Exxon Valdez Oil Spill
Gulf Ecosystem Monitoring and Research Project Final Report

Management Applications: Implementing the SEA Pink Salmon Survival Model – Tagging Technology

GEM Project 050758
Final Report

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Study History: GEM Project 050758 was a one year pilot project that began in spring 2005. This project was funded along with a related project (GEM Project 050757) intended to bring the pink salmon fry model back into operation. An annual report for project 050758 was submitted in September 2005.

Abstract: In July 2005 juvenile pink salmon *Oncorhynchus gorbuscha* were captured in southwestern Prince William Sound and tagged with Passive Integrated Transponder tags to estimate short-term mortality from tagging and handling. Survival to 96 hours was 92.5% (185 of 200), but 2 more fish had injuries that would have caused mortality. A lack of tagging experience probably increased the mortality because 6 of 15 mortalities were in the first 25 fish tagged. Examination of processing plants in Cordova for locations to scan for tags in returning adult pink salmon indicated that changes in the plant would be necessary to get acceptable detection probabilities. Detection tests in August 2005 at one processing plant in Cordova supported that assessment. Detection probabilities from three tests (n=51 tagged fish) were 0.14, 0.24, and 0.06. Changes to processing lines to reduce the amount of metal would be required to get acceptable detection rates.

Key Words: Juvenile salmon, *Oncorhynchus gorbuscha*, pink salmon, PIT tags, Prince William Sound, Survival.

Project Data: Data pertaining to the tagging, short-term mortality, and tag detection rates are stored in Microsoft Excel™ worksheets.

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EXECUTIVE SUMMARY

This report documents Gulf Ecosystem Monitoring Study 050758, a project designed to test a tagging technology that could be used in implementing the Sound Ecosystem Assessment Studies pink salmon *Oncorhynchus gorbuscha* survival model. The first objective, to estimate tag loss and tagging-induced mortality of juvenile pink salmon emigrating Prince William Sound, was met in July 2005. Pink salmon were captured in marine waters in southwestern Prince William Sound (Shelter Bay, Evans Island) and 200 were tagged with Passive Integrated Transponder tags. Most fish (92.5%) survived to 96 hours while kept in a tote with recirculating sea water. Forty percent (6 of 15) of the mortalities were from the first 25 fish tagged. This indicates that tagging and handling experience can increase the survival rate. The second objective, to determine optimal configurations of tag scanning equipment at each salmon processor in Prince William Sound and estimate tag detection rates at each processor, was partially met in August 2005. Visual examination of plants in Cordova suggested that processing plant changes would be necessary to obtain good detection probabilities. As expected, significant detection problems occurred at the first processing plant, so no further tests were completed. However, other studies indicate that changes in processing facilities, replacing metal pieces that can interfere with Passive Integrated Transponder tag detection with plastic, can increase detection to useable levels. Further testing of detection probabilities should be completed prior to the initiation of a large scale tagging project.

INTRODUCTION

This project was conceived during a pink salmon *Oncorhynchus gorbuscha* predictive workshop held in Cordova March 16-18, 2004. Workshop participants recommended that preseason forecasting and numerical model validation could be approached by a direct census of juveniles as they are leaving Prince William Sound (PWS). Validation of the Sound Ecosystem Assessment (SEA) program's pink salmon model (Willette et al. 2001) will require independent measures of fry surviving the critical early marine period in PWS. Model validation could be approached by a direct census of juveniles as they are leaving PWS. Catching juvenile pink salmon emigrating from southwestern PWS would also enable application of a second mark to partition survival between the early marine and oceanic life stages. Currently all juvenile pink salmon of hatchery origin in PWS (average of ~600 million; 2001-2005) have their otoliths thermally marked in the early embryonic rearing phase (Joyce and Evans 1999). There are four hatcheries releasing pink salmon in PWS (Figure 1).

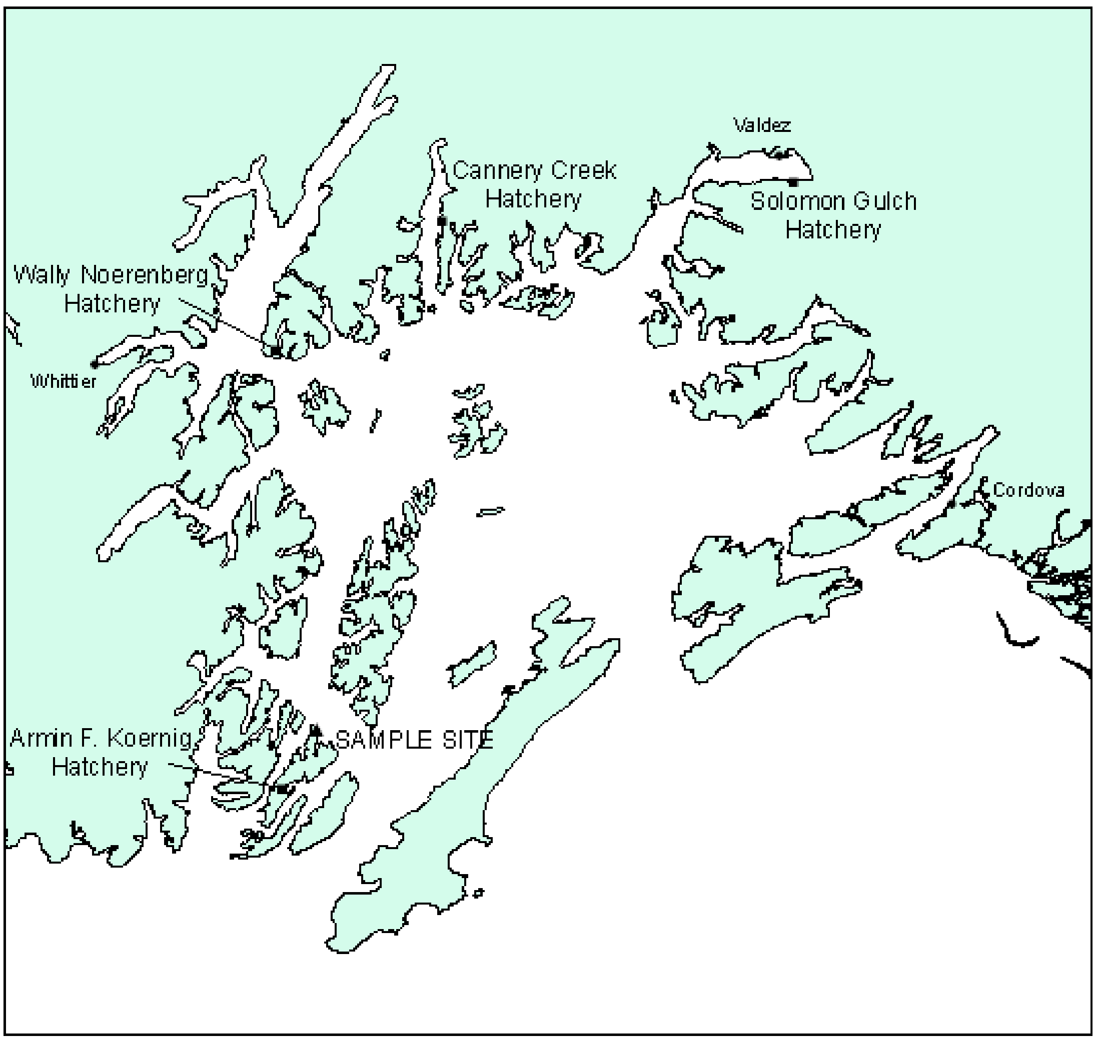

Figure 1. Hatcheries releasing pink salmon in Prince William Sound and PIT tag capture site in 2005.

This project tested the feasibility of using Passive Integrated Transponder (PIT) tags to mark juvenile pink salmon just before they leave southwestern PWS. Juvenile salmon injected with PIT tags generally have high tag retention rates (~100%) and survival rates if PIT tags are injected in the correct location (Prentice et al. 1990a). Double marking (thermal marks and PIT tags) may allow us to partition early marine and oceanic survival of pink salmon (Parker 1968, Karpenko 1998). Combining estimates of early marine survival and stock composition of the juvenile population obtained from otolith thermal marks will enable estimation of early marine survivals of each hatchery release group and a robust evaluation of pink salmon survival model simulations.

OBJECTIVES

1. Estimate PIT tag loss and tagging-induced mortality of juvenile pink salmon emigrating Prince William Sound in July,
2. Determine optimal configurations of PIT tag scanning equipment at each salmon processor in PWS and estimate tag detection rates at each processor.

METHODS

Objective 1: Estimate PIT tag loss and handling mortality

To estimate PIT tag loss and tagging-induced mortality, the ADF&G research vessel *R/V Solstice* was used to capture juvenile salmon just inside Shelter Bay, Evans Island on 5 and 6 July 2005 (Figure 1). An anchovy purse seine net (25 m deep with 1.5 cm stretch mesh) was deployed to capture fish, and the net was held open for 20 minutes each set. The total number of fish captured for each set were counted or estimated by species and life stage (juvenile or adult).

The first set, 5 July 2005, was used to test our capture and handling of juvenile salmon and practice implanting PIT tags. The seine was pursed and the net reduced in size until fish could be collected with a long-handled (~2 m), small mesh dip net. The web near the boat was kept about 2-3 m deep to allow jelly fish (Scyphozoa) to sink below the fish. Juvenile salmon were dip netted into 2 large coolers (121 liters) and 3 totes (68 liters) filled with salt water from the vessel’s saltwater wash pump. Salt water was pumped into two of the coolers and water was allowed to overflow. The totes were filled with salt water and refreshed about every 15-30 minutes. Each container also had a battery powered air stone (aerator) that ran continuously.

The juvenile pink salmon were separated into a tote until 20 fish were available. The remaining fish were kept in the two coolers with circulating sea water and air stones and monitored for signs of stress. Two to four juvenile pink salmon at a time were placed in a tote with a MS-222 (Finquil) solution and anesthetized. In a change from the original proposal procedures, MS-222 was used rather than clove oil because it was readily available, and project personnel were experienced with using MS-222. The fish were PIT tagged using procedures outlined by Prentice et al. (1990b) and allowed to recover in a tote of sea water. After testing the anesthesia and tagging process with 20 juvenile pink salmon, all tagged fish were exposed to a lethal level of MS-222 and dissected to examine tag placement. All remaining live fish were released close to the capture site.

A second purse seine set on the morning of 6 July 2005 captured all the fish required for PIT tagging (n = 200 juvenile pink salmon). Juvenile salmon were dip netted into the coolers and most of the juvenile chum salmon *O. keta* were separated and released. All tagging was completed with a 2 person crew. Four to five juvenile pink salmon at a time were anesthetized in a solution of MS-222, measured for snout to fork length to the nearest millimeter, and then tagged. The individually coded PIT tags (glass encased, 12 mm x 2.1mm, 125 kHz) were injected just posterior of the right pectoral fin off the ventral midline using a modified 12 gauge hypodermic needle and syringe (Prentice et al. 1990b). Needles were sterilized in isopropyl alcohol for a minimum of 10 minutes before the first use and after each use. Hypodermic needles were replaced if they became dull. An electronic PIT tag reader was used to scan each tag code into a file just prior to tagging. Additionally, the tag code, fish length, time of tagging (military time), and comments on the fish condition or tagging process were recorded on paper data forms. After tagging, fish were allowed to recover in a tote with clean sea water and then transferred to an insulated fish tote (898 liters) covered with mosquito netting or a clean cotton sheet to keep the fish from jumping out and protect them from avian predation. This study did not include a control group because our objective was to estimate the short-term mortality from tagging and handling.

After all fish were tagged and transferred to the large tote, all remaining fish were released. An aerator circulation pump was used until all fish were in the large tote. The aerator circulation pump was then removed and the tote was constantly supplied with sea water from the vessel wash pump and aeration was supplied by three battery powered air stones. The amount of water supplied by the pump was adjusted to keep the fish from swimming circles in the tank. Fish were kept in the tote on the deck of the *R/V Solstice* for 96 hours. The tagged fish were maintained in a tote on the *R/V Solstice* instead of a net pen near Armin F. Koernig Hatchery as outlined in the original proposal because this allowed more control over the water parameters (temperature, salinity), food availability, and protection from predators.

Approximately every four hours the tote was examined for dead fish and the water temperature and salinity were measured and recorded. Dead fish were removed, scanned for a PIT tag and the time and tag number recorded. After tagging the fish were not feed for approximately the first 48 hours. From 48-72 hours, the fish were feed zooplankton from approximately 25 vertical tows (20 m) and 1 horizontal tow (300 m) made with a plankton net (200 micron mesh; 75 cm dia mouth opening). Commercial fish food was used for the last 24 hours.

The short-term survival of tagged fish (S_t) was estimated from $S_t = m_L/m_T$, where m_L *is* the number of live tagged fish at the end of the experiment, and m_T is the total number of tagged fish at the beginning of the experiment. Tag loss (T_L) was estimated from $T_L = n_L/m_T$, where n_L is the number of live fish without a tag at the end of the experiment. The standard error of the estimates was calculated as described by Zar (1996).

Ninety-six hours after the last fish was tagged, all fish were exposed to a lethal level of MS-222 and then frozen. The fish were later thawed and checked for tag loss by scanning with an electronic tag reader. All fish were also examined for external injuries.

Objective 2: Determination of optimal scanning configuration at processor plant

The second objective of this project was to determine the optimal configurations of PIT tag scanning equipment at each salmon processor in PWS and estimate tag detection rates at each processor. This method of recovering PIT tagged fish was used by Willette et al. (2003) in Cook Inlet, Alaska. However, they injected PIT tags into the cheek muscle of adult salmon and were able to scan at PVC chutes just after the heading machine while our objective was to test configurations for scanning of adult salmon with the PIT tag in the body cavity.

During July and early August 2005 we examined the Cordova processing plants for processing line locations without excessive metal or electric motors that would interfere with tag detection. Unlike the experience of Willette et al. (2003), there did not appear to be processing line locations that would provide good detection rates without extensive modifications. Therefore, there were several changes from our original procedures outlined for this objective. No attempt was made to conduct detection tests at plants in Valdez or Seward, and we conducted our detection tests with 51 PIT tagged fish rather than 100 fish as outlined in our original objectives because preliminary configuration testing suggested we would not get good detection rates.

On 17 August 2005 we ran PIT tag detection tests at the Ocean Beauty Seafoods plant in Cordova. Tests were conducted at two locations in the plant: 1) a nonmetal conveyor belt in an aluminum frame, and 2) an aluminum belt with plastic conveyor sides. These appeared to be locations that would have the least interference from metal or electric motors. Fifty-one commercially harvested adult pink salmon were injected with PIT tags (12 mm x 2.1 mm, 134.2 kHz) in the same body cavity location described earlier for juvenile pink salmon. The fish were scanned with an electronic tag detector to ensure the tags were working, and then placed on the moving conveyor, one at a time, and transported past a handheld racket antenna and electronic tag detector. The antenna power, distance from the fish, and location of the antenna (under the conveyor belt vs. over the conveyor belt) was varied with a small number of fish to find a configuration that maximized the antenna current. Two different electronic detectors and racket antennas were tried for multiple configurations. The antenna current was lower than suggested by manufacturer for all configurations examined. Three tests with 51 tagged fish were completed and the numbers of tags detected were documented.

Tag detection rate (C_d) from each test was estimated from $C_d = m_d/m_t$, where m_d is the number of detected tags, and m_t is the number of known tagged fish scanned. The standard error of the estimate was calculated as described by Zar (1996).

RESULTS

Objective 1: Estimate PIT tag loss and handling mortality

Approximately 600 juvenile salmon were captured with the purse seine on the evening of 5 July 2005. Twenty juvenile pink salmon were PIT tagged and all tagged fish were subsequently sacrificed to check for correct tag placement. Tag placement matched that suggested by Prentice et al. (1990b); in the body cavity just posterior to pyloric caeca.

An estimated 500 juvenile pink and 300 juvenile chum salmon were captured in a purse seine set the morning of 6 July 2005. About 2 hours were required to sort and release most of the chum salmon. Tagging began at 1123 and was complete at 1659 with 25 minutes for lunch (~93 seconds per fish or 39 fish per hour). Tagged fish ranged from 66 to 129 mm snout to fork length (mean = 91 mm). About 42% of the fish tagged were between 80 and 90 mm (Figure 1).

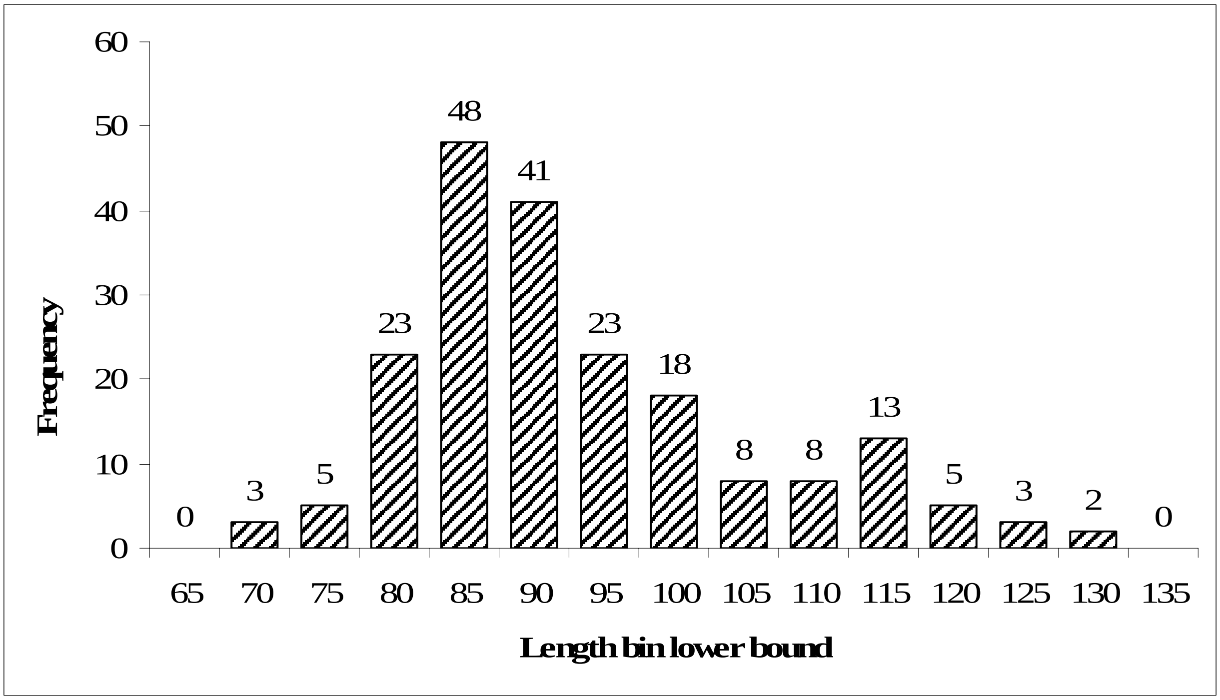

Figure 2. Length frequency of juvenile pink salmon PIT tagged in Prince William Sound to estimate short-term mortality from tagging and handling (n=200).

One hundred and eighty-five fish (92.5%; SE = 0.019) survived to 96 hours; however, 2 more fish would have not have survived because of caudal fin erosion and external skin and scale loss. None of the remaining fish (n = 183) had obvious external injuries that would have affected their survival. Cadual fin erosion and associated skin and scale loss were documented on 47% (7 of 15) of the mortalities. Sea lice were documented on 15% (30 of 200) of the fish tagged, but only 20% (3 of 15) of the mortalities had sea lice at the time of tagging. Forty percent (6 of 15) of the mortalities were from the first 25 fish tagged.

The water temperature in the insulated tote ranged from 14.9 to 17.9°C (average = 16.0°C; Figure 3). The salinity ranged from 22.1 to 26.3 ppt (average = 24.4 ppt).

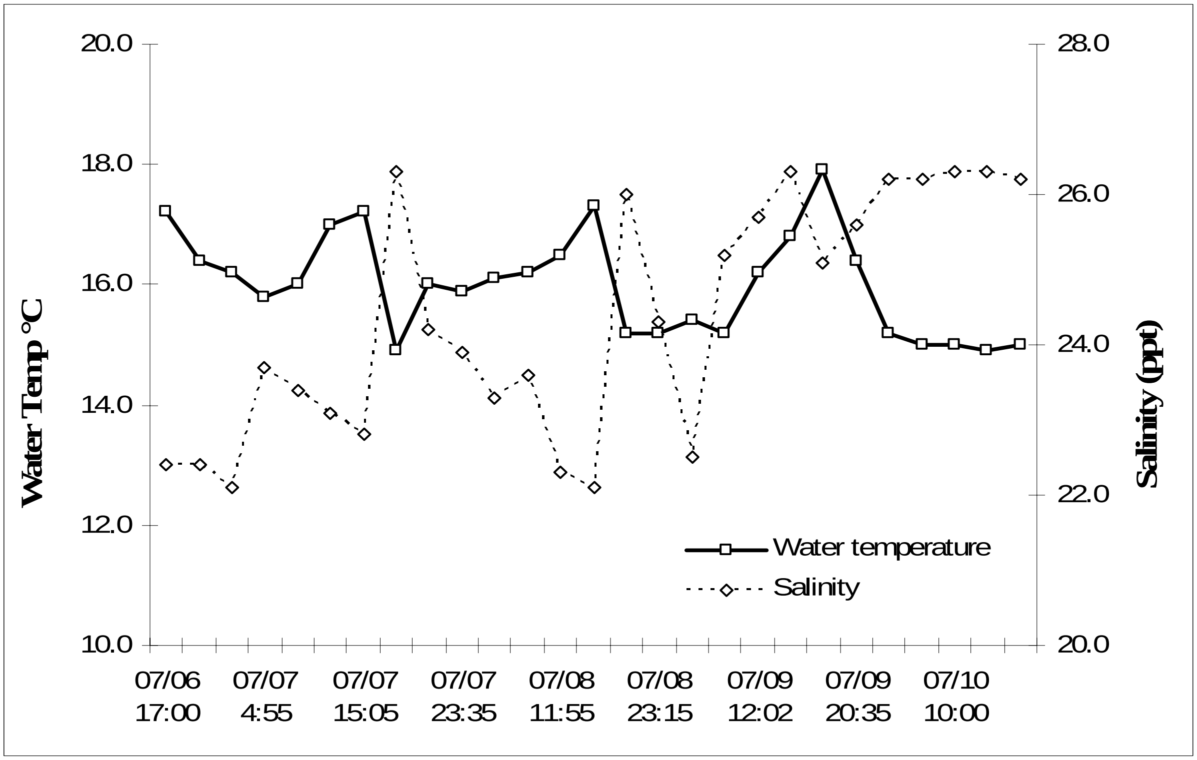

Figure 3. Temperature (°C) and salinity (ppt) of tote water juvenile pink salmon were held in during short-term mortality test.

Fish were scanned for a PIT tag after mortality or after 96 hours. No tag loss was documented among the 200 fish tagged (100% tag retention).

Objective 2: Determination of optimal scanning configuration at processor plants

The first tag detection test was completed on the nonmetal conveyor belt with a single antenna (100% antenna power) about 0.3 m above the belt. Only 7 of 51 PIT tags were detected (Table 1). The next test was again on the nonmetal conveyor belt with a single antenna (70% antenna power) about 0.15 m above the belt, and only 12 of 51 PIT tags were detected. The third test was completed on the aluminum belt with plastic sides with a single antenna (70% antenna power) about 0.3 m above the belt. Only 3 of 51 PIT tags were detected.

Table 1. Tests of PIT tag detection in adult pink salmon in the Cordova Ocean Beauty processing plant, 2005.

		Height	Antenna		Detected		
Test	Location	above belt (m)	Power	n	Number	Proportion	SE
1	Nonmetal conveyor belt	0.30	100%	51	7	0.14	0.049
2	Nonmetal conveyor belt	0.15	70%	51	12	0.24	0.060
3	Aluminum belt/plastic sides	0.30	70%	51	3	0.06	0.033

DISCUSSION

Objective 1: Estimate PIT tag loss and handling mortality

The high mortality rate in the first 25 fish tagged suggests the lack of tagging and handling experience contributed to early mortalities. The cause of injuries (caudal fin erosion) noted on about half the mortalities are unknown, but they are probably related to handling during the tagging process. They could also be related to damage from jelly fish, sea lice, or from swimming near the sides of the tote; however, only one of the seven mortalities with external injuries had sea lice at the time of tagging and visual observations suggest the circulating sea water in the tote kept fish from swimming near the sides of the tote.

The mortality rate from handling and tagging should be reduced with experience and some changes to the handling process. More experience separating juvenile pink salmon from other juvenile salmon species would decrease the holding time of fish prior to tagging. Additionally, more experienced tagging personnel would probably decrease the mortality. A better designed workflow would have also decreased the handling of fish during the process and probably increased fish survival.

The overall short-term survival rate in this study is lower than reported by Dare (2003) and Prentice et al. (1990a); however, this study is the first I am aware of to capture and PIT tag juvenile salmon in salt water. The tag retention from this study was slightly better than the reported in other studies (Dare 2003; Prentice et al. 1990a).

There is a possible bias if the short-term survival estimates from this study were used to correct release numbers. Dare (2003) reported that, on average, mortalities were collected ~11 days after PIT tagging Chinook salmon *Oncorhynchus tshawytscha* in fresh water. However, he also indicated that because of the long delay after tagging, disease or stress related to the hatchery environment may have contributed to the mortalities. If the same delayed mortality were to occur with pink salmon PIT tagged and released in the ocean, the mortality occurring after the PIT tagging event would be overestimated. In attempting to partition the mortality between the early marine stage and the later marine stage, this would cause a positive bias in the mortality of the later marine stage.

Objective 2: Determination of optimal scanning configuration at processor plants

Visual examination of processing plants in Cordova suggested that the detection rates would be too low without significant plant modifications. Because this was a one year project, it is unlikely that processing plants would be able to make the necessary modifications to increase tag detection rates. The poor tag detection rates match our expectations given the low antenna currents with the configurations tested.

If a large scale tagging study were conducted, processing plant modifications should allow a much higher tag detection rate than was documented in this study. For example, replacing the aluminum chutes that funnel fish to the processing line with heavy, food-grade plastic chutes would provide an antenna location with less metal interference. These modifications would be fairly inexpensive to complete; however, further work should be done to document that modifications would increase detection rates to useable levels prior to any large scale tagging project.

CONCLUSIONS

The major objectives of this study were to test the short-term survival of PIT tagged juvenile pink salmon captured in salt water and to evaluation PIT tag detection rates in area processing plants. The short-term survival rate of PIT tagged juvenile pink salmon indicate that excellent tag retention and survival rates can be achieved with increase tagging experience. The poor PIT tag detection rates documented at Ocean Beauty Seafoods plant in Cordova demonstrate that processing plant changes would be required to improve detection rates, e.g., replacing metal chutes with food-grade plastic to reduce tag detection interference. Further work should be done to document that modification could increase detection rates to useable levels prior to initiating any large scale tagging projects.

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