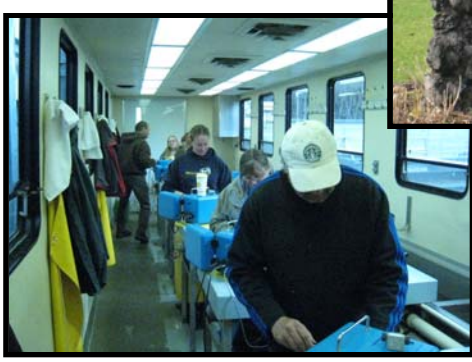
Comparative Injury, Adipose Fin Mark Quality, and Tag Retention of Spring Chinook Salmon Marked and Coded Wire Tagged by an Automated Trailer and Manual Trailer at Carson National Fish Hatchery

October 2008



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Abstract

The United States Fish and Wildlife Service's Columbia River Fisheries Program Office has been marking and tagging salmon with automated trailers consistently since 2006, in addition to the historically used manual trailers. Some hatchery managers have expressed concern that automated trailers may cause injuries at rates higher than historic marking and tagging techniques. To begin addressing these concerns, in 2006 we evaluated the two types of marking trailers at Warm Springs National Fish Hatchery, Oregon. To complement the study at Warm Springs National Fish Hatchery, in 2008 spring Chinook salmon at Carson National Fish Hatchery were adipose fin marked and coded wire tagged using both an automated and manual marking trailer. Fish injuries, fin mark quality, and coded wire tag retention rates were compared between the two trailers. Fish were randomly sampled from each trailer and evaluated in a single blind experiment. Injury rates, fin mark quality, and tag retention rates did not significantly differ between the two trailer types. The ability of these two types of trailers to tag fish without any differential injury, clip quality, or tag retention rates allows hatchery managers at Carson National Fish Hatchery to use either trailer with assurance that fish are being marked and tagged in accordance with the expected standards. Availability of experienced markers, cost, time constraints and many other factors should be considered when deciding what type of trailer to use when marking and tagging salmon at a particular fish hatchery.

Introduction

Coded wire tagging (CWT) and adipose fin marking are essential tools for studying and managing Pacific salmonids in the Columbia River Basin. Each year the United States Fish and Wildlife Service's (USFWS) Columbia River Fisheries Program Office (CRFPO) is tasked with coded wire tagging and/or fin marking over 31 million juvenile salmon and steelhead. Since the inception of the CWT in the 1960's, marking and tagging has been completed by manually excising the adipose fin and inserting a coded wire tag in the snout of the fish. In 1995, Northwest Marine Technologies (NMT) began development of an automated marking and tagging trailer, named the Autofish SCT. With this automated system, fish are sorted by size and redirected to size specific processing lines. At each line, fish are marked and coded wire tagged using advanced technology in conjunction with the fish's natural instinct to move in water currents. In 2006, the CRFPO Marking Program purchased three automated marking trailers which are currently being used to mark and tag fish at National Fish Hatcheries and other state and tribal facilities throughout the region.

Little is known about the short term and long term impacts to fish marked and tagged using the automated trailer. Northwest Marine Technologies, the Washington Department of Fish and Wildlife, and the United States Geological Survey initiated a study comparing the injury rates of fish marked using the automated trailer and fish marked using the traditional manual method (Lee Blankenship, Northwest Marine Technology, Inc, personal communication). Initial results of the study indicate a high level of injuries using both the automated and manual systems, with no differences between the two systems. Injuries to fish were mainly attributed to the initial netting of fish from the raceways, prior to marking (Dianne Elliot, U.S. Geological Survey, personal communication). In May 2006, a study was conducted at Warm Springs National Fish Hatchery (NFH) as described in Hand et al. (2007). The purpose of this study was to compare tag retention, mark quality, injury rates, post-tagging juvenile survival and adult survival between the two tagging systems (automated vs. manual). It was concluded from this study that use of an automated system increased mark quality and tag retention at Warm Springs NFH. Injury rates and post tagging juvenile survival were similar between the two methods. Information on adult survival will not be available until 2011. Hand et al. (2007) recommended that similar studies be conducted at other hatcheries, using different species and at different times of year to fully compare the automated and manual tagging methods. We conducted a study at Carson NFH to address the recommendations of Hand et al. (2007) and to compliment their study.

At Carson NFH, 100% of the spring Chinook salmon production is adipose fin marked with a smaller portion receiving a coded wire tag (Appendix A). The goal of the CRFPO Marking Program is to have a minimum coded wire tag retention rate of 95% (Jesse Rivera, USFWS personal communication). The tag retention at Carson NFH has been above the Marking Program goal in most years (Figure 1). A 90% retention rate was experienced for brood years 1988 and 2001, as well as a 94% retention rate for brood years 2002 and 2004. The automated trailer was first used at Carson NFH for brood year 2004 and originally only used for fin marking and not coded wire tagging. Brood year 2005 was marked and tagged using both an automated and manual trailer. Tag retention samples were obtained for both automated and manual trailers; however fin mark quality and injury rates were not assessed. Brood year 2006 was marked and tagged exclusively with the automated trailer. Both an automated trailer and a manual trailer were used to mark and CWT the brood year 2007 spring Chinook salmon at Carson NFH and these fish were used in this evaluation. The goal of this project is to compare the use of an automated trailer to a manual trailer for marking and tagging spring Chinook salmon at Carson NFH. Our objectives included making four comparisons between the two types of marking trailers: (1) injury rates, (2) injury location, (3) adipose mark quality, and (4) CWT retention rates. Results of this study will provide information to hatchery managers and the marking program on potential risks and benefits of using an automated trailer. Information gained from this study will help inform decisions on the use of different marking and tagging techniques in the region.

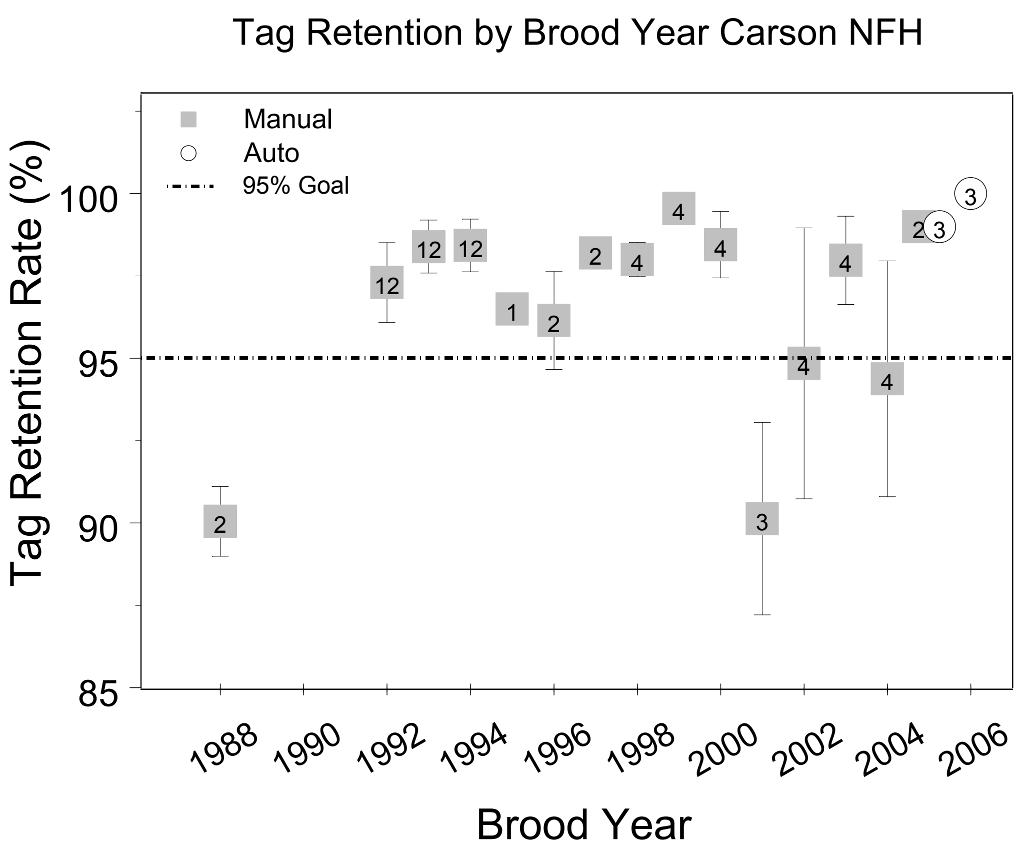

Figure 1. Tag retention rates for spring Chinook salmon tagged at Carson National Fish Hatchery from brood year 1988 – 2006. The number of tag groups is given and the error bars represent one standard deviation. The dotted line represents the 95% tag retention goal specified by the Columbia River Fisheries Program Office Marking Program. Brood year 2005 was marked using both trailers (adjacent circle and square symbols) and brood year 2006 was marked exclusively with the automated trailer.

Methods

Study Site: Carson National Fish Hatchery in operated by the USFWS and began operating in December 1937 for the purpose of mitigating the effects of Bonneville Dam, consistent with the

Mitchell Act as administered by National Oceanic Atmospheric Administration (NOAA) Fisheries. The facilities were remodeled in 1956 to establish a hatchery run of spring Chinook salmon in the Wind River. The hatchery is situated within the Gifford Pinchot National Forest at the confluence of Wind River and Tyee Creek. The Wind River flows south-east to where it enters the Columbia River at river mile 155, approximately 10 miles upstream of Bonneville Dam. The hatchery raises and releases 1.17 million spring Chinook juveniles which are released onsite and another 250,000 fish which are transported and released in the South Fork Walla Walla River as part of a tribal reintroduction program. All fish receive an adipose fin mark and a proportion also receives a CWT.

Trailer Operation: During marking and tagging, the automated trailer and the manual trailer were operated by experienced trailer supervisors and in accordance with standard operating protocols. Fish were netted from their raceways by the trailer supervisor and loaded into one of the two trailers. Fish were processed either manually (Schurman and Thompson 1990) or automatically (Northwest Marine Technologies, Inc. 2007) depending on which trailer they are placed in. In the manual trailer, fish were distributed evenly to one of six holding tanks. From the holding tanks the fish were netted by the markers and anesthetized in a solution of MS-222. Once anesthetized the adipose fin was excised with a pair of scissors and a CWT was injected into the fish's snout using a Mark IV tag machine (Northwest Marine Technologies Inc.). After receiving a CWT, fish exited the trailer through pipes which ponded the fish in the appropriate raceway where they recovered from the anesthetic. In the automated trailer, the fish were placed in a main holding tank in the front of the trailer. From this tank the fish were transported via fish pump to an apparatus that allowed for volitional entry into a sorter. The sorter measured the fish by length and then distributed them to another volitional entry device at the appropriate processing line. The trailer consisted of 6 processing lines which were setup to process fish in different size classes. Fish which are too big or too small for the processing lines are sent to the rear of the trailer to be processed manually. Upon volitionally entering the processing lines the fish encounter a series of sensor operated gates which deliver the fish one at a time to a set of clamps which gently hold the fish while it is being adipose fin marked and receiving a CWT. A set of cameras and computers photographs the adipose fin and determines where to excise the fin. After the fin is removed the camera and computer then determine if the fish received a successful fin mark. At the same time the adipose fin is being excised a CWT is injected into the snout of the fish. During this whole automated process, it is also important to note that fish are not anesthetized. A sensitive metal detector will verify if the fish was successfully tagged. If either the mark or the CWT were unsuccessful the line rejects the fish which will be processed manually in the back of the trailer. While in the trailer, fish spent the majority of their time in the holding tank and only a few seconds in the sorter and the processing line. After being processed the fish were ponded as outlined in Appendix A. Due to the fast speed in which the automated trailer can process fish, two of the CWT groups (50,000 fish) were processed using this trailer and the remaining tag group (25,000 fish) was processed using the manual trailer.

Injury Rates and Location: Samples were collected on April 25th 2008 while the trailers were simultaneously processing fish. Only juvenile Chinook salmon receiving both an adipose fin mark and a CWT for on-station releases were used in this assessment. Sampled fish came from three different CWT groups of 25,000 fish each. Fish sampled for this assessment were collected outside the trailer and prior to ponding. A total of 700 juvenile fish, divided evenly between the two trailers were randomly sampled for injuries. This study was conducted by a two person team. One person, the collector, was responsible for sampling the fish from the trailers and the second person, the evaluator, was stationed in a hatchery building. The evaluator did not know which trailer type the samples were collected from. The collector used a coin flip to randomly select which trailer from which to sample fish. Approximately 50 fish at a time were sampled from the trailer outflow and delivered to the evaluator in a five gallon bucket. The collector documented which trailer the fish were sampled from, the time the sample was collected, and which CWT code the fish received. Each bucket of fish had a unique identification number so that collector data and evaluator data could be linked together for the analysis. The evaluator would anesthetize the fish in MS-222, place them on a measuring board, record fork length and rank injuries by location and severity according to the guidelines in Appendix B. Any fish which was determined to have an injury was digitally photographed on both sides. Once all the fish were evaluated, the collector would return the fish to the appropriate raceway and record the time. This process was repeated until all 700 samples were collected.

Adipose Mark Quality: The same 700 fish evaluated for injuries were used to assess fin mark quality. The four categories for ranking fin mark quality are outlined on the bottom of Appendix B. Marks where the fin was not entirely removed or the cut was deep into the caudal peduncle were considered poor marks. Only marks where >75% of the fin was excised and no injury to the fish was observed were considered good marks.

Tag Retention: Fish sampled for tag retentions were collected by the marking trailer supervisor and held inside the hatchery building. Three groups of approximately 500 fish, representing each of the CWT release groups were collected from the trailer outflow and sampled throughout the period of marking and tagging. Two CWT groups were processed with the automated trailer and the third group was processed by the manual trailer. Holding a sample of fish separate from the raceway is a standard method used when fish in a raceway are not 100% coded wire tagged. The fish were held for 30 days post-tagging with standard care by hatchery staff. After the 30 day period the collector and evaluator returned to the hatchery and sampled the fish for presence of a CWT. These fish were anesthetized in a 100 mg/l solution of Tricaine Methanesulfonate (MS-222), measured for fork length, and scanned for presence/absence of a CWT using a Northwest Marine Technologies Inc. V-detector. The V-detector operates by identifying a small change in a magnetic field that is caused when a CWT is present in a fish. After scanning the fish they were returned to a raceway that contained the same CWT group.

Data Analysis: Mean fork lengths for the 700 fish evaluated in the injury and fin mark quality portion of this study were calculated and compared using a Student's t-test. Differences in injury rates and differences in fin mark quality were compared using Chi-square analysis. Differences in injury location between fish processed using the two trailers were compared using a Fisher's Exact Test. A Chi-square analysis with Yates' continuity correction was used to compare tag retention rates between the two trailers. Any p-value below $p=0.05$ was considered to be statistically significant.

Results

Fish Length: Mean lengths (standard deviation) of fish sampled from the automated trailer and the manual trailer were 70.1mm (2.9 mm) and 66.9 mm (2.9 mm), respectively (Figure 2). A two-tailed t-test suggests that mean lengths were significantly different between the two trailers ($p<.0001$).

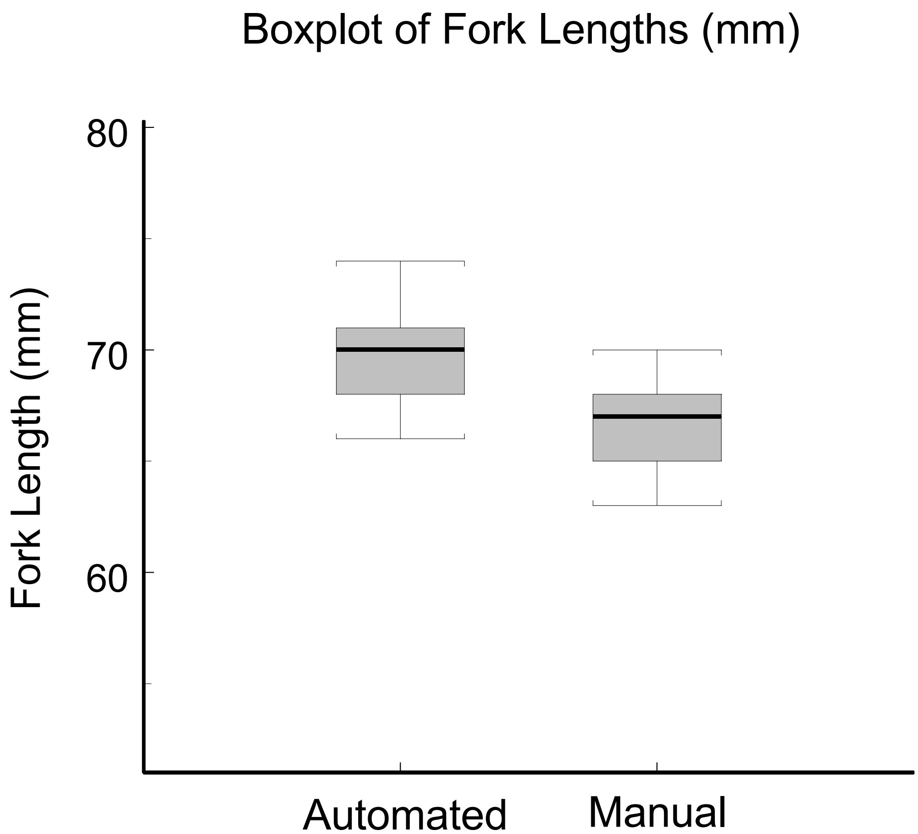

Figure 2. Boxplot of fork lengths for spring Chinook salmon sampled during the Carson National Fish Hatchery trailer evaluation. A two-tailed t-test suggests that mean lengths (n=350 fish/trailer) were significantly different between the two trailers (p<.0001). The whiskers extend to the 10th and 90th percentiles of the sample.

Injury Rates: The association between trailer type and injury rate was not statistically significant (χ^2=0.03, df=1, p=0.87). Also, no difference in injury location (head, body, fins) was detected between the two trailers (Fisher's Exact test, p=0.39). Approximately 5% of the fish sampled were classified as injured (33 injuries of 700 fish sampled); however all injuries were classified as minor with the exception of two head injuries from the automated trailer that were classified as major. The majority of injuries from both trailers were classified as fin injuries and split caudal fins were the most common type of fin injury (Figure 3).

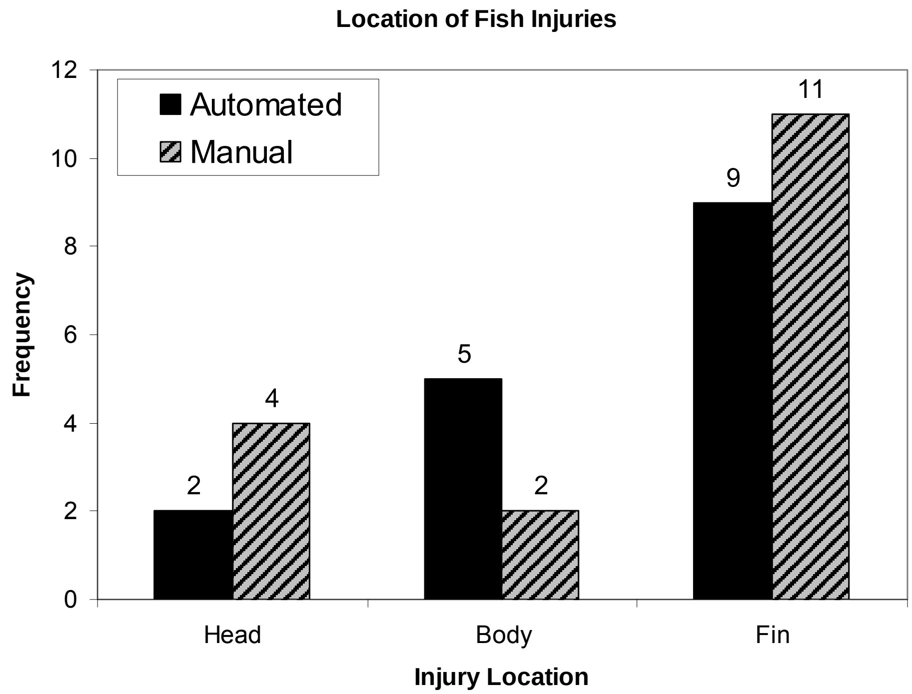

Figure 3. Frequency of fish injuries by location. No difference in injury location (head, body, fins) was detected between the two trailers (Fisher's Exact test, p=0.39). Numbers above the bars represent the number of fish with injuries in that location. All injured fish exhibited one injury with the exception of one fish processed by the auto trailer which displayed both a head and fin injury.

Adipose Fin Mark Quality: The association between trailer type and mark quality was not statistically significant (χ^2=1.17, df=1, p=0.28). Of the 700 fish sampled only 14 were classified with poor quality marks, nine from the automated trailer and five from the manual trailer. Poor marks from the automated trailer consisted of six marks where >100% of the fin was excised (rank 4) resulting in a gouge to the caudal peduncle. The other three marks were considered partial marks (rank 2) where only 25% - 75% of the fin was excised. All five marks from the manual trailer were classified as partial marks (rank 2).

Tag Retention Rates: The rate of tag retention between the trailers was not statistically significant (χ^2=0.92, df=1, p=0.34). Fish from the two CWT groups processed with the automated trailer retained 99.8% and 99.0% of the tags with an overall tag retention of 99.4%. A total of 1055 fish from the automated trailer were sampled for CWT retention and tags were found to be absent in six fish. Fish from the manual trailer CWT group retained 98.8% of the tags. A total of 513 fish from the manual trailer were sampled for presence of CWT with six fish not having a tag.

Discussion

There appears to be no significant difference in injury rates, adipose fin mark quality, and CWT retention rates between spring Chinook salmon marked and tagged using an automated trailer and a manual trailer at Carson National Fish Hatchery.

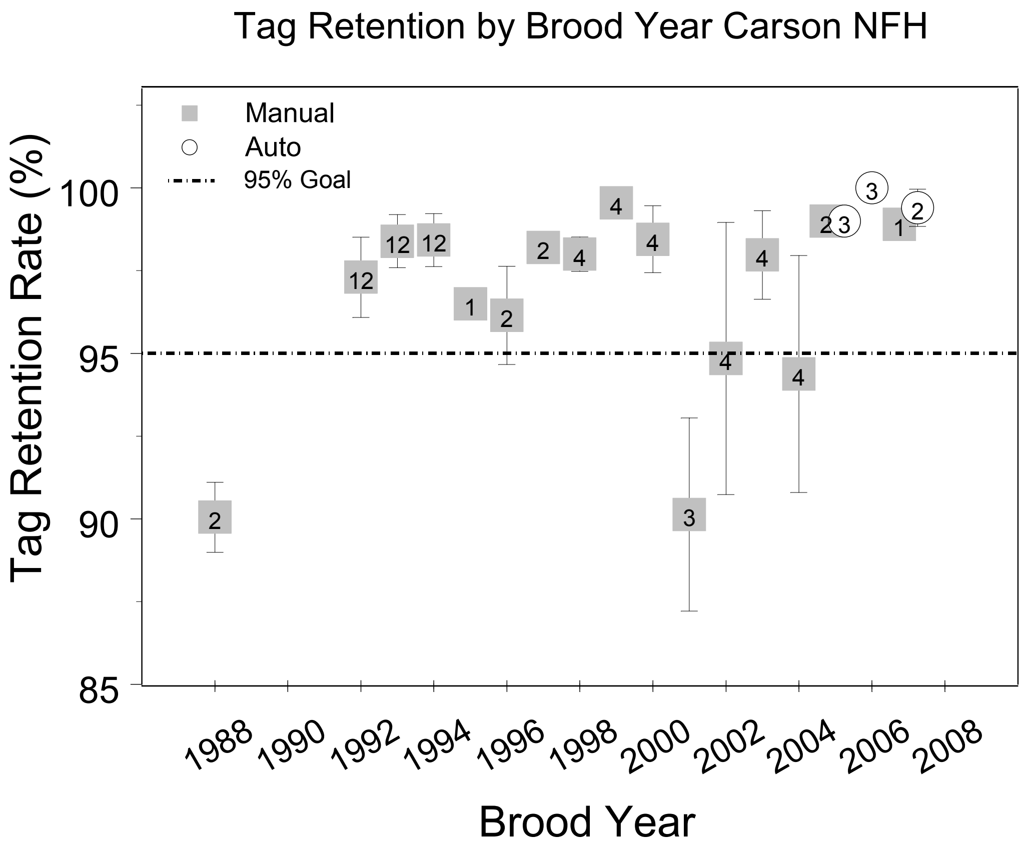

Figure 4. Tag retention rates for spring Chinook salmon tagged at Carson National Fish Hatchery from brood year 1988 – 2007. The number of tag groups is given and the error bars represent one standard deviation. The dotted line represents the 95% tag retention goal specified by the Columbia River Fisheries Program Office-Marking Program. Brood years 2005 and 2007 were marked using both trailers (adjacent circle and square symbols) and brood year 2006 was marked exclusively with the automated trailer.

In this study, we observed a difference in fish lengths between the two trailer types. The differences in fish lengths were likely due to differential growth experienced while rearing in different raceways at Carson NFH. Ideally, fish from the same raceway would have been used in this evaluation, however due to ponding constraints that option was not available. With the lack of differences in injuries, mark quality, and tag retention we believe that this length discrepancy added minimal variation to this study.

A similar trailer evaluation study conducted by the United States Geological Survey, described in Hand et al. (2007), suggested that the majority of the injuries they observed may have been caused by the initial netting of fish from the raceway and not by the actual process of marking and tagging. It is possible that netting procedures caused the split caudal fins we observed. Split caudal fins observed in this study may be of minor concern because Carson NFH spring Chinook salmon are held in the hatchery raceways for approximately one year after tagging and fins may have the ability to regenerate over this time frame. However, with a species like fall

Chinook, which are released shortly after tagging, a damaged caudal fin may reduce their ability to capture live prey and avoid predators. To minimize fin injuries, we suggest that trailers be loaded with multiple small net loads rather than fewer large net loads.

A partial fin mark allows for potential fin regeneration (Thompson and Blankenship 1997) and could cause a fish to be misidentified as a naturally produced individual. This study also documented a small portion of fish sampled for fin mark quality that exhibited a deeper than usual mark. This type of mark, known as a gouge, is an open wound on the caudal peduncle and has the potential to increase disease reception, lowering the survivability of that individual. When the rate of poor marks in our sample is expanded to the entire Carson NFH release of 1.42 million spring Chinook salmon, an estimated total of 13,100 would have a partial mark and 9,900 fish would have a mark resulting in a gouge to the peduncle. While this study suggests that there is no difference in mark quality between the two trailers, it is still important for trailer supervisors and markers to take the utmost care when adipose fin marking each fish.

The design and findings of this study parallel the results of Hand et al. (2007) in certain aspects but not in others. The study conducted at Warm Springs NFH consisted of a slightly different design than the Carson NFH study. At Carson NFH, a small portion of the fish production receives a CWT as opposed to Warm Springs NFH where 100% of the hatchery production is tagged. Hand et al. (2007) also evaluated the trailers over a longer period of time (8 days) and throughout different tagging periods (early, middle, and late) where as at Carson NFH simultaneous tagging and marking was only conducted for one day. At Warm Springs NFH, Hand et al. (2007) found that the automated trailer produced more head injuries in the early period than the middle and late periods. They also determined that the mark quality and tag retention of fish tagged with the manual trailer was poorer during the early period. When sampling periods were combined and the two trailers were compared to each other they found no difference in overall injury rates, however they were able to document a difference in mark quality and tag retention. For the metrics of mark quality and tag retention, they determined that the manual trailer performed poorer than the automated trailer. It is possible that the differences observed between the two studies were a function of the experience of the markers in the manually operated trailer. The marking crew at Carson NFH consisted primarily of markers that had participated in marking and tagging in previous years while the markers at Warm Springs NFH had limited prior experience. It has been demonstrated that coded wire tag retention depends on the technique and experience of the tagging crew (Elrod and Schneider 1986, Buckley and Blankenship 1990) and the trailer supervisor. At Carson NFH, both trailers exhibited tag retentions well above the 95% goal of the USFWS-CRFPO Marking Crew. These tag retention rates are in line with historic tag retentions demonstrated at Carson NFH (Figure 4).

The results from this study show that a manual marking trailer staffed with an experienced crew can produce a similar result in terms of injuries, mark quality, and tag retentions, as an automated tagging trailer. There are pros and cons to each trailer type. Initial and long term costs, time constraints, trailer availability, type of mark, employee experience, management goals and many other factors need to be considered by hatchery managers and marking crew supervisors when deciding what type of trailer to use when marking and tagging salmon.

Acknowledgements

We would like to thank the staff at Carson National Fish Hatchery for their assistance in implementing this study. Trailer supervisors, Pat Kemper and Tyson Lankford, operated the trailers, provided ponding plans, and collected samples for the tag retention portion of this study. We would also like to thank the experienced crew of markers that staffed the trailers. NOAA fisheries provided partial support through Mitchell Act funding. Use of trade names does not imply endorsement by the USFWS.

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Appendix A

Carson NFH 2008 CWT Proposed Marking and Ponding Plan

MG earth (upper dirt production)						MG raceway (raceway production fish)												Totals
18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
32,000	32,000	32,000	25,750 6,250 CWT 05-38-76	32,000	32,000	32,000	32,000	23,700 8,300 CWT 05-38-77	32,000	23,600 8,400 CWT 05-38-77	32,000	32,000	23,700 8,300 CWT 05-38-77	32,000	32,000	32,000	32,000	544,750 31,250
MG adult (production in adult pond)						**MG earth (lower dirt production)**												
36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	
32,000	19,500 12,500 CWT 05-41-81	32,000	32,000	32,000	19,500 12,500 CWT 05-41-81	32,000	25,750 6,250 CWT 05-38-76	32,000	32,000	25,750 6,250 CWT 05-38-76	32,000	32,000	25,750 6,250 CWT 05-38-76	32,000	32,000	32,000	32,000	532,250 43,750

South Fork Walla Walla River Transfers										Totals
37	38	39	40	41	42	43	44	45	46	
25,000	25,000	25,000	25,000	25,000 CWT 05-29-68	25,000	25,000	25,000 CWT 05-29-68	25,000	25,000	200,000 50,000

KEY	
1,077,000	Individual Pond Loading of Carson NFH Production (AD only
75,000	2008 Carson NFH Production (AD + CWT)
200,000	South Fork Walla Walla River fish transfers (AD only)
50,000	South Fork Walla Walla River (AD + CWT)
1,402,000	Total Ponding

Appendix B

Injury Ranking Guidelines

Type of Injury

<u>Head Injury</u>	
Eye:	Minor=slight discoloration, small tear in membrane Major=bulged, hemorrhaged, missing
Gill/Operculum:	Minor=minor bleeding, superficial damage to operculum/isthmus Major=severe bleeding, tearing, or creasing of opercle/gill arches, inverted gill arches, isthmus tear
Head (dorsal, above eye):	Minor=small head trauma, slight discoloration/indentation Major=severe head trauma, pronounced indentation, or disfigurement
<u>Body Injury</u>	
Body	Minor=small bruising/discoloration (<0.5cm) on one side Major=large bruising, widespread discoloration (>0.5cm) on at least one side
Descaling	Minor=<20% descaling on one side Major=≥20% descaling on one side
<u>Fin Injury</u>	Minor=split fin, small fraying at ends Major=multiple splits in caudal or dorsal fin, severe fraying, enough to impair swimming ability

Severity of Injury

1=No Injury Visible
2=Minor injury: visible but not life-threatening
3=Major Injury: visible, potentially life-threatening
4=Injury not due to marking, must be **obvious** (skeletal deformation, fungus/growth, emaciated)

Fin Mark Quality

1=Adipose fin mark (good), >75% of fin excised
2=Partial fin mark (poor), 25% to 75% of fin excised
3=No fin mark (poor), <25% of fin excised
4=Severe mark (poor), >100% of fin excised (gouge)