infected with IHN virus and they would all die or be killed. Most of the data available at the time supported this belief. This virus was not bound by simple laws of virus-host interaction; IHN virus was a foreboding presence we could neither understand nor predict.

A virus in the simplest terms is only a small piece of genetic material wrapped in a protective coat. A virus does little more than rest and replicate. Any sinister nature is of our own interpretation.

How did this virus get its name, Infectious Hematopoietic Necrosis virus? This is perhaps the first paradigm we all encountered when being introduced. It is probable that each of you was told that the virus specifically attacks a target tissue, the hematopoietic tissue of the kidney. Destruction of this tissue was very apparent in the first microscopic examinations of infected fish by histopathologists thirty years ago. That is how it was named.

In the 1970's I was involved with Dan Mulcahy, Ron Pascho, and Kay Genes (U.S. Fish and Wildlife Service, National Fisheries Research Center in Seattle) in a study to determine the pathogenesis of IHN virus in two-year-old sockeye. The pathogenesis of a disease is the road map the causative organism follows as the disease progresses through the host. The fish were infected by a dose of virus placed in the water. As time passed the infection was followed through the tissues of the fish. We quantified the amount of infectious virus found in these tissues. The virus first infected the gills and then moved quickly through the rest of the fish. Each tissue we examined was infected with high quantities of virus at some time or another in the course of the disease. Infected fish died in three distinct periods, the first was primarily associated with infection of the gills. These fish probably suffocated much as we would with untreated pneumonia. The second period of mortality was associated with a system-wide presence of the virus. The last period of infection, quite some time after the initial infection, was most associated with infection of the brain. Some of the infected fish did not die. The highest quantity of virus we found was in the gills. The infection of the brain was the specific situation most often associated with the death of a fish. Yet we are still told that the target organ of IHN virus is the hematopoietic tissue of the kidney. Paradigms are tenacious.

Consider a paradigm that is a little more universal; viruses are bad. Is it possible that IHN virus could ever serve a positive function among populations of sockeye salmon. Viral infections do make host organisms sick. They cause pain in sentient beings and sometimes death. Can this ever be positive? If overescapement is a real phenomenon, and in some situations where there are simply too many emergent fry for the production potential of a lake, it must be; how could the effect of too many spawners be moderated. Juvenile fish die from IHN. The spread of the disease is dependent on the density of the host. It is possible that this virus could act to moderate the effects of too many spawners in a system. When fish are spread out, the virus does not quickly spread and relatively few fish are affected. If the eggs and sac fry are very dense, redds superimposed on redds, then the virus has the opportunity to spread rapidly to the point where the population is thinned. And, in some cases perhaps well beyond that point. It is possible that there were overcrowded spawning areas in both Chenik and Hidden Lakes when IHNV was found in smolts leaving the systems. This is conjecture, but at least conceptually the virus might play a positive role in some situations.

Through the course of some 20 years we worked through a labyrinth of paradigms to eventually successfully culture sockeye in hatcheries; then, the problems of this last spring and summer. What happened in 1993? It seemed as though we had returned to the spring of 1980. Why were people taking the risks they took by modifying proven procedures? Why were the decisions to take these risks made so casually? Was the group lulled by the minimal losses to IHN in the last 7 or 8 years into a perception that sockeye culture is no different than other salmonid production?

Despite the paradigm shattering activities of the last 20 years, those who had done the pioneering work with sockeye had left only dogma behind; "carefully and exactly follow these procedures and you can work with sockeye". In recent years we have offered little explanation, justification, or discussion of these often cumbersome and expensive procedures. I suspect we had collectively grown tired of the old arguments and explanations, and assumed everyone fully understood the importance of these methods and the consequences of not following them. It has been a number of years since I have been excited by the old thoughts and arguments associated with IHN and sockeye. Those of you now entering the field have not had these arguments and experiences. The problems with IHN throughout the state this past summer suggest that it is time to go back and cover the old ground once again. That is the intent of much of this meeting.

There is added weight in this process the next several days. Today at this meeting we have reached a point in time when some of those who have been intimately involved with the development of sockeye culture and enhancement, from the first successful work at Big Lake and East Creek, will no longer be available to direct hatchery programs or share their thoughts. This is now especially noticeable with the closure of Big Lake Hatchery and Dan Moore no longer an active fish culturist, the conspicuous absence of Ken Roberson and several others, and the knowledge that some of those here admit to this being their last sockeye meeting. . . people like Dave Harding, who first told us of the program at Pitt River some years ago in Ketchikan and served as the bridge for Canadian and U.S. fish culturists interested in sockeye. It is time to begin passing these things to another generation of fish culturists.

And perhaps one last thought that might well serve this new group. Paradigms and perspectives . . . most of you look at the world as fish culturists. There are many other places to stand. If you are not aware of the color your paradigms are giving the world, you and your ideas can get left behind when what you see is in fact not what is before you.

Alaska Sockeye Salmon Hatchery Program
1993 IHNV Losses

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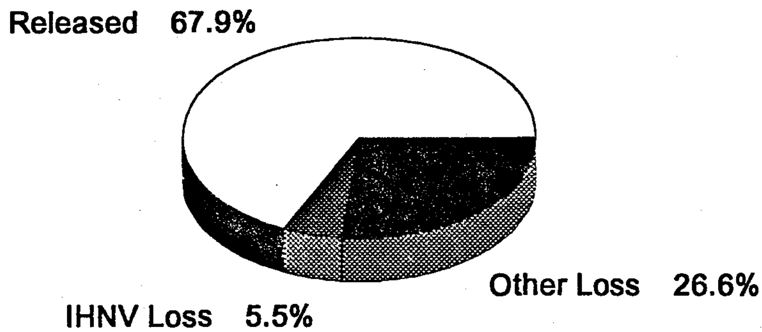
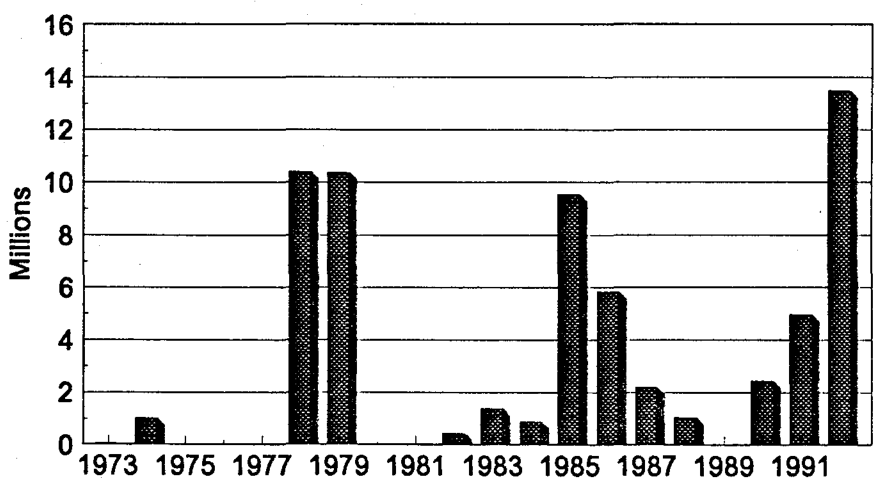
The sockeye salmon program has been rapidly expanding in Alaska. In 1992, we had 13 facilities taking a total of nearly 80 million sockeye eggs. Several facilities are also involved in smolt and presmolt programs. Since implementation of the Sockeye Culture Policy in 1980, losses due to IHN have been reduced and have averaged approximately 5% over the last 10 years. However, in the spring of 1993 we started to see a significant number of outbreaks with overall losses exceeding 13.6% of the sockeye salmon, totaling 15.8 million fish. In one facility, 58% of the sockeye salmon either died or were destroyed due to IHN. This number includes both mortality due to the infection and fish that were destroyed because the units were infected. The State of Alaska policy is to destroy all the fish in an infected unit. Therefore it is not possible to determine mortality due solely to the disease but high mortality is normally occurring prior to destruction of fish.

There were some factors common to several facilities that may have played a role in the high losses. If IHN virus was present in the water supply, outbreaks normally occurred. If one or more of the other factors was present, the infection spread to other units. Outbreaks which occurred in incubators and start tanks were normally contained. However, epizootics in outdoor raceways and net pens were more difficult to control and high losses followed. Alaska also experienced exceptionally wonderful summer weather resulting in high water temperatures. This may have favored viral replication. Expansion of sockeye rearing programs warrants reevaluation of disease control measures at each facility. Additional factors and recommendations are detailed on the following pages.

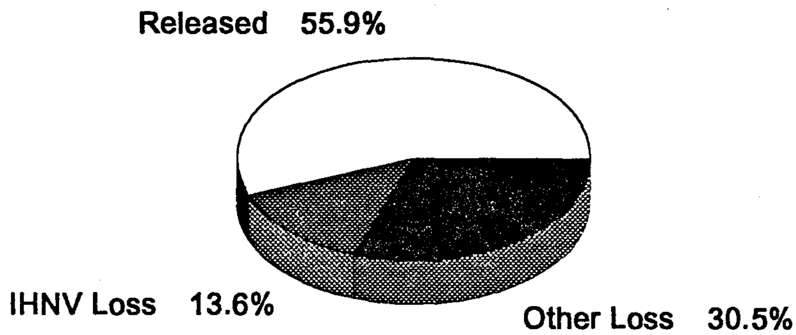
Alaska Sockeye Hatcheries
Historic Performance
BY 1973 to BY 1992



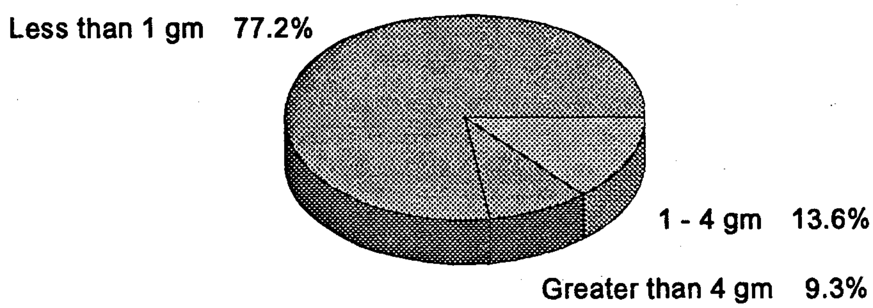
Alaska Sockeye Hatcheries
IHNV Loss by Brood Year



Alaska Sockeye Hatcheries 1993 Releases/Losses



IHNV Losses by Fish Size for 1993



Losses due to IHNV for Southcentral Alaska Sockeye Hatcheries for 1993

FACILITY	FISH DESTROYED	TOTAL SOCKEYE EYED EGGS	% LOSS/ FACILITY
Big Lake H.	0	8,364,000	0%
Crooked Creek H.	206,000	12,700,000	2%
Eklutna H.	577,000	2,495,000	23%
Gulkana I	1,300,000	15,000,000	9%
Gulkana II	0	1,300,000	0%
Kitoi Bay H.	2,600,000	4,481,000	58%
Main Bay H.	2,905,000	15,046,000	19%
Pillar Creek H.	4,250,000	12,929,000	33%
Port Graham	0	893,000	0%
Trail Lakes H.	2,275,000	12,343,000	18%
TOTALS	14,113,000	85,551,000	16%

Losses due to IHNV at Southeast Alaska Sockeye Hatcheries for 1993

FACILITY	FISH DESTROYED	TOTAL SOCKEYE EYED EGGS	% LOSS/ FACILITY
Beaver Falls H.	0	4,178,000	0%
Klawock H.	0	1,669,000	0%
Snettisham H.	1,683,400	11,351,000	15%
TOTALS	**1,683,400**	**17,197,000**	**10%**

Factors involved in precipitating or spreading hatchery outbreaks of IHNV

- Failure to use virus-free water source
- Poor separation/disinfection procedures
- Program changes
- Inadequate examination of fish for signs
- Failure to destroy fish in a timely manner
- Inadequate predator control
- Environmental variations
- Compromising of egg-take procedures

Failure to use virus-free water

- Net pens receiving undepurated effluent from hatchery
- Hatchery water source containing IHN susceptible species
- Undepurated water used in the facility even for brief periods

Poor separation/disinfection procedures during rearing

- Inadequate spatial separation between raceways or netpens.
- Failure to use separate utensils for each unit
- Insufficient or improper use of footbaths
- Possible aerosol spread, particularly in outdoor raceways

Program changes

- Potential risk factors include:
  - Fry transfers from different facilities
  - Making changes in the physical facility during incubation or rearing
  - Not maintaining individual stocks as discrete units
  - Crowding of fish and/or units
  - Long-term rearing
- Program changes warrant reevaluating stock interactions and disease prevention procedures

Inadequate examination of fish in rearing units or incubators

- Early detection is important
- Mortality records may provide early indications of viral outbreaks
- Thorough visual examination of moribund fish should be done regularly
- Samples of moribund fish should be promptly submitted to pathology section
- Incubator problems may be difficult to recognize

Failure to destroy infected fish in a timely manner

- Destruction based on mortality and signs at discretion of hatchery manager with consultation of the pathology section
- Destruction based on positive laboratory results
- Prompt destruction
  - Prevents spreading of virus in the facility
  - Prevents shedding of virus into the environment
  - May reduce numbers of carrier fish

Inadequate predator control

- Birds and small mammals may carry infected fish or contaminated materials to adjacent rearing units
- Outside raceways should be fenced and bird netting installed
- Net pens should be covered to reduce predator intrusion

Environmental variations

- High water temperatures result in more rapid replication and spread of virus
- Environmental stressors such as unsuitable salinity and poor water quality may result in a less fit fish
- Presence of other conditions such as gas bubble disease or vibriosis may also be a factor

The experience at Snettisham Hatchery with IHNV in 1993

by

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IHNV is always a concern at any hatchery that cultures sockeye salmon. This past year at Snettisham we had outbreaks in three separate Canadian sockeye stocks. There were no outbreaks in the Alaskan sockeye stocks. From visual observations we suspected seven incubation units as having mortalities due to IHN virus. In following the sockeye culture policy, samples were taken from these incubation units and sent to the pathology lab and then the fish were destroyed and the incubators thoroughly disinfected. Six of the seven samples (85%) were confirmed positive for IHNV by the pathology lab. Even though the one incubator didn't test positive for IHNV from the sample we sent in, there was mortality occurring in that unit and it may have tested positive later. The point here is, we didn't want to put at risk our overall production over one incubator that was in question.

The following shows the stocks, incubators, and number of fry that were destroyed from broodyear 1992. Also which incubators were confirmed positive for IHNV and the one incubator that wasn't.

Dates Fish Destroyed	Stock	Destination	Incubators	Number of fry	Pathology Results
5/22/93	Tahltan	Tuya	36 A & B	521,400	Positive
6/12/93	L. Trapper	L. Trapper	4B & 5B	412,000	Positive
6/14/93	L. Trapper	L. Trapper	5A	253,000	Positive
7/2/93	L. Trapper	L. Trapper	4A	251,000	Negative
7/19/93	Tatsamenie	Tatsamenie	23A	246,000	Positive

Total destroyed from broodyear 1992 = 1,683,400 = 21% of all eyed eggs
% destroyed that tested positive for IHNV = 85%

Totals by Stock:

Stock	# of incubators	# Destroyed	%	# Released	%
Tahltan	2	521,400	21%	1,947,207	79%
L. Trapper	4	916,000	45%	1,113,129	55%
Tatsamenie	1	246,000	21%	909,452	79%

The incubation set-up we used for broodyear 1992 consisted of two Kitoi box incubators, one stacked above the other. The water passed through the upper box, the lower box and then was discharged. This was done to obtain maximum use of our chilled water supply. The risk involved in this type of set-up is obvious. Any virus in the top box will be carried on to the unit below it. However, if the lower unit contains virus, it does not necessarily follow that the top box will also be found to have virus. However, this past year where ever the virus was found in one unit of a stacked pair, the other unit also tested positive.

May 22 - Tahltan/Tuya

The first problems associated with IHNV occurred on May 22 during the regular pathology screening, prior to release. None of the classic signs prior to this exam were noted. The incubators in stack 36 were removed and chlorinated, then the fry and substrate were incinerated. In addition, the incubators were also taken to the disinfection area outside the hatchery and steam cleaned.

The incubators on the bottom of stacks 4&5 were noted to have unusual behavior patterns. The signs of a possible IHN infection were present. The incubators in question were inclosed and isolated by plastic sheeting. This was a constant reminder to the staff that was working in the module to exercise caution when working in the area. After samples from these incubators were confirmed positive by the Pathology lab, we destroyed the fry in the infected incubators and followed our clean up protocol. Two days later on June 14, the top incubator in stack #5 showed signs of IHNV and the same process was followed.

July 2 - Little Trapper

Incubator 4A started to display the same symptoms as the other incubators had. However, pathology samples were still NEGATIVE. After a few days of high mortality, I made the call and disposed of the fish in the incubator. Not much fun but in my view a necessary act for the safety of the rest of the program.

July 19 - Tatsamenie

Incubator #23A pretty much went through the same sequence of events as the above incubators. The pathology lab confirmed this incubator as being positive for IHNV and it was dealt with as protocol dictates.

All of the out breaks this year were contained to the incubator stacks in which they occurred. There is no evidence to show that any were cross contaminated. We may have been able to reduce our losses by going to a single pass on our water system which we have done with our domestic stocks this year. One interesting bit of data that we observed during this time came from us monitoring our TDG levels. All of our outbreaks occurred after spikes of HIGH TDG and the corresponding high level of supersaturation of Nitrogen. No direct link or hard evidence to relate one to the other, but there seems to be a pattern of one event to the other.

Starting with the current brood year, we are in our newly remodeled hatchery that is designed for sockeye culture. in the new facility we'll be able to isolate individual stocks to their own modules. Also we will have the ability to control the dissolved gas levels and strip out the supersaturated nitrogen prior to entering the incubators. This will give us a great deal more control of our incubation and early rearing environment. I fully realize this is NOT a replacement for good fish culture practices. Nor is it a replacement for following the sockeye protocols for the production of sockeye. It will however allow us to better contain the beast that we are forced to live with in a Sockeye program. The new facility will also have two early rearing modules. This will allow us to maintain our isolation integrity during early rearing.

Pillar Creek Hatchery

1993 Annual Report

by

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and

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INTRODUCTION:

Pillar Creek Hatchery was constructed in the summer of 1990 under a cooperative agreement between the Alaska Department of Fish and Game, FRED Division, and the Kodiak Regional Aquaculture Association. It was designed as a 20 million sockeye salmon incubation facility located on the road system approximately seven miles from the City of Kodiak. The facility will create new fisheries for Kodiak Island seiners and gillnet fishermen by planting several barren lake systems with sockeye salmon fry from donor stocks. Depleted natural runs in need of rehabilitation will also be stocked with fry from their native system.

SUMMARY OF PROJECTS:

The largest project of Pillar Creek Hatchery is the stocking of late run sockeye salmon into Spiridon Lake. The donor stock for these fish is from Olga Lakes at Upper Station on the southwest end of Kodiak Island. The intent of this project is to stock 5 million fry into Spiridon Lake for the first two years, 8 million for the following two years, and reach the capacity of 11 million fry there after. The 1993 egg take goal will provide the second year of 5 million fry for stocking into Spiridon Lake. A broodstock for this project has been under development at Little Kitoi Bay using Upper Station eggs incubated at Kitoi Bay Hatchery. The fall of 1993 was the second year of returns to Little Kitoi Bay. Brood fish returning to Little Kitoi Bay are scheduled to eliminate the necessity of the remote egg take at Upper Station by 1995. For the 1993 egg take season, a total of 15.5 million eggs will come from a combination of Little Kitoi Bay and Upper Station stocks. All the eggs are taken by the Pillar Creek staff.

Other enhancement projects include taking 3.4 million eggs from Afognak Lake to stock Hidden Lake (Afognak Island) with 1.1 million sockeye salmon, Crescent Lake (near Port Lions) with .2 million fry, .3 million fry to Waterfall Lake, and a new project for 1993 is stocking .60 million fry into Little Kitoi Bay (Afognak

Island). Afognak Lake eggs will provide an early run stock for the above systems. Included in the above numbers is a pre-smolt rearing project which plans for release of .5 million 5 gram pre-smolt into Hidden Lake.

A rehabilitation project will take place on the Malina lakes with .9 million eggs being taken from and returned to the system. Of these, .070 million will be reared to pre-smolt size and the remainder released as fed fry.

ESTIMATED CONTRIBUTIONS:

Using an estimated 8% survival from fry to adult, which has been the average survival of other barren lake stockings, there should be 340,000 adults returning to Spiridon Lake from the 1993 stocking. Normal year class adults will return in 1996.

SUMMARY TABLES:

1993 Releases:

Stock	Released	Size gm.	Location
Upper Station RS	4.26 M	.2	Spiridon Lake
Afognak Lake RS	.205 M	.5	Waterfall Lake
Afognak Lake RS	.202 M	.5	Crescent Lake
Afognak Lake RS	.106 M	.5	Hidden Lake
	.448 M	.25	Hidden Lake
Afognak Lake RS*	.6 M	.5	Little Kitoi Bay
Malina Lake RS	.201 M	.25	Malina Lake
	.117 M	.5	Malina Lake
Monashka Creek SS	.010 M	.3	Monashka Creek

* Lost to IHNV

1993 Egg Inventory:

Stock	Goal	Eggs Taken
Upper Station RS	7.9 M	7.9 M
Afognak Lake RS	3.4 M	3.4 M
Malina Lake RS	.9 M	.9 M
Buskin River SS	.150 M	.150 M
Laura Lake RS	.30 M	.30 M
Pillar Creek Hatchery TOTAL	12.65 M	12.65 M
Upper Station/L. Kitoi RS at Kitoi Bay Hatchery	3.5 M	2.8 M
TOTAL	3.5 M	2.8 M

HIGHLIGHTS:

Construction projects include the installation of oxygenation system and replacement of the hatchery's main pipeline with a 12 inch pipeline. Pending projects include an additional backup water source and backup electrical generator.

Release of 6 million sockeye fry. Loss of 4.5 million to IHNV.

Egg take goals for 1993 have been fulfilled with approximately 12 million eggs currently being incubated.

First year egg take at Laura Lake with .3 million eggs taken.

RETURNS AND FISHERY CONTRIBUTIONS:

There will be no returns from Pillar Creek Hatchery production until 1994.

RELEASES:

There were 4.2 million sockeye fed fry stocked into Spiridon Lake in July 1993 from Upper Station donor stock. Fry were transported by float plane and released on the lake surface. They were not air dropped to insure increased survival. Condition of the released fry appeared to be good.

Afognak Lake donor stock were stocked into Hidden, Waterfall, and Crescent lakes. Releases of .55 million fed fry into Hidden Lake, .2 million fry into Crescent Lake and .3 million fry (.5 gram) into Waterfall lakes. Little Kitoi Bay received .6 million for early run pilot projects. Refer to Summary Tables for the details.

EGG TAKES:

The goal of 3.4 million eggs from Afognak Lake was achieved in August. These eggs were picked in mid-September and survival to eye was 74%. Due to high temperatures, survival was lower than normal.

This year, Malina Lake escapements were sufficient to lower the number of eggs needed for optimal densities. Survival to eyed egg stage is 71%, again lower due to extreme temperatures.

Upper Station egg take was successful this year due in large part to good weather. Approximately 7.9 million eggs were taken for Pillar Creek Hatchery and 1.8 million eggs were collected for Kitoi Bay Hatchery.

This was the second year of taking eggs at Little Kitoi Lake. Upper Station brood has been used to stock Little Kitoi Bay since 1989. An escapement of approximately 4,500 adult sockeye provided 1.0 million eggs for Kitoi Bay Hatchery. Combined with 1.8 million from Upper Station, Kitoi Bay hatchery is incubating a total of 2.8 million sockeye eggs.

Approximately 150,000 coho eggs were collected from the Buskin River. These eggs will be used for road system sport fishery enhancement and educational programs in the Kodiak area schools. Seven area schools have submitted paperwork for Sci Ed and Fish Transport Permits. The Buskin River stock will replace Monashka Creek stock for the school projects.

Summary of sockeye eggs taken, survivals, disposition and discussion of fry destroyed due to IHNV:

Approximately 12.5 million sockeye eggs were taken, from four different stocks (see list under egg inventory). This resulted in approximately 10.7 million eyed eggs (86% survival). From this group of eyed eggs, approximately 6 million fry were released and 4.5 million fry were destroyed due to IHNV.

During late May work on the hatchery's main water pipeline, combined with a problem of a back up well, necessitated pumping water out of the creek next to the hatchery. On June 8 the first signs of an IHNV problem occurred in an Upper Station incubator at emergence. A sample was taken from this incubator, sent to the pathology lab, and then the contents of the incubator approximately 250,000 alevins were destroyed. The sample was confirmed positive. On June 22-25, increased mortalities were noted in 5 raceways containing Upper Station fry and samples from each raceway were sent to the pathology lab. Mortalities continued to increase and the fry, approximately 3.25 million, in all 5 raceways were destroyed. Results from samples sent in confirmed IHN virus was present in all raceways. About one week after the Upper Station fry were destroyed, a mortality began in the Afognak fish and IHNV was isolated from samples of four raceways containing these fish. Hatchery personnel were notified by the pathology lab and all, approximately 400,000 fry, were destroyed. However, a few days before they received these results, approximately 300,000 fry were transferred to the Kitoi Bay Hatchery. These Afognak fry were also destroyed.

At the time the above mortalities were occurring, samples sent in of the Malina Lake fish were negative. However, about a week later fish began showing signs of IHNV and mortality began to increase. One raceway then tested positive for IHN virus and substantial mortality was present in all raceways, so the entire stock, approximately 350,000 fry were destroyed.

In looking back over what occurred, it appears the IHN virus was first introduced into the hatchery when it was forced to pump creek water through the facility for a day. What happened next was a spreading of the virus from one raceway to the next. These are outside raceways with practically no physical room between them. Also there was no bird netting covering these raceways and there were lots of birds in the area. Two more items worthy of noting were the higher than normal water temperatures (10-12°C) that favored the replication of the virus and the higher than normal rearing densities due to an unusual emergence pattern and new raceways on order that didn't get installed. All of these areas have been reviewed and corrective actions are being taken for 1994.

Kitoi Bay Hatchery's experience with IHNV in 1993
by
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The Little Kitoi zero age sockeye program suffered a major setback during the summer of 1993 because of an IHNV epizootic in the net pens. Most of the 2.3 million Upper Station fry were also confirmed of having vibriosis. I will try to explain what happened and what can be done to minimize the problem from occurring again.

All was going well with only minor pin head mortality until June 1 - 5 when the spruce trees started to shed their pollen and constant Easterly winds tended to stack the pollen into the head of the bay. This pollen is very sticky and looks very abrasive. A slight increase in mortality was noted after the pollen started to collect in the rearing area. Also, the surface water temperatures rose rapidly after a few days of intense sunshine to over 15° C.

On June 5 and 6, a fierce Easterly storm blew into the Kodiak Area and completely swamped our booms with white caps and swells. The salinities became constant from surface to bottom at around 25 ppt. This storm also mixed the pollen that had been on the surface completely into the water column. After that storm visibility in the water was reduced to 1 foot or less because of the pollen mixture.

On the evening of June 7 an increase in mortality was noted in pen 03. On June 8 it was very apparent that something was wrong with pen 03 and it was removed from the rearing complex and moved to a location down stream from the other pens. On June 9 samples were sent to the pathology lab to diagnose the problem. The external signs of the fish did not indicate IHNV, but on June 14 the results from cell cultures indicated that the fish were positive for IHNV. By that time mortality was high in all, but one pen. Fry samples from all the remaining pens were sent to pathology the next day. They all came back positive for IHNV and all but one positive for vibriosis. The one pen with less mortality was negative for vibriosis.

No one knows exactly what triggers an IHNV epizootic, but in the case of the zero age pen reared fish, the stress of high salinities along with the abrasive pollen may very well have been what put the fish over the wall of resistance. Another contributing factor may have been a higher viral load in Little Kitoi Lake from the above average sockeye escapement last fall. The pens were situated in the general area where Little Kitoi Lake discharges to saltwater. Vibriosis is a disease that usually can be associated with stress and those sockeye fry were definitely stressed on June 5 and 6.

In addition to the 2.3 million Upper Station fry lost in the net pens, approximately 300,000 Afognak fry received from the Pillar Creek Hatchery, were destroyed almost upon arrival due to the confirmation from the pathology lab of IHNV in that stock.

Not all the sockeye were lost. 180,000 Upper Station fry and 52,000 age zero smolts, that had not been put into net pens, were stocked into Little Kitoi Lake. Also there are still approximately 325,000 Upper Station fish on hand that will be released in the spring of 1994 as S1's.

In light of what occurred this past summer, if the zero age program is to continue several things can easily be done to try to farm around this problem.

1. The fry should not be stocked into net pens until after June 10 or after the spruce pollen has disappeared. This will require some extended freshwater rearing and will require a down sizing of the program unless additional freshwater space is installed. Rearing in freshwater to release size is the preferred option.

2. Prior to stocking the fry into the net pens some type of prophylactic treatment needs to occur to prevent the out break of vibriosis.

3. The escapement of adult sockeye that enter Little Kitoi Lake needs to be conducted so that nearly all of the adults can be captured and used for brood stock and removed from the system to reduce the viral load. This can be done by the installation of a barrier seine across the lake shortly beyond the fish ladder.

4. The intense storm systems cannot be controlled with today's technology. However, if the pollen is not present and the fish are of a larger size and have some immunity to vibriosis the saltwater intrusion may not be a problem. I doubt that a larger boom would have had much effect as white caps and mixing were occurring inside the booms from the intensity of the wind.

The occurrence of IHNV at Trail Lakes Hatchery 1992 - 1993

by

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June 1993

Several stocks of sockeye salmon were destroyed after being diagnosed as having Infectious Hematopoietic Necrosis Virus (IHNV) at Trail Lakes Hatchery during the spring of 1993. This outline is an attempt to record some of the events and anecdotes concerning the hatchery operation which may be of value in identifying the cause and possible spread of the epizootic and hopefully help limit the occurrence in the future.

COAL CREEK

In February, 1993 IHNV was diagnosed in our Coal Creek (Tustumena Stock) presmolts. The fish were approximately 6 grams (S1) at the time of the outbreak. The only other fish in the outdoor raceways were the Big River age zero's, all other stocks were under incubation. These fish were to be stocked into Coal Creek on the Kenai Peninsula near Kasilof.

The eggs for this program were taken by ADFG staff at Crooked Creek Hatchery in August 1991 and transferred to Trail Lakes at 0.3 grams on July 17, 1992. During the summer the fish experienced several minor fish health problems including, gas bubble disease, trichodina, furunculosis, costia, and cold water disease (myxobacteria). Despite the occurrence of these health concerns, mortality was minimal and the fish were feeding well.

The fry were started in raceways denoted D4 and D8 which are 20'* 4' * 30" deep. (*1) After the fish were tagged in September / October / November many of the fish were ponded into the indoor raceways F2 and F3. (*2) This bank of raceways has a history of gas bubble disease. A new airstripping tower system that had been installed appeared to be ineffective in reducing gas supersaturation. The fish were then transferred back outside into two groups of the large 50' raceways E5 and E6. Some of the fish did not pass through F2 and F3 since they had not been tagged prior to noticing gas bubble problems. Likewise, a small number of untagged fish did not receive the second treatment series for trichodina.

The fish again came down with trichodina for the second time in January and were treated with formalin. In addition, a small transparent worm, which was later identified as a nematode, began infesting the raceway. A 1:6000 treatment with formalin was effective in reducing but not eliminating the nematode. The fish were also treated for gill infections with Diquat.

Approximately half of the smolt in raceway E5 were split into E3 to limit the density.

Shortly after these treatments E3 and E5 came down with IHNV. The fish were destroyed on March 9th. The mortality was minimal, less than 1%, and the majority of the fish appeared very healthy. Fish are destroyed by dissolving HTH in buckets and soaking the raceway overnight. The fish are then netted out of the raceways and placed into double lined garbage bags. The bags and fish are then burned in the incinerator and all of the utensils and equipment thoroughly disinfected.

Raceway E6 did not test positive for IHNV for an additional 8 weeks (April 23rd). During that 8 week time frame the density was reduced by splitting approximately one half of the fish into E5.

ADFG's Pathology staff conducted a prerealese inspection on March 26. At that time the pathologist carefully inspected the stocks. They returned April 22nd for additional inspection and to gather more samples.

BIG RIVER AGE ZERO'S

The Big River stock (S0) were approximately 2 grams when they came down with IHNV in early April and were destroyed on April 9. These fish were accelerated through incubation and rearing on 8°C water. The fish were ponded in raceways D4 and D8 and by the time the epizootic occurred had been split into D2, D6 and D7. The Big River outbreak was similar to the Coal Creek group. The fish were doing fine with minimal fish culture problems, in fact the group had the lowest level of mortality of any age zero group cultured at Trail Lakes.

The nematode began appearing in the Big River stock in early March. The raceways were treated for 4 days with formalin. In addition, a iodine drip was tried to see the effect on the nematode. It was not effective in reducing the nematode. After two weeks of low level mortality samples were submitted to pathology and IHNV was diagnosed. These fish, (500,000) were immediately destroyed.

CHELATNA LAKE

Prior to ponding the Chelatna stock an incubator was destroyed because it had high mortality. Likewise, raceway C7 was destroyed immediately after ponding because the fish were in very poor health. Samples were not submitted to ADFG but there is little doubt it was IHNV. These were from incubators #8 (Lot 8) and #9 (Lot 9). Eventually the second incubator (#10) from Lot 9 was diagnosed as being positive. This raceway, C8, showed no clinical signs of IHNV. It was destroyed.

PACKERS LAKE AND HIDDEN LAKE

On April 15 samples from Packers Lake and Hidden Lake, which were still in incubators, were submitted to ADFG Pathology. These fish did not test positive for IHNV.

BIG RIVER FRY

At present, only two other raceways tested positive for IHNV, A1 and A3 from the Big River stock. Like raceway C8 from Chelatna, raceway A1 appears healthy. Raceway A3 was marginal and showed clinical signs of IHNV. These fish were all destroyed.

POSSIBLE CAUSES

In the past four years only two incubators from Packers Lake and one lot from Chelatna Lake have been destroyed due to IHNV. The high incidence this season has caused the staff to closely evaluate the possible origin and transmission of the disease. A summary of some of the possibilities and other anecdotes are listed below.

<u>STRESS</u>: The Coal Creek fish were subjected to many factors that as a total could have caused enough stress to predispose the fish to an IHNV infection. These include high levels of Trichodina,
coded wire tagging, several movements throughout the hatchery, formalin and diquat treatments, smolting behavior, nematodes and Gas Bubble Disease.

Gas Bubble Disease is a chronic problem with fish at Trail Lakes especially when under accelerated development. (Coal Creek fish did not receive heated water but had moderate to severe gas bubble disease, probably as an artifact of being in the F module)

<u>EGGTAKE METHODS</u>: The eggs from Tustumena Lake which were to be released at Coal Creek were not taken using ADFG protocol for sockeye culture. The stock has been inspected many times and is known to have a low incidence and titer of IHNV. In addition the staff at Crooked Creek has successfully planted fry from this stock for 15 (?) years. However, the past two years Chenik Lake, which is stocked with these fish has had a natural epizootic during the smolt migration, and now it has occurred at Trail Lakes at the smolt stage. It is possible that the low level of virus takes a full year to manifest itself.

<u>WATER HARDENING</u>: Trail Lakes staff has been refining its methodology for fertilizing, disinfecting and water hardening its eggs. One of the major changes, made in 1991, was to eliminate water hardening the eggs in individual cups. Instead the eggs are fertilized, rinsed, prewashed in iodophor and then placed into an incubator prepared with 100ppm iodophor. The eggs are hardened for an hour or more prior to the flow being turned back on. This is the only variation from strict adherence to the sockeye culture protocol outlined by ADFG. Mixing eggs from different families prior to water hardening may predispose "less resistant" eggs to infection from IHNV. This could explain some

of the losses in the start tanks.

BIRD PREDATION: During the midwinter months December/January the Coal Creek fish suffered losses through extensive bird predation. Several ravens, magpies and dippers were feeding constantly on the raceways. A total of 19 magpies were eliminated. There was no bird activity after this. As an additional precaution, bird netting was placed over some of the raceways to discourage others from coming back. A possible explanation for the occurrence of the nematodes and IHNV was the transfer from bird droppings. Moose Creek, which is adjacent to the hatchery, has a substantial run of sockeye salmon. (The last samples for IHNV were submitted in 1981).

STEAM CLEANING: Steam is used as a disinfectant at the hatchery. When steaming the raceways an aerosol is produced which under the prevailing breeze could conceivably go from the E bank of raceways to the D bank or beyond. In addition, it is possible that the steam is not adequately disinfecting the porous concrete. The fact that D4 and D8 had both of the Age zero and Coal Creek fish in it may not be a coincidence. However after an epizootic, the raceways are disinfected with chlorine, a viricidal soap and steam.

WELL SYSTEM: Whenever IHNV occurs an immediate evaluation of the water system is necessary. In review of the well logs and previous studies a scenario could be developed whereby surface water could be seeping into the well system.

The wells at Trail Lakes are approximately 80 to 100 feet deep. During the original well tests a level was reached where the draw down ceased. (The report identifies several possibilities from where a surface recharge could occur, including Moose Creek. Calculations show that it is possible to draw surface water through the sand/ clay substrate into the aquifer within thirty days, or faster if channeling occurs.

Trail Lakes has been using approximately 500 gpm more during the 1992-1993 rearing season to accommodate the increased production, and for the first time since CIAA has been operating the hatchery running wells off of both pads simultaneously. (*4) It is possible that the increased usage has created a situation were the surface water is partially recharging the aquifer.

NEMATODE/ PHOMA: The nematode and phoma never occurred prior to 1993. Phoma has occurred at Crooked Creek hatchery before, however, the Coal Creek fish are the only ones that had not been infected with phoma.

The nematode appeared in the Big River age zero and Coal Creek raceways. Its origin is from three possible sources, bird droppings, Crooked Creek transfer or the well system. A similar nematode was found in the head box of the main distribution system but it is not clear whether this is the same organism.

FISH CULTURE: The rare occurrence of IHNV in the past and the successful isolation of the occurrence has the staff confident of its fish culture and disinfection procedures.

However, the occurrence of the virus in 4 of 7 stocks in 1993 causes reevaluation of techniques used. Since all of the fish appeared very healthy during the midwinter months, it is possible a sense of complacency developed. Many of the standard disinfection procedures such as footbaths were not used outside.

It is possible that a transfer between Coal Creek and the age zero program occurred during that time.

BAFFLES: This past season baffles were not used because in previous years many smolt had abrasions and developed external fungal infections which was thought to be caused by rubbing against the sides of the raceways and the baffles during cleaning. The baffles are very effective in removing waste and keeping weaker fish to the tail of the raceway, where they can be removed. Without the baffles it is possible that fish with a low levels of infection could shed the virus at the head of the raceway thus exposing the whole group.

November 1, 1993

One additional raceway C5 was eventually destroyed. Another raceway (A2) from the Big River fry group tested positive for IHNV on the 27th day of cell culture. These fish had already been stocked into Bear Lake, Seward.

A meeting was held with ADFG staff in July to review some of the events at Trail Lakes and make suggestions for changes or improvements. The notes from the meeting, correspondences from pathology staff and replies from CIAA are on file.

CHANGES/IMPROVEMENTS AT TRAIL LAKES

HEADBOX SYSTEM: Additional degassing tubes have been installed in the headbox system. The original system did not allow for gases to escape after flow into the headbox manifold.

FENCING: A ten foot wooden fence was constructed around the perimeter of the outdoor raceway complex. Provisions were made to enable securing a netting tent to eliminate bird predation.

EGG DISINFECTION: During the 1993 eggtake season Trail Lakes staff experimented with using salad bowls as containers to water harden eggs.

All eggs, after fertilization, were prewashed with a "pure" iodophor solution. Previously, a common tub was used to dip the eggs in prior to depositing them into the incubator. This season a pitcher was used to pour iodophor solution over the eggs as a prerinse.

UTENSIL DISINFECTION: In the past, fish culture utensils, such as mort scoopers and brooms, were used in multiple raceways (the same stock of fish and with disinfection).

This season individual utensils and disinfection vats will be used for each raceway.

INTERFACILITY TRANSPORTS: Trail Lakes will not accept fish from facilities that do not follow the sockeye protocol.

(*1) D8 had an epizootic in 1990 with the Chelatna stock.

(*2) 280,000 fish had CWT. Several hundred fish were left over (untagged) and have been reared in a small tote inside the "clean room". These fish were held through August and did not come down with IHNV.

(*3) In March when it appeared that there might be a serious problem with IHNV the staff divided its chores. Two members focused on the "clean" Big River, Hidden Lake, Packers Lake and Chelatna Lake stocks. All of the fish culture and eventual destruction of the Coal Creek and age zero stocks were conducted by a single staff person.

(*4) Both of the wells used during the rearing season had new pumps installed in 1992.

Main Bay Hatchery's Experience with IHNV In 1993

by

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Main Bay Hatchery began producing sockeye smolts in 1987. This past year, 1993, was the first time mortality due to IHNV had occurred at the facility. The 2.9 million fish lost from broodyears 1991 and 1992 (see Table 1) represent approximately 19% of the total 15.0 million eyed eggs collected during these broodyears. The following pages summarize in outline form; the losses per stock, possible explanations, and procedural improvements to reduce future risk.

Prince William Sound Aquaculture Corporation

Main Bay Hatchery Juvenile Sockeye Salmon Loss

Freshwater Occurrence

Cause: IHN disease (virus)

Stock(s): Brood year 1992 Coghill(Davis Lake), Eshamy Lake Stock Sockeye

Life stage: Start-up Fry

Location: Start tanks in incubation area

Time: April - June (see table 2)

Impact on Production:

A. Production goal in number of smolts = 5,550,000

B. Expected release less loss to IHN = 4,650,000

C. Total loss to IHN 1,458,828

D. Release date 1994

E. Adult return years 1996 to 1997

Possible Explanations:

* Vertical transmission from adult to progeny.
* It is believed (although not proven) that environmental conditions and degree of maturity may play a role in the viral organisms present in adults. Overmature fish in crowded conditions in saltwater, such as occurred at Davis Lake, are thought to be the most likely carriers of high levels of IHN virus particles.
* Eggtake techniques developed for sockeye culture significantly reduce loss to IHN but do not guarantee it.

Possible Procedural Improvement to Reduce Risk:

* Avoid broodstock in the conditions stated above.

Saltwater Occurrence

Cause: IHN disease (virus)

Stock(s): Brood year 1992 Eyak Lake & 1991 Coghill (MBH), Eshamy Lake Stock Sockeye

Life stage: Smolt

Location: Saltwater rearing pens in front of MBH

Time: Late May - June (see table 2)

Impact on Production:

Stock: Eyak (On-site release)

A. Production goal in numbers of smolts = 71,000

B. Release less loss to IHN = 0

C. Total loss to IHN 108,692

D. Release date 1993

E. Adult return years 1996 to 1997

Stock: Coghill (MBH) (On-site release)

A. Production goal in numbers of smolts = 2,810,000

B. Release less loss to IHN = ~2,600,000 /1

C. Total loss to IHN 421,509

D. Release date 1993

E. Adult return years 1995 to 1996

Stock: Eshamy (MBH) (On-site release)

A. Production Goal in numbers of smolts = 700,000

B. Release less loss to IHN = 0

C. Total loss to IHN 915,340

D. Release date 1993

E. Adult return years 1995 to 1996

TABLE 2

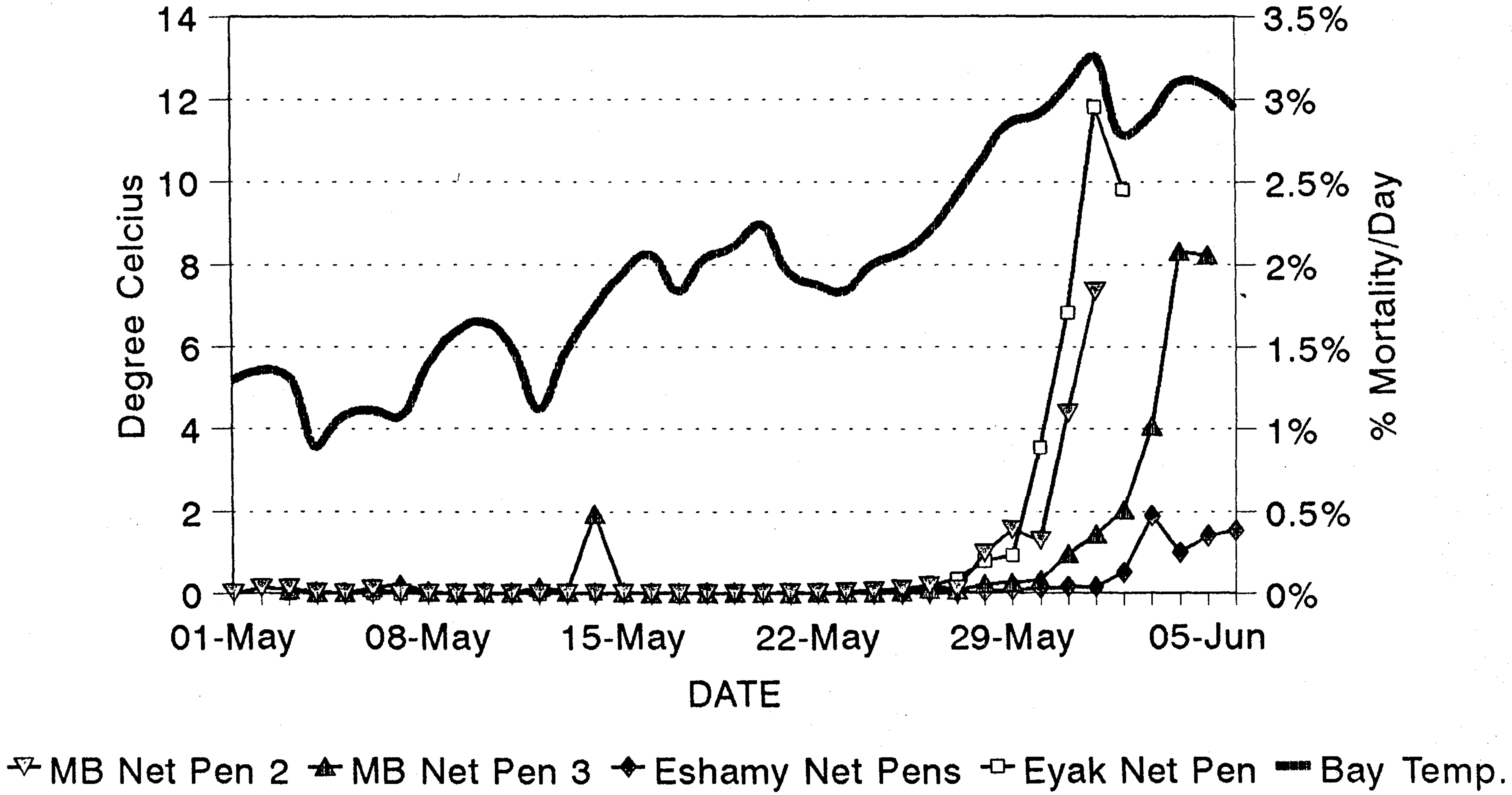
SAMPLES SENT TO FISH PATHOLOGY LAB - SPRING 1993

DATE	RER UNIT	WORK-UP DONE	DATE CONFIRMED	CLINICAL FINDINGS:
04/05	ST 14	Necropsy, Virology	04/09	**POSITIVE IHN**
04/05	ST 19	Necropsy, Virology	04/09	**POSITIVE IHN**
04/10	ST 17	Necropsy, Virology	05/03	NEGATIVE
04/10	ST 18	Necropsy, Virology	05/03	NEGATIVE
04/10	ST 20	Necropsy, Virology	05/03	NEGATIVE
04/10	NP 1	Necropsy, Bacteriology, Virology	05/01	NEG./OSMOREGULATORY FAILURE
05/18	ST 20	Bacteriology, Virology	05/24	**POSITIVE IHN**
05/18	NP 1	Necropsy, FAT	05/20	**Positive Myxobacteria**
05/26	NP 2	Necropsy, Bacteriology, Virology	06/02	**POSITIVE IHN**
05/31	NP 3	Necropsy, Bacteriology, Virology	06/05	**POSITIVE IHN**
06/01	NP 7	Necropsy, Bacteriology, Virology	06/05	**POSITIVE IHN**
06/01	NP 5	Necropsy, Bacteriology, Virology	06/06	**POSITIVE IHN**
06/01	NP 6	Necropsy, Bacteriology, Virology	06/06	**POSITIVE IHN**
05/26	ST 22	Necropsy, Virology	06/23	bact. and fungal infection
05/26	ST 23	Necropsy, Virology	06/23	bact. and fungal infection
05/26	ST 28	Necropsy, Virology	06/23	bact. and fungal infection
06/03	ST 22	Necropsy, Virology	06/23	bact. and fungal infection
06/03	ST 23	Necropsy, Virology	06/23	bact. and fungal infection
06/07	ST 22	Necropsy, Virology	06/23	bact. and fungal infection
06/07	ST 28	Necropsy, Virology	06/23	bact. and fungal infection
06/03	RW 8	FAT, Virology	07/01	NEGATIVE
06/29	ST 21	Necropsy, Virology	07/01	**POSITIVE IHN**
07/12	ST 17	Necropsy, Virology	09/08	**NEGATIVE - Fish Destroyed**
07/12	ST 18	Necropsy, Virology	09/08	**NEGATIVE - Fish Destroyed**

NP = SALTWATER NET PEN (SMOLTS)
RW = FRESH WATER RACEWAY (SMOLTS)
ST = FRESH WATER START TANKS (FRY)

Main Bay Hatchery 1993

Net Pen Mortality vs Bay Temperature



Eyak data is 10% of actual
IHN Outbreaks 4/04 & 5/18
Fish destroyed 4/07 & 5/24

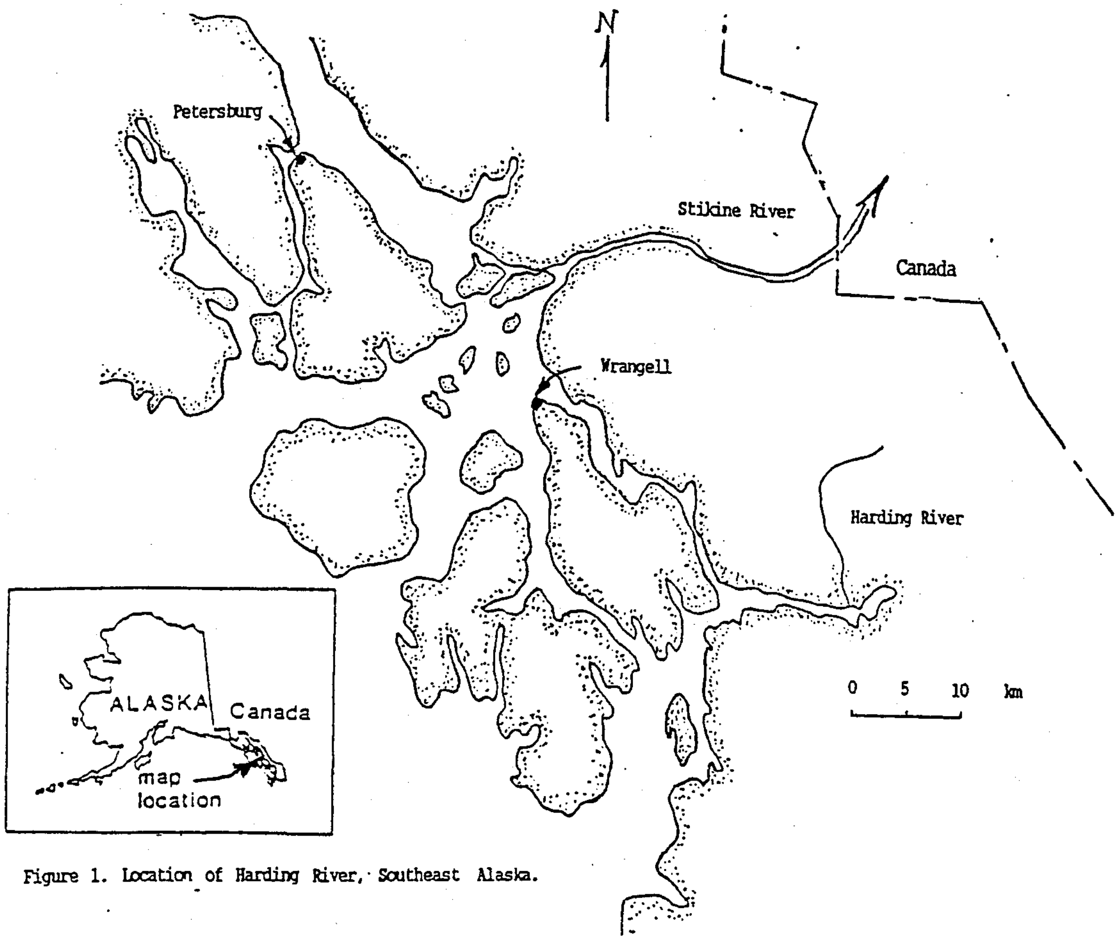


Figure 1. Location of Harding River, Southeast Alaska.

Table 1. Number of IHNV positive females detected from ovarian samples collected from salmon in the Harding River. Southeast Alaska. a/			
	Species		
Year	Chinook	Chum	Pink
1989	0 / 17	N.A.	N.A.
1991	0 / 8	N.A.	N.A.
1992	4 / 12 b/	N.A.	N.A.
1993	0 / 9	0 / 9	0 / 1

a/ Number of samples IHNV positive / Number of samples collected.
b/ A sample of 220 fry pooled into 11 groups of 20 fry were assayed following the detection of IHNV in the adult samples. The results were negative. which is not unusual.

ACCESSION NO.: 93-0510

ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU FISH PATHOLOGY LABORATORY, FRED DIVISION
3333 OLD GLACIER HIGHWAY, JUNEAU, AK. 99802
PHONE (907) 465-3577

REPORT OF LABORATORY EXAMINATION

LOT (YEAR, STOCK, SPECIES): Harding River chinook salmon
Oncorhynchus tshawytscha

SAMPLE DATE: 8/26, 9/1/92

DATE SAMPLE RECEIVED: 8/28, 9/4/92

CONTACT PERSON: Bob Zorich

FACILITY: ADF&G, FRED Division, Petersburg, AK

SPECIMEN TYPE: Kidney/ovarian fluids   STATE: Fresh on ice

STAGE: Adult fish used for spawning   WILD: Yes

NUMBER IN SAMPLE: 24 kidneys (12 each sex), 12 ovarian fluids

HISTORY/SIGNS: Minor levels of Rs antigen in adult fish (10/84) and no detection of virus (0/28)

REASON FOR SUBMISSION: Family Track for BKD and continue screening for viruses to establish a disease history.

FINAL REPORT DATE: 1/14/93

CLINICAL FINDINGS:

ELISA - (kidneys)

7/24 positive for the antigen of *Renibacterium salmoninarum* (Rs). Mean optical density values ≥ 0.095 were considered positive for the antigen.

Positive fish #s
♂ 1 = 0.098
♀ 2 = 0.119
6 = 0.096
7 = 0.109
9 = 0.096
♀ 10 = 0.097
11 = 0.096

Virology - (ovarian fluids)

4/12 fish (#s 2,3,4,6) positive for virus. Initial sample passage was using a quantal assay on EPC and CHSE-214 cells @ 14°C for 14 days with a blind passage of 19 days. Cells were pre-treated with PEG. The minimum level of detection was 5 infectious particles/ml sample and pH was maintained @ 7.2-7.4. No CPE was evident on the CHSE-214 cells after the first blind passage so this cell line was discontinued. However, suspicious rounding of cells was present in 4 of the samples on the EPCs after the first blind passage. These were passaged onto fresh monolayers which again produced suspicious rounding by 9 days. These samples were passed again with the same results by 6 days and again with definite CPE by 4 days. Four passages after initial inoculation were required to produce complete CPE and assurance that a replicating agent was present.

Transmission Electron Microscopy (TEM)

EPC cells with completed CPE from the fourth passage material were embedded in resin and examined by TEM, whereby rhabdovirus particles were observed budding from the plasma membranes of infected cells.

Serology

1. Immunoblot assays conducted three times on the Harding River isolate by FRED Juneau pathology staff using a mouse monoclonal antibody (Mab) against IHNV and a rabbit polyclonal antiserum against VHSV were negative. Viral titer was 10^6 which should have been sufficient for an immunoblot reaction. Control viruses stained with their homologous antisera.

2. Virus neutralization was performed by U.S. Fish and Wildlife staff at the Seattle lab using a rabbit polyclonal antiserum against IHNV. The Harding River isolate was neutralized by at least 3 $\log_{10}$ PFU/ml confirming identity as IHNV (results attached).

3. DNA probe analysis was performed by U.S Fish and Wildlife staff at the Seattle lab which further confirmed the identity of the Harding River isolate as IHNV (results attached).

COMMENTS AND RECOMMENDATIONS:

Although a moderate prevalence of Rs antigen was detected (29%) the levels were very low. Since these fish were being held in isolation and were going back to their natal system, culling of eggs from the positive fish was not recommended early on when these results were established in October.

However, this was a minor concern in comparison to the subsequent findings of IHNV-positive parent fish. Because the fish were in complete isolation, pathology staff were able to take the necessary time to adequately identify the virus rather than recommend destruction of fry right away. Nontheless, hatchery manager Jim Billi was informed of the initial virus-positive results when first confirmed on 11/23/92 so that he could take any other necessary precautions for containment of the fry which had since hatched.

Isolation of IHNV from a nonsockeye species in Alaska is rare and has always been traced to sockeye in the water supply as the source of virus. In this case a definite link has not been made since sockeye are not known to use the Harding River, although some minor population could exist. Another concern was the apparent unadapted behavior of the virus to tissue culture propagation such that several passages were necessary to obtain enough virus to work with. Lastly, the inability of the Mab to identify this virus when all other Alaskan IHNV isolates tested could be recognized strongly suggested that this IHNV might be a variant or different strain that, in the apparent absence of sockeye, could be adapted to chinook salmon. The latter possibility is of greatest concern to Alaskan aquaculture, especially when progeny of these fish are being reared at a premier chinook salmon facility. That they are in an isolation unit offers some margin of safety but knowing what we know now, this margin is no longer comfortable nor is it absolute regarding a potential accident.

A telephone conference with involved regional and headquarters staff on 1/13/93 indicated that all participants shared these same concerns and a decision was reached to destroy the existing 68,500 Harding River fry in the isolation unit at Crystal Lake Hatchery. Fry samples were taken beforehand for a virus assay as a matter of record. The project would continue next year with eggs incubated in two instream incubation units in the Harding River while ovarian fluid samples are again tested for IHNV. Fry would also be tested prior to outmigration from the incubators. Should any of the samples turn up virus-positive again, the project would be discontinued as per FRED disease policy regarding IHNV detection in nonsockeye species.

FISH HEALTH INVESTIGATOR: T. R. Meyers

TECHNICAL SUPPORT: S. Short, K. Lipson

COPIES TO: FY 93, Crystal Lake, R. Burkett, T.R. Meyers, K. Pratt, J. Billi, J. Burke, J. Koenings

FAX TRANSMITTAL COVER SHEET

U.S. Fish & Wildlife Service
National Fisheries Research Center
Building 204, Naval Station
Seattle, Washington, U.S.A. 98115

FAX Number: (206) 526-6654
Attendant's Number: (206) 526-6282

2 PAGES FAXED (including transmittal cover sheet)

To: Ted Meyers Date: ~~#~~ 1/7/93

To FAX #: (907) 465-3510

From: Bill Batts

Subject: Serum Neutralization Results

NOTES:

Procedures used and actual data will be provided upon request. Any questions, feel free to call.

Serum Neutralization of Alaskan Harding R. Chinook Salmon and Tahltan Lake Sockeye Salmon Isolates (12-28-92)

	---------- log_{10} PFU/mL remaining ----------				
Rabbit antisera (1:100 final)	Harding River chinook salmon isolate	Tahltan Lake sockeye salmon isolate	Cedar River control IHNV	Makah NFH control VHSV	MEM
α IHNV	1.5	1.2	<0.7	4.2	<0.7
α VHSV	5.3	4.8	3.6	<0.7	<0.7
MEM	5.4	4.9	3.7	4.3	<0.7

<u>Conclusion:</u> It is clear from this serum neutralization assay that both Alaksan isolates are indeed IHNV. Both unknown isolates were neutralized by over 3 log_{10} PFU/mL. Both of the control viruses (IHNV and VHSV) were neutralized by at least 3 log_{10} PFU/mL after incubation with their homologous antiserum, while not reacting with the heterologous antiserum. The results of the IHNV DNA probe test on 12/31/92 showed that the chinook isolate was IHNV, while the sockeye isolate was inconclusive.

Isolation of Infectious Hematopoietic Necrosis (IHN) virus and detection of neutralizing antibodies in maturing sockeye salmon (*Oncorhynchus nerka*)

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Biological Sciences Branch
Pacific Biological Station
Nanaimo, British Columbia
Canada V9R 5K6

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Buhl, Idaho
USA 83316

The life cycle of infectious hematopoietic necrosis (IHN) virus in salmonid populations is poorly understood. This rhabdovirus is typically isolated only from spawning adults and clinically infected juvenile salmonids although a few isolations have been made from yearling rainbow trout and 2-year-old kokanee salmon.

It has been suggested that survivors of the infection become latent carriers of IHN virus, with the virus only reappearing in tissues when the fish reach sexual maturity. However, IHN virus has not previously been isolated from salmon, including maturing salmon, during their marine phase. Studies by Amos et al.(1989)

suggested that a life-long carrier state does not exist and that horizontal transmission of IHN virus from freshwater reservoirs accounts for the presence of the virus in spawning salmon. Extensive sampling of freshwater organisms and sediments has, however, failed to identify a freshwater reservoir.

In 1992, IHN virus was isolated from the kidneys of 7/60 (11%) adult sockeye salmon collected in sea water from the Alberni Inlet, Vancouver Island, B.C. These samples were obtained in late September while the fish were still some 15 km away from their freshwater spawning river. Viral titers in the kidney tissue of the positive fish were high (range 6.6×10^3 to 9.7×10^5 pfu/g) indicating that the virus was replicating in these fish and not merely present in a carrier state. These results suggest that 1) a carrier or latent state exists is sockeye salmon, 2) a marine reservoir exists that can transmit the virus to sockeye salmon, or 3) that the virus was acquired from freshwater run-off. Of these possibilities, the first seems the most likely because earlier samplings of this stock conducted in July (183 fish) and August (120 fish) had proved negative for the virus. This is also consistent with previous studies that have shown that fish express the virus with the approach of sexual maturity. The lack of a previous isolation of IHN virus during the marine phase of the salmonid's life cycle may be partly due to the relatively few samples assayed.

Continued monitoring of this population of fish during the maturation period for IHN virus and neutralizing antibodies revealed that: 50/115 (43.5%) of the spawning fish were positive for IHN virus; and 24/115 (20.8)% were positive for neutralizing antibodies; and 41/115 (35.7%) did not have either detectable virus or neutralizing antibodies. Only one of the spawning fish with neutralizing antibodies also had detectable virus. None of the fish sampled at sea had neutralizing antibodies. The fact that maturing sockeye salmon are capable of an antibody response to IHN virus and that none of the fish in sea water had elevated antibody levels suggests that the virus found in the seawater fish was either recently acquired or recently expressed. Continued analysis of specimens collected from anadromous salmonids during the marine phase of their life cycle will be required before any conclusions can be made.

Amos, K.H., K.A. Hopper, and L. Levander. 1989. Absence of infectious hematopoietic necrosis virus in adult sockeye salmon. J. Aquat. Anim. Health 1:281-283.

An Overview of Sockeye Hatchery Production in Alaska Since 1973

by

Steve McGee
Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
P.O. Box 25526
Juneau, AK 99802-5526

The purpose of this report is to provide a brief review of the development of sockeye production from hatcheries in Alaska since 1973.

Enhanced production of sockeye began in 1973 with 290,000 eggs incubated at Crooked Creek Hatchery. In 1974 two facilities; Crooked Creek and Gulkana took a total of 1.5 million eggs. And in 1975 four facilities; Crooked Creek, Gulkana, East Greek and Big Lake took a total of 8.1 million eggs. In 1979 these same four facilities took a total of 23.0 million eggs. Unfortunately, during this time overall survivals ranged from a low of 42% in 1975 to a high of 59% in 1974. Overall survival equaled 56.3%.

In 1980 the ADF&G Sockeye Salmon Policy was developed and implemented. Overall survivals for the 33.1 million eggs taken that year rose to 76%.

Sockeye eggtakes continued to increase topping the 100 million mark in 1987 and continuing at this level through 1992. Overall green egg to fry release survival from 1980 until 1992 was approximately 70%. Of the 30% loss, only 4.1% was due to IHNV. "Farming around" the virus has proven to be effective.

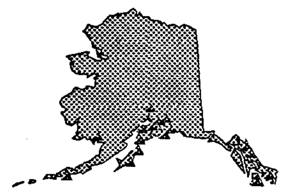
Most of the fish produced are stocked in lakes as fry. Only recently, the last six or seven years, have smolt releases become part of the program. Approximately 3-5% of the total fish released are now smolts.

1993 proved to be the largest loss to IHNV since the Sockeye Policy was implemented in 1980. Statewide, approximately 15.8 million sockeye out of 102.8 million were lost due to IHNV or roughly 15.4%. As a result, programs and procedures are getting thorough reviews.

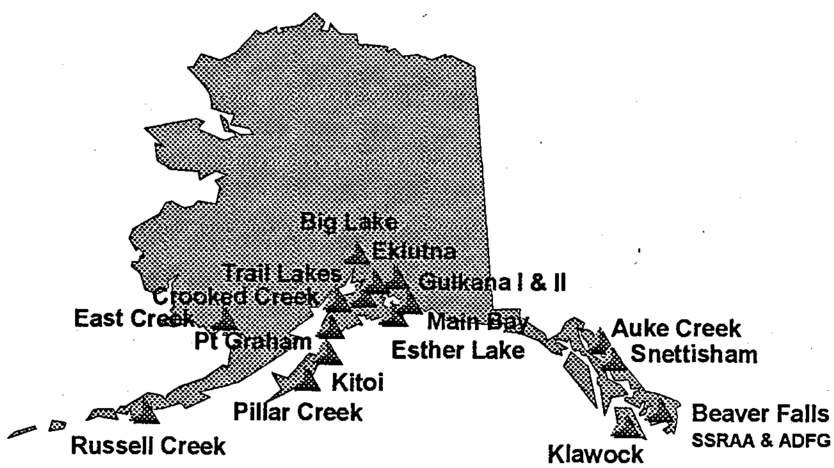
Covered in this report in the form of graphs are: the number of eggs taken per year, subsequent fry releases, adult returns and losses due to IHNV and other causes.

Production of Sockeye Salmon from Hatcheries in Alaska (1973 -1992)

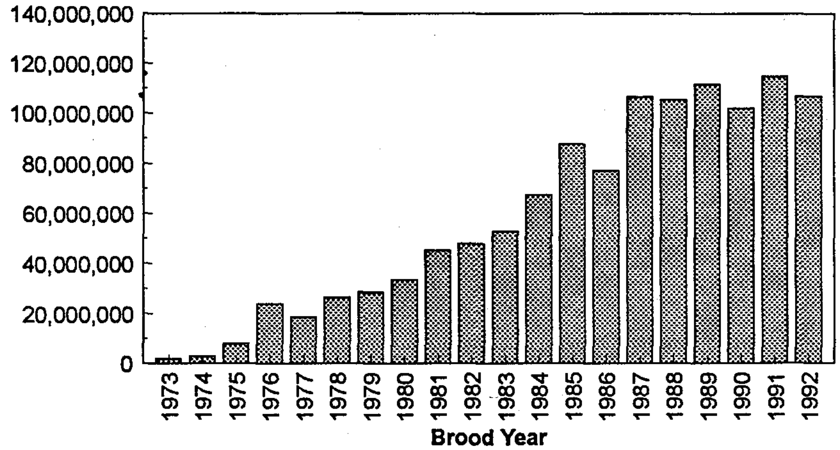
Steve McGee
Fishery Biologist
Alaska Department of Fish & Game



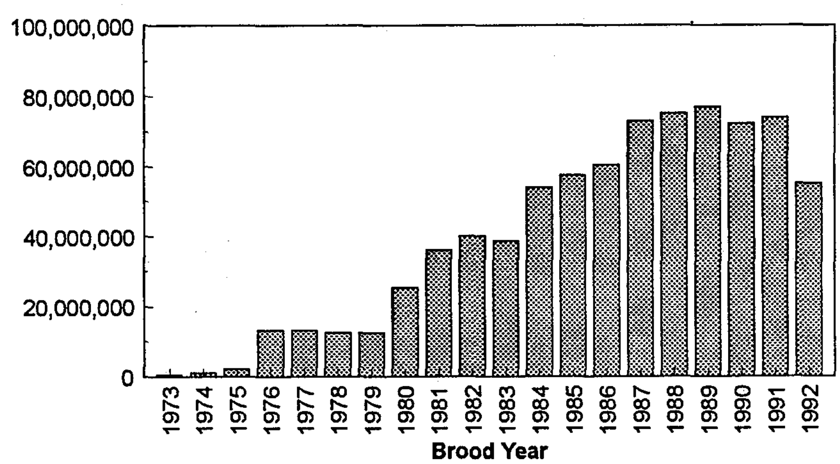
Alaska Sockeye Salmon Hatcheries 1973-1992



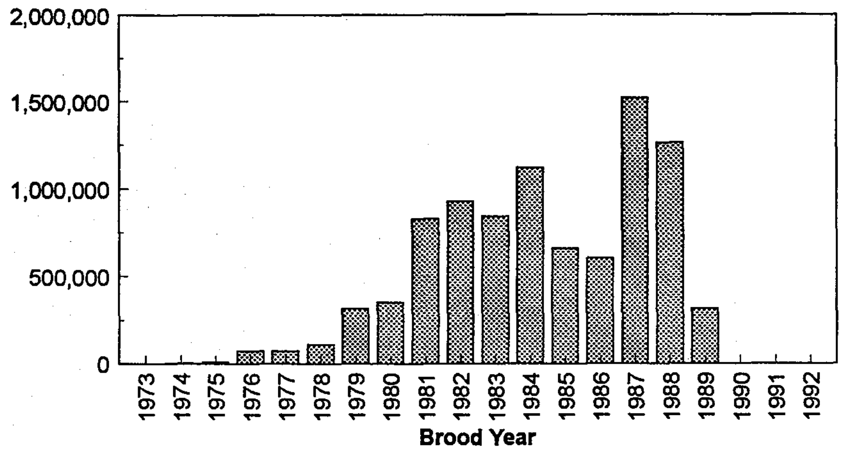
Alaska Sockeye Program
Egg Take



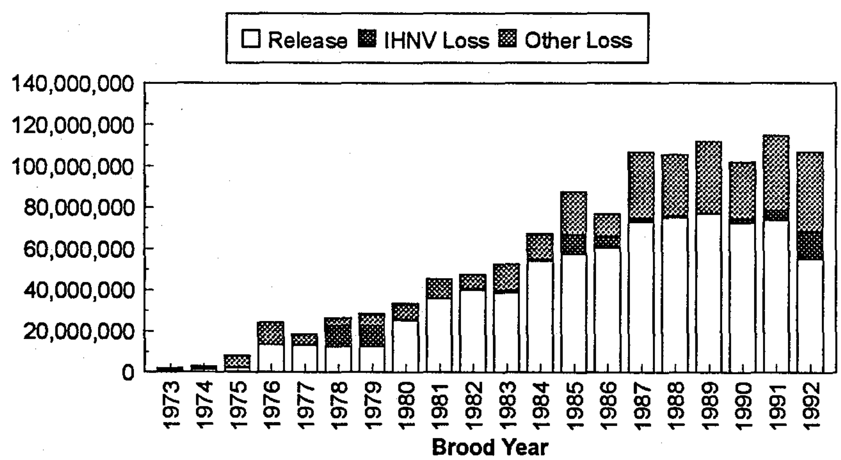
Alaska Sockeye Program
Releases

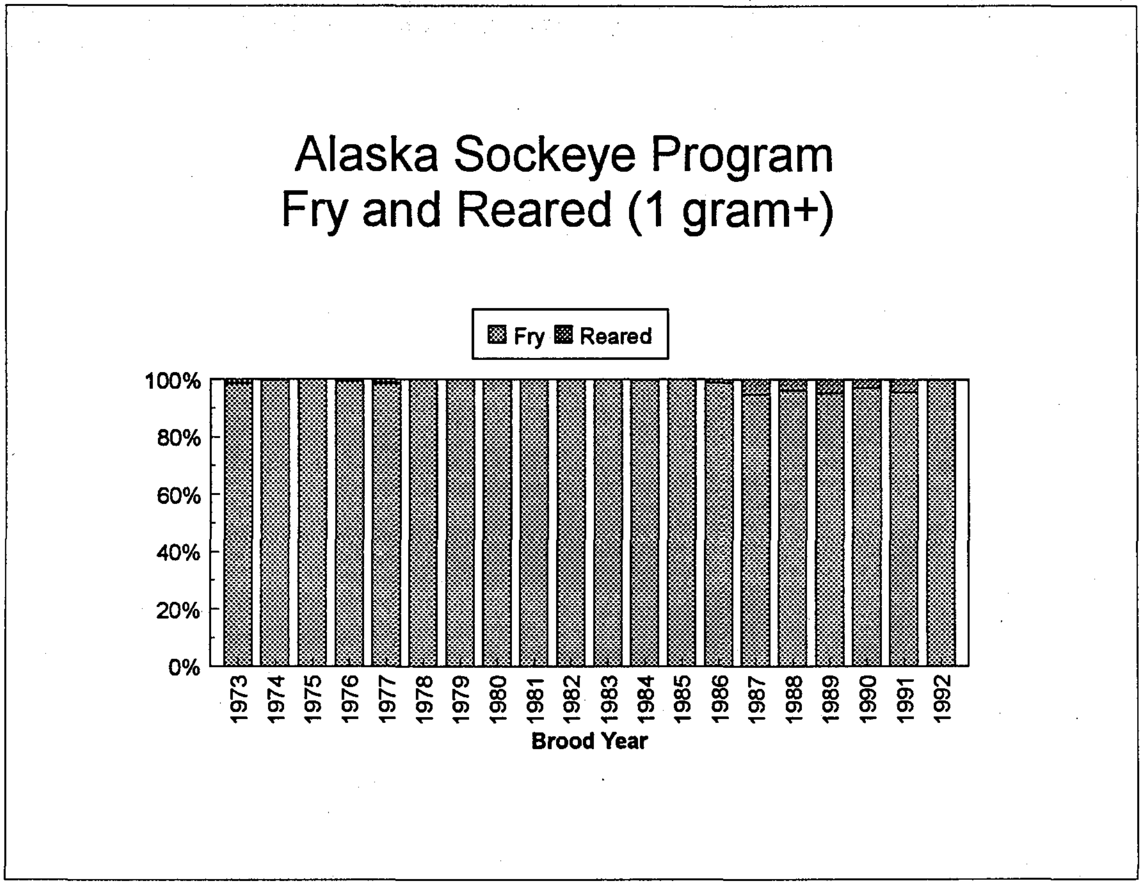


Alaska Sockeye Program
Adults



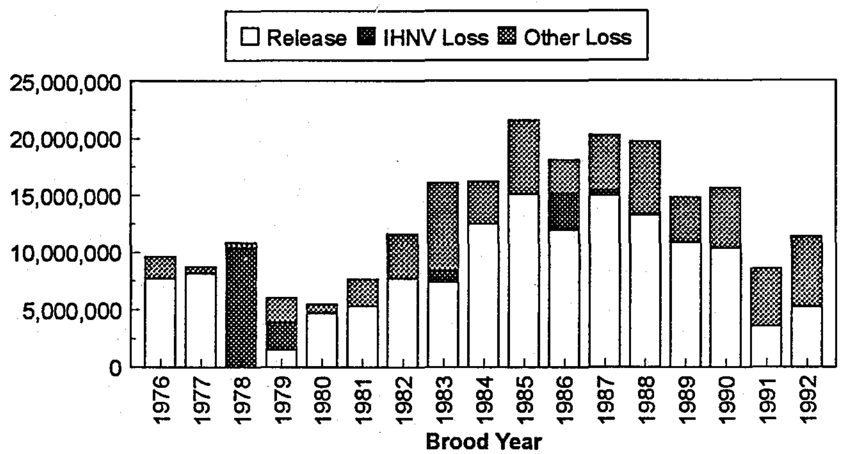
Alaska Sockeye Program



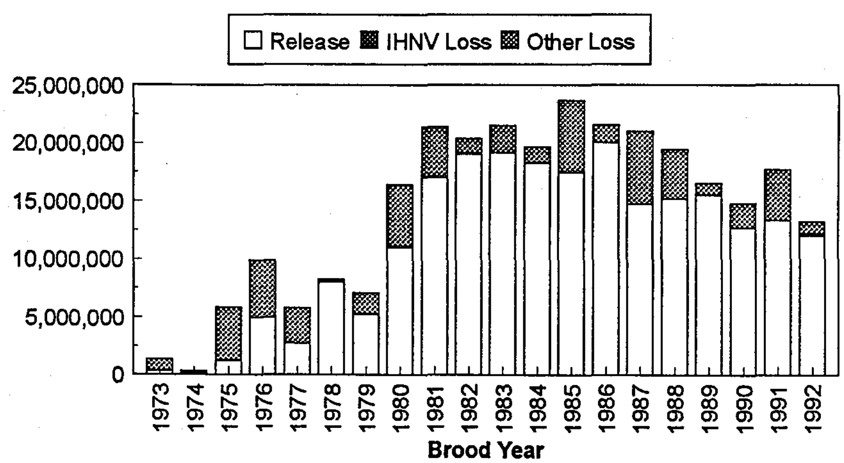


Alaska Sockeye Program
Fry and Reared (1 gram+)
Fry
Reared
100%
80%
60%
40%
20%
0%
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
Brood Year

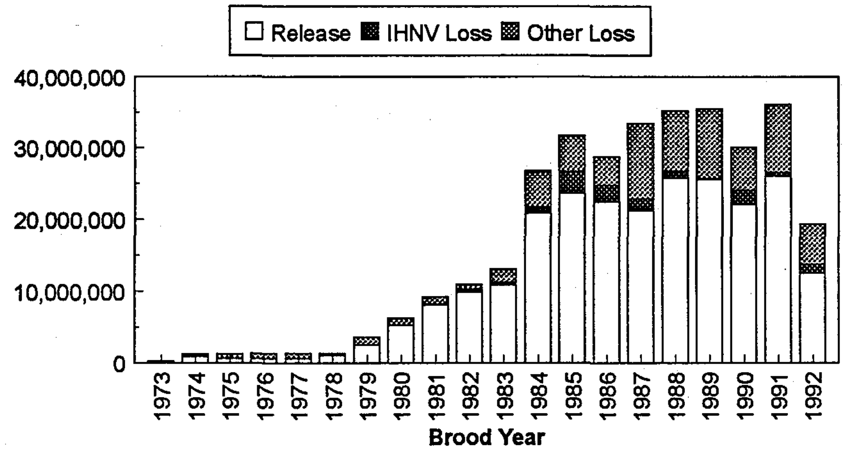
Big Lake Sockeye Program



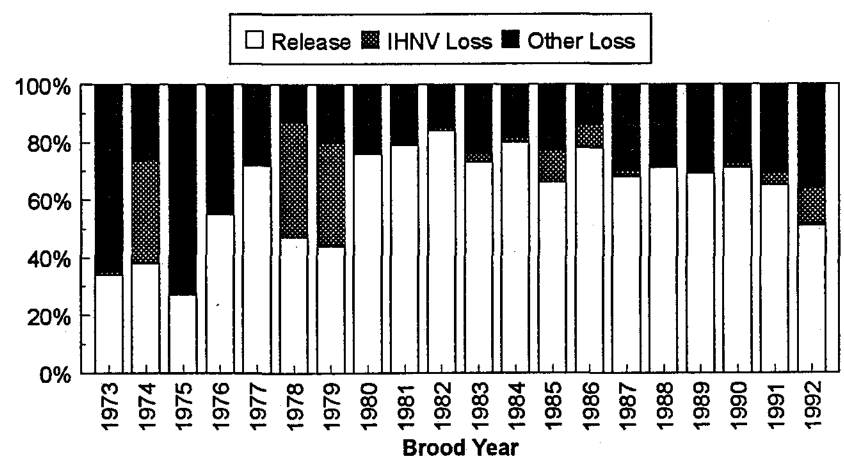
Crooked Creek Sockeye Program



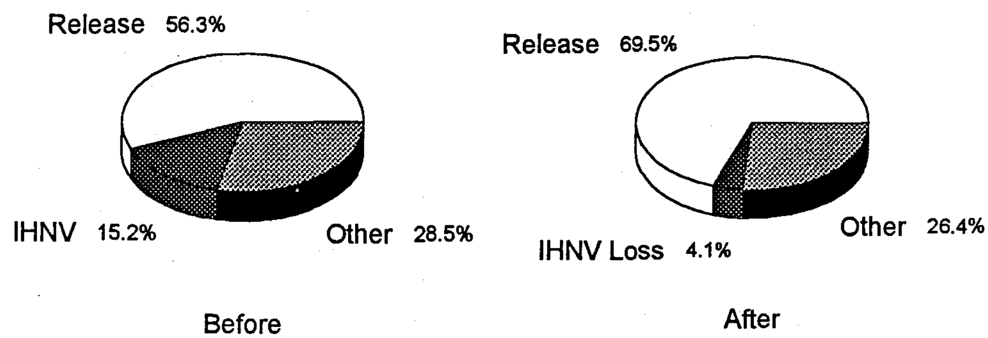
Gulkana I Sockeye Program



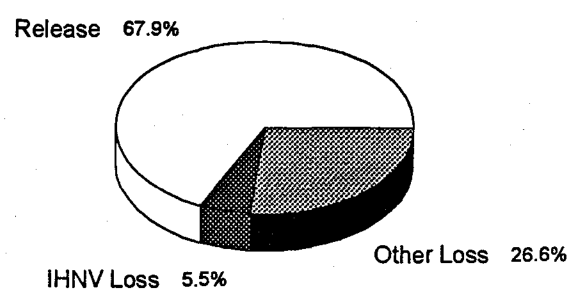
Alaska Sockeye Program



Alaska Sockeye Program
Before and After Policy



Alaska Sockeye Program
Overall Performance



BY 1973
thru BY 1992

Control Of IHNV In Alaskan Sockeye Culture
by

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P.O. Box 25526
Juneau, AK 99802-5526

Prior to 1980, IHNV was a formidable obstacle to successful sockeye culture in Alaska. At that time the then FRED Division of the ADF&G devised a policy to minimize the negative effects of this virus on sockeye culture. This policy includes procedures for taking and incubating eggs and rearing of fry that are based upon known and suspected biological parameters of the virus-host relationship. These are common sense approaches. The three cornerstones in the sockeye policy are:

1) A virus-free water supply

2) Disinfection

3) Containment by isolation and compartmentalization

Loses that occurred in 1993 were due in part to the successful culture of sockeye in Alaska these past years. There was a tendency for us all to become complacent, perhaps overconfident, in the thought that IHNV would not or could not become a problem again in the future. This was not true. In many respects points 1 and 2 are fixed and have become a way of life at many facilities in the culture of other species as well as sockeye. Point 3 is most likely the path of least resistance for complacency, because it requires a major effort and cost. Yet in hindsight, it is point 3 that allows for success when points 1 and 2 fail to prevent IHN from occurring.

Let's take a closer look at the specific criteria and purposes of these cornerstones in the sockeye policy.

<u>Water supply</u>

A. IHNV - FREE WATER SUPPLY VIA WELLS, DEPURATED OR FISHLESS WATER. DEPURATION OF HATCHERY EFFLUENT MAY BE NECESSARY TO MAINTAIN A VIRUS-FREE WATER SUPPLY FOR SALTWATER REARING CONTAINERS DOWNSTREAM (prevents horizontal fish exposure to the virus).

   FOR SOME HATCHERIES THE WATER SUPPLY CONTAINS WILD SALMONIDS BUT NO SOCKEYE OR IHNV - SO FAR IN ALASKA IHNV HAS RARELY BEEN FOUND TO SPONTANEOUSLY OCCUR IN NON-SOCKEYE SPECIES. Over 100 anadromous sockeye stocks have been examined in Alaska and all at some time have had detectable IHNV.

Disinfection

B. STRINGENT DISINFECTION OF UTENSILS, FACILITIES, EXTERNAL SURFACES OF BROODFISH, ETC. DURING AND AFTER THE EGGTAKE. USE OF DISINFECTANT FOOTBATHS, STEAM AND SEPARATE GEAR (prevents external contamination by virus).

Disinfection and Containment

C. SEPARATE WATER HARDENING OF EACH FAMILY OF EGGS IN 100 PPM IODOPHOR FOR 60 MIN WITH REPLENISHMENT AND ADEQUATE MIXING (reduces the potential virus contamination of other eggs by high titered gamete fluids; kills virus on the surface of the egg and in the perivitelline space; allows for more adequate disinfection of the smaller egg mass).

Containment

D. SEPARATE FERTILIZATION OF EGGS FROM EACH FEMALE USING 1-2 MALES (reduces the potential virus contamination of other eggs by high virus titered seminal fluid).

E. EGGS ARE POOLED INTO SEPARATE UPWELLING KITOI BOX INCUBATORS OR STACKS OF NOPAD TRAYS AT DENSITIES OF 250-300,000 EGGS (80-100 FEMALES). EACH INCUBATOR OR STACK IS CONSIDERED AN EXPENDABLE UNIT. SMALLER EXPENDABLE UNITS HAVE BEEN USED DEPENDING UPON THE NUMBER OF EGGS TAKEN. (Stacks usually contain a particular lot of eggs designated by day of eggtake and are usually five trays high).

USING THE EGGTAKE CRITERIA TO THIS POINT AN AVERAGE OF 2 MIL SOCKEYE EGGS/DAY CAN BE TAKEN WITH CREWS OF 5-7 PEOPLE WITH TOTAL EGGTAKES REACHING 20-30 MIL AT CERTAIN FACILITIES.

F. EACH SOCKEYE STOCK PHYSICALLY ISOLATED BY BARRIERS AND DISINFECTANT FOOTBATHS FROM ANY NON-SOCKEYE SPECIES AS WELL AS OTHER SOCKEYE STOCKS (protects other IHNV susceptible species as well as sockeye stocks).

G. REARING CONTAINERS FOR FRY AND FINGERLINGS ADEQUATELY SEPARATED BY DISTANCE OR PHYSICAL BARRIER TO MAINTAIN CONTAINMENT BY COMPARTMENTALIZATION AND ISOLATION. REARED FRY ARE POOLED IN RACEWAYS, ETC ACCORDING TO COMMON STACK OR DAY/TIME OR EGGTAKE. (virus prevalence and/or titers can vary with each eggtake or IHN can occur in a group of fish due to handling during a particular eggtake. Thus, fish are grouped according to common IHN risk).

H. ADEQUATE EXCLUSION OF BIRDS AND OTHER PREDATORS FROM OUTSIDE REARING CONTAINERS (maintains effective isolation/compartmentalization). Successful IHNV containment by limiting bird predation has been achieved by Clear Springs Trout Hatcheries in Idaho.

I. IMMEDIATE DESTRUCTION OF SUSPECTED OR CONFIRMED IHNV-POSITIVE INCUBATORS OR RACEWAYS OF FISH AND DISINFECTION REGARDLESS OR MORTALITY LEVEL. This accomplishes:

1. Protection from virus exposure for remaining lots or stocks of fish on site.

2. Prevention of release of IHNV-positive fish into a watershed where other juvenile sockeye or salmonid species may be negatively impacted by virus exposure.

3. Reduction in the number of returning adult fish carriers of IHN virus which, depending upon the circumstances, should not increase virus prevalences in stocks returning to the release site, be it a hatchery or remote watershed.

In most cases eventual high mortality will occur after the detection of IHNV in juvenile fish. However, this mortality may take longer to occur in larger/older juveniles or due to colder water temperatures.

Other

J. FRY RELEASED UNFED OR AFTER SHORT-TERM REARING (4-6 WKS).

Smolt programs underway at Main Bay, Beaver Falls, Kitoi Bay, Snettisham, Crooked Creek and Eklutna Hatcheries are a major deviation of this earlier concern about transporting healthy sockeye out of the hatchery as soon as possible.

Long-term culture of sockeye to smolts can increase the risk of IHNV occurring at a facility due to later expression of virus carrier fish and loss of control in containment if saltwater rearing is done. It is true that most IHN problems in Alaska have occurred in yolk-sac or swim-up sockeye fry. However, this was before smolt production and does not mean that IHN cannot occur in older fry, presmolts or smolts. Major mortality of large smolts in saltwater from IHN is possible and has happened in Alaska this past year. In many cases, individual incubators or rearing containers of sockeye tested virus-negative only to become virus-positive later during pre-release inspections.

K. STRESS

Stress of any kind can contribute to IHN outbreaks as has been observed several times with sockeye in Alaska. Confinement at a hatchery even under the best of fish culture conditions can also be stressful to fish.

Additional Disinfection Practices that have evolved to reduce the potential of IHNV exposure and the disease.

1. Rinsing eggs in various solutions including iodophor prior to or immediately after fertilization to get rid of potential virus contaminated ovarian and seminal fluids.

2. Flushing eggs with iodophor after picking at eyeup when eggs are reseeded with substrate in the incubators. This should reduce potential virus that may have been released by dead eggs or survived the initial disinfection procedures.

Periodic formalin flushes to control fungus may achieve the same result.

Importance of Containment

I want to go back to the three cornerstones of the sockeye policy, i.e., virus-free water supply, rigorous disinfection and containment by isolation/compartmentalization.

I am going to revisit a talk that I gave at the sockeye workshop in 1990 regarding containment because it is very appropriate for this meeting.

Virus-free water and adequate disinfection are very necessary rules for successful sockeye culture but the containment precautions can still allow for success when these other 2 criteria fail to prevent IHN from occurring in a few or one to two incubators or raceways. Such occurrences of IHNV are likely due to vertical transmission that is purely a random numbers event which increases with high titered parent fish and increasing numbers of eggs taken.

If more containment strategies are used then less fish inventory will be lost when IHN occurs. However, containment can be interpreted in many ways or degrees and is often where major effort and cost is involved to expand or start-up a sockeye program. Thus, it is easy to become complacent on containment procedures to save money and labor.

In most cases where IHN has been a problem this year lack of adequate containment has been a major factor in the outcome of these events. These inadequacies have included; insufficient physical separation of freshwater raceways, lack of predator bird control, failure to contain IHNV in hatchery effluent passing over saltwater netpens of fish, inability to contain the virus in saltwater netpens (whether this possible remains to be seen), and procrastination in killing fish infected with IHNV. Remedies to all of these shortcomings are difficult and expensive but require attention for future success.

Containment procedures for IHNV are just as important in the sockeye culture policy today as they were at the inception of the program. Hence, complacency on this or the other two cornerstones for sockeye culture can and will result in disaster, maybe not this year or next but at some point it will happen.

Open Forum For Group Discussion
Panel: Ted Meyers, Jill Follett, John Burke, Dan Moore
Moderator: Bob Burkett

Q. Is there an IHN vaccine currently available?

A. Ted - There is not an approved IHN vaccine currently on the market. Oregon State is presently field testing an IHN vaccine. It has been used in Alaska on the English Bay project. Some of the field tests have been successful and some have not. Because of these mixed results, the fate of this vaccine product is inconclusive at this time.

If a protective vaccine could be developed, it would be most useful in Alaska using fish of a larger size, say to smolt size. It wouldn't be useful with fry in the incubators where we see most of our IHN problems due to inability to administer the vaccine and the small fish size - less immunocompancy of this age group of fish.

Q. Rand Little - Is there any evidence of IHN being isolated from sediment or another vector in the marine environment?

A. John - The risk from the sediment appears to be very small, but we don't know enough to say there isn't any risk.

Garth Traxler - We have found IHNV in leeches in the marine environment during outbreaks, but we haven't found any freshwater vector.

Q. Mike Haddix - Has IHN been found in other salmonid species in the lower 48 in non-sockeye environments?

A. Ted - Yes indeed. IHNV is quite common in chinook and steelhead stocks where no sockeye salmon occur. However, IHNV infecting these species is generally of a different strain than the type 1 in sockeye salmon.

Q. Larry Malloy - Can you comment on the section of the sockeye policy that requires the destruction of all sockeye that have been exposed to IHNV?

A. Ted - This has been an issue for some time. Whether or not to release seemingly healthy fish that have been exposed, but are still surviving, say in the same raceway with fish that have died due to IHN. The policy was made to destroy any fish that had been exposed in order to protect wild fish that might become infected from these hatchery fish. This is a conservative approach to protect wild fish stocks.

Q. Lon Garrison - Do we know if there is any correlation between over escapements and IHN epizootics in the natural environment? What do we know about how IHN works in the natural environment?

A. Garth Traxler - A case occurred in B.C. in the late 70's of IHN in fry in the wild. That system had the highest escapement on record preceding this outbreak. This may be a natural way of controlling sockeye populations in the wild. An increase in escapements or density may contribute to subsequent IHN outbreaks.
Jill - We have had a similar experience at Chenik Lake. Stocking of fry from Crooked Creek Hatchery has increased adult returns to the lake. The thought now is that the increased escapement into the lake has resulted in subsequent losses of fry to IHN, although this is not conclusive.
Bob - I'm not sure that the loss at Chenik lake is density related.
Jill - The hydroacoustics data seems questionable - it didn't fit with the number of fry stocked and the number of smolts out.
Tom Mears - At Hidden Lake, since 1988, there have been years when there's been problems with IHN and years when there hasn't , but during the entire time the density was low.
John - Density is a relative term. You could have low density in a lake, but still have an area of high virus concentration - such as natural spring spawning areas in a lake.

Q. Bruce Bachen - How many adults are produced by the sockeye enhancement system?

A. Steve McGee - The toal number of enhanced sockeye for 1992 and 1993 were 3.9 and 5.0 million, respectively.

Q. Oliver Holm - Is IHN more lethal for chum than for sockeye?

A. Ted - No, IHN doesn't occur in wild populations of chums. Only in areas where chum and sockeye are present together or in hatcheries that have been associated with sockeye.

Garth Traxler - A hatchery in Northern B.C. that was culturing chum had an outbreak of IHN. 3 million fish were destroyed. The question is, where did the IHN come from? Possible answers, there were sockeye spawning above the hatchery, and there were sockeye spawning at the same time the chums were spawning.

Q. Larry McGovern - What studies are being done in the State on IHN?

A. Ted - Lots of money is being spent on the Columbia River for vaccine studies, strain typing and distribution of the virus. It has become apparent from this that the best way to deal with IHNV is to "farm around" it. It can't be eliminated, so minimizing the overall risk is the best approach.

Overview of Sockeye Fry Transports
by
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Most of the sockeye being produced (96%) at hatcheries in Alaska are fry for lake stocking programs. In reviewing the methods by which these fry are transported I found the following:

By aircraft (different types of planes)	63%
Direct Release from hatchery	22%
By truck	15%
	100%

The following transport data from four Alaska hatcheries that stock fry:

	Beaver Falls	Snettisham	Gulkana	Big Lake
Density (lbs/gal)	.5-1.4	.5-1.2	.9	.5
Duration of Trip (min)	30-45	20-120	30	75-90
Oxygen (lpm)	3-4	3-7	3-8	2
Fish size (gms)	.15-.8	.11-.2	.2	.2
Transport tank (gal)	200	200	400	(2) 70 ea.
Max. Fish/Trip	200,000	450,000	720,000	150,000
# of trips	12	20	9	8

In Summary

1) Transport density ranged between .5 and 1.4 lbs/gal. When beginning a program or for long hauls, it is best to start at .5 lbs/gal. for the first trip. Monitor parameters and adjust density upwards based on results.

2) Begin with O_2 set at 3 l.p.m. and adjust up or down as required.

Also, if possible, transport fish in water that is slightly cooler (1-2°C) than the lake being stocked. And do some short term holding to evaluate the transport.

Most hatcheries transporting in water temperatures of 3-7°C.

Two types of aircraft used. One type, Otter or Beaver, places transport tanks inside plane. Plane lands on lake and fry are discharged via hose and gravity feed. The other type, called a Thrush, has a built in 500 gal. tank and operates like a crop duster. The plane slows to an air speed of 90-95 mph, approximately 150-200 feet above the lake and then the pilot releases the bottom of the transport tank. Fry and water are released together. Survivals from this type of stocking are usually done by enumerating the resultant out migrating smolts from the lake.

SOCKEYE PRODUCTION MODELS AND EVALUATION OF REARING POTENTIAL IN NURSERY LAKES

by

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The purpose of this presentation is to provide an overview of the sockeye production and rearing models developed by the Limnology Section and to introduce two new models. In addition, through a whole-lake manipulation project, I will demonstrate why it is important to assess the rearing environment of lakes before and during stocking, as well as for lakes being managed for sustained wild sockeye production.

since 1974, between the Department and PNP groups, about 50 lake systems in Alaska have been stocked with over 600 million sockeye salmon fry, fingerlings, or smolts. The majority of these lakes were stocked with sockeye fry that reared in a lake for one or two years and utilize the zooplankton forage base.

During early discussions on some of these stocking projects I often heard the statement "lets stock more and see what comes back". In addition, I have heard similar comments by fishery managers that more fish allowed into a lake system will produce more smolts, and consequently a larger return. In general, this principle is true up to the point of the lake being capable of supporting the rearing fry. However, early on in the FRED Division days this philosophy soon faded as expected returns for some of the stocking projects did not occur. Even today, despite more rigorous in-lake assessments of sockeye from plants and productivity of sockeye nursery lakes, we have encountered several lake systems that have not either produced as expected, or have shown a major collapse in sockeye production, and we still do not have adequate data to know why. Examples of lakes I am referring to include Paint and Chenik lakes in lower Cook Inlet, and Big and Skilak lakes in upper Cook Inlet to name a few. However, the assessment data that we currently have allows us to focus further studies on the stage of life cycle that caused the system to fail or under-produce.

The two production or rearing models that most of you are familiar with are the euphotic volume and zooplankton biomass models. Both of these models are what can be referred to as empirical models aimed at developing a general conceptual framework from observations on individual lake systems. A new production model being developed by our group utilizes Ricker formulation for adult spawner-return analysis and integrates limnological factors relating to the rearing environment. Also, we have combined the limnological parameters of euphotic volume and zooplankton biomass into an additive multiple regression model to estimate smolt biomass production.

The EV model is based on the physical parameter of light penetration called the euphotic zone depth, and smolt population characteristics. The model was derived from data collected from lakes that produced threshold-size smolts which indicates full or maximum utilization of the rearing environment. Basically, we found a relationship between euphotic zone depth and smolt production in the form of smolt numbers and size. From this relationship we were able to model other life stage forms to come up with a systems-average production for each life stage as you see here. Keep in mind that this general model serves as a tool to understand or predict the various life stages but because each individual system can differ in limnological parameters the model should be cautiously utilized when new or additional information represents a departure from previous knowledge of the system. The whole-lake manipulation project at Pass Lake that I will present later will demonstrate this.

The zooplankton biomass model is predicated on the basis that when a rearing area is fully utilized, threshold-size smolts result, and the zooplankton community becomes predator resistant. In essence, this means the zooplankton community comprises of small-size individuals usually dominated by copepods, which are more mobile and elusive. As zooplankton becomes a homogenous, predator-resistant community, smolt biomass production is a reflection of annual zooplankton turnover. Thus, when competition for food is severe enough to limit juvenile growth, we found that smolt biomass, on average, is a function of zooplankton biomass. This relationship indicates that on average a lake system can be predicted to produce smolt biomass by multiplying the seasonal mean zooplankton biomass by approximately 2.

A new model that we are developing is based on using limnological response data to determine the beta factor in Ricker stock recruitment theory, which is the carrying capacity factor. There are many permutations of formulas that went into the final model, but the end result is that P max, which represents the escapement needed to maximize returns can be estimated by assigning beta a quantitative value based on limnological factors of euphotic volume and zooplankton biomass. As a result, this modified Ricker model provides a basis for determining escapement goals for systems without historical spawner-return data or for systems where sockeye salmon have been introduced.

In addition, we have integrated both euphotic volume and zooplankton biomass into a multiple regression model to predict the capacity of a lake system to produce smolt biomass. This model should provide a more accurate estimate as it combines two limnological parameters, and because we standardized the empirical data that made up the model by using zooplankton biomass per surface area.

Advantages of these models over the traditional spawner-return relationship to establish escapement goals and production for sockeye systems include: 1) the shorter time frame of necessary data, 2) data is used from multiple stocks, which gives more validity to the model, 3) the model has the ability to determine the cause of unexpected production, and accounts for short term variations in density-independent responses, and 5) avoids bold stock manipulations to vary stock size to determine sustainable yield.

To demonstrate why in-lake assessment is important for stocking projects, as well as management of natural stocks, I will present an overview of the whole-lake manipulation experiment conducted at Pass Lake.

Pass Lake is an oligotrophic lake located in western Prince William Sound and has a barriered outlet that prevents access to adult salmon. In 1988 and 1989 sockeye salmon fry were stocked at a density based on the EV model to fully utilize the limnetic rearing capacity. In 1989 and 1990 the lake was fertilized, in the fall of 1990 fingerlings were released, and in 1991 the lake was left untreated.

The introduction of sockeye fry in Pass Lake resulted in a major collapse of the zooplankton community after the first year of stocking in 1988. Specifically, zooplankton biomass decreased by 90% compared to the pre-enrichment mean. The nutrient additions to Pass Lake in 1989 and 1990 resulted in substantial increases in both phosphorus levels and primary production and the increase in standing stock of phytoplankton should have provided for a more robust zooplankton community. However, in subsequent years, despite two years of lake fertilization, the termination of spring fry plants, and one year of no treatment, the zooplankton biomass remained severely depressed. In addition, the smolts produced from the fry introductions were of threshold size. Consequently, an accentuated effect of fry predation appeared to cause a "population pit" where the zooplankton were cropped below a level such that short-term recovery was not possible. From this study and data on other lake systems we have found the degree to which juvenile sockeye restructure the zooplankton community influences the ability of zooplankton to recover.

In summary, traditionally, the main element of salmon management and stock assessment has been limited to adult returns. Some salmon researchers contend that varying stock size through escapement levels or stocking, even to the degree of overexploitation is first needed to determine the level of sustainable maximum production. However, in the cases we have studied to date, not only do persistent large sockeye escapements and overstocking result in negative trophic-level changes, but more importantly, these changes have been shown to affect subsequent fish production. We maintain that to preserve lake rearing environments, that the limnological approach of matching observed trophic responses to stock size through either lake-specific information or empirical models be incorporated in stock management, and in the planning and assessment of sockeye enhancement projects.

Crescent Lake Sockeye Salmon Enhancement Activities
1989 to 1993

by

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Crescent Lake is located in Port Snettisham approximately 30 miles south of Juneau, Alaska. Crescent Lake is a 326 hectare lake, is at 174 feet elevation and is classified as a semi-glacial system. The outlet of Crescent Lake flows for 1.5 miles and empties into the Whiting River which flows for 14 miles before dumping into Gilbert Bay (Figure 1).

Concerns over low adult escapements into Crescent Lake have led to efforts to rehabilitate the lake using hatchery methods. In 1989 adult sockeye salmon were captured in the lake and spawned, the eggs from these activities were incubated, and thermal marked, at the Alaska Department of Fish and Game, FRED Division, Snettisham Hatchery. Resultant unfed fry were stocked back into Crescent Lake the following spring. This procedure was followed for the 1990 and 1991 broods as well. All unfed fry planted into the lake have been otolith marked with unique thermal bands applied during incubation. For a summary of Crescent Lake enhancement activities to date refer to Table 1.

Table 1. Summary of Crescent Lake enhancement activities.

Brood Year	Eggs Collected	Unfed Fry Stocked	Stocking Dates	Pre-smolts Stocked	Stocking Dates	Smolts Stocked[b]
1989	547,000	216,000	6/9/90	0	-	0
1990	813,000	388,460	6/30/91	69,000	11/3/91	0
1991	987,000	551,556	6/24/92	83,000	10/20/92	66,500
1992[a]	1,586,000	-	-	-	-	-
1993[a]	2,500,000	-	-	-	-	-

[a] Eggs from brood years 1992-93 will be used for enhancement projects at Sweetheart Lake and Gilbert Bay.
[b] Smolts were stocked on May 23-24, 1993.

A second method of lake stocking which has been used to rehabilitate Crescent Lake is pre-smolt stocking. Pre-smolts are reared until late October or early November and then stocked into the lake. This technique was used for BY 1990 and 1991 eggs. Pre-smolts planted in 1991 were 100% coded-wire tagged because they had the same otolith banding pattern as unfed fry of that brood. Pre-smolts stocked in 1992 were differentially otolith marked and were not CWT'ed.

The third method of lake stocking which has been used is hatchery smolt planting. A portion of the 1991 brood was held and reared to smolt stage. These fish were 100% CWT'ed and were planted in May, 1993.

Standard CFMD Division survival assumptions for sockeye salmon are 30% spring fry to fall pre-smolt and 70% fall pre-smolt to spring smolt. Based on these assumptions we assume that 1 hatchery pre-smolt is equal to approximately 3 unfed fry. This relationship has important implications on stocking programs and broodstock utilization. If we document that stocking pre-smolts is a more effective enhancement tool than unfed fry stocking we could justify modifying our current stocking requirements. By planting pre-smolts, or smolts, we could free up eggs for use in other enhancement projects or we could provide more benefit with a limited number of eggs.

To gain some understanding of the effectiveness of the unfed fry and pre-smolt stocking in 1991 we sampled emigrating smolts in the spring of 1992. Smolts were captured in a fyke type trap. Crescent Lake smolts in 1992 could have come from three basic groups. They were: 1) age 1.0 and 2.0 wild fry, 2) age 1.0 and 2.0 hatchery stocked unfed fry, 3) age 1.0 hatchery stocked pre-smolts. In 1992 we sampled emigrant smolts twice, on May 25 and June 2. We captured approximately 600 and 750 sockeye smolts respectively on each trip. Otolith examination (50 fish each sampling trip) demonstrated that 1% of the fish captured were unfed fry, 5.1% were pre-smolts, and the remainder were wild. No estimate of total smolt emigration can be made. Smolt size and age results are summarized in Table 2.

Based on the results from 1992 we had concerns over the survival of unfed fry planted into Crescent Lake. We also had no idea of the total number of emigrating smolts from the lake. In 1993 we carried out an extensive sampling program which covered most of the emigration (Figure 1). Smolts were captured in a fyke type trap. We retained one of every fifteen smolts captured in the trap to ensure a random, representative sample for otolith examination. Sockeye salmon smolts emigrating in 1993 could have come from four different groups. They were: 1) age 1.0 and 2.0 wild fry, 2) age 1.0 and 2.0 hatchery stocked unfed fry, 3) age 1.0 and 2.0 hatchery stocked pre-smolts, and 4) age 1.0 hatchery stocked smolts. During the sampling period several mark recapture experiments were conducted to obtain a trap efficiency. Based on those results (1.2% trap efficiency) and the total number of smolts we captured (7,581) we had a population estimate of 631,197 (95% C.I. 313,939 to 948,455). The breakdown into the groups expected and the survival of BY 91 unfed fry and pre-smolts is summarized in Table 3. Smolt size and age for 1993 is summarized in Table 2.

During 1993 operations a total of 26 hatchery smolts were captured in the fyke trap, 16 on the night of release. With a trap efficiency of 1.2% if all of these fish left the lake we expected to capture 792. There are three possible reasons that so few were captured, they are 1) they all died, 2) most of the hatchery smolts stayed in the lake, and 3) the hatchery smolts were able to avoid being captured in the fyke. We reject the first option, the fish which were captured in the fyke were very healthy and nothing occured during stocking which would indicate abnormal mortality. To test if the smolts had stayed in the lake a capture effort using beach seines took place on July 13-15. No hatchery smolts were captured during this time. We did observe large smolts swimming in and out of the live box during trapping operations and so believe that trap avoidance was the cause for low hatchery smolt catches.

Table 2. Smolt age and size results for Crescent Lake sockeye smolts, 1992 and 93.

	Age Composition			Average Length(mm)			Average Weight(g)		
Year	1.0	2.0	Pre-smolt[a]	1.0	2.0	Pre-smolt	1.0	2.0	Pre-smolt[b]
1992	96.1%	3.9%	5.1%	54.5	70.3	56.5	1.3	3.2	1.5
1993	85.9%	14.1%	5.3%	52.6	61.8	59.2	1.2	1.9	1.8

[a] Percent of age 1.0 smolts which were of pre-smolt origin.
[b] Pre-smolts averaged 1.2 and 1.5 g at stocking for 1990 and 1991 broods respectively.

Table 3. Population estimate and breakdown of 1993 Crescent Lake sockeye salmon smolts.

Class	Percent of Emigration	Estimated Number in Emigration	Number Stocked	Percent Survival
Wild(1.0)	80.5%	508,113	-	-
Wild(2.0)	13.2%	83,318	-	-
Pre-smolt	5.3%	33,453	82,885	40.4%
Unfed Fry(1.0)	0.4%	2,525	551,556	0.7%
Unfed Fry(2.0)	0.6%	3,787	-	-
	Total:	631,197		

Based on the results from the 1992 and 1993 sampling the following Conclusions and Recommendations are made:

Conclusions

- -- Crescent Lake's rearing capacity has been exceeded,
- Unfed fry plants are not working,
- Pre-smolt stockings have been marginally successful.
- Hatchery smolts left the lake very quickly after stocking and successfully avoided being captured in the fyke net.

Recommendations

- Reduce escapement goal for Crescent Lake,
- Avoid unfed fry plants until causes for poor survivals are better understood and conditions have changed,
- Get pre-smolts to a larger size, at least threshold size of 2.0 grams, prior to stocking,
- Monitor success of hatchery smolt stocking by sampling sockeye salmon catches in the District 111 drift gillnet fishery,
- Continue to use Crescent Lake brood sockeye for Sweetheart and Gilbert Bay projects.

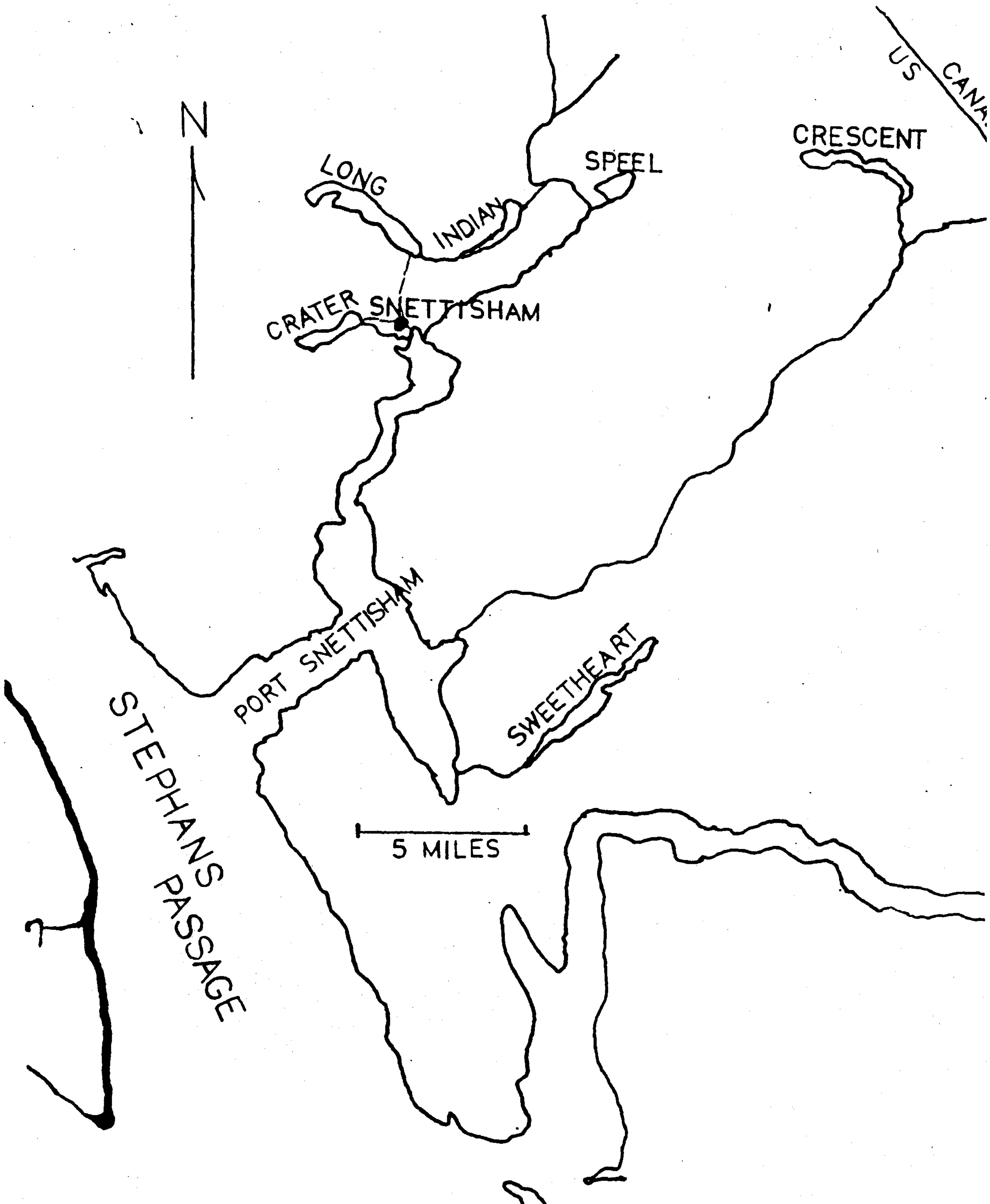
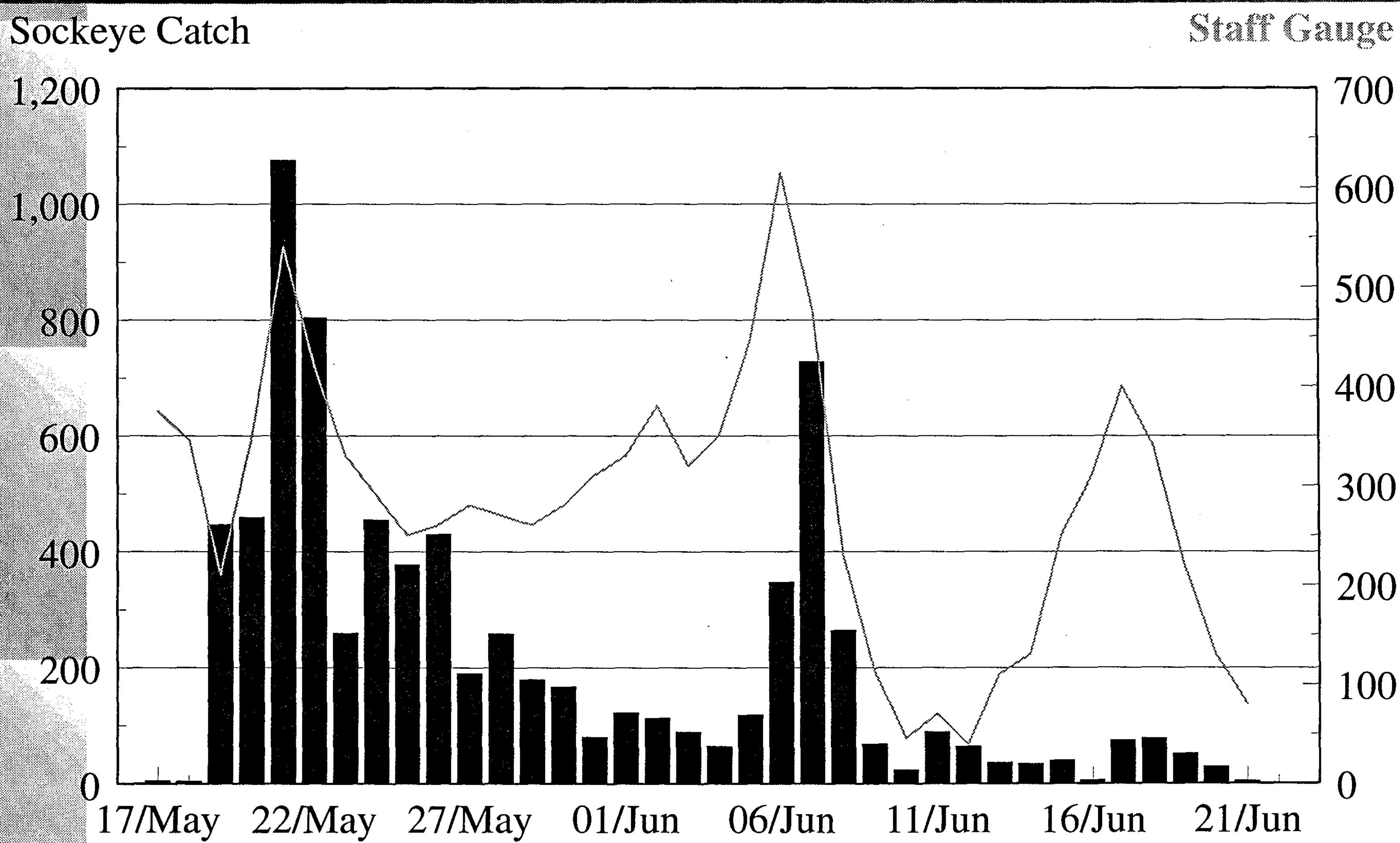


Figure 1. SITE MAP

Figure 2. Crescent Lake Sockeye Emigration Timing, 1993



ENGLISH BAY SOCKEYE SALMON FRESHWATER NET PEN REARING AND SMOLT PRODUCTION, 1991 - 1993

BY
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THE ENGLISH BAY RIVER IS LOCATED NEAR THE SOUTHWESTERN TIP OF THE KENAI PENINSULA ON LOWER COOK INLET, APPROXIMATELY 40 KM SOUTHWEST OF HOMER, AK. THE VILLAGE OF NANWALEK IS SITUATED ON THE BASE OF A NARROW SPIT OF LAND AT THE HEAD OF ENGLISH BAY. A 14 HECTARE TIDE WATER LAGOON BEHIND THE SPIT FORMS THE MOUTH OF THE ENGLISH BAY RIVER.

THE ENGLISH BAY DRAINAGE IS 11.3 KM IN LENGTH. THE WATERSHED ENCOMPASSES 63 SQUARE KILOMETERS. THERE ARE FIVE LAKES WITHIN THE DRAINAGE WITH A TOTAL SURFACE AREA OF 154 HECTARES. THE LAKES ARE ASSIGNED ASCENDING NUMERICAL NAMES AS YOU MOVE UP THE DRAINAGE FROM THE RIVER'S MOUTH. THE PROJECT FOCUSES ON SECOND LAKE, THE LARGEST LAKE IN THE DRAINAGE OCCUPYING 60.7 SURFACE ACRES, MEAN DEPTH OF 10.9 METERS AND MAXIMUM DEPTH OF 26 METERS. (total volume of 7.6×10^6 m^3). THE HYDRAULIC RESIDENCE TIME FOR SECOND LAKE IS 15 DAYS.

SOCKEYE, PINK AND COHO SALMON UTILIZE THE DRAINAGE ALONG WITH DOLLY VARDEN AND RAINBOW TROUT.

SOCKEYE ESCAPEMENT WAS MONITORED BY WEIR BETWEEN 1927 AND 1941, AND BY AERIAL SURVEY FROM 1947 UP TO 1991 (TABLE 1). IN 1984, THE ESCAPEMENT WAS 11,000 AND PLUMMETED TO 5,000 IN 1985. ADF&G CLOSED THE COMMERCIAL AND SUBSISTENCE FISHERIES IN 1985. THE CLOSURES WERE UNSUCCESSFUL IN REBUILDING THE FISHERY AND THE FISHERY REMAINS CLOSED TODAY.

TABLE 1. HISTORICAL RECORD OF SOCKEYE SALMON ESCAPEMENT IN THE ENGLISH BAY DRAINAGE.

SOCKEYE ESCAPEMENT IN ENGLISH BAY RIVER

Period	Range	Average	Method
1927-1941	14,000-40,000	21,542	WEIR
1947-1979	1,200-18,000	6,700	AERIAL
1980-1984	10,500-20,000	13,120	AERIAL
1985-1991	2,000 -7,000	4,585	AERIAL
1992-1993	6,400 -8,927	7,663	WEIR

IN 1990, THE CHUGACH REGIONAL RESOURCES COMMISSION, A NATIVE TRIBAL ORGANIZATION CONCERNED WITH NATURAL RESOURCES ISSUES IN THE CHUGACH REGION OF SOUTH CENTRAL ALASKA, PROVIDED FUNDING FOR ADF&G F.R.E.D. (Fisheries Rehabilitation, Enhancement and Development) DIVISION TO DEVELOP A FRY STOCKING PROGRAM THAT WOULD SUPPLEMENT WILD FRY PRODUCTION. THE INTENT OF THE PROJECT WAS TO REBUILD THE FISHERY SO THAT BOTH THE COMMERCIAL AND SUBSISTENCE FISHERIES COULD RE-OPEN.

IN 1990, APPROXIMATELY 1/3 OF A MILLION FRY WERE DIRECTLY RELEASED INTO SECOND LAKE. IN 1991 SMOLT WERE SAMPLED. THE AGE 1 SMOLT WERE AT THRESHOLD SIZE OF 60 mm & 2.9 g, INDICATING REARING CONDITIONS WERE NEAR CAPACITY. ZOOPLANKTON SAMPLING SHOWED SMALL SIZED ZOOPLANKTON AT LOW DENSITIES, SUGGESTING INTENSE COMPETITION FOR FOOD.

LAKE FERTILIZATION WAS NOT AN OPTION FOR INCREASING ZOOPLANKTON PRODUCTION DUE TO THE RAPID FLUSHING RATE OF THE ENGLISH BAY DRAINAGE. F.R.E.D. CONCLUDED THE BEST WAY TO BALANCE WILD STOCK PRODUCTION WITH A STOCKING PROGRAM WAS TO PEN REAR FRY TO PRESMOLT SIZE. PEN REARED FRY WOULD HAVE MINIMAL IMPACT ON THE ZOOPLANKTON COMMUNITY AND PROVIDE A SAFE ENVIRONMENT FOR FRY TO REACH PRESMOLT SIZE.

THE GOALS OF THE PROJECT EVOLVED INTO:

1) DEVELOPING PEN REARING TECHNIQUES FOR A 1 MILLION SMOLT PRODUCTION MODULE THAT COULD BE EXPANDED OR DUPLICATED TO PRODUCE A RETURN OF 200,000 TO 400,000 ADULT SOCKEYE. A RETURN OF THIS SIZE WOULD SUPPORT SUBSISTENCE AND COMMERCIAL FISHERIES ALONG WITH AN OPPORTUNITY FOR THE VILLAGE OF NANWALEK TO PROCESS AND MARKET THEIR FISH.

2) PRODUCING 4 - 5 g PRESMOLT, ASSUMING A 21 % OR BETTER SMOLT TO ADULT SURVIVAL, TO MEET THE ESCAPEMENT GOAL.

3) TRAINING THE RESIDENTS OF NANWALEK TO RUN ALL ASPECTS OF THE PROJECT.

TO ACCOMPLISH AND EVALUATE THESE GOALS FOUR INTERRELATED ENHANCEMENT TECHNIQUES WERE INITIATED. THEY INCLUDE:

1) MONITORING THE SOCKEYE SMOLT OUT-MIGRATION AND ADULT ESCAPEMENT

2) SUPPLEMENTING FRY PRODUCTION THROUGH LAKE PEN REARING

3) EVALUATING PEN REARING THROUGH CODED WIRE NOSE TAG RECOVERY

4) ANNUAL IN SYSTEM EGG COLLECTION

1991 PEN REARING

IN JUNE OF 1991, 98,943 FRY WERE PLACED IN ONE (12x12x12') NET PEN LOCATED IN SECOND LAKE. TWELVE PERCENT OF THE PEN REARED FRY WERE CODED WIRE NOSE TAGGED AND ADIPOSE FIN CLIPPED FOR FIELD IDENTIFICATION. AN ADDITIONAL 155,931 FRY WERE DIRECTLY RELEASED IN THE LAKE, FIVE PERCENT WERE CODED WIRE TAGGED.

PEN REARED FRY SUFFERED HIGH MORTALITIES (14,186) DUE TO POOR FEEDING TECHNIQUES

AND THE COMBINED OUTBREAK OF FURUNCULOSIS AND THE GILL PARASITE TRICHOPHYRA. TO PREVENT FURTHER HORIZONTAL TRANSMISSION OF BOTH AGENTS IN THE CROWDED NET PEN, THE REMAINING 84,757 FRY WERE RELEASED ON SEPTEMBER 18. DESPITE HIGH MORTALITIES, THE PEN REARING RESULTS WERE ENCOURAGING. AT RELEASE, FRY AVERAGED 4.6 GRAMS (range 1.6-11.4 grams) AT A DENSITY OF 8 Kg/m³.

1991 AND 1992 SMOLT MIGRATION

SMOLT WERE ENUMERATED IN 1991. THE TRAP WAS IN PLACE BETWEEN MAY 24 - JULY 14 AND CAPTURED APPROXIMATELY 67 % OF THE RIVER CHANNEL. IT WAS MONITORED 24 HRS PER DAY AND WASHED OUT PERIODICALLY - 16,597 SMOLT WERE ENUMERATED - AT THAT TIME, ADF&G FELT THEY MIGHT HAVE MISSED A PORTION OF THE SMOLT OUT-MIGRATION THAT OCCURRED PRIOR TO MAY 24.

IN 1992, LARGER SMOLT TRAP WAS SET UP ON APRIL 11 (5 WEEKS EARLIER THAN 1991). WE DESIGNED THE TRAP TO CAPTURE THE ENTIRE STREAM CHANNEL IN ORDER TO GET A TOTAL COUNT ON SMOLT AND EFFICIENTLY SAMPLE FOR RECOVERY OF CODED WIRE TAGGED SMOLT. TRAP LEADS WERE 30.5 METERS LONG, AND POSITIONED AT A REDUCED ANGLE TO THE RIVER'S FLOW TO MINIMIZE THE DAMMING EFFECT.

ON APRIL 29 WE HAD TO PULL THE TRAP BECAUSE LARGE NUMBERS OF PINK SALMON SMOLT WERE IMPINGING ON THE TRAP'S PERFORATED PLATE. FIFTY SOCKEYE SMOLT HAD BEEN COUNTED UP TO THAT POINT IN TIME. THE TRAP WAS REINSTALLED ON MAY 13, AFTER PINK SMOLT HAD EMIGRATED. ON MAY 28 HIGH WATER WIPED OUT THE TRAP. TRAP LEADS WERE SHORTENED TO 12 METERS WITH THE TRAP POSITIONED IN THE THALWEG. A TOTAL OF 43,409 SMOLT WERE ENUMERATED BETWEEN MAY 13 AND JULY 15. THE RUN PEAKED BETWEEN MAY 26 - JUNE 11. WATER TEMPERATURES DURING THE PEAK FLUCTUATED BETWEEN 9-10 C.

SOCKEYE SMOLT MIGRATED DURING THE NIGHT SO THE TRAP WAS MONITORED NIGHTLY FOR 12 HRS BETWEEN 5PM and 5AM. SMOLT WERE RANDOMLY SAMPLED FOR AWL's (TABLE 2) AND EXAMINED FOR ADIPOSE FIN CLIPS (CODED WIRE TAGS).

Table 2. WEIGHTED NUMBER, PERCENT, AVERAGE LENGTH (mm) AND AVERAGE WEIGHT (g) OF SOCKEYE SMOLT, BY AGE CLASS, FROM ENGLISH BAY, 1991-1992.

	1991			1992		
	Age 1	Age 2	Combined	Age 1	Age 2	Combined
Number	10,456	6,141	16,597	42,107	1,302	43,409
Percent	63	37	100	97	3	100
Length	68	75	69	75	74	75
Weight	2.9	3.8	3.0	3.8	3.5	3.7

AWL SAMPLES INDICATED THE PEN REARED FRY CONTRIBUTED TO SMOLT PRODUCTION. THE AVERAGE SIZE OF AGE 1 SMOLT WERE ALMOST A GRAM LARGER (3.8 GRAMS IN 1992 COMPARED TO 2.9 IN 1991) AND THE PERCENTAGE OF AGE 1 SMOLT INCREASED FROM 63% IN 1991 TO

TO 97% IN 1992. AGE 2 SMOLT WERE SIMILAR IN SIZE FOR BOTH YEARS.

125 CWT SMOLT WERE RECOVERED DURING THE PEAK OF THE RUN (TABLE 3). ALL WERE TRACED BACK TO THE NET PEN. THE CODED WIRE TAGGED SMOLT AVERAGED 5.7 GRAMS (RANGE 1.9 - 9.3 GRAMS).

TABLE 3. COMPARISON OF AGE 1 SMOLT SIZE IN 1991 AND 1992 TO RECOVERED CODED WIRE TAGGED (CWT) SMOLT IN 1992.

	AGE 1 SMOLT		
	1991	1992	1992 CWT
Number	10,456	42,107	125
Length	68	75	88
L Range	51-90	56-117	50-104
Weight	2.9	3.8	5.7
W Range	1.2-6.0	1.2-10.7	1.9-9.3

INSUFFICIENT NUMBER OF CWT WERE RECOVERED AND COULDN'T BE USED TO STATISTICALLY EVALUATE OVER WINTER SURVIVAL OF PEN REARED FRY. HOWEVER, WE KNEW THAT THE 84,757 FRY RELEASED IN 1991 AVERAGED 4.6 GRAMS. IF YOU LOOK AT 4 GRAM SMOLT AND LARGER IN THE AWL SAMPLE, 35 % OR (14,737 FRY) FALL INTO THIS CATEGORY. BASED ON THEIR SIZE, ONE COULD ASSUME THESE FRY WERE FROM THE 1991 NET PEN (TABLE 4). FROM TABLE 4 YOU CAN SEE THAT THE WILD SMOLT (2.9 g) FALL IN LINE WITH THE SIZE OF AGE 1 SMOLT SAMPLED IN 1991, PRIOR TO PEN REARING ACTIVITIES.

TABLE 4. AVERAGE LENGTHS (mm) AND WEIGHTS (g) OF AGE 1 SMOLT 4.0 g + COMPARED TO CWT AND WILD SMOLT SAMPLED IN 1992.

	AGE 1 SMOLT		
	AWL's	CWT*	Wild
LENGTH	86	88	68
RANGE	68-117	50-104	56-75
WEIGHT	5.4	5.7	2.9
RANGE	4.0-8.7	1.9-9.3	1.2-3.9

* 84,757 FRY RELEASED IN 1991 AVERAGED 4.6 GRAMS (RANGE = 1.6 - 11.4 g)

IF WE ASSUME THE 14,737 SMOLT THAT WERE 4 GRAMS AND LARGER WERE FROM THE NET PEN, THE OVER WINTER SURVIVAL WAS 17 PERCENT. (14,737/84,751 = .17).

EXPLANATIONS FOR LOW OVER WINTER SURVIVAL OF 1991 PEN REARED FRY:

1) THEY WERE RELEASED EARLY TO PREVENT FURTHER SPREAD OF FURUNCULOSIS AND GILL PARASITES. HOWEVER, IT IS POSSIBLE THE TWO AGENTS CONTINUED TO SPREAD AFTER THE FRY WERE RELEASED.

2) AT RELEASE, THE WATER TEMPERATURE WAS WARM AND PROMOTED FEEDING ACTIVITY. GIVEN LOW ZOOPLANKTON DENSITIES FRY MAY HAVE WENT INTO THE WINTER WEIGHING LESS THAN THEY DID AT RELEASE

3) FRY COULD HAVE BEEN PREYED ON BY DOLLY VARDEN.

1992 PEN REARING

IN JUNE, 290,000 FRY WERE TRANSPORTED TO SECOND LAKE FROM THE ADF&G BIG LAKE HATCHERY. THE PEN REARING WAS EXPANDED TO 171,398 FRY WHICH WERE APPORTIONED INTO SIX PENS OF APPROXIMATELY 30,000 IN EACH PEN. TEN PERCENT OF THE PEN REARED FRY WERE ADIPOSE FIN CLIPPED AND CODED WIRE TAGGED. AN ADDITIONAL 118,900 FRY WERE DIRECTLY RELEASED INTO SECOND LAKE, NONE OF THESE FRY WERE TAGGED.

IN 1991, WE LEARNED THAT IT WAS POSSIBLE TO RAISE FRY UP TO 4.0 - 5.0 grams. SO OUR GOAL WAS TO PRODUCE 5.0 gram FRY BUT KEEP DENSITIES AT OR BELOW 4 Kg/m^3 TO MINIMIZE ANOTHER VIRAL OR PARASITIC OUTBREAK. INITIAL AVERAGE WEIGHT OF THE FRY WAS .25 g. FRY WERE FED EVERY 1/2 HOUR BETWEEN 6 AM AND 10 PM. PENS WERE CLEANED 2 TIMES PER WEEK.

BY AUGUST 10 FRY RANGED BETWEEN 2.2-3.2 grams AND WERE DIAGNOSED TO HAVE TRICONDIA. ON AUGUST 16 FRY WERE DIAGNOSED TO HAVE COSTIA. TREATMENT FOR BOTH PARASITES INVOLVED IMMERSING THE FRY IN A FORMALIN BATH CONTAINING 1 PART FORMALIN TO 6,000 PARTS WATER FOR 1 HOUR (29.5 ML FORMALIN : 177,600 ml WATER). WE USED A FISH TOTE TO HOLD THE FORMALIN BATH. OXYGEN WAS DELIVERED TO THE BATH AT 2 LITERS PER MINUTE. APPROXIMATELY 6,500 FRY WERE IMMERSED IN THE BATH AT ONE TIME. NO IMMEDIATE MORTALITIES WERE ASSOCIATED WITH THE TREATMENT.

ON SEPTEMBER 8, FURUNCULOSIS WAS DIAGNOSED. FRY WERE FED MEDICATED FEED FOR 10 DAYS BEGINNING SEPTEMBER 18. MORTALITIES DECREASED BY 75%.

TOTAL MORTALITY THROUGHOUT THE PEN REARING WAS ESTIMATED AT 10,118 fry (6 %). ON OCTOBER 14, A TOTAL OF 161,280 FRY WERE RELEASED. THEY AVERAGED 8.0 g (4.0 - 9.4 g). DENSITIES RANGED BETWEEN 4.8

and 6.9 kg/m³.

1993 SMOLT OUT MIGRATION

SMOLT TRAP WAS IN PLACE BETWEEN MAY 6 AND JULY 8. WE EXPECTED TO SEE 80 TO 100,000 SMOLT (assuming 50% or better over-winter survival of 161,000 released from 1992 pens). TOTAL NUMBER OF SMOLT WAS 45,553. THE TRAP WASHED OUT FOR 12 DAYS BETWEEN MAY 13 AND 24 DURING WHAT APPEARED TO BE THE BEGINNING OF THE PEAK OF THE OUT-MIGRATION. WATER TEMPERATURE DURING THE WASH OUT PERIOD AND PEAK OF THE RUN WAS 8 - 9 C. BY JUNE 7, THE PEAK OF THE RUN WAS OVER. AGE 1 SMOLT AVERAGED 6.6 GRAMS AND RANGED BETWEEN 1.5 AND 13.0 g. NO AGE 2 SMOLT WERE SAMPLED (TABLE 5).

TABLE 5. LENGTH (mm) AND WEIGHT (g) OF AGE 1 SMOLT SAMPLED IN 1993

	AGE 1 SMOLT	
	AWL's	CWT
LENGTH	91	96
RANGE	52-120	76-120
WEIGHT	6.6	7.3
RANGE	1.5-13.0	3.5-11.7

A TOTAL OF 431 SMOLT WERE EXAMINED FOR CODED WIRE TAGS; 85 OF THESE SMOLT WERE TAGGED AND AVERAGED 7.3 GRAMS (RANGE 3.5-11.7 g). ALL RECOVERED CODED WIRE TAGS WERE TRACED BACK TO THE 1992 PEN REARED FRY. GIVEN THE SMALL SAMPLE SIZE OF RECOVERED CWT SMOLT, THE OVER-WINTER SURVIVAL IS BIASED LOW AT 24 % (TABLE 6). IF YOU COMPARE THIS ESTIMATE TO THE NUMBER OF 5 GRAM AND LARGE SMOLT (ASSUMING THEY CAME FROM THE 1992 PENS) THE OVER WINTER SURVIVAL WAS ESTIMATED AT 22 %. WITH 6 GRAM AND LARGE SMOLT THE ESTIMATE WAS 17 %.

TABLE 6. ESTIMATE OF OVER WINTER SURVIVAL OF 1992 PEN REARED FRY OBTAINED FROM RECOVERED CWT SMOLT, COMPARED TO OVER WINTER SURVIVAL ESTIMATE BASED ON AGE 1 SMOLT 5.0+ AND 6.0+ g IN 1993.

	AGE 1 SMOLT		
	# of Smolt	# of Fry Released	Over-winter Survival (%)
5.0 g +	35,075	161,289	22
6.0 g +	26,876	161,280	17
CWT est	38,491	161,280	24

EXPLANATION FOR LOW OVER-WINTER SURVIVAL OF 1992 PEN REARED FRY:

1) FURUNCULOSIS AND GILL PARASITES MAY HAVE WEAKENED FRY

2) PREDATION BY DOLLY VARDEN (PRIMARILY ON THE SMALLER FRY)

3) SMOLT TRAP FAILURE AND INADEQUATE CWT SAMPLE (PROBABLY THE MAIN REASON FOR LOW OVER WINTER SURVIVAL ESTIMATE).

1993 PEN REARING

PEN REARING WAS EXPANDED TO 751,370 FRY. APPROXIMATELY 600,000 WERE TRANSPORTED FROM BIG LAKE HATCHERY IN 4 TRIPS BETWEEN JUNE 12 AND 25. EACH TRIP CARRIED BETWEEN 115,000 - 170,000 FRY WEIGHED .20 g. 150,000 FRY WERE TRANSPORTED FROM THE PORT GRAHAM HATCHERY IN ONE TRIP ON JUNE 29. PORT GRAHAM FRY WEIGHED .33 g (150,000 eyed eggs from Big Lake were transported to incubators at Port Graham as a "shake down" run for the Port Graham Hatchery - in 1993 all eggs will be incubated at Port Graham). FRY WERE PLACED IN 5 INDIVIDUAL NET PENS MEASURING 12X12X12 FEET. TRANSPORT MORTALITY RANGED FROM 446 TO 2,800 FRY PER TRIP. TOTAL MORTALITY FOR THE MONTH OF JUNE WAS ROUGHLY 10,000 FRY.

BIOMASS CALCULATIONS FOR AVERAGE WEIGHTS AND FEED QUANTITIES WERE CONDUCTED APPROXIMATELY EVERY TWO WEEKS THROUGHOUT THE PEN REARING. FRY WERE FEED BETWEEN 1.3 AND 3 % OF THEIR BODY WEIGHT PER DAY INITIALLY, FRY WERE FED SMALL AMOUNTS OF FOOD EVERY 1/2 HR - 16 HOURS A DAY UNTIL THEY REACHED 1 GRAM. AT THAT TIME THE FEEDING SCHEDULE WAS CHANGED TO A LARGER AMOUNT OF FEED 5 TIMES EACH DAY. WE DID THIS TO MAXIMIZE FOOD AVAILABILITY TO ALL FRY IN THE PEN. BY FEEDING FRY LARGE AMOUNTS OF FEED LESS OFTEN THROUGHOUT THE DAY, FRY NEAR THE SURFACE BECAME SATIATED AND ALLOWED MORE FEED TO FILTER DOWN TO THE FRY BELOW. THIS MINIMIZED A LARGE SPREAD IN THE SIZE RANGE OF THE FRY.

WATER TEMPERATURES WENT FROM 10 TO 17 C BETWEEN JUNE AND MID-AUGUST. DISSOLVED OXYGEN RANGED BETWEEN 12 AND 8 MG/L THROUGHOUT THE PEN REARING.

WHEN THE FRY REACHED 1 GRAM WE SPLIT 626,748 OF THEM INTO 11 PENS - EACH PEN CONTAINING APPROXIMATELY 56,000 FRY. WE KEPT THE

REMAINING 114,482 FRY IN ONE PEN (PEN #7) TO COMPARE FRY GROWTH WITH THE OTHER PENS CONTAINING ROUGHLY HALF THE NUMBER OF FRY PER PEN (TABLE 7).

TABLE 7. SUMMARY OF FRESH WATER PEN REARED FRY GROWTH AT ENGLISH BAY, 1993

		--------11 Pens--------			--------Pen #7-------		
		NUMBER OF FRY	AVG WT (g)	DENSITY (Kg/m³)	NUMBER OF FRY	AVG WT (g)	DENSITY (Kg/m³)
June	30	626,748	0.48	0.58	114,482	0.39	0.91
July	12	623,178	0.90	1.05	114,023	0.61	1.42
Aug	9	480,961	2.13	2.20	113,252	1.00	2.32
Aug	25	450,828	3.37	3.48	113,192	1.79	4.14
Sept	7	450,541	4.27	4.37	113,109	2.53	5.85
Sept	25	449,599	5.81	5.96	112,879	3.59	8.29
Oct	11	448,515	7.25	7.43	112,661	4.66	10.74
Oct	18	448,341	7.64	7.72	112,651	5.06	11.66

PRECAUTIONARY MEASURES TO PREVENT ANOTHER VIRAL AND/OR PARASITIC OUTBREAK INCLUDED: 1) CLUSTERING THE PENS IN GROUPS OF 4 AND 5 TO MINIMIZE SPREAD OF EITHER AGENT; 2) CLEANING THE PENS EVERY OTHER DAY WITH A HONDA PUMP AND 2" DIA HOSE; 3) FEEDING 2% MEDICATED TETRACYCLINE FEED FOR 14 DAYS BETWEEN AUGUST 10 AND AUGUST 24 (IN THE PAST, FRY WERE VULNERABLE TO FURUNCULOSIS DURING THIS TIME PERIOD). IT HELPED, ESPECIALLY CONSIDERING THE WARM WATER TEMPERATURES. THERE WASN'T AN OUTBREAK OF FURUNCULOSIS THIS YEAR. THE GILL PARASITE TRICHOPHRYA WAS OBSERVED HOWEVER, THE MORTALITY ASSOCIATED WITH THE PARASITE WAS LESS THAN .001%.

IN MID SEPTEMBER, FRY WERE CODED WIRE NOSE TAGGED ON SITE. IN

PRIOR YEARS TAGGING WAS DONE AT THE HATCHERY. 20,000 FRY WERE TAGGED IN 9 DAYS.

BY OCTOBER 18, NINE PENS HELD 448,341 FRY (~ 50,000 EACH) AND PEN #7 CONTAINED 112,651 FOR A TOTAL OF 560,992 FRY. THE INITIAL NUMBER OF FRY IN MID-JUNE WAS 751,370. TOTAL MORTALITY WAS 25%. THERE WERE SEVERAL REASONS FOR THE HIGH MORTALITY (MORTALITY MEANING THE NUMBER OF FRY NOT IN THE PENS). WE LOST ~ 50,000 FROM A HOLE IN ONE PEN. HOWEVER, THESE FRY MINGLED AROUND THE PENS BUT THERE WAS NO WAY TO ESTIMATE THE NUMBER THAT SURVIVED. THEY WERE 2.0 GRAMS WHEN THEY ESCAPED. IN MID-JULY ANOTHER 50,000 WERE LOST TO NEGLECTED PEN CLEANING. THESE FRY DIED FROM LACK OF OXYGEN. ANOTHER 50,000 WAS LOST TO PREDATION BY OTTERS (THERE WERE 7 OTTERS SIGHTED AT ONE TIME). THE NUMBER OF MORIBUND FRY COUNTED AND REMOVED FROM THE PENS WAS 35,000.

THERE WAS A DIFFERENCE IN FRY GROWTH FOR FRY IN PEN #7 COMPARED TO FRY GROWTH IN THE OTHER PENS. ON OCTOBER 18, AVERAGE WEIGHT OF FRY IN PEN #7 WAS 5.0 g, AT DENSITY OF 11.6 KG/M^3, COMPARED TO AN AVERAGE WEIGHT OF 7.6 g AT A DENSITY OF 7.7 KG/M^3 FOR THE FRY IN THE OTHER PENS (TABLE 7). ALL OF THE FRY WERE RELEASED ON OCT 30. WATER TEMP WAS 5.2 C.

IN THE FUTURE, WE PLAN ON KEEPING THE NUMBER OF FRY PER PEN AT 50,000 FOR SEVERAL REASONS: 1) GET LARGER PRESMOLT; 2) SMALL PEN SIZE (12X12X12) EASIER TO MAINTAIN AND; 3) IT IS EASIER TO ISOLATE A SMALL PEN WITH DISEASED FISH)

DURING THE 1994 SMOLT OUT-MIGRATION WE HOPE TO SEE HIGHER OVER WINTER SURVIVAL OF PEN REARED FRY BECAUSE:

FRY WERE HEALTHY AND LARGE (7.6 g) AT RELEASE

FRY WERE RELEASED IN COOLER WATER TEMPERATURES COMPARED TO PREVIOUS YEARS

LESS PREDATION GIVEN THEIR SIZE

WE WILL MODIFY THE SMOLT TRAP SO THAT IT IS NOT PRONE TO WASH OUT DURING THE PEAK OF THE SMOLT OUT-MIGRATION. THIS MAY ASSURE BETTER RECOVERY OF CODED WIRE TAGGED FISH

Sockeye Salmon Smolt Production and Zooplankton Response from Stocking Sweetheart Lake

by

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Sweetheart Lake is an oligotrophic lake located near Juneau, Alaska, and a series of falls on the outlet stream form a natural barrier to anadromous fishes. Fishery and limnological observations, when applied to empirical sockeye salmon (Oncorhynchus nerka) production models for coastal Alaskan lakes, suggested that the lake's rearing potential was underutilized. Juvenile sockeye salmon were stocked (2.45×10^6 in 1990, 1.3×10^6 in 1991, 0 in 1992, and 0.77×10^6 in 1993) in order to realize more of the lake's rearing potential and create a new salmon fishery.

Holopedium biomass decreased during the first two years of stocking, rebounded when no fish were stocked in 1992, and was not affected by the 1993 stocking. Holopedium abundance decreased during the first two years of stocking, rebounded when no fish were stocked in 1992, and was moderately affected by the 1993 stocking. *Holopedium* seasonal mean body length increased during stocked years but returned to pre-stocking conditions in the unstocked years.

Cyclops abundance, biomass, and seasonal mean body length decreased during the first two years of stocking, continued decreasing during the unstocked year in 1992, and rebounded during the low stocking in 1993.

These changes in the zooplankton community occurred even though only 12-38% of the sockeye production model estimates were stocked. Stocked juvenile-to-age 1.0 smolt survival was 32% for the 1990 stocking and decreased to 26% for the 1991 stocking, and age 1.0 smolts averaged 6.0g in 1991 and 6.3g in 1992. Observed survival and growth exceeded those expected when rearing limitation occurs, and the smolt size was near the optimum (about 90 mm) for maximum ocean survival.

These zooplankton and sockeye responses are similar to responses in density-dependent systems, and indicate that Sweetheart Lake was stocked below capacity with respect to the number of smolts produced per fry stocked, but near the management goal of having the greatest number of adults return per fry stocked.

Baker River Sockeye

by

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Overview - The Baker River is located on the west slope of the Cascade Mountains in northern Washington State. It drains into the Skagit River at the town of Concrete. The Baker River has two hydroelectric dams on it at river miles 1 and 9. The reservoir behind the Lower Baker Dam is Lake Shannon, and the reservoir behind the Upper Baker Dam is Baker Lake. Prior to the construction of the dams there was one lake on the Baker River, Baker Lake. The original Baker Lake was enlarged when the upper dam was built. The original Baker Lake supported a sockeye run.

The groups concerned with the operation and management of the fish facilities on the Baker River have formed the Baker River Committee. This committee consists of representatives from the following organizations:

Washington Department of Fisheries
Washington Department of Wildlife
Puget Sound Power and Light Company (Puget Power)
Skagit System Cooperative
National Marine Fisheries Service
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Park Service

The Baker Committee serves as a forum for discussion and decision making for activities related to fish resources in the Baker River basin. These activities include the operation of the fish facilities, experiments, data collection, and modifications to dam operations or facilities.

In 1896 the state opened a sockeye hatchery on Baker Lake. In 1899 the facility was sold to the Federal government (U.S. Fish Commission, later the Bureau of Fisheries). Baker sockeye eggs were distributed widely from the hatchery. In 1924 Puget Power began construction of the lower Baker Dam for producing hydroelectric power. The flooded area upstream from the dam was called Lake Shannon. In 1925 the dam prevented all but 40 sockeye from reaching Baker Lake. That year the number of sockeye below the dam was estimated to be 8,000 - 10,000. By 1926 adult fish handling facilities were in place. The facilities consisted of a low weir extending across the river just upstream from the powerhouse, and a concrete fish ladder extending from the tailrace to a collecting pool. An 800 ft long highline cableway was used to transport the fish in small steel tanks from the collecting pool to the top of the dam, where the fish were released into a chute leading to the reservoir. After entering Lake Shannon the fish would move through the reservoir and move up river toward Baker Lake. The hatchery trapped fish just below Baker Lake. The difference in the number of sockeye enumerated at the trap below Baker Lake was significantly less that the number of sockeye passed over the dam, in every year that both were in operation (8 yrs). The fish facilities at the dam proved to be undersized and resulted in fish dying before they could be transported, when there were large numbers of fish. The weir was damaged by high flows and the equipment deteriorated over time. It has been reported that because of the decline in the sockeye escapement to Baker Lake, after the dam was built, sockeye production at the federal hatchery ended in 1934. It has also been reported that the rearing of sockeye in Puget Sound was discontinued due to high disease losses.

In July 1959 Puget Power completed constructed of a second dam, creating a second reservoir. The second dam is called the Upper Baker Dam and flooded the original Baker Lake. The lake level was raised 60 ft. As part of the new dam the adult fish handling facilities were reviewed and it was decided to replace them. Construction of a barrier dam and fish trap began in November 1957, with the completion date scheduled for July 1, 1958 (or earlier). The new facility was located a short distance upstream from the confluence of the Baker and Skagit Rivers. The new adult fish facilities consist of a barrier dam, a fish trap with a brail and hopper arrangement, and two tanker trucks for hauling adult fish to the Baker Lake (reservoir). The tanker trucks may be replaced in the near future with trailer mounted tanks.

Spawning Beaches - WDF surveys during the 1954 and 1955 sockeye spawning seasons indicated that greater than 95% of the Baker River sockeye spawned on the shores of Baker Lake. Spawning was restricted to areas of upwelling spring water. With the construction of Upper Baker Dam Baker the original Baker Lake would be under up to 60 ft of water. Therefore, after the upper dam was constructed sockeye could not use their usual spawning areas. If the sockeye found new spawning areas around the shore of the new Baker Lake most of their eggs would be lost when the reservoir (Baker Lake) was drawn down during the winter. The eggs would be lost to desiccation and freezing.

To compensate for the loss of sockeye lake spawning habitat associated with the second dam, WDF, with funding from Puget Power, designed an experimental spawning beach (beach 1) on Channel Creek, at the upper end of the area to be flooded by Upper Baker Dam. Beach 1 was designed with a gravel area of 20 ft by 50 ft, and upwelling water. Construction of Beach 1 was completed in the spring of 1957. In 1957 24 sockeye pairs were put into Beach 1. From the number of fry that were enumerated as they left the beach survival from egg to fry was estimated at

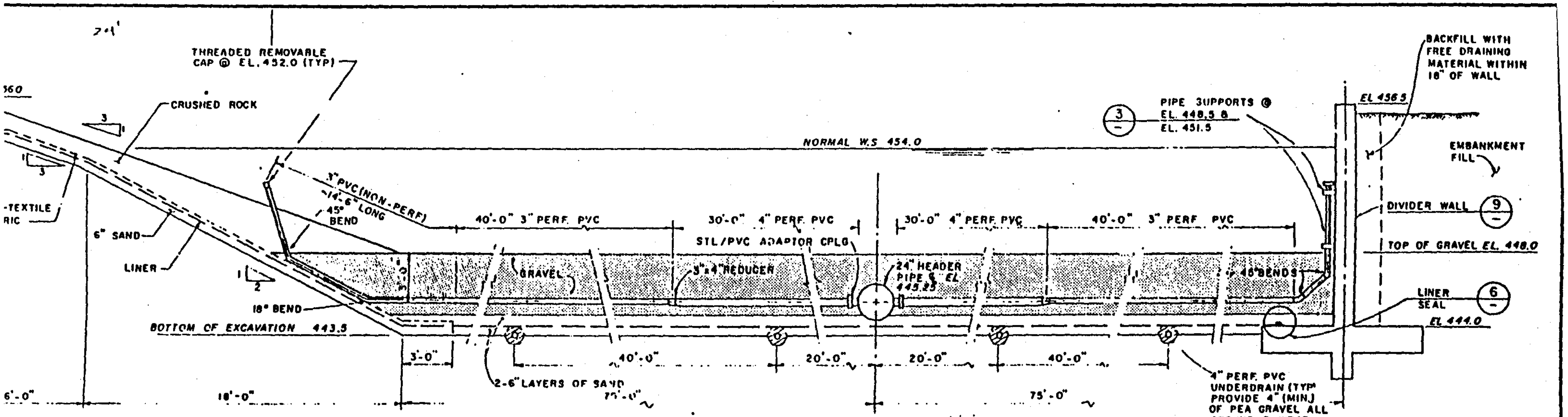
43.5%. This was a minimum estimate of survival, due to unspawned eggs, and fry that were not enumerated. Based on this a second beach (#2) was constructed and completed in July 1959.

Beach 2 was designed as a production beach, with dimensions of 100 ft by 150 ft. The designed capacity of Beach 2 was 1,500 sockeye. Beach 1 was operated through the 1964 brood year. Use of Beach 1 was discontinued when timbers under the gravel rotted out. In 1966 construction of a third beach was completed adjacent to Beach 2, with the same dimensions as Beach 2. Beach 3 was stocked with adult sockeye for the first time in the fall of 1967. Originally beaches 1 and 2 were constructed with fish ladders, so that adults could be hauled by truck to the lower end of Baker Lake, then hold in the lake and, when they were ready to spawn, moved up into the spawning beaches. The plan was to put adult sockeye in the beaches for the first four years then after that they would return to the beaches on their own. The fish apparently did not come back to the beaches on their own, and the prespawning mortality in the beaches was low, so trucking of adult sockeye to the spawning beaches was continued.

Juveniles hatched in these spawning beaches (1,2 & 3) voluntarily leave the beaches through outlets which carry them into Channel Creek which in turn carries them into Baker Lake.

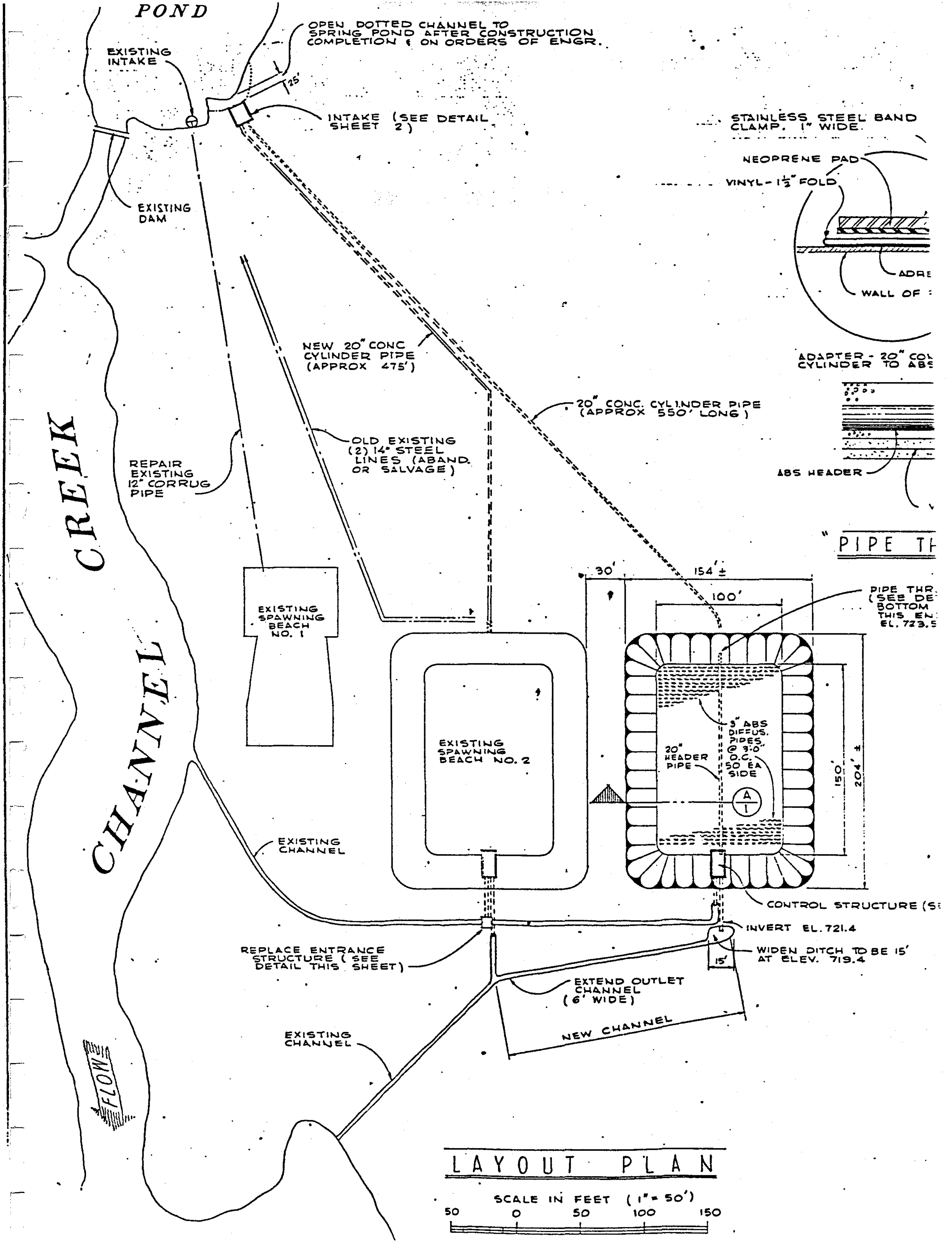
In the mid-1980s Puget Power proposed that a new site be used for a sockeye spawning beach. Their proposal was to replace the old spawning beaches (2 & 3) with a new beach. Puget Power's proposal was in response to the threat of flooding at the old site, the need of some major renovation at the old beaches, and the expense of operating such a remote site. WDF and Puget Power ultimately agreed to construct the new spawning beach (beach 4). The beach was designed to have the same total area as the two old beaches (2 & 3) together. Therefore, the designed capacity of beach 4 was 3,000 sockeye. Because of its location below Baker Lake all fry from beach 4 must be collected and hauled by truck to Baker Lake.

Beach 4 began operating in 1990. From the start there were problems with silt entering the water supply. During construction there was a slide at the intake. The water in beach 4 often turned muddy during the first season of operation. In 1990 egg-to-fry survival from beaches 2 and 4 were compared to check on the performance of beach 4. Of the returning 1,976 adults, 700 were put in beach 4. The rest were put in beach 2. Egg-to-fry survival was estimated at only 9.6% in beach 4, contrasted with 25.2% survival at beach 2. The low survival in beach 2 was attributed to the very cold weather that winter. Because of the warmer water in beach 4 and because the electronic counter for counting fry migrating from beach 4 to Baker Lake was installed late, it is possible that fry in beach 4 may have emerged and begun migrating out of the beach before counter installation. Therefore, survival in beach 4 may have been higher than the 9.6% estimate. Also the outlet screens were defective. The frames had been notched to fit into the slots.



CROSS SECTION THROUGH SPAWNING BEACH (A/30)

SCALE: 1/4" = 1'-0"


POND
OPEN DOTTED CHANNEL TO SPRING POND AFTER CONSTRUCTION COMPLETION & ON ORDERS OF ENGR.
EXISTING INTAKE
25'
INTAKE (SEE DETAIL SHEET 2)
STAINLESS STEEL BAND CLAMP, 1" WIDE
NEOPRENE PAD
VINYL - 1½" FOLD
EXISTING DAM
WALL OF
ADAPTER - 20" CO CYLINDER TO ABS
NEW 20" CONC CYLINDER PIPE (APPROX 475')
20" CONC. CYLINDER PIPE (APPROX 550' LONG)
OLD EXISTING (2) 14" STEEL LINES (ABAND. OR SALVAGE)
REPAIR EXISTING 12" CORRUG PIPE
ABS HEADER
CREEK
CHANNEL
PIPE TH
30'
154' ±
100'
PIPE THR. (SEE DE BOTTOM THIS EN EL. 723.5
EXISTING SPAWNING BEACH NO. 1
EXISTING SPAWNING BEACH NO. 2
3" ABS DIFFUS. PIPES @ 3.0" O.C. 50 EA SIDE
20" HEADER PIPE
A/1
150'
204' ±
EXISTING CHANNEL
CONTROL STRUCTURE (S
INVERT EL. 721.4
WIDEN DITCH TO BE 15' AT ELEV. 719.4
15'
REPLACE ENTRANCE STRUCTURE (SEE DETAIL THIS SHEET)
EXTEND OUTLET CHANNEL (6' WIDE)
NEW CHANNEL
EXISTING CHANNEL
FLOW
LAYOUT PLAN
SCALE IN FEET (1" = 50')
50 0 50 100 150

Fry could pass through the notches prior to reaching the counters, so the true number of surviving fry was not known.

In 1991 WDF and Puget Power tested egg-to-fry survival from beach 4 by comparing it with beach 3. To make the comparison, of the 480 adult spawners which had been hauled to beach 3, 100 were moved to beach 4 prior to the beginning of spawning. Survival from beach 4 was 16.4% contrasted with 92.5% from beach 3. Values for both beaches were based on the assumption that average fecundity was 3,000 eggs per female. In 1991 49% of the wild sockeye were five-year-olds, who would be expected to have higher than average fecundity. The difference in survival between the two beaches clearly indicated a problem with beach 4. Examination of the gravel showed that it was covered with sand and muck which prevented water from upwelling evenly throughout the spawning gravel.

By the time these problems were identified, Puget Power only had about two months between the time fry left beach 4 and adults returned in which to clean and replace the gravel and pipes. All 3,000 cu yd of gravel were removed from the spawning beach for cleaning. During the process it was discovered that much of the gravel (which had been installed for Puget Power by an independent contractor) was smaller than WDF specifications. The gravel was cleaned and regraded. The lateral pipes were removed, cleaned and replaced. Beach 4 was back in operation on July 10.

To address the silt problem filter fabric was placed in areas above the intake to reduce the intrusion of sand. To avoid future problems with silt and sand, a turbidity meter has been installed in the intake pipe for beach 4. If turbidity exceeds acceptable levels a valve will turn off the water supply to the spawning beach.

In 1992 2,422 sockeye adults returned to the Baker trap. They were distributed among beaches 2, 3 and 4 with the following results:

	No. Spawners	%Egg-to-fry Survival
Beach 2	1,100	26.9
Beach 3	425	85.7
Beach 4	917	76.1

Although beach 4 appeared to be functioning, there was a problem with beach 2. The reason for the problem is not known. The counter at beach 2 was working properly. It is possible that the old asbestos pipes or steel main lines in beach 2 are deteriorating and that water circulation in the spawning gravel was inadequate as a result. Because of the higher density of fish in Beach 2 WDF expected the egg to fry survival to be a bit lower, due to over spawning. However, over spawning does not explain the large difference in survival.

In 1993 3,818 sockeye spawners returned to the Baker trap (a small number of these may be steelhead or Dolly Varden).

Approximately 2,927 sockeye were put into beach 4, about 769 were put into beach 3 and 121 were released into Baker Lake. Beach 2 was not used, because of the poor survival from the previous year. Because the sockeye escapements have been less that the capacity of the spawning beaches adults have not been released into Baker Lake since at least 1973. Presently, there is no way to measure the productivity of the lake spawners. Extensive spawner surveys for coho and sockeye in Baker Lake and the Baker River above the lake began in October, 1993. It is unlikely that sockeye spawners will be seen in the lake. Visibility is poor because the water is very dark.

It is expected that any eggs laid in Baker Lake at higher elevations will be lost when Puget Power reduces the water level in Baker Lake. It is unknown if there are any impacts from the draw down to the eggs in redds that are not left high and dry.

Moving the spawning from beaches 2 and 3 to beach 4 is beneficial to adult spawners but worse for juveniles. Adults benefit because the trip from the trap to beach 4 is shorter than the trip to beaches 2 and 3. However, there is no physical connection between beach 4 and Baker Lake so fry must be hauled 8 to 12 miles for release into the lake. The effect of this handling on fry is not known. Beginning in 1994 WDF is requiring Puget Power to truck fry from beach 4 to Baker Lake at night to more closely resemble natural migration. In addition, the water temperature in beach 4 is higher than that in beaches 2 and 3 during incubation and cooler during the late summer when the adults are being held. Beaches 2 and 3 and Baker Lake usually freeze over each winter, beach 4 does not freeze. The difference is due to a temperature difference in the water supply. The effect of higher water temperature on juvenile survival is not known.

All spawning in the spawning beaches is natural (fish are not killed and spawned artificially). Carcasses are counted and collected daily. Lengths and samples of scales and otoliths are collected. The sampling ceases at beaches 2 and 3 when they freeze. Some carcasses are lost to scavenging eagles, coyotes and raccoons.

After fry have left the spawning beaches, or prior to the adults returning in June, the gravel in the beaches is disinfected with chlorine. The water quality is tested by bioassay prior to releasing the chlorinated water. The bioassay is conducted by placing 20 fry into a garbage can of water from the chlorinated beach. If more than 10% of the fry die in 48 hr the chlorinated water is not released. Since this testing was begun we have not had any mortality of the test fish, even after 5 days.

Although IHN is endemic at low levels in Baker sockeye, there has not been a major disease outbreak. Until now ! . . . spring of 1994.

The Gulpers - In 1950 the International Pacific Salmon Commission (the predecessor to the present Pacific Salmon Commission) began a study on the impacts of Lower Baker Dam on smolt emigration. The study showed that 95% or more of the smolts went out over the spillways and less than 5% through the power tunnel and turbines. This was when the tunnel entrance was 85 ft below the surface. Based on the recovery of marked smolts the mortality that occurred to sockeye passing over the spillway was 63.5%, and 33.6% for the sockeye passing through the turbines. Based on the recovery of returning marked adults the mortality was 62.7% for sockeye passing over the spillway and 37.0% for sockeye passing through the power tunnel. In 1955 experiments were conducted with a ski-jump spillway at Lower Baker Dam. These experiments showed improved survival with the new spillway. A permanent ski-jump spillway was later installed. However, due to the lost power production and limitations on reservoir operations other methods were explored for collecting and passing smolts by the existing dam and the planned Upper Baker Dam. Thus the Gulpers were developed.

The Baker Gulpers are floating traps used to collect out migrating juveniles and direct them through pipes in the upper and lower dams instead of through the turbines in the dams. The lower gulper (for the lower reservoir) was constructed in 1958, some 34 yr after the lower dam was built. The lower gulper is an inclined plane trap with a pump to create an attraction flow into the trap. Once juveniles enter the trap, they move through flexible hosing into a box for counting, then are directed back into a hose, then to a pipe through the dam. Originally the pipe ended a short distance from the dam and the fish fell to the pool at the foot of the dam. Later the pipe was extended down stream to a pool just across from the powerhouse.

This design was duplicated and improved for the upper dam in 1960. The upper gulper has approximately twice the pumping capacity of the lower gulper to create greater attraction flow and has wing nets to guide smolts into the trap. The gulpers are operated only when smolts are migrating. In 1993 this was from 22 March to 11 August.

In the mid 1980s it was estimated that 40% of outmigrating juveniles were being lost between the counting traps in the upper and lower gulpers. Consequently, use of the upper by-pass pipe was discontinued, and in 1987 Puget Power began collecting juveniles from a box at the upper dam, and trucking them to a location on the Baker River below Lake Shannon, bypassing both dams. In 1992 the Upper Baker Gulper guide net (1/4-in mesh) was further improved. It now runs from shore to shore and from the surface to the bottom of the reservoir to prevent out migrating smolts from going over the spillway or through the turbines of the upper dam.

Mark-recapture studies from 1988 to 1993 suggest that the upper gulper captures at best about 60% of out migrating coho. In 1993 the collection efficiency was about 27% for coho and 12% for sockeye. These numbers are unacceptably low. It is possible that the marked fish, which are hauled from the net pens to Baker Lake may have some mortality associated with hauling which would result in underestimation of gulper collecting efficiency. Gulper efficiency may increase if more water is spilled over the upper dam during out migration, to increase the attraction to the gulper. However, Puget Power begins to fill Baker Lake at this time of year and usually spill does not occur. At the time of year that the sockeye smolts are migrating the reservoir is being filled. This results in low turnover of the lake. The flow through the lake is probably reduced from filling the reservoir and the increased lake size, compared to the conditions in the original Baker Lake. This may impact the ability of the sockeye to find the outlet of the lake and the gulper. It is possible that the apparent low collecting efficiency of the gulper may reflect a shift from anadromy to fish becoming land-locked (residualization) in Baker Lake, and thus are not attracted to the gulper.

Net Pens - The low return (99) of adult spawners in 1985 led Puget Power to propose rearing fry to smolt stage in net pens in Lake Shannon (because it does not freeze in winter). WDF collects fry at the spawning beaches and trucks them to the net pens. The following table details the numbers reared and released.

Brood Year	No. Fry to Pens	Smolts Released	Year Released	Smolts Tagged
1985	30,000	27,966	1987	9,599
1986	60,000	57,300	1988	9,192
1987	60,000	57,060	1989	9,410
1988	60,000	45,348	1990	9,829
1989	141,677	113,367	1991	9,779
1990	130,793	102,993	1992	28,177
1991	130,683	87,038	1993	27,806

Sources of mortality at the pens include poaching (juveniles are poached for use as bait), predation by birds and otters and natural mortality.

The sockeye net pens are adjacent to pens used for coho and steelhead, and water temperatures can rise above 70 degrees F, so there is concern about the potential for spread of disease if major outbreaks should occur. Net pen fish are routinely given medication (TM-100) in food to treat *Columnaris* outbreaks and treated with formalin for *Costia* infections.

Puget Power operates the net pens and most of the smolts are released through the Lower Baker Gulper, into the Baker River across from the Lower Baker Powerhouse. Some smolts are released into Baker Lake to evaluate the Upper Baker Gulper.

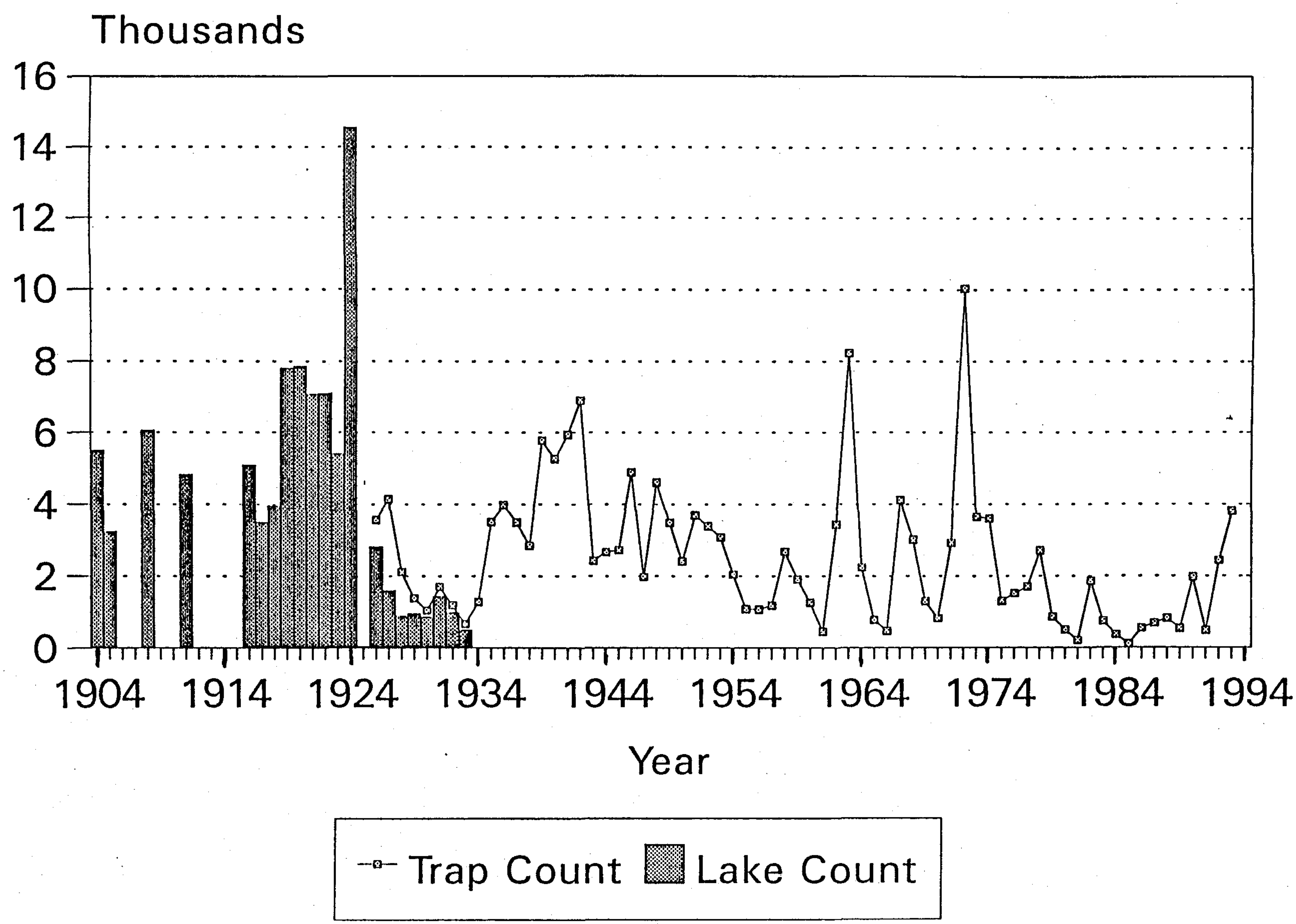
Coded wire tag data and otolith data indicate that the smolt-to-adult survival of net pen fish is approximately 10% of the survival of fish which rear naturally in Baker Lake. The reason for the difference is not known. Net pen fish are reared to the same size and released at the same time as wild fish (May 1), but may not be developmentally or behaviorally equivalent to their wild counterparts. The Baker Committee is now experimenting with different release strategies. This was begun with the 1992 releases and is continuing through at least the 1994 releases. There are now groups of net pen sockeye coded wire tagged for early (April 15) and late (June 1) release. All groups of net pen fish, including the normal timed release will be coded wire tagged. About 10,000 fish per group are tagged.

Underyearling Program - An experiment is being conducted with raising some sockeye on an accelerated basis. Water temperature is raised 10 degrees F above normal and juveniles will be released as zero-age smolts The study proposal calls for two groups, each of 10,000 fish to be raised under accelerated conditions. These fish are all coded wire tagged. The planned release time for these groups of fish in mid and late May, if they can be reared up to over 4 gm. If they are not up to size they are released when they reach 4 gm. This experiment was begun in 1993.

BAKER RIVER SOCKEYE ESCAPEMENT COUNTS

Year	Escape-ment	Year	Escape-ment	Year	Escape-ment	Year	Escape-ment
1896	na	1926	3,578	1956	1,070	1986	542
1897	na	1927	4,150	1957	1,177	1987	683
1898	na	1928	2,121	1958	2,692	1988	818
1899	na	1929	1,379	1959	1,911	1989	536
1900	na	1930	1,036	1960	1,258	1990	1,976
1901	na	1931	1,710	1961	450	1991	480
1902	na	1932	1,186	1962	3,449	1992	2,443
1903	na	1933	666	1963	8,241	1993	~3,800
1904	5,489	1934	1,284	1964	2,242		
1905	3,241	1935	3,524	1965	774		
1906	na	1936	3,990	1966	468		
1907	na	1937	3,510	1967	4,121		
1908	6,048	1938	2,857	1968	3,022		
1909	na	1939	5,775	1969	1,295		
1910	na	1940	5,266	1970	821		
1911	4,828	1941	5,937	1971	2,931		
1912	na	1942	6,894	1972	10,031		
1913	na	1943	2,435	1973	3,656		
1914	na	1944	2,688	1974	3,611		
1915	na	1945	2,737	1975	1,303		
1916	5,091	1946	4,892	1976	1,518		
1917	3,510	1947	1,980	1977	1,707		
1918	3,965	1948	4,610	1978	2,716		
1919	7,800	1949	3,494	1979	865		
1920	7,850	1950	2,416	1980	499		
1921	7,075	1951	3,705	1981	208		
1922	7,080	1952	3,401	1982	1,860		
1923	5,408	1953	3,091	1983	735		
1924	14,558	1954	2,046	1984	358		
1925	40	1955	1,076	1985	99		

Baker River Sockeye Escapement



Baker River Sockeye Net Pen Program

By

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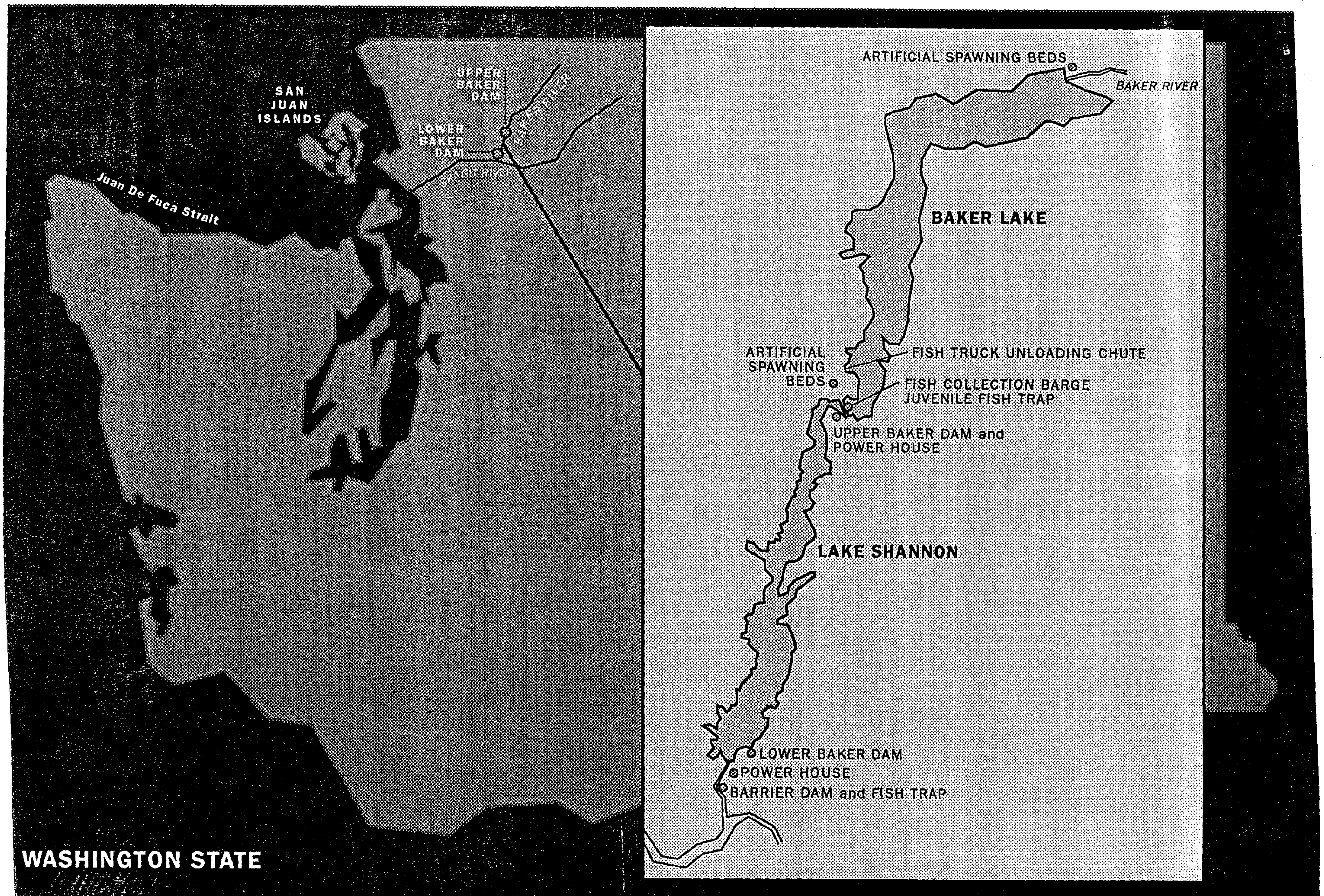
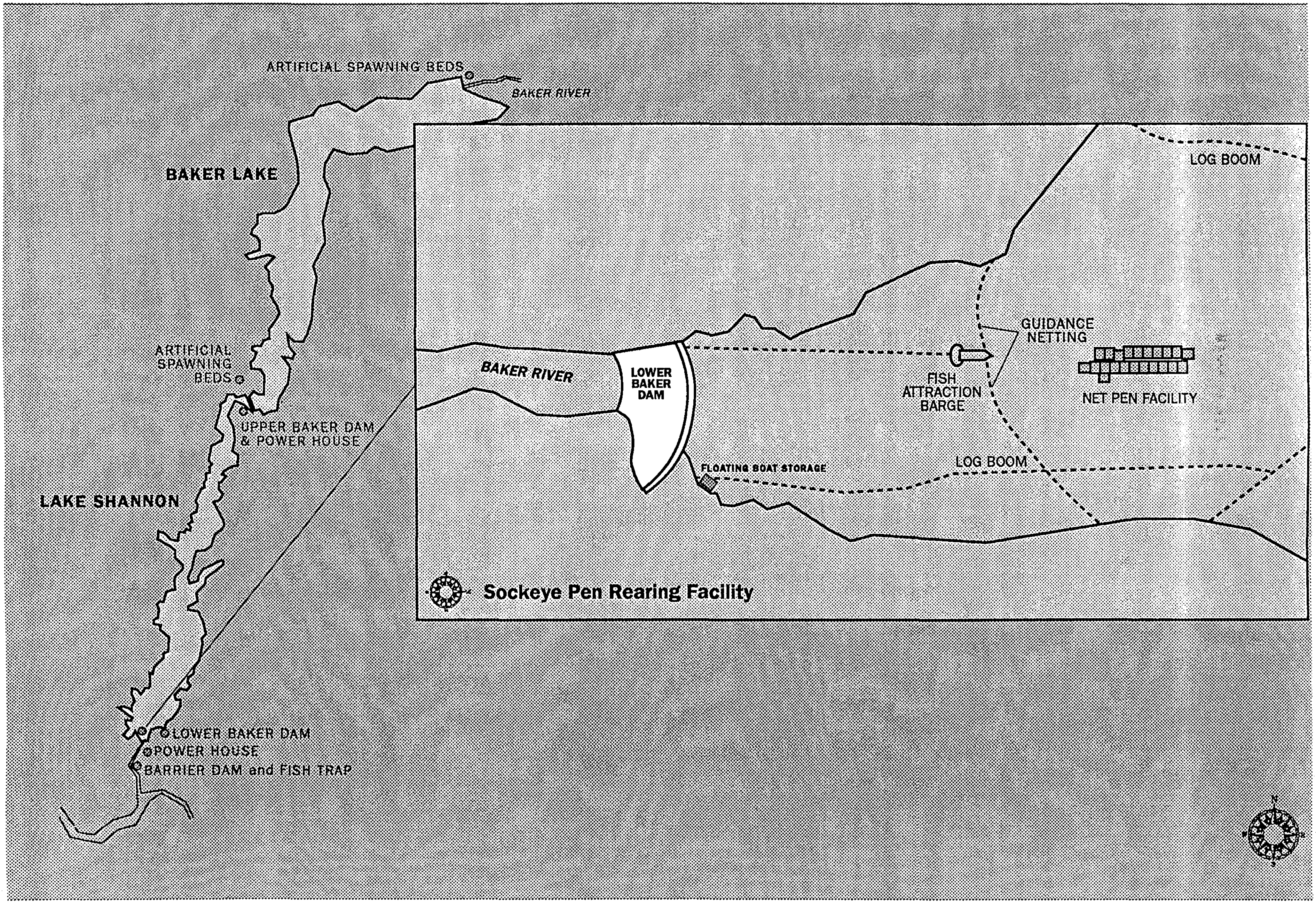
November 3, 1993

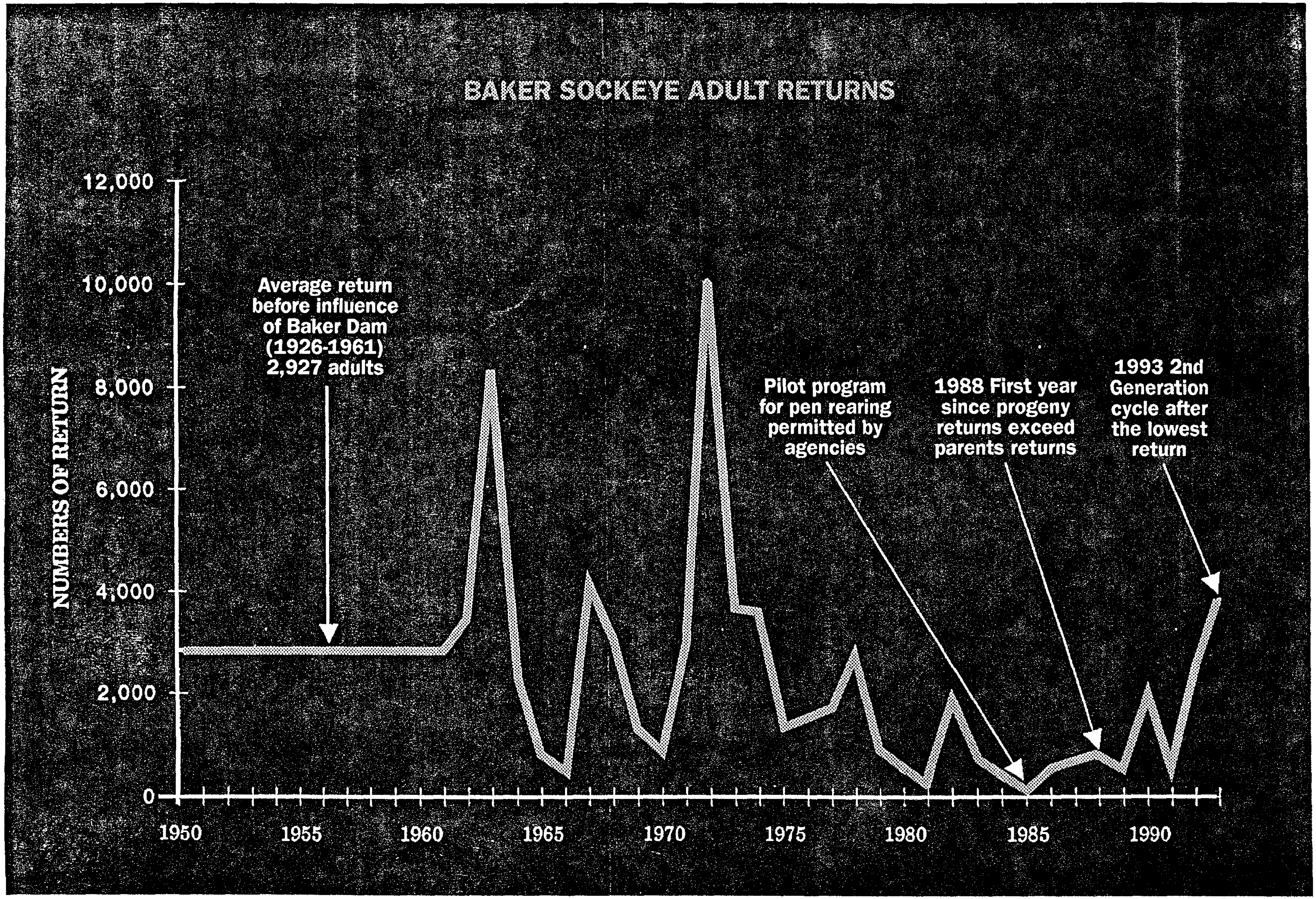
Historically, the Baker River Sockeye returns averaged approximately 3,000 with some of the largest returns occurring after completion of the Upper Baker Development. However, during the late 1960s through the mid 1980s the stock declined to approximately 3% of the historical average. Today, the stock might have been listed as endangered. Puget Power and the fisheries agencies initiated a study to investigate potential causes for the decline and agreed to undertake a number of efforts to restore the Sockeye run.

In 1986, a study was initiated by the Baker River Committee (an ad hoc group comprised of State and Federal fisheries and resource agencies, consortium of three local Indian tribes and Puget Power) to evaluate Sockeye Salmon juveniles reared in floating net pens located on Lake Shannon in the Baker River watershed in Washington State. This pilot program was undertaken to bolster the sagging Sockeye return which hit an all-time low of 99 spawning adults in 1985. The Sockeye net program would also permit studies along the lines of Sockeye restoration. A portion of the progeny from the 99 fish return were transferred to net pens and reared to yearling (1+) smolts. The results of the program have been encouraging in respect to fry to smolt survival and the program is continuing into it's eighth year.

Simultaneously, we found ways to improve natural migration out of the Baker system. In 1989, the first returns from the Baker Sockeye net pen program accounted for nearly 100 per cent of the 536 adult Sockeye, progeny of the 1985 brood. The progeny from the 1989 returns came back this summer with the highest return number since 1972 at 3,818 fish. However, contribution of the net pen Sockeye has declined, despite quadrupling the program. Comparison of the first 3 years of returns for net pen Sockeye and for natural reared Sockeye show net pen Sockeye have a much lower estimated survival from smolt to adult than natural reared Sockeye. We are currently addressing this problem by releasing marked net pen Sockeye at different times. This begun with smolts released in 1992 which will return as adults in 1994.


SAN JUAN ISLANDS
UPPER BAKER DAM
LOWER BAKER DAM
BAKER RIVER
SKAGIT RIVER
Juan De Fuca Strait
ARTIFICIAL SPAWNING BEDS
BAKER RIVER
BAKER LAKE
ARTIFICIAL SPAWNING BEDS
FISH TRUCK UNLOADING CHUTE
FISH COLLECTION BARGE
JUVENILE FISH TRAP
UPPER BAKER DAM and POWER HOUSE
LAKE SHANNON
LOWER BAKER DAM
POWER HOUSE
BARRIER DAM and FISH TRAP
WASHINGTON STATE


ARTIFICIAL SPAWNING BEDS
BAKER RIVER
BAKER LAKE
ARTIFICIAL SPAWNING BEDS
UPPER BAKER DAM & POWER HOUSE
LAKE SHANNON
LOWER BAKER DAM
POWER HOUSE
BARRIER DAM and FISH TRAP
LOG BOOM
GUIDANCE NETTING
BAKER RIVER
LOWER BAKER DAM
FISH ATTRACTION BARGE
NET PEN FACILITY
LOG BOOM
FLOATING BOAT STORAGE
Sockeye Pen Rearing Facility


BAKER SOCKEYE ADULT RETURNS
NUMBERS OF RETURN
12,000
10,000
8,000
6,000
4,000
2,000
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
Average return before influence of Baker Dam (1926-1961) 2,927 adults
Pilot program for pen rearing permitted by agencies
1988 First year since progeny returns exceed parents returns
1993 2nd Generation cycle after the lowest return

Baker River Sockeye Net Pen Program

•Initiated in 1986 to evaluate Sockeye juveniles reared in floating net pens.

•This pilot program was undertaken to bolster the sagging Sockeye return which hit an all-time low of 99 spawning adults in 1985.

•The program would permit:

(1) **immediate shot in the arm to bolster the sagging return**

(2) **allow studies along the lines of Sockeye restoration.**

•Results of the program have been encouraging in respect to fry to smolt survival and the program is continuing into it's eighth year.

•In 1989, the first returns from the Baker Sockeye net pen program accounted for nearly 100 per cent of the 536 adult Sockeye progeny of the 1985 brood.

•However, contribution of the net pen Sockeye has declined, despite quadrupling the program.

•We are currently addressing this problem by releasing marked net pen Sockeye at different times.

Lake Shannon Net Pen Rearing Average Water Conditions:

	Temperature (C)	pH Units	D.O. (PPM)
January	6.5-7.5	6.95	11.1
February	6.0-7.0	6.96	11.9
March	6.5-9.5	6.81	11.8
April	9.0-12.5	7.59	9.4
May	10.0-12.0	7.16	12.2
June	10.5-12.5	7.97	10.7
July	12.5-16.5	7.12	10.0
August	16.5-17.5	7.04	8.7
September	15.5-17.0	7.28	10.2
October	13.0-15.0	7.24	9.2
November	9.5-12.5	6.85	9.4
December	8.0-10.0	6.88	11.0

Disease:

- Bacterial
  - Columnaris (TM-100, 2.25% bwd, usually for 10-14 days)
  - Bacterial Gill (25 ppm Diquat, 1 hour)
  - Kidney Disease
- Ectoparasites (microscope on station for quick checks)
  - Costia (1:6000 formalin, 1 hour)
  - Gyrodactylus

Loading Density & Splits:

	Volume (ft3)	Loading lbs.fish/ft3	Lbs. of fish per pen	Size (fish/lb.)	(gm/f)	Timing of Splits
6'x8'x8'	384	0.25	96	<2,400-350	<0.2-1.3	Apr-Jun
8'x12'x15'	1140	0.25	360	350-150	1.3-3.0	Jun-Aug
12'x16'x18'	3072	0.25	768	150-50	3.0-9.0	Aug-Oct
12'x16'x15'	2880	0.25	720	50-10	9.0-45	Oct-May

Feed Size for Fish Size and Conversion:

Feed Type	Size	Timing	Rate (% bwd)	Conversion
Bio. #1	<2,400-1,200	Apr-May	Satiation	N/A
Bio. #2	1,200-550	May-June	4%	0.8
Bio. #3	550-350	June	4%	0.8
OMP 1/32	350-200	June-July	3.5%	0.9
OMP 3/64	200-150	July-Aug	3%	1.4-1.6
OMP 1/16	150-80	Aug-Sep	3%	1.4-1.6
OMP 3/32	80-50	Sep-Oct	2.5%	1.4-1.6
OMP 1/8	50-10	Oct-May	1.5-3%	1.8

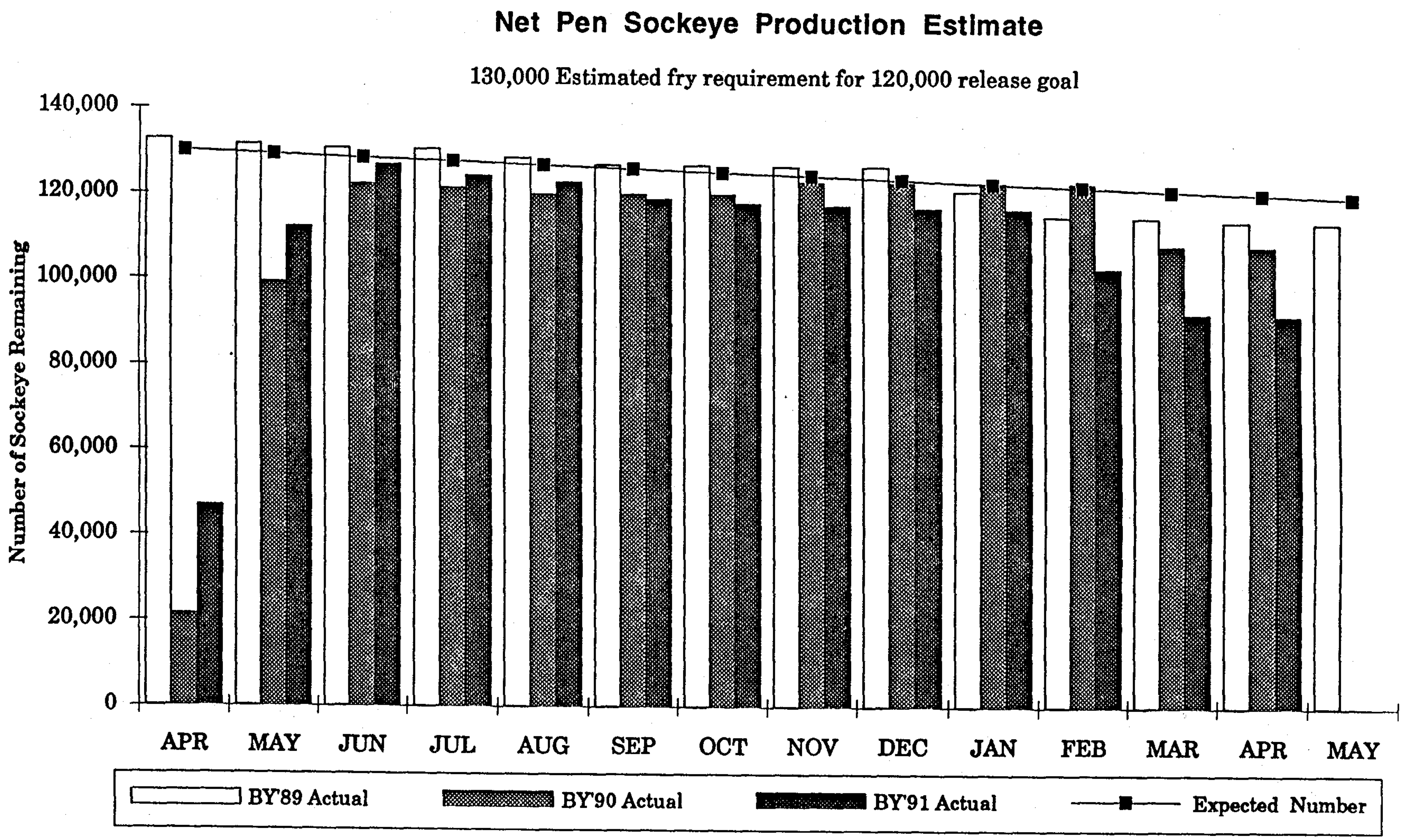
Wild and Net Pen Sockeye Survival Comparison:

Brood Year	Wild Outmigrants Counted	Wild Fry-Smolt Survival	Wild Smolt-Adult Survival	Net Pen Releases	Net Pen Fry-Smolt Survival	Net Pen Smolt-Adult Survival
1985	95	0.14%	12.00%	27,966	93.22%	2.66%
1986	9,819	1.52%	14.20%	57,300	95.50%	1.30%
1987	6,349	1.15%	1.90%	57,060	95.10%	0.10%
1988	24,448	3.83%	•4.67%	45,348	69.77%	•2.80%
1989	15,050	4.51%		113,367	87.21%	
*1990	89,290	21.46%		107,945	83.03%	
*1991	25,200	6.86%		92,064	70.82%	

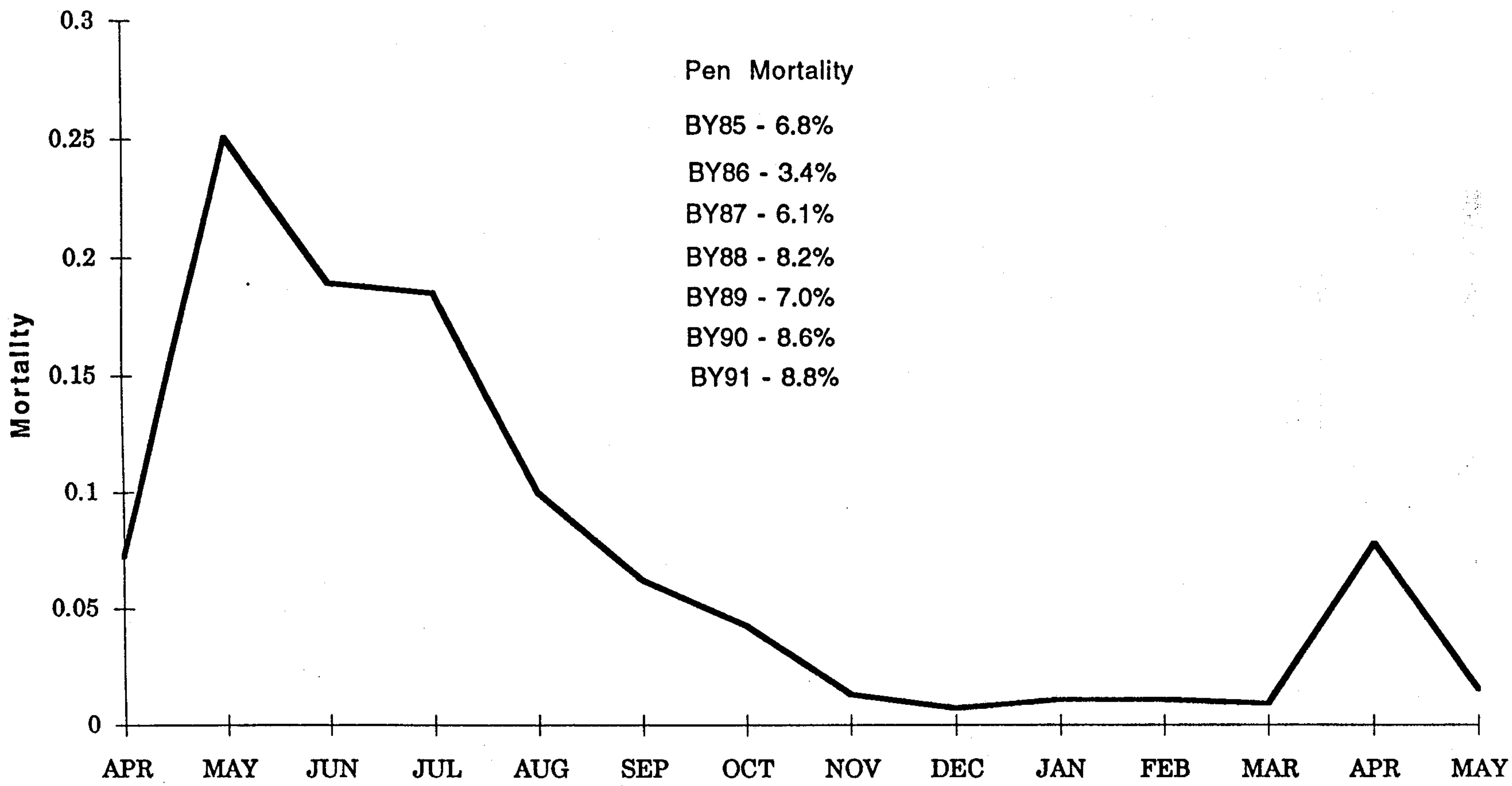
Year of Return	Adult Return	% Adult Return as Net Pen	
1989	536	97.95%	Based on Tag Recovery
1990	1,976	40.40%	Based on Tag Recovery
1991	480	26.30%	Based on Otolith/Scale Sample
1992	2,423	•52.40%	Based on Otolith/Scale Sample

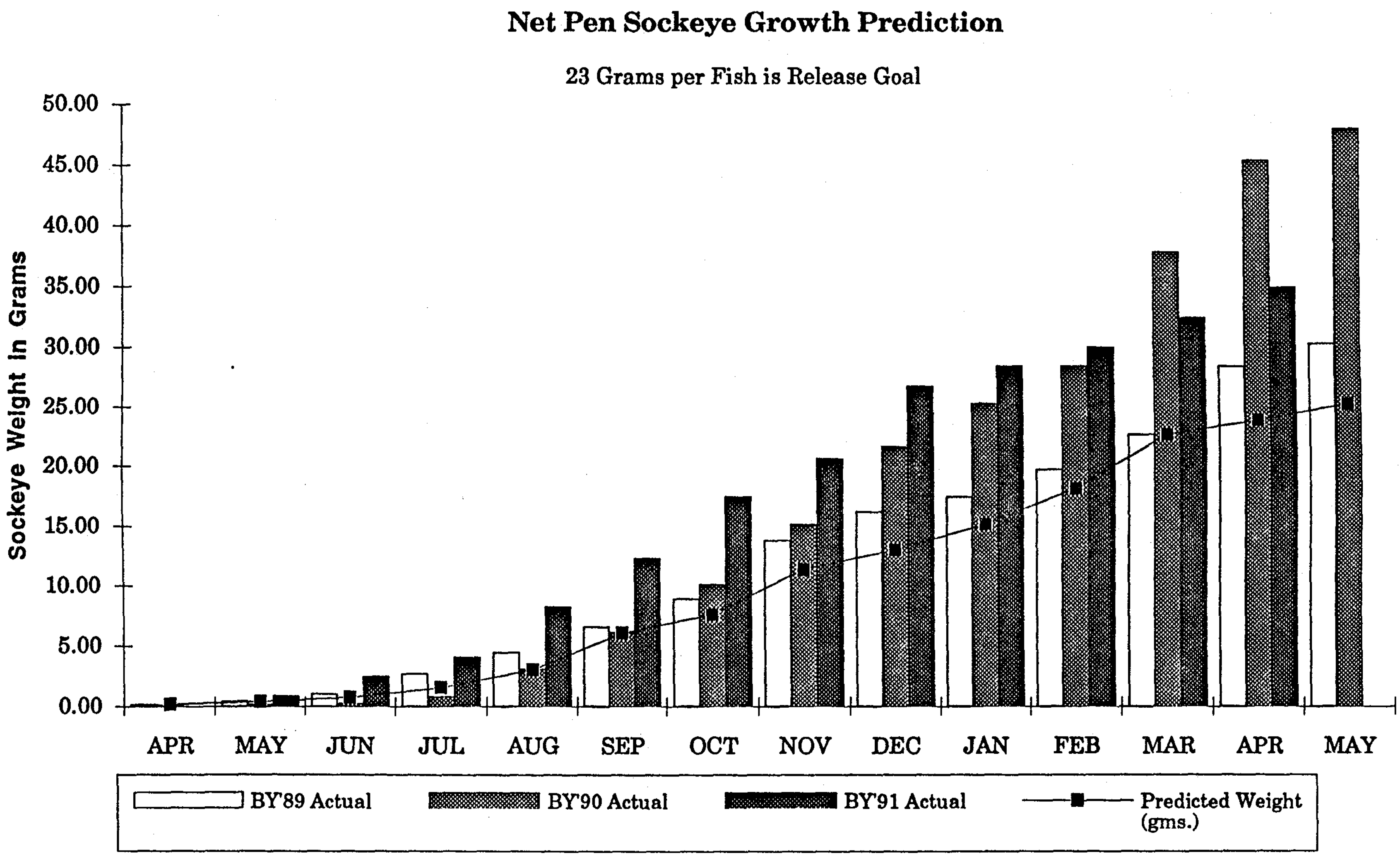
* Problem of Low Pen Returns Prompted a Study of Different Release Times.

• Preliminary


Net Pen Sockeye Production Estimate
130,000 Estimated fry requirement for 120,000 release goal
Number of Sockeye Remaining
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
BY'89 Actual
BY'90 Actual
BY'91 Actual
Expected Number

Timeframe of Pen Rearing Mortality BY'85-91




Net Pen Sockeye Growth Prediction
23 Grams per Fish is Release Goal
Sockeye Weight In Grams
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
BY'89 Actual
BY'90 Actual
BY'91 Actual
Predicted Weight (gms.)

CEDAR RIVER SOCKEYE ENHANCEMENT

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Washington Department of Fisheries (WDF) began its enhancement of Cedar River sockeye in 1991 in response to disappointing presmolt estimates. The survival to presmolt has reached a level at which the run cannot sustain itself. The last several years have shown a decline in adult returns even worse than anticipated in the forcasts. The 1992 returns were part of a previous cycle of high returns and escapement had been originally expected to be almost double (Figure 1). This year the return was anticipated to be approximately 110,000 but is either late or not materializing.

In the spring of 1991 artificial enhancement was proposed at a site adjacent to the Seattle Water Department's Landsburg diversion dam at river mile 21. When the decision was made to go ahead, WDF had only two months to put the operation together. The facility had to be temporary, cost minimal money, and get by on existing permitting obtained when the site was used in the early 1980s for eggbox incubation.

Incubation Facility

The water supply originates from seep springs on the hillside above the incubation site and runs 44-48°F year around. Some improvements were made on two water collection sites by adding screen boxes to exclude debris and piping the water to the hatchery using gravity flow. Additional water was pumped from a pool collecting spring water located adjacent to the incubation building. All water then went through a tank on a tower to provide a constant head in the hatchery building.

The hatchery "building" consisted of a 40 foot shipping container in which 20 stacks of 8 FAL trays were installed. The FAL isolation stacks were used and each set of ten stacks were fed by an open head trough. Four Remote Site Incubators (RSIs) were installed outside for additional capacity. These are constructed of 55 gallon black polyethylene plastic barrels and were developed by WDF for hatching eyed eggs at unattended stream side locations.

Adult Collection

In 1991 the goal was set to produce 2 million fry for release. Time was insufficient to obtain permits to put a weir in the river to collect adults, so a gill netting operation was organized. Four sites were chosen to provide sufficient representation of run distribution. Initially confiscated gill nets were used but eventually WDF had nets made specific for the size of the sockeye and for the river. The nets were manned by borrowed hatchery personnel, volunteers and individuals from other agencies. Eventually we learned to be reasonably efficient with the nets and the goal was reached before flows made fishing impossible. In 1992 the target was increased to 3 million using the same capture techniques.

Green fish were frequently encountered and it was decided to hold the females until they ripened. The fish were transported back to the Landsburg dam and held in small netpens in the river until ready to spawn. The netpens were below the diversion dam but above the pipeline crossing that prevents sockeye passage. Initially garbage cans were used for the transport but as time permitted plastic fish totes supplied with bottled oxygen were set up.

Spawning
Access to the collection sites was generally limited and all of the supplies had to be carried in and out of the site each day so minimal equipment was used. Fish were killed, placed on a tarp and disinfected with iodophor. Each fish was spawned individually according to standard sockeye spawning techniques. The eggs were collected in 16 ounce (cottage cheese) containers and the milt in 8 ounce (yogurt) containers. The containers were put into coolers on ice and transported back to the hatchery site by truck. In 1991 a total of 2,326,900 green eggs were taken from 10/9 to 11/20 (Figure 2). In 1992 a total of 3,269,266 green eggs from 9/22 to 12/8 (Figure 3).

Fertilization, Disinfection and Waterhardening
Each female's eggs were transferred to a 48 ounce clear plastic (salad) bowl to permit an adequate ratio of iodophor to eggs. One female's eggs were fertilized with milt from one male initially and then milt from a second male was added to ensure fertilization. After fertilization the eggs were rinsed with a 100 ppm iodophor until free of milt and blood. The bowls were then filled with iodophor, kept chilled and left to waterharden for a minimum of one hour.

Incubation
In 1991 four female's eggs were placed into each tray of the FALs. To accommodate the increased eggtake goal in 1992 five female's eggs were loaded into each tray and three additional RSIs were installed. This equalled 13,000 - 15,000 eggs/trays or 90 - 100,000 eggs/stack of seven trays. The top tray was initially left empty to settle out debris. When the eggs were shocked and picked they were redistributed into the top tray. Folded ½" vexar screening was added at this time for substrate. Problems encountered the first year were: water entering top tray created turbulence and rolled the eggs; a few vexar screens were folded incorrectly restricting flow; and debris clogged one incoming water line and blocked flow.

The RSI incubators contain trays which were loaded with eight female's eggs/tray or 250,000 eggs/barrel of ten trays. Saddles were added for substrate when eyed eggs were put down for hatching after picking.

During incubation the fish were marked using chilled water to produce distinct identifying bands on their otoliths. Chillers were used to produce the required 8°F below ambient water temperatures which were applied in 8 hour increments. These marks will be used to assess their performance as juveniles and identify returning adults.

Emergence and Release
No rearing or feeding of the fry is being done at this time. For a number of reasons

volitional emergence was not feasible. To determine when to pond fry the condition factor (KD) of the immigrating wild fry was checked. When the proper KD was reached, the trays were emptied into four foot diameter fiberglass circulars supplied with well water. The water was tempered with river water throughout the day and the fish released at dusk. All fry from the 1991 brood then went directly into the river at Landsburg dam. However, sampling done on these fry at the mouth of river indicated potential river survival problems so in 1993 a portion of the releases were made from a site approximately one mile from the mouth of the river.

The 1991 brood fry were released from 2/8 - 3/24/92 (Figure 4) and releases totaled 2,079,100 fish. Survival from green egg to fry was 90%. The 1992 brood fry were released from 2/6 - 4/6 (Figure 5) and releases totaled 3,067,400 fish. Survival from green egg to fry was 94% in 1992 (Figures 6 and 7).

IHNV Screening of Hatchery Fish

During the project extensive viral sampling was done approximately once per week on ovarian fluids from the spawning females and on every lot of fry released. In 1991 the average of INHV prevalence in adults was 8.5%. This is regarded as a low prevalence for this stock and virus was not detected until the near the end of the eggtakes on 11/13/91. In 1992 average IHNV prevalence in adults was 41.9% with the first virus detected on 10/8/92 (Figure 8). Figure 9 shows the prevalence over time.

On the second year we were surprised to discover that holding the fish in the net pens substantially increased the prevalence of IHNV over the prevalence in females spawned at time of capture. The fish spawned at capture had an average IHNV prevalence of 27.3% while the netpen held fish spawned on the same days had an average of 84.7%. Figure 10 shows the breakdown of prevalence by spawning site over time. The actual length of time each fish was held in the netpens was not tracked but it was believed be approximately one week. Since no sockeye reach this section of the river it is likely that little, if any virus, is present in the water. River flows at this time of year are set at a minimum of 250 cfs so there was considerable flushing through the pens. This increase in virus prevalence could either be from the stress of transport and holding and/or the close contact of the holding conditions.

No IHNV was detected in any of the outmigrating fry either year. The first year a total of 852 fry were sampled and the second year 2018 fry.

Quantification of Fry Outmigration

In the winter an inclined plane trap was installed at mouth of river to measure outmigration. Bismarck brown dyed fish were released on alternate nights to determine trap efficiency. One hundred fry were kept from each night for otolith analysis the first year. In the spring of 1992 the trap operated from February 8 to May 9. The total fry outmigration was estimated to be 11.5 million. Otolith marks indicated that only 26% of hatchery fish survived the 21 mile journey downriver. Next year trapping occurred from January 11 through June 1, 1993 and 150 fry were sampled each night for otolith analysis. Estimated outmigration was 27 million fry. Otoliths have not yet been read to determine relative hatchery contribution for that year.

IHNV Results in Trapped Fry

Each week fish were collected from the trap and tested for virus. We targeted wild fry by sampling as long after hatchery releases as possible in order to exclude hatchery fry. Generally 100 fish were sampled and assayed in five fish pools of whole fry. In 1992 virus was detected in the first sample at the rate of one positive pool out of nine pools, all healthy appearing fry. In 1993 the detection of virus increased. IHNV was detected in most samples from January 13 through April 13 (Figure 11). This presents a great concern because of the intent to eventually build a spawning channel on this system. It would be impossible to isolate infected fish in a spawning channel therefore the channel could greatly magnify any infection. In the future we hope to investigate if the infected fry originate from particular sites in the river. Some sampling was performed on fry taken from redds but no virus was detected. Adult fish are still spawning in the system, particularly in side sloughs, until at least February. One possibility is that the virus these adults are shedding could be infecting the fry.

Experimental testing

We conducted a live box experiment to determine if the hatchery fry, which appeared to be free of virus, might become infected in travel down river. Hatchery fry were held in a live box just below the trap for 16 days and sampled periodically. No INHV was detected in any of these fry even though we were detecting virus in fry caught at the trap during the same time period (Figure 12). Although this test was on a small scale it indicates that the hatchery fry are unlikely to become infected during their short time in the river. Infection may occur in the lake but as the fry spread out and with the additional dilution of virus the chance of horizontal infection will diminish.

Viral testing was also performed on the presmolts captured during the trawl surveys done as part of the presemolt estimate survey. All were fish tested were negative, however numbers of fish were very low.

1993 Eggtake

This fall the eggtake goal was increased to nine million eggs. Again funding was not available until a short time before the eggtake, most of it provided by SWD in a mitigation settlement with the Muckleshoot Tribe. The incubation capacity was expanded by adding 24 Kitoi boxes. An additional head box containing a screen filter to remove debris was installed to supply the Kitoi boxes. Plans for Kitoi boxes were supplied by ADF&G. A few modifications were made: installed a second intake water line, a venting tube was added at back to expel air that might get trapped under the perforated plate, and the incubators were mounted at a slight incline to encourage air to migrate to the back. This is still a temporary facility so the Kitoi incubators were installed with aluminum lids for security and placed with on concrete slabs.

Permitting was also obtained to allow a temporary weir to be installed in the river approximately 6 miles from the mouth. Adults are being collected at the weir and transferred daily to a location just below the incubation site and held in fiberglass circular ponds on spring water. The eggtake is proceeding now and this week is expected have the largest eggtakes. Fish have not been arriving as expected and we are hoping the run is late rather than smaller that anticipated. As of October 29th 2.4 million eggs have been taken and enough females are being held for an additional 1.7 million eggs. IHNV was detected by the second week of spawning on October 12th. The eggs will again receive chill marking of the otoliths but release strategies have not been finalized.

For now the spawning channel referred to in the 1991 meeting is on hold for four more years. During this time studies will be conducted to determine the limiting factors causing the decline of the Cedar River sockeye. The marked fry produced from our enhancement operation will be used to evaluate survival to various life stages.

ADULT RETURNS
CEDAR RIVER SOCKEYE

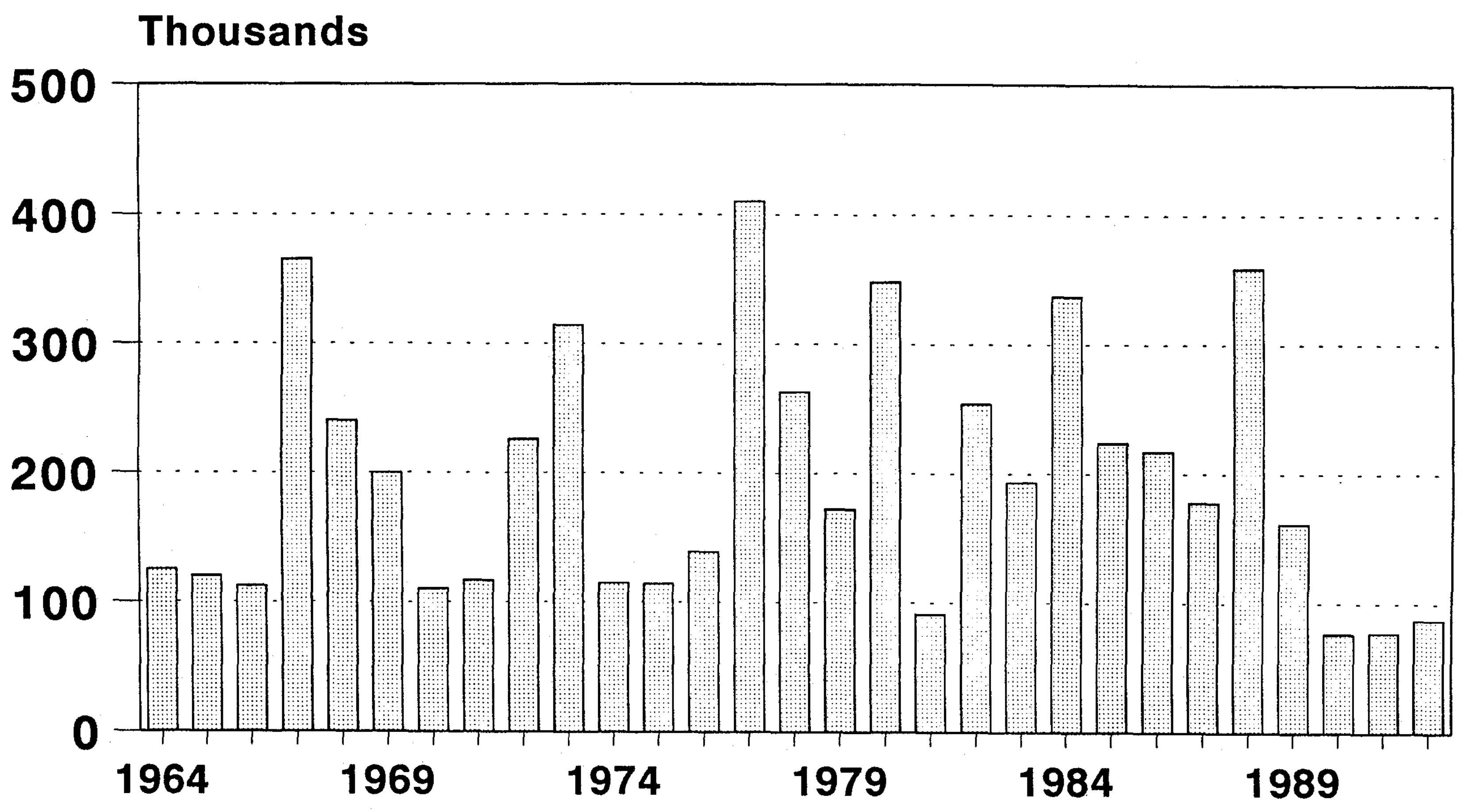


Figure 1

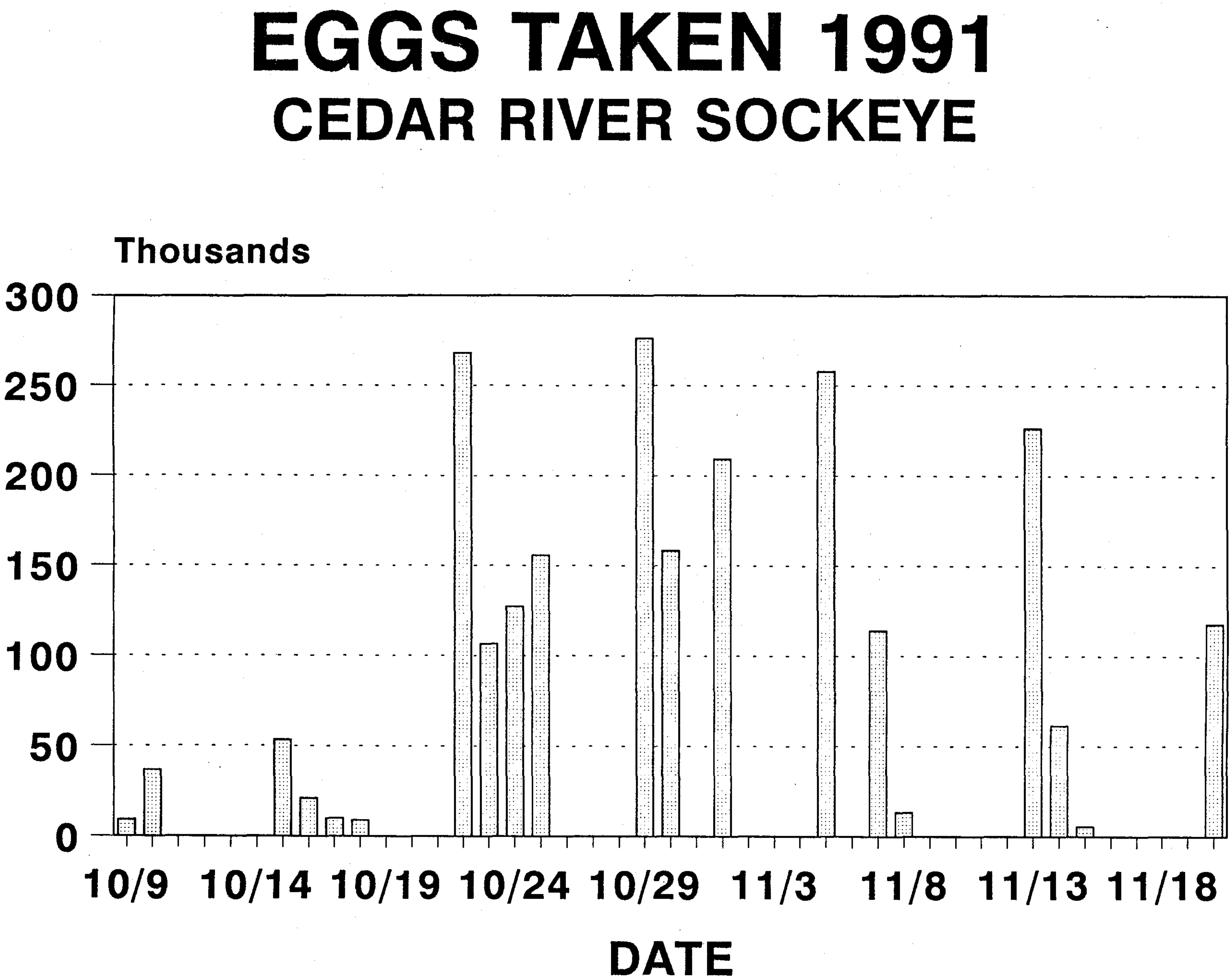

EGGS TAKEN 1991
CEDAR RIVER SOCKEYE
Thousands
300
250
200
150
100
50
0
10/9
10/14
10/19
10/24
10/29
11/3
11/8
11/13
11/18
DATE

Figure 2

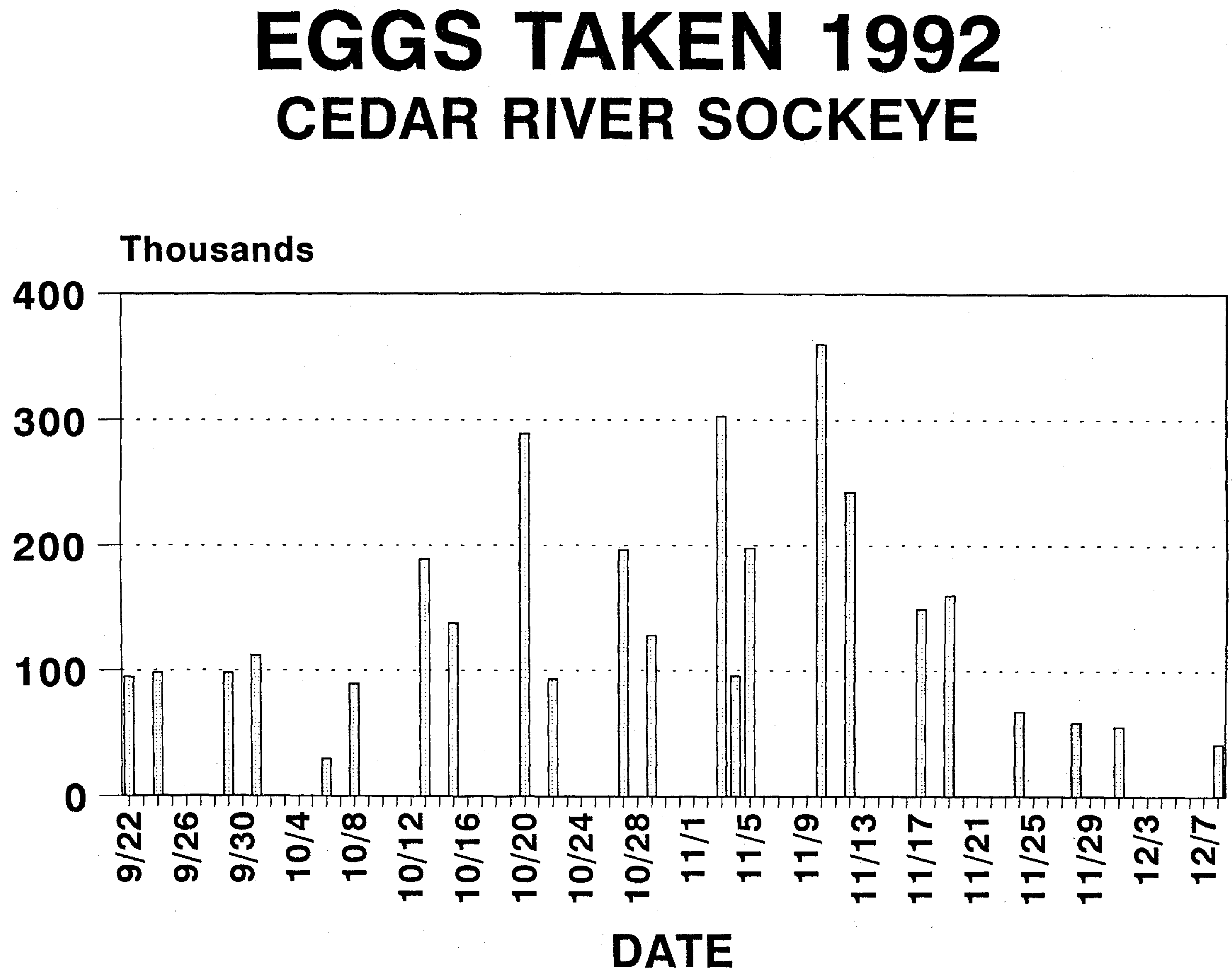

EGGS TAKEN 1992
CEDAR RIVER SOCKEYE
Thousands
400
300
200
100
0
9/22
9/26
9/30
10/4
10/8
10/12
10/16
10/20
10/24
10/28
11/1
11/5
11/9
11/13
11/17
11/21
11/25
11/29
12/3
12/7
DATE

Figure 3

1991 BROOD FRY RELEASES
CEDAR RIVER SOCKEYE

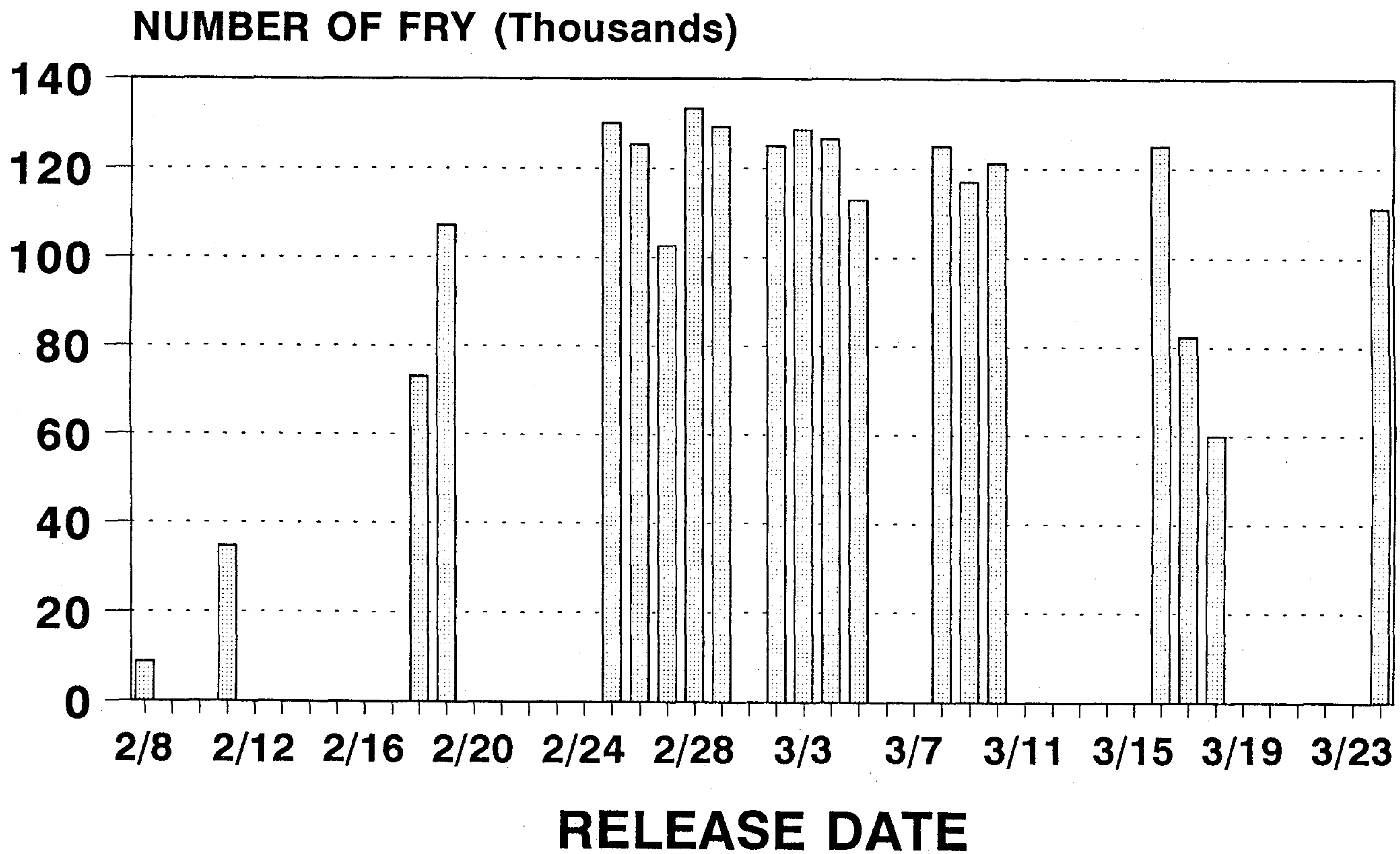


Figure 4

1992 BROOD FRY RELEASES
CEDAR RIVER SOCKEYE

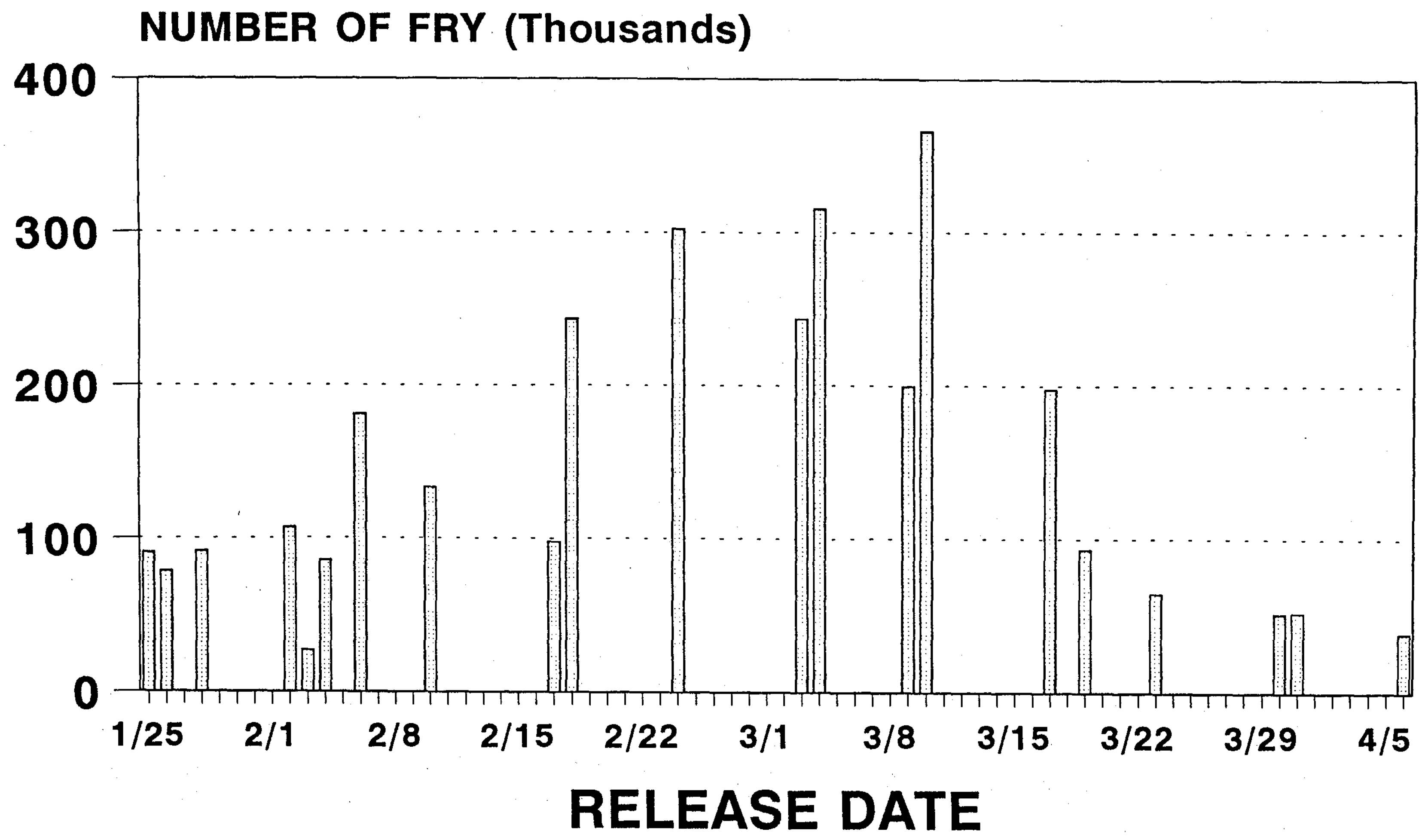


Figure 5

TOTAL EGG TAKE/FRY RELEASE
CEDAR RIVER SOCKEYE

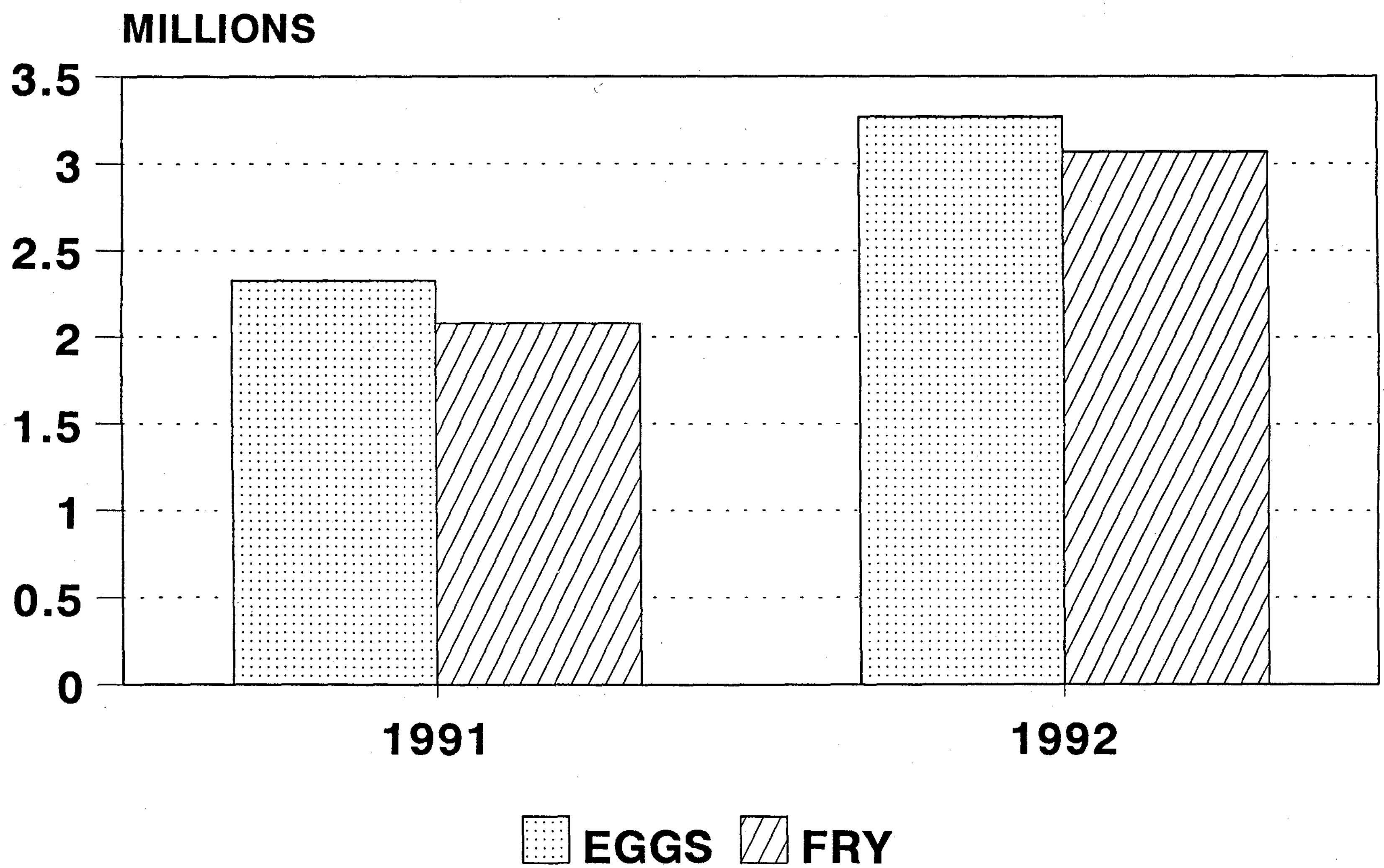


Figure 6

EGG TO FRY SURVIVAL
CEDAR RIVER SOCKEYE

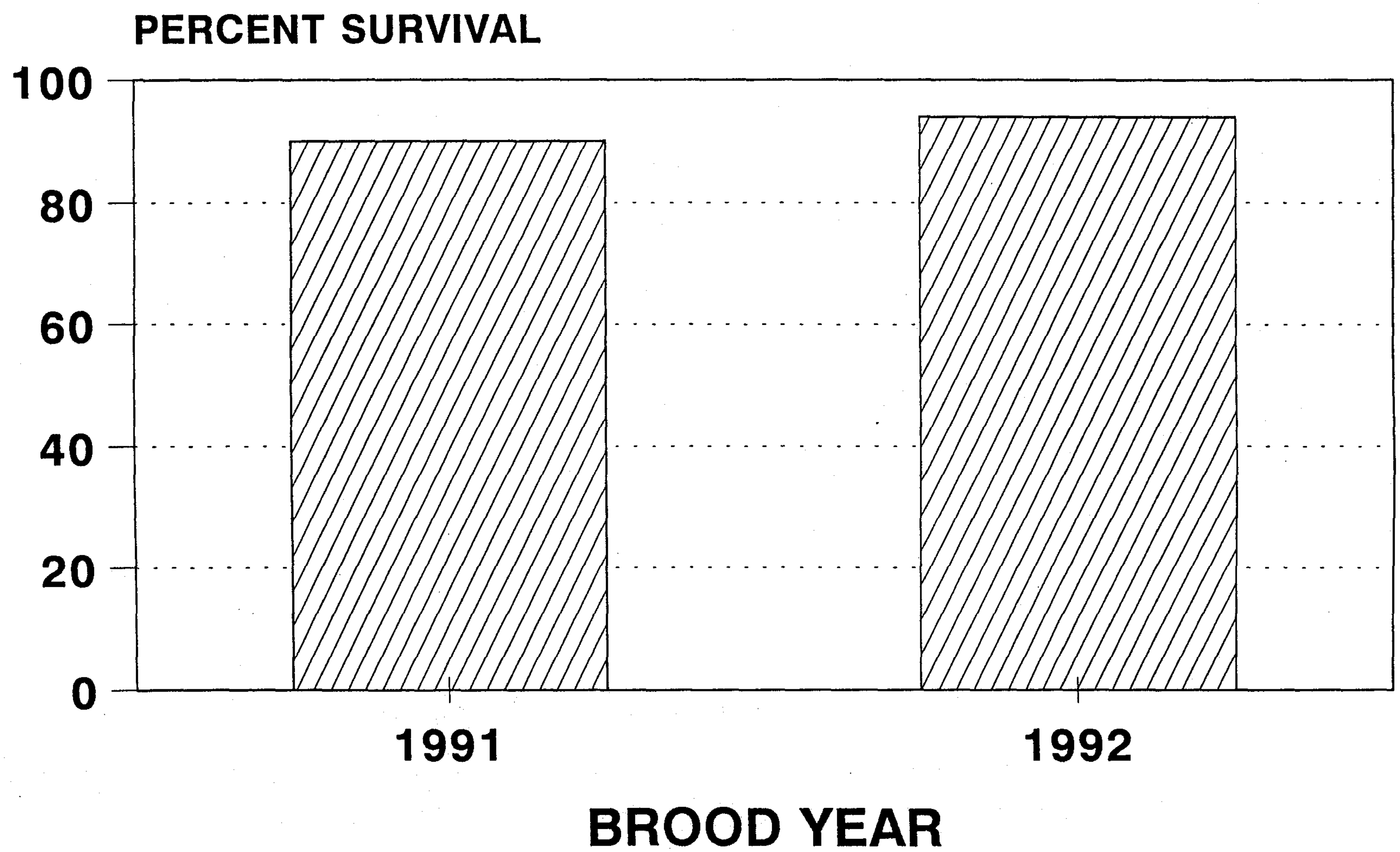


FIGURE 7

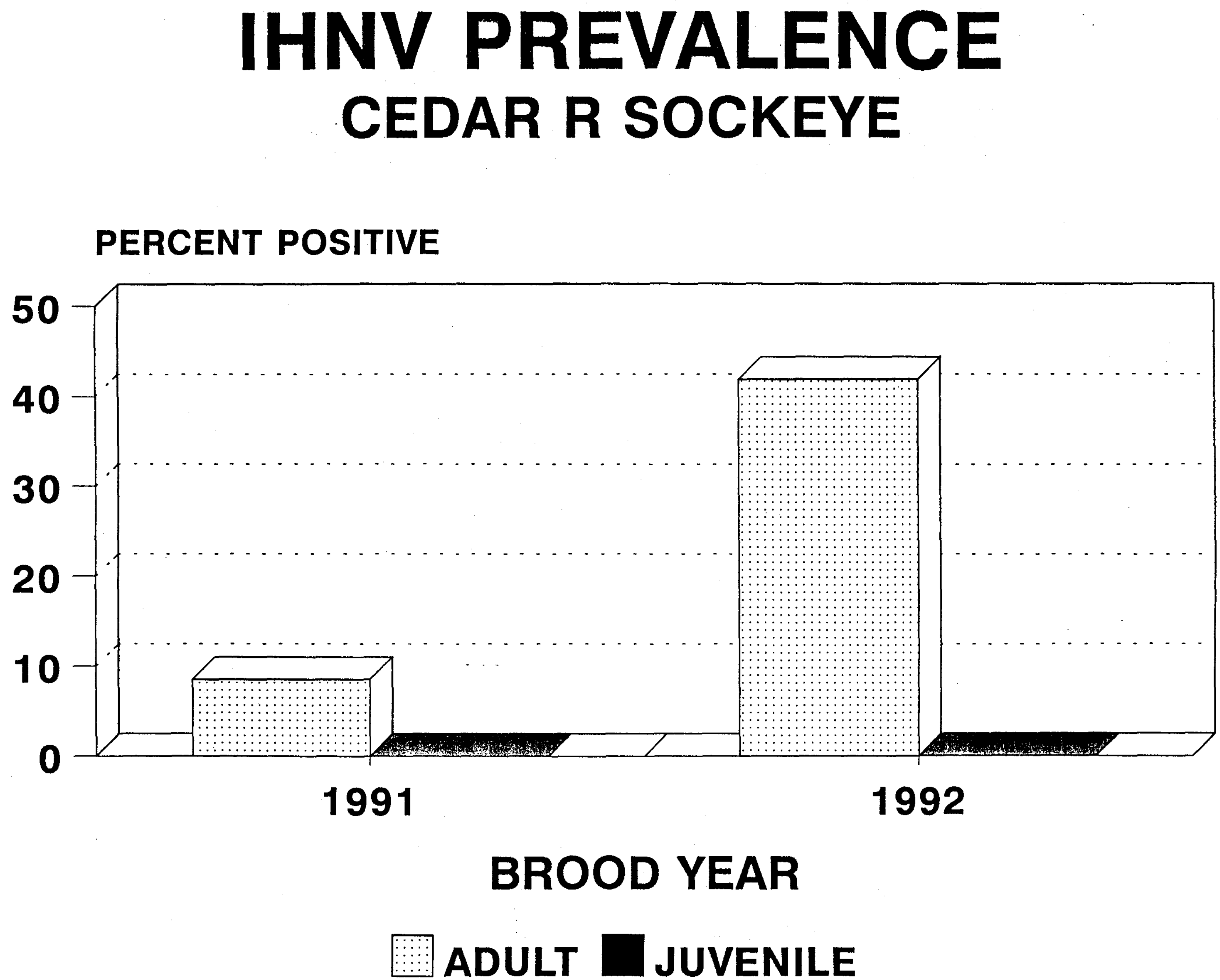

IHNV PREVALENCE
CEDAR R SOCKEYE
PERCENT POSITIVE
50
40
30
20
10
0
1991
1992
BROOD YEAR
ADULT
JUVENILE

Figure 8

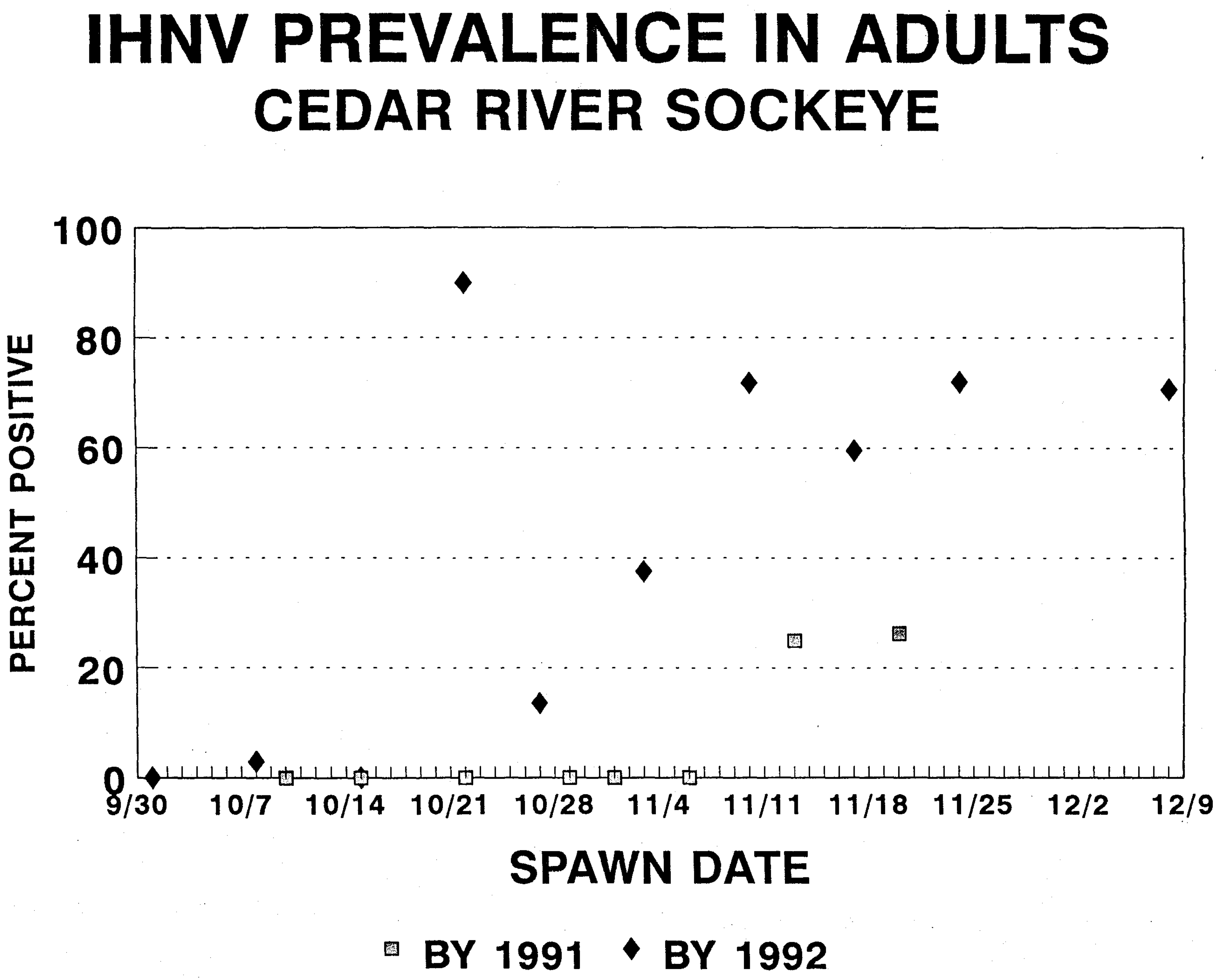

IHNV PREVALENCE IN ADULTS
CEDAR RIVER SOCKEYE
PERCENT POSITIVE
100
80
60
40
20
0
9/30
10/7
10/14
10/21
10/28
11/4
11/11
11/18
11/25
12/2
12/9
SPAWN DATE
BY 1991
BY 1992

Figure 9

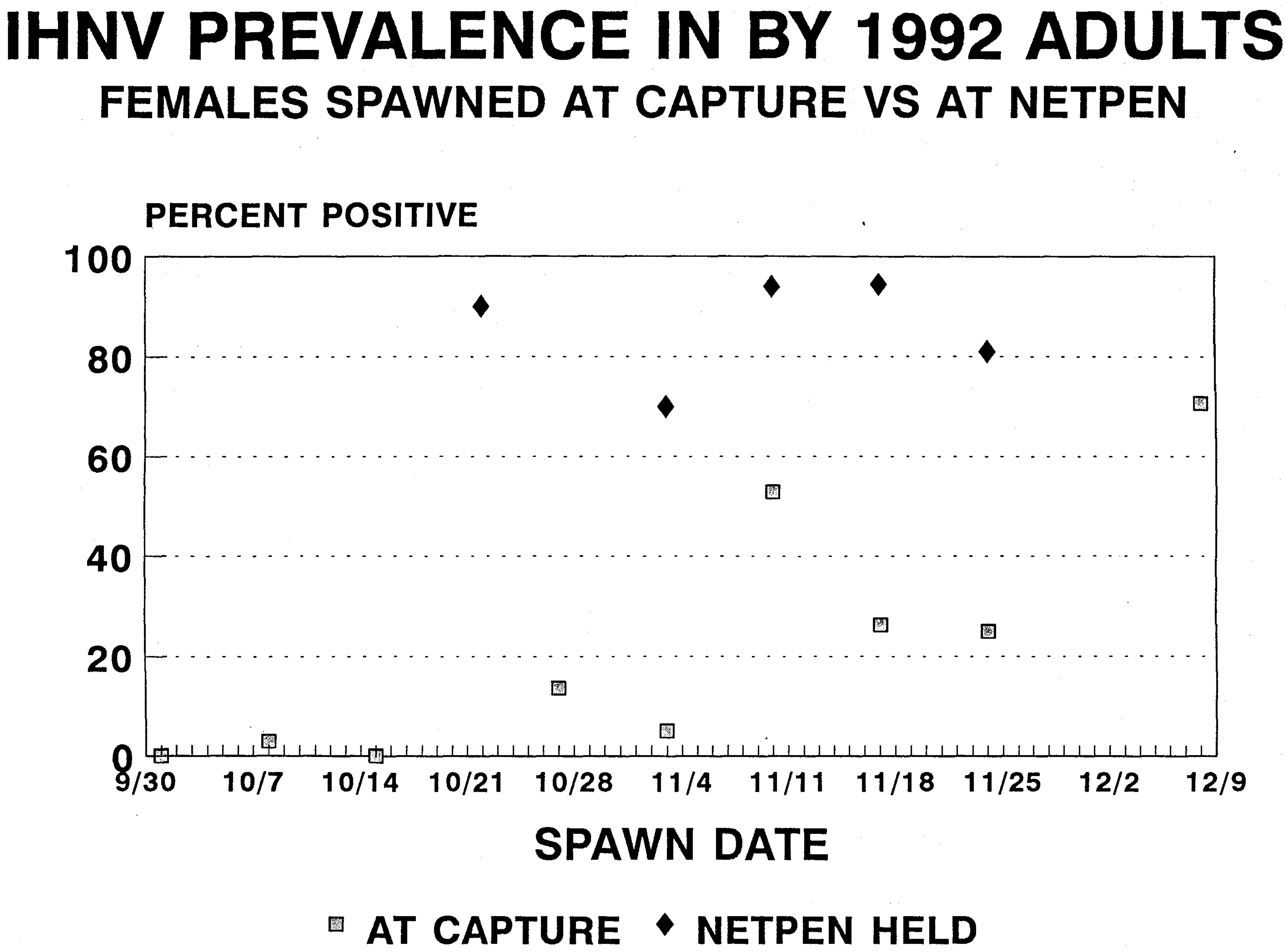
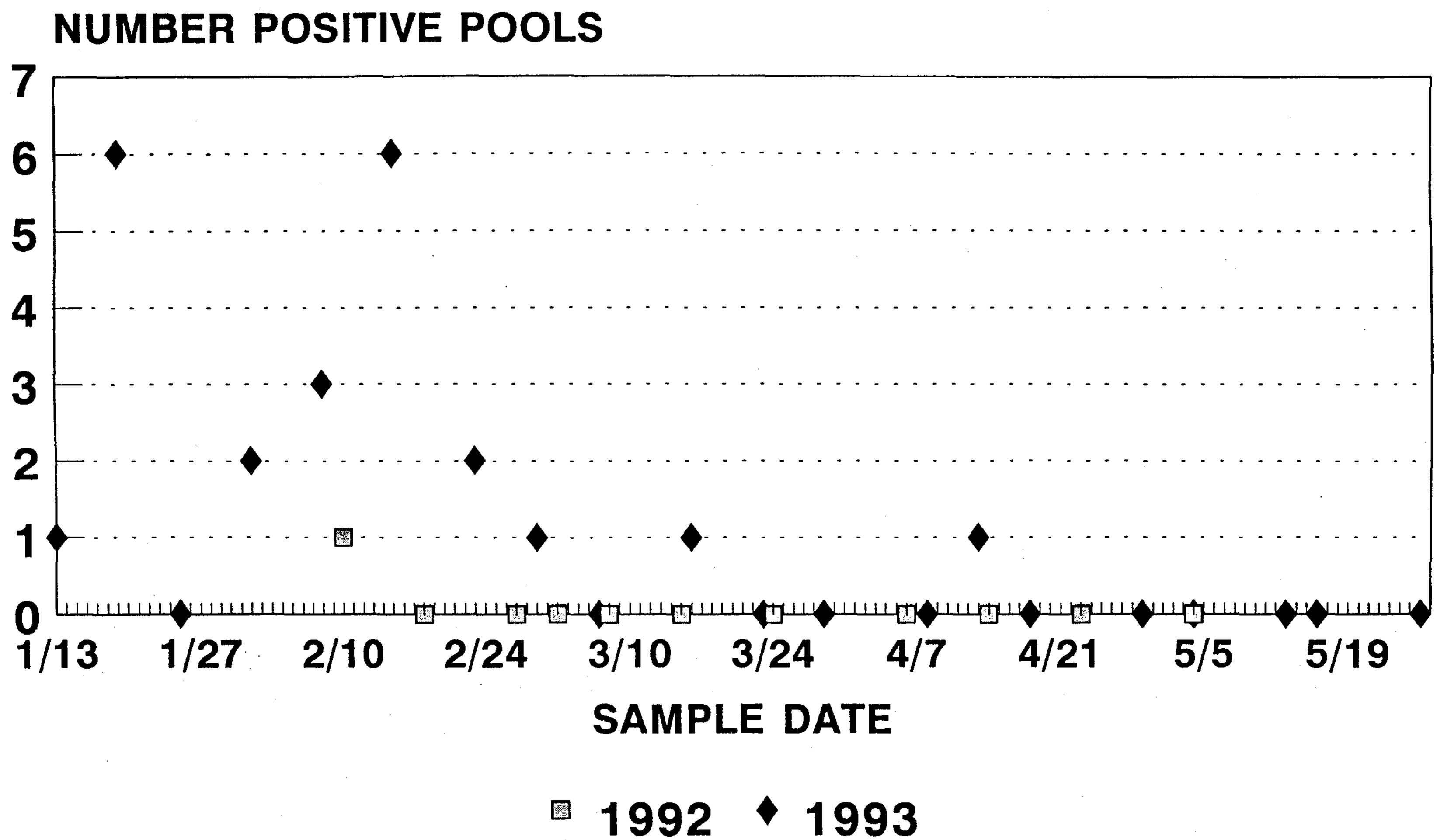

IHNV PREVALENCE IN BY 1992 ADULTS
FEMALES SPAWNED AT CAPTURE VS AT NETPEN
PERCENT POSITIVE
100
80
60
40
20
0
9/30
10/7
10/14
10/21
10/28
11/4
11/11
11/18
11/25
12/2
12/9
SPAWN DATE
AT CAPTURE
NETPEN HELD

Figure 10

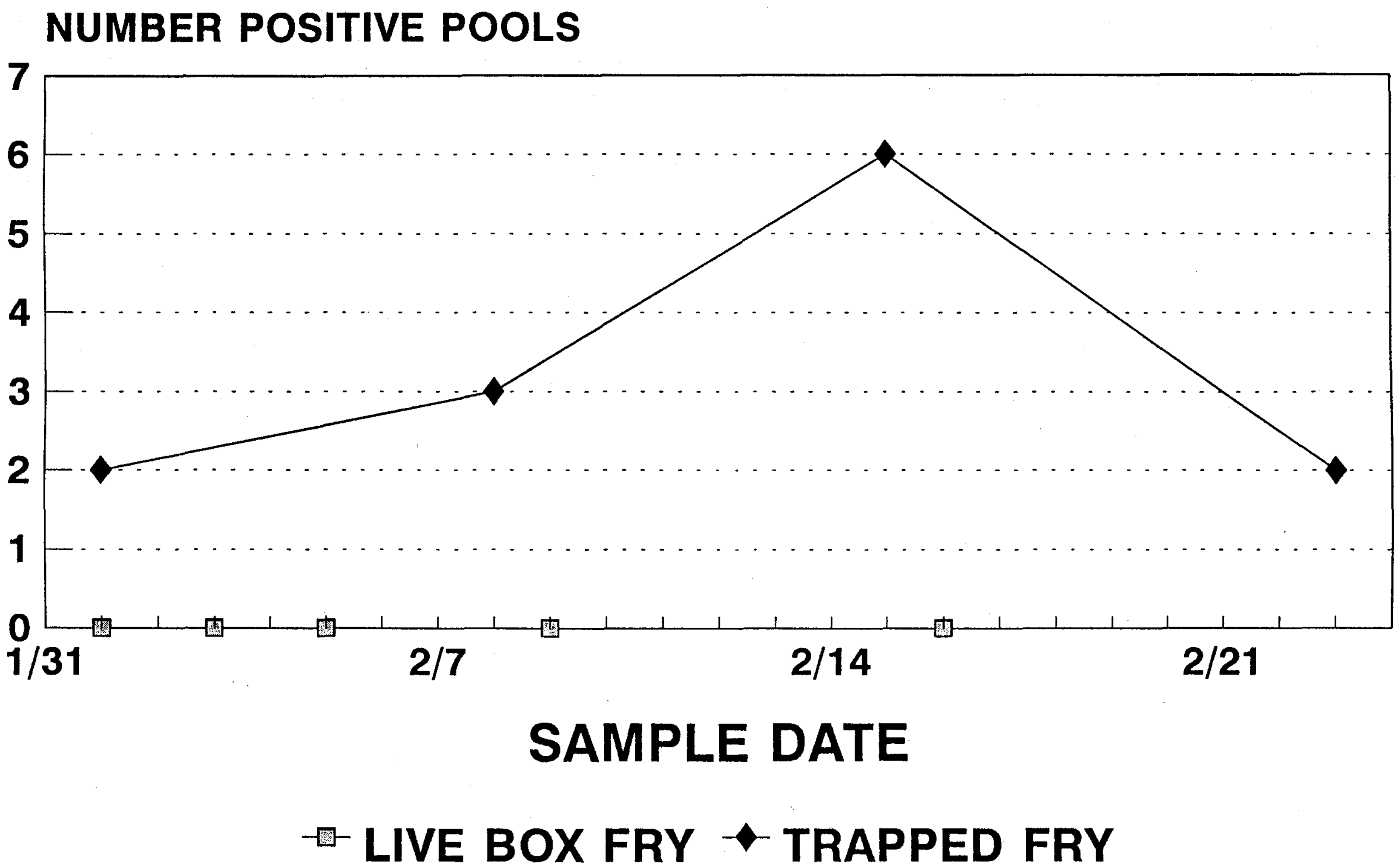
IHNV FINDINGS IN MIGRATING FRY
CEDAR RIVER SOCKEYE



Approximately 20 pools tested at each sample date.
Fish processed in 5 fish pools.

Figure 11

HATCHERY FRY IN LIVE BOX VS FRY FROM TRAP
CEDAR RIVER SOCKEYE



Live box - 12 pools/sample, trapped fry - approximately 20 pools/sample
Fish processed in 5 fish pools.

Figure 12

Consequences of and Solutions to Early Fry Release Timing in Virginia Lake

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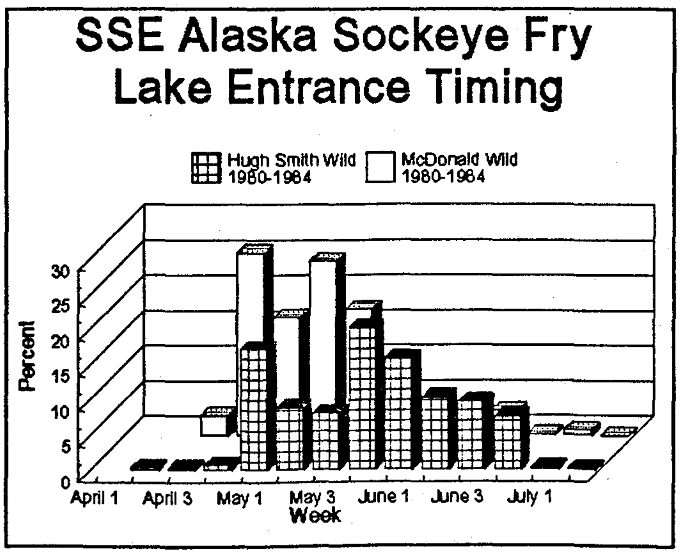
Virginia Lake is located on the mainland, 15 km east of the City of Wrangell in Southeast Alaska. It has a surface area of 260 hectares (643 acres), a maximum depth of 54 m, a mean depth of 27.5 m, and an elevation of 32 m. The lake is typical of many Southeast Alaska lakes. It is a clear lake with some slight seasonal glacial influence during extended warm dry periods.

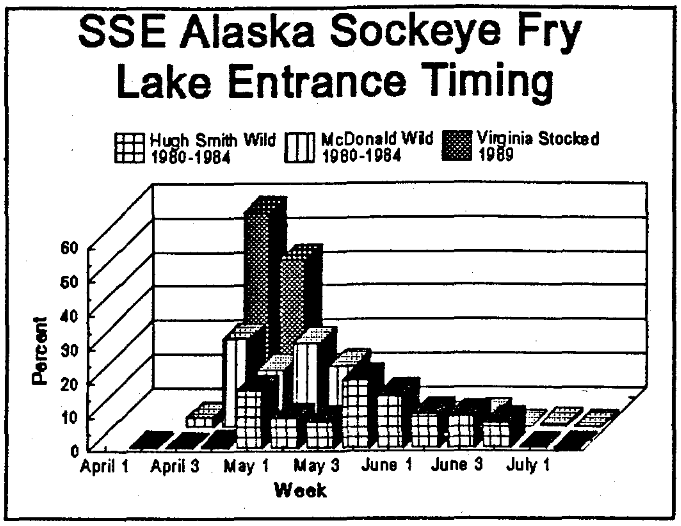
Historically, the system had a very small population of anadromous sockeye. The outlet stream had a flow limiting barrier which barred access to the lake except during periods of specific discharges associated with the proper tide levels. In the years just prior to the project, the entire run was estimated to be less than 100 fish. No other anadromous fish were found in the lake, but resident fish populations of cutthroat trout, dolly varden, kokanee, stickleback, and cottids were present.

In 1988, the U.S. Forest Service constructed a fish pass into the system to allow unimpeded access to the lake and stream habitat. In an attempt to increase utilization of the newly accessible habitat, a sockeye salmon enhancement program was initiated in which a second sockeye stock was used to supplement the small natural run. This was a cooperative project involving ADF&G, SSRAA, USFS, and the S.E. Alaska Gillnetter's Association of Wrangell. Eggs were taken from a wild brood source in 1988 at McDonald Lake, incubated at the SSRAA Beaver Falls Central Incubation Facility (CIF), and planted into Virginia Lake in 1989.



Sockeye planting densities were calculated using a Euphotic Volume Model developed by Koenings and Burkett (1987). Based on this model Virginia Lake was estimated to have a spring fry capacity of 2.15 million sockeye.

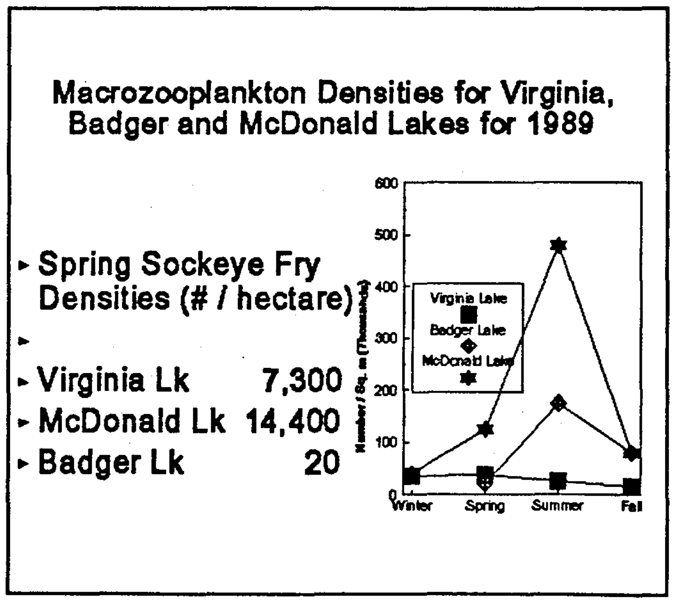
Studies of several S.E. Alaska lakes have shown that wild sockeye fry enter lakes from early April to early July with the peak migration around mid-May.



In 1989, due to warm climactic and water conditions at the Beaver Falls CIF, the sockeye fry emerged earlier than expected. There were no holding or short-term rearing facilities in existence which could hold the fry until the desired release time. Due to this lack of rearing space, 1.9 million sockeye fry were planted in Virginia Lake on 28 April and 2 May 1989.

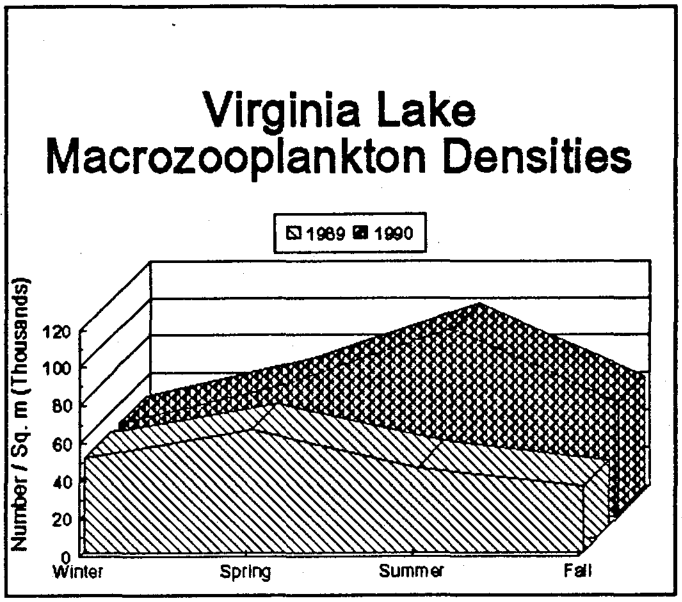
Pre-stocking zooplankton densities were similar to other lakes in early spring. There were few planktivores (kokanee, sockeye, steelhead) in the lake prior to planting.

After the fry were planted, the normal increase in zooplankton densities that usually occur in mid to late May did not occur. Instead the zooplankton densities declined immediately. The zooplankton population did not recover and went into the fall season at very depressed levels. This resulted in poor growth rates and overall planted fry to smolt survival of 3.4%.



In order to correct the problems of low zooplankton densities and poor fry survival, it was decided that fry densities would be reduced for the 1990 fry plant (eggs had already been taken). Fry emergence was later than 1989 which provided a more suitable release timing. 888,800 emergent fry were planted on 18 May 1990.

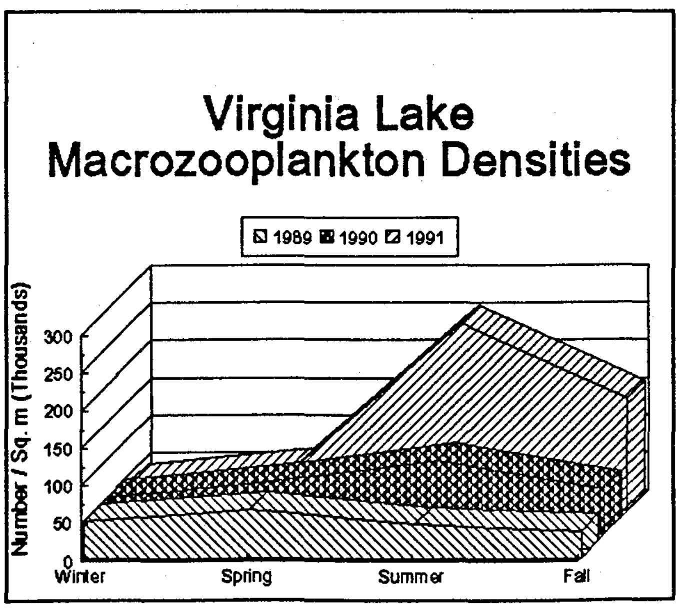
With this change, a small positive result in increasing zooplankton densities occurred which did increase slightly through mid-summer as expected. The fry to smolt survival was still only

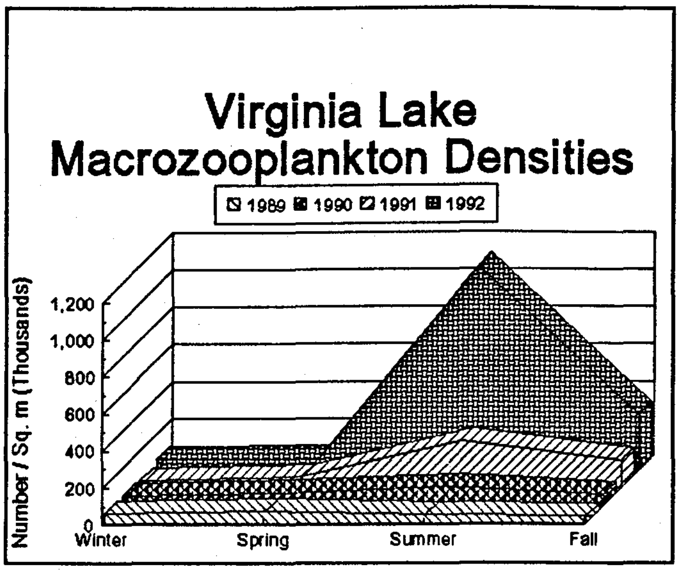


4.9% - even with the much lower density.

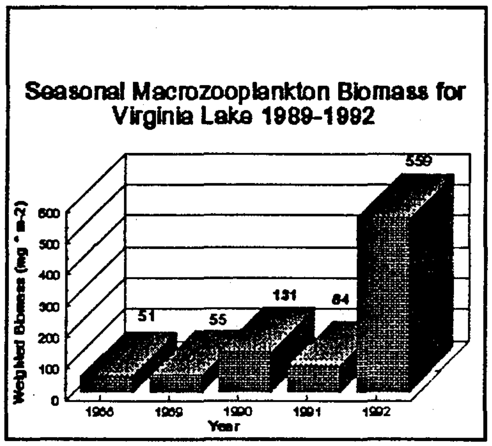
At this time our thoughts were to not stock sockeye fry in 1991; to let the zooplankton rebound and start over again. A second idea was to develop a short-term rearing facility at the Beaver Falls CIF to further delay release timing. And still a third idea was to fertilize the lake to stimulate zooplankton production. A combination of short-term rearing and a spring through early summer lake fertilization program was decided to be the most feasible way to approach this zooplankton dilemma.

The 1991 fed fry plant of 736,753 was made on 3 July. 2,640 gallons of 20-5-0 and 1,080 gallons of 32-0-0 liquid fertilizer (total of 40,920 lbs or 18,578 kg) was applied bi-weekly between 17 May and 23 August 1991. Zooplankton populations responded to the fertilization and later release timing. Planted fry to smolt survival was 10.7%.

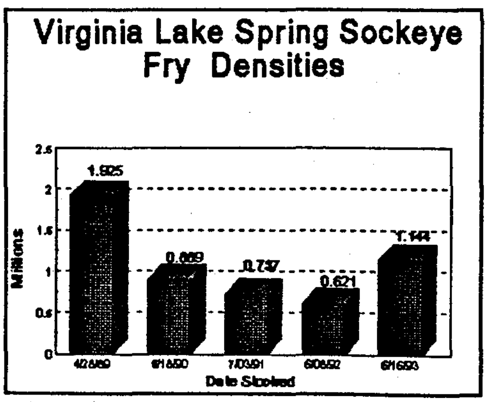




The 1992 plant of 620,800 fed fry was on 8 June 1992 in conjunction with an increased fertilizer application of 4,320 gallons (21,574 kg) of 20-5-0 applied bi-weekly from 23 May to 17 August. A major increase in zooplankton densities occurred with an enhanced zooplankton population going into the fall and winter months. After this years results it was decided to continue the same program combination through the summer of 1994.



In 1993 the sockeye fry plant was increased to 1,144,572 fed fry with a late release on 16 June. The fertilizer was increased to 7,490 gallons (37,450 kg) with a combination of 32-0-0 and 20-5-0 used. With the perfect climactic conditions which prevailed during the summer of 1993 the lake ecosystem should have had maximum benefit from the nutrient additions. The limnological and fisheries data for 1993 has not been finalized. The first adult returns from stocking were enumerated in 1993. The escapement count from one survey was estimated at 2,000 sockeye. With normal harvest rates of 50% the marine survival on the first group of introduced sockeye is approximately 21%. This survival rate appears to follow the other sockeye systems in SE Alaska which we evaluate. We plan to fertilize one more year and bring the fry densities back to 2 million in 1994. The wild Fl fry recruitment for 1994 should be about 300,000 and 1.75 million sockeye eggs were also taken from McDonald Lake.



In conclusion, there are two criteria which we must adhere to in fry planting programs; the obvious one of planting at densities which to zooplankton forage base support, and the second, not so obvious criteria of planting at a time when natural zooplankton populations are increasing.

Literature Cited:

Koenings, J.P. and R.D. Burkett. 1987. The production patterns of sockeye salmon (*Oncorhynchus nerka*) smolts relative to temperature regimes, euphotic volume, fry density, and forage base within Alaskan lakes. *In:* H.D. Smith, L. Margolis, and C.C. Woods [eds.] Sockeye salmon (*Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish Aquat. Sci. 96 p.

SPIRIDON LAKE - KODIAK ISLAND, ALASKA

SOCKEYE SALMON DEVELOPMENT

by

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ABSTRACT

Spiridon Lake is the third largest lake on Kodiak Island. A series of cascading falls on the lake outlet creek prevents access to anadromous fish. Since the 1970's, there has been interest in enhancing Spiridon Lake with sockeye salmon (*Oncorhynchus nerka*); however, not until the recent completion of Pillar Creek Hatchery has the potential existed to consider a stocking project. Lake investigations began in the fall of 1987 to determine the rearing potential for sockeye salmon in Spiridon Lake. In addition, sampling was conducted to determine the mortality of smolts negotiating the falls on the lake outlet, and site surveys were conducted to determine the possibility of bypassing smolt around the falls area. The results of these investigations indicated that Spiridon Lake could support an estimated 11 million sockeye salmon fry, and due to significant falls mortality, a smolt bypass system would be necessary. Stocking began in 1990 and a smolt bypass system on the lake outlet was constructed in 1991 and 1992. Although this lake is capable of supporting 11 million fry, a gradual approach to stocking has been recommended. This will ensure maintenance of a macro-zooplankton community capable of supporting a long-term stocking project.

BACKGROUND

Spiridon Lake, located on the west side of Kodiak Island, is the third largest lake on the island (Figure 1). The lake lies at an elevation of 136 m above sea level. It is 9.6 km long; its greatest width is 1.6 km, and its total surface area is nearly 9.2 x 10^6 m^2 (Figure 2). It has relatively little shoal area and has a maximum depth of 82 m. The water is clear and it is a typical oligotrophic system. Spiridon Lake does not have anadromous fish because there is a series of cascading falls on the lake outlet.

Lake investigations began in the fall of 1987 to determine the rearing potential for sockeye salmon in Spiridon Lake. In 1988-1993, limnological data was collected from the lake, and the system was stocked with sockeye salmon fry from 1990-1993. The eggs were originally from the late-run Upper Station Lake sockeye salmon. A smolt bypass system was built in 1991 and 1992 to pass fish around the outlet falls. The bypass consists of 36 m smolt weir and 756 m long by 15 cm diameter pipeline. The pipeline drops approximately 90 meters in elevation over the length and does not exceed 20° drop in any location.

METHODS

Lake limnology samples were collected, as described by Koenings *et al.* (1987), from each of two stations during four sampling periods. In 1990-1993, a total of 0.2, 3.5, 2.2 and 4.3 million sockeye

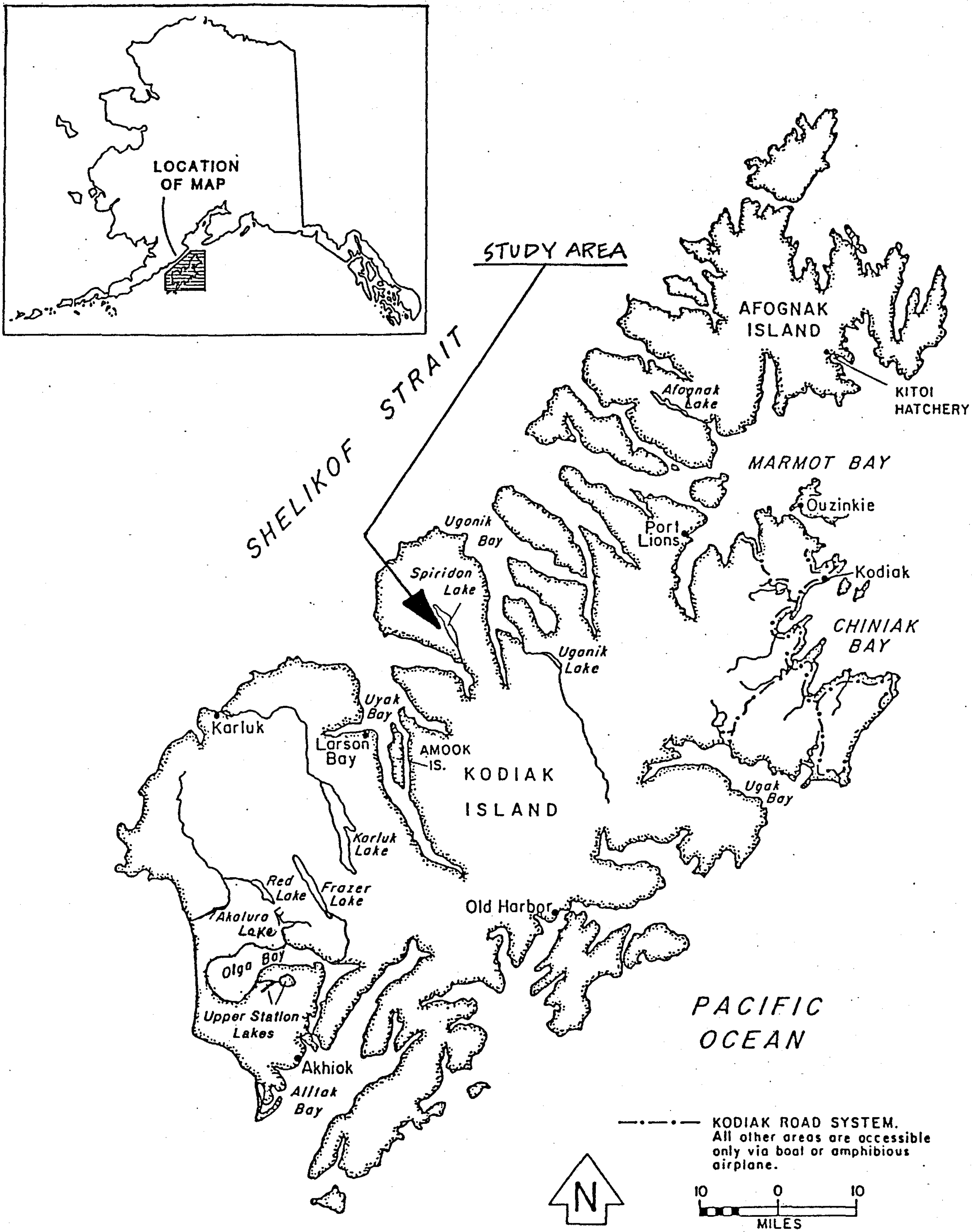

FIGURE 1. Location of Spiridon Lake Sockeye Development Project Study Site, Kodiak Island.

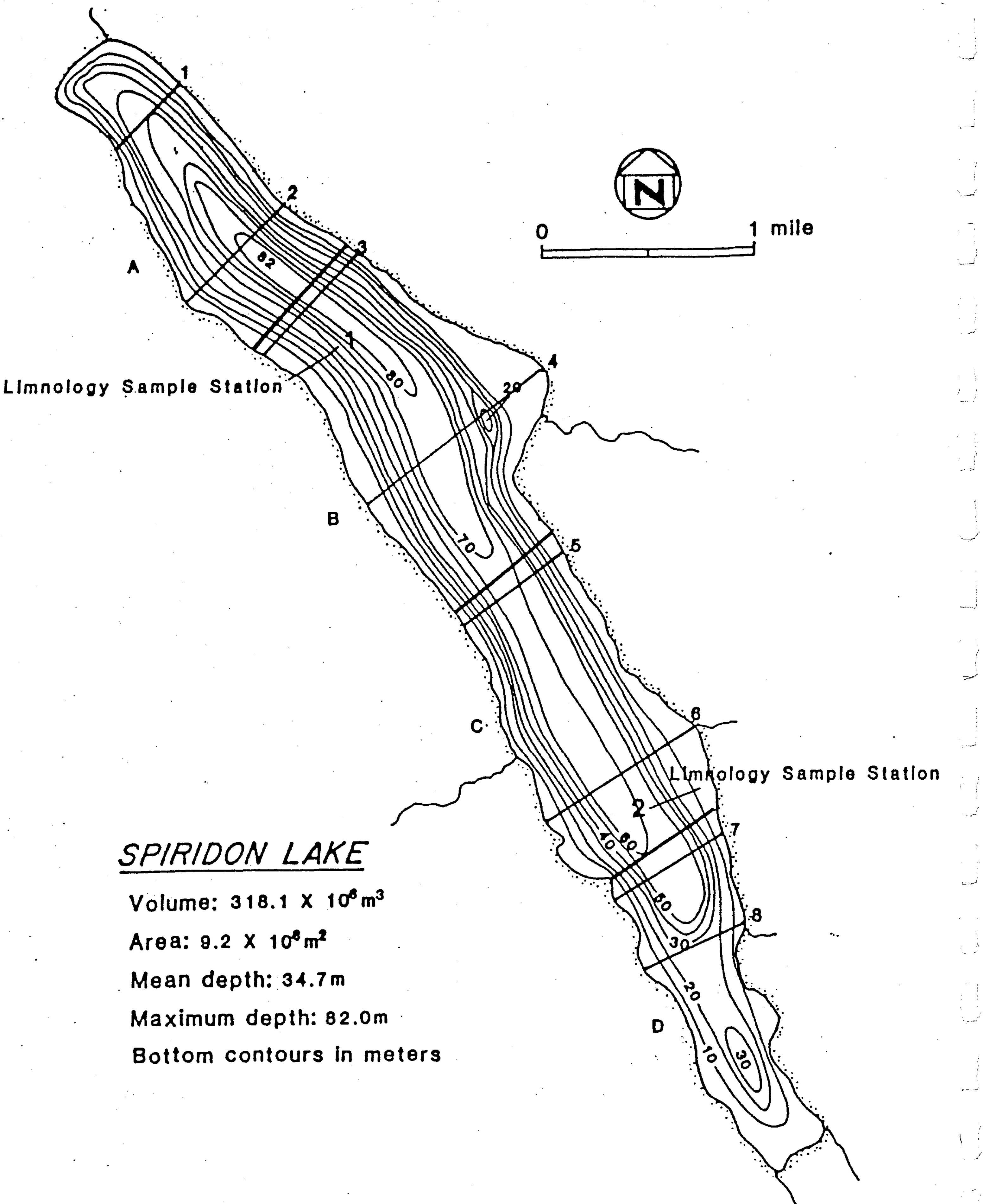

FIGURE 2. Bathymetric map of Spiridon Lake showing location of the limnological sampling stations, hydroacoustic areas (A-D) and transects (1-8).

salmon fry were transported in an aluminum tank mounted in an amphibious-equipped Beaver aircraft with oxygen provided. The fish were released into the lake at separate points along the lake shore.

Age, length and weight measurements were made of smolt as they migrated through the bypass system. Smolts were anesthetized using MS-222, measured, (mm, FL) weighed (0.1 g), and scale samples taken.

The smolt population size was estimated from daily enumeration from the bypass system. In 1992, smolt were weight sampled through the system. In 1993, they were estimated by twice hourly subsamples during the major migration hours 0000 hour to 0500 hour.

RESULTS

The seasonal mean of macro-zooplankton density in Spiridon Lake ranged from 244,963 (Station 2) to 508,000 (Station 1) organisms/m^2 from 1988-1993 (Table 1). The zooplankton community was characterized by a high percentage of copepods (Figure 3). *Bosmina sp.* body sizes substantially exceeded the 0.40 mm threshold size for elective consumption by sockeye fry (Koenings and McDaniel, 1983) for all years (Table 2).

A total of 596, 1,403 and 735 smolt were sampled in 1991-1993 (Table 3).

TABLE [illegible]:

Seasonal mean macrozooplankton density (no./m^2), and weighted biomass (mg/m^2), in Spiridon Lake, 1988-1993.

	Station 1		Station 2	
Year	No./m^2	Mg/m^2	No./m^2	Mg/m^2
1988	266,123	890	244,963	823
1989	481,317	990	450,159	821
1990	422,718	1,259	318,949	990
1991	508,000	1,220	458,656	1,099
1992	300,093	1,044	339,745	1,019
1993	370,966	979	327,654	555

FIGURE 3.

Cladoceran and copepod mean density and percent composition for Spiridon lake, 1988-1993.

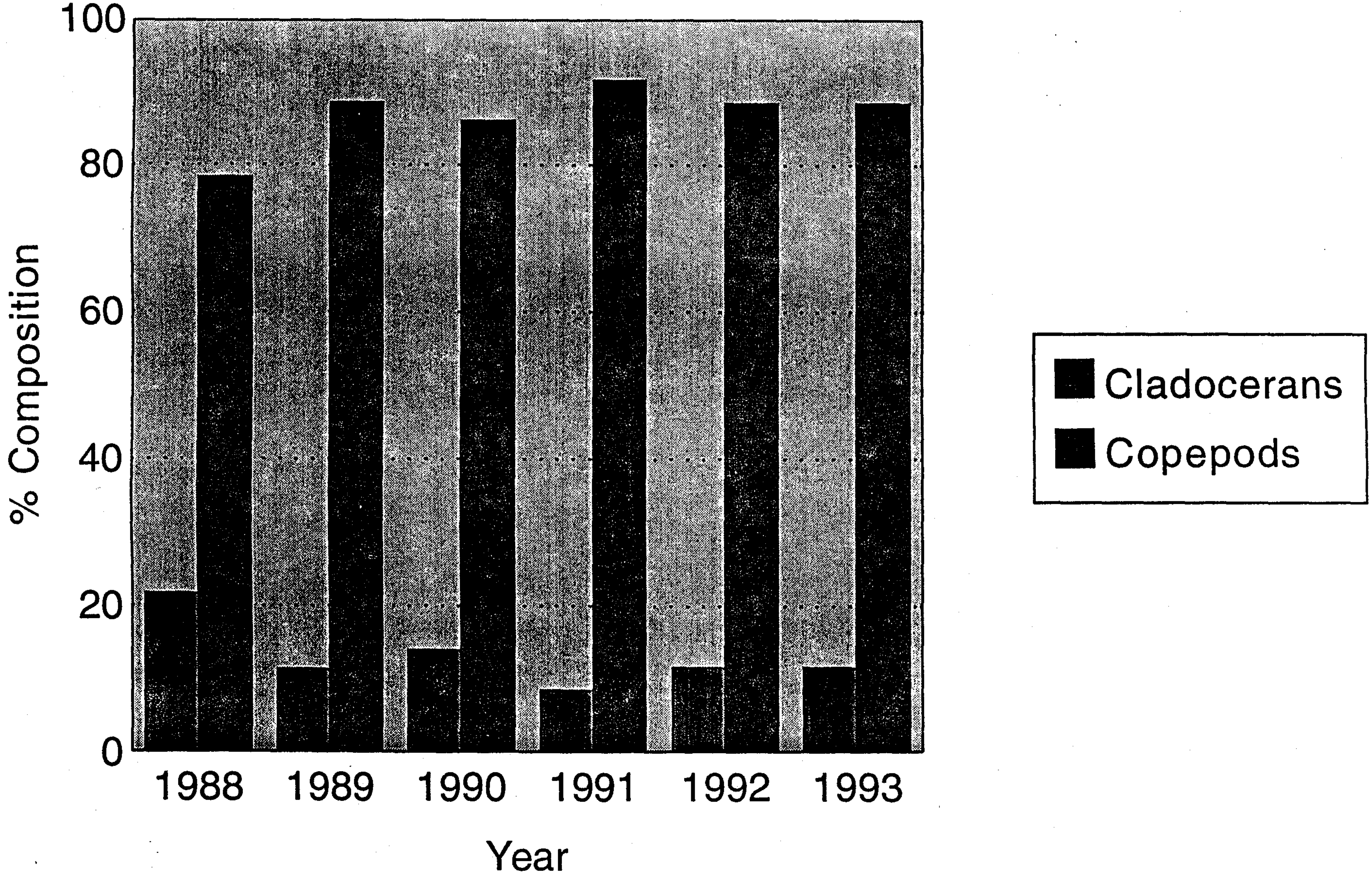

TABLE 2.

Bosmina sp. seasonal weighted mean length (mm) for stations 1 and 2 and both stations combined in Spiridon Lake, 1988-1993.

Year	Station 1	Station 2	Both Stations
1988	0.62	0.59	0.61
1989	0.56	0.56	0.56
1990	0.57	0.6	0.59
1991	0.56	0.56	0.56
1992	0.59	0.61	0.60
1993	0.53	0.52	0.53

TABLE 3.

Age composition, weight, length and condition coefficient of sockeye salmon smolt from Spiridon Lake, 1991 - 1993.

Year	Sample Size	Age	Age (%)	Weight (g)	Length (mm)	Condition (k)
1991	596	1	100.0	19.3	127	1.08
1992	1389	1	98.9	12.7	115	0.81
	14	2	1.1	58.9	183	0.80
1993	493	1	66.8	13.4	116	0.83
	240	2	33.0	33.8	155	0.88
	2	3	0.2	50.7	178	0.90

Age composition shifted from 98.9% age-1 in 1992 to 66.8% age-1 in 1993. Age-2 comprised 33.0% in 1993. Migrants were large with age-1 smolt 12.7 g, 115 mm in 1992 and 13.4 g, 116 mm in 1993.

The population of smolt in 1992 and 1993 was estimated at 1,484,000 and 353,000, respectively (Table 4). Bypass mortality is estimated at 5.9 and 4.4% for both respective years (Figure 4 and 5). The estimated smolt survival for fry stocked in 1991 was 45.3%. The first returns (≈ 3,500) to Spiridon, below the falls, occurred in 1993. Of 196 sampled on September 3 for age data, 98% of the sockeye salmon were 1.1 fish (Table 5).

DISCUSSION

The smolt were very large for age-1.0 fish. They were larger than Karluk age-3.0 smolt, which are the largest smolt on Kodiak Island. The Spiridon smolt are also robust as indicated by the mean condition factors. The favorable rearing conditions in this barren lake and resultant large smolt are similar to the pattern observed at nearby Frazer Lake in the 1970's (Kyle *et al.* 1988). Frazer Lake was also a barren system to anadromous fish until it was stocked in 1951 and now supports a major fishery in Olga Bay.

At Spiridon, the first adult sockeye salmon returns were observed below the falls on August 3, 1993. A total of 3,500 sockeye salmon were estimated below the falls. The age sample shows the majority of the fish were age-1.1 "jacks". It is interesting to note that

Table 4. Number of sockeye salmon fry stocked, smolts produced and fry to smolt survival for Spiridon Lake, 1990 -1993.

Fry Stocking Year	Fry Stocked (millions)	Smolts Produced (millions)				Fry to Smolt Survival (%)
		Age 1	Age 2	Age 3	Total	
1990	0.2	\a	0.016	0.007	0.023 \b	\b
1991	3.5	1.468	0.116	\c	1.584	45.3 \b
1992	2.2	0.235	\c	\c	0.235	10.7 \b
1993	4.3	\c	\c	\c	\c	\c

\a population estimate not available.

\b incomplete brood year data.

\c smolt of this age have not migrated.

FIGURE 4.

Five day sockeye smolt catch, and bypass system mortality for Spiridon Lake, 1992.

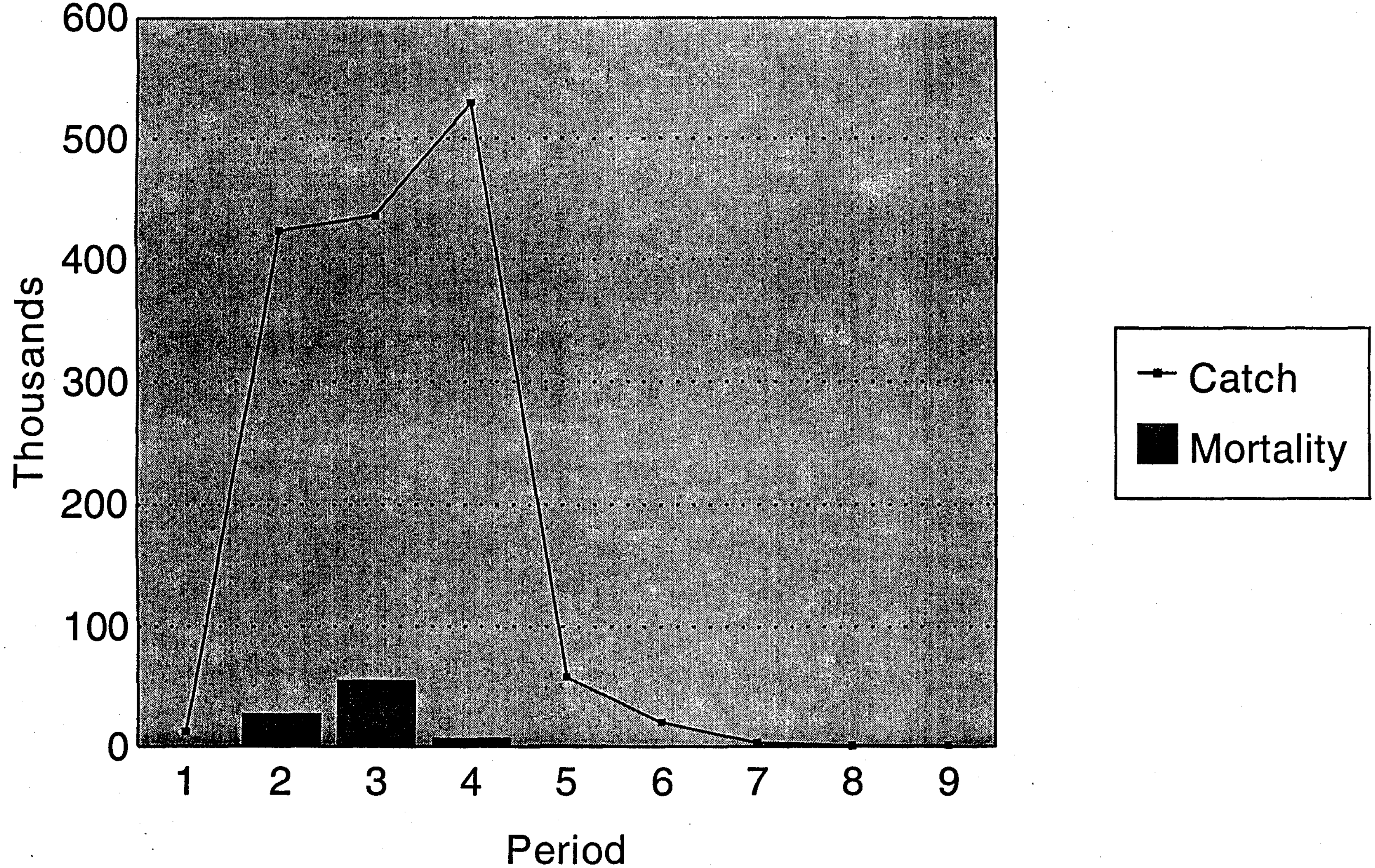

FIGURE 5.

Five day sockeye smolt catch, and bypass system mortality for Spiridon Lake, 1993.

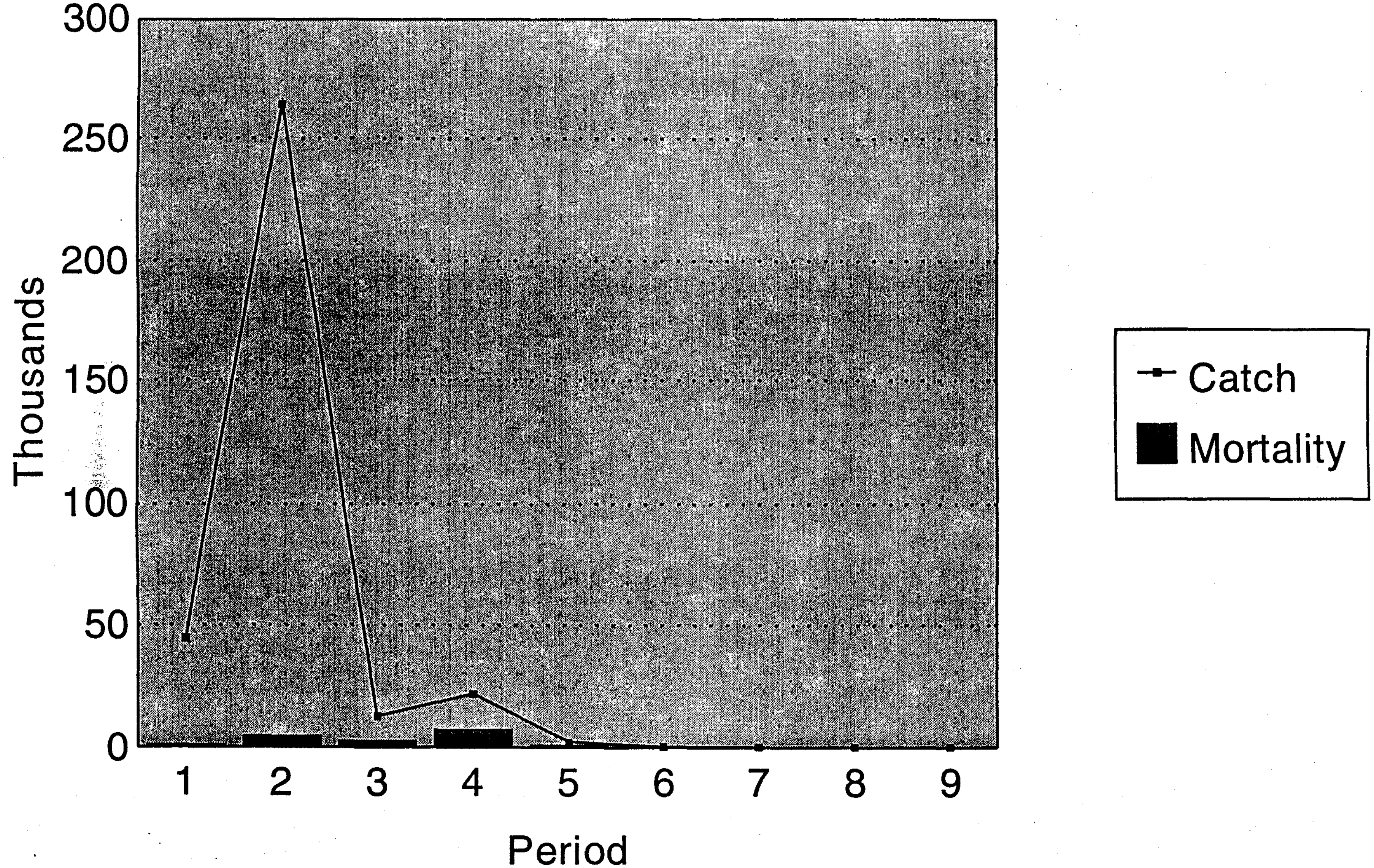

TABLE 5.

Estimated age composition of the Telrod Cove (Spiridon) sockeye salmon escapement samples by week, 1993.

		Ages			
Week		1.1	1.2	2.1	Total
36	Number	192	3	1	196
	Percent	98.0%	1.5%	0.5%	100.0%

few adult fish have been observed from the 1990 plant of 0.2 million. This data confirms earlier findings that the falls can induce heavy mortality on smolt.

Based on the smolt migration in 1992 and the jack returns in 1993, we are projecting ~100,000 - 150,000 adult sockeye salmon for the commercial fishery in 1994. Forecasting returns is difficult at this point, since a history has not been developed.

The small smolt migration observed in 1993 is somewhat of a disappointment. However, the parent stock for this year class were predominately (70%) two fresh water check fish. We may witness more two check fish in the 1994 smolt migration.

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LAKE WENATCHEE SOCKEYE

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The information I am presenting was provided by Bill Duplaga and Kathy Hopper. The chart on the following page is the same as presented at the 1991 meeting with results added for the last two years.

This is a mitigation program which has remained basically unchanged since its initiation five years ago. Adults are collected at Tumwater dam and transported approximately 20 miles to netpens in Lake Wenatchee where they are held 3-4 months before spawning. The fish are spawned individually according to standard sockeye spawning techniques and eggs transferred approximately 50 miles to Eastbank Hatchery where they are fertilized and waterhardened in 100 ppm iodophor. They are incubated on well water in iso-buckets (4 females eggs/bucket) until eye, shocked and picked, and put into FAL isolation incubators for hatching. The numbers of eggs/stack has varied depending on space available but generally has been 7-8000/tray or approximately 60,000/stack of eight trays. At emergence the fry are transferred to the netpens in Lake Wenatchee.

Target release size has been 20 fpp (23 g) in the past but basically the fish were held for as long as weather permitted in the fall. The fish then overwinter in the lake. At outmigration the hatchery fish have been larger than the wild smolts so this year releases are being split to determine effects of release size on survival.

	DATE	RELEASE NO.	SIZE (FPP)	SIZE (GRAMS)
EARLY	8/13	71,457	108	4
MIDDLE	9/7	135,200	64	7
LATE	10/26	133,900	24	19

The adult fish are sampled each year for IHNV and positive findings have been sporadic: 1989 positive, 1990 positive, 1991 negative, 1992 negative, 1993 negative. There has been no IHNV detected in the juveniles.

With the juveniles the main problem has been warm lake temperatures causing losses due to columnaris. This was treated with oxytetracycline medicated feed for 14 days. The adults have had very high losses some years, primarily caused by columnaris and fungus exacerbated by high water temperatures and handling. In the future plans are to inject the fish with oxytetracycline at the trap to prevent columnaris. Will also continue erythromycin injection as close to spawning as feasible for control of BKD.

This was the first year of adult returns from hatchery fish. Of the adults collected for the netpens 31/316 were hatchery fish. The fish were checked by scale analysis at the pens and fish identified as hatchery returns were excluded from the eggtake. A total of 37,312 fish returned to the lake and preliminary results from the creel census confirms that 10% of the returns are hatchery fish. The 1989 release included progeny from IHNV positive adults culled from the NMFS project which more than doubled our planned releases. With a return of an estimated 3,731 adults from a release of 260,400 fish survival was 1.3%. This is considered excellent for one year class considering these fish travel 575 miles down the Columbia River past seven dams.

LAKE WENATCHEE SOCKEYE
1989 to 1993 Data
Data compiled by W.K. Duplaga

Adults	'89	'90	'91	'92	'93
Arrivals	July/Aug.	July/Aug.	July/Aug.	July/Aug.	July/Aug.
Trapping	3rd wk in July	3rd wk in July	4th wk in July	2nd wk in July	2nd wk in July
M/F Ratio	1:1.12	1:1.01	2.68:1	1:1.04	1:1.03
Ave. Wt.	3 lbs	3 lbs	3-3.5 lbs	3 lbs	3 lbs
No. Trapped	291	333	357	362	316
% Prespawn Survival	66m/41f	96m/96f	91m/92f	97m/90f	67m/58f
Females Spawned	57	150	89	163	99
Males Spawned	58	152	110	157	108
SPAWNING/INCUBATION					
Take Dates	9-26,28	9-17,24,27	9-23,25,30	9-23,28,30	9-15,20,22,
	10-2	10-1,4	10-2,6	10-5,7	27,29;10-4
M/F Ratio	1:1	1:1	1:1	1:1	1:1
Pools/incubator	2f	4f	3f	4/5f	3/2f
Incubator Type	Isolation buckets and FALs........				
Avg Eggs/Female	2600	2255	2680	2420	2420
% Loss					
Fert. to Eye	13.9	12.9	20.14	7.45	Not Avail.
Eye to Ponding	5.5	2.8	5.0	2.0	Not Avail.
Ponding to Release	1.3	1.95	3.5	1.24	Not Avail.
RELEASE					
Date	10-24-89	10-19-91	10-20-92	8-13-93	Not Avail.
				9-7-93	
				10-26-93	
No.WDF	107000	270802	167523	71457	Not Avail.
Size (fpp)	25	24	22	108	
				135200	Not Avail.
				64	
				133900	
				24	
No.NMFS	153400	101100	0	0	0
Size (fpp)	25	63			
RETURNS					
No. of Hatchery Returns in Adult Brood Collected *	no returns expected	no returns expected	no returns expected	no returns expected	31
Percent of total collected					9.8

* by scale analysis

REDFISH LAKE SOCKEYE SALMON
CAPTIVE BROODSTOCK PROGRAMS

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INTRODUCTION

In December 1991, the National Marine Fisheries Service (NMFS) listed Snake River sockeye salmon (*Oncorhynchus nerka*) as endangered under the U.S. Endangered Species Act (ESA). This action was the result of a petition presented to NMFS by the Shoshone-Bannock Tribe of Idaho. The petition requested NMFS to consider the status of these fish under the ESA. Subsequently, NMFS conducted a formal Biological Status Review for these fish. After considering the precipitous decline of this population, from a healthy status in the 1950s to few fish returning in the late 1980s, as well as the ecological significance and biological integrity of the species, the NMFS Biological Review team concluded in favor of listing (Waples et al. 1991).

NMFS is developing a formal Recovery Plan for Snake River sockeye salmon. In cooperation with the Idaho Department of Fish and Game (IDFG), the Bonneville Power Administration (BPA), and others, NMFS has begun interim recovery measures for anadromous Snake River sockeye salmon. These efforts focus on protecting the last known remnants of this stock: sockeye salmon that return to Redfish Lake in the Sawtooth Basin of Idaho at the headwaters of the Salmon River. Because of the critically low population size of Redfish Lake sockeye salmon, interim recovery measures are centered around a series of captive broodstocks to maintain the species while habitat improvements are underway (Flagg 1993, Johnson 1993).

There are several known forms of *O. nerka*. The anadromous sockeye salmon usually spends 1 to 2 years in its nursery lake remain at sea for 2 to 3 years before returning to the natal area to spawn (Foerster 1968, Groot and Margolis 1991). Two other *O. nerka* forms remain in fresh water to mature and reproduce. Residual sockeye salmon are progeny of anadromous fish and produce mostly anadromous offspring (Ricker 1938, Foerster 1968, Groot and Margolis 1991). The more distinct kokanee form appears to have diverged from anadromous stock in recent geological time and is fully adapted to fresh water (Foerster 1968, Groot and Margolis 1991). Residual sockeye salmon in Redfish Lake were included in the anadromous gene pool for ESA protection, while kokanee were excluded.

Since both anadromous and residual forms of sockeye salmon inhabit Redfish Lake along with kokanee, a continuing challenge has been to differentiate them from the kokanee in developing broodstocks. Fortunately, there are a number of mechanisms to help differentiate sockeye salmon from kokanee. First, there is both spatial and temporal separation of the two *O. nerka* forms in Redfish Lake. The anadromous and residual forms are beach spawners that spawn in the lake in late October, whereas the kokanee spawn in a tributary to the lake in early September. Also, kokanee skin and flesh may be more red at spawning than sockeye salmon maintained on the same diet (Waples 1992). This is because kokanee, which live in a carotenoid-poor environment, appear to be more efficient than sockeye salmon at utilizing carotenoid in the diet. In addition, recent investigations have indicated that anadromous and residual sockeye salmon can be differentiated from kokanee by both protein electrophoresis[1] and DNA analysis (Brannon et al. 1992). Recent information also suggests that since anadromous fish spend time in seawater, an environment rich in strontium, it is possible to distinguish the progeny of anadromous parents based on the elevated strontium/calcium ratio in the primordial core of their otoliths (Kalish 1990). All of the criteria described above are being used in helping differentiate kokanee from anadromous sockeye salmon.

This paper describes the current status of Redfish Lake sockeye salmon captive broodstock recovery programs.

STATUS OF CAPTIVE BROODSTOCKS

Between 1991 and 1993, a number of captive broodstocks have been initiated to preserve the Redfish Lake sockeye salmon. Sources for these broodstocks include: 1) juveniles captured during their outmigration from Redfish Lake; 2) adults captured returning to Redfish Lake; and 3) mature residuals captured in the lake. Most past attempts to rear sockeye salmon to maturity in seawater have ended in failure due to high mortality from disease and poor gamete quality of captive-reared spawners[2,3].

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[1] Robin Waples. National Marine Fisheries Service. Northwest Fisheries Science Center. Seattle, Washington. Pers. commun. October 1993.

[2] Chris Wood. Department of Fish and Oceans. Pacific Biological Station. Nanaimo, B.C., Canada. Pers. commun. 1991.

However, culture in pathogen-free fresh water has generally resulted in higher survival to spawning and higher percentages of viable gametes[2,3]. One of our primary obligations when maintaining an endangered species in protective culture is ensuring the highest possible survival. Therefore, full-term freshwater rearing was chosen for these endangered species captive broodstocks.

In most cases, fish in the captive broodstocks will be grown to maturity, spawned, and their progeny released into Redfish Lake. Enhancement strategies include growing the juveniles in a hatchery or in net-pens in Redfish Lake for presmolt release to the lake in the fall. These juveniles would overwinter in the lake and outmigrate naturally as yearling smolts the next spring. Other juveniles may be reared in the hatchery for release into Redfish Lake as yearling smolts in the spring. In addition, a few maturing adults from Idaho captive broodstocks may be released in the fall to spawn naturally in Redfish Lake.

Outmigrant-based captive broodstocks

Juvenile *O. nerka* were captured by IDFG in a smolt trap as they exited Redfish Lake during the spring in 1991, 1992, and 1993. Presumably, these fish are progeny of the single pair of anadromous adults observed in the lake in 1989 mixed with residuals and resident kokanee.

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[3] William Waknitz. NMFS, Manchester Marine Experimental Station. Manchester, Washington. Pers. commun. 1991.

In spring 1991, *O. nerka* outmigrants were collected in the smolt trap and moved to the IDFG Eagle Hatchery near Boise, Idaho. It is estimated that another 4,000 outmigrants passed downstream in 1991. About 50% of the 759 outmigrants captured in 1991 have survived 2.5 years, from the time of capture to fall 1993. Some mortality during rearing was attributable to bacterial kidney disease (BKD) and aeromonad infection. Although these were mostly yearling fish at capture (1989 brood), and were expected to mature in 1993 as Age-4 fish, very few (about 15%) appear to be maturing in 1993. Only twenty-four maturing adults (12 males and 12 females) from this broodstock were released into Redfish Lake in late August to spawn naturally. These fish were sonic tagged and are being tracked to identify their spawning locations. It is projected that another 15 to 20 females will spawn in captivity this year, resulting in 30,000 to 40,000 eggs. Over 250 immature fish will be held at Eagle Hatchery to be spawned during the next 2 years.

In spring 1992, 79 *O. nerka* outmigrants were collected in the smolt trap and moved to the IDFG Eagle Hatchery. It is estimated that another 1,200 fish outmigrated in 1992. Survival of these fish during the 1.5 years from capture to fall 1993 has been about 88%. We expect most of these fish to spawn between fall 1994 and 1996.

In spring 1993, 35 *O. nerka* outmigrants were collected in the smolt trap and moved to the IDFG Eagle Hatchery. It is estimated that another 600 fish outmigrated in 1993. Survival of these fish during the 6 months from capture to fall 1993 has been almost 100%, and most of these fish should spawn between fall 1995 and 1997.

We are most interested in breeding the portion of these captive broodstock populations that originated from anadromous parents. A combination of factors described above (e.g., age and time of maturity, Sr/Ca ratios, skin and flesh color, genetics, etc.) will be used to help separate sockeye salmon from kokanee. Only gametes from fish of confirmed anadromous parentage will be used in recovery programs.

Residual captive broodstocks

Members of the NMFS Biological Status Review team theorized that residuals helped maintain the Redfish Lake sockeye salmon population during historic population lows (Waples et al. 1991). In fall 1992, a number of residuals were observed spawning on the Sockeye Salmon Spawning Beach in Redfish Lake and some of them were captured. Thirty-five eggs were recovered from a "spawned-out" female and were fertilized with milt from a residual male that was also captured. Survival of these fish during the year, from capture to fall 1993, has been almost 100%. We anticipate that most of these fish will spawn between fall 1996 and 1998.

IDFG is undertaking efforts to capture more residuals in fall 1993. To date, eight male and two female residuals have been captured. These fish will be spawned in November 1993.

Anadromous captive broodstocks

The most valuable of the captive broodstocks are derived from adult sockeye salmon returning to Redfish Lake. We are confident that these fish are part of the anadromous sockeye salmon gene pool from Redfish Lake. Progeny of returning adult sockeye salmon have the highest likelihood (of the available broodstocks) of aiding the recovery of the species in Redfish Lake.

In 1991, three males and one female adult sockeye salmon returned to Redfish Lake and were captured and held by IDFG. The female spawned volitionally with an unknown combination of males, on gravel placed in the holding tank. This spawning resulted in deposition of about one-half of the female's eggs (about 1,000 eggs). The female was then removed from the tank and the remaining eggs strip spawned. About four-fifths of the stripped eggs were separated into three lots to be fertilized with milt from individual males. The remainder were fertilized with pooled milt from all three males. Two geographically separate captive-brood populations were established from these egg lots in order to reduce the risk of catastrophic loss due to mechanical failure, human error, or disease.

Approximately one-half the progeny of adults that returned to Redfish Lake in 1991 were transferred to NMFS Northwest Fisheries Science Center in Seattle, Washington. Survival of these fish has been about 72% during 1.75 years of rearing (from hatch in January 1992 to fall 1993), with most mortalities due to

BKD. The remaining 1991-brood Redfish Lake sockeye salmon are in the custody of IDFG and are being held at Eagle Hatchery. Survival of the fish at IDFG has been over 90% during 1.75 years of rearing. We anticipate that most of these fish (at both NMFS and IDFG) will mature during the fall of 1995 and 1996 as normal Age-4 and Age-5 fish.

In fall 1992, a single male sockeye salmon returned to Redfish Lake, and its milt was cryopreserved for mating with future generations.

In fall 1993, two female and six male sockeye salmon returned to Redfish Lake. These fish were held by IDFG at the Sawtooth Hatchery and strip spawned in October 1993, producing over 6,000 eggs. A full-factorial mating design resulted in six half-sib groups from each female. In addition, a portion of each female's eggs were crossed with cryopreserved milt from the single male sockeye salmon that returned to Redfish Lake in 1992. It is anticipated that NMFS and IDFG will subdivide each of these 14 mating crosses for captive-broodstock rearing.

DISCUSSION

The use of captive-broodstock technology holds promise as a means of accelerating recovery of depleted stocks. One of the current barriers to restoration of many depleted stocks of salmonids in the Columbia River Basin and elsewhere is the availability of suitable numbers of juveniles for supplementation. The relatively high fecundity of Pacific salmon, coupled with potentially high survival in protective culture, allows captive broodstocks to produce large numbers of juveniles in a single generation. We believe that maintenance of each year-class of broodstock in captivity for only a single generation or a limited number of generations should help assure that genetic integrity and adaptability to native habitats are preserved.

Captive broodstocks should be viewed as a short-term measure to aid in recovery, never as a substitute for returning naturally spawning fish to the ecosystem. The first juvenile sockeye salmon from our captive broodstocks will be released into Redfish Lake in 1994. Other research is underway in Redfish Lake to determine the carrying capacity and the feasibility of lake fertilization as enhancement strategy (Spaulding 1993).

The relatively stable egg supply provided by the captive broodstock program should help guarantee the success of recovery efforts for Redfish Lake sockeye salmon. It is a virtual certainty that, given the critically low population size, without the captive broodstock programs, Redfish Lake sockeye salmon would soon be extinct.

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Evaluation of BY 1989 Age Zero Sockeye

Beaver Falls Hatchery

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1994

Evaluation of BY 1989 Age Zero Sockeye Beaver Falls Hatchery

Southern Southeast Regional Aquaculture Association has performed experimental age zero sockeye salmon releases since 1986, principally from the Beaver Falls Sockeye Facility in George Inlet near Ketchikan, Alaska. A second release site at Shrimp Bay, on the Northwest side of Revillagigedo Island has been used since 1988 as well. The broodstock from BY 1985 to BY 1990 at both sites was from the Karta system on Prince of Wales Island. From 1991 to the present, broodstock from the mainland McDonald Lake system has been released exclusively at Shrimp Bay.

The intent of the SSRAA sockeye program was to develop a age zero sockeye culture strategy that contributed sockeye to the common property fisheries and was economically viable. Additionally, any cost recovery at the terminal site would be used to fund other sockeye enhancement such as lake fertilization and sockeye lake fry plants, in Southern Southeast Alaska.

The success of the sockeye age zero enhancement effort depended on the ability of the culture methods to produce smolts at a size and a time of migration to the sea that would maximize survival to adulthood. The experimental releases by SSRAA have attempted to match the time and size of naturally produced yearling smolts outmigration using age zero hatchery produced smolts. The review of natural outmigration timing in S.E. Alaska, Zadina and Haddix (1989) and the smolt size and ocean survival relationship, Koenings and Burkett (1987) concentrated the age zero efforts for BY 1989 to an experimental design that would test releases of two smolt sizes at three different times.

In Southern Southeastern Alaska, mid-May is typically the peak of the migration for 65 mm smolts. The results of the first two SSRAA releases suggested that a larger smolt would be required. Given that water temperature and food availability are the principle limiting growth factors, an optimum smolt size between 83 and 101 mm (4.7 to 7.0 grams) could be attainable using currently available, cost effective technology. A heat exchanger using the George Inlet estuary as the heat source was fabricated to warm the ambient fresh water ($2^{o}C$) in order that the larger smolt could be produced, and the production experiment performed.

Each release of BY 1989 sockeye from saltwater netpens consisted of a large smolt (>85 mm) and a smaller smolt (65 to 79 mm) group.

Date	Wt.(g)	Length (mm)
May 19, 1990	6.5	86.3
	6.0	85.3
	3.0	67.6
June 3, 1990	6.0	85.8
	3.8	70.7
June 15, 1990	6.0	84.2
	4.7	79.6

Each treatment was differentially identified with half length coded wire tags, and evaluated by recoveries in the common property fishery and "at the rack" at Beaver Falls Hatchery.

The total ocean survival results have been disappointing but there appears to be a positive correlation of size at release to ocean survival, although the results from the BY 1989 test does not suggest an economically viable age zero sockeye strategy from the George Inlet release site.

The rack returns were evaluated for age at return, size at return, run timing and scale evaluation of non-tagged adults was performed to differentiate age zero produced adults from other local naturally produced sockeye. The commercial fisheries data was evaluated to identify interception by gear group, area and timing of catch.

A subsequent release of age zero sockeye BY 1990 was done at both Shrimp Bay and George Inlet at similar sizes which may show the difference release site have an ocean survival. Releases at Shrimp Bay BY 1991 and 1992 of McDonald Lake stock, may also demonstrate a difference in survivals although no releases of McDonald stock were done at George Inlet in those years.

In spite of the survivals of age zero sockeye from Beaver Falls being very poor, some optimism is still warranted. The two ocean age survivals of the BY 1990 sockeye appear to be higher at Shrimp Bay than at Beaver Falls with only commercial catch data evaluated for the Shrimp Bay site. The survivals of age zero sockeye from Auke Creek, Taylor (pers. comm.) look very encouraging and suggest also that release site may be extremely important.

The cooperation of the Alaska Department of Fish and Game (Koenings, Burkett, Burke, Ellison, Haddix, Zadina), and NMFS (Heard, Taylor) to name a few is greatly appreciated.

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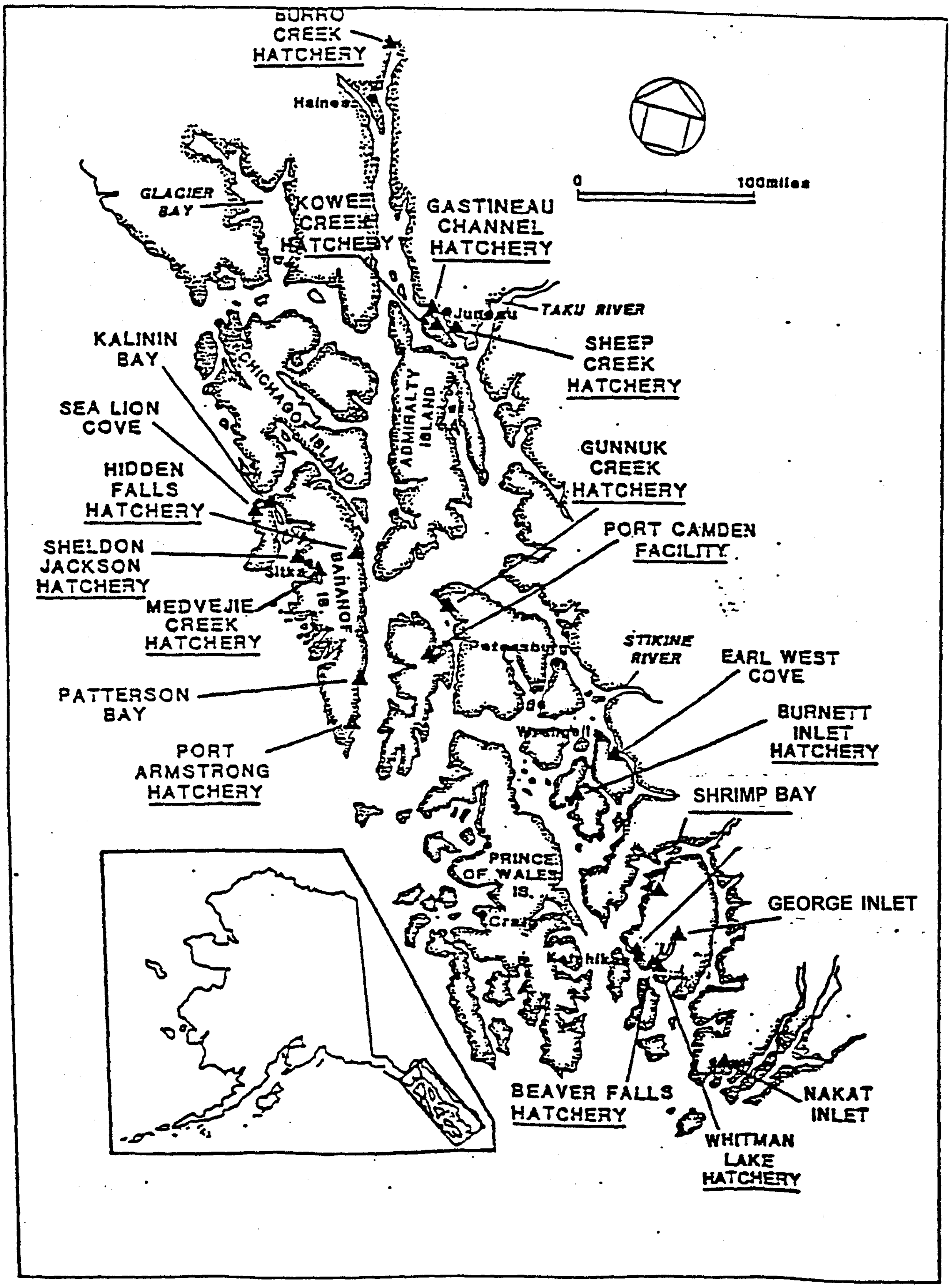
BURRO CREEK HATCHERY
Haines
GLACIER BAY
KOWEE CREEK HATCHERY
GASTINEAU CHANNEL HATCHERY
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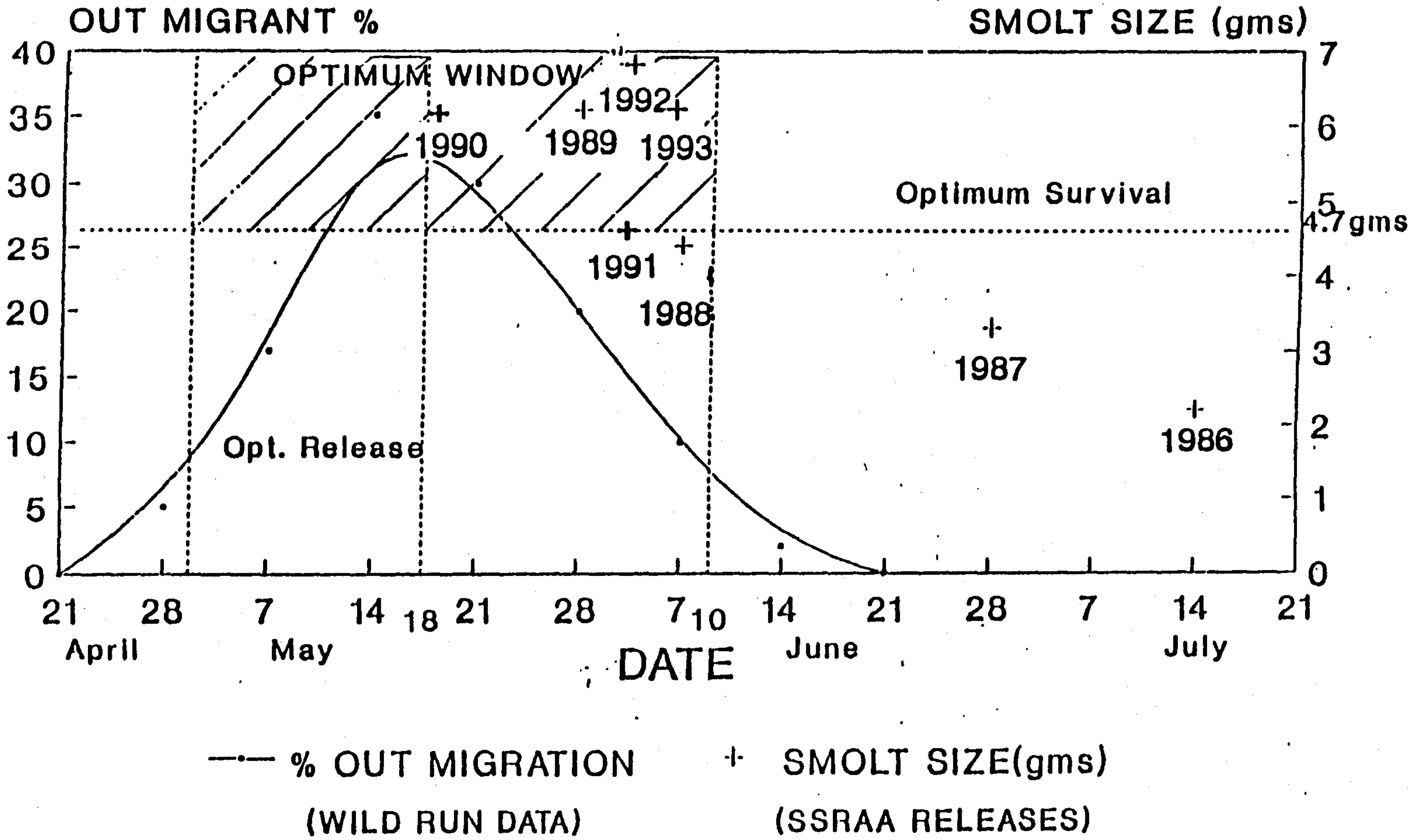
Juneau
TAKU RIVER
SHEEP CREEK HATCHERY
KALININ BAY
CHICHAGOF ISLAND
ADMIRALTY ISLAND
SEA LION COVE
GUNNUK CREEK HATCHERY
HIDDEN FALLS HATCHERY
PORT CAMDEN FACILITY
SHELDON JACKSON HATCHERY
Sitka
BARANOF IS.
MEDVEJIE CREEK HATCHERY
Petersburg
STIKINE RIVER
EARL WEST COVE
PATTERSON BAY
BURNETT INLET HATCHERY
Wrangell
PORT ARMSTRONG HATCHERY
SHRIMP BAY
PRINCE OF WALES IS.
GEORGE INLET
Craig
Ketchikan
BEAVER FALLS HATCHERY
NAKAT INLET
WHITMAN LAKE HATCHERY

OPTIMUM RELEASE TIMING

SOCKEYE



SSRAA

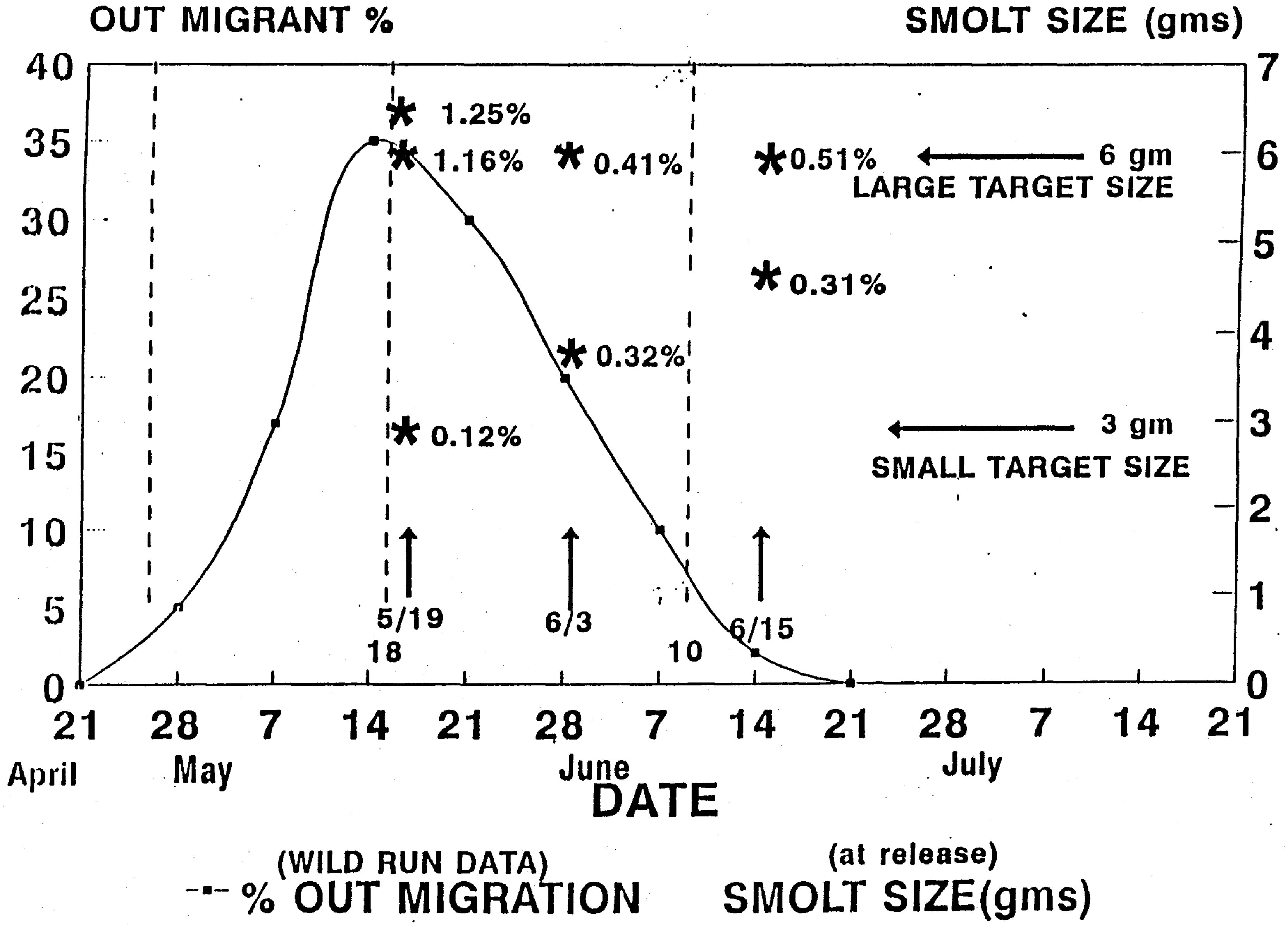
AGE ZERO SOCKEYE RELEASES

BROOD YEAR	RELEASE DATE	RELEASE WT(G)	RELEASE L(MM)	SURVIVAL %	OCEAN AGE 2 %	OCEAN AGE 3 %	OCEAN AGE 4 %
BEAVER FALLS							
1985	7/15/86	2.2	48.1	0.00	0	0	0
1986	6/30/87	3.3	68.2	0.02	3	97	0
1987	6/6/88	4.5	76.6	2.00	4.7	94.7	0.6
1988	6/1/89	6.3	86.1	2.14	13.5	85	0.5
1989	5/19/90	6.5	86.3	1.25	25	75	n/a
1989	5/19/90	6.00	85.3	1.16	19	81	n/a
1989	5/19/90	3	67.6	0.12	26	74	n/a
1989	6/3/90	6	85.8	0.41	3	97	n/a
1989	6/3/90	3.8	70.7	0.32	7	93	n/a
1989	6/15/90	6	84.2	0.51	9	91	n/a
1989	6/15/90	4.7	76.6	0.31	3	97	n/a
1990	6/1/91	4.2	77.6	0.07	100	n/a	n/a

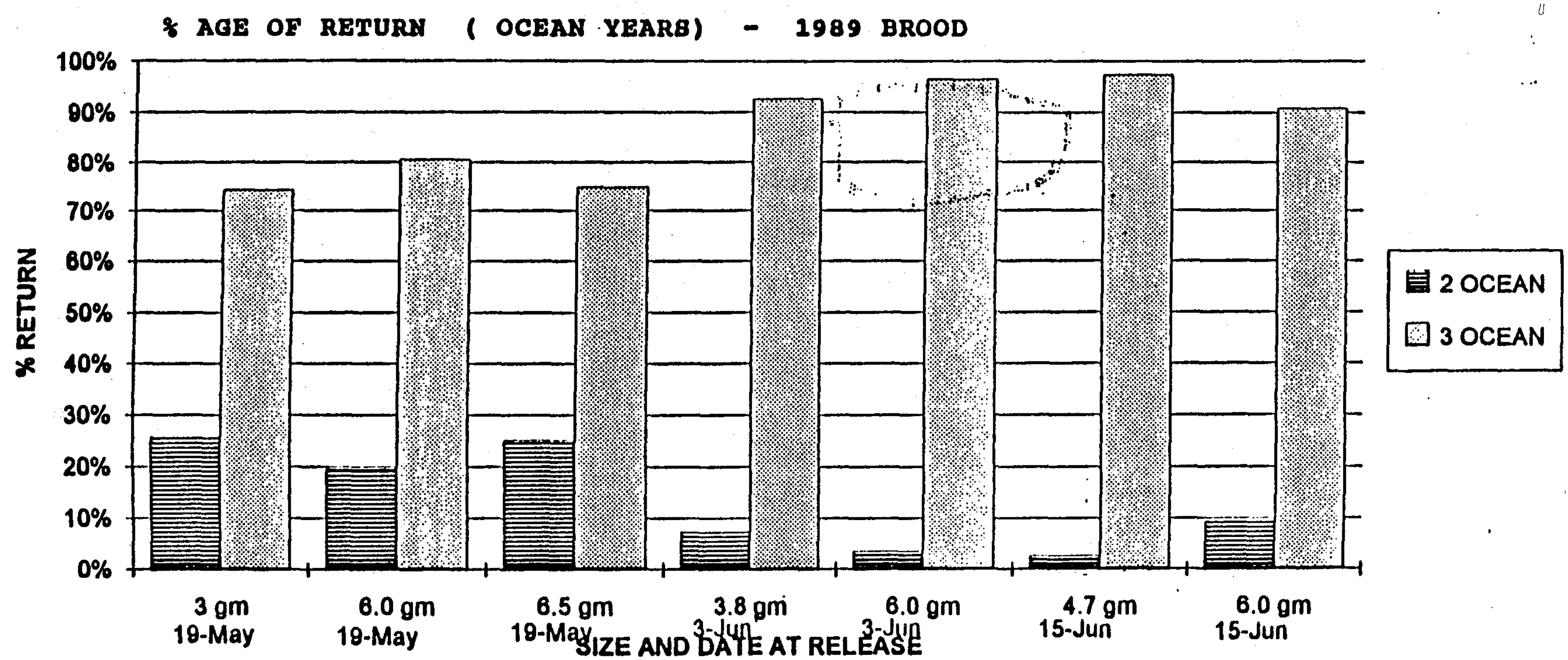
SHRIMP BAY BROOD YEAR	RELEASE DATE	RELEASE WT(G)	RELEASE L(MM)	SURVIVAL %	OCEAN AGE 2	OCEAN AGE 3	OCEAN AGE 4
1987	6/4/88	3.5	72.9	0.02	0	100	0
1988	6/1/89	6.2	85.9	2.45	0	100	0
1989	no release						
1990	6/1/91	4.7	79.3	0.22	100	n/a	n/a
1991	6/4/92	6.1	85.2	n/a	n/a	n/a	n/a
1992	5/27/93	4.5	79.6	n/a	n/a	n/a	n/a
1992	6/4/93	6	83.8	n/a	n/a	n/a	n/a

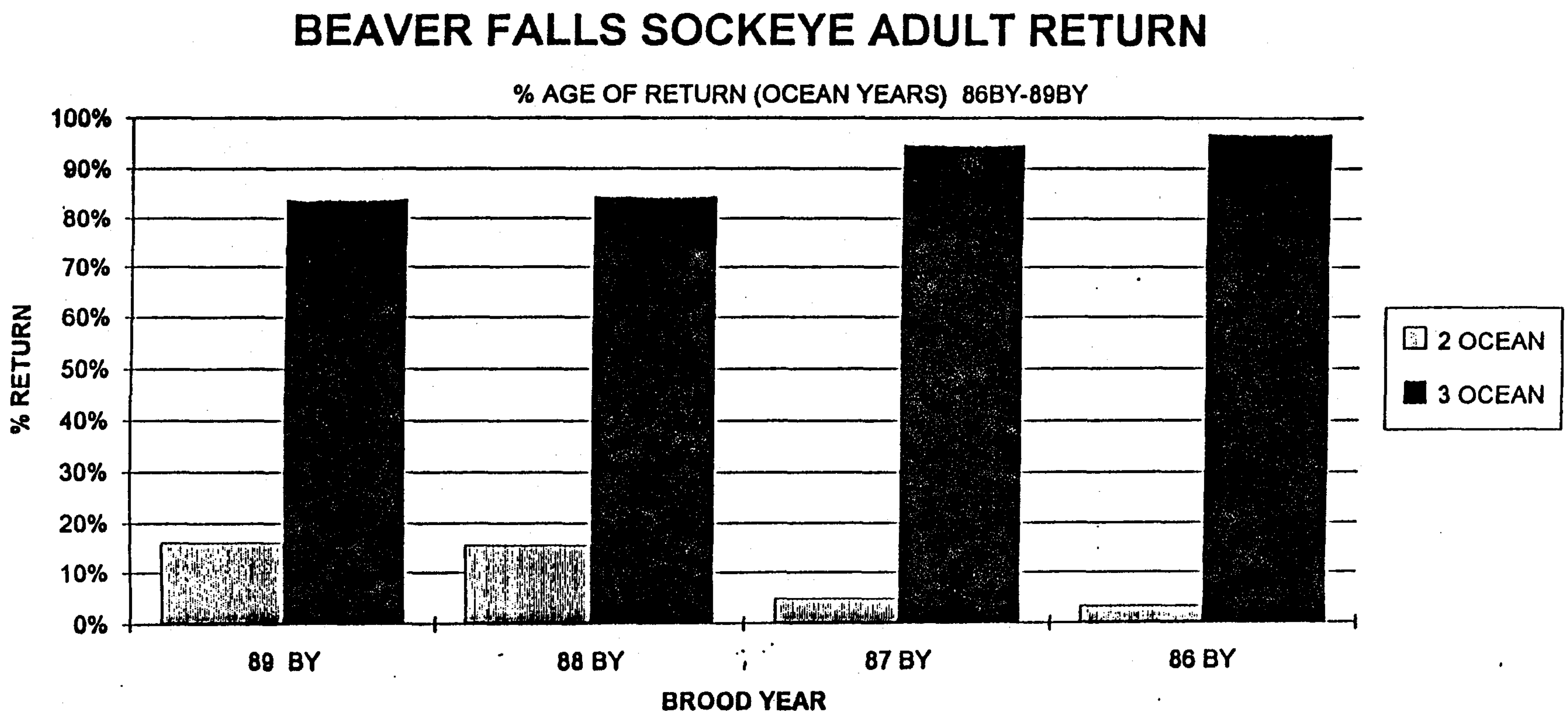
SSRAA TIME/SIZE OF RELEASE

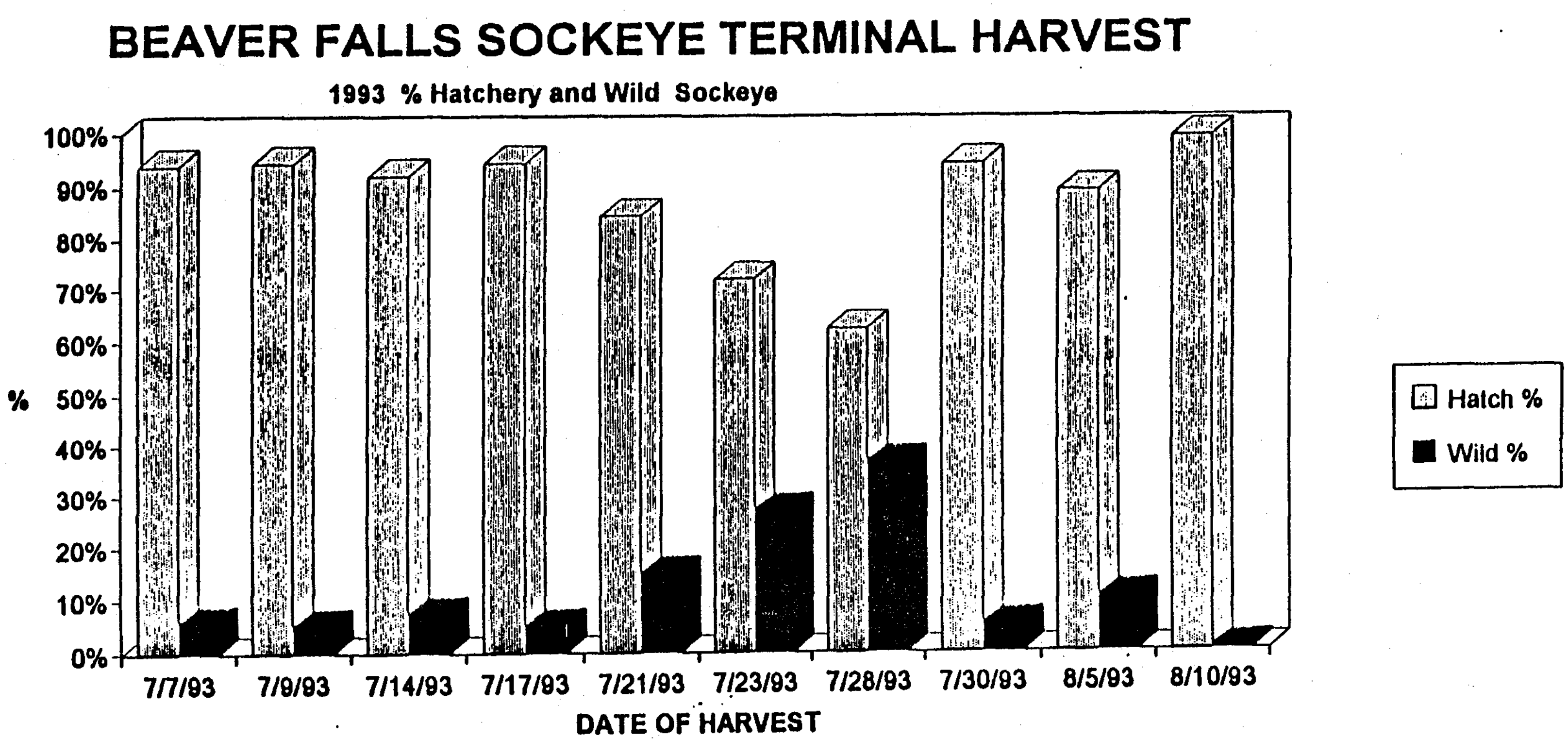
SOCKEYE % TOTAL OCEAN SURVIVAL 1989 BROODYEAR
ZERO PROGRAM

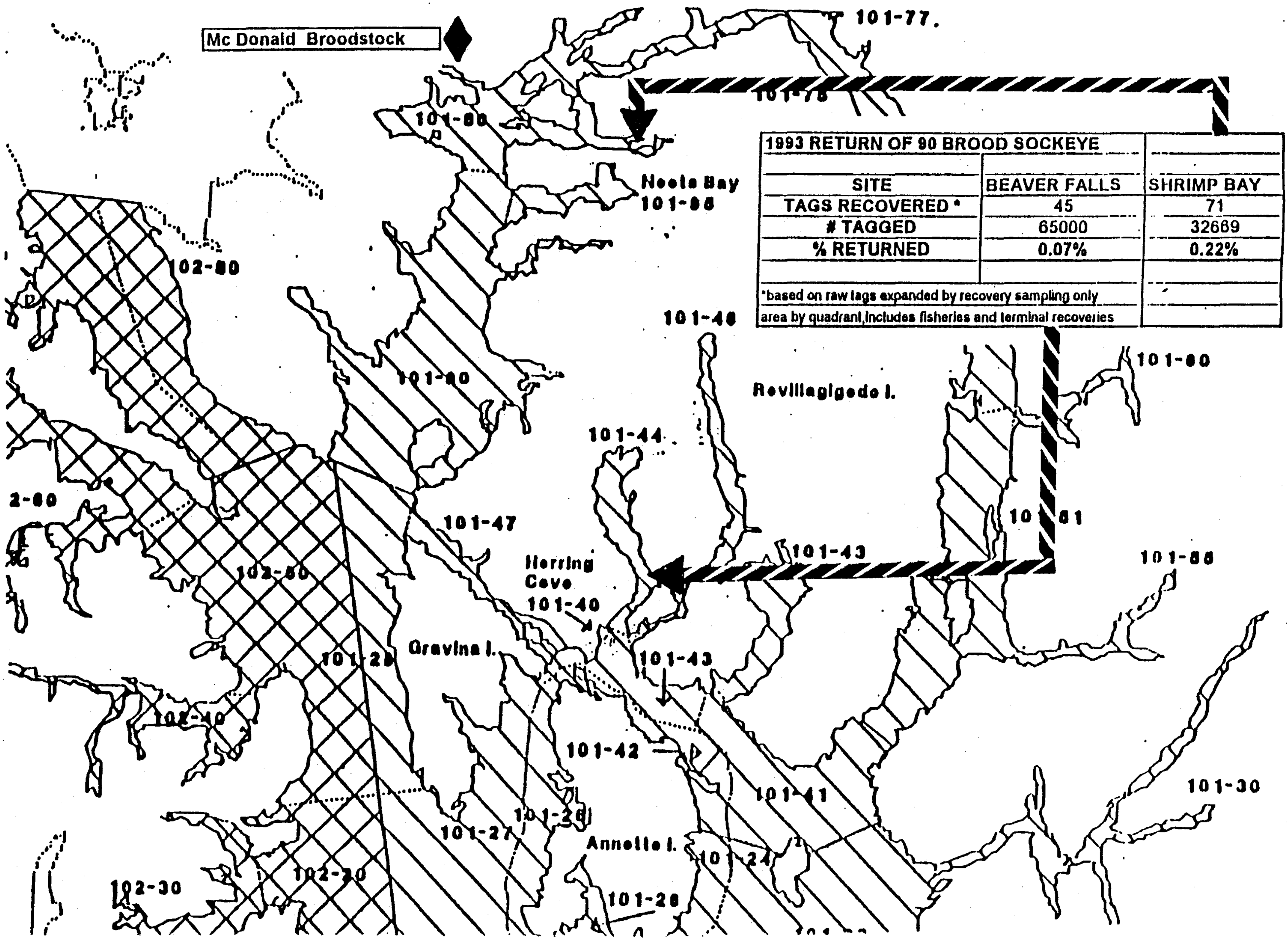


BEAVER FALLS SOCKEYE ADULT RETURN




BEAVER FALLS SOCKEYE ADULT RETURN
% AGE OF RETURN (OCEAN YEARS) 86BY-89BY
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% RETURN
2 OCEAN
3 OCEAN
89 BY
88 BY
87 BY
86 BY
BROOD YEAR


BEAVER FALLS SOCKEYE TERMINAL HARVEST
1993 % Hatchery and Wild Sockeye
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
%
7/7/93
7/9/93
7/14/93
7/17/93
7/21/93
7/23/93
7/28/93
7/30/93
8/5/93
8/10/93
DATE OF HARVEST
Hatch %
Wild %



1993 RETURN OF 90 BROOD SOCKEYE		
SITE	BEAVER FALLS	SHRIMP BAY
TAGS RECOVERED *	45	71
# TAGGED	65000	32669
% RETURNED	0.07%	0.22%

*based on raw tags expanded by recovery sampling only
area by quadrant,includes fisheries and terminal recoveries

Auke Bay Age Zero Sockeye Smolt Summary
Jerry Taylor, Auke Bay Lab

Brood Year	Treatment	Release Date	Release Size - gm	Release Size - mm	Survival %	Ocean Age 3 - %
1986	SW	July 24, 1987	6.0	84	2.9	80
1987	FW	June 21, 1988	4.4	75	5.2	90
1987	SW	June 21, 1988	6.2	84	6.2	95
1988	FW	June 21, 1989	2.7	65	1.6	81
1988	SW	June 21, 1989	4.8	78	3.2	93
1989	FW	June 21, 1990	2.8	67	5.6	94
1989	SW	June 21, 1990	6.2	85	9.7	96
1989	FW	July 6, 1990	4.3	76	5.5	97
1989	SW	July 6, 1990	11.9	103	11.3	96

FW - Entire culture in freshwater and release in Auke Creek

SW - Signifies some culture in seawater and release in seawater survival is for all ocean age classes combined. Ocean age % is for 3-ocean fish only.

Note: Percent survivals are based on return to the rack only. No common property tag recovery.

19/18A

ADULT SURVIVALS OF THREE BROODS OF AGE-0 (UNDERYEARLING) SOCKEYE SALMON SMOLTS REARED IN FRESH AND SEA WATER AT AUKE CREEK, ALASKA

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The life history of sockeye salmon usually includes 1 or 2 years of freshwater residency before the smolts migrate to the ocean, although smaller components of some stocks in certain situations do migrate naturally to sea as age-0 smolts. Enhancement methods for sockeye in Alaska usually follow one of two strategies. The first involves stocking fry in appropriate lake environments where the juveniles then spend 1 or 2 years rearing to smolt stage before migrating to the ocean. The second method is to rear sockeye fry in a hatchery for 1 year before release as yearling smolts.

Auke Bay Laboratory scientists initiated a series of studies in 1987 to investigate the feasibility of rearing age-0 sockeye smolts in a hatchery as a possible alternative enhancement procedure for this species. The studies were conducted at the experimental Auke Creek Hatchery, Auke Bay, Alaska and were part of a broader enhancement effort to rehabilitate a badly depressed sockeye salmon run in the Auke Lake system. Basic strategy of the research was to attempt accelerated egg and juvenile development so that age-0 smolts could be released within the normal temporal windows of seaward migration 1 to 2 years earlier than their wild cohorts. This report covers results of research on the first three broods of Auke Lake sockeye tested.

Sockeye salmon eggs were collected in August from spawners in Lake Creek, the major tributary to Auke Lake, in 1987, 1988, and 1989, and incubated at Auke Creek Hatchery at the head of tidewater on Auke Creek. Lake Creek sockeye are endemic to Auke Lake, and normally produce only yearling and older age smolts.

Development of eggs and juvenile fish in the hatchery was accelerated by using a dual water intake system that allowed the mixing or independent use of surface water from Auke Creek and subsurface water below the thermocline in Auke Lake. Surface water in Auke Creek often exceeds 20°C in August, when sockeye eggs were placed in hatchery incubators, and is usually warmer than subsurface water through mid November. Subsurface water, 7-m depth from Auke Lake, seldom exceeds 8°C. In August, eggs were incubated in a mixture of surface and subsurface water to maintain temperatures <14°C, and then on surface water until the occurrence of the fall temperature inversion of Auke Lake, approximately mid November of each year. Subsurface water was used throughout the winter and early spring until surface water temperatures exceeded subsurface ones.

All water for incubation and rearing in the hatchery passed through an in-line filter (200 micron, multi-filament polyester mesh) that removed plankton and debris. Filtered water then entered an ultraviolet disinfection unit before passing to the incubation and rearing tanks.

Within 5 months from spawning, the fry had completed development, and were placed in fresh water rearing tanks and fed several times each day. Culture of sockeye to produce age-0 smolts involved two approaches. One group of fish was reared entirely in fresh water, while another group was reared in fresh water until they could survive in salt water, approximately 1.5-2 g, then were transferred to seawater net pens in Auke Bay near the mouth of Auke Creek. Fish cultured in sea water received 4 to 6 weeks of rearing in net pens.

Growth of sockeye in the net pens was greater than in fresh water, and at time of release, the seawater reared fish were larger than those reared in fresh water. Growth rates in freshwater averaged 1.2%/day during January to April, and 2.4%/day during April through July. Growth in sea water during May averaged 2.5%/ day and in the June through early August period ranged from 4 to 8%/day. Average sizes of sockeye reared in sea water ranged from 78 to 103 mm, while freshwater reared sockeye averaged 65 to 76 mm at release (Table 1).

Eight groups of age-0 sockeye salmon smolts were released in this study; two groups of fish, one each freshwater and seawater reared, were released on June 21, 1989, 1989, and 1990 and on July 6, 1990. Freshwater reared smolts were released in Auke Creek and emigrated about 50 m downstream to Auke Bay. Seawater smolts were released directly into Auke Bay at the net pen site. Two months before release all fish were marked by excision of the adipose fin and tagged with coded wires; a different tag code identified each culture group. A final size inventory was made the day before release.

Marine survival of smolts, and age and size at maturity of adults were determined from sockeye salmon that returned to Auke Creek. From 1989 through 1993, every sockeye salmon that entered the fish counting weir at the mouth of Auke Creek was examined for a missing adipose fin. A subsample of marked sockeye was killed to recover coded wire tags, and the remainder of the fish were released to spawn. Among groups of underyearling smolts released on the same dates, those that had received some rearing in seawater net pens had significantly higher survivals than those reared entirely in freshwater (Figure 1).

Smolt-to-adult survivals ranged between 3.3 and 11.3% for seawater reared sockeye, and 1.5 and 5.6% for those reared in freshwater (Table 1). These percentages represent minimal survival values because no adjustments were made for undetermined levels of fishery harvest. While no systematic fishery sampling for tagged adult sockeye was possible in the region, several Auke Creek sockeye tags were recovered in each of the adult return years coincidental to sampling programs for other species.

There was a significant, positive relationship between smolt length at release and marine survival (Figure 2). Most sockeye that returned from this study spent 3 years in the ocean, exactly like wild fish from Auke Lake. There were no significant differences in length of sockeye adults between groups released in the same year (Figure 3), and each year adults from hatchery-reared smolts were indistinguishable in size from their wild counterparts.

This project has demonstrated that culture of underyearling sockeye salmon is a feasible enhancement method. Underyearling smolts can be successfully reared from a stock that naturally produces only yearling or older age smolts. Juveniles reared in seawater net pens for 4 to 6 weeks were larger than fish reared entirely in fresh water, and survived at a higher rate.

Table 1. Data relating to release and return of 1987, 1988, and 1989 brood year sockeye salmon reared at Auke Creek Hatchery as age-0 smolts. Release data includes release group (designated by brood year and rearing treatment in fresh, fw, or sea water, sw), release date and number and size of smolts. Adult returns include total number of all age groups, proportion of each release group that returned after 3 years in the ocean (3-oc.), average length of 3-ocean adults (cm) and marine survival (%) determined at Auke Creek weir.

smolt release					adult return			
group	date	number	mm	gm	number	3-oc.	cm	%
87-fw	6/21/88	16,432	75	4.4	873	0.88	51.9	5.30
87-sw	6/21/88	19,888	84	6.2	1,235	0.95	53.2	6.2
88-fw	6/21/89	15,991	65	2.7	239	0.79	51.3	1.5
88-sw	6/21/89	18,369	78	4.8	599	0.92	50.0	3.3
89-fw	6/21/90	12,599	67	2.8	703	0.94	53.6	5.6
89-sw	6/21/90	13,618	85	6.2	1,325	0.96	54.0	9.7
89-fw	7/6/90	12,077	76	4.3	669	0.97	54.1	5.5
89-sw	7/6/90	11,655	103	11.9	1,318	0.96	53.3	11.3

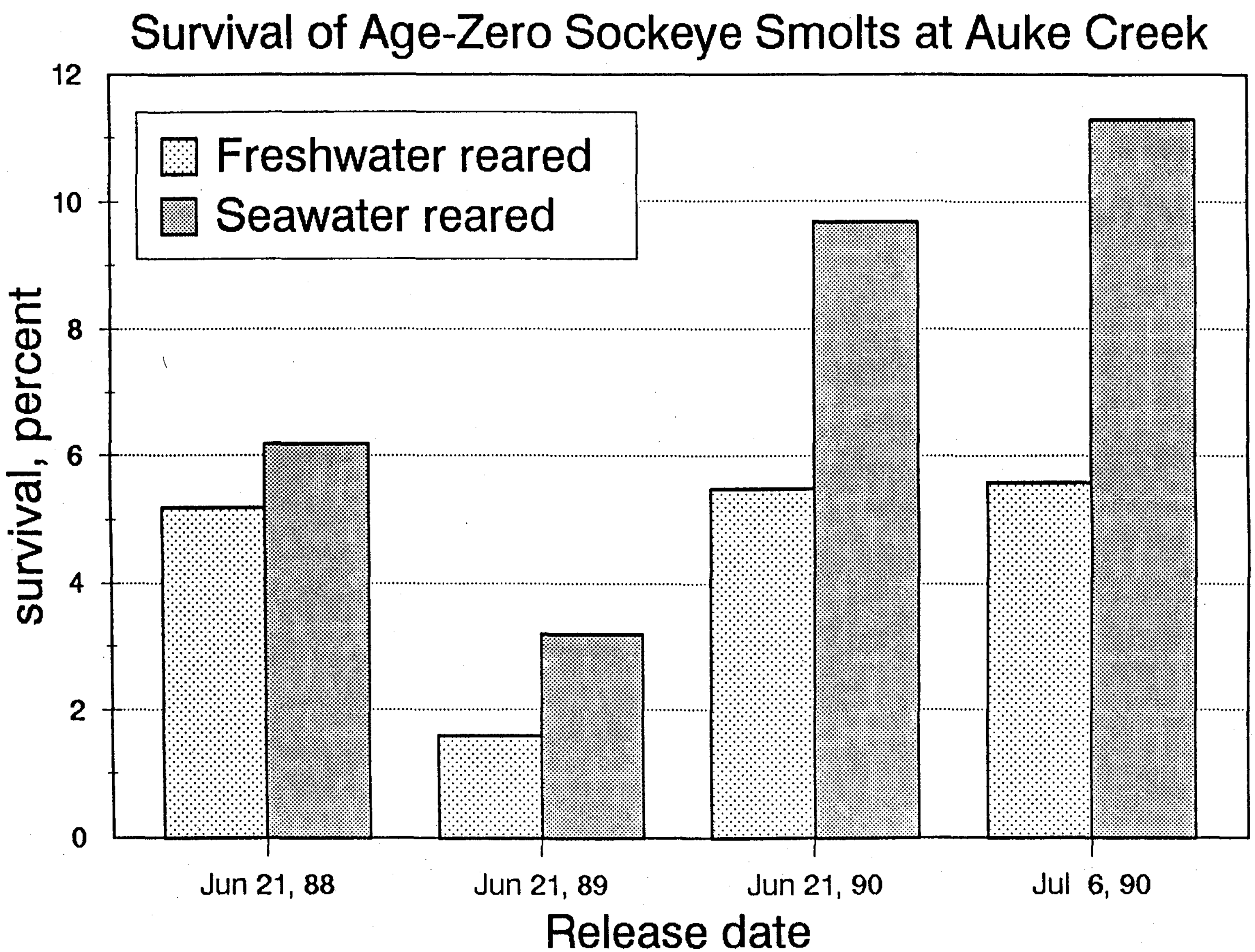

Figure 1. Marine survival of 3 broods of hatchery-produced age-0 sockeye salmon reared in fresh- and seawater and released at Auke Creek, Alaska, on June 21, 1988-90 and July 6, 1990.

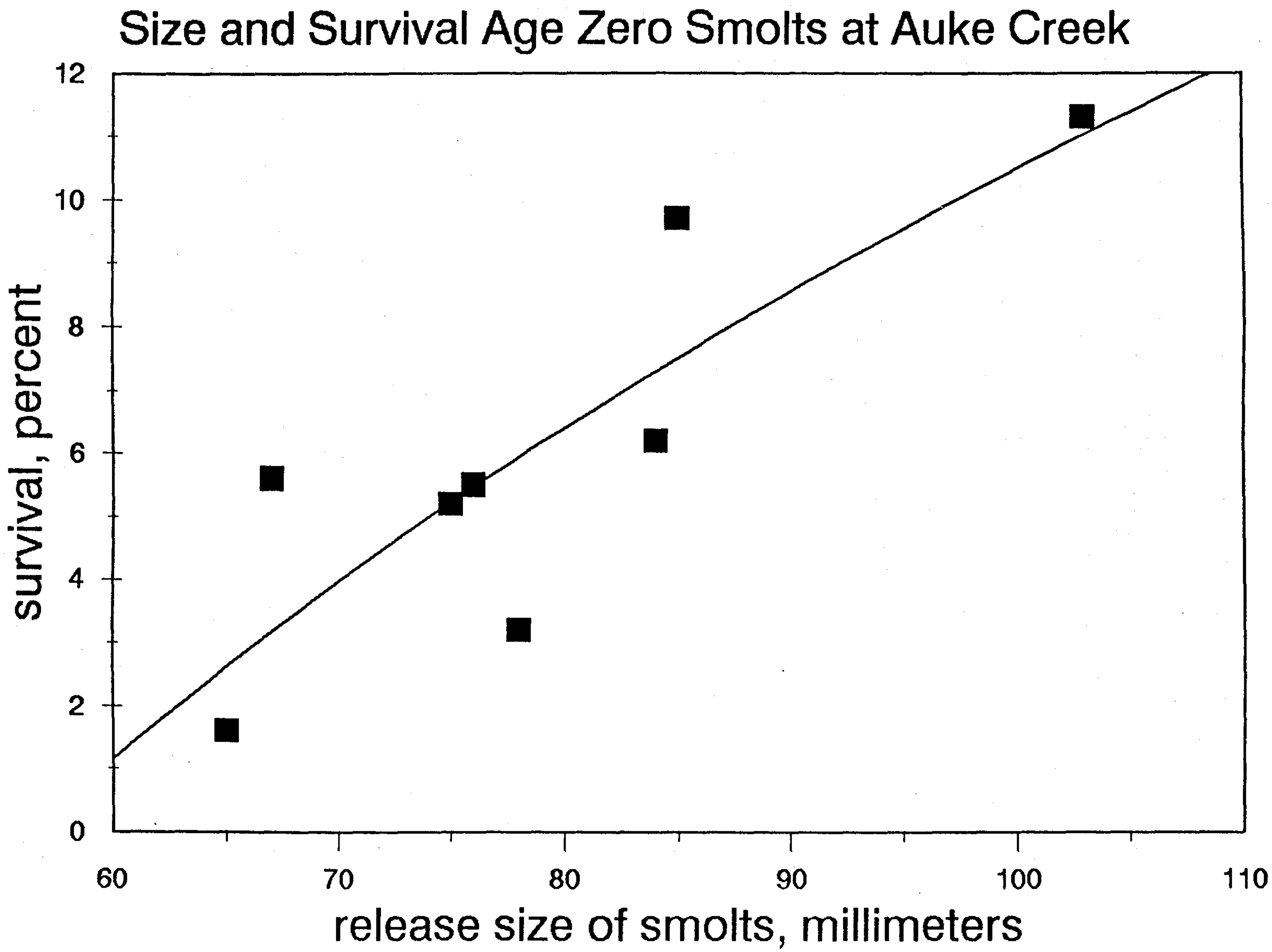

Figure 2. Relationship of size and marine survival of age-0 sockeye salmon smolts at Auke Creek, Alaska. Data are combined for fresh- and seawater reared groups from the 1987-89 brood years.

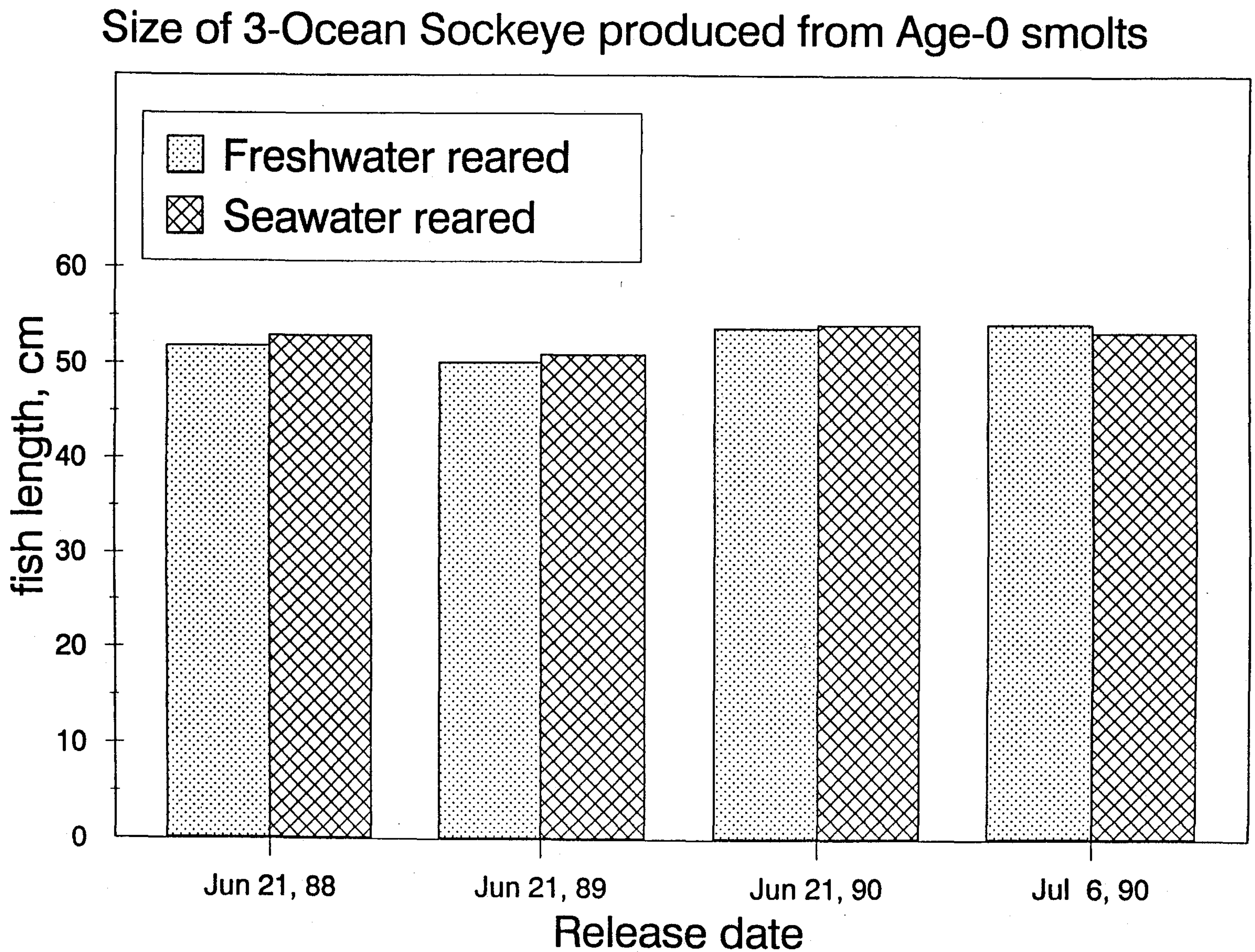

Figure 3. Average lengths of 3-ocean sockeye salmon resulting from releases of hatchery-produced age-0 smolts reared in fresh- and seawater.

Some conclusions from sockeye smolt experiments at Main Bay Hatchery (1987 through 1990; adult returns through 1993):

by

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Main Bay Hatchery is located Prince William Sound. It is a large facility by Alaska Standards, with a consistent supply of IHN-free water; and subsequently the potential to produce a large number of sockeye salmon smolts, perhaps as many as 20 million. We felt the risk associated with sockeye culture at Main Bay was acceptable if three key elements were stressed in the culture practices: 1. an IHN-free water supply; 2. appropriate isolation; and, 3. rigorous disinfection at appropriate points in the process.

In 1987 Main Bay began producing sockeye smolts. Eggs, sac fry and emergent fry were kept isolated in single-incubator lots until the fry had been feeding for at least three months, after which time we felt vertically transmitted virus was not significant risk to the fish. The rearing fry were then mixed with other lots of fish in raceways and reared until the following spring when production scale experiment to determine the most efficient way to produce adult sockeye salmon. The parameters evaluated were; release of smolts directly from freshwater or release after rearing for at least two weeks in seawater; differing rearing densities in raceways; size of smolts at release; and, time of release. The results from the final adult return numbers in 1993 are preliminary.

It appears that each manipulation had significant consequences.

1. **Freshwater vs seawater rearing prior to release.** It appears that sockeye need not be reared to achieve maximum survivals from smolt to adult. Smolt released at 10g directly from freshwater in 1989 had a greater survival rate to adult (17.8% vs 16.6%) than 9.9g smolt released from net pens in seawater.

2. **Smolt size and survival to adult.** Sockeye smolts above 8g do not necessarily have a greater chance of surviving to adult. Smolts released at 8g in 1989 had a greater survival rate to adult than smolts released at 15.1g (16.5% vs 15.7%).

■The **age of an adult sockeye** is strongly related to the size of a smolt. About 50% of the 8g smolts returned as 2-ocean adults, where greater than 80% of smolts larger than 14g returned as 2-ocean adults. There was a strong correlation in a simple linear regression between smolt size and age at maturity.

3. Rearing density and survival to adult. It is probable that rearing density is related to adult survival, though this experiment was somewhat influenced by the time of release of each of the treatment groups. The greatest survivals were achieved at the lowest rearing density (maximum density reached in the lowest density raceway was $33kg/m^3$).

■Though the greatest survival came from the smolt reared in the least dense rearing environment, **the greatest adult production for a single raceway was from the smolt group reared at the highest rearing density** (maximum density attained during rearing was $88kg/m^3$.

■A higher % of the returning adults were 1-ocean "jacks" from the groups of smolt reared at higher densities.

4. Time of release. Survival to adult is greatly influenced by time of release within a fairly small time window. We found that time of release had the strongest influence on survival among the parameters that we measured. As little time as a week, between the release of two groups of similar smolts, may make a substantial difference in survival to adult.

■The optimal release time in 1990 was the last several days in May and the first several days in June.

■The later smolt releases in 1990 tended to produce fewer 1-ocean "jacks".

■The later smolt releases in 1990 tended to produce relatively more 3-ocean adults.

Yearling Sockeye Smolt
Main Bay

Treatments:

1986 brood; 1988 release; 330,025 smolts:

1. Moist feed, released from freshwater, 110,900 smolts;
2. Moist feed, released from seawater, 40,270 smolts;
3. Dry feed, released from freshwater, 77,082 smolts; and,
4. Dry feed, released from seawater, 101,773 smolts.

1987 brood; 1989 release; 3,576,600 smolts:

1. Size at release, smaller (7-9g), 1,209,517 smolts;
2. Size at release, larger (14-18g), 617 smolts;
3. Released from freshwater, 948,027 smolts; and,
4. Released from seawater, 1,148,287 smolts.

1988 brood; 1990 release; 2,616,498 smolts:

1. Rearing densities @ 1,000,000; 800,000; 600,000; and 400,000 smolts per raceway, and
2. Release timing, smolts released on 15 May, 22 May, 29 May, and 5 June.

1987 Brood; Total Return from Smolts Released from Freshwater or Seawater Rearing

Treatment	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total return (%)
Released freshwater (@10.0g)	949,000	278 (0.0)	98,591 (10.4)	70,334 (7.4)	169,203 (17.8)
Released seawater (@9.9g)	1,150,000	2,323 (0.2)	113,459 (9.9)	74,871 (6.5)	190,653 (16.6)

1987 Brood; Total Return from Smolts Released at Two Different Sizes (7-9g and 14-18g)

Treatment	Smolts released	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total return (%)
"Smaller" smolts (@ 7-9g)	1,210,000	2,300 (0.2)	100,053 (8.3)	97,343 (8.0)	199,696 (16.5)
"Larger" smolts (@14-18g)	618,000	0 (0.0)	82,098 (13.3)	15,096 (2.4)	97,194 (15.7)

1988 Brood: Return from Smolts Released after Rearing at Different Densities

Treatment (peak den.)	Smolts released (date @ wt)	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total 2's & 3's (%)	Total return (%)
1,000,000 (88kg/m^3)	848,544 (5/26 @ 15.0g)	25,907 (3.1)	98,130 (11.6)	21,565 (2.5)	119,695 (14.1)	145,602 (17.2)
800,000 (67kg/m^3)	642,752 (5/24 @ 13.4g)	12,746 (2.0)	103,576 (16.1)	10,341 (1.6)	113,917 (17.7)	126,663 (19.7)
600,000 (48kg/m^3)	461,915 (5/28 @ 17.0g)	12,109 (2.6)	64,138 (13.9)	5,595 (1.2)	69,733 (15.1)	81,842 (17.7)
400,000 (33kg/m^3)	317,793 (6/6 @ 16.9g)	6,043 (1.9)	54,618 (17.2)	16,140 (5.1)	70,758 (22.3)	76,801 (24.2)

1988 Brood: Return from Smolts Released on Different Dates

Treatment release date	Smolts released (@ wt)	1-ocean "jacks" (%)	2-ocean adults (%)	3-ocean adults (%)	Total 2's & 3's (%)	Total return (%)
15 May	90,775 (@13.5g)	1,745 (1.9)	11,670 (12.9)	1,706 (1.9)	13,376 (14.8)	15,121 (16.7)
22 May	76,935 (@15.6g)	2,083 (2.7)	13,475 (17.5)	891 (1.2)	14,366 (18.7)	16,449 (21.4)
29 May	96,027 (@16.1g)	1,185 (1.2)	18,745 (19.5)	3,805 (4.0)	22,530 (23.5)	23,735 (24.7)
5 June	87,147 (@16.5g)	287 (0.3)	16,770 (19.2)	3,652 (4.2)	20,422 (23.4)	20,709 (23.8)

Some conclusions from sockeye smolt experiments at Main Bay Hatchery (1987 through 1990; adult returns through 1993):

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- The later smolt releases in 1990 tended to produce relatively more 3-ocean adults.