Exxon Valdez Oil Spill
Restoration Project Final Report

Port Graham Pink Salmon Project

Restoration Project 99225
Final Report

This final report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project results.

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Restoration Project 00225
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Study History: The project effort was initiated under Restoration Project 96225. This is the fifth and final year of a scheduled five-year project.

Abstract: This project helped to supply pink salmon (*Oncorhynchus gorbuscha*) for subsistence use in the Port Graham area during the broodstock development phase of the Port Graham hatchery. Because local runs of coho and sockeye salmon, which are the more traditional salmon subsistence resource, are at low levels, pink salmon were more heavily relied on for subsistence. This project helped ensure that pink salmon remained available for subsistence use until the more traditional species were rejuvenated. By increasing the fry to adult survival of Port Graham hatchery pink salmon during the hatchery's broodstock development phase, more pink salmon were available for subsistence use. Two primary methods were used with the first being to increase marine survival of hatchery fish, i.e., the number of hatchery released fry that return as adults, and the other being to increase the utilization of the adult return through increased monitoring. The principal method being applied to increase marine survival is to increase the size of the fry prior to release into the wild. Rearing the fry to at least .75 grams and preferably 1.0 gram before releasing them can significantly improve marine survival. The hatchery released 6.05 million pink salmon in 1996 in two different groups which returned as adults in July and August of 1997. About 205,000, or 3.3%, of the 6.2 million fingerling released in 1996 survived to return as adults in 1997. This was the highest overall marine survival rate for pink salmon as well as the largest adult return to the hatchery to date. In 1997 about 920,000 fry emerged from the incubators. The production group of 900,000 reached an average weight of 1.0 gram while the 18,000 experimental accelerated pinks reached 1.4 grams. Both groups were released on June 9. All of the accelerated pinks were marked with an adipose fin clip and a coded wire tag. An estimated total of 20,471 adult pinks returned to the hatchery in 1998. This equates to a 2.3 % marine survival. The 1998 escapement up the Port Graham River was 12,559 pinks and 5,092 chums (coho were not counted). The CWT tag data indicate that the accelerated pinks experienced nearly twice the level of marine survival of the normal production group. Due to a fire in January of 1998, which destroyed all of the hatchery pink and sockeye salmon, there were no hatchery adult pink returns in 1999. Approximately 70,000 adult pinks returned in 2000, which is only 1.52% of the 4,617,362 released. While this years return was disappointing, the pink returns in most of South Central Alaska and many other areas of the state were very low this year which suggests large scale open water mechanisms were involved. The additional stream surveys, which was the second strategy for maximizing use of the adult return through increased monitoring, went quite well in FY 98 & FY99. This resulted in providing the local Alaska Department of Fish & Game (ADF&G) fisheries manager with additional information with which he was able to allow more subsistence and broodstock harvesting opportunities without jeopardizing the wild escapement.

Key Words: *Exxon Valdez*, pink salmon, broodstock development, Port Graham, subsistence, marine survival, coded wire tagging, otolith marking.

Project Data:

1. Description of data
   The project data is primarily growth rates expressed as millimeters in length per Temperature Unit (mm/TU) and percent body weight per day (%BW/day); marine survival; condition factor (length/wt3); conversion rates (kg feed/kg flesh gained) as well as overall comparative performance of accelerated groups vs. non accelerated groups.
2. Format of data
   Excel spread sheets, Figures and data analysis table, and text files
3. Custodian
   The Port Graham Hatchery Office has all of the project data most of which is on the hatchery computer with digital back up and hardcopies in file folders.
4. Availability
   The data and reports from this project are available for anyone that requests a copy and should be requested either as summarized or complete information.

Citation: P. McCollum. 2001. Port Graham pink salmon project, *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 00225), Port Graham Village Council, Port Graham, Alaska.

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Executive Summary

This project helped underwrite the hatchery production of pink salmon for subsistence use in Port Graham. Normally pink salmon are not heavily utilized for subsistence. However, the local coho and sockeye runs had been very depressed and are just now beginning to respond to rehabilitation efforts. The coho subsistence harvest has been about 15% of its historic level. This resulted in more subsistence pressure on pink salmon at a time when the hatchery is building broodstock and needs to utilize as many of the returning adults as possible for hatchery spawning. The goal of this project has been to increase subsistence-gathering opportunities for the Port Graham and Nanwalek villages by increasing the fry to adult survival of Port Graham hatchery pink salmon during the hatchery's broodstock development phase. Two strategies were applied to help mitigate this problem. One is an attempt to increase marine survival of hatchery fish, i.e., the number of hatchery released fry that return as adults, and the other is maximizing the utilization of the adult pink returns through increased monitoring.

The principal strategy has been to increase marine survival is to increase the size of the fry prior to release into the wild. Port Graham Hatchery pink salmon fry emerge from the incubators weighing about 0.23 grams on average. It was hypothesized that rearing the fry to at least .75 grams and preferably 1.0 grams before releasing them in early June can significantly improve marine survival.

In 1993 and 1994 the hatchery experimented with growing a batch of pink salmon fry to eight grams before releasing them into the wild. Eight grams was chosen because that is the approximate size that juvenile pinks are believed to leave the near shore area. It was thought, that by enhancing survival through the near shore period, the survival to the adult stage should be greatly increased. Preliminary results looked promising as marine survival of fish reared to the eight gram size before release exceeded 10% compared to the approximately 1% survival to adult that the hatchery was getting from fry that were reared only a short time prior to release. (Daisy, personal communicated on June 1999) Because of this success it was decided to make producing 8 gram pink fingerling for release the main vehicle for enhancing survival.

An outbreak of a bacterial disease called vibriosis in the group of fish being reared to the 8 gram size curtailed that effort and caused the project to forgo this procedure in the future. Instead, it was decided to produce pink salmon fingerlings in the .75 to 1.5 gram range for release in early June which is the preferred release timing and is also before water temperatures reach the warmer range (8-10°) where vibriosis is more likely to occur.

The hatchery program released 6.2 million pink salmon in 1996 in two different groups. The first group contained about 1.5 million fingerling. It was released into the major zooplankton bloom on May 23rd with an average weight of 0.5 grams. The second group contained about 4.5 million fingerlings. It was released on June 10 and had an average weight of 1 gram. None of these fish were tagged because the tagging equipment was not working properly.

Fingerlings released in 1996 returned as adults in July and August of 1997. An estimated 205,000 (3.3%) of the 6.2 million fingerling released in 1996 survived to return as adults in 1997. This was the highest overall marine survival rate for pink salmon as well as the largest

adult return to the hatchery to date. Although none of the fish in the 1997 adult return were marked, it seemed likely that the release of larger sized smolt by early June, was the main reason for the improved marine survivals.

In 1997 approximately 920,000 fry emerged from the incubators. The production group of 900,000 fry reached an average weight of 1.0 gram while the 18,000 experimental accelerated pinks reached 1.4 grams. Both groups were released on June 9. All of the accelerated pinks were marked with an adipose fin clip and a coded wire tag while a percentage of the production group was also tagged.

It appears that a .75 to 1.2 gram pink smolt is the practical growth limit for an early June release at Port Graham using accelerated incubation techniques. Releasing approximately 1 gram fingerlings during the first week of June, which is considered still within the optimum release window (approximately May 20th through June 10th) is expected to greatly enhance marine survival rates from the hatchery releases.

The availability of heated water allowed the hatchery to initiate an otolith-marking program in FY 98. Unfortunately the devastating cannery/hatchery fire in January of 1998 destroyed the hatchery and all of the pink and sockeye salmon and associated equipment. All of the 1997 brood pinks and sockeye eggs/alevin had been successfully marked with thermally induced otilith bands but were lost in the fire.

Additional stream surveys were the second strategy for maximizing efficient utilization of the adult returns through increased monitoring. Aerial and ground counts, as well as closer monitoring of pink salmon entering the Port Graham subdistrict were underwritten by this project. This resulted in providing the local Alaska Department of Fish & Game (ADF&G) fisheries manager with additional information with which he was able to allow more subsistence and broodstock harvesting opportunities without jeopardizing the wild stock escapements.

Introduction

The primary goal of this project has been to increase subsistence-gathering opportunities for the Port Graham and Nanwalek villages by increasing the fry to adult survival of Port Graham hatchery pink salmon during the hatchery's broodstock development phase. In order to achieve this goal and help mitigate the subsistence problems, strategies have been applied that are increasing the number of adults returning from hatchery released fry. The project also provides the local ADF&G fisheries manager with additional information which can be used to optimize management and decisions allow more harvest or broodstock collection opportunities without compromising the wild escapement goals.

In the past pink salmon fry emerging from the incubators were placed in saltwater rearing pens, put on feed and released during the first mature zooplankton bloom. The bloom normally occurs within two to three weeks after the fry emerge from the incubators. Using this approach the fry experienced only a 20% to 40% weight gain prior to release. The marine survival of pink salmon reared and released in Alaska in this manner often results in lower marine survivals.

In 1993 and again in 1994 the hatchery experimented with growing a small group of pink salmon fry to eight grams before releasing them into the wild. Although preliminary results looked promising, there were two main problems with this approach. The first being unacceptably high risk from mid to late summer exposure to temperatures conducive to vibriosis outbreaks and the second being the prohibitive costs of additional fish food. For these reasons this practice was discontinued.

It was then decided that rearing fry to 1+ gram size before release significantly improved marine survivals to adult. Although rearing fry to larger sizes is more expensive compared to shorter term rearing, the additional adults produced from this procedure would help allow the hatchery to maintain its broodstock development schedule and allow for a larger subsistence harvest. This approach is expected to produce more fish at a better cost/benefit ratio.

At the 1996 Hatchery Manager's Workshop several papers were presented by other pink salmon hatcheries in the state that were doing their own experiments with longer term rearing of pink fry to enhance survival to adults. Generally, it was found that rearing pinks to at least 0.5 grams was more important in enhancing survival than releasing into zooplankton blooms. The various tests that were conducted grew fry up to 1.5 grams before release with survivals increasing with the fish size upon release. Adult survivals averaged around 5% for the 0.5 gram fish to over 7% for fish grown to 1.5 grams before release.

To explore how the management of the Port Graham subdistricts fisheries could be improved to allow more fish to be harvested either for subsistence or hatchery broodstock a meeting was held with the local ADF&G fisheries manager. The department expends a relatively small portion of its resources in the subdistrict because of the low number of fish and minor fisheries that occur there. By doubling the number of stream surveys and adding an additional aerial survey of the subdistrict each week the manager felt he would have adequate information to maximize the harvest and still protect wild escapement. It was agreed that if funds could be found to pay for the additional surveys the manager would conduct them.

Objectives

Use the Port Graham hatchery to provide pink salmon for local subsistence use while maintaining the hatchery's pink salmon broodstock development schedule and continuing to work towards the best size and timing of released fish for achieving optimum returns.

Methods

Two strategies were employed to meet the objective. The first was to supplement the ADF&G monitoring of the Port Graham pink salmon return and the second was to enhance the marine survival of the hatchery produced pink salmon through an extended rearing program.

The Port Graham River pink salmon run is the source of the hatchery broodstock. A program was established to work closely with ADF&G in monitoring the pink salmon return to Port Graham each year in order to get as precise an estimate as possible on the wild and hatchery return. This project provided funds that increased the normal stream and bay surveys of Port Graham that ADF&G conducts. It included conducting additional stream and bay surveys as well as closely monitoring the subsistence fishery harvest. It also established a regular line of communications between Port Graham and ADF&G in order to coordinate the monitoring effort.

The other strategy of this project involved using an experimental accelerated incubation process for rearing pink salmon fry for more extended periods to increase their size at release. This method uses warmer water to slightly accelerate the development of the eggs and alevin so that all lots are ready for ponding into the salt water net pens by the first week of April which is three to four weeks earlier than usual.

Results

Of the 6.2 million pink smolt released in 1996, around 205,000, or 3.3%, survived to return as adults in 1997. This was the highest overall marine survival rate for pink salmon as well as the largest adult return to the hatchery to date. Although none of the fish in the 1997 adult return were marked it seems reasonable to assume that the release of larger sized fingerling was a major factor in the increased marine survival rate. The 1997 adult return was more than sufficient to meet subsistence needs and provide enough broodstock for a record egg take of 15 million eggs.

The experimental pinks reared in 1997 were placed on an accelerated growth program and were successfully ponded into the net pens on April 16th. Their overall growth was significantly better than the non accelerated groups. Of particular interest is that the period of over a month that these fish were held and fed in the indoor raceways with pumped saltwater, very little growth took place and for the first few weeks, it didn't look like these fish were feeding at all. At the end of the indoor phase, these fish were only about .03 grams and 3 millimeters larger than the non-accelerated groups. By being pre-acclimated to saltwater they did not have to spend precious energy converting the osmoregulatory process to salt water when they were placed ponded out into the saltwater net pens and being already balanced their osmoregulation and used to feeding, these fish immediately began aggressive feeding behavior within a day or two of being placed in the net pens. This "head start" is probably the key factor responsible for their significantly better pen reared growth response. The initial size difference is not really significant and these results seem to point out the extreme importance of how quickly pinks achieve osmoregulatory equilibrium as well as aggressive feeding behavior. While these fish were not significantly larger than their counterparts, they had been feeding for a couple of weeks prior to ponding in the saltwater net pens.

These preliminary results suggest that it may be possible to go ahead and pen up fish in the production pens about two weeks to a month early using heated water to accelerate their development and early exposure to sea water to accommodate early transition or osmoregulation to salt water. It is often very difficult to get any significant growth on pinks in early spring time temperatures of less than 4 degrees when they are first ponded. Preliminary results of this study however suggests that it might be appropriate to revisit this issue and try a couple of test pens using varying amounts and durations of adding heated water including a control with no heated water at all. This would demonstrate whether or not heated water was necessary which would of course be much more feasible to accomplish at production levels.

The following table presents the rearing and release data for the brood years 1996 through 1999 as well as the adult coded wire tag recovery data for the 1996 brood year.

Table #1: **Pink Salmon Rearing Data, 1996 through 1999:**

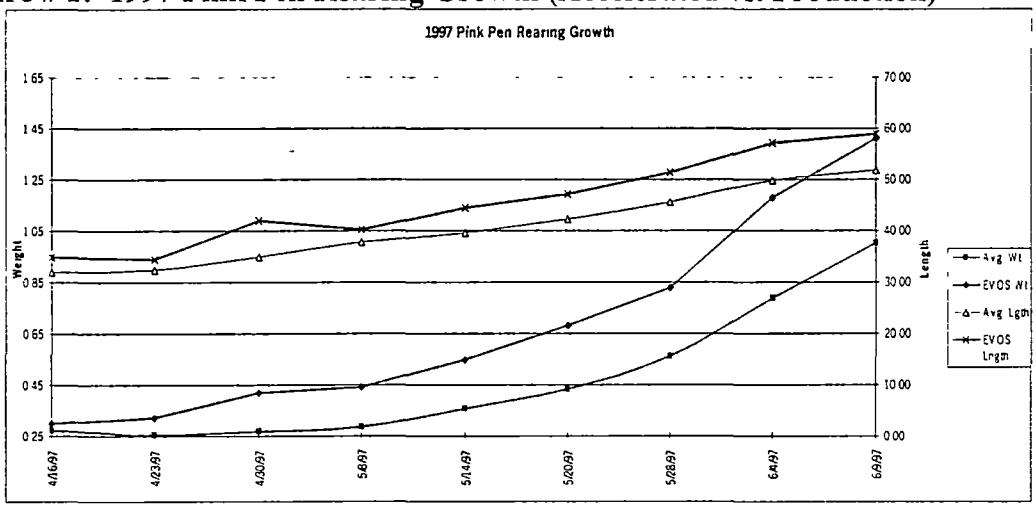
Brood Year:	1996p	1996a	1998p	1998a	1999
Size at Release	1.00	1.41	1.07	1.63	1.27
Date of Release	6-9-97	6-9-97	6-8-99	6-8-99	6-6-00
Number Released	909,527	18,353	3,605,765	1,011,597	1,148,187
Survival to Release	57%		58%		
Growth Rate (mm/TU)	.055	.067	.080	.088	.075
Growth % BW/Day	6.88%	9.98%	5.01%	6.85%	7.50%
Conversion	1.2	.69	1.2	.99	.95
Condition Factor	.00725	.00687	.00684	.00766	.00664
# Marked	6,911	9,986	3,605,765	1,011,597	1,148,187
% Marked	.77%	55.48%	100%	100%	100%
Adult Return Data					
# Scanned for Marks	3,688	3,688	0	0[1]	
# Marks	18	51			
% Marks	.49%	1.38%			
Est. Marine Survival	1.41%	2.77%			
Average Size (kg)	1.541	1.885			

A total of about 918,000 pink fry were reared in 1997 from 1996 brood fish. They were all released on June 9th. The rearing went extremely well with excellent growth resulting from warm temperatures and consistent feeding. Net Pen #'s 18 and 22 were the production pens totaling about 900,000 released with an average weight of 1.0 gram and an average length of 51.63 mm for a condition factor of .0073. The accelerated group of 18,000 fry grew much faster than non

[1] After preliminary information that a thermal mark was successfully applied, the follow up verifications at pre release revealed that the mark was too weak to be monitored at production levels and that excessive time would be needed to read the otiliths. This was due to equipment limitations due to the fire in January of 1998, which destroyed most of the hatcheries heat/thermal marking equipment.

accelerated fry and reached 1.41 grams at release. This appears to be due to the early acclimation to salt water and warrants additional testing and research.

Figure # 1: 1997 Pink Pen Rearing Growth (Accelerated vs. Production)

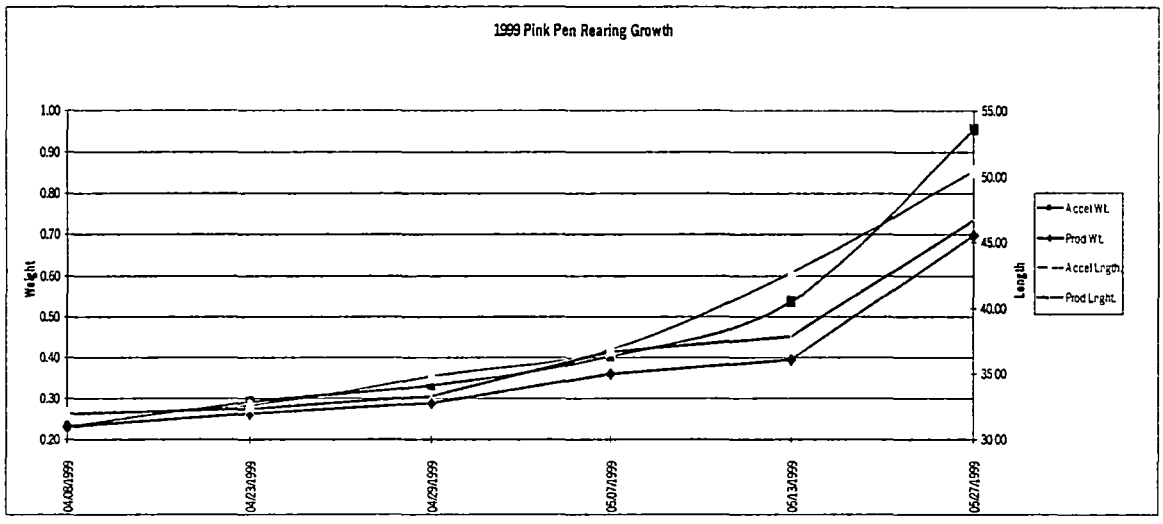


The preceding graph shows the dramatically improved growth achieved by the EVOS funded accelerated pinks compared to the regular production pinks for the 1996 brood fry reared and released in 1997.

For the 1996 brood pink release in 1997, the pens were towed out to the outer bay and released late in the evening to minimize predation. A total of 799 kilograms of feed was fed which produced a total biomass gain of 664 kilograms which equates to a conversion factor of 1.2. The initial rearing temperature started out at 5.0 degrees C and gradually increased to a maximum of 8 degrees by May 25th. The average rearing temperature was 6.58 degrees and the average growth rate was .055 mm/TU (length) and 5.01% BW/day. Tagging was conducted from May 30th to June 9th with 16,897 fish coded wire tagged (1.84%).

No rearing occurred in 1998 due to the fire. In 1999, at total of 4,617,362 pink fry/smolts were reared and released with 1,011,597 accelerated and 3,605,765 normal production reared. The differences in their respective growth can be seen in the following graph in figure # 2. Again the accelerated group performed significantly better than the normal production group. The different performance indices comparing the accelerated against the normal group were: .88 vs .80 mm/TU; 6.85% vs 5.01% body weight gained per day; and a .99 vs 1.2 conversion factor (kgs food fed per kg weight gained).

Figure # 2: 1999 Pink Pen Rearing Growth (Accelerated vs. Production)



For the 1998 brood pinks, reared and released in 1999, the total amount of feed fed was 1,111 kilograms which equates to a conversion (kilograms of feed per kilogram of flesh gain) of .95 which great for salt water net pen rearing with pinks. The average ration was 1.69% body weight per day. The average growth rates were 7.5% body weight per day and .073 millimeters per TU. The average temperature was 6.05 degrees C. The mortality was low (5,461) and averaged .008% per day. The pinks were in excellent shape at the time of release.

In the spring and early summer of 2000, the final year of this project, approximately 1.44 million 1999 brood pink salmon fry were reared, all of which where accelerated for early salt water acclimation. They were released on June 6th at high tide (7 p.m.) with a strong easterly wind blowing out the bay. The release size was 1.27 grams and 57.63 millimeters in length. A total of 1,142,726 pink smolts originating from the English Bay River stock were released on June 6th, 2000. They were reared a total of 56 days and gained 1,173 kilograms of total body weight (biomass).

During the adult pink return in 2000, which was this final year of the project, all of the available fish were used for brood and there was no cost recovery or commercial fishery on the hatchery pinks. An estimated 22,000 were not captured and ended up straying up the bay and into nearby streams.

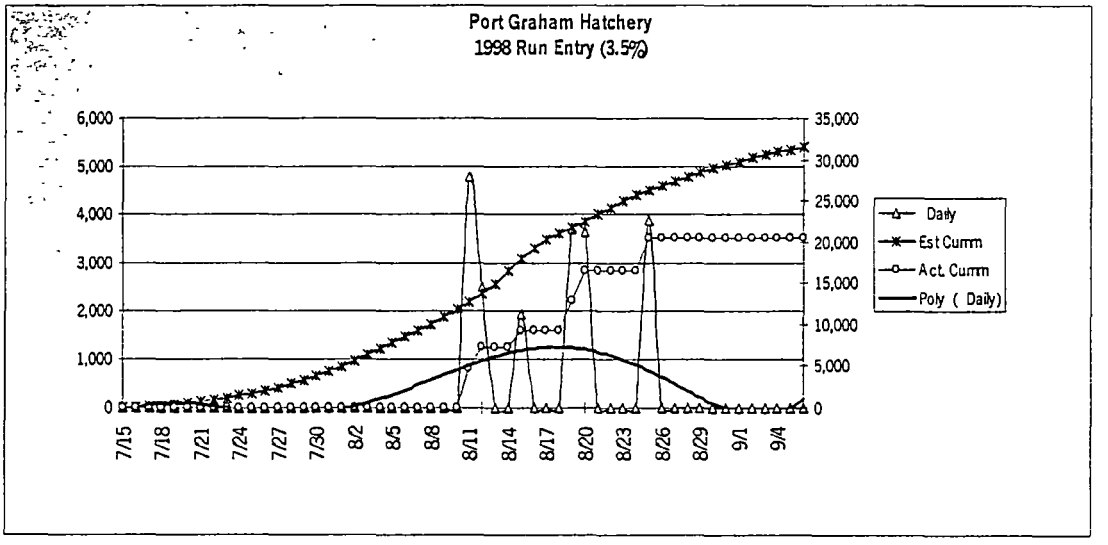
The following table lists the annual production numbers for pink salmon for the 1996 through 2000 brood years.

Table 2: Port Graham Hatchery Production Records:

Brood Year:	1996	1997	1998	1999	2000
# Eggs Taken:	1,501,671	15,489,306	7,620,889	1,177,500	33,877,042
# Brood Stock:	4,900	36,888	12,705	1,270	42,927
# Fish Sold:	0	86,562	0	0	0
# Subsistence Catch:					5,000
# Commercial Catch:		53,794			0
Total PGH Return:	4,900	177,244	20,500		70,000

Figure 3, below, illustrates the adult return timing of the 1998 adult pink salmon run entry.

Figure # 3: 1998 Adult Pink Run Entry



Annual Port Graham River pink salmon escapement and catch levels from 1996 through 2000 are shown in table 3 below. The average escapement during those years was 8,990 adult pink salmon.

Table 3: Port Graham River Pink Salmon Escapements and Catch Data:

Return Year:	1996	1997	1998	1999	2000
PG River Escapement:	7,039	3,600	12,559	6,150	15,600
PG River Subsistence Catch:	400	200	800	400	200
PG River Commercial Catch:	1,500	4,000	598	0	0
Total PG River Return:	8,939	7,820	13,957	6,450	15,800

Discussion

Of particular interest is that preliminary analyses of the 1996 brood/1997 reared CWT tag data indicates that the accelerated pinks (EVOS funded project) experienced twice the level of marine survival as the normal production group and were not significantly different in size. This project has provided some very important findings that are likely to result in major improvements to the marine survival for the hatchery pink salmon.

This project helped the local Alaska Department of Fish & Game (ADF&G) fisheries manager by providing additional information with which he was able to allow more subsistence and broodstock harvesting opportunities without jeopardizing the wild stock escapement. This information included stream survey counts (both aerial and ground counts) as well as closer monitoring of pink salmon entering the Port Graham sub-district. The strategy of maximizing use of the adult return through increased monitoring went quite well throughout the project. It was also very instrumental in establishing a better working relationship between the local ADF&G management staff and the village.

The FY 98 otolith marking was successfully accomplished but the all of the fish were lost in the fire. Otilith marking will be continued to facilitate this projects objectives. The advantage of otolith marking is that all fish in a group are marked rather than a representative sample as in cwt marking. Otolith marking has less impact on the fish, is easier to apply and is cheaper than cwt. The only disadvantage is that the fish are marked as eggs and must be kept segregated during incubation and rearing to ensure a particular mark receives the treatment intended for it.

The FY 99 and FY 00 years both contributed to the overall achievements and success of this project. Even though the otilith marks were not good enough in quality to evaluate the difference in survival rates of the two groups returning in 2000, the information learned in the earlier phases of this project show that it is very likely that the accelerated group had a significantly higher marine survival level than the non accelerated group. This information will be carried forward and utilized throughout the hatcheries future production and research programs.

Conclusions

The 1998 pink return provided evidence that the new accelerated pink program works very effectively. The success of this group of accelerated pinks has opened the door for numerous other opportunities to apply this tool for ultimately improving adult marine survivals. The availability of more heated water will also permit the project to use otolith marks to differentiate groups of fish as opposed to the current cwt/ad clip marking. Cooperative management efforts with ADF&G were very successful and will be continued.

Even though the fire in 1998 was a major set back, and certainly interfered with the project as well as the entire hatchery program, its disastrous affront was met head on with a united major local push to get the program back on track. into its full potential. The information learned from this project, combined with the new hatchery and a revitalized program will go a long way towards optimizing the overall production and sustainability of the hatchery program.

The suggested results of this project need to be further tested and proven, but they fit in well with other research. Examples of this other research includes NMFS' APRISE program in South East Alaska and the EVOS sponsored SEA program in South Central Alaska. These, as well as other more limited studies, suggest that hatchery pink salmon survival is not necessarily plankton abundance limited but more likely a size/ temperature/growth limitation. In this hypothesis, the larger size of the pink smolt within a reasonable release time window to allow time for the pink smolt to get out into the open ocean in a reasonable timeframe, and results in better burst speed and predator escape success. Additional review of various other hatchery and research project results such as those from the APRISE study will be carefully continued. The APRISE study demonstrated a strong correlation between warmer water temperatures and faster fry and smolt growth and resultant adult marine survivals. Such studies point out the potential that, regardless of plankton abundance, water temperature is the single most important growth controlling function which equates to increased growth and ultimately marine survivals. This is presumably due to the faster growth relating to increased burst speed capabilities which then results in less predation. This data, combined with information learned from this project, will help the Port Graham Hatchery to better understand the controlling mechanisms of the marine survival of the pink salmon runs it enhances. It will also potentially enable other Alaskan hatchery operators to achieve greater marine survivals from hatchery reared and released pink salmon. The Port Graham Hatchery will follow up on the important information learned from this project and continue to work towards maximizing operational efficiency and providing more fish to the subsistence, commercial and sport users.