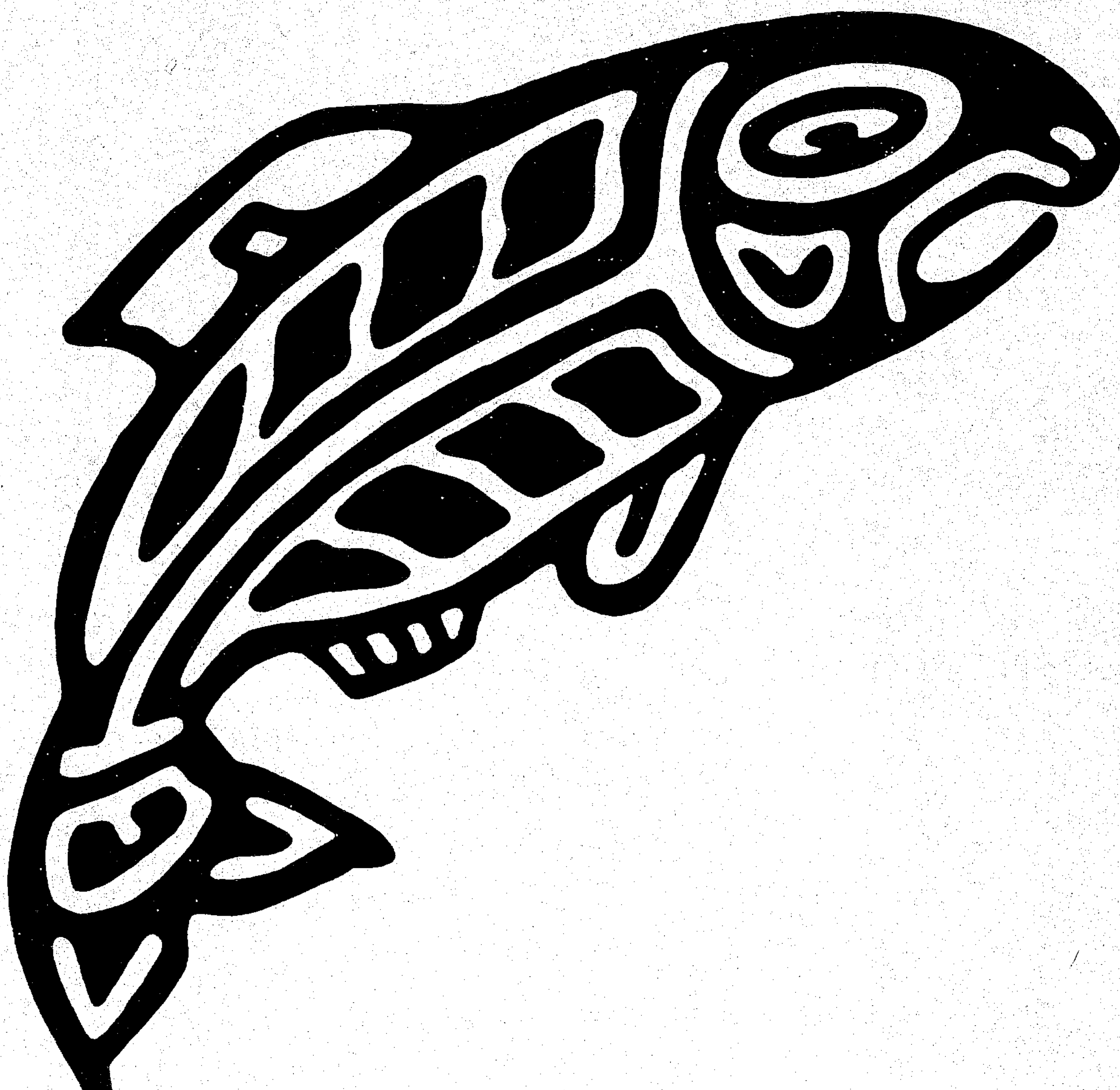
A

SOCKEYE CULTURE WORKSHOP

July 12-13, 1988
Ketchikan, Alaska



ALASKA DEPARTMENT OF FISH & GAME
Division of Fisheries Rehabilitation,
Enhancement, and Development

PROCEEDINGS OF THE 1988 ALASKA SOCKEYE CULTURE WORKSHOP

Ketchikan, Alaska
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Sam Bertoni - Meeting Chairman

The Annual Sockeye Culture Workshops are informal meetings for the exchange of information and ideas concerning all areas of sockeye culture. Active discussion and constructive criticism are encouraged. Question and answer sections are included after most presentations.

The contents of these proceedings are informal records and are not to be interpreted or quoted as a publication.

An attempt was made to tape record the proceedings, but with limited success. Also there were many presentations made without abstracts or papers being submitted. Thus, the contents of these proceedings are a cumulation of the summary notes of three workshop attendees (Dr. Roger Saft, Dr. Bob Davis, and Terry Ellison), papers presented, and discussions transcribed from the tapes.

TOPIC	PRESENTOR
Summary of Commercial Salmon Harvests in Alaska	Keynote Speaker - Brian Allee
Prevalence and Biology of Zero-Check Sockeye Salmon in Southeast Alaska	Scott McPherson
Broodstock Ripening Survey and the Klawock Sockeye Program	Dan Rosenberg
Yakima Basin Sockeye Salmon Restoration Feasibility Study - IHN Certification & Fish Culture Program	Lee Harrell
The Pit Tag System and its Suitability in Sockeye Salmon	Thomas Flagg
Chemical Tagging	Jeff Short
Beaver Falls Sockeye Program	Dave Bright
Reducing Chemical Use in Sockeye Culture	Chris Clevenger
IHN Prevalence in 1988 and Ongoing Pathological Concerns	Ted Meyers
Limnology Projects in Southeast	Mike Haddix
Capture and Tagging of Sockeye Smolt	Tim Zadina
Incubation and Rearing Questionnaire	Chris Clevenger
Sockeye Smolt Production at Main Bay	Larry Peltz
Kodiak - Karluk Lake Sockeye Program	Lorne White
Northern Cook Inlet Sockeye Smolt Program	Bob Chlupach
Auke Bay Sockeye Program	Jerry Taylor
British Columbia Sockeye Program	Dave Harding
Southern Southeast Regional Aquaculture Association Sockeye	Bill Halloran

Summary of Commercial Salmon Harvests in Alaska - Brian Allee

Dr. Brian Allee, the Director of F.R.E.D. Division, gave the keynote address. He presented a brief summary of commercial salmon harvests in Alaska from the early 20's to the present, pointing out the cyclic nature of returns. The most recent low point was in the early 70's when statewide harvests were approximately 23 million fish. More recently, during the 80's, the commercial harvest has been at or above 100 million fish reaching a peak of 145 million in 1985. Although hatcheries have contributed substantially to this increase, there has also been a phenomenal rise in the wild stock abundance.

With the current price per pound of sockeye, he noted that the value of each sockeye adult was approaching 2 barrels of oil (legislative language). During the past year, FY87, about 104.5 million sockeye eggs were taken at state facilities. Projected revenues of adults returning from BY87 = 20 million dollars.

Dr. Allee stated that the challenges in sockeye enhancement work for the near future include:

1) Smolt rearing
2) Adult ripening/maturation
3) Less expensive mass marking/evaluation programs
4) Continued development of sockeye culture techniques - aiming for statewide survivals of 80% to eye up, 20% to smolt, 12% marine survival.

DRAFT 11 July DRAFT

PREVALENCE AND BIOLOGY OF ZERO-CHECK SOCKEYE SALMON IN SOUTHEAST ALASKA

by

Scott McPherson

Alaska Department of Fish and Game
Division of Commercial Fisheries
Juneau, Alaska

July 1988

LIFE HISTORY

General life history and definitions

Before describing the alternative life history of sockeye salmon a definitions of terms is in order.

Glossary

Lake-type adults:	Adult sockeye sockeye which spawn in con-conjunction with a lake system.
River-type adults:	Adult sockeye salmon which spawn along rivers in areas with no access to lake systems.
Lake-type smolts:	Smolts which outmigrate from lake systems; ages at outmigration are 1+, 2+, and rarely 3+ or 4+.
Zero-check smolts:	Smolts of 'river-type' adults which outmigrate as underyearling (age 0+) or zero-check fish. Other authors may refer to these as 'sea-type' sockeye salmon.
River-type smolts:	Smolts of river-type adults which outmigrate as age 1+ (and rarely as age 2+) after rearing for one or more years in river lagoons or pools.

Adult sockeye salmon utilize either lake or riverine habitat and can be classified as lake- or river-type adults, accordingly. Lake-type progeny outmigrate from the lake environment from 2 to 5 years after egg deposition, and hence the age designations of 1+ to 4+ following the European age formula. Since the European designation only accounts for visible annuli on a scale pattern, an age 1+ smolt delineates a fish whose egg was deposited in 1983, hatched in spring 1984, reared overwinter as a fry in 1985 (laying down its winter annuli), and outmigrated in the spring of 1986; total age as a smolt is 2 calendar years from deposition. River-type progeny rear in lagoons, pools, or river deltas of large river systems. River-type smolts are almost exclusively age-0+ or -1+ and hence outmigrate at a younger average age than lake-type smolts.

The designation of two types of adults (lake and river) and three types of smolt (lake, river, or sea/zero-check) by others (Semko 1954; Wood et al. 1987) confuses the issue of alternative life history for sockeye salmon. Simply put, for the purposes of this pater, I shall refer to only 2 types of sockeye salmon, lake- and river-type, following the adult spawning phenomena. Age-at-maturity and length of juvenile habitation in freshwater are highly variable in sockeye salmon (Foerster 1968). Freshwater age of river-type progeny is probably simply determined by location of adult spawning, fry density, and the following spring river water levels. I shall reserve zero-check to refer to the subset of river-type progeny which outmigrate to marine habitat within one calendar year.

Because many of the river-type eggs incubate in areas of upwelling, it is probable that these fish incubate for a shorter period of time than fish in non-upwelling areas and hence obtain a head start on the growing season.

It is known that zero-check fry rear both in upper river areas and near river mouths in lagoons and estuaries (Wood et al. 1987; Birtwell 1987; Heifetz et al. 1988). Heifetz et al. (1988) documented that zero-check fry grew faster in river mouth areas compared to upriver areas in the Situk River near Yakutat. He found that peak water temperature in the Situk estuary was near optimum (15.1 C) according to Reiser and Bjornn (1979), whereas in upriver areas water was usually cooler and ranged from 8 C to 21 C. The Situk estuary also exhibited salwater influence, from 0-30 ppm. Birtwell (1987) studied sockeye fry migration and rearing patterns on the Fraser River delta in 1977 and found that optimum rearing for zero-check fry was in a lagoon with mean tempurature of 13.7 C and salinity of 0.2 ppm. He also found this lagoon to provide abundant prey for sockeye fry. Additionally, Birtwell found that age-1+ and -2+ fry passed through this area rapidly and were present for only 6 weeks while zero-checks were found during 21 consecutive weeks in the delta area. Murphy et al. (1988) found simular findings in the Taku River sockeye smolt outmigration. Zero-check sockeye fry utilized the lower Taku River delta and estuary extensively and were present long after the older age sockeye had outmigrated.

Migratory Timing:

Migratory timing of zero-check sockeye smolts occurs after sockeye smolt of greater freshwater age (Birtwell 1987; Heifetz et al. 1988; Murphy et al. 1988). Birtwell found that in the Fraser River that the mean of the migration of zero-check sockeye was located 6 weeks later (mid-June vs. early May) in time than older freshwater age smolts. Birtwell, Heifetz, and Murphy all found that fish that were at least age-1+ had cleared the estuary area by 1 July and that zero-check sockeye were utilizing estuarine habitat until September or October in small numbers. All three studies found that the peak of the zero-check outmigration occurred in July. Heifetz concluded that zero-check fry in the Situk estuary increased approximately 0.4 mm/day from April to late July whem mean size was about 70 mm or the same size as the smaller of the age-1 smolts migrating in May and June. He also found that salinity tolerance was directly related to fish size, and a size of 50 mm was required for survival in seawater. Additionally, only 67% and 30% of sockeye 40-49 mm and 30-39 mm, respectively, survived, and concluded that estuarine rearing enables zero-check sockeye to grow large enough to adapt to seawater and migrate to sea as underyearlings.

PREVALENCE OF ZERO-CHECK SOCKEYE IN SOUTHEAST ALASKA

Stikine River

The Stikine River sockeye salmon population is comprised of two groups, those fish that spawn at Tahltan Lake and all others, which are mostly rivers, the East with 55% (244,978 fish) and the Situk with 29% (128,619 fish), accounted for 84% of the return (Riffe et al., in press). All fisheries and escapements included zero-check fish, ranging from less than 1% in the Situk escapement above the weir to 98% in the East catch. Overall the return was composed of slightly more than a quarter of a million (57%) age 0. sockeye salmon, 93% of which was contributed by the East River. It is interesting to note that the East River was part of the Alsek River until the late 1960's and has since become a separate entity fed by clear ground-water upwelling through gravel deposits (Don Ingledue, Alaska Dept. of Fish and Game, Douglas, pers. comm.).

DISCUSSION

Information presented in this paper is intended to provide an overview of life history requirements of zero-check sockeye and prevalence of significant populations of zero-check sockeye in Southeast Alaska. For detailed information and specific items, the appropriate literature should bereferenced.

In summary, river-type adult sockeye salmon are found in large numbers in Southeast Alaska only in Yakutat area, but smaller numbers of adult spawners are found along the Chilkat Mainstem and in Berners Bay on the U.S. side of the border. Populations of river-type sockeye in the Taku and Stikine River spawn in the Canadian reaches of these two rivers. River-type sockeye salmon are different genetically and may contain larger eggs; brood selection for zero-check enhancement projects should be from river-type donors.

Evidence suggests that zero-check eggs may incubate in areas of upwelling and hatch earlier due to warmer overwinter water tempuratures. Rearing zero-check fry grow faster in warm (12 - 15 C) water and can tolerate dilute seawater as well. Zero-check fry can survive in seawater after attaining a length of 50 mm.

In addition to utilizing habitat unique to most sockeye populations, zero-check sockeye provide other tools as well. As mentioned earlier, age composition data can be used to identify river-type populations migrating through several commercial fisheries. From an enhancement standpoint, age 0. fish provide an opportunity to realize returns one year earlier plus greatly reduce the overall cost of raising fish by eliminating the need to overwinter the fry for one year in a hatchery environment.

Sockeye bound for the Taku River enter inland waterways through Cross Sound and are exploited to a small degree in the U.S. Icy Strait purse seine Districts 112 and 114. Further exploitation occurs in the U.S. District 111 drift gillnet fishery and in the Canadian inriver commercial gillnet fishery. Total return in recent years (1984, 1985, and 1986) has averaged approximately 185,000 fish (Andrew McGregor, Alaska Dept. of Fish and Game, Douglas, pers. comm.). The District 111 fishery has taken an average of 73,000 fish annually during those years (approximately 80% of this total is bound for the Taku and the remainder for Port Snettisham), the Canadian inriver fishery catch has averaged 19,000 fish, and the escapement (mark-recapture) estimates have averaged approximately 95,000. Scale patterns analysis is used to allocate catches and a comprehensive scale sampling and tagging program operates just below the Canadian border at Canyon Island where samples taken from fish captured in fishwheels provide upriver stock and escapement estimates.

Migratory Timing:

The relative abundance of age 0. fish climbs as the season progesses in District 111, at Canyon Island, and in the Canadian fishery, comprising up to 40% of these catches in some weeks (Figure 4). The consistency of these age composition data both among fisheries and years suggests that zero-check timing can be used to indicate timing of river-type fish, regardless of freshwater age. This is further supported by the fact that the proportion of age 0. scales samples collected at Canyon Island is closely mirrored by the run timing of mainstem river stocks as documented from spawning ground recoveries of tagged fish (Figure 5).

It is interesting to note that the peak of zero-check fish in the northern portion of District 112 occurred in statistical week 31, just prior to peak abundance of zero-check fish in the Taku fisheries. These fish were not bound for other zero-check producing systems in northern Southeast Alaska since the run timing of the only other significant stock of age 0. fish (Lynn Canal) peaks approximately one month earlier, and suggests that the presence of age 0. fish provides a means of stock identification through various fisheries.

The 1985 return of approximately 190,000 sockeye to the Taku River was comprised of an estimated 10% (19,000) age 0. fish.

Lynn Canal

Electrophoretic studies demonstrated that the Chilkat and Chilkoot Lake stocks were significantly different at several loci from the river-type stock found along the mainstem of the Chilkat River (Jack Helle, National Marine Fisheries Service, Auke Bay, AK. pers. comm.). River-type sockeye salmon are also found in three of the four rivers that drain Berners Bay.

Chilkoot Lake and Chilkat Lake systems contribute most of the 400,000 to 600,000 total return of sockeye salmon to Lynn Canal each year. River-type stocks from the Chilkat River and Berners Bay also contribute to the catches, however (Figure 6). In 1986 56% of the Chilkat mainstem and 38% of the Berners Bay scale samples were zero-checks (McPherson and Jones

13. McPherson, S. 1987. Contibution, exploitation, and migratory timing of returns of sockeye salmon (O. nerka Walbaum) stocks to Lynn Canal in 1985. ADF&G Tech. Data Rept. (in press).

14. McPherson, S. 1987. Contibution, exploitation, and migratory timing of returns of sockeye salmon (O. nerka Walbaum) stocks to the Lynn Canal drift gillnet fishery of 1986. ADF&G Tech. Data Rept. (in press).

D. Yakutat

15. McBride, D., and A. Brogle. 1983. Catch, escapement, age, sex, and size of salmon (Oncorhynchus spp.) returns to the Yakutat area, 1982. ADF&G Tech. Data Rept. No. 101. 95pp.

16. McBride, D. 1984. Compilation of catch, escapement, age, sex, and size data for salmon (Oncorhynchus sp.) returns to the Yakutat area, 1983. ADF&G Tech. Data Rept. No. 126. 98pp.

17. McBride, D. 1986. Compilation of catch, escapement, age, sex, and size data for salmon (Oncorhynchus sp.) returns to the Yakutat area, 1984. ADF&G Tech. Data Rept. No. 164. 104pp.

18. Riffe, R., S. McPherson, B. Van Alen, and D. McBride. 1987. Compilation of catch, escapement, age, sex, and size data for salmon (Oncorhynchus sp.) returns to the Yakutat area, 1985. ADF&G Tech. Data Rept. (in press).

E. Stikine River, Taku River, Lynn Canal combined under one cover

19. McGregor, A. 1983. Age, sex, and size of sockeye salmon (O. nerka) catches and escapements in Southeastern Alaska in 1982. ADF&G Tech. Data Rept. # 100. 124 pp.

20. McGregor, A. J., S. A. McPherson, and J. E. Clark. 1984. Abundance, age, sex, and size of sockeye salmon (O. nerka) catches and escapements in Southeastern Alaska in 1983. ADF&G Tech. Data Rept. # 132. 180 pp.

21. McGregor, A. J., and S. A. McPherson. 1986. Abundance, age, sex, and size of sockeye salmon (O. nerka) catches and escapements in Southeastern Alaska in 1984. ADF&G Tech. Data Rept. No. 166. 233 pp.

22. McPherson, S., and A. McGregor. 1986. Abundance, age, sex, and size of sockeye salmon (Oncorhynchus nerka Walbaum) catches and escapements in Southeastern Alaska in 1985. ADF&G Tech. Data Rept. No. 188. 222 pp.

OTHER LITERATURE CITED

Bergmann, W. 1978. Salmon spawning populations of the Stikine River. Report by Alaska Dept. of Fish and Game, P.O. Box 20, Douglas, AK 99824, 26 pp.

Ward, H. 1921. Some of the factors controlling the migration and spawning of the Alaska red salmon. Ecology 2:235-254.

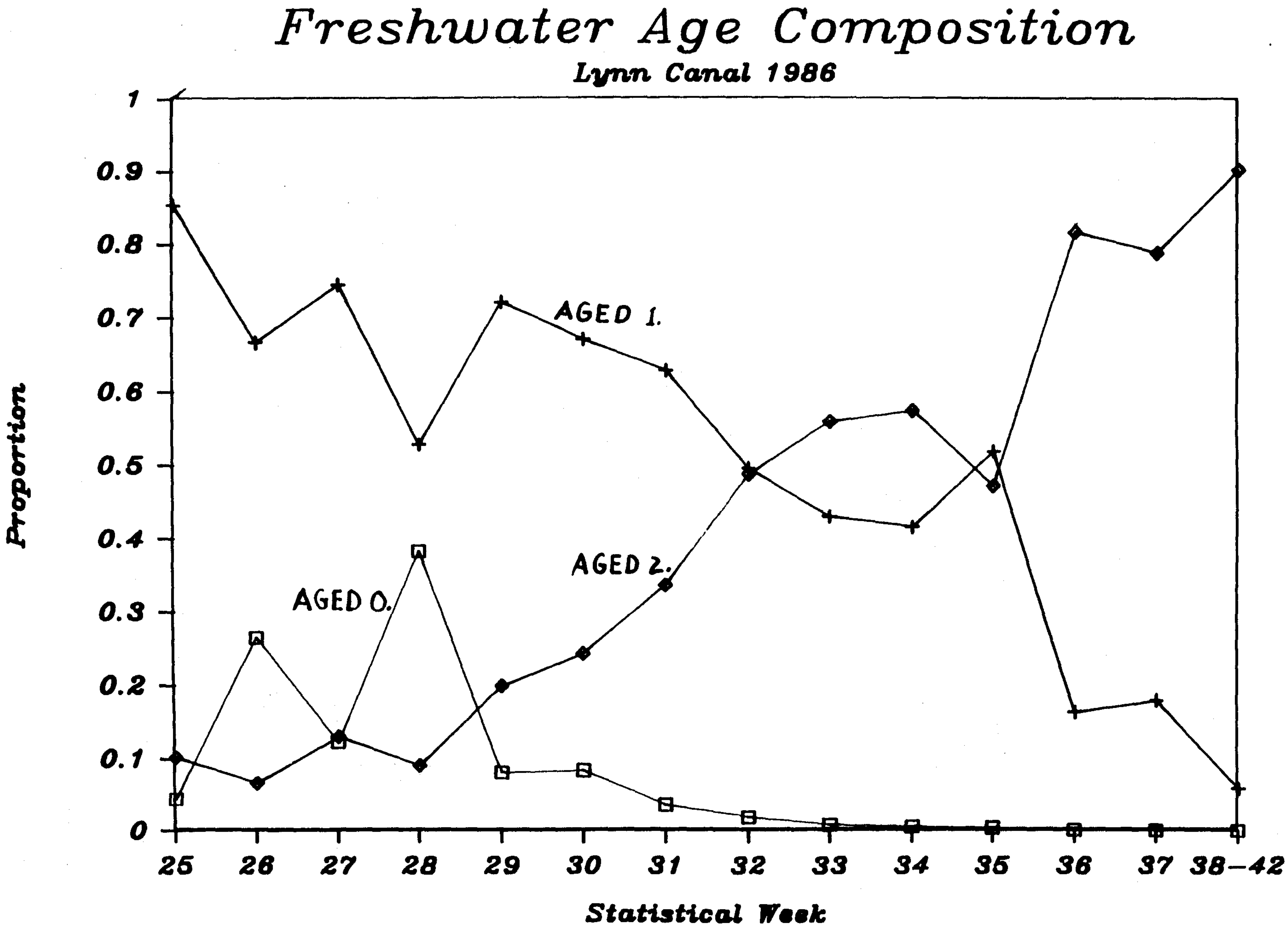

Figure 9. The weekly age composition by freshwater age class in Lynn Canal.

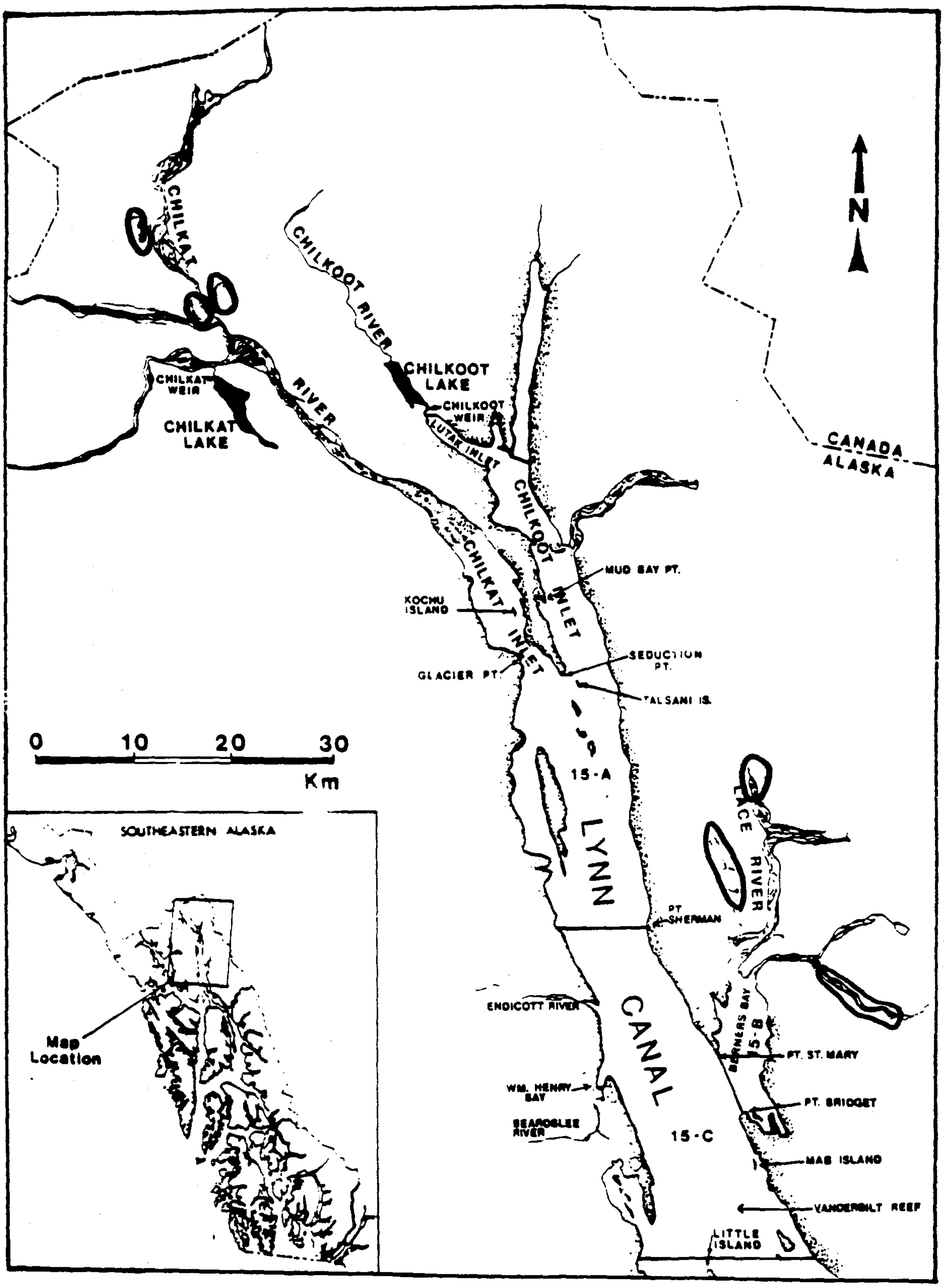

Figure 6. Map of Lynn Canal showing the fishing district and sections (e.g., 15-C) and principal spawning and rearing areas.

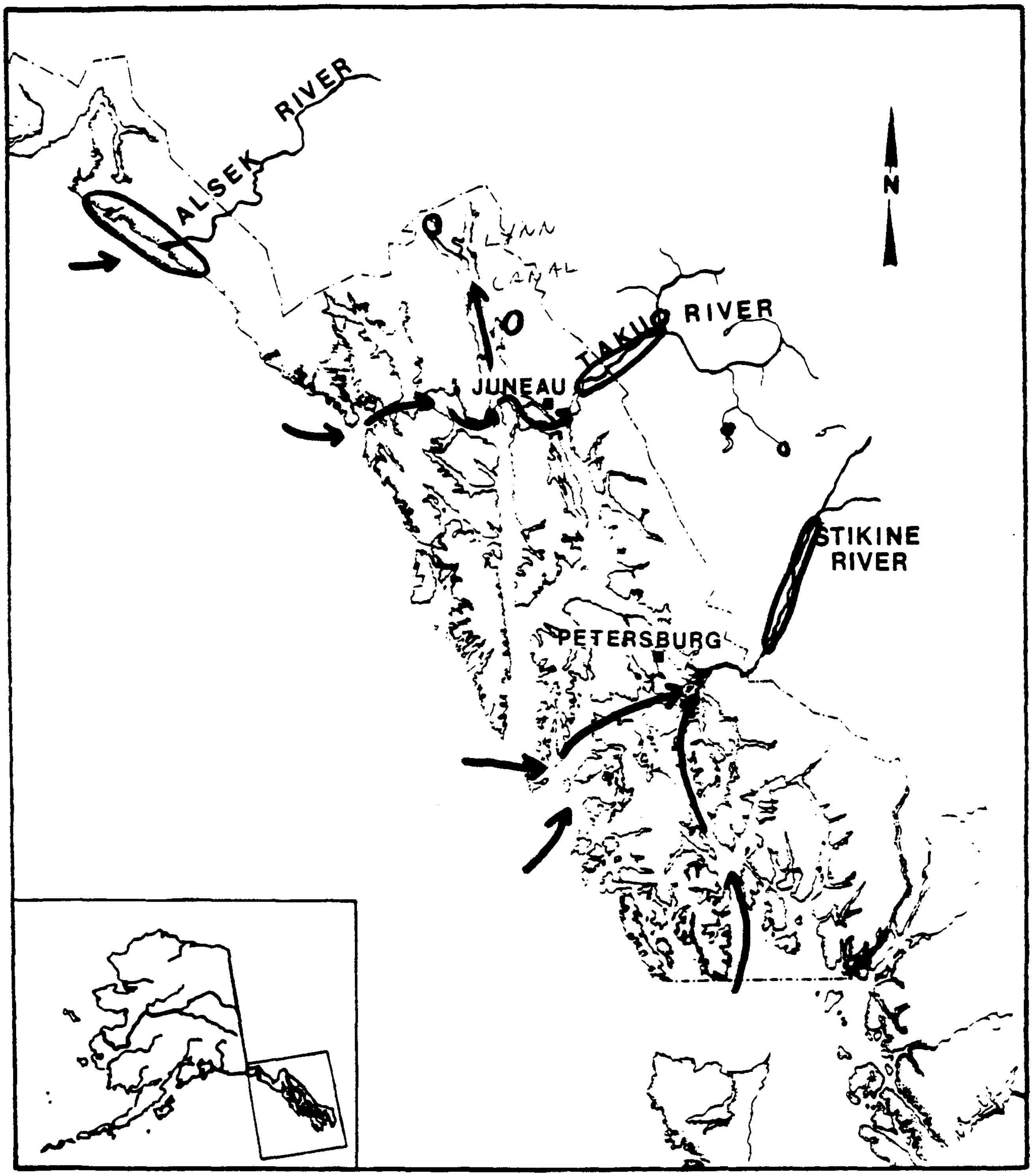

Figure 2. Map of Southeast Alaska showing locations of major populations of zero-check sockeye salmon and migration routes.

QUESTION: Scott, if they're going out later and coming back earlier, aren't they smaller developed?

MR. McPHERSON: They're a little bit smaller. They average something like 20 millimeters smaller than Chilkoot and Chilkat fish. We're not talking about that much. But they are, average weight, they're probably half a pound less than Chilkoot, which is about average for Southeast.

QUESTION: Do you know, Scott, the Bohm River, just the next one down, that flows into the East River, right above tidewater?

MR. McPHERSON: I think it does, yes.

A VOICE: And there's kind of a long real slow slack water -- I don't know, maybe it's partly saline estuary there. ....

MR. McPHERSON: Yes.

QUESTION: Might not this be a contributor, providing some real warm rearing for those fish.

MR. McPHERSON: Looking at the scale pattern, I can see that's probably true. I don't think they rear in the streams very much.

QUESTION: There's no lake system up there either, is there? There's some small lakes on the Dome?

MR. McPHERSON: Yes, there's three or four puddles I think that the sockeye may rear in there. They're not a very healthy pattern, but they are zero checks.

QUESTION: When you fly over that area in a plane, don't almost all of those systems have a big estuarine area behind the bar there?

MR. McPHERSON: Right.

QUESTION: Isn't that real common to all those systems there?

MR. McPHERSON: Yes.

MR. WHITE: We've got several zero check populations around Kodiak we've seen. Most of them also do involve some lake residents, fish spawning in rivers between two lakes and then rearing in shallow ponds that warm up tremendously and they seem to put on that additional fast growth that you talked about and then go out immediately. The size that you talked about that were seen in the smolts going out there, 55 millimeters, two gram fish going out there naturally. And we've also seen them in this kind of up-welling area that you're talking about in other systems where there's like a hundred percent zero checks and then there's a warm water system nearby, and what they call silver salmon lake next to Olga Bay at the south end of Kodiak, again a warm lake where they can get that growth and going right out immediately. So there seems to be something in what you're saying as far as spring water or warm water which you get in rivers between two lakes. It gets the higher temperature units which creates the right environment for that.

MR. McPHERSON: Right. I think it would be successful with zero check sockeye. We've got to get it down somehow or other, to make up that smolt size basically within two months whereas the regular lake type have all year over-wintering to do that.

MR. WHITE: Yes. Did you notice anything on the fecundity of these fish? You talked about the riverine grouping generally of a larger size, egg and fry, does that mean lower fecundity ?

MR. McPHERSON: I guess that it would be. That's something I haven't seen documented on the spawning ground.

QUESTION: I think my question has just been answered, but that's one of the questions that we've had for some time now, is whether the zero check is genetically different or it's just an environmental factor, just reaching the critical size at the right time in that first year, and it appears the answer is that it's environmentally reaching the critical size in the first year.

MR. McPHERSON: Yes.

MR. ALLEE: That's the raging debate though. Whether you have to do that or not.

A VOICE: Have you gotten any jack returns ?

MR. McPHERSON: We haven't had enough fish out yet to get any returns in that category. Next year will be our first year.

QUESTION: Well, we'll probably go into this later on, but in any of your work, did you see any zero checks occur in the lakes anywhere?

MR. McPHERSON: Not that were reared in lakes in my mind.

MR. PELTZ: It does happen in the Copper River. We do have it.

MR. McPHERSON: Is that a lake system?

MR. PELTZ: Yes. I don't know that its common, but it does occur in some areas there.

MR. McPHERSON: Doesn't that population occur quite a ways up the river?

MR. PELTZ: No, in the delta stock.

MR. WHITE: Scott, do you have any idea as to whether the marine survival in these critters is less than the others because they,re smaller going out as smolts than the others?

MR. McPHERSON: Usually survival is related to smolt size within the natural variation of the system. I think these guys are programmed to go out as smaller fish, and whether they compete pretty well I'm really not sure. I do know that a lot of them go down and rear in the estuaries for a while and put on some additional growth after they come out of fresh water,in the rivers. They grow pretty fast down there. I think the over-all survival rate or return per spawner from at least the Taku stock of this size is less than it is on the lake stocks.

MR. WHITE: Okay, so it's less return per spawner.

MR. McPHERSON: I think in wild stocks it's less, because we have a less stable environment to deal with.

MR. WHITE: So what you're saying is, you're not sure whether it's freshwater or saltwater then?

MR. McPHERSON: I'm not sure, no. They are on the average smaller smolt, there's no doubt.

DAVE HARDING: Scott, every year in the Fraser River we have probably thousands of sockeye fry swimming around in the estuary where there is a freshwater lens, and yet when we look at the scale pattern we don't see any evidence of this. Could there be a problem in identification?

MR. McPHERSON: Of misreading the zero check as a second one year check?

MR. HARDING: Yes.

MR. McPHERSON: I'm sure that does occur in minor cases, but I think as a whole it isn't a big problem.

MR. HARDING: The smolts show something like 7-10 circuli in freshwater, I was just wondering if there's a possibility that we aren't confusing them.

MR. McPHERSON: You don't see a distinct annulus?

MR. HARDING: Well, there appears to be an annulus, yes.

MR. McPHERSON: But you think maybe they're actually zero checks, but being aged as one checks?

MR. HARDING: I think that's possible. They're mistaking an estuary check for the freshwater annulus.

MR. McPHERSON: It's certainly possible. I've seen patterns up in the Yakutat area where they actually over-wintered down in the lagoon, with this tremendous growth patterns, and they still put out an annulus, but it doesn't look anything like what you see in totally freshwater anyway.

MR. HARDING: If you can go just ahead of the inlet and look down, it's just swarming with sockeye. And you know, it seems an awful waste if none of them ever return.

MR. McPHERSON: How large are they? 3-5 grams?

MR. HARDING: That's the normal smolt going out of the lake itself, but it wasn't what we see down in the estuary, as newly emergent sockeye size.

MR. PELTZ: You see the same things with cohos don't you in Southeast? It's real common to see these little coho frys swimming around down in the estuaries like nomads by all the people there, nobody ever knows if they come back. They're out there, they're living and they're surviving, nobody ever knows if they come back or what they contribute.

MR. HARDING: Yes.

MR. ALLEE: That's an interesting comment, because there's some speculation that in fact they overwinter and therefore you don't see them. It's not necessarily misreading them, as they're a one check smolt, but their strategy is not using the lake, using an estuarine or a body of water to overwinter, which is true with respect to coho.

MR. HARDING: These ones in the head of the inlet, though disappear.

MR. ALLEE: Oh, they disappeared?

MR. HARDING: Yes. By the end of the summer you don't see them any more.

MR. ALLEE: Well, that would sure be an interesting thing to study.

Broodstock Ripening Survey and the Klawock Sockeye Program - Dan Rosenberg

Dan presented the following three papers - (1) A summary of holding strategies for sockeye salmon broodstock, (2) Klawock Hatchery: 1986 & 1987 sockeye salmon adult holding data, and (3) Database questionnaire: Sockeye Salmon Adult Holding Data.

Klawock sockeye returns have declined from an average escapement of 31,000 fish in the 1930's to 4,400 fish in the 1980's. Hatchery goals include 12-15 million eggs producing 225-275,000 adult returns.

Broodstock holding density in 1986 = .51 fish/ft^3. Held assortment of 736 bright to dark pigmented fish for 26 days. Most however, were dark. Eighty-six percent of these were spawned and 14% either died or never matured (see handout). Broodstock holding density in 1987 = 1.2 fish/ft^3. Of the 5,181 fish held for 26 days, most were bright, compared to mostly dark in 1986. Nineteen percent of these were spawned and 81% either died or never matured (see handout).

Consensus of group was don't hold bright fish for ripening in large production numbers. If large number of eggs are needed, either collect for holding well pigmented fish or go to natural spawning areas. We need to continue to research methods for holding and ripening bright fish to maturity. This is a problem that needs to be solved very soon for many large scale sockeye hatcheries.

A SUMMARY OF HOLDING STRATEGIES FOR SOCKEYE SALMON BROODSTOCK

Dave Bright
FC III, Ketchikan

1987-1987: Hugh Smith Lake, Heckman Lake and Salmon Lake. Up to 425 spawners were held up to 10 days in 11.5 ft. x 11.5 ft. x 11.5 ft. floating net pens (.3 fish/$ft.^3$). At Heckman and Hugh Smith, prespawning mortality was well below 1% (water temperature ranged from 10 to 14°C). At Salmon Lake, mortality was 10-15% (water temperature was approximately 18°C). 7.5 million eggs were harvested in 1987.

John Burke
FC II, Main Bay

Tried to ripen fish in net pens during experiments at Karluk Lake, East Creek Hatchery and at the Woods River Lakes, Bristol Bay. Bright fish were found to be very sensitive to handling and died easily. Fish with well developed pigmentation were tougher and eventually ripened.

Tim Burke
FC II, Clear

1978-1980: East Creek, Francis Creek and Killian Creek. Up to 200-300 spawners per 4 ft. x 8 ft. x 3 ft. net pen resting on the creek bottom. Fish are separated into pens by sex. Fish were held at all stages of ripeness. Water temperatures were 6-8°C during holding period of 10 days or less. 2.5 to 7.5 million eggs harvested with prespawning mortality less than 5%.

Bill Gaylor
FC III, Trail Lakes

1986: Hidden Lake. Each of 24 silver bright spawners (12 males and 12 females) were held in separate 4 ft. x 1 ft. x 2 ft. aluminum isolation chambers. Each chamber was fed by its' own separate water system. Throughout the holding period, 9/22/86 - 11/20/86 fish were kept in darkness, without physical or chemical cues, and each chamber was devoid of any substrate. After 91 days of holding, two fish (one male, one female) were ripe. 22 fish died.

L.E. White
FB III, Kodiak

1978-1986: Karluk Lake. Spawners were held in 1728 $ft.^3$ net pens (12 ft. x 12 ft. x 12 ft.). Holding period was approximately 2 weeks. Only fish with some degree of pigmentation were selected for holding. Net pens were covered to reduce sunlight. Water temperature profile during holding period was 6-12°C. Prespawning mortality was approximately 20% on males and 10% on females. Up to 23 million eggs harvested per year.

Dave Parks
<u>FC III, Clear</u>

1981-1982: East Creek. Same procedures as Tim Burke with essentially the same results. Approximately 5-7 million eggs were harvested with less than 5% prespawning mortality. Water temperature were 8-9°C.

Lee Ohlinger
<u>FC II, Trail Lakes</u>

1982-1988: Hidden Lake. Approximately 2000 spawners were held in instream picket enclosures (fish would not ripen in net pens). Approximately 1½ weeks are required to ripen with water temperatures normally around 10-3.5°C. All fish held were "well-pigmented".

Tom Flagg
Research Biologist N.M.F.S.
<u>Manchester, Washington</u>

1987: Wenatchee River. Broodstock held in 16 ft. x 16 ft. x 25 ft. net pens (.02 fish/ft.^{3}). 130 adults per pen (mixed sex). Mortality was about 5% over a 90 day ripening period. Water temperature during holding = 11.7-12.8°C. 375 thousand eggs were harvested. Fed fish through this 90 day period.

This page and the following page should be in reverse order.

Klawock Hatchery: 1986 sockeye salmon adult holding data

fish held: 736 (density = 0.51 fish/ft^3)
fish spawned: 632 (321 females, 311 males)
fish died: 81 (22 jumped out onto ground, 59 died in raceway)
fish which remained green: 23 (not spawned)
eggs harvested from raceway: 963,000
holding period: 9/4 - 9/30/86
egg harvest dates: 9/17 (108 females, 100 males);
9/24 (187 females, 183 males);
9/30 (26 females, 28 males)
total # adults counted through weir: 14,800
time period of adult spawning run: 7/28 - 10/10/86
peak weir counts: 8/6 - 8/8 (8,000); 8/18 (1,500); 8/25 (1,100); 9/2 (2,200);
general condition of broodstock at collection: nearly ripe (dark)

raceway dimensions: 48' x 12' x 4'
approximate water volume = 1,440 ft^3
approximate water inflow rate: 200gpm (1986 value); 800gpm (present value)
water exchange rate (R value): 1.1 (1985 value); 4.4 (present value)
temperature regime (^oC) during adult holding period: 9.4 - 7.7
temperature regime (^oC) during adult migration period: 10.5 - 9.4

Note: during the coming 1987 season, 3 raceways will be used for holding broodstock. Water inflow rates for each unit will be set at approximately 800gpm (3040/1/min) which should enable us to hold approximately 4,000 fish (based on the 1986 IHNV workshop value of 1.5 fish/ft^3 or Wester's 3kg/ft^3 @ R=4.5)

Klawock Hatchery: 1987 sockeye salmon adult holding data

fish held: 2,642 females; 2,539 males
fish spawned: 499 females; 478 males
fish dies: 2,143 females; 2,061 males
egg harvested: 1,422,000
holding period: 9/12 - 10/08/87
holding mortalities: females = 81.1%; males 81.2%
spawning days: 8
Temperature regime: 11.0 - 4.0 ^{o}C
Three raceways (combined volume = 4,320 ft^3) were used to hold 5,181 fish. The holding density was 1.21 fish/ft^3 (in 1986 it was .5 fish/ft^3). fish were initially impounded at all stages of ripeness (bright silver to dark).

During the coming 1988 season, our holding facilities will include: 3 raceways (total volume = 4,320 ft^3); one large in-stream picket enclosure (total volume = > 12,000 ft^3); and two deep floating net pens anchored in the lake (total volume = 6,000 ft^3). Total combined holding volume will be approximately 22,000 ft^3.

Approximately 10,000 adults are needed for the scheduled 15 million eggs scheduled to be incubated this year. At this level, the holding density will be approximately 0.5 fish/ft^3 (the same density encountered in 1986).

Database: Sockeye Salmon Adult Holding Data

1. Holding dates (start to end):

2. # fish held:

3. # fish successfully spawned:

4. # fish died:

5: # fish which remained alive, never ripening:

6. Water temperature during holding:

7. Geographic area:

8. <u>Degree of pigmentation at start of holding period:</u>

   # silver bright fish:
   # with some pigmentation:
   # dark fish:

9. <u>Holding structure</u>

   Type:

   Dimensions:

   Location: (stream); (lake); (other ____________________)

10. Comments: Any observations which account for the success or failure of your holding strategy.

Please use this questionnaire as a master to make enough copies to accommodate each year you held sockeye brood (past and future). Your attention is much appreciated.

Send copies to : Dan Rosenberg
P.O. Box 101
Klawock, AK 99925

MR. ALLEE: Dan, in terms of the mortality in '87, was it constant, sort of chronic mortality, was it front-endloaded or what?

MR. ROSENBERG: The fish were captured right off within say, a week and a half, we had the fish that we needed. We held them, and they just started dying. You know, like we had maybe a week, week and a half of no problem, and then you just started seeing it. The more you got in there and started handling them--it got to be a panic situation, we've got to get our eggs, and so you get in there, you start handling them, you start stressing them, and you can just see it the next day, you start getting die-offs, and they just started accumulating. There were other factors that I should mention on this '87 mortality, and that is we were into a city water system that was plugged in the day before the fish arrived, and we had problems with super-saturation. I can't tell you what the exact saturations were, but I can tell you that the water was so highly saturated that it looked like a milkshake, and we had fish in that. So there's another stress factor at the front end. We had a little higher temperature in '87, about one degree or so higher than previous years, so there's another factor. The key, I think, would be to keep them in the river for as long as we can, and then start handling them.

QUESTION: What was your temperature during the time you were handling them, and was there any other pathological factor?

MR. ROSENBERG: Our temperature started out at around 11° centigrade at the front end of the holding, and at the tail end it was down to about 4° centigrade. The year before the temperature was, I believe, 9.4 or 9.5° centigrade, and it dropped down at some point, it seemed to, 7 or 6°C. So we did have a wider temperature profile, higher at the higher end and lower at the lower end.

A VOICE: Was there any other pathological explanation other than the super saturation problem?

MR. ROSENBERG: I don't even know if they had a gas saturation problem. All I'm saying is that there was obvious problems with the saturation. We had no count on IHN, so we didn't know if it was a problem.

There was no diagnostic work done.

QUESTION: Did yo see any problems with fungus?

MR. ROSENBERG: At the very end, the morts were the only ones that started showing fungus. But no, they looked like good fish, the only problem is that they died. They just started rolling, you know, just like I say it was a chronic situation.

QUESTION: In your '86 group when you were relatively successful, only had 10% responding mortality, what was the success of the subsequent eggs, what was the percent of fish that ripened that year?

MR. ROSENBERG: We harvested somewhere in the neighborhood of 963,000 eggs that year. It was like 600,000 fry or something like that, that we released that year.

QUESTION: What was your survival to eyed?

MR. BRIGHT: The green eggs to eyed that year was 76%.

MR. ROSENBERG: So now the next question is, how did we do last year in the '87 release. The '87 release grew out of those, whatever it was, 2,000 females. We took about 1,500,000 eggs. Out of those eggs, we released about 600,000 fry. So the question is what happened? Well, we had water problems. They weren't biological problems. We had mechanical problems along the way. It was a system that the bugs had not been worked out of prior to those eggs being installed.

QUESTION: Did you measure flow per adult?

MR. ROSENBERG: In the raceway?

A VOICE: Yes.

MR. ROSENBERG: Yes, the flow was like 600 gallons a minute through the raceway. The DO's were high enough so that you knew that they were getting enough water. We had taken DO's all along, so I think for the most part the biological parameters as far as flow rate and densities were within the ballpark, but the problem was the 30-day holding period, starting with fish that were just super bright.

The year before though, we had fish that were the full spectrum, we had bright, we had dark fish, and as I said we lost about 10%. So those other factors, that weren't there in '86 that were there in '87, may have been the factors associated with the mortality.

MR. SAFT: Don asked a question about disease factors and IHN testing, I don't mean to answer the question, but the two years are roughly the same. The '87 year was 96.8% ovarian fluid IHN positive and the '86 year was 100% positive.

QUESTION: These are of ripe fish?

MR. SAFT: Yes.

MR. ROSENBERG: Correct. But at the front end there weren't any, we had no IHN counts on the front end, we were towards the middle of eggtake counts.

MR. SAFT: All we were doing was testing the population.

MR. ROSENBERG: Right.

MR. SAFT: So the population is certainly...

MR. ROSENBERG: Oh, it's high, it's probably the highest system in Southeast, from what I can glean from the literature.

MR. SAFT: The titers were literally identical for the two years we're talking of 1.0 times 10 to the 5th for ovarian fluids for both years.

MR. HADDIX: Well, if I could just make some general comments about trying to take eggs at alternate sites after having spent considerable time looking at quite a few systems in Southeast. If you look at some of the data, for example Hugh Smith were we have good tag data, the mean length of time a fish is in that lake is 60 days. They go up to 90 days, and over 90 days, from the time they enter the system until they ripen in the creek. So just from that standpoint, and that's not an exception, all the other systems are the same that we looked at, except for McDonald Lake. That was, I'm sure the change in the behavior of those fish due to the long number of years that a hatchery was there taking eggs out of a certain selected part of that run. But that's what you're dealing with, an it just seems like anywhere that you're going to go take eggs from the sockeye system, you want to take it from the spawning fish, not fish entering the system. You're just asking for a lot of problems trying to take eggs at Klawock Lake at the outlet of the lake. I know that the fish disperse and it's a lot more difficult to get the number of eggs that you're talking about, but it makes a lot more sense to me to develop a good eggtake system in one of the spawning streams up the creek than to continue to try to take eggs at the hatchery. That's my opinion after looking at all the systems.

MR. ROSENBERG: Right.

MR. HADDIX: All of the old sockeye hatcheries were on the upper ends of the lakes.

MR. ROSENBERG: Well, there are more people involved in doing just that, in harvesting eggs from spawning beds and below spawning beds, then there are people that are actually holding the sockeye brood.

QUESTION: I want to pin down your timing of your mortality just a little bit more.

MR. ROSENBERG: Okay.

QUESTION: When you said with bright fish you had a high mortality, did that occur prior to your handling or after you started handling the fish? How long a period after you started holding fish did that occur, and what was your temperature at the time you started holding that batch when the mortality started? Could you just kind of pin that down a little bit more, please?

MR. ROSENBERG: Sure. Mortality started as soon as we started handling fish. There may have been some mortality that went on prior to getting in there and spawning, but after our first eggtake, then you could see that the mortality became more obvious.

QUESTION: And how long a period of time from the time the fish came in until you started spawning them?

MR. ROSENBERG: I'd say, a week and a half to two weeks. And as far as the temperature, it started out as I said somewhere in the neighborhood of 11 degree centigrade.

QUESTION: So it was 11° when you started handling the fish?

MR. ROSENBERG: It was 11° when they went into the raceway. Now, when we started handling fish it was somewhere between 11° and 4° centigrade, and I would say we're probably looking at about 10°, 9½ to 10° at the time we started handling. But to answer your question fairly, I'd have to sit down with the data in front of me. I'm trying to construct a database for a whole new broodstock, and within that packet that I've passed out, I've got a questionnaire and anybody that's working on broodstock, I would appreciate it if you could drop me a line and answer those questions.

MR. SAFT: Perhaps I could have a word to put some of this in perspective and along the lines of what Mike Haddix was talking about. Yes, I'm sure we would be more successful if we go to the stream of origin and take eggs, but what's going on at Klawock is bigger than the Klawock program. There are reasons why we want to be able to ripen sockeye adults in aluminum type raceways, using pathogen free water as a part of our smolt program, and the development of methods is frankly more important than getting more fish back into Klawock Lake. So I do appreciate the ideas, but we still need to go through the nuts and bolts of how to ripen the sockeye before they get into the Klawock system where we can get large numbers of eggs and where we put them through in this case, city water or Big Lake well water.

MR. HADDIX: Well, what is the matter with egg transfer? I can see your point and I'm sure that's an important aspect to have that program ongoing, but it doesn't make sense to continue to take large numbers of fish and try to hold them and if those eggs are taken from other locations and incubated in that water source, it's just like Beaver Falls or anywhere else. I have a hard time understanding what you're saying there. I can see that there's a need for the research, and to be able to develop something like that because obviously other people are going to have the same problems, but logic just says that if you're going to try to develop this sockeye program that you should go where you're going to be successful initially, and then work out those other problems. And it's pretty obvious looking at these systems, natural systems, that it's difficult to do and there's a lot of problems with just the life history of the fish. Are you going to stay in the lake for three months before they ripen up? Some of the fish that you collect aren't going to ripen up for three months.

MR. ROSENBERG: If you want to fill the facility, we've got to do more than hold adults in raceways. Now we don't have any more water available to build more raceways, and we can't put in, as Ken Leon suggested doing some work with Sears' swimming pools, we don't have the space and we don't have the water. So there it is. What are you going to do?

A VOICE: Dan, I appreciate your problems because I know we're going to be facing this ourselves very soon, that's why I kind of asked the question I did, but yes we may be asked to do the impossible. But what we're proposing to do is the situation where we're going to have to hold fish for a period of time. We don't have the option. We will not have the option of going to the estuary and getting our eggs, we'll have to hold them.

MR. ROSENBERG: Is that at Beaver Falls?

A VOICE: Yes, wherever we go, I don't care where, it's just the way we operate our program. If we can't hold fish, we're not going to have an operable program, we'll do something different. But we're proposing to hold the fish in saltwater with a freshwater lens, with a floating raceway that fish can swim in.

MR. ROSENBERG: Aren't you going to have a plastic apron or something to create a lens?

A VOICE: Right.

MR. ROSENBERG: So you'll have the best of both worlds.

A VOICE: We're hopeful, but that may not work, but at least we're going to be faced with the situation of holding bright fish for a long period of time while trying to get them to spawn, and in conjunction with this, we're going to be doing photo period manipulation as well as hormone injection and other things to try and shorten that period and looking at it pathologically at the same time, to see if we can't pin down where these problems are. But you know, we consider this a very serious problem.

MR. BERTONI: Well, you know there's been Tom Flagg, down in Manchester, he took bright fish, and what was it, 30 or 90 days you held them for?

MR. FLAGG: We held them for 90 days.

MR. BERTONI: 90 days, and he felt that had something to do with their success. But you were dealing with smaller numbers, you harvested something like 375,000 or 400,000 eggs, something like that?

MR. FLAGG: Something like that, right, we held 260 fish.

A VOICE: Right.

MR. FLAGG: We're down in low numbers.

MR. ROSENBERG: See, and we're talking about holding 10,000 fish.

QUESTION: Dan, I've got some questions about understanding the life history of the sockeye, and particularly Klawock and some other lake systems, similar lake situations.

I have a question; when you hold these fish, are you not holding these fish under stream water temperatures?

MR. ROSENBERG: We're holding them under Klawock lake water, it's the city lake water, it's about a degree or two below the Klawock Lake water temperature. And then the fish that would be held, if they're going to be held in the lake or the river, they would be subject to that temperature.

QUESTION: Okay. That brings up a question I had. It' relatively similar to the stream temperature by only a degree or two?

MR. ROSENBERG: That's right.

MR. CHLUPACH: Mike, on your weir, have you seen where these fish ripen up, do you see them ripening up on the beaches or at the streams?

MR. HADDIX: Usually they come through the weir and...

MR. CHLUPACH: And they ripen up in the lake.

MR. HADDIX: Yes, between 30 and 90 days, and Klawock's the same. The creek that they get their water out of for the raceways is one of the main spawning streams. They had the lake and reservoir for water supply, and they show up there a month or two months after they come through the weir.

MR. CHLUPACH: Do you also have well water?

MR. ROSENBERG: No.

MR. CHLUPACH: No well water. I guess my point is that we're attempting to hold these fish perhaps under an artificial situation that is not characteristic to their life history, meaning that if those fish get in a lake they're probably not ripening up in the top, say two or three meters of the lake, they may be slowly ripening up at further depths. And I really believe that happens, in Big Lake I know it happens. That's why I suggest that perhaps that could be part of the problem, is not trying to duplicate what's happening in the natural life history of those fish in the lake.

MR. ROSENBERG: That's a good point.

A VOICE: In the situations I'm familiar with where sockeye spawn in lake environments, you will not find those fish ripening up in the warmer thermal layers of the water. When they come in the stream, sure, they're in the warm temperatures, but the first thing they do is they go down, they don't sit along the surface at all when they migrate to the lake.

MR. ROSENBERG: And you're right, we're just subject to the ambient temperature, the surface temperature. I think the water is drawn at about five to ten meters. I'm not sure. Mike, you remember what the depth on that intake is?

MR. HADDIX: It's not very deep.

MR. ROSENBERG: Yes, it's not very deep. So there you have it.

MR. CHLUPACH: That brings up a question, if you had well water, I would suggest or at least I would think one of the experiments would possibly be to run some well water through these fish to get a different temperature regimen, and try that, and as you come further along in your season ripening these fish, introduce some warm water on top of that and gradually warm this...

MR. ROSENBERG: I know this may or may not have anything directly to do with it, but I know that Bill Gaylor at Trail Lakes, had tried to ripen fish in cold water, colder water then Hidden Lake, which is where I guess they were originally from, and he had some serious problems.

MR. CHLUPACH: I'm not suggesting ripening up in cold water. I'm talking about tempering them for awhile in that cold water, and slowly ripening those fish up, and then tempering that water with the warmer creek water and gradually phasing these fish into a natural adaptability that they've got genetically built in.

MR. ROSENBERG: From a production standpoint how would you do that? Would you keep them on cooler water for a week and then go on a daily increment and raise it a degree each day, something like that?

MR. CHLUPACH: That's kind of the theory I'm trying to get at.

MR. ROSENBERG: Well, we are open for anything at this point.

A VOICE: It's one advantage that we'll have, I think, is we have that heat exchanger where I think we'll be ale to manipulate some of that, that's kind of the theory behind it. But the other question I had--the question I had here is based on these stream spawning fish, we talked about in the zero check systems that way. Do these fish come in and hold for that long a period of time, in stream water? They don't go through a lake system. Do they hold this long, or do they come in and spawn immediately?

MR. ROSENBERG: No, they go through a lake system. They come up the Klawock River.

A VOICE: No, no, I'm talking about these zero check programs, you were talking about earlier today, that spawn in stream systems where they just come in. Do they hold in there for two or three months in the stream?

A VOICE: I think they hold in the estuary for a while and then they go up and find some nice deep pool with cooler water. You'll see them down in the fishery in the Lynn Canal in June and early July, and they won't be on the spawning grounds until mid-August, the first week of August.

A VOICE: So they'll hold in saltwater or in the freshwater...

A VOICE: I think they're holding in the freshwater, the deep pools up there in the river someplace.

A VOICE: And what kind of temperatures are they holding at in there?

A VOICE: I have no idea.

MR. PELTZ: It's the same on the Copper River, all the zero checks that are non-lake systems, they just move into the sloughs and deep holes and they hold there, I don't know how long, 30 days, 45 days, and then when the time's right they just go up and do it, and the water temperatures there, I don't think vary that much from the streams, they're pretty cold.

A VOICE: I think the Chilkat River in the summer is like 6 or 7°.

MR. WHITE: I know at Upper Station and Silver Salmon Lake in Kodiak they come into the lake. But those lakes are fairly warm, about 10 or 12°, and they hold for nearly a month or 45 days.

MR. ALLEE: I think one of the other ways to look at this thing, is that why did you get 10% pre-spawning mortality the previous year. It seems to me there's an opportunity for selling sockeye short. I guess I would conclude from all the litany of things that you talked about, the new water lines, the pressure, etc., handling the fish, probably really didn't do the best by those fish. It sounds like the system, however, wasn't quite the way you wanted it. Increased production obviously requires more space, more water, and you need to deal with that.

A VOICE: Dan, I'd like to make one comment. The difference is between 1986 and 1987 too, that I observed, was probably directly related to the environmental conditions. We had an extremely dry year last year, where our adults were holding out in the saltwater system, probably for a month longer than the preceding year, which may explain some of the skein conditions. It looked like a process of reabsorption might be taking place. And that may have led to our mortality problems also.

MR. ROSENBERG: That's good, because I think that given the right front end, given the right environmental conditions, that we can do it.

YAKIMA BASIN SOCKEYE SALMON

RESTORATION FEASIBILITY STUDY--IHN CERTIFICATION

By

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July 1988

INTRODUCTION

During 1987, our Fisheries Enhancement group began a study supported by the Bonneville Power Administration to determine the feasibility of re-introducing sockeye salmon into the Yakima River drainage. In the early part of the century this river supported one of the major sockeye runs in the Columbia River Basin (Mullan 1986). Construction of irrigation dams and diversion systems during the past 90 years have converted this formerly arid area into one of the nation's leading producers of fruit and vegetables; however, it no longer produces sockeye salmon.

The fish culture program and methods are described by Flagg and Mighell (this volume).

Infectious hematopoietic necrosis (IHN) causes acute viremia, resulting in severe necrosis of the kidney and spleen and high mortality in fry or fingerling salmonids. It is generally accepted that the virus is transmitted "vertically" from the parents in reproductive fluid or directly within the egg (Mulcahy and Pascho 1985). Although not proven by definitive studies, it is widely believed that most, if not all, adult sockeye salmon are infected with the IHN virus at the time of spawning. This belief has been based primarily on examinations of mature sockeye on their natural spawning grounds. In the present study, sockeye salmon brood-stock were captured before they reached their spawning grounds; the fish were held in net-pens in Lake Wenatchee until maturity. This was done to enhance the survival of these fish and to determine if this procedure would reduce the prevalence of the virus in spawning fish.

Fisheries agencies desire to minimize the risk of spreading IHN virus disease to the Yakima River system or anywhere else. Therefore, we requested and applied the guidance of the members of the Northwest Fish Health

Protection Committee. The Washington Department of Fisheries (WDF) conducted pilot studies similar to ours on three separate occasions (1983, 1984, and 1985) using sockeye salmon captured at the Government Locks on Lake Washington. These fish return to the Cedar River and usually have high incidence of IHN on the spawning ground. In all three years of the WDF study, the adults were held to maturity away from the spawning grounds and were determined to be IHN-free at spawning (Amos et al. 1983; Hopper et al. 1984; LeVander et al. 1985). Unfortunately, we were unaware of WDF's successes with this strategy during the initial agency discussions of our program.

METHODS

A quarantine facility was established at the Northwest and Alaska Fisheries Center in Seattle where all effluent from egg incubation and juvenile rearing is directed into the Seattle sewer system (see Flagg and Mighell, this volume). Each individual spawner was sampled and kidney/spleen tissue and ovarian fluid/milt were assayed for replicating virus at the Battelle Marine Laboratory in Sequim, Washington. Duplicates of some of these samples were sent to the fish virology laboratory at the University of California at Davis (UCD) for further confirmation of disease status. Tissues were tested for the presence of virus on EPC and CHSE-214 cell lines using standard techniques as described in Amos (1985).

Detection of virus in either parent would have led to destruction of all eggs from that particular mating. Also, any subsequent occurrence of salmonid virus in fry or juveniles cultured from these gametes was deemed cause for the destruction of all fish within a quarantined lot.

RESULTS AND DISCUSSION

A total of 226 sockeye brood-fish were assayed at Battelle, and 37 of these fish were also examined by the virology laboratory at UCD. No evidence suggested virus infections. No cytopathic effects (CPE) indicative of IHN or infectious pancreatic necrosis (IPN) viruses were observed from any of the individual samples at any dilution on either the CHSE-214 or EPC cell lines. In the positive controls, both cell lines exhibited CPE when exposed to IHN or IPN virus. An additional eight female sockeye salmon were spawned on 1 October 1987, but tissues from these fish were accidentally discarded and therefore not assayed for virus. All eggs from these fish were destroyed in the quarantine hatchery.

No significant mortality has been observed in the fry. Sixty fish were sampled for virus on 8 March and again on 22 April 1988. Tissues from these fish were processed and assayed for virus on CHSE-214 and EPC cell lines in 12 pools of 5 fish each, using standard methods (Amos 1985). No CPE indicative of viral infection was observed in these samples.

The lack of detectable virus in the brood stock indicates that these fish were free of IHN or IPN at the time of spawning. Therefore, the progeny of these fish will likely be free of IHN if maintained in a virus-free environment. Contrary to common beliefs, these results demonstrate that not all returning sockeye salmon are infected with IHN virus. It is not known if salmonids are carriers of IHN throughout their life-span, or if they become reinfected upon reaching their spawning grounds. Why the sockeye salmon in the present study were not infected was not determined, but apparently the capture of the fish before they reached the spawning ground prevented infection, or at least the expression of the virus.

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YAKIMA BASIN SOCKEYE SALMON

RESTORATION FEASIBILITY STUDY--FISH CULTURE PROGRAM

By

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July 1988

INTRODUCTION

The purpose of the Cle Elum Lake study is to assess the feasibility of restoring sockeye salmon runs to the Yakima River Basin. The Yakima Basin historically supported large runs of anadromous sockeye salmon that contributed significantly to the Columbia River harvest (Robison 1957; Mullan 1986). The development of irrigation storage reservoirs without fishways during the early 1900s eliminated these runs.

This program is a cooperative effort between the National Marine Fisheries Service (NMFS) and the Bonneville Power Administration (BPA). The study focuses on Cle Elum Lake; however, the information obtained should be applicable to other irrigation storage systems within the basin. The initial phase of the program concentrates on providing disease-free juvenile sockeye salmon for research.

The program uses a modification of captive brood-stock rearing concepts developed by NMFS for restoration of threatened runs of Atlantic and Pacific salmon (Harrell et al. 1984a, 1984b, 1985). While other NMFS brood-stock programs have centered on rebuilding depleted gene pools, no anadromous sockeye salmon presently exist in the Yakima River drainage. The Wenatchee River (adjoining the Yakima Basin) still has a viable anadromous sockeye salmon run with an annual spawning population of approximately 25,000 adults. Lake Wenatchee also has many geographic and limnological similarities to the lakes of the Yakima River system. Therefore, returning adult sockeye salmon from the Wenatchee system were selected as a suitable donor stock for NMFS investigations at Cle Elum Lake.

RESULTS AND DISCUSSION

Adult Collection and Holding

During the last 2 weeks of July 1987, 263 adult sockeye salmon were captured at the denil ladder and fish trapping facility at Dryden Dam on the Wenatchee River. All fish were transported (by tank truck and barge) to two 16- by 16- by 25-ft deep net-pens anchored together in about 45 ft of water at the north end of Lake Wenatchee and held (at a density of 0.1 lbs/ft^3, or less) until spawning during late September and early October. Lake water temperatures during holding generally stayed between 10° and 13°C; however, on a few occasions it ranged to near 15°C at the surface. Total mortality during the approximately 90-d pre-spawning holding period was 13 fish (4.9%).

During the 1987 holding period, the fish fed actively on a maintenance diet of frozen krill. When the fish were captured at Dryden Dam many had open wounds and abrasions. However, by the time of spawning most external wounds had healed and fish were vigorous. We feel that feeding contributed to this success, since krill contains relatively high levels of vitamin A, an essential factor in epithelial regeneration.

Spawning

The fish were visually sorted according to stages of maturity during mid-to-late September. Gametes from 232 adult sockeye salmon (137 females and 95 males) were collected between 24 September and 13 October (Table 1). All females that survived to maturity were spawned; however, 18 surviving males were judged to have poor sperm quality and were not spawned. Spawnings were conducted using individual male:female pairs; however, because of unequal numbers some males were used for multiple spawnings. Male spawners averaged 544 mm and females averaged 519 mm. All spawners were surveyed for the presence of viruses and determined to be free of infectious hematopoietic necrosis (IHN) and other replicating viruses (results reported elsewhere in this workshop series).

Females had an average fecundity of 2,644 eggs. However, fertilization success rates were lower than expected (averaging about 40%) (Table 1). There is no apparent correlation between fecundity, egg viability, spawner size, or date of spawning. It is believed that extensive handling and disinfection procedures (implemented in an effort to lessen IHN transfer risk) contributed to the low fertilization rate. Of particular concern was the addition of iodophor disinfectant (a known spermicide) prior to fertilization. In the future, protocol will allow adequate time for fertilization prior to disinfection. It is believed that this procedure will improve egg fertilization rates.

Egg Incubation

During summer 1987, an isolation egg-incubation system (designed to accommodate the spawn from 200 females) was constructed by NMFS at the Montlake Laboratory in Seattle, WA. This system is based on a NMFS design in use for several years, and provides the ability to individually incubate eggs from a large number of females while minimizing water needs and maintaining quarantine standards (Novotny et al. 1985). Each isolation incubator consists of two 7.6-l polyethylene buckets arranged to hold the spawn from 1 female. The unit functions as a down-welling system with the inner bucket, which has the bottom removed and replaced with plastic screen, acting as the incubator and the outer bucket functioning as the reservoir.

Each incubator is individually supplied with water via a commercial spray-mist delivery system typically used in greenhouses. This spray-mist system is inexpensive and allows controlled water flows of up to 600 ml/min/incubator. Dual water supplies (chilled and ambient) are available and provide both back-up and temperature control. Pathogen-free, dechlorinated City of Seattle water was used for incubation. All discharge water from the quarantine incubation station was directed into a domestic sewage system, and eventually through a City of Seattle sewage treatment plant (METRO).

Each incubator was numbered (to individual male/female spawners) for later comparison with virus analysis results. These down-welling incubators have been shown to provide excellent incubation-to-hatch results (Novotny et al. 1985). However, water flows in these incubators are not sufficient for the hatch-to-swim-up stage. Therefore, all certified egg lots were transferred to Heath-type incubators for hatching.

Initiation of egg incubation occurred from 24 September (first spawning) to 13 October (final spawning) (Table 1). Hatching began on 10 December 1987 and ended on 18 January 1988. In an effort to coincide with natural hatch timing, chilled water was used throughout incubation to provide the longest possible period between fertilization and ponding of fry. During incubation, the temperature ranged from 11.0°C (September) to 6.5°C (January); during the alevin-to-swim-up stage, temperatures ranged from 6.5°C (January) to 4.5°C (March). Egg fertilization to hatching required an average of approximately 750 (°C) incubation temperature units (range 697 to 773); hatch to swim-up averaged about 420 temperature units (range 393 to 498). Although egg viability averaged only about 40%, eyed-egg to hatch survival generally averaged over 99%. This suggests that the low egg viability was an acute (fertilization) problem rather than a chronic problem associated with egg quality.

Fry Rearing

A quarantine fry-rearing facility was also constructed at the NMFS Montlake Laboratory. The facility currently consists of 22 2.4-m diameter and 5 2.4-m diameter fiberglass tanks housed in a building that provides limited access and the ability to maintain quarantine standards. Current capacity is about 150,000 fry to approximately 3-g average weight. NMFS is expanding the facility to provide space for rearing over 300,000 10- to 15-g sockeye salmon smolts. Pathogen-free (dechlorinated) water is being used for rearing; all discharge is directed to METRO in a manner similar to that described for egg incubation.

A total of about 143,000 swim-up fry survived to ponding (96.8% survival from eyed egg). Fry were ponded in March and early April 1988. Swim-up fry averaged about 0.1 g and approximately 6,000 were ponded per 2.4-m tank, for an initial ponding density of under 0.1 lb/ft^3.

Survival to July 1988 has been good, with over 90% survival from eyed egg to fry (Fig. 1). Most mortalities have been associated with genetic anomalies or normal attrition. NMFS has over 135,000 Lake Wenatchee stock sockeye salmon fry in culture; mortality is minimal at this time, and survival is expected to remain high throughout the culture period.

One objective of the sockeye rearing program is to provide 10- to 15-g smolts for outmigration studies in spring 1989, and ration and rearing temperature regimes are being adjusted to obtain this target size. Water temperature during fry rearing is maintained at 8° to 11°C through a chiller system and fry are fed a commercial[1] ration (either Biodiet or Moore-Clarke Semi-moist). Initial feed ration was set at 5% of body-weight/d for the first

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[1] References to trade names do not imply endorsement by the National Marine Fisheries Service, NOAA.

30 d and 3% of body-weight/day thereafter. This feed level lies about mid-way between the optimum and maximum ration for juvenile sockeye salmon defined by Brett et al. (1969). This combination of temperature and ration should provide a growth profile close to natural while maintaining fish health and quality. To date, the average weight of the sockeye salmon fry in culture is about 0.5 g (Fig. 2).

As of July 1988, the Lake Wenatchee stock sockeye salmon fry under culture by NMFS have been checked twice (60 0.12-g average fry on 9 March 1988 and 60 0.25-g average fry on 22 April 1988) and determined to be free of replicating viruses. Quarantine standards are being maintained in the culture facility and IHN certification of juveniles will continue through smoltification.

SUMMARY AND CONCLUSIONS

All project goals have been accomplished to date. Donor stock adults from Lake Wenatchee have been successfully captured and spawned. NMFS currently has 135,000 disease-free sockeye salmon fry in culture to provide for outmigration studies in Cle Elum Lake in 1989. In addition, NMFS is planning to collect 520 sockeye salmon adults in summer 1988 to provide juveniles for outmigration studies in 1990. NMFS is continuing to develop brood-stock holding and culture techniques that offer potential as management tools around IHN problems.

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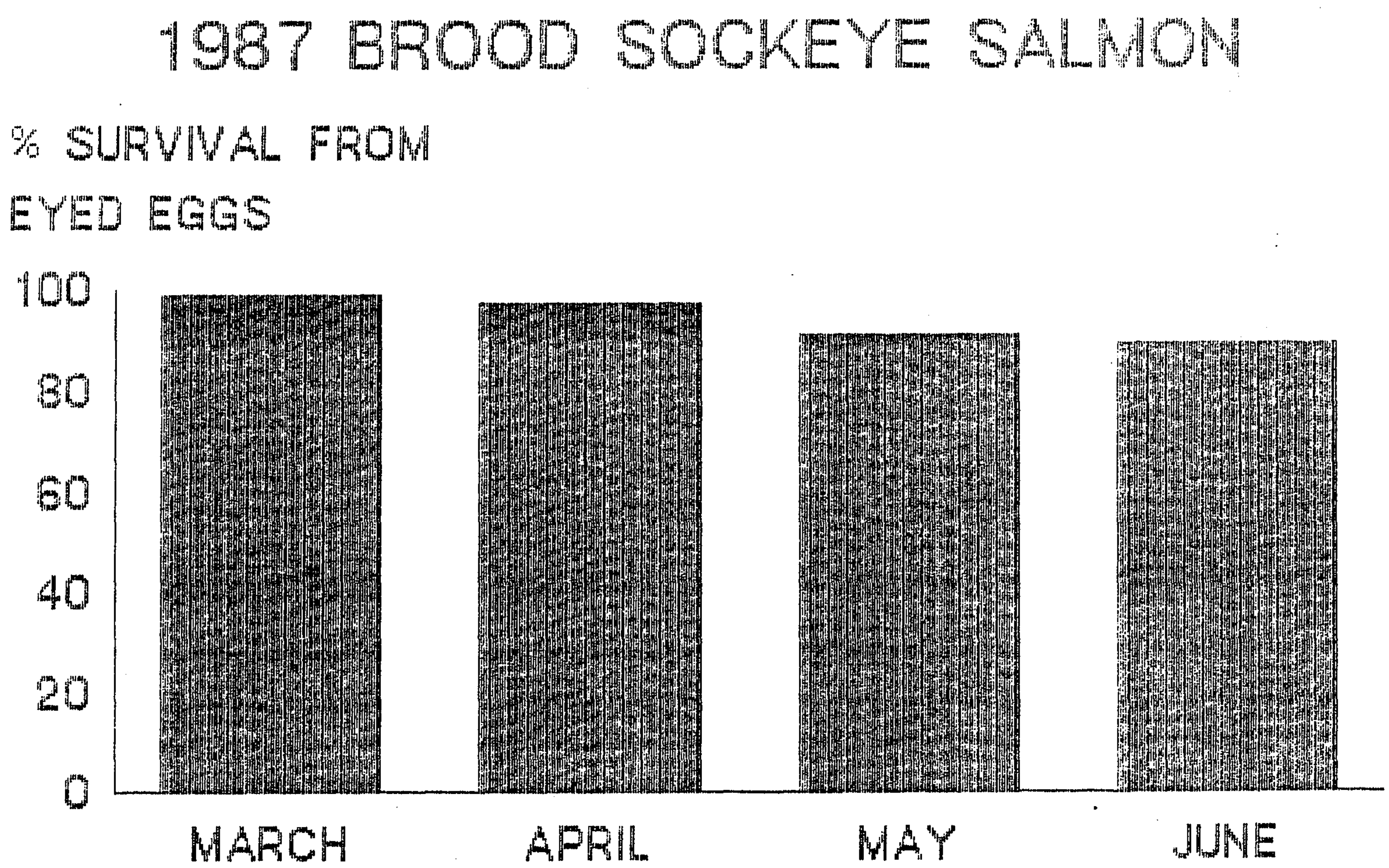
FIGURES

Figure 1.--Survival from eyed egg for the 1987 brood Lake Wenatchee stock sockeye salmon reared at the NMFS Montlake Quarantine Hatchery in 1988.

Figure 2.--Growth from swim-up for the 1987 brood Lake Wenatchee stock sockeye salmon reared at the NMFS Montlake Quarantine Hatchery in 1988.


1987 BROOD SOCKEYE SALMON
% SURVIVAL FROM
EYED EGGS
100
80
60
40
20
0
MARCH
APRIL
MAY
JUNE

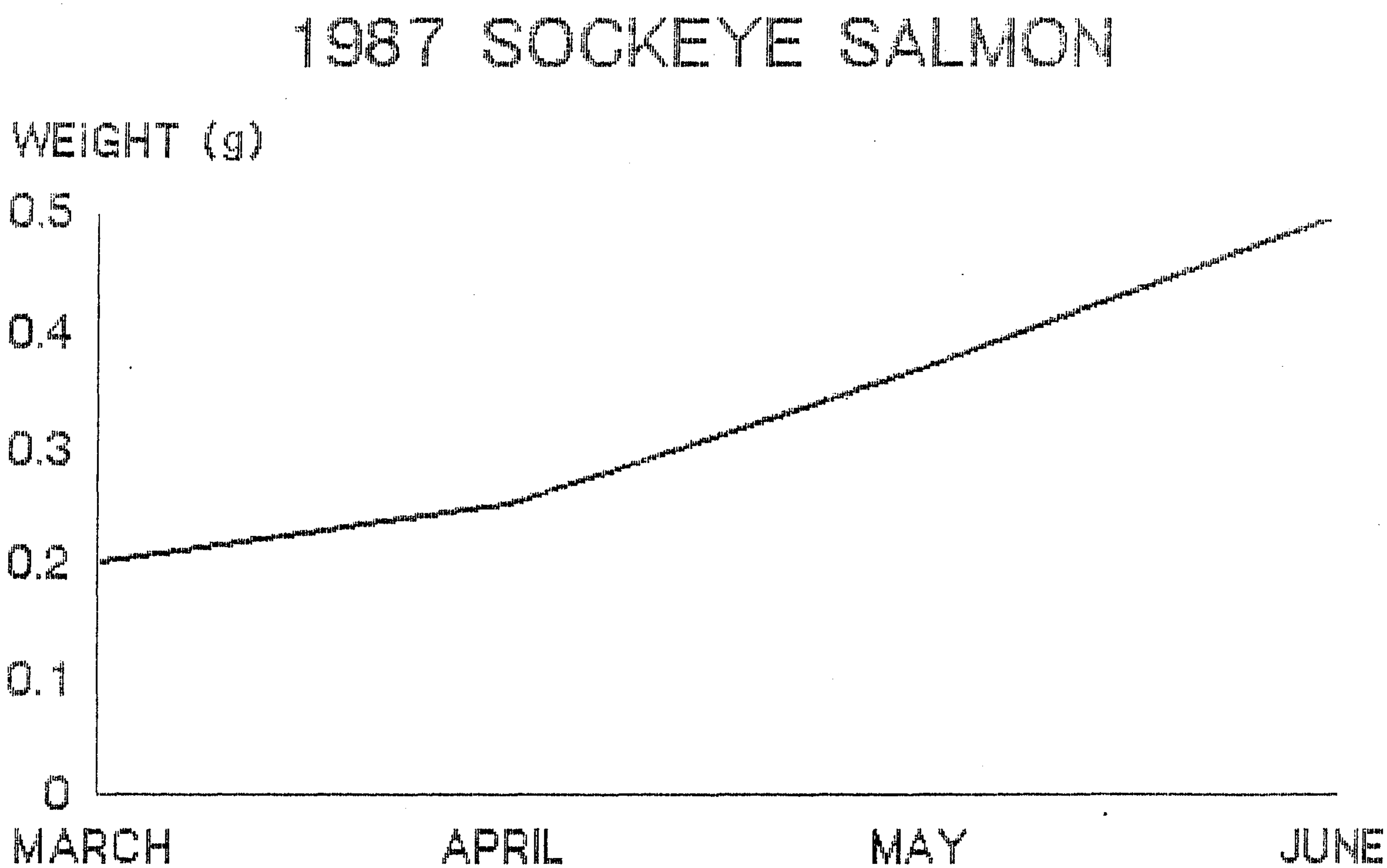

1987 SOCKEYE SALMON
WEIGHT (g)
0.5
0.4
0.3
0.2
0.1
0
MARCH
APRIL
MAY
JUNE

Table 1.--Spawning dates, number of females and males spawned, and average length, fecundity and egg- viability for Lake Wenatchee sockeye salmon spawned from NMFS net-pens in 1987.

	Number spawned			Average			
				Length			Eyed-egg
Date	Female (n)	Male (n)	Total (n)	Female (mm)	Male (mm)	Fecundity (n)	viability (%)
9/24	13	12	25	528	532	2,888	49.1
10/01	64	56	120	517	546	2,597	33.2
10/06	25	12	37	514	561	2,738	47.7
10/08	22	9	31	522	551	2,546	48.5
10/13	13	6	19	529	542	2,615	32.8
TOTAL	137	95	232	-	-	-	-
AVERAGE[a]				519	544	2,644	39.8

[a] Combined average of all female (n = 137) and male (n = 95) spawners.

MR. HARRELL: Are there any questions on the IHN certification or fish culture programs?

MR. MEYERS: I'd like to make a comment. One of the things that might be occurring here, is you're playing a numbers game with vertical transmission of virus. It's possible that you've got a small enough number of fish that they are not infected with the virus, and so consequently if they don't go up to the natal stream where horizontal transmission occurs, then it's very possible that you're going to end up with a clean 250 or 260, however many fish you had there.

MR. HARRELL: We originally had about 240, right Tom?

MR. FLAGG: 240.

MR. MEYERS: A pretty small population.

MR. HARRELL: They were not very dense, Tom's going to go into that.

MR. MEYERS: But if you don't get a positive fish, a carrier fish that would spread that horizontally in an exposed closed situation, then the virus isn't getting started. And what we're finding is that the greater numbers of eggs that you take, it increases your probability, obviously, for transmission.

The two questions I had were: 1) where the virus starts, is there an average titer that you have for that stock of fish, high or low?

MR. HARRELL: I don't know, we didn't' check it this year. The Department of Wildlife did and I don't know if they had any titers. They just said there was an incidence of 95 plus, and Mulcahy's been doing it before he left for years, and said that they were always high in incidence. On what the titers were, I don't know.

MR. MEYERS: The other question I had was 2) what about the Yakima River stock. They must have IHNV?

MR. HARRELL: We checked--there's no sea-run in Yakima, there's no sockeye in Yakima.

A VOICE: There's no sockeye in there?

MR. HARRELL: No, it's gone. We checked kokanee albeit few, and didn't see any.

THE PIT TAG SYSTEM

AND

ITS SUITABILITY IN SOCKEYE SALMON

By

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JULY 1988

INTRODUCTION

Since 1983, the National Marine Fisheries Service (NMFS) has been involved in a cooperative research program with the Bonneville Power Administration (BPA) to evaluate a new uniquely coded miniature identification system that can be used in tagging fish. The system is referred to as a passive integrated transponder (PIT) tag. The PIT tag has undergone extensive biological testing and technical (systems) development. The primary use of the PIT tag has been in pilot studies by NMFS and other researchers to address fish migration issues within the Columbia River Basin. Results indicate that, for migration studies, the PIT tag can provide more reliable data than traditional (freeze brand) methods while often allowing up to 95% reduction in required sample size. This paper is an overview of the status of the PIT tag system--detailed information and test results can be found in Prentice et al. (1984, 1985, 1986, 1987) and Prentice (1987a, 1987b). In addition, specific information on the biological suitability of the PIT tag to sockeye salmon is presented.

Sockeye salmon were once plentiful in the Columbia River Basin, however, for many reasons their numbers have decreased. At present, there are enhancement programs for re-establishment of sockeye salmon in the Columbia River Basin (e.g., Cle Elum Lake on the Yakima River system). The PIT tag could be an important tool in evaluating the success of these restoration efforts. Therefore, PIT tag evaluation tests using sockeye salmon were initiated in 1987 to determine the minimum size sockeye salmon which could be PIT-tagged without affecting growth or survival while maintaining high tag retention.

PIT TAG OPERATION AND INTERROGATION

The PIT tag consists of an antenna coil that is bonded to an integrated circuit chip. The electronic components of the tag are encapsulated in a glass tube about 12 mm long and 2 mm in diameter. Each tag is preprogrammed at the factory with one of a potential 34 billion unique (10 digit alpha-numeric) code combinations. The tag is passive, having no power of its own, and, therefore, must rely upon an external source of energy to operate. A 400 kHz detector signal energizes the tag, and unique 40- and 50-kHz signals are transmitted (from the tag) to the interrogation equipment where the tag code is immediately processed, displayed, and/or stored to a computer.

Several types of PIT tag interrogation systems are available. Portable battery-powered (hand-held) scanners are used in a variety of tagging and detection applications. Larger portable AC units have been installed at the juvenile fish bypass facilities at McNary, Little Goose, and Lower Granite dams on the Columbia and Snake Rivers [these dams are among a series that have been modified to collect and/or divert juvenile outmigrants as a method of increasing overall survival]. In addition, a monitoring system has been installed at the adult collection facility at Lower Granite Dam. The monitoring systems at these dams are capable of detecting 95%, or more, of all PIT-tagged fish, with a tag code reading-accuracy of 99%.

The interrogation range of the PIT tag varies with the monitoring equipment. With the hand-held scanner, the tag detection range is up to 7.6 cm; with a fixed loop interrogator the range is about 19 cm. The tag can be read through soft and hard tissue, liquid (seawater and fresh water), glass, and plastic, but not through metal. Extremes in temperature (-273° to 60°C) do not affect the detection or reading of the tag. In addition, the tag is not affected by instantaneous pressure changes of 0 to 5 atmospheres.

Successful tag monitoring can take place at velocities up to 3.6 m per second. The tag's operational life is unknown at this time, however, it is thought to be at least 10 years.

PIT-TAGGING SYSTEMS

PIT tags are injected into fish using a 12 ga hypodermic needle. A modified hypodermic syringe was developed for portable applications. This hand-held unit requires each tag to be manually inserted into the needle and is satisfactory for small numbers of fish. An automated (bench mounted) tagging machine has also been developed and has advantages in rapidly tagging large numbers of fish. With this system, tags are housed in a removable clip that gravity feeds to an air-ram-activated plunger which pushes the tag through the needle. The tagging rate using the automated system is up to 400 fish per hour, more than double that of the hand-held injector.

The body cavity was selected as the best area to implant the PIT tag. At tagging, the needle is positioned just posterior of the pectoral fins and slightly off-set from the mid-ventral line. The needle is inserted to place the tag posterior to the pyloric caeca in the region of the pelvic girdle. Properly implanted PIT tags have a 99% retention rate and little affect on the fish's survival.

After tagging, tag presence and code identity are obtained using a detector/decoding system. The system can be a portable battery-powered scanner unit or a computer-interfaced detection system. Computer-interfaced detection stations are normally used and allow automated entry of length, weight, tag code, and other comments. This computer-based system was developed by NMFS and makes it possible to electronically maintain records on large numbers of individual fish.

BIOLOGICAL EVALUATION OF THE PIT TAG

Laboratory and field tests have been conducted using juvenile and adult chinook salmon (Oncorhynchus tshawytscha) and steelhead (Salmo gairdneri), juvenile sockeye salmon (O. nerka), juvenile coho salmon (O. kisutch), and adult Atlantic salmon (S. salar). Fish ranging in size from 2 to 10,000 g were tagged, and tests indicated that the PIT tag does not adversely affect growth, survival, or spawning success in otherwise healthy fish.

Of the salmonid species evaluated, sockeye salmon are considered to be among the most sensitive to handling. In 1987, a cooperative study of the effects of PIT-tagging sockeye salmon was initiated at the British Columbia Department of Fisheries and Ocean's Rosewald Hatchery located near Nanaimo, British Columbia. Hatchery-reared sockeye salmon were used in this study. Two populations of fish were maintained in tanks with near constant temperature (about 10°C) fresh well-water. Standard husbandry practices were followed in maintaining the fish, with the exception that the fish in one tank received an accelerated photoperiod to produce 0-age smolts. PIT-tagging studies were conducted on two sizes of presmolted and one size of smolted sockeye salmon (Table 1). The minimum and maximum range of weight and length (fork length) at the time the test groups were established was 1.3 to 11.5 g and 55 to 107 mm. Each size- group consisted of control (fish handled but not tagged) and tagged groups (n = 200 fish per group). Comparisons were also made between the hand-held and automatic PIT-tag implantation methods described above. The observation periods for the test groups ranged between 6 to 8 months and, in all cases, the tagging methods produced similar results to each other and to the controls. Survival and tag retention were uniformly high and ranged between 95.0 and 99.5% and 98.5 and 100%, respectively. In addition, growth of control and PIT-tagged fish was similar for each size-group of fish observed (Table 1).

CONCLUSIONS

The results suggest that sockeye salmon populations averaging as little as 2.5 g can be successfully PIT-tagged. The results of these and previous tests with other salmonids are in general agreement and suggest that the PIT tag can be injected into juvenile salmonids without jeopardizing growth or survival. In addition, NMFS has recently conducted pilot PIT-tagging studies with migrating 8- to 15-g sockeye salmon captured and tagged at Priest Rapids Dam on the Columbia River. Of the approximately 2,000 tagged migrants, about 10% were held for 1 wk and had near-100% survival. The remaining fish were released and showed a high (about 60%) PIT tag interrogation rate at McNary Dam. This further indicates that the PIT tag is a viable tool for field work with sockeye salmon.

The PIT tag has a strong potential wherever the repetitive recognition of individuals is required. The PIT tag is a passive system which should stay with the fish throughout its life-cycle. It can be detected and decoded in living fish, potentially eliminating the need to anesthetize, handle, restrain, or sacrifice fish during data retrieval.

MR. FLAGG: Are there any questions on the Pit Tag System?

MR. ALLEE: Tom, what's the bottom line here then about cost?

MR. FLAGG: Well, it depends on who you buy your tag from. We just bought 60,000 tags for three and a quarter a tag. Detectors, we bought, those hand detectors are running us about, just under $1200. The factory representative from IDI, said he expected this tag to be down to a dollar or two dollar range. It may not be a hold your breath situation, but the costs are going to go down as more and more of these are being used.

The monitoring systems that we're looking at, that we have in place on the dams, are pretty costly. About $40,000 for a system. Thirty of that will be electronics, computers, all the associated gear that causes the tag to be read and interrogated is reasonably expensive. You've got about a $7,000 computer in there, and about a $7,000 sighter system that amplifies the signal and receives the signal, and you've got a power supply, and you've got some of this and that, and then you've got to have an IBM compatible computer to read it into. So it's not real cheap. For our use on the Columbia system, when we compare it to traditional costs where we captured those fish and then have groups of men or women standing there all day long, looking at the fish, reading the brands, determine the species, whatever, it's probably going to be a cost effective system, I'm certain it will be a cost effective system.

MR. ALLEE: What's the prognosis from the manufacturer about getting a smaller tag with say for instance less discrete information for smaller fry like pinks and chums and sockeye?

MR. FLAGG: They feel that they're just about where they are i size of tags right now. Remember for this, you've got to have a microchip and you've got to have an antenna, and until microchip technology grows smaller, they're sitting about where they are. Frankly until some of the costs go down, they're probably sitting pretty close to where they are, down to about $2 a tag cost too. They won't get below that until chip costs go down.

A VOICE: The transmission of this, does it transmit through air or is it just water?

MR. FLAGG: It will get through everything but it doesn't do too well through metals, but it will go through hard and soft tissues, water, it will send through saltwater, freshwater, and as I said we can detect it at about 12 feet per second, at high flows, high velocity. And we've also dumped it into liquid nitrogen and pulled it out and read it, and we stuffed it in an oven up to 273° and pulled it out and read it, so it appears that it will hold within the normal that we'll find fish in.

A VOICE: What's the maximum distance that you can have your detector away from the fish and still detect it.

MR. FLAGG: At this point, for those big detectors is something in about a 14-inch circle. We think some time this year we'll have the technology out to about two feet by three feet. There's some talk about frequencies and so on and so forth, that may some day push it to four by six, six by six, but that would be it, and I wouldn't even realistically look for that. I think two by three is going to be--two by three will do what we need.

A VOICE: Does it matter the angle of the tag going through the detector for picking it up?

MR. FLAGG: It's better if the tag goes in so that the long axis of the tag, is the same as the long axis of the fish, it reads better. Again when the fish is tagged, it's put in the body cavity and lies along the long axis. We're running 99% on our ability to read these tags. The only place that we started to fall down, is if we have too many tagged fish going through at once, and then like I say we're down. We get about seven out of ten in a full tag population with a heavy load moving through the detector.

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Table 1--Growth, survival, and PIT tag retention for sockeye salmon tagged by both hand-held and automatic injector methods as compared to controls for three size-ranges of fish (n = 200 per treatment at start).

Test group[a]	Test period (d)	Survival (%)	Tag retention (%)	Weight (g) Start Mean	Weight (g) Start SD	Weight (g) End Mean	Weight (g) End SD	Length (mm) Start Mean	Length (mm) Start SD	Length (mm) End Mean	Length (mm) End SD
Group 1 - presmolt											
-Hnd Inj	229	99.5	99.0	2.5	0.5	29.0	7.0	68.0	4.1	137.0	10.7
-Control	230	99.5	--	2.5	0.6	28.6	6.5	67.0	4.8	135.0	9.6
Group 2 - presmolt											
-Hnd Inj	172	99.0	98.5	5.2	1.3	25.4	6.6	83.0	6.5	130.0	10.2
-Auto Inj	181	95.0	100.0	4.6	1.2	28.3	6.7	82.0	7.0	134.0	10.4
-Control	182	98.5	--	4.6	1.3	28.7	6.8	82.0	6.8	134.0	10.1
Group 3 - 0-age smolt											
-Hnd Inj	173	96.5	100.0	9.1	1.1	34.7	6.6	99.0	3.8	144.0	9.2
-Auto Inj	182	97.0	100.0	8.0	1.0	35.8	7.5	97.0	4.5	146.0	9.4
-Control	194	97.0	--	7.9	0.9	33.1	6.9	96.0	4.0	143.0	9.3

[a] Hnd Inj = PIT tags implanted with hand-held injector; Auto Inj = PIT tags implanted with semi-automatic injector; Control = non-injected controls.

<u>Chemical Tagging - Jeff Short</u>

MR. SHORT: I'm involved in exploring ways of successfully marking hatchery bred fish with a chemical tag that will be economically feasible to do in a mass production setting.

I got involved with this through initial discussions with people at the University of Alaska in Juneau who had been working with analytical methods of detecting tetracycline in hard tissues of fish, particularly in otoliths. The method they were using was taking the otolith and dissolving it and then trying to analyze tetracycline in the solution, and it struck me that a much more sensitive way to do it would be if you could analyze the tetracycline inside, and so that was the way I approached this problem, and it was not until quite recently in fact a recent fish marking symposium in Seattle, that I came to the conclusion that the analytical methods were not really a problem at all, the problem was getting the tetracycline into the fish, especially very small fish.

The two candidate modules that have been used or marking these kinds of tissues, hard tissues, the tetracyclines and calcein. Tetracycline is particularly attractive because it can be used for antibiotic purposes as well as for marking the fish. Oxytetracycline is the one you're probably the most familiar with because it's approved by the FDA for use in fish. Calcein is another more recently used compound that is a fluorescein dye, it is a preferential binding for calcium, and from preliminary indications, it looks like it has certain real advantages so it's worth exploring as well.

We're trying to mark fish that are around 35 millimeters long. When marked deposition occurs, it occurs along the perimeter of the otolith or on the outer surface of the otolith and then more material is deposited on top of that. The calcein is comprised of principally calcium carbonate, about 99.5% calcium carbonate, and it's in a protein matrix.

As an aside, the way temperature banding works that we've heard a lot about recently, it induces different amounts of calcium deposition into the otolith, so that high temperature or relatively high temperatures, if the animal is exposed to fluctuation in temperature, calcein is preferentially deposited during the high temperatures, as the temperature goes down, less calcein is deposited, and you get a dark band corresponding to an increased relative protein level.

Now the reason I want to bring that up is because in what I say in a little bit, temperature is going to play a big part. What temperature does is, the higher temperatures help accelerate the deposition of calcium. And it's important because the way both tetracycline and calcein work, is they find calcium in the otolith.

Internal chemical markers have got a lot of advantages which is why many of you, I imagine, are interested. If I miss some advantages, you let me know, for consideration. One big one is that you can mark--it's feasible 100% of the population, and it really helps your statistics on the recapture.

It can be relatively inexpensive. One can conceivably mark fish for, on the order of pennies a fish.

If the mark is successfully incorporated, its' usually incorporated for the life of the fish, particularly if the chemical marker is a chemical marker that goes into the hard tissues. Once tetracycline gets glued into the internal parts of the otolith, it's very difficult for it to go anywhere. Migration rates of organic molecules to the inorganic matrices are of the order of geologic time periods, so I don't worry too much about that.

There's some big disadvantages to internal marks in general, and internal chemical marks in particular. They're a lot tougher to detect, right off the bat than external markings. This is a big consideration. Especially with marking the otolith, and marking in a fish that is 35 millimeters long, has a diameter of 100 microns, a 10th of a millimeter, that's a little bit hard to find out of a fish that's coming back. That's why a lot of thought has to go into the analytical end of things. You can mark the fish for pennies a fish, but you pay for it when you try to detect the mark and it costs you tens or hundreds of dollars. So you rally have to pay attention to the south side of this. What do you do when the fish comes back? It's no fun marking the fish and having him die in the ocean. That cancels the whole program. And so marking toxicity is something we have to evaluate, what's the toxicity of the marking that you're going to use, and this is a real big problem too. There's been some studies that have shown that everything works fine in the laboratory, and you get 50% mortality when you mark fish in the marine environment for who knows why.

The problem we have is to figure out how to mark salmonids under Alaskan conditions,and these are different conditions and they make a big difference compared to the work that's been done down south.

The other thing we're actively engaged in is trying to figure out ways to read salmonids that have been marked in a cost effective manner.

In Alaska especially, as I mentioned before, the two compounds that are the favorites are OTC or calcein. Most of the efforts have been focused on oral administration of these compounds. I will argue in a little bit that that is a big mistake.

Again most of the previous efforts at marking fish have focused attention on marking larger juveniles, and in general we found that in preliminary studies at Auke Bay, that the larger the fish the more likely you are to successfully mark the fish.

Another important factor is that the lower the temperatures is at which marking occurs the lower the rate on marking success.

Well, as I said, I attended this symposium in Seattle a couple of weeks ago, and talked with four research groups that had presentations there that dealt with marking fish with either calcein or OTC, and they were unanimous in the following four points that I'll point out to you.

The first point was that marking by immersion was far superior to oral administration. All four groups said that oral administration sometimes works, sometimes it doesn't, none of them could predict when it would work, but once the bugs were worked out of the immersion marking system, it's reliable.

Secondly, it's critical to keep any divalent cations out of the immersion water. Divalent cations of magnesium, calcium, anything in the second column of the periodic table. They simply have to be absent.

You can mark fish in seawater, you can mark juvenile fish in seawater, provided it's fake seawater and does not contain these divalent cations.

Thirdly, the system has to be buffered or you'll run into great problems, killing your fish, because OTC especially is a weak acid, and in the absence of any buffer the Ph sufficiently stress the fish, then you run into accelerated toxicity problems.

And finally number four, the higher the temperature the easier it was to mark. Now I say this represents a consensus of our independent research groups; they all agreed on these four points.

The bonus, if there is one, of this kind of administration scheme, is that if you follow these four points, all you need is two to four hours of contact time and that's I believe a sufficient time to leave an easily detectable permanent mark on the fin, the vertebra, the otolith or scales. Chemically, this makes a lot of sense. If any of you had tetracycline prescriptions, your doctor will tell you, don't take it on a full stomach, don't take it with milk products. The reason for that is because of divalent cations. If there's divalent cations around, the OTC or calcein is going to accumulate in those cations, and the accumulated complex doesn't get absorbed.

If you're going to feed them OTC, make sure they have an empty stomach.

Secondly, as I pointed out earlier, calcein deposition, the deposition of calcein on the otolith or any other hard structure, increases with temperature. So the warmer you can have your fish during that two to four-hour window when you're tying to deposit these chemical markers on the hard structures, the more likely you are to be successful.

So what this all means to us up here in the frozen north, is that we would probably want to, in a hatchery setting, try to mark the fish just prior to releasing them, and the reason for that, is because you want to try and get the temperature up to at least 10°C, 12°C is better, actually the higher the better, without running into biological problems.

So what I envision wanting to do, is when you're ready to mark the fish coming out of the hatchery, is you would put them in a holding pen, recirculating pen, and start to warm them up at whatever rate you feel you can get away with, and start to get any divalent cations out of that water.

Once you've got the fish as warm as you feel comfortable getting them, you would then expose them to OTC for two to four hours. Then, move them out and let them go.

Finally, we plan a series of experiments beginning next winter where we will study the effect of how big a fish is, what temperature it's marked at and how long it's marked or what the exposure to the mark is, and see what the effect of those three parameters is on marking success.

And we will also do some experiments to evaluate what toxicity is under the conditions that we are going to try marking them.

QUESTION: Yes, one of those groups down there marked eggs, they dipped the eggs in the OTC. Are you guys going to play with that at all?

MR. SHORT: We might. The problem we're having with fooling with eggs is, consider that if you have a 35 millimeter fish, the otolith has a diameter of maybe a hundred microns, I don't know what the diameter is, when its inside an egg but I'd bet it's quite a bit less than a hundred microns. A hundred microns is a target I feel a wonderful new invention can hit, but it's getting down there. There's a limit somewhere to where you just can't hit that small of a target reliably. And that's a problem that I face, that anybody who is into this faces. If you want the mark to be readable in an adult, there's probably going to be a limit on how small the fish can be.

QUESTION: Has anybody detected OTC successfully on scales?

MR. SHORT: Yes. It doesn't appear to last as long, at least it doesn't appear to fluoresce as long in the scale as the otolith. That doesn't mean it's not still there.

MR. HARDING: How long does the procedure take?

MR. SHORT: Well, coupled with the otolith process, and if you would do it on a continuous sequence, we're hoping to cut the processing time down to two minutes per fish.

MR. HARDING: That's including otolith preparation?

MR. SHORT: Yes. It takes about two minutes. We're hoping it will take about two minutes to process the otolith. We already know it takes about two minutes to do the spectra, so while you're processing the otolith, the machine that does the spectra, you just push the "O" button and it takes care of itself, so the two can be done at the same time.

QUESTION: So that would be an adult otolith?

MR. SHORT: Yes. That doesn't count the time that's required to get the otolith out of the fish.

The disadvantage of the calcein is that it's not FDA approved, and who knows what they're going to say?

QUESTION: Is OTC FDA approved?

MR. SHORT: Yes, it is.

A VOICE: For fish application?

MR. AMEND: For fish application. It was approved before it's use as a therapeutic medication. It was the first thing that was approved on fish, as a marker on bones. By the Montlake Laboratory.

QUESTION: You talked a little bit about the temperature marking on these otoliths which I guess we're going to be doing in the egg stage, we're going to be trying it at Snettisham, I believe. That's detectable with the microscope, conventional microscopes?

MR. SHORT: Yes, optical microscope.

Beaver Falls Sockeye Program - Dave Bright

Start up goals for FY85-87 were 1.5 million sockeye eggs while redesigning and modifying their existing facility. They achieved 80-85% survival to the eyed stage at this level. The next phase goals are 7.5 million sockeye eggs for FY88 & 89. They are presently expanding their facility to handle 20 million eggs in five separate modules. In FY88 they took 6.7 million sockeye eggs. They transported resulting fry at 0.15g, for lake stocking. A 200 gal. tank set in an otter on floats was used for transport. Four hundred thousand (400,000) fry (about 132 lbs.) per load, with a transport time of 30-35 minutes.

Returning broodstock were held in 11' x 11' x 6' net pens in freshwater. Approx. 400 fish/net pen or a density of about 4 lbs./$ft.^3$. Only dark or pigmented fish were placed in the pens for holding.

MR. BRIGHT: Any questions?

QUESTION: What kind of condition are the broad fish in when you hold them?

MR. BRIGHT: They're all colored, no silver fish, not bright fish whatsoever. They're all dark.

A VOICE: How long do you hold them?

MR. BRIGHT: Well, it depends. Some of them are ripe when we get them, but we've held them up there as long as 14 days. They don't deteriorate, they don't die.

QUESTION: Do you disinfect your eggs?

MR. BRIGHT: We do disinfect the eggs in the field.

QUESTION: But they're not disinfected after that point?

MR. BRIGHT: No. Once they get back to the hatchery the cooler and outside of the bag are disinfected and then the eggs are placed in incubators.

Reducing Chemical Use in Sockeye Culture - Chris Clevenger

Chris went over the following paper entitled "Reduced Chemical Use and Exposure at Big Lake Hatchery" - self explanatory. He said they are trying to switch from using Betadine and chlorine to detergents and steam for disinfecting.

REDUCED CHEMICAL USE AND EXPOSURE AT BIG LAKE HATCHERY

LESS USE:

1. Keep hatchery clean, not necessarily sterile.

2. Disinfect fish and egg containers only.

3. Use detergents and steam to clean with instead of sterilizing with chemicals for general hatchery clean up.

4. When using disinfectants, know and measure the correct amounts of chemical to use.

LESS EXPOSURE:

1. Chemical storage building. Compatible hazardous chemicals are in a storage building separate from the main hatchery. This building is off limits to those who don't give treatments. Chlorine is stored separately from other chemicals. Personal protective equipment is worn when entering the chemical storage building.

2. Chemical treatments are administered from the chemical storage building with a metering pump and delivered to raceways and incubators through tubing.

3. All chemical treatments are administered after working hours so that personnel are not exposed.

4. All personnel are supplied with personal protective equipment.

5. The hatchery and eggtake building are ventilated.

6. Hatchery disinfection: After cleaning with detergents and rinsing with water, the modules are steam cleaned. Sockeye modules are sprayed with betadine and rinsed thoroughly with water by one person after working hours.

7. when spraying betadine with a pressure washer, remove the nozzle so that the betadine is not atomized. This is a good way to disinfect our large aluminum raceways.

8. Surgical gloves are worn during eggtake to keep betadine off the skin.

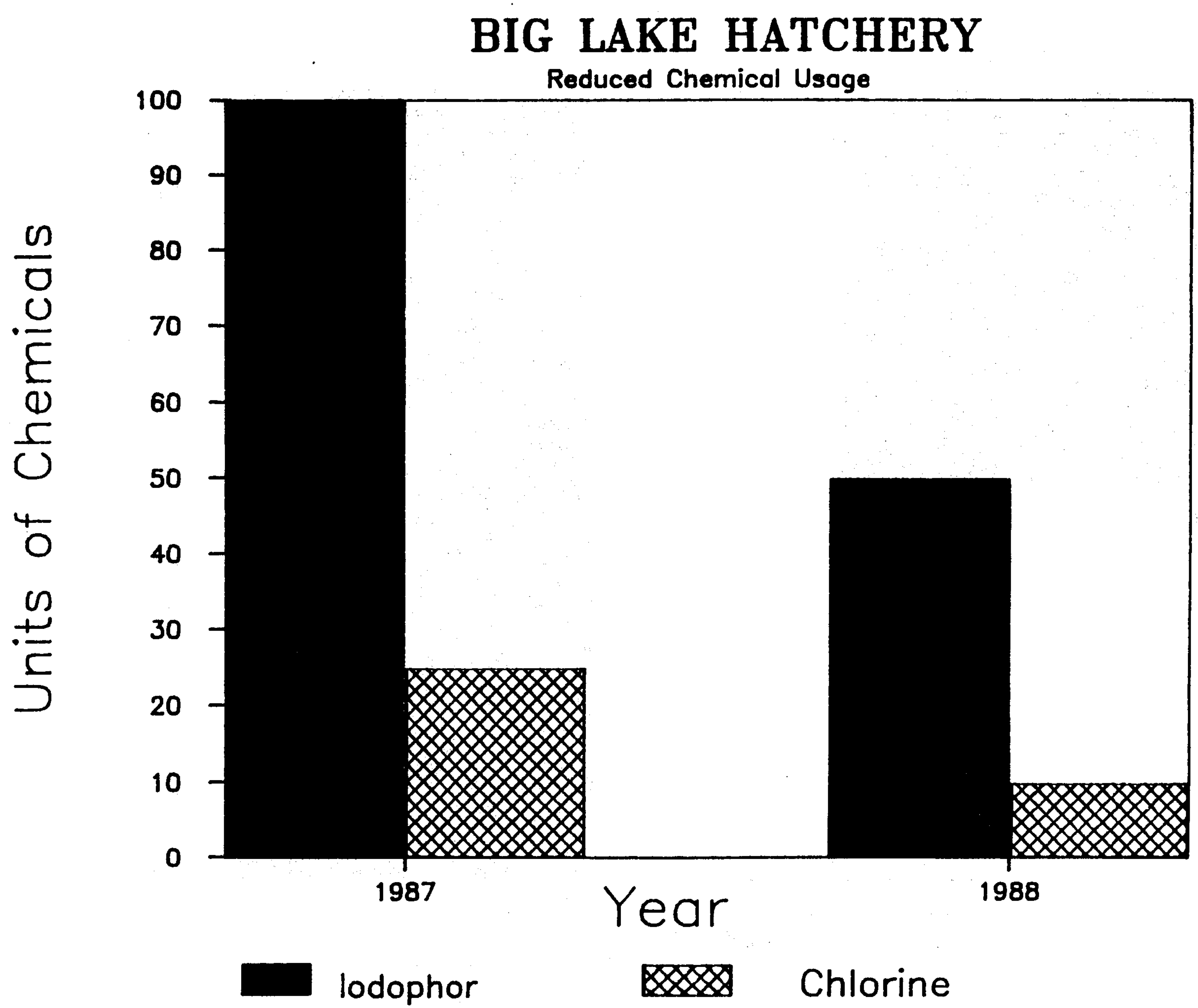
9. Enviroquat is used in footbaths instead of chlorine.

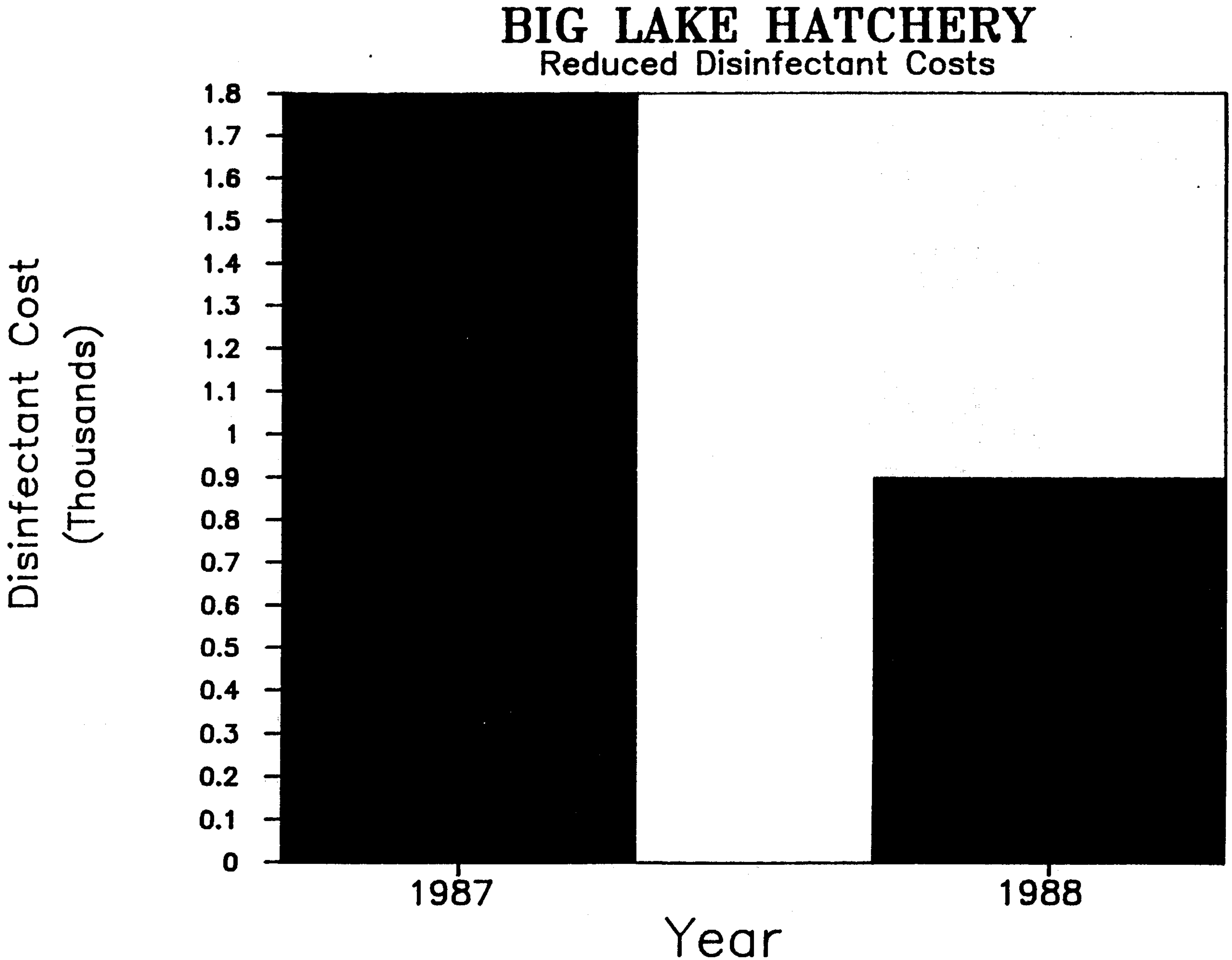
10. $1\frac{1}{4}$" valves have been plumbed in to flush the floor in the sockeye module.

11. Disinfectants are kept covered to reduce vapors. Ice chests work well as containers for disinfecting utensils.

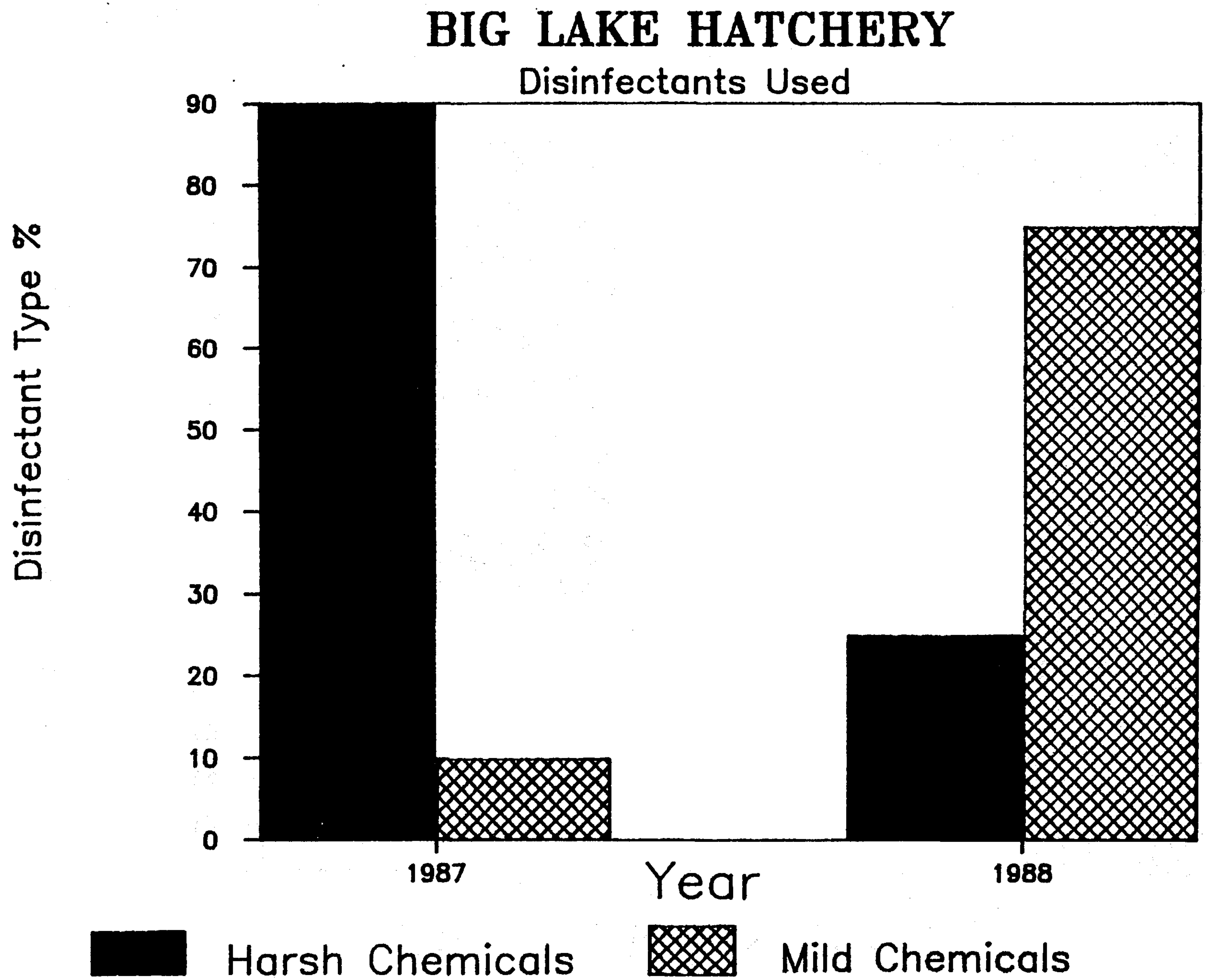
12. Betadine and chlorine are neutralized with sodium thiosulfate after through using.

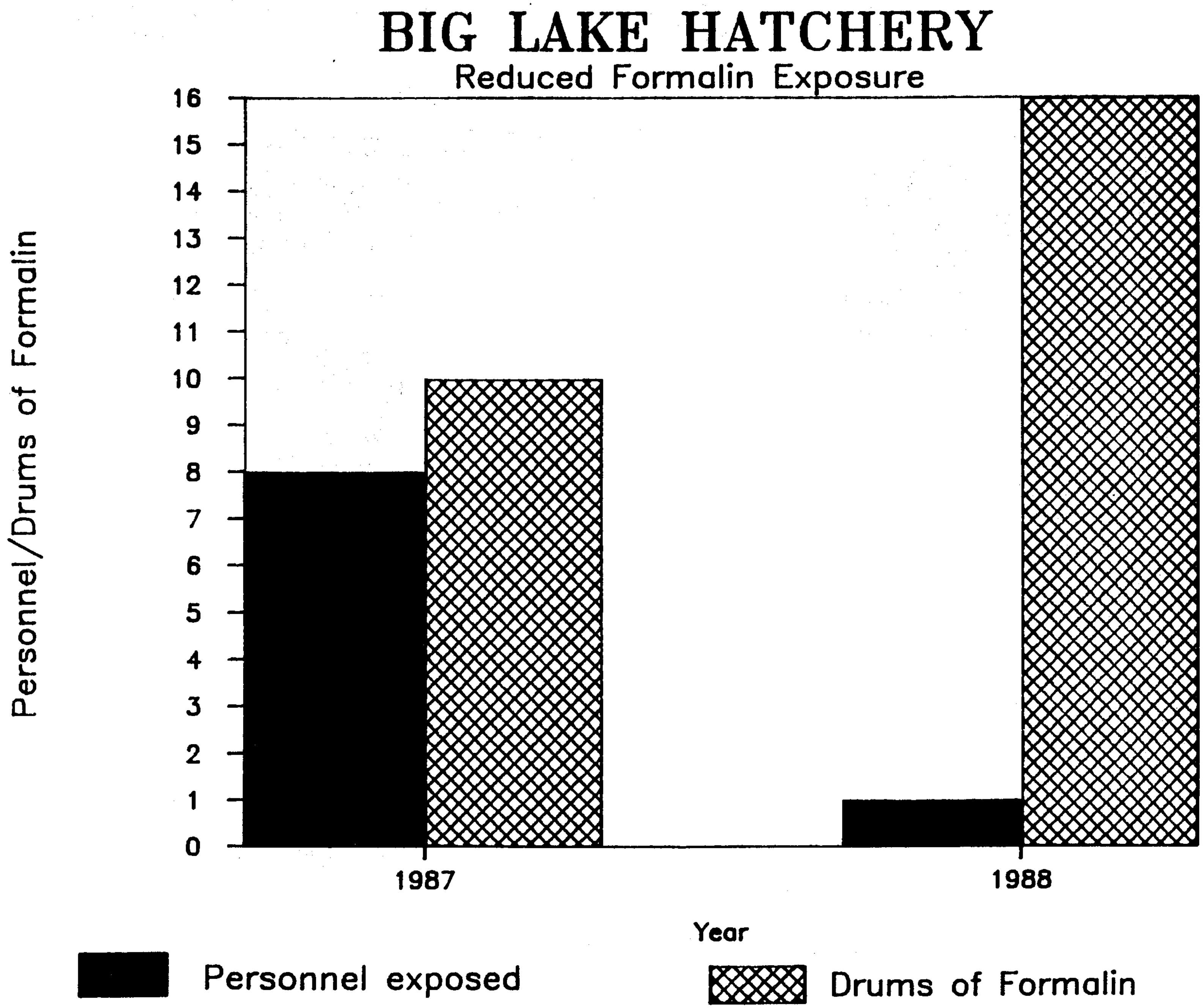
13. Biweekly safety meetings help to identify and solve any hazards which exist.


BIG LAKE HATCHERY
Reduced Chemical Usage
Units of Chemicals
100
90
80
70
60
50
40
30
20
10
0
1987
1988
Year
Iodophor
Chlorine



BIG LAKE HATCHERY
Reduced Disinfectant Costs
Disinfectant Cost
(Thousands)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1987
1988
Year


BIG LAKE HATCHERY
Disinfectants Used
Disinfectant Type %
90
80
70
60
50
40
30
20
10
0
1987
Year
1988
Harsh Chemicals
Mild Chemicals



BIG LAKE HATCHERY
Reduced Formalin Exposure
Personnel/Drums of Formalin
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1987
1988
Year
Personnel exposed
Drums of Formalin

MR. ALLEE: I was at the last sockeye workshop and there was a lot of concern over chemical safety from the people that worked at the Big Lake Hatchery, and I think they were doing the lion's share of that kind of disinfection. So I think it's much to your credit, the work that you've got done there, and we can all use that as an example. And it's a very serious problem. We had a young fellow who has separated from the State service and has gotten a recent Court claim and has no doubt damaged himself permanently by the improper use of betadine in his zeal to deal with the IHN problem, and it's a very serious problem. You've done a heck of a fine job.

MR. CLEVENGER: You know it's not just the problem at Big Lake, there are several people in the system that have had problems, and we've got to get a handle on it, and just to get an increased awareness is the first step.

There's a lot of chemicals you think are safe from the material safety data sheets that you read and yet people are still having health problems. It's important that you be careful because sensitizing can happen over a period of time where you think you're not having problems with it, and all of a sudden you do have problems with it. So we've all got to learn the proper procedures.

QUESTION: I was just wondering on your bi-weekly meetings, are they pretty rich with discussion?

MR. CLEVENGER: What we do is have a safety meetings, we sit down and say, okay, what's unsafe. People will sit and think for a minute, and remember from the past week their mental notes, and these are brought up at these meetings. So everything that's brought up is put on a list and we add that to our list of things to do the following week. We try to set priorities for those safety violations. We also have a person with a checklist, and we'll send that person around and check chemicals or electrical cords or power tools.

QUESTION: You've got a safety officer?

MR. CLEVENGER: Right.

QUESTION: Do you show films at your safety meetings?

MR. CLEVENGER: Our last safety meeting we did have a couple of videos. One was on fire extinguishers. It worked out really well. We really communicate well in that type of a meeting.

IHN Prevalence in 1988 and Ongoing Pathological Concerns - Ted Meyers

Statewide sockeye numbers for 1987:

104.5 million eggs taken
79.7 million resulting fry (76.3%)
3.0 million killed due to IHN present (3.8%)

A small number of fry we also destroyed that later were found not to have IHN. The bottom line here is that with the pathology guidelines being used and the hatchery managers keeping a close eye on their fish, we are losing very small numbers of fish to IHN. Certainly nothing that prevents large scale production.

The larger the scale of eggtakes, the higher the probability of IHN _if_ high titers are present. Titers are more important than prevalence in probability in IHN. Some examples:

Crooked Creek	-	low prevalence, low titers, large scale eggtake, no IHN
Gulkana & Big Lake	-	high prevalence, high titers, large scale eggtakes, some IHN every year
Trial Lakes	-	medium prevalence, medium titers, medium size eggtakes, IHN some years
Beaver Falls	-	high prevalence, high titers, but small eggtakes, no IHN

The larger the scale of eggtakes, the greater the risk of vertical transmission.

In terms of rearing, IHNV is reduced in saltwater versus freshwater, but still present.

Quite frankly the IHN has not impacted our production that much, statewide in the '87-88 year. I think we've reached the point where IHN is certainly a concern, is something to keep on top of all the time, but it's not an obstacle that's going to impede our successful production. This is from egg to fry. When we start talking about smolt, then we'll see.

Overall survival from egg to fry, is 79.7%. If you count IHN into the equation, then our egg to fry survival drops to about 76%. Not really all that bad. So the FRED sockeye policy works.

Probably the biggest concern that we have from a pathology perspective, is to keep IHN in the sockeye and not let it get in any other IHN susceptible non-sockeye species. That's probably our biggest concern, and we are addressing those concerns in terms of the statewide policies of where we plant sockeye.

At any rate, I think the future is pretty bright and we are going to get burned from time to time, I understand, but as long as we maintain our facilities, in other words compartmentalize and so forth, we will be able to sustain the losses.

Does anybody have any questions? It's a whole new ball game when we go to smolt, of course. We'll probably run a lot higher risk of having problems with virus.

MR. ALLEE: I was just going to point out, there are things with respect to smolts that are quite encouraging. The Main bay facility where they did produce smolts from the Coghill eggtake, there was no incidence of IHN.

MR. MEYERS: The titers were pretty low. Again I think titer is more important than prevalence. Because of the disinfection procedure and the single family procedures we're using, they do two things: One, it reduces, I'm not saying it eliminates, but it reduces the potential for vertical transmission during water hardening, and two, it also reduces the chance of cross-contamination from a hot fish, from ovarian fluids from a hot fish to another egg block. So what we do is we minimize that basically and we reduce the random possibility of it happening.

Anyway, I think it's a job well done.

MR. CHLUPACH: Would we be more likely to see IHNV at the initial emergence stage or at a fry/fingerling stage in the wild?

MR. SAFT: Well, if the fry die they're going to be swimming in the lake and they're going to be along the shore and if somebody doesn't happen to stumble onto them.....

MR. CHLUPACH: I guess what I'm asking is it more susceptible to the younger individual as opposed to the older?

MR. SAFT: Well, there are theories. There is a breakpoint somewhere, and maybe a good example would be Trail Lakes. A few years ago, three years ago now, they had fish in the raceways of different ages, and the first egg take came out first, obviously, and those were the larger fish and the last -- if my memory serves me right -- the last group of fish to come out of isolation were the ones that felt the disease, and through them it spread through all the raceways, and you could definitely see a mortality difference as the larger fish had a much less mortality than the smaller fish. So we do reach a point somewhere.

MR. HALLORAN: I may have talked with you about this last year, about Bob Bush, talking about how they're routinely now exposing some of their trout to IHN, different sizes, because they get differential mortality, and so they kind of expose them to it, get the mortality out of the way, and then go on with their trout rearing.

MR. MEYERS: That's interesting.

A VOICE: Yes, that's an interesting concept, I don't think we're quite ready for that though. But I think that might answer your question about the size, they seem to have different abilities to withstand IHN.

MR. MEYERS: The idea that Bill indicated Bob Rush is using and that Bob Chlupach questioned here, is one of the parameters that Main Bay is testing. John might indeed be correct, that if we get them up to a certain size, their susceptibility might be much less to the virus. I don't think that's been adequately tested. I certainly hope that's the case. But I don't have any data to indicate that.

A VOICE: You know there's another variable in terms of rearing smolt and that is in saltwater rearing it wouldn't be as much of a problem as it is in freshwater.

MR. ZORICH: Our policy about not introducing sockeye and chinook into the same systems and that, is that continuing to be re-evaluated as we get more information into that?

MR. MEYERS: Yes, it is. If somebody wants to introduce chinook into the sockeye system it's not necessarily going to be refused or not even considered. It depends on the situation. It's evaluated on a case by case basis.

It's much more severe to consider putting sockeye into a chinook system for example, where they don't exist already. That's a little more serious concern there.

MR. WHITE: There's been some speculating, at least in Kodiak, about natural zero checks. We're just wondering whether culturing them in the saltwater, would that have a tendency of reduced exposure to IHN because of the saltwater?

MR. MEYERS: That may well be in saltwater. The virus is reduced considerably in the titers by being in saltwater, but it's not totally eliminated. There have been tests on activating the virus in sea water versus freshwater for example, and the virus is still detectable, although just barely at 25 parts per thousand. So it can survive, but not very well. But in a net pen situation we have an infected fish, it's probably shedding a lot of virus in the feces. And if you watch fish in a pen, they'll eat the feces of their cohorts and there's not much problem of that virus being activated in saltwater, so therein lies the potential.

MR. MEYERS: We're really not trying to do anything yet in terms of altering the fish or the virus, at this point, we're just trying to monitor it and reduce the prevalence. We know it happens in nature anyway, almost every sockeye that's ever been looked at up here in Alaska was positive for IHN, and what we're trying to do is just minimize the problem in the hatchery. But you're right, all that gets back to the concern of getting a strain of virus to adapt to another species of fish other than sockeye. That's our biggest concern up here. We don't have the problems that the Columbia River Basin has with IHN in its chinook and its steelhead, and we had found IHN in chinook occasionally up here in Alaska, and it's always when those fish have been in association with sockeye, either in the hatchery or in the natural spawning situation. But normally we don't find IHN in those non-sockeye species, and if that virus were able to adapt, in other words if we were to promote rearing sockeye with other susceptible species, we could possibly do that, cause the virus to adapt to those other species, and that's our big concern.

MR. BROWN: Just an observation. I wound up with IHN in chums in some form. We had two high incubators that we used, but we had so much silt and so forth like this, it could have been something else and we sent those in and found out that they did have IHN and we killed them. Then we went ahead and checked the rest of the incubators. During this period of time we were holding our chums and feeding them, feeding them on ADP. There were some that we had fed for over a month at that time, and we had almost no problem. It was one of the best rearing programs that we had ever had there. Nothing had broken out, they were eating very vigorously, growing very well, and yet when we checked the incubators we found IHN in virtually, all of the incubators which we had to recirculate water through. If we had not seen those two hot incubators, who knows.

We might not have ever known we had IHN in the hatchery?

MR. MEYERS: A similar thing could have happened in Eklutna where they had 80% mortality in their chums, and then those fish that were released came back, those were the first returns bound to be positive, as I understand.

Limnology Projects in Southeast - Mike Haddix

MR. HADDIX: Jeff Koenings wasn't able to make it, so I'll try to cover the Limnology Program overall, in Southeast, and basically go over what type of programs we're working on and go over the projects and then Tim Zadina is going to talk about coded-wire tagging at remote sites, and wild sockeye smolt which we've been involved in for about seven or eight years now. He's also going to cover some other projects he has going on down here in conjunction with some of our sockeye work.

Over-all the Limnology Sections have been involved in lake ecosystem work, trying to determine what makes these lakes work as far as sockeye production, and so all the projects are oriented towards trying to determine what the production potential of a particular lake is, or what you could do to increase that production potential. So most of our limnology programs involve surveys, and we're looking basically at limnology programs involving physical characteristics of a lake, lake morphology, lake chemistry, primarily looking at the chemical characteristics of the nutrients, etc. Lake biology, looking at primary production used in phytoplankton measurements. Secondary production, zooplankton, tertiary production, usually in the form of sockeye salmon, which may be simplistic in most cases, but in most cases that's about all we can look at in these systems and we look at the tertiary production (in the form of sockeye and in some cases stickleback or other species that can be in with the sockeye.

So that's basically what our over-all programs are, and we've been involved in a lot of work on a lot of lakes within the state. If you look at the total number of lakes since last year that we worked on, conducted limnological lake studies, there's 18 lakes in Southeast Alaska and 22 lakes in Southcentral. All the surveys in Southeast are divided. There's three of us working full time down here now, myself and Tim Zadina in Ketchikan taking care of all the southern Southeast lakes, and Dave Barto is working out of Sitka and Juneau now, taking care of surveys on the northern Southeast Lakes.

So this will give you an idea of the number of lakes that we're working on, and nearly all these lakes have some kind of a sockeye project, or oriented towards sockeye. Some of the work that we're doing to determine the production potentials and so forth requires looking at survivorship and the various life stages of sockeye in lakes and in the freshwater environment. We collect information that will be used to develop a model for looking at production. We're looking at these different aspects of sockeye life histories, the escapement counts, the fish entering the systems, and potential egg deposition. We're able to estimate, from egg deposition based on hydroacoustic surveys, in conjunction with tow netting, the survivals from egg to fry.

From there we go on and estimate the number of smolt that are produced by a specific number of fry, again using hydroacoustics, tow netting and recapture or other methods. On some of these systems we've been able to get a better handle on egg deposition using pre-emergent sampling than what we estimated was the potential based on escapement.

We've used those different methods to estimate smolt numbers, and then we've been involved to a certain extent of also trying to get a better handle on adult production. In some of the Southeast lakes we wanted to know how many smolts were going out, we also wanted to know what the total production was. We wanted to know what the harvest was in this particular stock so we would know the total production. So we got into some coded-wire tagging of wild sockeye smolts on these systems, so that we'd know what the total production amount from these systems was. That's basically what we're doing, and that's sort of an over-simplification, but with all these lakes that are involved in collecting this kind of data, we can help determine what we need to do to increase production or bring production up to what it was at one time.

__Capture and Tagging of Sockeye Smolt - Tim Zadina__

MR. ZADINA: As you can see with all these lake-stocking projects going on and the evaluations, things are getting a little busy down here.

The easiest place to capture these fish for evaluation is as smolt, because they are out in the lakes and we've set up weirs.

The first two years we had mortality problems because of the flows and trying to hold fish and crowding them in the buckets, trying to tag too many at a time, and it didn't take long to figure out that you can't do that with these smolt.

We've kind of evolved to the point where we're seeing more and more of our systems being stocked with fish and we cannot be spread out in eight different directions all at the same time. This all happens in May, and we looked at other alternatives to tagging, and one was in lake pen rearing. We did a couple of pilot studies at Hugh Smith Lake from our hatchery incubated stocks, and we did just a real small study in '85 to see if we could raise them or not in a lake. Then in '86 we did the main study, and I fed them for 62 days. The feeding rate was between 4.5 and 11.9% wet body weight per day. The reason there was such a variance was that's back calculated. It was supposed to be 5%, and we had problems with predators eating holes in the side of the pen and a few of them escaping, so we back calculated with the actual numbers we had by the time we tagged them.

We had a starting weight from the hatchery of .128 grams, and in 62 days they ended up at just over 1.5 grams and 2.1 grams in the two pens they were in. And it ended up being a 27% difference in body weight between the two pens that were three percent fed difference, which was very significant. Now the water temperatures during this feeding time ranged from 12-1/2 to 18° Celsius which is fairly high, but it's pretty much the mean for that time frame for that lake over the past seven years.

At approximately 60 millimeters, these fish were all tagged with a coded wire tag. We're looking at feeding a large number and tagging them as fry instead of smolt, and then releasing them in the lake.

So we tagged the entire lot with coded-wire tags, and with them being in a pen it only took two days to do 30,000 fish. We also fed them the OTC mark which we talked about earlier, and we fed this OTC food to them over a 14-day period after they reached a size of 42 millimeters, which we figured was the size when actual true bone structure would be laying down. It turned out that during this time period the water temperature was high, it was 16 to 18°C, and the pH in the system was very low, it was very soft water, and at the time we didn't know all these were happening, but obviously we did it the right way.

We ended up with a minimum of 20% survival, from fry that we released in July to smolt the following spring, and we don't know how many of those fish went out as two-year old's the next year. They had problems with their weir the year that they counted these, so it could have been a lot higher. So that's a minimum number.

From that study we saw a few things, that we could feed them in remote lakes and tag them at that time. You would have to tag a larger number because of the survival differences, but it can be done then instead of waiting for the smolt.

And the other thing I wanted to talk about was our alternative enhancement for sockeye. Instead of utilizing hatcheries, we were looking at a way to increase sockeye production with minimal costs in the system, and we came up with an in lake incubation system. We were looking at a way for ease of construction, high surface area over volume ratio, and ability to incubate and hold the alevins until they emerged.

We ended up making our incubation units out of sandwiched Washington pond trays that were no longer utilized by the hatcheries down there. We used plastic saddles between the two as substrate. This was the first design of it. Since then it's been modified. With this design, between the sandwiches, there's blocks of wood to keep them spaced apart, and the second year we modified this where we used threaded rod with I bolts around the edges. With this setup you needed a jig to actually put them in each time, and with the I bolts they assembled very easily, and you could put them together. The second year we did it, we seeded 72,000 eggs in a little less than an hour after we had water hardened the eggs in the two units. The actual cost of the unit from start to finish was less than $200, which makes it real cost efficient. The first year we did it at Hugh Smith Lake, we seeded them at 3500 eggs per tray and 14,000 eggs per unit. We only had the stacks four units high. And survivals on these ranged from 32.6% to 95.5%.

MR. ZADINA: Primarily the survival rates varied by where the units were placed in the lake. High survival was off of one of the inlet streams, which we found the next year, that it was actually off to the side. It wasn't getting the direct flow, and the three lower ones were at the outlet. The only one that didn't have a lot of detritus on it was the one that was off to the side of the inlet stream. So the next year we modified our units and we set two out, one we had 4,000 eggs per tray, that's 24,000 eggs per unit, and we tried with 8,000 eggs per tray and 48,000 eggs per unit. And the survival on the lower number of eggs varied from 21 to 39%.

The reason they were lower was because we put them right off the inlet stream, right out in front of it where all the junk came, and that's primarily what happened. We had a lot of detritus and salmon carcasses and everything else which just happened to go right there and drop off. The higher egg seeding, we had 17 to 42% survival, so there really wasn't much of a change in survival of these units on the second year.

Primarily we figured that the poorer survival was due to the site selection more than the style of the incubator. We've got a non-anadromous lake above McDonald Lake which has no opening and a small trout population, and we'd like to put these incubators in there with a large number, between three and four hundred thousand eggs and see if we do get good survival, do they live as fry. That' s one question that people have asked us and we've asked to, is do they definitely swim out and did they live after they swim out. From inspection of the first year, the alevins definitely stayed in these trays until they're ready to swim up. We pulled one unit up and they were not buttoned up yet, and they were still inside the trays. We feel that these incubation units do work, it's just a matter of where to place them and more adjustments to our style of incubation.

MR. HADDIX: Yes, one thing we did, we tried to make sure we placed them in an area that was down below the one percent light level. And of course the ideal location is just off the mouth of one of these streams. We still have some flow but you're not getting all this trash and so forth coming out.

And then the design. The screens on the trays, the bottom screen is such that they can't swim down through it or emerge. But the top screen, they can swim up through the saddles and they can go out the top, so whenever they feel like coming out they do eventually swim out obviously, but they don't just fall out when they emerge. What happens to them after they go out? We don't know. We assume they just swim off just like a fry would and come down the creek.

QUESTION: Haven't you put some of these in some barren lakes, Mike?

MR. ZADINA: That's what we plan on doing this fall.

A VOICE: So then you'll know.

MR. ZADINA: Yes, and we'll have enough in there to evaluate with hydroacoustics to see if there are numbers in the lake.

MR. HADDIX: But these things might be, you know, something that will be real useful for any intensive rehabilitation type projects or something where you don't have a hatchery available.

One of the things that we looked at when we did this pen rearing, we were looking at an easier way to get fish tagged, so we didn't have to deal with smolt, basically. Well, it's pretty expensive to do that. We had people out there on site that were doing something else. There was Commercial Fish Division people out there running the smolt weir and then they were running the adult weir there in the lake, so we were able to have them keep the fish and so forth. I'm not so sure it would be cost effective. Maybe on a large scale some lakes if we had access like

Klawock Lake or maybe some lakes up in South Central where you can just drive out there and you didn't have to fly food out, it might make some sense. But if you look at it from a cost per fish standpoint, and you have to pay people to go out there to feed the fish, get them up to the size to tag them, then you're back at about the same cost as tagging smolt.

So I mean it has some potential in certain situations.

So you've got to look at each situation individually when you're trying to trap these wild smolt, and you have to be really careful you don' t have any situation where they impinge on the net or they have to be handled, transported, or whatever in any manner, because they're too fragile. But we have had success tagging them once we got these problems worked out.

MR. ALLEE: What kind of mortality, post-tagging, have you documented?

MR. HADDIX: Well, initially at Hugh Smith Lake, we had some fairly high mortalities on tagged fish. At McDonald Lake they were fairly low. I mean the survival of the tagged fish was essentially the same as the other fish going out, based on our smolt counts.

MR. ZADINA: Most of our mortalities came right after we tagged them.

MR. HADDIX: Now we've got it down, so that our initial mortalities are really low, and we do hold the fish. But the systems are quite different. At McDonald the river is a mile downstream, and there's a big slough for the fish to hold in, once they leave the tag site. Whereas, at Hugh Smith and Redoubt the fish go right out into saltwater. So I think those are special considerations.

QUESTION: How about after you mark the fish, did you look for retention?

MR. ZADINA: Okay, the fish were held for 14 days after tagging, this would have been barely three weeks after the OTC mark was placed. And we took a sample of 50 and froze them immediately and they were sent to the Soldotna lab and Jeff Koenings. He was going to analyze them and I have not gotten results back on that yet.

Also last fall there was a sample of 50 of them kept. So there are 50 of each and I have not gotten the results back from those. But we're expecting adults from that, starting this year.

QUESTION: How many green eggs have you put in one of your in lake incubation boxes?

MR. ZADINA: Well, we decided we were going to try and max it out with the 8,000 per tray. To physically handle it, with six trays, that's about all you can physically handle to get them out of the boat and into the lake. And that was 48,000 eggs per unit.

And the survival rate was not any different between that and the lower numbers, that we could see. One thing we did do a couple of different ways; the first year when we seeded these eggs, they were green. I mean they hadn't water hardened or anything. We fertilized them, submerged each tray into the water and poured the eggs on them. The second year we did it, we water hardened half of them to see how the ease of pouring into these units would be, and the water hardened eggs definitely were easier to handle. We had a few problems with the other eggs when they were squishing between the saddles. And with the water hardened eggs we've just not had that problem.

QUESTION: Do the eggs out of the incubator boxes hatch about the same time as your wild eggs?

MR. ZADINA: It really depends on where they're at. If they're too deep, you know, where you've got a constant water temperature, they were a lot later.

MR. WHITE: In the beginning of this project when it was being handled by someone else, they talked about different survivals and different depths. Have you just gone to one standard depth, is that what you do?

MR. ZADINA: What we decided on was we were going to find our one percent light level and put them just below that.

SOCKEYE WORKSHOP QUESTIONNAIRE July 12 and 13, 1988
Compiled by
Chris Clevenger

INCUBATION:

1. **What type incubator used? Dimension of incubator?**

BIG LAKE HATCHERY: Kitoi box. 2′x 3′x 2′ deep

MAIN BAY HATCHERY: Kitoi box. 2′x 3′x 2′ deep;No-Pad tray. 4′x 4′

CROOKED CREEK: No-Pad Box. 4′x 4′

GULKANA HATCHERY: Modified Bams type. 8′ x 4′x 4′

KLAWOCK HATCHERY: Kitoi box. 2′x 3′x 2′

TRAIL LAKES: Kitoi box (Hidden Lake). 2′x 3′x 2′
Zenger (No-Pad) (Packers Lake). 4′x 4′

NSRAA: In-Lake Incubator. 2.5′ x 4′ Individual Cells
" x " x 1" deep

YAKIMA: Individual Bucket (Spray Mist). 12" diam. top 10" diam. bottom 12" height

2. **Number of green eggs/incubator? Eyed eggs/incubator?**

BIG LAKE HATCHERY: 288K

MAIN BAY HATCHERY: 250-300K

CROOKED CREEK: 380-400K

GULKANA HATCHERY: 500K

KLAWOCK HATCHERY: 300K

TRAIL LAKES: Kitoi 250K Zenger (No-Pad) 180K

NSRAA: 8K

YAKIMA: 969-4,612

3. **Water source?**

BIG LAKE HATCHERY: Well

MAIN BAY HATCHERY: Main Lake

CROOKED CREEK: Crooked Creek

GULKANA HATCHERY: Spring Water

KLAWOCK HATCHERY: Reservoir, before chlorination

TRAIL LAKES: Well

NSRAA: Redoubt Lake

YAKIMA: Seattle City Water, Tolt R. 70%; Cedar R.30%

4. **Water flow to hatch? Water flow from hatch to emergence? (Mean not Range - like Big Lake below)**

BIG LAKE HATCHERY: 8gpm to hatch 10 gpm to emerge

MAIN BAY HATCHERY: 10-12gpm Kitoi (up to 15gpm)
15-18gpm NoPad; 18,000 available

CROOKED CREEK: 25gpm per stack

GULKANA HATCHERY: 20-25gpm

KLAWOCK HATCHERY: 6-10gpm

TRAIL LAKES: Kitoi: 7gpm to eyed; 10gpm after eyed
Zenger (Nopad): 18-20gpm per stack

NSRAA: Natural lake water movement,wind and wave action.

YAKIMA: .6L/Min.

5. **Incubation water temperature - range and mean for sockeye programs?**

BIG LAKE HATCHERY: 3 C

MAIN BAY HATCHERY: 2-10 C. Adjustable by using surface water or water at 65'.

CROOKED CREEK: 0-12 C

GULKANA HATCHERY: 4 C

KLAWOCK HATCHERY: 11-12 C at eggtake; lowest .5C; emerge 8C

TRAIL LAKES: 3-4 C

NSRAA: 9 C-4 C

YAKIMA: 4.5-11 C

6. **Celsius temperature units to eyed egg, hatch and emergence? Total days eggtake to emergence? (Mean, not range)**

BIG LAKE HATCHERY: 280 to eyed, 670 to emerge.

MAIN BAY HATCHERY: 300 to eyed, 620 to emerge.

CROOKED CREEK: 370 to eyed, unable to compute to emerge; 6 mo. @0 C.

GULKANA HATCHERY: N/A to eyed, emerge begins 650- peaks 830-870.

KLAWOCK HATCHERY: 200-250 eyed, 450 hatch, 550-650 emerge.

TRAIL LAKES: 300 to eyed, 950 to emerge.

NSRAA: 350 to eyed, 800 to emerge.

YAKIMA: 685-761 to hatch.

7. **Type and depth in inches of substrate used?**

BIG LAKE HATCHERY: Saddles 12" deep. JEBUDS didn't work well in Kitoi boxes.

MAIN BAY HATCHERY: Saddles, 30 gal/Kitoi box.

CROOKED CREEK: Saddles.

GULKANA HATCHERY: Pea gravel 3"; covered by 12" of 1 " minus to 3/4" rounded gravel.

KLAWOCK HATCHERY:

TRAIL LAKES: Saddle loop substrate 4" deep.

NSRAA: " x " x 1" cells with perforated aluminum.

YAKIMA: No substrate.

8. **Emergent size? (Mean, not range) Volitional or nonvolitional?**

BIG LAKE HATCHERY: .15g Volitional.

MAIN BAY HATCHERY: .17-.20g Volitional.

CROOKED CREEK: .11g Volitional.

GULKANA HATCHERY: .15g 27.5mm Volitional.

KLAWOCK HATCHERY: .20g 1-3% yolk sac. - nonvolitional

TRAIL LAKES: Packers Lk. .17g; Hidden Lk. .10g; both nonvolitional

NSRAA: Both

YAKIMA: .09g-.15g nonvolitional.

9. **Survival green to eyed and emergence? (Mean, not range)**

BIG LAKE HATCHERY: 87.5% to eyed; 77.5% to emerge.

MAIN BAY HATCHERY: Don't know yet-next year.

CROOKED CREEK: 94% to eyed; 99.5% to emerge.

GULKANA HATCHERY: 74.5-87.6% to emerge.

KLAWOCK HATCHERY:

TRAIL LAKES: 89% to eyed; 98% to emerge.

NSRAA: 71% to eyed; 92% to emerge.

YAKIMA: 41.8% to eyed; 40.5% to emerge.

10. **Past mechanical problems?**

BIG LAKE HATCHERY: Iron bacteria deposits.

MAIN BAY HATCHERY: None

CROOKED CREEK: Daily air bubbles; lots of organics & silt.

GULKANA HATCHERY: Need to revise water intake system.

KLAWOCK HATCHERY: Water system; air locks & supersaturated.

TRAIL LAKES: Zenger (Nopads); air trapped under perf. plate causing dead spots.

NSRAA: Poor design of top fastening to cells and bottom fastening to cells.

YAKIMA: Plugging of spray mist with debris; screen size too large to prevent alevin from plugging holes.

11. **Other significant information that could be added.**

BIG LAKE HATCHERY:

MAIN BAY HATCHERY:

CROOKED CREEK: No history of IHNV at hatchery since beginning (1973)

GULKANA HATCHERY: Researching plastic totes for incubators.

KLAWOCK HATCHERY: 4-5 lb. adults.

TRAIL LAKES: Minimize handling of eggs.

NSRAA: Need for production unit.

YAKIMA:

REARING:

12. **Size and type of rearing container?**

BIG LAKE HATCHERY: 8′ x 4′ x 80′ aluminum raceways.

MAIN BAY HATCHERY: 'Start Tank' 4'x 2' 3" water depth x 16'; Water depth determined by weight on bldg. structure.

CROOKED CREEK: 6' x 15' x 60' Concrete raceway.

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: 23' x 4' x 30" Concrete raceways (~230 cu.')

NSRAA: N/A

YAKIMA: 4' diam. fiberglass.

13. **Rearing density in lbs./ft^3 - start and end?**

BIG LAKE HATCHERY: .15 lbs./ft^3

MAIN BAY HATCHERY: 3.12 lbs./ft^3 (kg/m^3)

CROOKED CREEK: 1.5 lbs./ft^3

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: .5 lbs./ft^3 initial to 1.4 lbs./ft^3 at planting.

NSRAA: N/A

YAKIMA: .1 lbs./ft^3 at emergence to 1.0 lbs./ft^3 present.

14. **Rearing water temperature - range & mean for period?**

BIG LAKE HATCHERY: 3-35 C.

MAIN BAY HATCHERY: 2-10 C.

CROOKED CREEK: 0-12.2 C.

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: 6 C. 1st 30 days, then 4 C. after that. (Wasn't enough)

NSRAA: N/A

YAKIMA: 8 C. to 13 C.

15. Length of rearing time and to what size?

BIG LAKE HATCHERY: 2-6 weeks to .2 g.

MAIN BAY HATCHERY: 15 months to ~10 g.

CROOKED CREEK: 2-6 weeks, depending on emergence, to .19-.24g.

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: 1st lot 8 weeks to 984/lb.
Last lot 6 weeks to 1507/lb.

NSRAA: N/A

YAKIMA: 90 days to 1.0g.

16. Rear indoors or outdoors? Feed by hand or automatic feeders? If automatic feeders what brand type?

BIG LAKE HATCHERY: Outdoors

MAIN BAY HATCHERY: Indoors primarily; up to 3 months for some individuals in saltwater net pens.

CROOKED CREEK: Outdoors

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: Outdoors

NSRAA: N/A

YAKIMA: Indoors

17. Feed: Type, % Body weight fed, intervals, and length of feeding day.

BIG LAKE HATCHERY: OMP mash, 3%, 20 min., 16 hrs.

MAIN BAY HATCHERY: OMP & ADP, hatchery model adjusted weekly, 15 min./hr.

CROOKED CREEK: ADP3 mash, on demand (+/-2.1 to 4%),10 hrs.

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: ADP mash, ~1.0%, hourly, 9 hrs./day.

NSRAA: N/A

YAKIMA: 1) Biomoist, 3) Moore Clark Semi-Moist, 2) Biodiet, 4) Moore Clark OMP 5-8%/day; 5 times/day; 10 AM to 2 PM.

18. Feed conversions? For each type of food? (See Main Bay below)

BIG LAKE HATCHERY: 2 lb fed to 1 lb fish = 2.0

MAIN BAY HATCHERY: OMP freshwater 1.2; OMP saltwater .94; ADP freshwater 1.32; ADP saltwater 1.54.

CROOKED CREEK: 2 to 1 = 2.0

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: 0.8

NSRAA: N/A

YAKIMA: Data not completed

19. Water source and exchange rates? (Mean, not range)

BIG LAKE HATCHERY: Well; R 1.5-2

MAIN BAY HATCHERY: Saltwater - Pacific, Prince William Sound Freshwater-Main Lake; R of 3

CROOKED CREEK: Gravity creek water; R-2

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: Well water; ~50gpm., R-2.

NSRAA: N/A

YAKIMA: City water; .8/hr at start, 2.4/hr at 1.0 g.

20. Mechanical problems? i.e. cleaning, tailscreens, baffles, etc.

BIG LAKE HATCHERY: Leaky tailscreens

MAIN BAY HATCHERY: Cleaning start tanks at high fry densities is very difficult.

CROOKED CREEK: Lots of debris and silt. Screens constantly need cleaning (3x/day).

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES:

NSRAA: N/A

YAKIMA: Fine mesh screening requires brushing daily.

21. Other significant information?

BIG LAKE HATCHERY:

MAIN BAY HATCHERY: Maybe significant drop-out mortality in 1988 due to not ponding soon enough.

CROOKED CREEK: Too much heavy sand for baffle use.

GULKANA HATCHERY: N/A

KLAWOCK HATCHERY: N/A

TRAIL LAKES: When feeding lake spawning sockeye stocks it appears that heating the water for the 1st 30 days is necessary to get the fry feeding well. Temp. will vary with stocks.

NSRAA: N/A

YAKIMA:

MR. CLEVENGER: I'd just like to put in my plug for this questionnaire. It's a real important document. We can look at all the rearing information. We're just now getting into the rearing and nobody knows what's right and what's wrong.

It's a fair exchange method that we can see what everybody else is doing.

A VOICE: Right. As time goes on why these numbers are going to become more solidified and we'll see what kind of performance we get. It's going to save us all lots of trouble if we exchange that information rather than each hatchery going out on their own trying to find out what the best way to do it is.

MR. CLEVENGER: Right.

A VOICE: And I think it's also important to include all the other people where they're dealing with this, in the Lower 48 and B.C.. We can exchange information with them.

A VOICE: Maybe this meeting is the right forum to exchange that information and to get it into some kind of format.

MR. BERTONI: I have a couple of questions. Have you used any other incubators besides the Kitoi boxes for sockeye?

MR. CLEVENGER: In the past we have used Zenger boxes and we just switched over completely to Kitoi boxes the last year. The year prior to that we lost 3 million fry, or pre-emerging fry. We lost the top tray of a five tray stack. When that happens, you loose everything below it. So with the Kitoi boxes it's all separate and single units. If you lose one incubator, you just lose one incubator, you don't have to destroy any of the others that are downstream from it. If, say we had two boxes go down this year, if those two had been top trays of a Zenger stack, we'd have lost ten instead of two. Kitoi boxes are a little bit more expensive to run, you've got to put eight to ten gallons per minute to each box instead of 15 to 20 gallons through each stack of five. So we've got nearly triple our water use through that incubation period for the Kitoi box, but it's going to be well worth it.

MR. BERTONI: Do you guys use egg trays?

MR. CLEVENGER: We experimented with them this year. We used, I think, a half dozen egg trays. They worked good so long as your survival in terms of green egg to eyed egg is 90 percent or better.

QUESTION: Are the egg trays a one piece thing or layered?

MR. CLEVENGER: It's one piece. It's similar to a louver window or venetian blind. The louvers set in there at an angle with a slight bend at the top, and there's several louvers, and it's in a frame. I should have brought a sample.

QUESTION: So do you just use one layer for one Kitoi box?

MR. CLEVENGER: We tried several layers, we put one layer in one box and two layers in another, and I think we had four boxes total, and we went up to four layers, and it really didn't make any difference because they used the bottom layer, even when there was more than one layer in there, they were all staying at the bottom. But it wasn't very successful with the sockeye in the Kitoi box incubators. So we're holding off on the sockeye, for those two reasons.

QUESTION: Chris, were those purchased to the dimensions you wanted or did you just buy it and cut it to the size you wanted?

MR. CLEVENGER: It was purchased. We used a half dozen of those eggs trays in the Kitoi boxes. The rest we picked. We put all of the coho eggs in the eggs tray.

MR. CLEVENGER: There's another idea, that if there's dead eggs, and your sac fry are hatching and falling down through all those dead eggs, if you had picked them all the dead eggs would have been out of there before they hatched.

Then on the other hand when you're using the egg trays you're getting all the dead eggs out, so when you pull those out all you have in there are the sac fry, whereas when you pick the eggs and seed them back down, you don't get all the dead eggs. So you have some fungus and possible IHN.

QUESTION: You're treating those eggs for fungus?

MR. CLEVENGER: Yes, up till hatch. We treated four incubators with Betadine, and those four incubators didn't have IHN.

Sockeye Smolt Production at Main Bay - Larry Peltz

MR. PELTZ: First, for the official record, I'd like to say that I'm not a fish culturist.

Many of you may not be familiar with Main Bay Hatchery. Main Bay is in Prince william Sound. It's a remote hatchery, out in the middle of nowhere. They get a barge once every two weeks. They get a mail plane once a week. They don't have a telephone. Their only communication link is the radio that works about 80 percent of the time. So that's the kind of a setting that we're working with.

Main Bay was designed to be a chum hatchery, it was a chum hatchery from 1982 to 1987. In May of 1987 Main Bay was switched to a sockeye smolt facility, full term smolt facility. At the time it was the only full term smolt facility in the State of Alaska.

Let's look at what happened with the brood year '86 fish.

We got approximately 300,000 sockeye on September 18th. The people at Trail Lakes did a real good job, they were about 1.5 grams when we got them. We split them into two raceways downstairs. One got fed ADP only and one got fed OMP only. There appeared to be quite a behavior difference between the two fish. John alluded to the ADP fish as wild and OMP fish as tame.

The ADP fish were real nervous and skittery. If somebody went down there and made a racket they'd go off food for a couple of days. The OMP fish they just kind of sat there and ate and what have you.

On the 15th of April, roughly, we split these out. Half of these went to the saltwater net pens and the other half stayed in freshwater raceways. We released them about May 15th. The ADP fish were a little bit smaller, at nine grams, the OMP were 10.7g. Saltwater, 11.4 as opposed to 12.9 grams. So there's not a whole lot of difference there.

We had two bunches of fish, and one's real wild and one's kind of tame, and we got to thinking, maybe the wilder fish even though they're a little bit smaller, they might have a survival advantage because when we kick them out the door, if you have a bunch of tame fish sitting around waiting to get fed, they might not do quite as well. So maybe even though the ADP fish are a little smaller, the fact that they're wilder might give them a survival advantage.

We put 10,000 coded wire tags in each of these groups, so when these fish come back we'll be able to tell whether the ADP fish survived better or not, and we'll also be able to tell if the freshwater release versus the saltwater release survived better.

Okay, so let's take a look at brood year '87, what happened with the first big bunch we got. We went to Coghill Lake last fall, we took 11 million eggs. Out of that we got somewhere in the neighborhood of 7 million eyed eggs. From the 7 million eyed eggs we got approximately 5.4 million fry. We took 1.4 million of these fry and we stocked them in barren lake systems in Prince William Sound last month. So that leaves us 4 million to rear to smolt. We've got eight raceways, and one of the first questions we could ask is what size do we want to make these things? How big a smolt will we need to get the best survival.

So we're going to divide it into two groups for this part of the experiment. We're going to shoot for a six gram smolt and a 12 gram smolt. Those seem to be pretty good sizes, they're much bigger than what occurs in nature in that area. You know you can obviously rear twice as many six gram as twelve gram, so if there's no big difference between them we're better off raising smaller fish. So we're going to assign two of these raceways to six gram smolt production and two of them for 12 gram smolt production. When these fish get to a point when they're going to have to do something with them, John figures they're going to be about 62 kilograms per cubic meter.

Now this is not just some pie-in the-sky number. At Main Bay we have reared chum salmon for short periods of time at these densities without any problems at all.

The other question, we can't answer, is everybody asks us what our capacity is. Everybody wants to know, how many fish will it make? They want to know how many smolt we're going to produce, how many adults we're going to get back. Well, we don't know how many smolt we can produce. We're just starting out with this. John decided that he was going to find out right off the bat how many smolt he could produce. He's going to take three raceways, and he's going to put 1.2 million in one raceway, 1.1 million in the next raceway and a million in the third raceway. He's going to keep the feed down on these and he's going to target for approximately the same density when we have to split these out the following spring.

We left one raceway empty. Why did we leave this race empty? Well, we left this raceway empty? Well, we left this raceway empty so that at any point in time that we've got a problem, we're going to thin out, and they're going to go into that extra raceway. We're not going to jeopardize these fish, we're not going to take any chances, we've got one empty raceway, and if we've got a problem, we'll split the fish off and they can go into the empty raceway.

So with the six gram and the 12 gram smolt, we're going to split those out and do the same thing we did with the previous batch. Half of them go to saltwater and half of them go to fresh water. This will occur sometime mid-March, mid- April. Here again we'll have four tag lots, 25,000 fish in each tag lot so we'll be able to evaluate and see which of these do best. The high density ones we're going to split out as soon as we can. As soon as the fish are in the saltwater pond, if they don't have an ice problem out in the bay, half of them are going to go out in the saltwater.

We're not going to take any chance this year either. As soon as we can get them out and get the densities down, we' re going to do it.

On the smallest, target size is May 15th - June 1st, somewhere in that ballpark.

We're also doing some fry stocking in some select lakes in Prince william Sound. I personally feel this has a real limited application. The largest lake we're dealing with is 200 acres. Prince William Sound does not have a natural abundance of productive lake systems like you have in Southeast. I quite frankly don't think there's a lot of potential for this program. I doubt very seriously if it will continue past 1990. Right now I've got a cooperative program with the Forest Service and we'll evaluate this lake stocking program and determine whether or not it works, so we're not tied into an unsuccessful program for a long period of time.

Okay, 1989, theoretically we could add Eyak Lake stock. Eyak Lake is the lake that Cordova is kind of built around; it's accessible by road. It's right there. It produces large numbers of fish for the Copper River Delta fishery. Eyak Lake also has lots of different stocks of fish. Fish spawn in there for a four-month period of time. The run timing for the particular stock that I would like to get would be approximately May 1st to June 1st. That would be when the commercial fishery would be, May 1st there's no other commercial fisheries in the State, nothing out there to interfere with it, so from a fish standpoint it's a good project.

We've got a pilot project that I initiated this year. Most of you are contemplating zero checks. I took eggs on June 16th from this particular stock of fish. I got 100,000 eggs, and put them in an incubator box that's sitting on Eyak Lake. We've got approximately 200 TU's on them right now and they should be eyeing up any time now. They should hatch out, we're guessing, some time in August, and we should have emergence sometime in September. Now if you get a fish in September, between September and next spring we've obviously got some zero check potential there. If we can't make a 4 or 5 gram fish between September and May, then we're not doing something right. Commercial Fishing Division helped me with this egg take. They also sent out a crew to take scale samples. We took approximately 250 scale samples off this particular stock of fish. 25 percent of those are natural zero checks. So this population has a high predominance of zero checks.

Now, I'm talking about adding this stock. Well, I can't get very many eggs out of this stock. It's not an extremely large stock. I could probably get 100,000 eggs a year without too much problem. We can probably accommodate this small number of fish in the hatchery setup as it is now. We can isolate a couple of the raceways off to the side, put up a temporary wall, take one of the end raceways downstairs and put up a partition, we can probably raise one raceway of fish. In the next four years we can probably go through a broodstock buildup phase so we have fish coming back to the facility and get all the eggs we need. But after that point in time, we're going to need separate modules, built-in raceways, whatever, to accommodate this particular broodstock.

QUESTION: Are you proposing more than one stock of fish being based at Main Bay, coming back to Main Bay?

MR. PELTZ: You bet! The run times would not overlap at all. We're going to be spawning these fish when the other ones are just starting to show up in the bay.

Okay, the third phase would be to add another stock of fish, the Eshamy Lake stock. Eshamy Lake is in the same district as Main Bay, it's just around the corner. It's got a historic gill net fishery on it. That's why this district is a gill net district. This stock of fish has more of a prolonged run time, from about July 15th to the 1st of September. Eshamy Lake is on a four year cycle, but it's only got one strong year class; one year out of four it gets enough fish back to operate at carrying capacity. The other three years it's way below it's carrying capacity. So we've got lots of options here if we want to use this stock. We could stock fry, we could rear fry or presmolt sized fish in the fall of the year, or we could stock smolt. Anything we do with this stock of fish, all the fish are going to go back to Eshamy Lake. We don't want these fish to come back to Main Bay Hatchery because there is a potential overlap of the target stock, and we'd just as soon keep our stocks isolated.

Here again if we're going to do this one, we need a separate module, almost a separate hatchery. We don't want to mix different stocks in the hatchery.

Finally, the Coghill Lake Enhancement.

Coghill Lake is the donor stock for our hatchery. Coghill Lake has historically produced anywhere from 50,000 fish in a year to a million fish. It's had a return of a million fish, I think that was 1982. The lake is 3,000 acres. It's semi-glacial. There's a big fishery on this lake. There's another separate fishing district geared totally towards the sockeye return to this lake. However, we've had a hatchery added (PWSAC), built a hatchery at Esther Island which is in this district.

They are going to be producing in 1990-1991, somewhere in the neighborhood of one to two million adult return on their chum salmon. And chum salmon that they're producing happen to have the same run timing as this sockeye stock. So they're going to be harvesting roughly one to two million chums at the same time that we're going to be trying to get the fish back into this lake for escapement purposes, which may not be a problem, if there's a lot of sockeye. But if there's not a lot of sockeye, it could be a big problem.

So in anticipation of that problem, I think that we should take a part of our Coghill Lake stock and put them back into the lake in some form or other; fry, pre-smolt, or smolt. Once again, our goal there should be to maintain the adult returns at the main fishery here, and I think that's a pretty realistic number. I think we can accomplish that. It's going to take some research and it's going to take some dollars to figure that out.

Now this four-phased approach, there is some rhyme and reason to this.

If we do this, there will be fishing in this commercial fishing district from May 1st to the 1st of September, which is something that is politically very good right now, the way the political climate is. Gill netters feel that they're not getting their fair share of hatchery fish, they're not getting their equitable dollar value, the seiners are getting all the fish, so politically this is very smart. Biologically, as far as commercial fisheries managers are concerned, it doesn't cause them any problems either, because we've either spatially or geographically isolated all these stocks so they could fit in and they don't cause any problems with anything close that's already existing there. So it makes sense.

MR. PELTZ: Questions?

QUESTION: Larry, how much did it cost to switch from chum to sockeye?

MR. PELTZ: I have no idea. It wasn't that expensive. We had to have all those little raceways for upstairs, the start tanks, and then Kitoi boxes, whatever those were. That's essentially it. Everything else was already there and in place. A few minor things. I don't think it cost that much.

QUESTION: What percentage of tagged fish do you expect to recover?

MR. PELTZ: We're going to have to take roughly 10,000 fish for broodstock. We'll look at all the broodstock, and we should get the information we need.

If we take 10,000 fish for broodstock, and one out of every 10 is marked and we look at them all, that's a thousand tags. So that's got to be enough.

QUESTION: You don't use this for commercial expansion then, it's just for evaluation of your experiments?

MR. PELTZ: There's nothing else out there. We don't have to prove that they're our fish. They're the only fish that will come back. We don't have to prove this. So it's not quite the same situation here. That's what we've been trying to shy away from, getting mixed stock issues. That's a nightmare. Everybody in this room knows it. We don't want to get involved in that. I think that's a large part of the planning performed in all these facilities.

QUESTION: Is there a window in the spring for these sockeye smolt in the saltwater?

MR. PELTZ: Well, we're going to find that out too. Every two weeks we're going to take a bunch out to saltwater and let them do a saltwater challenge and see what happens. It may be such that we can moVe these things out in January. We don't know. We're going to test all those pieces and we're going to find out. I assume that we're going to be setting the groundwork for a lot of other people in the future, so if we make mistakes, we can learn by our mistakes. If we find out something good we'll save somebody a lot of trouble.

SUCCESSFUL REHABILITATION OF A SOCKEYE SALMON STOCK UTILIZING AN EGG PLANTING DEVICE

by

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November
1986

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ABSTRACT

This report describes the sockeye salmon (Oncorhynchus nerka) rehabilitation work at Karluk Lake, Kodiak Island, Alaska during 1978 to 1986. The primary objective of this project is the rehabilitation of the early run Upper Thumb River stock of Karluk by massive eyed egg plants. A total of 85 million eggs were planted during this period. Pre-emergent fry survival results, from brood year 1979-1985, indicate survival of 42.5% from eyed eggs planted to pre-emergent fry. The return of 20,000, 22,000, 29,000, and 34,000 sockeye spawners to the systems in 1983 to 1986 respectively were the best recorded to the system since the 1920's and coincides with the returns from the egg plant effort.

KEY WORDS: Karluk Lake, sockeye salmon, (Oncorhynchus nerka), rehabilitation, eyed egg plants, tagging.

INTRODUCTION

Karluk Lake, on the south end of Kodiak Island (Figure 1), at one time supported a sockeye salmon run of greater magnitude, in relation to lake size, than any other sockeye salmon producing system in the world. In the early years of overexploitation the runs ranged from 1 million to 5 million fish. The recent (1978 to 1984) escapements have averaged only 323,000 sockeye salmon with the catch mainly incidental to the westside pink sockeye salmon fishery. In 1985 and 1986 there were 1.1 and 1.6 million sockeye salmon in the escapement and catch, a record going back to the 1930's (Table 1).

There are many theories advanced for the decline of the Karluk sockeye salmon. Most stem from the belief that over fishing occurred and resulted in an upset of the life cycle of the fish. The US Fish and Wildlife Service has been recently studying the predators and competitors. The Department of Fish and Game has been conducting pre-fertilization studies since 1978, and has been actively planting sockeye salmon eggs since the 1978 broodyear.

A stream side egg eyeing facility was constructed in the spring of 1980 on Upper Thumb River, Karluk Lake. This site was selected because historical records indicated Upper Thumb River, which was formerly a major producer, had become a minor producer of sockeye relative to the other subpopulations of Karluk Lake.

The approach used to rehabilitate the Upper Thumb River component of the Karluk sockeye population is to artificially incubate the eggs to get the increased green to eyed egg survival that this technique provides, in excess of 80% compared to 13.6% for eggs spawned naturally (Drucker 1970).

At Karluk Lake in the fall of 1977 and spring of 1978, a new salmon egg planting device (SEPD) was tested and compared with the conventional shovel method of planting eggs. Bothe methods were tested in natural streambeds with 465,000 eyed sockeye salmon eggs. The egg planting device was 3.5 times faster and easier to use than the shovel method. Eyed egg to fry survival was 11.0% for the conventional method and 50.8% for the new egg planter (White 1980).

After the initial test, massive egg plants were undertaken from 1978 to 1986. Since the project's commencement, it has become the largest rehabilitation effort in the State of Alaska. It is also the largest egg plant operation to be conducted anywhere in the North Pacific.

REHABILITATION EGG TAKE, INCUBATION AND EYED EGG PLANT 1978 to 1986

Methods

Supplemental production of sockeye salmon to Upper Thumb River was accomplished primarily by taking eggs and milt from sockeye salmon returning to Upper and Lower Thumb Rivers. Eggs were taken by incision and fertilized

Table 1. Karluk River ten year average sockeye salmon run 1882-1980, 1981, 1982, 1983, 1984, 1985, and 1986.

Year	Average Escapement	Average Catch	% of Average Run Caught	Total Average Run
1882 - 1890 a/	-	1,326,397	-	-
1891 - 1900	-	2,503,987	-	-
1901 - 1910	-	2,205,012	-	-
1911 - 1920	-	1,342,637	-	-
1921 - 1930	1,182,125	974,198	45.6	2,136,323
1931 - 1940	972,238	799,054	45.1	1,771,292
1941 - 1950	656,200	487,351	42.6	1,143,551
1951 - 1960	403,150	146,135	26.6	549,285
1961 - 1970	389,445	219,939	36.1	609,384
1971 - 1980	338,662	107,030	24.0	445,692
1981	222,706	95,143	29.9	317,849
1982	164,407	146,755	47.2	311,162
1983	436,145	140,950	24.4	577,095
1984	420,268	258,375	38.1	678,643
1985	995,948	145,443	12.9	1,141,393
1986	887,171	762,717	46.2	1,649,888

a/ Nine year average

Source: Barnaby, 1921-1936; U.S. Fish and Wildlife Service, weir reports and agent's reports, 1937-1956; ADF&G, Comm. Fish. Div., Area Annual Reports, 1957-1986.

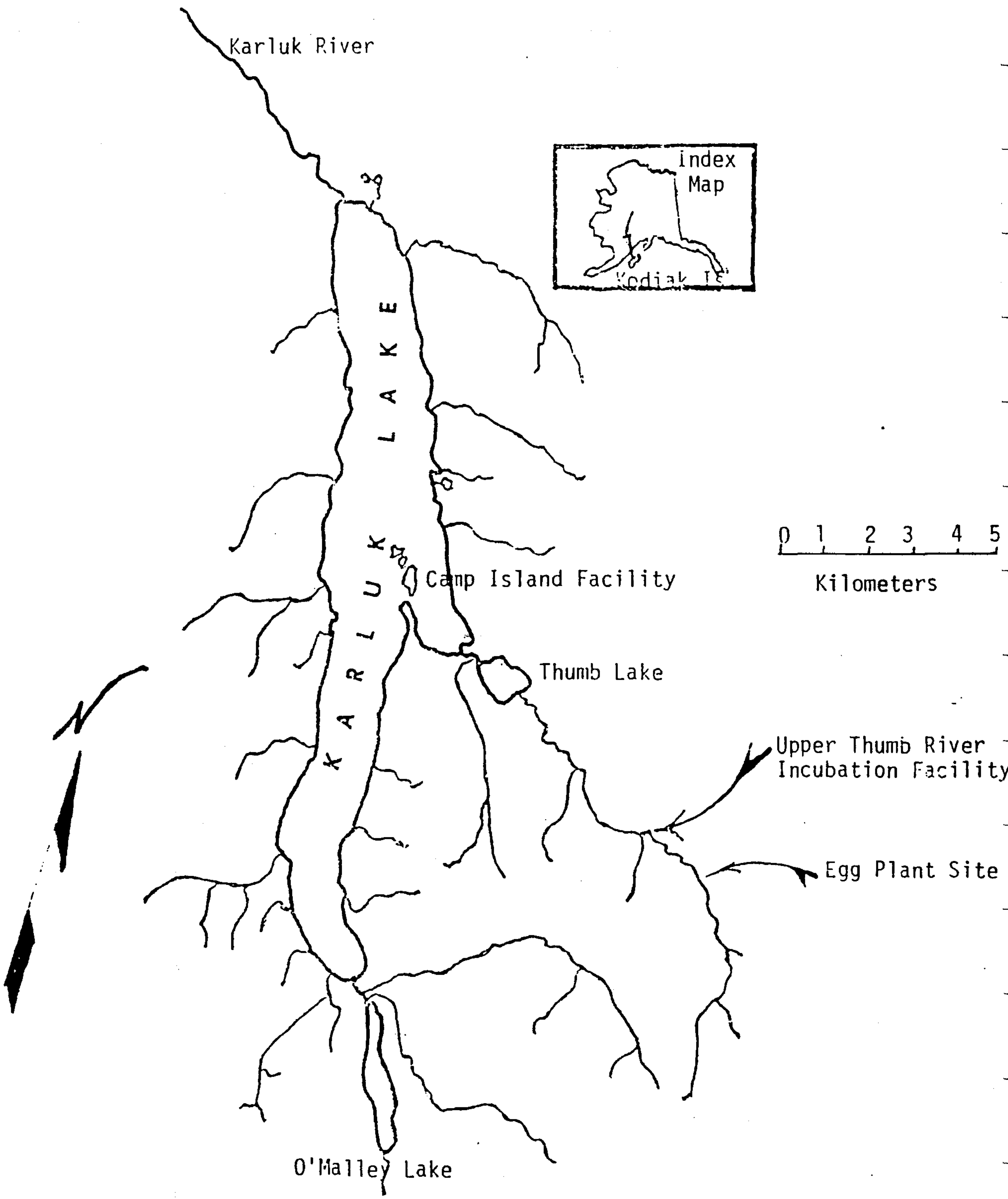

Figure 1. Karluk Lake, Alaska, showing major tributaries important for sockeye salmon spawning and rehabilitation facilities.

in the spawning bucket or plastic container. During the years 1978 to 1980, six females and two to three males were used per bucket and from 1981 to 1984 the gametes from each female and two to three males were stripped into individual containers. During the latter period each container of fertilized eggs was isolated until eggs were water hardened and disinfected with a Betadine solution for ten minutes. Water hardened and disinfected eggs were then consolidated and transported 2.75 km to the incubation facility. In 1978 and 1979 eggs were incubated at Devil's Creek on the United States Coast Guard base in Kodiak and at the Kitoi Bay Hatchery on Afognak Island. In 1980, a new incubation facility was constructed on the East Fork of Upper Thumb River (Figure 2) and from that period on, all eggs were incubated at this site. Eggs were primarily incubated in 74 cm diameter incubators. Flows were maintained at approximately 30 liters per minute. Eggs were treated with Formalin at 1:1000 to 1:600 concentration for 15 minutes every third day during the entire green to eyed egg incubation stage. The eyed eggs were shocked and culled with a photoelectric egg picker, and counted, primarily by volumetric displacement.

Eyed eggs were backpacked (0.5 km to 6.0 km) from the incubation facility to the planting sites above the first and second falls on the East and North Fork of Upper Thumb River (Figure 1) in areas barren of natural spawners.

With the aid of an egg planting device (Figure 3) described by White (1980) most eggs were planted in areas where past pre-emergent sampling indicated the highest survivals could be expected. The probe end of the device was driven approximately 30 cm into the streambed and eggs were hydraulically planted at the rate of 455 eggs per probe plant at a distance of 15 cm or more between each plant.

Results

The 1978 to 1986 early run egg take results are shown in Table 2. The egg takes at Thumb River have resulted in 85,041,000 eyed eggs from early run fish. Green to eyed egg survival has averaged 84.0%. The nine year egg planting summary is shown in Table 3. The egg plant density has averaged 1,377 eggs/m^2 during this period.

Discussion

In the initial years, 1978 to 1981, the egg takes averaged only 5.6 million eggs annually. This was a result of weak natural returns to Upper Thumb River (10,000 fish or less) and project plans which called for using not more than 50% of the natural stock for egg take purposes. In contrast to this, the annual egg takes from 1982 to 1986 have averaged 17.3 million eggs. This is a direct result of strong returns of fish to Upper Thumb River, coinciding with the first returns from the initial rehabilitation effort in 1978-1980.

The average green to eyed egg survival of 84.0% (range 73.8 to 88.8), is below the desired 90% survival level. Mortality can be attributed to the additional handling associated with the half-hour backpack from the egg take site to the incubation facility in the latter years and hour-long charter flights in the former years.

Figure 2. Upper Thumb River, Karluk Lake streamside incubation facility.

Figure 3. Eyed sockeye salmon eggs being planted in Upper Thumb River, Karluk Lake with aid of a salmon egg planting device.

Table 2. Summary of the egg take records for the early run[1/] rehabilitation effort at Upper Thumb River, Karluk Lake 1978 - 1986.

Brood Year	Brood Source	Number of Eggs Taken	Females Spawned	Males Spawned	Egg Take Fecundity	% Survival Eyed Eggs	Number Live Eggs	Incubation Location
1978	Upper Thumb	3,071,000	1,030	525	2,982	84.1	2,583,000	Devil's Creek
1979	Upper Thumb	4,816,000	1,491	489	3,298	81.9	3,945,000	Devil's Creek
1980	Lower Thumb	4,115,000	1,563	925	2,679	73.8	3,038,000	Upper Thumb
1981	Lower Thumb	2,902,000	1,241	701	2,338	81.0	2,343,000	Upper Thumb
1982	Upper Thumb	11,190,000	4,888	1,404	2,282	82.0	9,206,000	Upper Thumb
1983	Lower Thumb	15,256,000	6,353	2,138	2,401	80.0	12,284,000	Upper Thumb
1984	Upper Thumb	15,475,000	6,452	3,324	2,399	85.8	13,207,000	Upper Thumb
1985	Upper Thumb	20,949,000	8,471	3,057	2,473	89.4	18,612,000	Upper Thumb
1986	Upper Thumb	23,443,000	9,259	3,804	2,532	84.6	19,823,000	Upper Thumb
Total or Average:		101,217,000	40,748	16,367	2,484	84.0	85,041,000	

1/ Early run fish are those spawned in July to mid-August and late run are those fish spawned from mid-August to October.

Table 3. Summary of early run egg plants in Upper Thumb River, Karluk Lake from 1978 to 1986.

Brood Year	Number of Eggs Planted	Area Planted (M^2)	Mean Density (eggs/M^2)	Rate of Planting Eggs/Man Hour 1/
1978	2,583,000	1,779	1,452	--
1979	1,449,000	680	2,121	--
1980	3,038,000	1,566	1,940	10,060
1981	2,344,000	1,037	2,260	13,000
1982	9,206,000	2,489	3,691	38,206
1983	12,284,000	5,017	2,448	18,869
1984	13,207,000	14,359	919	26,796
1985	18,612,000	27,850	668	46,488
1986	19,823,000	5,148	3,851	49,067
Total or Average:	82,546,000	59,925	1,377	28,926 2/

1/ Man hours does not include packing time.

2/ Annual average.

A total of 82.5 million eggs have been planted over the nine year period. I know of no other egg plant operation of this magnitude in the North Pacific. In 1983 to 1986 there were so many eggs to plant that new planting areas had to be explored and evaluated. The major area of expansion took place in the upper stream area of Upper Thumb River. This area is so remote, 5 km to 6 km from the incubation site, that it required up to one and a half hours to backpack uphill to the site.

EGG PLANT TO FRY SURVIVAL

Background

Eyed egg plant survivals were estimated by mark-recapture and pre-emergent fry sampling. The two methods insure an overall estimate should one method or the other fail to provide reliable data because of early spring floods.

Methods

Mark-recapture Fry Sampling:

Survival estimates by the mark-recapture method were based on hand counts of fry caught in an index fan trap, described by Ginetz (1977). Fry were marked with Bismark brown Y solution in a method described by Ward and Verhoeven (1963) and released approximately 100 m upstream from the trap. The daily fry population estimate was based upon the ratio of marked to unmarked fish which were hand counted.

The mark-recapture population estimate is expressed mathematically in terms of:

N = total number of fish in the population
D = total number of marked fish in the population
n = number of fish sampled
d = number of marked fish recaptured in the sample
$\hat{N}$ = estimate of N

The estimate is computed according to the following formula (Rawson 1984):

$$\hat{N} = \frac{nD}{d}\left[1 + \frac{D-d}{Dd}\right],$$

and its confidence interval is obtained using the following formula for estimating the variance of $\hat{N}$ (Rawson 1984).

$$Var\,(N) = (n+d)\ D\ (D-d)\ /d^3$$

Pre-emergent fry sampling:

In the spring of 1980 to 1986, fry were pumped out of the gravel at randomly selected and marked areas in the egg plant site. Fry were collected in a cylindrical shaped net of 0.1 m^2, circumference 1.12 m, and then hand counted. The method used is similar to that described by McNeil (1964).

Results

Mark-recapture fry population estimate:

The average estimated survival from eyed egg to emergent fry at Upper Thumb River during the 1979 to 1985 brood year period (Table 4) was 40.3% (range 1.4% to 70.0%) using this method.

Pre-emergent fry sampling:

Pre-emergent fry sampling over the 1979-1985 brood year period, (Table 5) resulted in an average survival estimate of 42.5% (range 1.4% to 61.3%).

Discussion

During the period of estimating the population by mark-recapture, from 1979 to 1983, fishing time was lost each year due to high water conditions. There were 5,1,2,3, and 1 days of fishing time lost in 1979, 1980, 1981, 1982, and 1983 respectively. The fry population was unknown during these high water periods. Fry trapping in 1984 to 1986 was exceptional in that no fishing time was lost during high water periods.

When comparing the pre-emergent and mark-recapture estimates (Table 6) over the years, the pre-emergent estimates exceeded the mark-recapture by only 1,014,000 more fry. Overall, the pre-emergent estimate appears to be more reliable because flooding has not affected the results.

The pre-emergent data has also been useful in identifying survivals by specific planting areas. Many streambed areas that have been avoided after the sampling indicated low survival because of apparent streambed instability. The highest mortality (or disappearance of eggs and fry) appears to be caused by flooding which shifts streambed gravel. Longer and more severe floods create greater mortality. Water discharge records, kept by the United States Geological Survey (USGS) over an eight year period at Upper Thumb River (USGS 1976 to 1983), indicated a mean discharge of 2.068 m^3/s was recorded for a 17 day period in October and a 10 day period in November. The pre-emergent index after this flood was 5.5 fry/dig, which was the worst pre-emergent survival data recorded.

In 1980 a flood period of six days in October resulted in an index of 120 fry/dig, which is slightly below the five year average of 136 fry/dig. In 1981

Table 4. Mark-recapture fry population estimate of early run eyed egg plant fry from Upper Thumb River, 1978 to 1985 brood years.

Brood year	Sample year	Number of eyed eggs planted	Number fry estimated	95% Upper	C.I. Lower	Mean % survival
1978	1979	2,583,000	724,000	-	-	28.0
1979	1980	1,449,000	21,000	24,000	20,000	1.4 1/
1980	1981	3,038,000	663,000	705,000	622,000	21.8
1981	1982	2,344,000	1,643,000	1,689,000	1,597,000	70.0
1982	1983	9,206,000	2,715,000	3,164,000	2,055,000	29.5
1983	1984	12,284,000	4,811,000	5,154,000	4,469,000	39.1
1984	1985	13,207,000	5,704,000	5,559,000	5,849,000	43.0
1985	1986	18,612,000	8,970,000	8,882,000	9,066,000	48.2
Total or Average		62,723,000	25,251,000	-	-	40.3

1/ Low survival due to planting technique and floods in October and November, 1979.

Table 5. Pre-emergent fry population estimate of eyed egg plants from Upper Thumb River, 1979 to 1985 broodyear.

Brood year	Sample year	Number of eyed eggs planted	Number of pre-emergent fry estimated	Sample size	No. of fry/dig	Mean % survival
1979	1980	1,449,000	20,000	80	5	1.4 1/
1980	1981	3,038,000	1,013,000	47	120	33.3
1981	1982	2,344,000	1,437,000	43	279	61.3
1982	1983	9,206,000	4,483,000	123	221	48.7
1983	1984	12,307,000	4,797,000	73	177	39.0
1984	1985	13,207,000	6,728,000	125	215	51.0
1985	1986	18,612,000	7,063,000	124	184	38.0
Total/Average		60,140,000	25,541,000	615	136	42.5

1/ Low survival due to floods in October and November, 1979.

Table 6. Pre-emergent and mark-recapture population estimates of fry projected from eyed egg plants at Upper Thumb River, Karluk Lake, 1978 to 1985 brood years.

Brood year	Sample year	Mark-recapture population estimate	Pre-emergent population estimate	Pre-emergent minus the mark-recapture difference
1978	1979	724,000	-	-
1979	1980	21,000	20,000	-1,000
1980	1981	663,000	1,013,000	+350,000
1981	1982	1,643,000	1,437,000	-206,000
1982	1983	2,715,000	4,483,000	+1,768,000
1983	1984	4,811,000	4,797,000	-14,000
1984	1985	5,704,000	6,728,000	+1,024,000
1985	1986	8,970,000	7,063,000	-1,907,000
Total Difference:				+1,014,000

there were only three flood days between October and November. This probably greatly contributed to the index count of 279 fry/dig for 1981, which was the highest pre-emergent density recorded in the study period. In 1979, the worst year, the flood damage was apparent in a lack of not only live fry but also a lack of dead fry and eggs as well. There was physical evidence of streambed erosion, a portion of the egg plant area was covered with gravel and became part of a new stream bank. The disappearance of fry is assumed to be mortality. However, it is quite conceivable that some of the eggs or fry which were washed out of the egg plant area may settle in low velocity areas and survive unrecorded, in areas downstream from the evaluation project.

The annual egg to fry survival of naturally spawned sockeye salmon at Karluk, based on the actual egg deposition, was 29.4% (range 19.0% to 42.8%) in the period from 1964 to 1967 (Drucker 1970). In our study the eyed egg to fry survival was 42.5% (range 1.4% to 61.3%; Table 5). Canadian spawning channels egg-to-fry survivals for sockeye salmon in 1983 averaged 46.3% (range 32.6% to 80.4%) at Upper Pitt, Weaver Creek, Gates Creek and Nadina River (INPFC 1984). At Jones Creek, annual egg-to-fry survival of pink salmon, (O. gorbuscha) was 37.7% (range 8.5% to 79.1%) over a 15 year study period (Frazer and Fedorenko 1983).

In comparision, the egg-to-fry survivals of the Karluk egg plant operation are within the range of survivals experienced by the Canadians in their spawning channels. The survivals for the egg plant are also higher than those reported for both potential and actual egg deposition from natural spawners as reported by Drucker (1970) in his eight year study at Grassy Point Creek, Karluk Lake.

The pattern of fry emergence was similar to that recorded previously by biologists at Karluk Lake (Drucker 1970). Migration was nocturnal. As the season progressed and daylight increased, the period of fry emergence shifted to later in the evening. The emergence period lasted from mid-March until mid-June with the peak periods from the first week of April to the last week of May, depending upon floods or freshets which apparently trigger bursts of emergence.

FRY MARKING INVESTIGATIONS

Background

In the spring of 1979, 1981, 1984, and 1985 early run sockeye salmon fry were marked for identification of adult returns to the rehabilitation effort. In the 1979 and 1981 period sockeye salmon fry were marked by the removal of an adipose (AD) and the left ventral fin. In 1984 and 1985 fish were marked with a "half length" 0.5 mm coded wire tag (HLCWT).

Fry that were used for the marking project were from eggs planted above a falls, an area barren to natural spawning sockeye salmon.

Methods

Fry from the egg plant were marked by the removal of a fin in a manner described by Bams (1972) and Moberly, et al. (1977). The HLCWT program was conducted in a manner described by Rawson, et al. (1986) except the adipose fin was not removed in our study. A quality control program was conducted during the entire project to insure that only valid marks were recorded for each marked group. Marked fry were released in the evening or at night when the natural migration occurred.

Returning adult sockeye broodfish were inspected for missing fins in July at Upper Thumb River, in conjunction with the egg take in 1983 - 1986.

Because there are multiple age groups of sockeye salmon with the same mark, each sockeye salmon inspected has to be aged to determine brood year of the marked and unmarked fish. The age of broodfish was determined from otolith samples.

Results

Fry marking from 1978 to 1985 is summarized in Table 7.

A total of 43,827 adult sockeye salmon broodfish were inspected for marks in 1983 - 1985 (Table 8). This sample contained 591 valid marked fish with missing fins. There are still 3.3 age fish for the 1980 brood year to return in 1987.

Discussion

The 1978 broodyear marked returns were substantially less than the 1980 broodyear. The 1980 broodyear has contributed to over half of the 2.7 million Karluk sockeye salmon returns in 1985 and 1986. So it is not surprising that the survival of 1980 brood year marked fish was greater than the 1978 group. The overall 1.3% survival of marked fish to returning adult is close to the 1 to 2% survivals expected.

The HLCWT of young sockeye in 1984 and 1985 was an effort to solve the problem of fin regeneration and obtain a life-long tag that would possibly aid in following the fish from juvenile to smolt and finally to adult return. This is the first time that sockeye salmon fry have been tagged without the removal of an adipose fin for external identification. Adults will have to be inspected with a quality control device for tag detection from 1987 to 1991.

ADULT RETURNS

Background

Escapement records have been kept since 1921 at the Karluk River weir to

FIGURE 4. Early run peak survey counts of ckeye adults at Karluk Lake 1971–1986

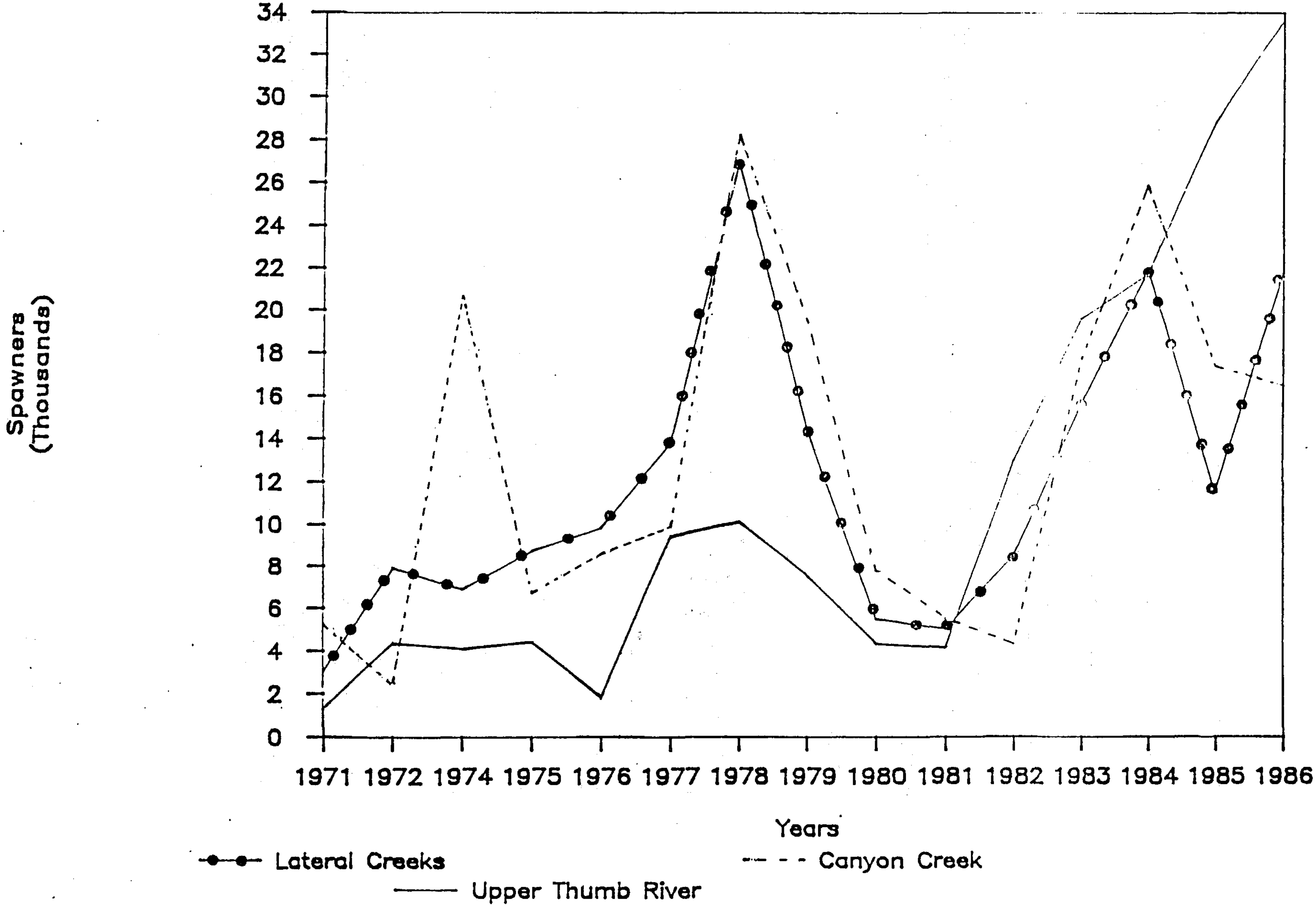

Table 7. Summary of early run fry marked at Upper Thumb River, Karluk Lake, 1979 to 1985.

Brood stock	Brood year	Origin	Mark type	Number fry marked	Number unmarked fry released
Upper Thumb	1978	Egg Plant	AdLV	27,700	691,000
Upper Thumb	1980	Egg Plant	AdLV	70,600	942,400
Upper Thumb	1983	Egg Plant	HLCWT	117,000	4,683,000
Upper Thumb	1984	Egg Plant	HLCWT	141,000	5,562,000

Table 8. Recovery of marked Upper Thumb River, Karluk Lake sockeye salmon by brood year, 1983-1986.

Brood Stock	Brood Year	Mark Type	Number Marked Fry (%)	Number Unmarked Fry (%)	Number Adults Marked (%)	Number Adults Unmarked (%)
Upper Thumb	1978	ADLV	27,700 (1.9)	1,406,300 (98.9)	31 (0.2)	19,869 (99.8)
Upper Thumb	1980	ADLV	70,600 (6.1)	1,092,400 (93.9)	560 (2.3)	23,367 (97.6)
Total	1978 + 1980	ADLV	98,300 (3.8)	2,498,700 (96.2)	591 (1.3)	43,236 (98.7)

Table 9. Upper Thumb River Escapement and Forecast For Early Run Sockeye Salmon.

	AGE GROUP AT RETURN[1]				
Return Year	4 Yr.	5 Yr.	6 Yr.	7 Yr.	Escapement (Forecast)[2]
1982	169	6,969	5,516	323	12,977
1983	1,393	12,986	5,237	0	19,616
1984	1,198	8,057	11,432	1,089	21,776
1985	837	22,717	4,618	693	28,865
1986	239	8,674	24,587	649	34,149
1987	(3,130)	(27,340)	(13,598)	(471)	(44,539)
1988	(3,501)	(47,992)	(23,666)	(714)	(75,873)
1989	(5,808)	(53,683)	(41,543)	(1,243)	(102,277)
1990		(89,056)	(46,469)	(2,181)	(137,706)
1991			(77,088)	(2,440)	
1992				(4,048)	

[1]1982-1986 age return based upon otolith samples. Forecast of (1987-1990) age based upon mean brood year age for 1982-1986.

[2]( ) Indicates forecast of return, based upon 1.76% survival from fry to adult return.

document the daily escapement of salmon species into the system. Stream surveys have also been kept since the 1920's to document the spawning area use of the escapement. The peak spawning area survey counts are the highest number of live and dead sockeye salmon observed at one time. The numbers are considered conservative, as they do not take into account those fish that may have spawned between survey periods or been taken by predators.

Results

The return of 1.1 and 1.6 million sockeye salmon to Karluk Lake in 1985 and 1986 respectively were the highest returns to the system since the 1930's (Table 1).

The Upper Thumb River returns of 20,000, 22,000, 28,800, and 34,000 were the best to this system since the 1920's (Gilbert and Rich 1927) and coincide with the initial rehabilitation efforts in 1978 to 1980. Figure 4 demonstrates the relationship between Upper Thumb River and the other major early run tributary spawning systems at Karluk over the past 15 years. The recent, 1983-1986, escapement is a four fold increase over the pre-rehabilitation escapement.

Discussion

Sockeye salmon escapements were well distributed to both the early and late portions of the run in 1985 and 1986 and were a close reflection of the management goals (Manthey 1983). The catch of 762 thousand Karluk sockeye salmon in 1986 had an ex-vessel value of 5.9 million dollars, resulting in a significant improvement in the value of Kodiak Island Westside fishing districts.

The return of fish to Upper Thumb River in 1984 and 1985 approached the rehabilitation goals of the project. The forecast of returns in 1987 - 1991 (Table 9), based upon fry produced from the last five years of increased production, should allow for the completion of rehabilitation of the system and for a moderate fishery in June.

SUMMARY

The objective of the Karluk Lake Sockeye Rehabilitation Project was to plant massive numbers of eyed sockeye eggs in the underutilized streambed of Upper Thumb River and thus increase the returns of adult fish to that system. The project proceeded on the fundamental assumption that egg take and egg plant survivals would exceed natural survivals. The project has been successful, in that massive numbers of eggs have been seeded annually into the Upper Thumb River streambed since 1978. The subsequent increase of fry from the egg plant has resulted in a return of 20,000, 22,000, 29,000, and 34,000 adult sockeye to Upper Thumb River in 1983 to 1986 respectively. This was the best recorded return to that system to the 1920's, and is a four fold increase in the escapement over the pre-rehabilitation levels. Since the project's commencement, it has become the largest single rehabilitation effort in the State of Alaska and is the largest egg plant effort to be conducted anywhere in the North Pacific. Returns projected from 1987 to 1991 are expected to reach and exceed the goals of rehabilitating the system - allowing for a moderate early run fishery.

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Evaluation of a New Planting Device for Salmon Eggs

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ABSTRACT: In 1977 and 1978, a new planting device for salmon eggs was tested and compared with the conventional shovel method of planting eggs. Both methods were tested in natural stream beds with eyed eggs of sockeye salmon (*Oncorhynchus nerka*). The egg-planting device was 3.5 times faster to operate than the shovel method and was less cumbersome. Both methods immediately and significantly reduced fine intragravel material. Survival of eyed eggs to the fry stage was 11.0% for the conventional method and 50.8% for the new egg-planting device. Fry emergence from the conventional plots was earlier and lasted longer than from plots where the egg-planting device was used. The conventional shovel method produced fry that were heavier at emergence than those produced by using the device.

Recent improvements in artificial propagation of salmon in the North Pacific have lead to the expansion of hatcheries with the objective of increasing fry and smolt production, for the ultimate increase of adult salmon. One method of artificial propagation is planting eyed salmon eggs in natural stream beds (Stockley 1954; International Pacific Salmon Fisheries Commission 1959, 1977; Russell 1972; Blackett 1979; Gangmark and Broad 1955). Egg plants made by this technique have met with varying degrees of success and have been difficult to evaluate because of freshets, natural disappearance of eggs, and mixing of wild and artificial stocks.

Preliminary investigations were begun in 1977 to evaluate a new salmon egg-planting device (SEPD) which reportedly produced high survival, reduced the labor of planting, removed intragravel fines, and planted eggs at a low density (Jones et al. 1977).

The conventional shovel method of planting eggs was used as a control when the device was tested. Of primary interest in the study were the man-hour efficiency, removal of fine particulate matter, and the survival and quality of fry.

Method and Materials

A test of the SEPD was conducted in 1977 and 1978 at Karluk Lake, Kodiak Island, Alaska. Two lots of eggs of sockeye salmon (*Oncorhynchus nerka*) were taken from Upper Thumb River and Canyon Creek stocks on 28 and 29 July 1977. At the head of Karluk River, eggs were taken on 8, 9, and 11 September 1977. Eggs taken by incision from five females were placed in a bucket and fertilized by adding and mixing the sperm from two to three males. Four buckets of fertilized eggs were added to a common basket. When the eggs were water-hardened, they were transported to instream incubators on Karluk Lake for the July spawning stock and to Akalura Lake for the September spawning stock. Routine treatment procedures for green eggs were followed. After the eggs were eyed, they were shocked and picked before they were transported and planted.

A stream-bottom gravel sampler like that described by McNeil and Ahnell (1964) was used at Upper Thumb River, Karluk River, and Spring Creek to measure the removal of fine particulate matter by the two planting methods. The sampler was a 15-cm stainless steel cylinder section that was manually forced into the stream bed. The contents of the cylinder were removed by hand and placed in an 11-L plastic bucket. Each sample was separated into 10 size classes by washing and shaking through nine standard Tyler sieves with square-mesh openings of 25.40, 12.70, 6.35, 4.00, 3.33, 2.00, 1.00, 0.50, and 0.12 mm. The volume of solids retained by each sieve was measured by water displacement. In Karluk River, locations for gravel sampling were randomly chosen; in Spring Creek and Upper Thumb River, gravel samples were taken from test plots established for this study.

The SEPD (Fig. 1) is a 1.45-m-long instrument made primarily of stock polyvinyl chloride (PVC) material. The probe end of the device (2.5 cm in diameter, 100 cm long) is driven about 25 cm into the stream bed. A centrifugal water pump, capable of delivering 530 L/min through a flexible rubber hose (12 m long and 3.7 cm in diameter), is used to provide water pressure. This pressure facilitates driving the probe into the stream bed, removes intragravel fines to provide physical space for the eggs, and develops water flow channels to facilitate the gravity flow of eggs through the stream bed. Eggs were volumetrically measured and planted at a rate of

Fig. 1. Egg-planting device used to plant eggs in Karluk River, October 1977.

200 to 300 per probe plant. The distance between plantings was 15 cm or more, for a total density of 2,000 to 3,000 eggs/m².

The tools used for the conventional shovel method of planting eggs consisted of a garden spade and a metal cylinder 60 cm in diameter by 60 cm high. A stream-bed depression or "redd" was hand-dug to 25 cm inside of the cylinder. The cylinder reduced water velocity over the "redd" to facilitate shoveling and planting and prevented eggs from drifting downstream. After 2,000 or 3,000 eggs were planted in a depression, gravel from outside of the cylinder was placed over the eggs until the hole was filled and the cylinder was removed.

Man-hour efficiency was tested in October and November 1977 on Karluk River. Survival and fry quality were evaluated on Upper Thumb River and Spring Creek in areas barren to wild sockeye. For each planting method 16 test plots, 8 on Upper Thumb River and 8 on Spring Creek, were selected for survival and fry quality estimates. Eggs were planted no closer than 15 cm to the edge of the test plots. Fry-emergence nets (Phillips 1966; Phillips and Koski 1969) were installed over each plot. A cap of nylon netting was placed over the "redd" and the edges buried 25 cm. The nets, consisting of 0.31-cm delta-mesh netting 1.0 m long with a 60-cm tapered cod end for fry collection, were spaced about 0.5 m apart. Although Phillips and Koski (1969) reported efficiency approaching 100% with fry of coho salmon (*O. kisutch*), the trap had not been tested with fry of sockeye salmon. Trap efficiency with sockeye salmon fry was tested by installing a weir 30.5 × 91.4 cm across the downstream end of the test plots at Spring Creek.

Fry quality samples were taken from the SEPD and shovel plots, from fry incubated in PVC Intalox Saddles (Norton Company, Akron, Ohio) at Kitoi Hatchery, and from wild fry from Upper Thumb River. Fry were preserved in 5% formalin in "whirl-pack" plastic bags at emergence periods projected for 10-15, 20-25, 45-55, 70-75, and 90-95%. After 6 weeks, the length from tip of snout to fork of tail (0.1-mm accuracy) and wet weights (0.1-mg accuracy) were recorded for individual fry. A development index, K_D (Bams 1970), was computed for individual fry.

Results

In terms of man-hours, the SEPD was more efficient than the shovel method when tested in Karluk River at a planting density of 3,000 eggs/m². Five time-tests showed a mean of 36,200 eggs planted per man-hour (range, 28,820 to 53,200); four time-tests with the shovel method showed a mean of 10,244 eggs planted per man-hour (range, 7,500 to 15,651). The SEPD also required less physical effort than the shovel method and could be used in deeper pools and in flows of higher velocity, which enables planting in a wider range of areas.

The gravel sampling in the experimental plots showed no significant difference ($P > 0.05$; Student's *t*-test) between the Upper Thumb River and Spring Creek with respect to intragravel fines smaller than 4.0 mm. In the Karluk River, however, intragravel samples showed fewer fines than in the Upper Thumb River ($P < 0.05$) and in Spring Creek ($P < 0.01$).

The shovel method immediately reduced the fines (less than 4.0 mm) in the Upper Thumb River ($P < 0.001$) and in the Karluk River ($P < 0.005$). Similarly, the SEPD immediatey reduced fines of the same size in the Upper Thumb River ($P < 0.01$) and in the Karluk River ($P < 0.025$).

A comparison of fines removed by the SEPD after 196 days at Spring Creek showed no significant difference ($P > 0.05$) from those removed from untreated plots; after 244 days at Upper Thumb River, however, there was still a significant reduction ($P < 0.05$) in fine material over that from undisturbed plots. During the same period, in the same area, there was no difference ($P > 0.05$) between shovel plots and undisturbed plots.

Test results of the efficiency of the emergent fry trap clearly demonstrated that it is not an effective tool for measuring egg-to-fry survival for sockeye salmon. At Spring Creek a total of 2,563 fry (41.4% of the fry that emerged) escaped from the test plots and were captured downstream in the fry weir. Although survival for individual test plots was not obtained because fry moved laterally out of the traps, the different pattern of fry emergence made it possible to ascertain survival of fry planted by the two methods. Fry emergence from the shovel plots began earlier and lasted longer than the intense emergence from the SEPD plots. The total number of fry captured by 5-day periods at the shovel, SEPD, and weir sites are given in Table 1; data in the adjusted fry catch column were allocated from the weir catch on a percentage basis. Survival from eyed eggs to

Table 1. Numbers of fry captured at Spring Creek between 16 March and 14 May 1978, from shovel and SEPD test plots. Adjusted catch columns include proportional fry allocations from the fry caught in the weir.

Period	Fry caught in weir	Total catch in traps		Adjusted catch	
		SEPD fry	Shovel fry	SEPD fry	Shovel fry
16-19 March	37	4	175	5	211
20-25 March	57	1	88	2	144
26-30 March	45	2	62	3	106
31 March-4 April	104	2	72	5	173
5-7 April	56	1	65	2	120
8-14 April	54	145	35	188	46
15-19 April	658	724	62	1,330	114
20-24 April	1,360	1,232	63	2,526	129
25-29 April	181	746	43	917	53
30 April-4 May	3	81	4	84	4
5-8 May	7	10	0	17	0
9-14 May	1	4	0	5	0
Total	2,563	2,952	669	5,084	1,100

emergent fry was 50.8% of the 10,000 eggs planted by the SEPD and 11.0% for the 10,000 eggs planted by the shovel method. Survival data for Upper Thumb were not obtained because freshets eliminated the fry weir.

Fry quality from the 1977 brood stock in Karluk River is shown in Table 2. Fry from the SEPD plots were larger and slightly more developed at emergence than were fry incubated in Intalox saddles. Only a small sample of fry from the shovel plots was obtained due to the low survival of that group of fish. The development index indicated that these fry were heavier and had a higher K_D value than the SEPD fry. Wild fry from Upper Thumb River were observed in spring water pools upstream from the index trap in which they were captured. Because these fry may have fed on their downstream migration, the K_D index may be an expression of condition rather than development.

Discussion

The first year's operation of the SEPD at Karluk Lake demonstrated several advantages over the shovel method of planting eggs: (1) 3.5 times faster rate of egg planting for equal densities and man-hours, (2) less physical labor, (3) ability to plant eggs in a wider variety of stream conditions, and (4) 4.6 times greater emergent fry survival.

In the past, eyed-egg plants in natural stream beds required cumbersome equipment, involving either a large expenditure of labor or a high-density egg plant. Under conditions of high water, these operations are inefficient and often infeasible. Planting by the shovel method is wet and tiring, and personnel must work in an uncomfortable stooped position. Under conditions of high water the shovel operator is often forced to use

Table 2. Mean lengths, weights, and development indices (K_D) of SEPD, shovel, wild, and incubator sockeye salmon fry from Karluk Lake, 1977 brood year. Standard deviation is given in parenthesis.

Source	Number of fish	Length (mm)	Weight (mg)	K_D index
Karluk River Fry				
SEPD Plots[a]	492	31.42 (0.958)	256.75 (23.752)	2.022 (0.0471)
Shovel plots[b]	24	30.41 (2.547)	257.29 (18.930)	2.118 (0.2330)
Saddle incubator[c]	148	29.64 (1.123)	227.89 (25.305)	2.059 (0.0481)
Upper Thumb and Canyon Creek Fry				
SEPD plots[d]	134	28.84 (0.781)	177.80 (15.927)	1.969 (0.0452)
Shovel plots[e]	76	28.55 (1.165)	185.67 (21.043)	1.996 (0.0530)
Wild fry[f]	97	27.79 (2.334)	174.63 (18.312)	2.027 (0.2437)

[a] Yolk sac 95-100% absorbed.
[b] Yolk sac 100% absorbed.
[c] Yolk sac 80% absorbed.
[d] Yolk sac 80-100% absorbed to ventral slit closed.
[e] Yolk sac 90% absorbed.
[f] Yolk sac 95-100% absorbed.

MR. WHITE: Are there any questions on what I covered?

QUESTION: I might have misunderstood. I didn't understand what you thought the survival from fry back to the lake was?

MR. WHITE: Fry to returning adults?

A VOICE: Yes.

MR. WHITE: Right now it's at 2.76%, that's survival from fry to returning adult, that's what it is now. It's ranged, actually, from 1½% to up to 5% for the peak of the third year. Five percent is awful high for sockeye, but I think they were just in the middle of some real good conditions.

We had a very unusual thing happen at Karluk. The fishermen were on strike for pink salmon, and we had over 2 million pink salmon run into Karluk, and there's only sufficient spawning area for about a million within the Karluk River, Karluk outlet. So a lot of fish moved up into the lake and subsequently all those carcasses wound up in there; and we've seen a tremendous increase in the number of fry out of that. It's speculative all things kind of falling in line, but it sure looks like it was something do with lake fertilization and getting the plankton level up.

QUESTION: One clarification; from fry to returning adult, that's out-migrating smolt you're talking about?

MR. WHITE: No, I'm talking about fry.

QUESTION: And what about the smolt?

MR. WHITE: I don't have a handle on that. We tried to get smolt information there, we've thrown everything at it; from sonar counters to mark and recapture, but nothing worked very well.

Northern Cook Inlet Sockeye Smolt Program - Bob Chlupach

At the beginning and end of the smolt migration from Big Lake, both sockeye and coho tend to come out of the lake from 10pm-2am. However, during the middle or peak of their outmigration, they come out during the middle of the day (10am-2pm). Perhaps something to keep in mind for people releasing smolts.

Bob showed graphs of sockeye and coho smolt populations in Big Lake. When the sockeye population is up the coho population is down and vice versa. He is also working on graphs using total biomass. However, it looks like a very possible predator/prey relationship between the coho and the sockeye. Interesting data to look at when considering the proposals for Bear Lake near Seward.

Fry are tagged at Big Lake Hatchery at 0.15g.

Fingerling to smolt survivals have ranged from 5-15%, average 7-9%. Big Lake out migrant smolt sizes and ages:

sockeye 1+ 115 mm & 18-20g.
coho 2+ 128 mm & 23-24g.
Smolt to adult survivals range 24-50%.

The Big Lake Hatchery contribution has really changed through the years. At the beginning we were dealing with 40 percent contribution, and then it went to 60 percent, and then it went to 80 and now we're seeing it at 90 percent contribution of the Big Lake drainage.

QUESTION: With your crystal ball there, what are the possibilities that our coho production is on the upswing now, and how will that effect production with the sockeye?

MR. CHLUPACH: Well, we've been putting in a lot of coho the last two years, which will go out next spring, and I think, I'm hoping that data point will show us or help guide us after that year. I kind of think that the sockeye will build back up and the coho will start to drop a little bit. But I think when you look at all this, what you'll see is an increased production. I'm also working on how much fingerling production can this lake take, and that's what I'm trying to get at right now with this biomass thing. It may be such that it might be maxed out for fingerling production, and it might be the only way to have further enhancements as far as sockeye, may be with smolt. I don't know. Again next year at this time maybe I'll have something more to tell.

QUESTION: Are the sockeye and coho occupying the same areas in the lake?

MR. CHLUPACH: The juvenile fish move into the very west end of the lake, and the west end of the lake is characterized by a lot of meadow area, lots of plankton production.

When we go down there and net we catch thousands of sockeye, but we also catch coho right with them. It's just that they're fewer in numbers. The sockeye dominate in numbers, but I don't know what the proportion or ratio should be in a predator-prey relationship, if indeed that is happening.

QUESTION: Are they zero age coho or one-plus coho?

MR. CHLUPACH: All our coho will stay in freshwater for two years.

MR. CHLUPACH: One other thing I forgot to mention was, that in our outmigration, to give you some idea of where we're coming from as far as our reliability of our data. For instance in 120,000 outmigrating coho smolt this year, we physically looked at 60,000, so we got a pretty good handle on that. In terms of the 600,000 outmigrating sockeye smolt, we looked at a third of that, so I feel that we have a real good handle on that. And some of our smolt work that we've done, total 100 percent sampling, I've worked with 10 percent, 20 percent, and some time counts and weight sampling counts when the run is so large that I can't do anything else, and I've found that I've got my smallest variances by counting as many fish as we can, and then when the run is so large, we do a weight sampling and pro-rate the numbers of fish on the basis of weight. I found that to give us the lowest variances.

NMFS - Auke Bay Sockeye Program - Jerry Taylor

Jerry has been doing work with saltwater challenges of various size sockeye. To date his results indicate that sockeye 1.5g or larger have no problems handling salt water. Fish 1.0g - 1.5g could handle salinities of 21-24 ppt and maybe higher. He is presently testing fish below 1.0g. He has also been working with the time/size window for smolt release. There was a lot of interest in this area from the group, especially in view of a 0-check smolt program. Growth rates in saltwater pens during the summer when temperatures were 10-14°C, were 5-6% body weight/day. The following paper was the basis of his presentation at the workshop.

Sockeye Salmon Culture at Auke Creek Hatchery: Lake Stocking of Juveniles and Production of Age-Zero Smolts, 1986 and 1987 Broods

by

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Ketchikan, Alaska
July 1988

INTRODUCTION

Biological investigation of Auke Lake sockeye salmon began in 1961 and has continued on a more-or-less annual basis. Before 1973, studies focused on adult enumeration, spawning ground surveys and smolt emigration estimates. A limnological investigation of Auke Lake (Hoopes 1963) and a Master's Thesis (Bucaria 1968) on lacustrine growth of juvenile sockeye are exceptions. Much of the pre-1973 data lacks continuity and analyses are difficult. Data for the period 1961 to 1972 was compiled by Taylor and Bailey (1972). Artificial enhancement studies were conducted using the 1973- and 1974 broods, and Dewey (1977) reviewed all the sockeye data and summarized the material up to that time. Current research results and stock situations through the 1986 adult migration were summarized by Taylor (1987).

Adult sockeye salmon escapements to the Auke Creek system have been enumerated annually since 1963. Escapements during this period have ranged from 240 to 16,683 spawners. The mean escapement for the 1963-77 period is 7,982 spawners. Escapements have been in a declining trend since 1977 and mean escapement for the period 1978-1987 is 2,600 spawners.

Scale collections from adult sockeye salmon exist for all years from 1962 to 1987. Scale analysis has determined that five and six-year old adults predominate in the escapements. It is not uncommon to have large numbers of three-, four- and seven-year old sockeye in some runs at Auke Creek. Approximately 50% of the returning females and 40% of the returning males are six years old (age 2.3, where the digit to the left of the period is the number of winters spent in freshwater and the digit to the right is the number of winters spent in the ocean). Spawners of ages 1.3 and 2.2 occur in significant numbers. No adults derived from age-zero smolts have been observed in the Auke Creek sockeye salmon stock.

The decline of the Auke Lake sockeye run prompted development of a restoration project that includes detailed limnological sampling in the lake, evaluating possible changes in spawning areas and enhancement of the recent weak escapements. The restoration project is a cooperative program involving several agencies and is intended to boost the return of endemic stock to Auke Lake to at least 5,000 fish. This would permit sufficient numbers of spawners into the system in order to evaluate spawning success in the lateral tributaries to Auke Lake. The program began in 1985 with a year-long water quality study to assess the sockeye rearing capabilities of Auke Lake. The purpose of this report is to present the results of the enhancement programs using the 1986- and 1987-brood year sockeye salmon at Auke Lake.

ENHANCEMENT STUDIES

1986 Brood

The objective of the enhancement work using 1986-brood sockeye salmon was to rear fry in the hatchery and stock juveniles in Auke Lake in early summer. An additional objective involving age-0 smolt culture was included later.

Eggs were collected after capturing ripe fish in Auke Lake and in Lake Creek, the major tributary to Auke Lake. Eggs and milt were collected in individual plastic bags and transported to

Auke Creek Hatchery for fertilization. The eggs and milt were combined in pairs, one female to one male, water-hardened for 1 hour in buffered iodophor solution, then rinsed and placed in individual Heath trays. Subsurface lake water from the 7-m depth in Auke Lake was used for incubation and rearing. Temperatures ranged from 7-8°C in late summer to 3-4°C in winter (Fig. 1). Influent water passed through an in-line filter (200 micron, multifilament polyester mesh) that removed plankton and debris. Filtered water entered an ultraviolet sterilizer intended to destroy bacteria and viruses. The filtered, ultraviolet treated water was used for all incubation and rearing. Weekly flushes of salt water, that raised the salinity to 28-30‰ for about 1 hour, were used to control fungus.

The entire brood stock was screened for infectious hematopoietic necrosis (IHN) and bacterial kidney disease (BKD). Males and females tested positive for IHN, 89 and 60%, respectively, but none tested positive for BKD. Because so few eggs were available in 1986, only 10 females were spawned, all eggs kept and not destroyed. The families were pooled in four populations relative to amount of IHN virus in the adults.

The resulting fry in the four groups were reared in separate fiberglass tanks at Auke Creek Hatchery. The fry were placed in tanks on February 27, and reared in filtered, ultraviolet treated water. The fish were fed several times daily and the number of feedings increased as photoperiod increased. A commercially prepared, semi-dry food was used, and feed size and ration amount were those recommended by the manufacturer. Biweekly samples of

50 fish from each tank were individually weighed and measured to determine growth. Growth rates of juveniles were determined from measured increases in weight over time. The growth rate, r, expressed as percent body weight gained per day, was described as:

$$r = [Ln(W_2/W_1)/t]100$$

where $W=_1$ and $W=_2$ are fish weighed at the beginning and end of the time period, and t is time in days. The mean sizes and growth rates of all fry are presented in Table 1.

The fish were marked by feeding a diet containing the antibiotic oxytetracycline (OTC). The oxytetracycline was premixed with the feed at a rate of 4.5%. Feeding oxytetracycline-treated diet began May 5 when average fish size was 0.43 gm, 37 mm. Feeding the OTC-treated diet continued for 14 days by which time the fish averaged 0.66 gm, 42 mm. Water temperature during marking was 5-6°C (Fig. 1).

The OTC mark was detected by microscopic observation under ultraviolet light. The skeletons were exposed by removing the flesh on one side of the treated fish. When exposed to ultraviolet light, the OTC mark was visible as a florescent yellowish spot or ring within the calcified bones, especially the vertebrae. The mark was also visible on the otoliths and proximal sections of the ribs. The OTC mark was visible on 100% of the fish examined.

On May 20, the sockeye fry were divided into two release groups. The lake-release group of 16,600 fry was stocked in Auke Lake. A total of 1,000 fish, designated the age-0 group, was retained at the hatchery and reared in 10-12° water. Between May 20 and June 29, the growth rate of the age-0 group averaged 3.3%/day. A seawater challenge on June 23 revealed no mortalities after 96 h, average fish size was 1.5 gm, 54 mm. On June 30 the age-0 fish, average size 2.9 g, 63 mm, were placed in seawater net pens in Auke Bay. The age-0 fish were fin clipped and later released on July 24, at which time they averaged 6.0 gm, 84 mm (Fig. 2). Growth rate while in the net pen averaged 3.5%/day. Salinities in the net pens ranged from 20-24°/...

Sockeye salmon smolts from the 1986-brood lake release group migrated downstream at Auke Creek as age-1 fish in 1988. Between May 5 and June 26, a total of 19,200 sockeye salmon smolts left the lake. Samples of age-1 smolts collected throughout the run were sampled for OTC mark determination. This revealed 3,830 fish were from the lake release group, and represented 23% of the group released in Auke Lake in May 1987. Mean size of the age-1 smolts from the lake release group was 5.6 gm and 87 mm, while the wild age-1 smolts averaged 5.2 gm and 84 mm.

1987 Brood

The objectives of the enhancement studies with 1987 brood sockeye salmon was to incubate eggs and rear fry at higher temperatures than in the previous year, and determine the feasibility of producing age-0 smolts that were similar in size and migration time to age-1 wild smolts. An ancillary objective involved determining the seawater tolerance of juveniles on an accelerated growth schedule.

Eggs were collected and handled by the same methods used in

1986, with the exception of the incubation and rearing temperatures. In 1987, a pipeline was installed to deliver surface water from Auke Creek to the hatchery. Water temperatures in Auke Creek are generally greater than 15°C during August, then gradually decreased to 8°C by mid-October. Surface and subsurface lake temperatures decrease, but are usually similar, until mid-December, after which the lake temperatures remain at 3-4°C. The dual nature of the water system for Auke Creek Hatchery permitted changing between surface and subsurface water in order to take advantage of whichever source was the higher temperature. It is also possible to mix the sources of influent water to reduce the surface water temperature. During the 1987-88 rearing season, the surface water was used from August through October, the subsurface lake source was used from October through mid-April and surface water was used thereafter.

The 1987-brood adults were tested for IHN and BKD prevalence. Only 2 of 86 females tested positive for IHN virus, 2.3%. Since the prevalence and titers of IHN virus were extremely low, the eggs from the positive fish were not destroyed. None of the 60 fish sampled for BKD tested positive.

The resulting fry were placed in rearing tanks in mid to late December, depending upon the date of spawning. Approximately 25,000 fry were reared in each of 6 tanks, 1.8 x 1.8 x 0.8 m, which held an estimated 2.5 m^3. The fish were fed several times daily by automatic feeders. Feed rations were those recommended by the food manufacturer, and generally ranged from 2 to 4% of fish body weight/day. I attempted to simulate a natural photoperiod in the hatchery by conducting daily activities where florescent lights were used only during normal daylight hours. Biweekly samples of 50 to 100 fish were individually weighed and measured throughout the rearing period. Mean sizes and growth rates are presented in Table 2.

The experimental design for 1987-brood allowed for four groups of juvenile fish, each of which received different rearing experiences before release. The four treatment groups were: 1) May lake plant of fed fry, 2) freshwater reared age-0 smolts, 3) seawater reared age-0 smolts, and 4) August lake plant of large juveniles. Each group was distinctively marked before release.

All 1987-brood sockeye salmon juveniles regardless of treatment group, were marked by feeding a diet containing OTC. Feeding the OTC treated diet began April 22 when mean fish size was 0.85 gm, and 44 mm and continued for 10 days. Mean size at the end of feeding the OTC diet was 1.1 gm, 47 mm, and water temperature during marking ranged from 6-8°C (Fig. 1). The freshwater and seawater reared groups of age-0 smolts and the August lake plant group were marked by adipose fin excision and tagged with group-specific coded-wire tags.

All groups were released in 1988, at different population numbers and fish size. Approximately 100,000 fry in the May lake plant group were reared entirely in freshwater and released in Auke Lake on May 6. These fish averaged 1.2 gm and 47 mm at release. A total of 16,400 freshwater-reared age-0 smolts were reared entirely in freshwater. These fish were released in Auke Creek downstream from the fish counting weir on June 20. The freshwater reared age-0 smolts averaged 4.4 gm and 75 mm at release. A total of 20,000 seawater reared age-0 smolts were transferred from freshwater tanks to seawater net pens in Auke Bay on May 31, 1988, at which time the fish averaged 2.2 gm and 60 mm. Salinities in the net pens ranged from 10-15 °/‥ at the surface and 15-20 °/‥ at 4-m during rearing. The seawater-reared age-0 smolts were released in Auke Bay on June 20, at which time they averaged 6.2 gm and 84 mm (Fig. 3). There were no mortalities in the 21 days of netpen culture before release. The August lake plant group were released in Auke Lake on August 1. There were about 5,000 fish in that group and they averaged 12.7 gm and 105 mm.

The 1987-brood juveniles were tested to determine their ability to tolerate seawater. Beginning in late March and continuing at weekly or biweekly intervals through June, small lots of juveniles were exposed to different concentrations of seawater, 21, 24, 26 28 and 30 °/‥, for 96 h. Mortalities were removed and recorded daily. Total mortality after 96 h was expressed as a percentage of the original number of fish exposed to each concentration of seawater. Seawater tolerance increased (mortality decreased) over time as the fish increased in size (Fig. 4). By May 2, the fish averaged 1.1 g, 47 mm, and experienced no mortalities in salinities of 26°/‥ or less. There was no mortality in 28°/‥ salinity after mid-May, average fish size 1.5 g, 54 mm. Mortality in 30°/‥ salinity continued at 10 to 28% during May, but decreased to no deaths by mid-June, average fish size 3.3 g, 70 mm.

SUMMARY AND CONCLUSION

Enhancement projects with 1986- and 1987-brood sockeye salmon at Auke Creek achieved the objectives of each study. Incubation and rearing of the 1986-brood provided new data related to sockeye salmon culture. First, incubation and rearing in filtered, ultraviolet-treated water and stringent disease control measures in the hatchery prevented any disease problems. This occurred even though IHN virus was present in extremely high quantities in the parent broodstock. Second, juvenile fish at a mean size of 0.4 g, 36 mm, were successfully marked with OTC, and the mark was present in the smolts one year later. Third, lake stocked juveniles migrated as age-1 smolts at the same time and similar size as wild smolts of the same age, and contributed significantly to the total smolt migration at Auke Creek. Fourth, initial tests with age-0 smolt rearing indicated juvenile sockeye salmon could tolerate moderate salinities and experience significant growth.

Incubation and rearing of the 1987-brood contributed significant information related to sockeye salmon culture. First, egg incubation could be adequately accelerated by using surface creek water instead of cooler subsurface lake water. This resulted in a 10-week earlier initial feeding of 1987-brood fry, as compared to 1986-brood fry. The dual water system at Auke Creek Hatchery allowed incubation and rearing in whichever water source was the highest temperature. Second, tests of juveniles indicated that fish as small as 1.1 g, 47 mm, could tolerate salinities up to 26°/... Third, feeding and consistent growth during the winter period resulted in fry attaining the mean size of age-1 wild smolts within the normal migration time of wild fish. Fourth, the results of tests with the Auke Creek stock indicates it is feasible to produce age-0 smolts from a wild stock in which age-0 smolts do not naturally occur.

In conclusion, the enhancement studies at Auke Creek have revealed important information related to the culture of age-0 smolts. Sockeye salmon eggs obtained from a brood stock with a high prevalence of IHN virus can be successfully reared to the age-0 smolt stage, if filtered, ultraviolet-treated water are used and good fish culture practices observed. Incubation and rearing at higher water temperatures will accelerate development and growth beyond that observed in the wild fish. Growth during the winter and spring periods results in hatchery-reared fish attaining smolt size 10 months after spawning, compared to 21-22 months for age-1 wild fish. Salinity-tolerance tests revealed that juveniles can osmoregulate in moderate salinities at the 1.0-1.5 g size. The use of the Auke Creek stock of sockeye salmon for enhancement studies revealed that it is possible to produce age-0 smolts from a stock that does not naturally produce fish of that age.

Future work on sockeye salmon at Auke Creek include continued evaluation of projects using 1986 and 1987-broods and enhancement studies on age-0 smolts. Freshwater survival, migration timing, and size of juvenile sockeye stocked in Auke Lake will be determined in 1989. Tests with 1988-brood sockeye salmon will be conducted to determine the best timing to begin seawater rearing of juveniles. Marine survival from smolt to adult will be determined for wild and hatchery-reared groups of the Auke Creek sockeye salmon stock.

Table 1. Mean size, grams, growth rates and percent per day of 1986-brood sockeye salmon in freshwater at Auke Creek Hatchery and in seawater in Auke Bay including events in culture history of those fish.

Date	Size gm	Rate %/day	Rearing event
Feb 27	0.17	--	Initial feeding
Mar 31	0.22	0.85	
Apr 21	0.32	1.69	
May 5	0.44	2.27	OTC feeding (May 5-19)
May 20	0.66	2.74	Lake release of fry
June 2	0.97	2.95	
June 16	1.71	4.07	
June 29	2.47	2.83	Transfer to seawater pen
July 24	6.00	3.50	Age-0 smolt release

Table 2. Mean size, grams, growth rates and percent per day of 1987-brood sockeye salmon in freshwater at Auke Creek Hatchery and seawater in Auke Bay, including important events in culture history of those fish.

Date	Size gm	Rate %/day	Size gm	Rate %/day	Rearing event
Dec 17	0.18	--			Initial feeding
Jan 13	0.21	0.56			
Feb 3	0.27	1.21			
Feb 16	0.32	1.43			
Feb 29	0.41	1.78			
Mar 14	0.47	1.11			
Mar 28	0.59	1.60			
Apr 4	0.64	1.17			
Apr 22	0.85	1.58			OTC feeding begins
May 2	1.12	2.76			OTC feeding begins
May 12	1.35	1.87			Lake release (May 6)
May 31	2.16	2.47	2.16	--	Seawater pen transfer
June 6	2.66	3.47	2.91	4.97	
June 13	3.34	3.25	3.96	4.40	
June 20	4.42	4.00	6.17	6.34	Age-0 smolt release

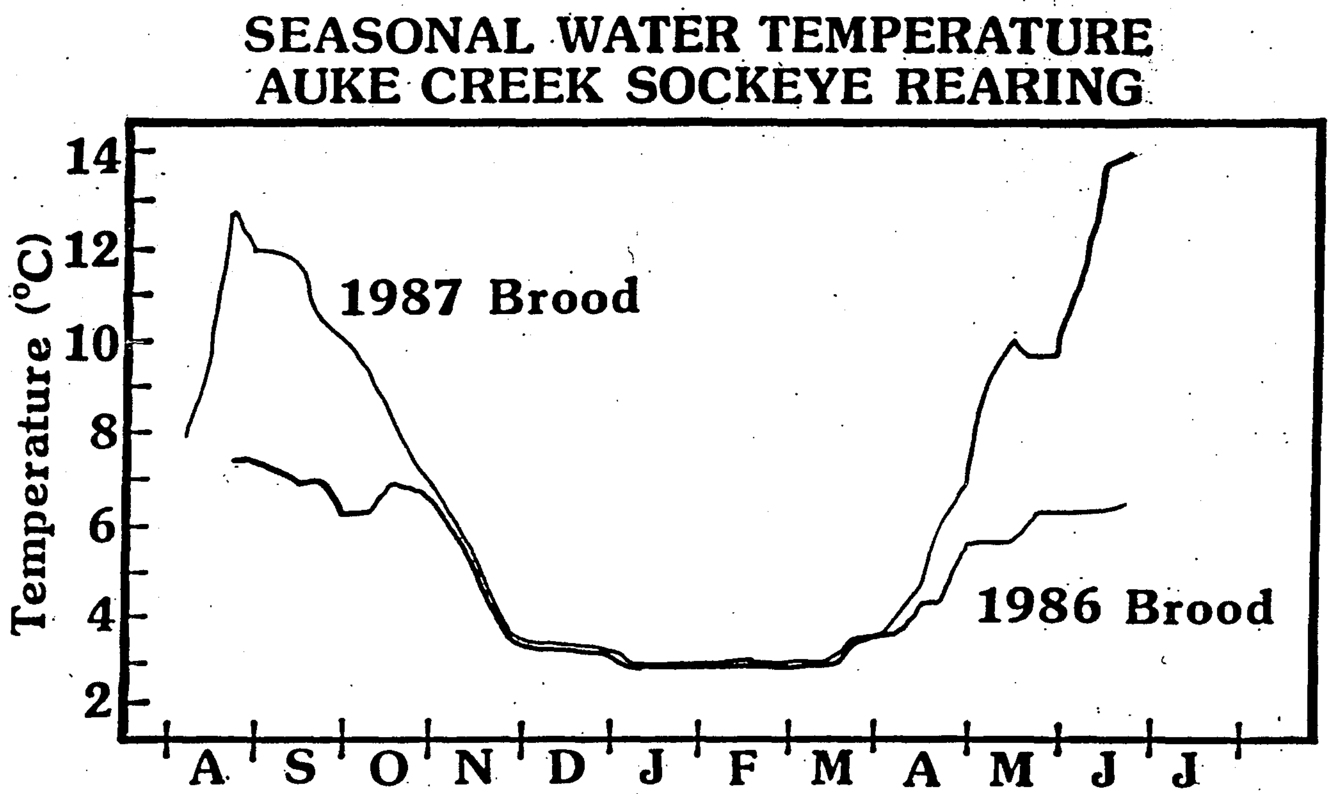

Figure 1. Seasonal water temperatures at Auke Creek Hatchery during rearing of 1986- and 1987-brood sockeye salmon.

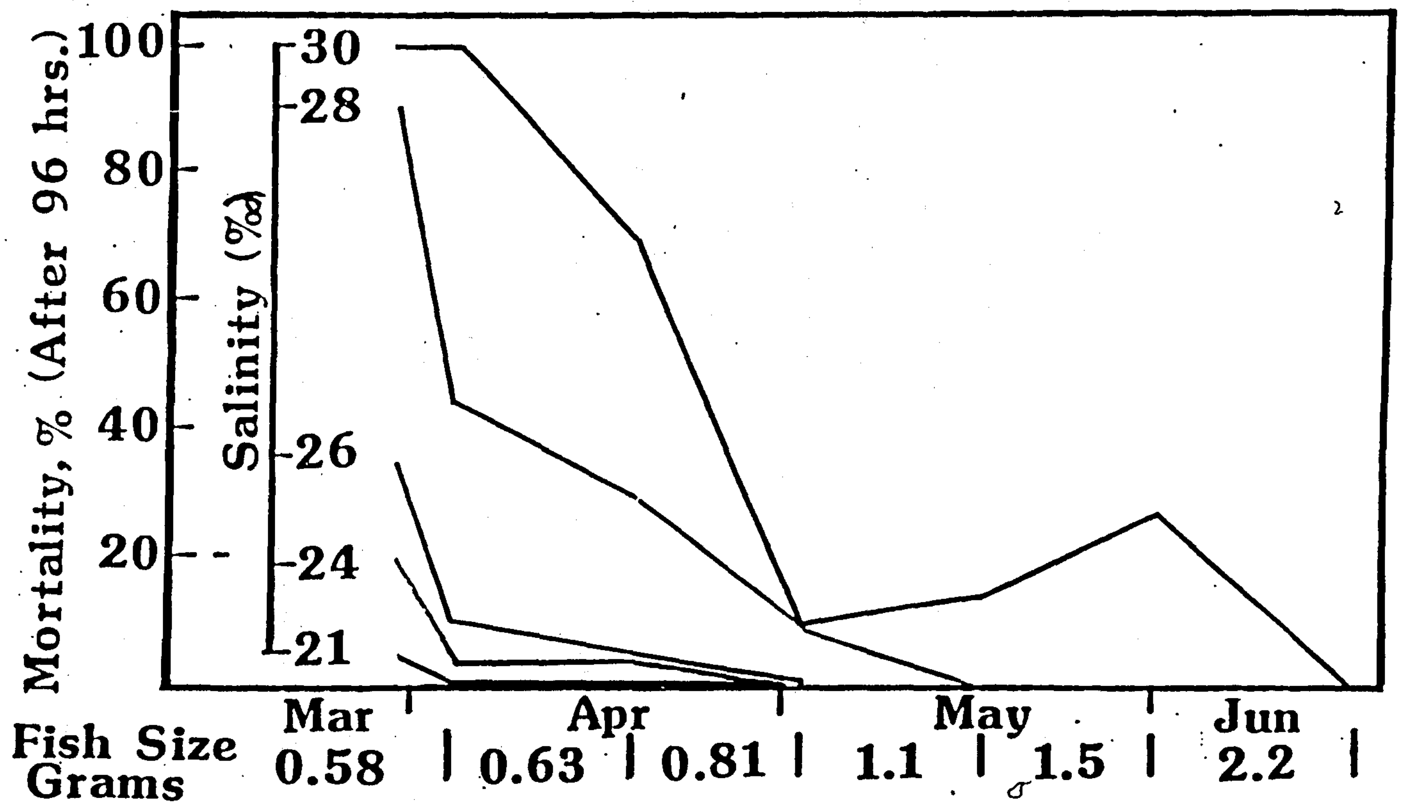

Figure 4. Mortality of sockeye salmon after exposure to different concentrations of seawater for 96 hr. Mean fish sizes at each exposure precede the short vertical bars beneath the x-axis.

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MR. TAYLOR: Are there any questions?

QUESTION: On your salinity test, you didn't follow up on it to see how long it took them to go on feed, the ones that survived, how long it took them to go out and feed, and if they lost any weight or if they went for a tailspin, how much time it took them to recover from that?

MR. TAYLOR: There is some stuff going on with the physiology department here at the lab. I'm not too familiar with it. I know they're looking at it. I can tell you I took my fish from freshwater at the hatchery, five minutes, skipped right over to the net pen and just dunk them right in, and they were eating later that day.

It didn't seem to phase them at all. They went from freshwater right to salinity and just never stopped.

BRITISH COLUMBIA

SOCKEYE PROGRAM

by

DAVE HARDING

Historically, hatchery production of sockeye salmon in British Columbia dates from the 1880's. The early hatchery program was terminated in the late 1930's due in large part to expected increases in adult production not occuring that could be attributed to the hatchery program. At the peak there were 17 hatcheries operating some of which had capacities approaching 50 million eggs. Although most of these facilities were incubation only, some rearing was done. Eyed-egg plants were frequently made. Early records are incomplete but large losses occured and there is anecdotal information on disease outbreaks, some with IHNV-like symptoms.

From the end of this early phase to the end of the Second World War there was no artificial production of sockeye and no facilities were constructed until 1960. Some experimental and small rehabilitational work was done in this period.

In the 'sixties the I.P.S.F.C. constructed 2 spawning channels and 1 incubation facility for sockeye. The Upper Pitt site operated as a normal hatchery for 2 years before being modified to an eyeing station and upwelling incubation ponds. Also in the 'sixties federal Fisheries built and operated a sockeye hatchery and incubation channel and initated the Babine Lake Development Project which reached full production in the 'seventies. The hatchery and incubation channel were closed after the 1965 season. IPSFC constructed a third spawning channel for sockeye in the early 'seventies. In 1985 IPSFC facilities were turned over to federal Fisheries which now operates them along with the BLDP.

New projects include sidechannel development and low maintenance spawning channels. Also experimental rearing has been carried out at Upper Pitt for 2 years and some form of experimental rearing will probably be carried out in the coming year. In addition 3 million eggs will be taken at the Shuswap Falls Hatchery, of which 2 million will be reared to double their emergent size and released.

The facility at Pitt was in need of rehabilitation, so we decided it was a good time to look at alternatives to the trough and basket incubation there. The 1986 brood eggs were incubated experimentally in Heath trays and in modified Atkins cells where the eggs were layered in the media. Heath tray fry were smaller and emerged earlier, but there was no difference between Atkins cell fry or those incubated in the usual upwelling ponds. At emergence fry were placed in intermediate rearing troughs and reared to 2.5 g when they were moved into 3 metre diameter circular tubs. A release was made at this time (late July) and one a month earlier. Another release was made in early October at 7.5 g and the remainder were released on April 24,1988 at 18.6 g.

The 1986 brood grew well, fed voraciously even at low temperatures and suffered very little mortality. During the spring, though, some fish developed gill problems.

The 1987 brood was incubated in modified Atkins cells, in some of which eggs were layered in the media while in others the eggs were placed in a layer on top. Different densities were tried as well but no treatment effects were observed. Survival to hatch was less in this brood and growth so far has been slower. Mortalities during rearing have also been higher due to gill irritation probably from the higher level of suspended solids in the water supply than encountered with the first brood.

So far this stock has been free of disease except for some secondary gill infection. Adults and juveniles are monitored for pathogens including IHNV but so far are negative for this virus. Naturally spawning adults at death have not been tested to date for presence but that will be done this fall.

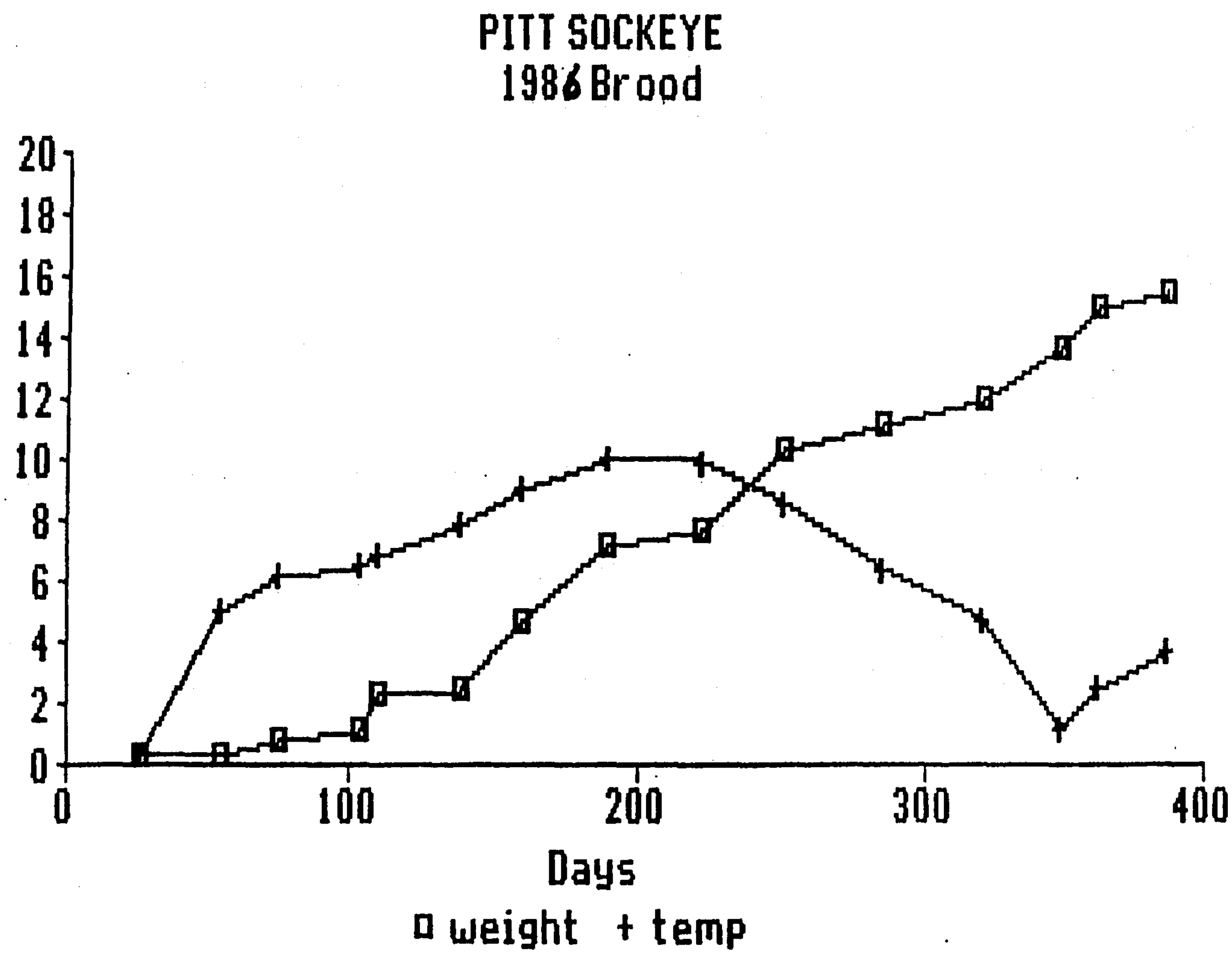
PITT SOCKEYE 1986 BROOD ! REARING UNIT TYPE(1) IRT#3
JUVENILE INVENTORY ! TYPE(2) CT#1

DATE	PERIOD MORTS	TRANS /REL (+/-)	BALNC LIVE	MEAN WEIGHT (G)	MEAN TEMP (C)	FOOD %BDWT /DAY	GROW %BDWT /DAY	FOOD CONV	MORT /DAY %	LOAD RATE KG /LPM	DENS KG/M3	COMMENTS
870404		67600	67600	.25	5.0				0.00%	.09	7.35	
870430	80		67520	.35	6.1	2.16%	1.30%	1.41	.00%	.12	10.27	
870528	268		67252	.78	6.5	5.47%	2.90%	1.26	.01%	.27	22.81	
870618	439		66813	1.15	6.9	4.76%	1.87%	2.15	.03%	.40	33.41	
	(787)	-29286	37527	1.15	6.7					.22	18.76	
870716	335		37192	2.39	7.8	5.17%	2.65%	1.37	.03%	.46	38.65	
870722	5		37187	2.55	9.0	2.67%	1.09%	2.40	.00%	.49	41.23	
	(340)	-17187	20000	2.55	9.4					.27	7.61	
870820	14		19986	4.74	10.0	4.19%	2.16%	1.42	.00%	.49	14.14	
870910	6		19980	7.1	9.8	3.48%	1.96%	1.46	.00%	.74	21.23	
871010	20		19960	7.7	8.5	1.89%	.26%	7.06	.00%	.80	22.94	
	(40)	-9945	10015	7.5	7.2					.39	11.24	
871112	14		10001	10.3	6.4	1.30%	.95%	1.18	.00%	.53	15.31	
871211	9		9992	11.1	4.6	.69%	.27%	2.47	.00%	.58	16.55	
880114	9		9983	12.0	1.2	.29%	.23%	1.21	.00%	.62	17.89	
880219	26		9957	13.7	2.5	.49%	.36%	1.32	.01%	.71	20.30	200% RTN
880317	29		9928	15.0	3.6	.40%	.35%	1.14	.01%	.78	22.23	EVERY
880331	44		9884	15.5	3.6	.41%	.23%	2.07	.03%	.80	22.84	2ND DAY
	(131)	-1750	8134	15.5	3.9					.66	18.79	′′
880425	202	-8	7924	18.6	4.4	.56%	.73%	.84	.10%	.77	21.94	′′
	(202)	-7924	0	18.6	5.0							

PITT SOCKEYE 1987 BROOD ! REARING UNIT TYPE(1) IRT#1

JUVENILE INVENTORY ! TYPE(2) CT#1

DATE	PERIOD MORTS	TRANS /REL (+/-)	BALANC LIVE	MEAN WEIGH (G)	MEAN TEMP (C)	FOOD %BDWT /DAY	GROW %BDWT /DAY	FOOD CONV	MORT /DAY %	LOAD RATE KG/LPM	DENS KG/M3	COMMENTS
880405		100000	100000	.21	3.9				0.00%	.11	9.13	
880418	165		99835	.23	5.0	2.90%	.84%	3.36	.01%	.12	10.16	
880428	46		99789	.26	5.0	3.10%	1.10%	2.70	.00%	.14	11.32	
880506	49		99740	.28	6.1	2.98%	.66%	4.48	.01%	.14	11.93	
880512	96		99644	.30	6.7	3.10%	1.23%	2.47	.02%	.15	12.82	
880519	585		99059	.31	6.7	3.22%	.80%	4.40	.08%	.16	13.48	P-H MORTS
880526	1231		97828	.36	6.7	3.14%	1.86%	1.79	.18%	.18	15.14	'
880602	897		96931	.45	6.7	3.42%	3.40%	.95	.13%	.23	18.96	'
880702	(3069)	-71931	25000	.81	7.2		1.98%			.11	3.02	GILLS



PITT SOCKEYE
1986 Brood
20
18
16
14
12
10
8
6
4
2
0
0
100
200
300
400
Days
weight
+ temp

QUESTION: The highest density you got up to at the Pitt Sockeye Hatchery was 41 or 42kg/m^3?

MR. HARDING: Yes.

QUESTION: At that point in time, you guys felt that the density was too much and you'd better knock them down?

MR. HARDING: Yes, we saw that the growth curve flattened a little bit there.

Southern Southeast Regional Aquaculture Association Sockeye - Bill Halloran

Bill went over the following paper entitled "Questions Regarding SSRAA's Sockeye Programs", they, much like Main Bay and Auke Bay are working with saltwater challenges and the time/size window for smolt releases. The SSRAA likewise found that 1.0 to 1.5g sockeye have no problems in handling saltwater. They are presently testing fish less than 1.0g.

The rearing is aided by the use of a heat exchanger built into their hatchery water system. By using warmer water, they were able to increase their 2.2g July release smolts (1986) to a 4.4.g June 6, 1988 release smolt and are hoping to make a 0-check fish out of a 1+ broodstock through the use of the warmer water.

Questions Regarding SSRAA's Sockeye Program

Sockeye salmon are economically the most important of the Pacific salmon. The fishing industry in S.E. Alaska developed on the harvest of sockeye, and by the 1920's nearly 2 million sockeye salmon were harvested annually. However, the recent ten year average harvest of sockeye salmon in S.E. Alaska has been only 638,000. When the Comprehensive Salmon Plan was developed in March of 1981, a goal was established to increase the annual harvest back to the 2 million level.

Lake fertilization and lake fry plants have shown some success in sockeye enhancement, especially in South Central Alaska. However, both of these techniques rely upon enhancing wild stocks. These procedures do not resolve the mixed stock harvest problem, and especially the problems of quotas imposed by the U.S./Canada Treaty. The best solution to harvesting more sockeye salmon is to enhance them into Alaska waters that minimize wild stock interception. One way to avoid the treaty quotas and wild stock management problems is to release sockeye fry in areas where sockeye do not naturally exist and can be harvested after they separate into terminal areas. This requires rearing sockeye in hatcheries and releasing them using techniques similar to SSRAA's chum salmon program.

In 1983, the SSRAA staff proposed a plan to develop a sockeye salmon broodstock, but the proposed plan was experimental and there was no similar rearing of sockeye that existed anywhere. The basic plan was to obtain eggs from an early returning wild broodstock, rear them in a hatchery environment free of disease, and release the fry as underyearling smolts in terminal areas for cost recovery, and commercial harvest. However, several key questions had to be resolved.

<u>Question 1</u>: Could sockeye salmon eggs be successfully collected from wild broodstock, incubated and reared in a hatchery environment?

<u>Answer</u>: The SSRAA staff has taken sockeye eggs from Karta River broodstock for three consecutive years. Gametes were collected separately, transported to the Beaver Falls Sockeye Facility, fertilized, incubated, and reared in tanks. All of these procedures used standard techniques used on other salmon species. No problems have been encountered. The answer is yes.

<u>Question 2</u>: Can sockeye fry be reared in a hatchery environment without catastrophic losses to IHN virus?

<u>Answer</u>: The scientific literature indicated that IHN disease could be prevented if the fry are reared in a water supply that do not contain fish with the IHN virus, and if the eggs are disinfected prior to placing them into the incubators. Silvis Lake has no history of having fish with IHN virus, and this is the water supply for the Beaver Falls Facility. The gametes

were collected from individual fish, and eggs were disinfected and incubated as single family units. Procedures were used to avoid cross contamination and strict sanitary precautions were taken. After 3 years of rearing sockeye fry at Beaver Falls, no IHN disease has been detected even though the parent broodstock had the virus. The answer is yes.

Question 3: Can sockeye fry be introduced into the marine environment and released as a underyearling smolt?

Answer: The scientific literature documents that there are natural systems where sockeye fry typically migrate to the ocean as underyearling smolts. The minimum size that sockeye could tolerate saltwater was unknown. No data existed on marine tolerance of sockeye fry smaller than 5 grams, even though outmigrating smolts were usually smaller than 5 grams. SSRAA conducted studies in 1984, that showed a 1 gram sockeye fry could tolerate the marine environment. A goal was established to introduce our sockeye fry into marine netpens at a 1.5 gram size and release them after attaining a minimum of 3 grams in size. SSRAA has successfully reared sockeye fry in marine netpens, and released as underyearling smolts. The answer is yes.

Question 4 : Can underyearling smolts be reared to a 3 to 4 gram size by early June?

Answer: Although sockeye were successfully reared in 1986, and 1987, the smolts were not released until July, and only in 1987 did the smolts reach the 3 gram size. The scientific literature indicates that wild sockeye smolts migrate to the ocean in mid-May to early June. Ocean survival is poor if fry are released in July or later. The problem at Beaver Falls and most other S.E. Alaska lakes is that the water temperature is very cool in the winter and early spring. Fish just do not reach the proper size for migration and that is why wild fish typically spend one year in a lake before migrating to the ocean. SSRAA installed a heat-exchanger at Beaver Falls in 1988, that used the deep marine water as a heat source to warm the freshwater. Using the heat-exchanger, sockeye fry reached the 1.5 gram size by mid-May and were released from marine netpens in early June at a 4.4 gram size. The answer is yes.

Question 5: Can returning adult sockeye broodstock be held in captivity and mature?

Answer: ADF&G has tried to hold sockeye adults in netpens in freshwater lakes until they matured, but they have not always been successful. Sockeye returning to Beaver Falls will have to be held for about 6 to 8 weeks in floating freshwater raceways before they can be spawned. High freshwater temperatures and the long holding period are expected to be poor conditions for maturing sockeye salmon. The heat-exchanger will be used to lower the freshwater temperature using the cooler deep saltwater. Tests are planned to accelerate the maturation process using photoperiod and gonadotroin injections. The results will not be known for at least one more year. Answer is unknown.

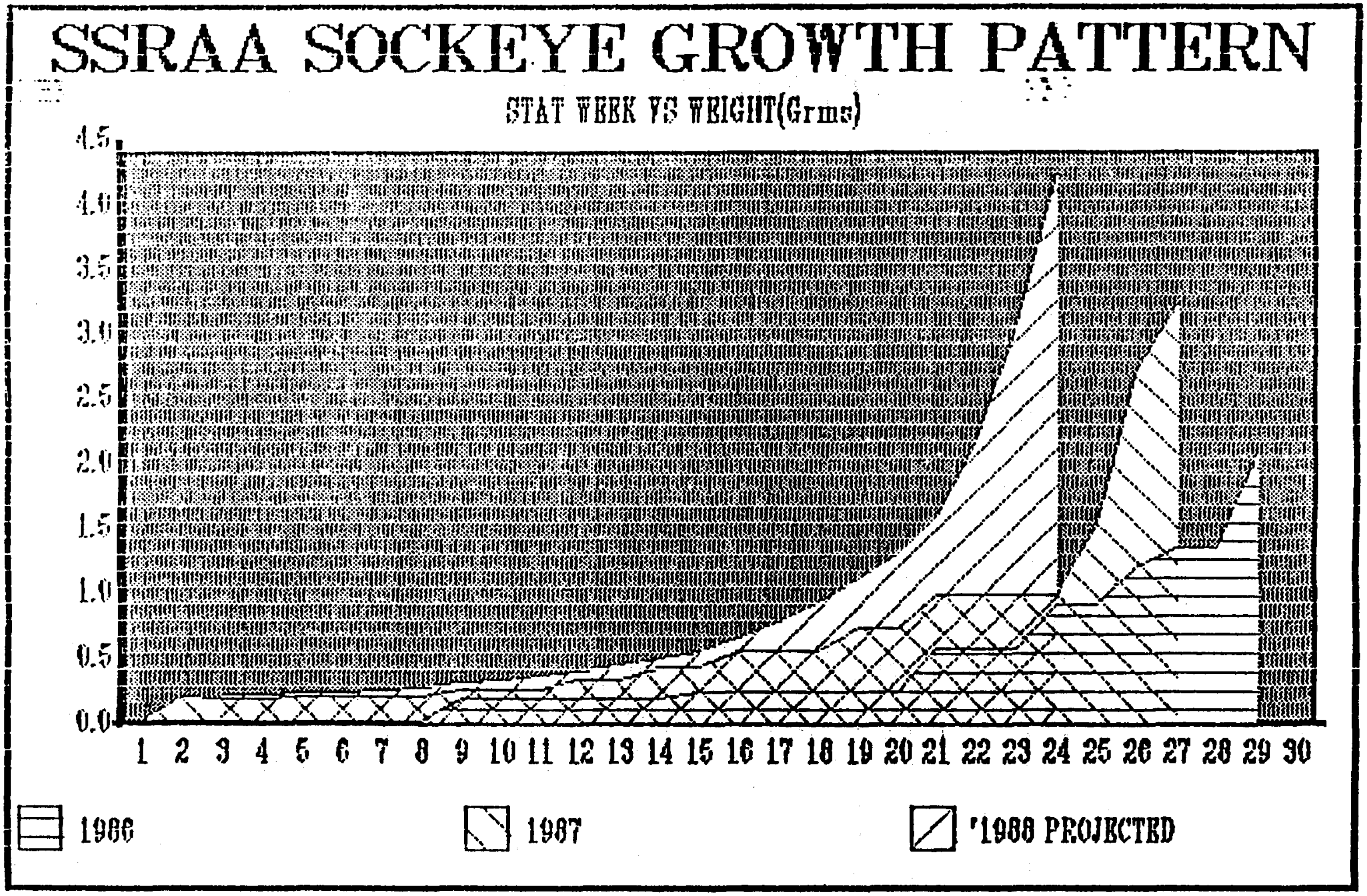
<u>Question 6</u>: What is the ocean survival rate of underyearling sockeye smolts?

<u>Answer</u>: Based upon lake stock planting by ADF&G, the ocean survival of sockeye has averaged about 12%. However, no information exists regarding underyearling smolts, but it is assumed that survival would be the same. SSRAA is using a more conservative 6% survival for planning purposes, but survival rates will not be known for another 3 to 5 years. Answer is unknown and will not be known for a few more years.

<u>Question 7</u>: Will the project be cost effective?

<u>Answer</u>: The Sockeye Development Plan is based upon a phased approach to reaching full production capacity. The research and development phase has been nearly completed, only the broodstock maturation question needs to be resolved. The next phase will be to increase the production at Beaver Falls to a 1 million capacity. The next phase will be to increase to a 5 million capacity at Shrimp Bay, with the ultimate goal of a 20 million egg facility at Shrimp Bay. Investment is planned according to the production goals, and according to answers to the above questions. If ocean survival rates average 6% or more, the project will pay for all costs by cost recovery, and still provide over $3.5 million annually to the common property fishery. The money most likely will have to be borrowed from the State Salmon Enhancement Loan Fund. The start-up operational costs will have to be subsidized by cost recovery, but a significant amount will be generated by cost recovery on sockeye salmon as the program develops. The actual cost effectiveness of the project will not be known until ocean survival rates are known, the operational costs developed, and the actual capital investment is identified. Answer is unknown.

CES/10/12


SSRAA SOCKEYE GROWTH PATTERN
STAT WEEK VS WEIGHT(Grms)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
1986
1987
'1988 PROJECTED

SSRAA SOCKEYE SALMON GROWTH PATTERN, 1986 - 1988 SEASONS
BEAVER FALLS FACILITY

DATE	STAT.WK	WEIGHT (gms) (* ACTUAL) 1986	1987	1988	1988 FW-EXP (@ DSG=2.5%)	1988 SW-EXP (@ DSG=5%)
1/6	2		0.19 *			
			0.19	0.22 *		
	4		0.19	0.22		
1/30			0.2 *	0.23 *		
	6		0.21	0.24		
			0.22	0.26		
	8		0.24	0.28		
2/25		0.19 *	0.26 *	0.3		
	10	0.2	0.28	0.33 *		
		0.21	0.31	0.36		
3/16	12	0.22	0.33 *	0.4		
		0.23	0.37	0.44		
3/31	14	0.24	0.41 *	0.49 HEAT EXCHANGER		
4/7		0.24 *	0.48	0.55 ON		
4/15	16	0.29	0.54 *		0.65	
		0.34	0.6		0.77 *(.78 predicted)	
	18	0.39	0.66		0.92	
5/5		0.44	0.72 *		1.23 *(1.1 PREDICTED)	
	20	0.5	0.85		1.5 MOVE TO SW	1.6
5/21		0.56 *	0.98 *			2.2
	22	0.67	1.1			3.1
		0.78	1.26			4.3
6/10	24	0.91 *	1.37			
6/16		1.05	1.52 *			
6/26	26	1.2	2.76			
6/30		1.35 *	3.26 *			
	28	1.73				
7/15		2.1 *				
	30					

QUESTION: When you had this 105% saturation, what kind of unit was it?

MR. HALLORAN: They were in a two meter circular tub.

QUESTION: Did you tag any of your fish?

MR. HALLORAN: Yes. We tagged at least 50 percent of them upon release, of the smolts. When the tagging was originally done the first year, we didn't have any IHN virus. We were looking for an IHN free broodstock, and so we were thinking that least when these fish come back, we will only spawn our tagged fish. We have since differentially tagged, some differential on titers, to see if there's any difference.

QUESTION: Your fish are on the way back, should be coming back this year?

MR. HALLORAN: Well, we could see some, but I think it's much more likely we'll see the first group come back next year (1989).

QUESTION: So you'll have some two-ocean check to zero checks coming back?

MR. HALLORAN: Predominantly zero three's? We'd love to see that first salmon, but I really don't think we're going to see any until next year.

Also that first year, being so late and the fish so small, that's not really the product that we were going for.

A VOICE: Zero check sockeyes are going out now in July.

MR. HALLORAN: What size are those?

A VOICE: They're 50 millimeter, two grams or so.

MR. HALLORAN: Maybe we will be surprised at our returns.

MR. AMEND: I think we've got a good shot now of maybe six gram plus by some time in May, maybe the 1st of June, if we can have the benefit of warmer water in November instead of late March, and get that benefit through the winter, there's an opportunity there to really get out some nice size smolts.

Like I say that heat exchanger, I think I was perhaps the only one on the staff that was optimistic that it was going to work, but I'm an eternal optimist anyhow, so they have to always dampen me down a little bit, but I think all of us, including myself, that thing exceeded I think everybody's expectations in how well it worked.

MR. HALLORAN: If anybody is interested in some more details on the rearing or the heat exchanger itself, the paper provides this.

A VOICE: Did you share the capital cost and the maintenance cost for that heat exchanger?

MR. HALLORAN: We got a grant for the heat exchanger, and it's about $175,000 to build the pipeline and the heat exchanger, and pipe out to saltwater. The saltwater is pumped up to the heat exchanger which is on land. So far it looks like the maintenance costs are going to be almost nothing. We ran it for two months and there was no maintenance costs. It's very easy to take care of.

QUESTION: There is an electrical cost?

MR. HALLORAN: Right. Now that's about 800 dollars a month.

A VOICE: What kind of volume are you looking at?

MR. HALLORAN: I think the pump pumps about a thousand gallons a minute?

MR. AMEND: The heat exchanger, for the number of plates we have in it now, is at maximum capacity, a thousand gallons a minute, but it's expandable.

MR. HALLORAN: It looks almost identical to the two that are up at Fort Richardson, just much smaller.

MR. AMEND: It's very simple, there's no moving parts.

SOCKEYE WORKSHOP ATTENDEES
JULY 12-13, 1988
KETCHIKAN, ALASKA

Samuel Bertoni	ADF&G/FRED	Juneau
Tim Zadina	ADF&G/FRED	Ketchikan
Forest Parsley	ADF&G/FRED	Ketchikan
Harold Heinkel	ADF&G/FRED	Juneau
Roger R. Saft	ADF&G/FRED	Anchorage
David C. Waite	ADF&G/FRED	Homer
Steve Reifenstuhl	Northern Southeast Regional Aquaculture Assoc. (NSRAA)	Sitka
Jeff Short	National Marine Fisheries Service (NMFS)	Auke Bay
Steve Leask	Tamgass Hatchery	Metlakatla
Terry Ellison	ADF&G/FRED	Anchorage
Clayton Brown	ADF&G/FRED	Russell Creek
Ted Meyers	ADF&G/FRED	Juneau
Jerry Taylor	NMFS	Auke Bay
Jim Cochran	ADF&G/FRED	Douglas
Brian Allee	ADF&G/FRED	Juneau
Chris L. Clevenger	ADF&G/FRED	Big Lake
Bob Chlupach	ADF&G/FRED	Big Lake
Lorne White	ADF&G/FRED	Kodiak
Rod Neterer	Southern Southeast Regional Aquaculture Assoc. (SSRA)	Ketchikan
Carol Coyle	ADF&G/FRED	Douglas
Dave Harding	SEP Enhancement Operations	Vancouver, B.C.
Bob Zorich	ADF&G/FRED	Petersburg
Paul Novak	ADF&G/FRED	Ketchikan
Robert Davis	ADF&G/FRED	Anchorage
John McNair	ADF&G/FRED	Juneau
Ken Leon	ADF&G/FRED	Douglas
Carol Denton	ADF&G/FRED	Ketchikan
Larry Peltz	ADF&G/FRED	Cordova
Mike Haddix	ADF&G/FRED	Ketchikan
Dan Rosenberg	ADF&G/FRED	Klawock
Michelle Leitz	SSRAA	Ketchikan
Ron Josephson	ADF&G/FRED	Douglas
Dave Bright	ADF&G/FRED	Ketchikan
Bill Halloran	SSRAA	Ketchikan
Tom Flagg	NMFS	Manchester, WA
Lee Harrell	NMFS	Manchester, WA
Scott McPherson	ADF&G/Commercial Fisheries	Douglas
Don Amend	SSRAA	Ketchikan
Steve Hansen	ADF&G/FRED	Klawock
Mark Tollfeldt	SSRAA	Ketchikan