Evaluation of Electronic Detection for Coded-Wire Tags in Coho Salmon (*Oncorhynchus kisutch*)

by

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ABSTRACT

The purpose of this study was to evaluate electronic detection in a variety of tribal CWT sampling programs. Two types of equipment were tested: a hand held "Wand", and a stationary unit with a fish passage tube (R-8 tube). Sampling was conducted at 20 sites, representing a cross section of tribal CWT sampling situations. These included truck buyers, a buyer boat, buying stations, processing plants, hatcheries, and spawning grounds. The specific objectives of the study were:

1. Test the reliability of CWT electronic detection equipment
    a. Measure detection rates achieved during field sampling
    b. Evaluate equipment durability
2. Evaluate the feasibility of the equipment under different sampling situations
3. Compare sampling time and effort of electronic detection with traditional visual sampling methods.

Field tests revealed high detection rates for both types of equipment. The mean detection rate for all tests combined was 96.9 % for the tube and 99.3 % for the Wand. False detection rates for all tests combined was 2.0 % for the R-8 tube and 0.5 % for the Wand. It was found that fish that had sediment on the skin (e.g. fish that had been in contact with a river bank, truck bed, or pavement) could cause false detections with the R-8 tube, and to a lesser extent with the Wand. The rates of false electronic detection were compared with false detection rates from visual sampling (adipose marked but untagged fish). Although the results were inconclusive, these rates appeared comparable.

Practical use of the R-8 tube appeared limited to sites with level surfaces and clean, wet fish (e.g., processing plants, buying stations, and hatcheries). Calibration of the equipment is critical for both detecting tags and avoiding false detections. Use of the tube was not feasible at truck buyer sites for in-river fisheries. The use of a diverting gate with the tube seems essential to realize any significant advantages over the Wand. The Wand, although slower, can be more universally used. The Wand requires no set up time or calibration and would probably be the method of choice in situations with low fish numbers and at undeveloped sites.

Replacing the current method of visual sampling with electronic sampling will involve significant increases in time and effort. In electronic sampling each fish has to be lifted, and often moved, to be tested. Adaptations in processing plants (e.g. customized tables) should be considered to eliminate the need to lift and move each fish. These increases in time, handling, and movement of fish will undoubtedly be met with some resistance by commercial buyers, processors, and hatchery managers. Although limited paired testing was available, it appears that use of the R-8 tube may approximately double the time required to sample fish, and use of the Wand may double or triple the amount of time required for sampling. In order to maintain current sampling rates, increases in sampling staff will be required in many situations

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INTRODUCTION

Selective fisheries are now being proposed for hatchery stocks of coho salmon (*Oncorhynchus kisutch*). Prior to implementing a selective fishery, the hatchery stocks targeted for harvest must be marked with a visible external mark. A report by the Pacific Salmon Commission (PSC) Ad-hoc Selective Fishery Evaluation Committee (PSC, 1995) recommended the adipose fin as the best mark for hatchery fish because of cost, ease of recognition, and minimal mark induced mortality. Since no other mark was determined adequate for a visual identifier, and since the adipose fin mark is currently sequestered as a flag for fish with coded-wire-tags (CWTs), electronic detection was recommended as the alternate method of detecting CWTs. The report also emphasized the need to maintain the integrity of the coastwide CWT program. The CWT system is the most important stock identification technique used on a coastwide basis for chinook and coho management and research (Johnson 1990 and PSMFC 1992). Therefore, if selective fisheries are to be implemented, electronic sampling will have to be integrated into existing CWT sampling programs.

Two types of electronic detection equipment were evaluated: a hand held unit (Wand), and a stationary unit containing a fish passage tube (R-8 tube). The feasibility, reliability, and cost of detecting CWTs with this equipment has not been extensively evaluated.

The purpose of this study was to evaluate electronic detection in a variety of tribal CWT sampling programs. The specific objectives of the study were:

1. Test the reliability of CWT electronic detection equipment
    a. Measure detection rates achieved during field sampling
    b. Evaluate equipment durability
2. Evaluate the feasibility of the equipment under different sampling situations
3. Compare sampling time and effort for electronic detection of equipment compared to traditional visual sampling methods.

Tribal CWT sampling programs occur in a wide variety of logistical situations. These include truck buyers, buyer boats, buying stations, processing plants, individual fishermen, hatcheries, and spawning grounds. The two types of equipment were tested at numerous sites in an attempt to assess the feasibility of the equipment in situations representative of this variety. This study did not attempt to quantify the increases in cost and manpower that would be required in a transition to electronic CWT detection.

This research was part of a joint effort by the Washington Department of Fish and Wildlife (WDFW) and the Northwest Indian Fisheries Commission (NWIFC) to evaluate electronic detection for CWTs in coho salmon. The field work was funded under a Saltonstall-Kennedy grant (NA66FDO105).

SAMPLING LOCATIONS

Sampling was conducted at 20 sites (Table 1). These included truck buyers, a buyer boat, buying stations, processing plants, hatcheries, and spawning ground surveys. As the season progressed it became apparent that coho returns were generally depressed in Puget Sound but abundant on the coast. The actual sampling schedule was therefore often dictated by the availability of fish. It also became apparent that there was a geographical difference in the size of returning coho. Fish size of coastal Washington stocks was significantly larger than stocks from central and southern Puget Sound. Consequently, an attempt was made to include additional coastal sites for testing the equipment. The specific sites are described below.

Table 1. Tribal Sampling Sites for Testing CWT Electronic Detection Equipment in 1996.

Sampling Site	Fishery	Days of Sampling	Fish Sampled	Sampling Equipment
Puyallup River Truck Buyer	Puget Sound Net - Area 81B	15	1219	R-8, Wand
Arcadia Truck Buyer	Puget Sound Net - Area 13D	3	164	Wand
La Push Truck Buyer	Quillayute R. Net - Area 73H	1	63	R-8, Wand
Shilshole Marina Truck Buyer	Coho Test Fishery - Area 10	2	28	R-8, Wand
River Fish House - Lummi	Nooksack R. Net - Area 77B	1	241	Wand
Tulalip Bay Buyer Boat	Puget Sound Net - Area 8D	1	548	R-8
Olympic Fish - Neah Bay	In-River Net - Area 74C	4	513	R-8, Wand
San Juan Seafoods	Puget Sound Net	1	331	R-8
Quinault Processing Plant	Coastal Net	9	1209	R-8
Clear Creek Hatchery	Hatchery Rack	3	665	R-8, Wand
Kalama Creek Hatchery	Hatchery Rack	3	83	Wand
Lummi Bay Hatchery	Hatchery Rack	1	47	R-8
Salmon River Hatchery	Hatchery Rack	1	209	R-8, Wand
Makah NFH	Hatchery Rack	4	71	R-8, Wand
Quilcene NFH	Hatchery Rack	3	389	R-8, Wand
Quinault NFH	Hatchery Rack	3	1324	R-8, Wand
Grovers Creek Hatchery	Hatchery Rack	1	146	Wand
Tulalip Creek Pond	Hatchery Holding Pond	1	233	R-8
Coastal Rivers	Spawning Survey	1[a]	99	Wand
Salmon River	Spawning Survey	2	55	Wand

[a] Sampling occurred on numerous days in Quinault, Queets, Humptulips and Chehalis River drainages. All marked carcass snouts were removed and taken to the QfiD CWT lab for processing.

Truck Buyers

Puyallup River Truck Buyers

The Puyallup River fishery was targeted for sampling because CWT groups of coho, with and without adipose marks, would be returning. Samplers could therefore not rely on the adipose mark to indicate the presence of a CWT. Sampling occurred at a boat ramp and a bank site on the lower Puyallup River. Fish were from terminal net fisheries in Commencement Bay and the Puyallup River. The sampling situation is characteristic of other treaty in-river fisheries where individual fishermen bring their catch to a truck buyer.

Arcadia Truck Buyer

This site is representative of many truck buying situations in southern Puget Sound. At this particular site, fish from the Area 13D treaty fishery arrive at the buyer by boat and are placed into a buyer's scale hanging over the water. Fish are weighed and rinsed by the buyer.

La Push Truck Buyer

Approximately 2,000 coho from the Quillayute River fishery are annually sampled for CWTs by the Quileute Tribe. Sampling occurs in La Push at a truck buyer or at a fish processing plant. The fish processing plant was not operating on the day of sampling. The truck buyer was located in a parking lot adjacent to the marina at the mouth of the Quillayute River. As with the Puyallup truck buyers, fish are brought by vehicle to the site and sampling occurs between the scales and the iced totes in the truck.

Shilshole Marina Truck Buyer

Shilshole Marina is utilized as the buying location for fish from the South Puget Sound coho gillnet test fishery. This test fishery is annually conducted by the Suquamish and Muckleshoot Tribes. The fishery occurs for 3-5 nights over a one week period. Fish are sold to either truck buyers or boat buyers. Truck buyers are located on the pier above the docks, and fish are either carried up a steep ramp or hoisted by crane to the top of pier.

Buyer Boat

Tulalip Bay Buyer Boat

Sampling occurred aboard the tender *Integrity*, which was moored in Tulalip Bay while buying fish from the Tulalip Bay (Area 8D) treaty fishery. The boat was of typical size, if not larger, than other buyer boats in Puget Sound. Selling terminal area fish to a tender is a common practice in Puget Sound and the Strait of Juan de Fuca, but sampling these boats is logistically difficult and often done at the processor. However, tenders will often buy fish from different areas before off-loading at a processor. Since the fish can be from mixed fishery areas and mixed gears, sampling at the processor can cause problems for reporting and expanding CWTs, and result in a loss of data.

Buying Stations

River Fish House - Lummi

The River Fish House is a buying station on the Lummi Reservation, located on the west bank of the Nooksack River at Marietta. The building is small and narrow and has little room to spare for sampling activities. Fish are brought to the station by boat or truck. Fish are loaded into a weighing bucket on a hoist that travels the center of the building and extends past the doors on each end. Fish are then placed into iced totes for truck transport to processors. The site can receive high numbers of fish from the Nooksack River and Lummi Bay terminal fisheries.

Olympic Fish - Neah Bay

This processing plant / buying station handles high volumes of fish from numerous fisheries in the area. The sampling area is indoors and has ample room for equipment.

Processing Plants

San Juan Seafoods

This is a high volume fish processing plant located on the waterfront in Bellingham. Fish from numerous fisheries arrive by truck and boat. The site has concrete floors, water availability, and spacious working areas. Fish are currently sampled in a variety of ways at this site: tote to tote outside, tote to tote inside, on the cutting line, and on conveyer belts from buyer boats.

Quinault Processing Plant

This processing plant is located in Taholah and owned and operated by Quinault Tribal Enterprises. The plant processes a high volume of coho from all rivers where Quinault tribal net fisheries occur, including the Queets, Quinault, Copalis, Humptulips, and Chehalis. Fish arrive in totes, are labeled by river of origin, and iced down for temporary storage. CWT sampling occurs on totes of fish in a separate area of the plant prior to fish delivery to the butchering line. The site has concrete floors, water availability, and spacious working areas. The Quinault Fisheries Division (QFiD) staff conducts the CWT sampling operations at the plant.

Hatcheries

Hatchery Sites

Sampling was conducted at five tribal hatcheries: The Lummi Tribe's Lummi Sea Pond Hatchery, the Nisqually Tribe's Kalama Creek Hatchery, the Nisqually Hatchery at Clear Creek, the Suquamish Tribe's Grovers Creek Hatchery, and the Quinault Nation's Salmon River Fish Culture Facility. In order to increase the number of Wand tests, and to include more sites with larger fish, sampling was also conducted at the three USFWS National Fish Hatcheries (NFH) in the region. The Quilcene NFH was included because of the availability of fish from an early returning-run. The Makah and Quinault NFHs were included because of the opportunity to sample larger fish. All of the hatcheries included in this study conduct CWT sampling during routine spawning operations. Immediately after spawning, fish are observed for marks and marked fish are thrown to a separate area for processing. These hatcheries all had level, paved, and spacious areas for sampling.

Lower Tulalip Creek Pond

Fish returning to the Tulalip Salmon Hatchery pass over a fish ladder and enter a pond on lower Tulalip Creek. The pond is adjacent to Tulalip Bay and downstream of a spawning facility. The hatchery does not presently rely on returning fish for brood stock (eggs are obtained from the WDFW Wallace River Hatchery), and coho production is intended to support an intensive terminal fishery. Coho that escape the fishery and enter the pond are sampled for CWTs and surplused. To obtain these fish the pond is drawn down and the fish are seined onto the bank.

Spawning Surveys

Salmon River

Salmon River is a major tributary to the Queets River. The QFiD annually conducts coho spawning ground surveys where carcasses are sampled for CWTs. Because of returning CWT groups to the drainage, the River presents a good opportunity to encounter tagged carcasses.

Coastal Rivers - Laboratory Analysis

The QFiD also conducts coho escapement surveys and samples carcasses for CWTs on the Queets, Quinault, Humptulips and Chehalis Rivers. It has been suggested that if carcass encounter rates are low, it may be more efficient to remove all snouts in the field and conduct electronic sampling in the laboratory. To test this concept, snouts removed from marked carcasses on these rivers were sampled with the wand at the QFiD CWT recovery lab.

METHODS

Equipment Tested: Two types of electronic detectors were tested: a hand held unit that is rubbed on the snout of a fish (Wand), and a stationary unit containing a fish passage tube (R-8 tube). All equipment was manufactured by Northwest Marine Technology. A prototype deflecting gate for use on the end of the R-8 tube was available for occasional periods during the study. One R-8 tube and two Wands were available for most of the study period. When logistics permitted, both types of equipment were used on a group of fish.

The R-8 tube is rectangular in shape, measuring 30 cm in height, 39 cm in width, and 105 cm in length. The unit weighs approximately 34 kg. The unit is constructed with a central rectangular shaped tube running the length of the unit and is operated at an inclined position so that a fish placed in one end will slide out the other. Detected fish are indicated by an audible beep. The unit was mounted on a hospital gurney to make it semi-portable. The deflecting gate was designed to bolt onto the exit end of the tube and is electronically integrated with the unit. A positive detection activates a solenoid which opens a gate, directing tagged fish out at a different angle than undetected fish. The gate has a counter for automatically tallying both tagged and non-tagged fish. Prior to using the R-8 tube on a group of fish, the gain level indicator (light bar) was checked and set in accordance to the manufacturer's recommendation. A tagged fish was also sent through the tube to verify detection capability.

The Wand is 41cm in length and weighs 0.57 kg. To use the Wand, the fish was held by the gill area with one hand, and the end of the wand was rubbed on the snout to detect the presence or absence of a tag. All samplers were instructed to move the Wand in a brisk anterior to posterior motion, while moving across the snout area to one eye and back across to the other eye. The Wand is equipped with both a light and an audible signal to indicate a positive detection. The Wand does not have the ability to automatically count fish. Since the unit is highly sensitive to electro-magnetic fields, the user must be careful to avoid having metal objects (e.g. watches, jewelry, metal surfaces) close to the tip of the Wand.

Data Collection: Sampling was classified as either "non-sorted" or "sorted". In **non-sorted** tests the fish had not been pre-sampled for marks (adipose fin clips). The intent of this type of testing was to determine the CWT detection rate achieved by samplers using the equipment in actual fishery situations. Wand samplers were instructed not to look for adipose marks until after a group had been electronically sampled. Despite the fact that samplers were experienced CWT samplers and accustomed to looking for adipose marks, they did not have a problem conducting this procedure.

Sorted tests refer to situations where testing occurred on groups of fish that were adipose marked (i.e. mark sampling had occurred and adipose clipped fish had been separated out). Because the sampler knew that there was a high probability that each fish carried a tag, these tests were recorded separately to compare results between the two types of sampling. Sorted tests were only conducted with Wands at hatchery sites and escapement surveys.

Snouts were removed from all fish that registered a positive detection, and from all fish that had an adipose mark. As with current CWT sampling procedures, snouts were removed from fish if there was any question about the possibility of the adipose fin indicating a mark. All removed snouts were sent to a CWT recovery laboratory for dissection, tag verification, and code reading.

Sampling at the Quinault Processing Plant and the coastal escapement surveys was conducted by QFiD CWT sampling staff. All other sampling was conducted by NWIFC Fisheries staff. Field sampling was often coordinated with tribal CWT sampling staff in order to solicit their opinions upon observing the equipment. Survey forms were used for recording observations on feasibility. Prior to field testing, a training session was conducted for WDFW and tribal staff to standardize the use of equipment

Data were collected and recorded in a manner which allowed the data to be used in ongoing CWT sampling programs. Modified CWT sampling forms were used for recording data on individual fish and sample groups. Fish from Puget Sound sites were processed by the WDFW CWT lab, fish sampled by QFiD staff were processed by the QFiD CWT lab, and fish sampled at the National Fish Hatcheries were processed by a combination of the USFWS and the WDFW CWT labs.

Timed Tests For Sampling Rates: In order to evaluate the additional time required to conduct electronic sampling, timed tests were conducted to measure sampling rates (fish per minute) for the different methods of sampling. The sample design was for one sampler to conduct sequential tests (electronic vs. visual method) on groups of 100 fish at a given site.

Analysis: In analyzing sampling detection rates, the following statistics were used: ***Detection Rate, False Electronic Detection Rate,*** and ***False Visual Detection Rate***. These rates are defined as follows:

Detection Rate = % of tagged fish detected by the equipment:

$$\frac{\text{\# fish with tags electronically detected}}{\text{\# fish with tags}} \times 100$$

False Electronic Detection Rate = % of untagged fish where equipment indicated a detection but no tag was found during lab dissection:

$$\frac{\text{\# false tag detections}}{\text{\# untagged fish}} \times 100$$

False Visual Detection Rate = % of adipose fin marked fish that did not have a tag:

$$\frac{\text{\# untagged fish with an adipose mark}}{\text{\# untagged fish}} \times 100$$

RESULTS

Detection Rates

Testing of electronic detection equipment occurred from August 23, 1996 to January 9, 1997 at the 20 sampling sites (Table 1). Results of CWT detection rates, by sampling sites, are presented in Tables 2 - 4. Results are further summarized by equipment (Table 5) and by sampling location type (Table 6). Three of the sites had high false detection rates attributed to excessive sediment acquired on the fish during the sampling process. These included R-8 tube testing at Tulalip Creek Pond and Lummi Bay Hatchery, and Wand testing at Salmon River Hatchery. Since these tests involved equipment or procedures that would probably not be used in a future electronic sampling scenario, false detection rates from these sites were not included in the overall means reported for each type of equipment.

Table 2. Results of Tribal Field Tests of the Wand and R-8 Tube in Combination in 1996.

COMBINED WAND AND R-8 TUBE TESTS																
			CWTs Present with Ad Mark		CWTs Detected with Ad Mark		CWTs Missed with Ad Mark		CWTs Detected without Ad Mark		False Detections			Detection Rate (%)		False Detection Rate (%)	
Sampling Site		Fish Sampled	Wand	R-8	Wand	R-8	Wand	R-8	Wand	R-8	Wand	R-8		Wand	R-8	Wand	R-8
		(Non-Sorted Fish)															
Puyallup Truck Buyer		246	11	11	11	11	0	0	1	1	0	0		100	100	0.0	0
La Push Truck Buyer		63	0	0	0	0	0	0	0	0	0	5[a]		N/A	N/A	0.0	7.9[a]
Shilshole Truck Buyer		28	2	2	2	2	0	0	0	0	1[b]	0		100	100	3.8[b]	0
Olympic Fish		147	17	17	17	17	0	0	0	0	0	0		100	100	0.0	0
Quinault NFH		513	75	75	75	75	0	0	0	0	0	0		100	100	0.0	0
	Totals	997	105	105	105	105	0	0	1	1	1	5	Mean	100	100	0.76	1.6
		(Sorted Fish)															
Quilcene NFH		59	46	46	46	46	0	0	N/A	N/A	0	0		100	100	N/A	N/A
Makah NFH		42	27	27	27	27	0	0	N/A	N/A	3[a]	2[a]		100	100	N/A	N/A
	Totals	101	73	73	73	73	0	0			3	2	Mean	100	100		

[a] Affected by sediment on fish
[b] Metallic object found in head

Table 3. Results of Tribal Field Tests of the R-8 Tube Detector in 1996.

R-8 TUBE TESTS (All Fish Non-Sorted) Sampling Site	Fish Sampled	CWTs Present with Ad Mark	CWTs Detected with Ad Mark	CWTs Missed with Ad Mark	CWTs Detected without Ad Mark	False Detections		Detection Rate (%)	False Detection Rate (%)
Tulalip Bay Buyer Boat	548	21	18	3	0	1 [b]		85.7	0.2 [b]
Olympic Fish	261	39	32	7	1	19 [a]		82.1	8.6 [a]
San Juan Seafoods	331	11	10	1	0	0		90.9	0.0
Quinault Plant	1209	52	51	1	0	32		98.1	2.8
Clear Creek Hatchery	183	8	8	0	0	0		100.0	0.0
Lummi Bay Hatchery	47	3	3	0	0	3 [c]		100.0	N/A [c]
Salmon River Hatchery	110	9	9	0	0	3		100.0	3.0
Tulalip Creek Pond	233	9	9	0	0	20 [c]		100.0	N/A [c]
Totals	2,922	152	140	12	1	78	Mean	94.6	2.4

[a] Affected by sediment on fish
[b] Fish hook in head
[c] Sampling affected by sediment and not included in overall mean reported for each type of equipment

Table 4. Results of Tribal Field Tests of the Wand Detector in 1996.

WAND TESTS Sampling Site	Fish Sampled	CWTs Present with Ad Mark	CWTs Detected with Ad Mark	CWTs Missed with Ad Mark	CWTs Detected without Ad Mark	False Detections		Detection Rate (%)	False Detection Rate (%)
(Non-Sorted Fish)									
Puyallup Truck Buyer	973	63	63	0	15	7		100.0	0.8
Arcadia Truck Buyer	164	6	6	0	0	0		100.0	0.0
River Fish House	241	5	5	0	0	0		100.0	0.0
Olympic Fish	105	12	12	0	0	1		100.0	1.1
Clear Creek Hatchery	353	15	15	0	0	0		100.0	0.0
Salmon R Hatchery	99	9	8	1	0	12 [c]		88.9	NA [c]
Quinault NFH	811	38	38	0	0	5		100.0	0.6
Grovers Creek Hatchery	146	15	15	0	0	0		100.0	0.0
Salmon River Survey	55	3	3	0	0	0		100.0	0.0
Totals	2,947	166	165	1	15	25	Mean	98.8	0.3
(Sorted Fish)									
Clear Creek Hatchery	129	87	87	0	N/A	2		100.0	N/A
Kalama Creek Hatchery	83	68	68	0	N/A	3		100.0	N/A
Makah NFH	29	26	26	0	N/A	1		100.0	N/A
Quilcene NFH	330	264	262	2	N/A	2		99.2	N/A
Coastal River Surveys	99	82	80	2	N/A	0		97.6	N/A
Totals	670	527	523	4		8	Mean	99.4	

[c] Sampling affected by sediment and not included in overall mean reported for each type of equipment.

Table 5. Summary Results of Tribal Field Tests of the R-8 Tube and Wand CWT Detectors in 1996.

Sampling Equipment	Number of Fish Sampled	Mean Detection Rate (%)	Mean False Detection Rate (%)
R-8 Tube	4020	96.9	2.0
Wand	4715	99.3	0.5

Table 6. Summary Results of Tribal Field Tests of Electronic Detection Equipment, by Sample Location Type, in 1996.

R-8 TUBE TESTS Sampling Location Type	Fish Sampled	CWTs Present with Ad Mark	CWTs Detected with Ad Mark	CWTs Missed with Ad Mark	CWTs Detected without Ad Mark	False Detections		Detection Rate (%)	False Detection Rate (%)
Truck Buyers	337	14	14	0	1	5		100.0	1.6
Boat Buyer	548	21	18	3	0	1		85.7	0.2
Buying Stations	408	56	49	7	1	19		87.5	5.4
Processing Plants	1540	63	61	2	0	32		96.8	2.2
Hatcheries	1187	194	194	0	0	28		100.0	2.8
Totals	4,020	348	336	12	2	85	Mean	94.0	2.4

WAND TESTS Sampling Location Type	Fish Sampled	CWTs Present with Ad Mark	CWTs Detected with Ad Mark	CWTs Missed with Ad Mark	CWTs Detected without Ad Mark	False Detections		Detection Rate (%)	False Detection Rate (%)
Truck Buyers	1474	97	97	0	15	8		100.0	0.6
Buying Stations	493	34	34	0	0	1		100.0	0.2
Hatcheries	2594	670	667	3	0	28		99.6	1.5
Escapement Surveys	154	85	82	2	0	0		97.6	0.0
Totals	4,715	886	880	5	15	37	Mean	99.3	0.6

R-8 Tube: Detection rates for R-8 tube tests ranged from 82.1 to 100 % with a mean detection rate of 96.9 % for all sample sites combined (Table 5). A total of 12 tags were missed, the majority of which occurred during two sampling events. Three of these tags occurred on the Tulalip Bay buyer boat. Although it is unknown why the fish were missed, one possibility is that the sensitivity (gain) was adjusted too low because of electrical / magnetic interference from the metal boat or associated equipment. Seven of the missed tags occurred consecutively during a timed test at the Olympic Fish buying station at Neah Bay. The sampler was unable to identify a reason for the failure, and all of the fish tested positive with the Wand.

False detection rates varied from 0.0 to 8.6 % at the sites. Early in the study it became apparent that sediment on fish could cause false detections when using the R-8 tube. This was found to be a common problem with fish from in-river fisheries, where some of the fish had come in contact with sand or mud. An example of this correlation between sediment and false detections was observed at the Lummi Bay Hatchery. Anesthetized live fish were tested on a cement area adjacent to the beach. During sampling three unmarked fish squirmed out of the hands of the sampler and onto the concrete. The fish picked up some sand and all three produced false detections. These fish were rinsed and re-tested correctly by the R-8 tube. The washing and re-testing of fish was also found to eliminate or minimize false detections at other sites: Olympic Fish, La Push, and Tulalip Creek Pond. Although not quantified, observations led to speculation that the magnetism of the sediment may also vary from site to site.

Wand: Detection rates for the Wand ranged from 88.9 to 100 % with a mean detection rate of 99.3% for all sample sites combined (Table 5). Only five tags were missed by the Wand.

Overall false detection rates (Table 5) were lower with the Wand (0.5 %) than the R-8 tube (2.0 %). As with the R-8 tube, false detections varied among sites and ranged from 0.0 to 3.8%. Almost half of the total false detections (12 of 25) came from a test at the Salmon River Hatchery. At locations where both types of equipment were used there were mixed results. Although the Wand did not seem to give false detections at commercial sites where the R-8 tube did (e.g., Olympic Fish and LaPush), it did produce higher numbers of false detections at two hatchery sites: Salmon River Hatchery and Makah NFH. However, the difference between equipment at Salmon River was undoubtedly a result of the difference in fish tested by the two types of equipment. The fish that were sampled with the R-8 tube were clean fish taken from a tote. The fish that were sampled with the Wand had fallen on muddy ground prior to being tested, and the sampler noted that these fish gave only a weak and intermittent signal. The reason for the false detections at Makah NFH is unclear. Although the fish were not noticeably dirty, the sampler washed the fish and re-testing eliminated the false detections. Because of a similar situation with false detections of Sooes and Waatch River fish at the Olympic Fish site, it is speculated that the sediment in the area is highly magnetic.

Metal objects within fish (other than CWTs) can also produce false CWT detections. This occurred on at least two fish and were the result of a fish hook and a piece of metal. It is probable that some of the other false detections were caused by hooks not lodged in the snout. For example, a partial fish hook in the side of a fish registered a detection with the R-8 tube at the Quinault Processing plant. Because the hook was visible, it was removed and the fish was not recorded as a false detection.

R-8 Diverter Gate: The R-8 diverter gate was only available for intermittent periods throughout the sampling period. When it was working, the gate appeared to perform well, but no extensive testing was conducted on its accuracy.

Comparison of Electronic and Visual False Detections

Under current visual CWT sampling, a certain percentage of fish will be adipose marked, but untagged. The majority of these "false visual detections" probably result from the following: 1) Tag loss - a low percentage of tagged fish shed their tags between the time of tagging and release. This tag loss is measured and accounted for by adjusting the number fish released for each tag code; and 2) A low percentage of fish will return with damaged, deformed, or naturally missing adipose fins. Since CWT samplers are instructed to remove the snout of any fish with a questionable adipose mark, these untagged fish are sampled and processed by the tag recovery labs. These untagged fish are ignored in the use of CWT data, since analysis is only based on actual CWT recoveries. However, an increase in extra snouts would require additional work for samplers and tag recovery labs. Fish buyers would also prefer to minimize the number of snouts removed. The rate of false detections in electronic sampling is therefore an issue of interest.

Results of a comparison between the rate of false electronic detections and the rate of "false visual detections" (# marked but untagged) are presented in Table 7. The results indicate that the number of false detections (untagged snouts) would increase for the sites sampled with the R-8 tube, and would decrease at the sites sampled with the Wand. However, the calculations were largely influenced by the results of a few sites with high rates, and are therefore inconclusive.

Table 7. Comparison of False Electronic and False Visual Detection Rates in 1996 Field Tests.

R-8 Tube Tests

Sampling Site	Fish Sampled	False Electronic Detection Rate (%)	False Visual Detection Rate (%)
Puyallup River Truck Buyer	246	0.0	0.4
La Push truck Buyer	63	7.9	0.0
Shilshole Marina Truck Buyer	28	0.0	0.0
Tulalip Bay Buyer Boat	548	0.2	0.2
Olympic Fish - Neah Bay	408	4.7	0.9
San Juan Seafoods	331	0.0	0.0
Quinault Processing Plant	1209	2.8	1.8
Clear Creek Hatchery	183	0.0	0.0
Salmon River Hatchery	110	3.0	5.0
Quinault NFH	513	0.0	2.7
	Mean	1.9	1.1

Wand Tests

Sampling Site	Fish Sampled	False Electronic Detection Rate (%)	False Visual Detection Rate (%)
Puyallup River Truck Buyer	1219	0.6	0.5
Arcadia Truck Buyer	164	0.0	0.0
Shilshole Marina Truck Buyer	28	3.8	0.0
River Fish House - Lummi	241	0.0	0.4
La Push Truck Buyer	63	0.0	0.0
Olympic Fish - Neah Bay	252	0.5	0.0
Clear Creek Hatchery	353	0.0	0.9
Quinault NFH	1324	0.4	2.0
Grovers Creek Hatchery	146	0.0	1.5
Salmon River Survey	55	0.0	7.7
	Mean	0.5	1.3

Equipment Durability

Two equipment failures occurred with the Wand, requiring the units be returned to the manufacturer. Moisture in the battery compartment also resulted in adopting a daily maintenance procedure to remove moisture from the compartment. No mechanical problems occurred with the R-8 tube. Numerous problems initially occurred with the prototype gate which limited its availability. Its construction did not seem durable enough for long term use. Battery longevity was good for both units. A list of recommended improvements was forwarded to the manufacturer.

Feasibility Assessment

The results and observations from the field tests allow a qualitative assessment of the appropriateness of the equipment for each sampling situation. A description of the sampling logistics and an assessment of the equipment is described below for each site. This assessment is summarized as recommendations in Table 8.

Table 8. Assessment of CWT Electronic Detection Equipment Feasability in 1996 Tribal Field Tests.

		Recommended Equipment			
Sampling Site	Fishery	R-8	Wand	Either[a]	Undetermined
Puyallup River Truck Buyer	Puget Sound Net - Area 81B		✓		
Arcadia Truck Buyer	Puget Sound Net - Area 13D		✓		
La Push Truck Buyer	Quillayute R. Net - Area 73H		✓		
Shilshole Marina Truck Buyer	Coho Test Fishery - Area 10			✓	
Tulalip Bay Buyer Boat	Puget sound Net - Area 8D				✓
River Fish House - Lummi	Nooksack R. Net - Area 77B			✓	
Olympic Fish - Neah Bay	In-River Net - Area 74C	✓			
San Juan Seafoods	Puget Sound Net	✓			
Quinault Processing Plant	Coastal Net	✓			
Clear Creek Hatchery	Hatchery Rack			✓	
Kalama Creek Hatchery	Hatchery Rack			✓	
Lummi Bay Hatchery	Hatchery Rack			✓	
Salmon River Hatchery	Hatchery Rack			✓	
Makah NFH	Hatchery Rack			✓	
Quilcene NFH	Hatchery Rack			✓	
Quinault NFH	Hatchery Rack			✓	
Grovers Creek Hatchery	Hatchery Rack			✓	
Tulalip Creek Pond	Hatchery Pond		✓		
Salmon River	Spawning Surveys		✓		
Coastal Rivers	Spawning Surveys		✓		

[a] Dependent on number of fish and sampling logistics.

Puyallup River Truck Buyers: Sampling occurred on 10 days between September 3 and September 26. Fish were transferred from the buyer's scale or tote, sampled by either Wand or R-8 tube, and returned to the buyer's tote. Fish were very small, with an average fork length of 53 cm for the marked fish. Running water was not available at the sampling areas and sand or mud was present on some fish. Although false detections were not a problem, the relative dryness of the fish and friction from the grit prevented fish from sliding through the tube. This proved to be an insurmountable problem for the R-8 tube. Samplers even attempted to "throw" fish down the R-8 tube to achieve the desired velocity for proper detection. Use of the R-8 tube was quickly terminated and the majority of sampling was conducted with the Wand.

Under the current conditions, and with the current R-8 tube, the Wand is the only feasible piece of equipment for sampling at this site. Results indicated high detection rates and acceptable false detection rates (Table 4). The portability of the Wand, and the ability to sample inside a tote where fish had already been iced, were also necessary for this sampling situation. The equipment manufacturer has indicated that the next model of the R-8 tube will have a teflon coated tube to reduce friction. It is unknown how much of difference that will make for "dry" fish.

Arcadia Truck Buyer: For sampling at this site, fish were placed in floating totes, electronically sampled, and returned to the buyer's truck. All fish were either visually sampled or sampled with a Wand. The R-8 tube was not tested because WDFW was conducting testing of that equipment at the site. Sampling was conducted on three separate days and a total of 164 fish were sampled. Results showed that the Wand detected all tags and had no false detections (Table 4).

The Wand seemed feasible for this type of sampling. As with current visual CWT sampling, fish could be sampled directly from the scale to the buyers tote. However, timed tests of sampling rates (Table 9) indicated that use of the Wand approximately doubled the amount of sampling time.

La Push Truck Buyer: A total of 63 fish were sampled with the R-8 tube and Wand. Some of the fish were dry, had noticeable sediment on the skin, and did not slide easily through the R-8 tube. Although there were no CWT fish in the sample, five false detections occurred (12.5%). These fish were sampled with a Wand and tested negative. The fish were then washed and re-tested with the R-8 tube, resulting in no false detections.

It was evident that magnetic sediments occurred on some of the fish sampled from the river fishery. Washing fish to minimize false detections may not be practical at the truck buying location. The Quileute Tribe operates their own CWT recovery lab and the extra untagged snouts would impact the efficiency of their lab. A Wand detector should be feasible for sampling at this site. Additionally, the sample numbers may not require an R-8 tube for this site. Sampling at the processing plant should be feasible with either the Wand or R-8 tube.

Shilshole Marina Truck Buyer: Sampling occurred on two days, with a total of only 28 fish sampled. Fish were sampled from the weighing bucket into totes, which were then carried to the truck by fork lift. The Wand and R-8 tube were both used and functioned well at the site.

Because of the low numbers of fish, timed sampling rate tests were not conducted. It was interesting to find that the Wand indicated a detection in an unmarked fish where the R-8 tube did not. Analysis at the tag recovery lab found a small piece of rusted metal embedded behind the eye of the fish.

If the fish are brought to the top of the pier, the volume of fish would influence which piece of equipment would be most efficient. The area is level and spacious with water available for R-8 tube sampling. If fish are bought by a buyer boat, sampling would have to be conducted with the Wand. The ramp is too narrow and steep, and the walkways are too cramped for use of the R-8 tube.

Tulalip Bay Buyer Boat: For this one day sample, two samplers attempted to electronically sample the catch as it came on board the tender. A Wand and R-8 tube were transported to the vessel via a small gillnet boat. Three people were needed to lift the R-8 tube (without gurney), over the ship's gunnels to the deck. This was a precarious task and if sampling of this type is repeated, a safer method for man and machine must be found. Fish are loaded from boats into weighing nets lowered by hoist over the side by the tender. The tender normally lifts and weighs the load, swings the net over the open hatch, and deposits the catch into the hold. For this test the fish were spilled to either side of the hatch, enabling sampling on the deck and moving undetected fish directly into the hold.

The Wand malfunctioned immediately and could not be tested. The R-8 tube, with deflector gate, was positioned partially over the hold so that undetected fish fell into the hold and the detected fish fell into a tote on deck. Because of the need to recover all marked but undetected fish, the second sampler was alerted when a marked fish passed through the R-8 tube. All marked but undetected fish were caught in a net for snout removal and lab analysis. The R-8 tube was moved from side to side to process fish from both sides of the boat. A design modification to the deflector gate, allowing a choice of which side detected fish exit, would have made this easier. In a timed test this site had the fastest sampling rate recorded for tests of the R-8 tube (12.1 fish per minute). However, the R-8 tube was unable to keep up with the buying of fish, and when there were too many fish scattered about the boat deck the skipper moved some fish directly to the hold. Approximately 80% of the catch was sampled during the test.

The R-8 tube missed three CWTs during this sampling. As discussed under Detection Rates, it is unknown why the tags were missed. Care was taken to catch all of the undetected marked fish as well as keep an eye on the accuracy of the deflector. One possibility is that the sensitivity of the R-8 tube was adjusted too low, because of electrical / magnetic interference from the metal boat or associated equipment. Additional testing is needed to determine if the R-8 tube can provide reliable detection under these conditions. Because of logistics and space constraints the Wand may be more feasible for use on buyer boats.

River Fish House - Lummi: Wand sampling was conducted from tote to tote, and a total of 241 fish were sampled. All CWTs were correctly detected and no false detections were registered. Sampling with the R-8 tube was not conducted because of space constraints within the current building configuration.

If space was allotted for the operation of a tube, this would probably provide the most efficient sampling at this site. A table constructed for the R-8 tube would enhance its use, especially if the bucket could be dumped directly onto the table. Water was available if fish needed to be washed. The space required by an R-8 tube and table would reduce the storage capacity of the building by 2 - 4 totes. The Wand detected tags accurately, but it is doubtful that it could keep up with the volume of fish during a busy season.

Olympic Fish - Neah Bay: Sampling was conducted on four days from October 14 - 30, 1996. During this time, fish from the Sooes and Waatch River fisheries were bought at this site. Fish were brought in by individual fishermen, unloaded into carts for weighing, and sorted into graded totes for shipping to another processing plant. Sampling occurred between fish weighing and grading. The fish were large, with an average fork length of 69 cm for the marked fish.

In one of the R-8 tube timed tests, seven consecutive CWTs were missed. As discussed under Detection Rates, the sampler was unable to identify a reason for the R-8 tube failure to detect the tags. The sampler suspected that tags were being missed and tested the marked fish with a Wand. All of the fish tested positive with the Wand. The R-8 tube also had problems with false detections at this site. Although sediment did not appear to be a significant problem, it was noticed in some batches of these fish from the Sooes and Waatch Rivers. Washing the positive fish and re-sampling with the R-8 tube would increase the sampling time but improve accuracy. Since this is a high volume plant, handling fish from many fisheries, the R-8 tube should be the most efficient piece of equipment. This was not indicated by the results of the sampling rates tests, due to the additional time to wash and re-test the fish when using the R-8 tube. It is assumed that fish from marine fisheries would not present a problem with sediment. Sampling with the R-8 tube would be facilitated by construction of a custom table. The Wand did function well at the site, and could be used on low volume days.

San Juan Seafoods: On the day of sampling, two totes of fish were set aside from the cutting line. Fish were sampled from tote to tote with an R-8 tube and diverter gate. A total of 331 coho were sampled, with one missed tag and no false detections. It is unknown why the R-8 tube missed the tag. A Wand was used to re-sample the marked fish, and it detected all of the CWTs.

The high volume of fish makes this an unlikely site for Wand usage. This is another location where a sampling table could be designed to facilitate R-8 tube efficiency and reduce excessive strain and fatigue on the samplers. Since the plant is noisy, modifications to the R-8 tube will need to be made to enable samplers to hear or see detected fish by the machine. Faster processing speed or two machines may be necessary if the R-8 tube is to be used in conjunction with the cutting table production line. Configuration within the cutting table processing line would be a logical step for achieving efficient sampling at this site.

Quinault Processing Plant:
Testing of the R-8 tube was conducted on eight days between September 16 and October 24, 1996. A total of 16 lots of coho were tested, ranging from 36 to 184 fish, for a total of 1,209 fish. This total compares to the number of coho that might be sampled during a single day's catch sampling session during the fall when high volumes of fish are delivered to the plant. Sampling occurred under what could be describes as ideal conditions. There was no pressure to

sample quickly and the area was spacious, covered, and well lighted. Ice did not cling to the fish, and the fish were clean and wet when passed through the tube. The diverter gate was not available for the testing.

The size of coho returning to coastal rivers was larger than average in 1996. Marked fish had a mean fork length of 73 cm and a mean weight of 5.16 kg (11.36 lb.). The largest coho would not fit through the tube. These fish, five out of the 1,209, were in the 18 to 20 pound size range. Coho from 15 to 18 pounds were frequently encountered and often would not slide through the tube unaided. This was not viewed as a desirable situation for fish handling or CWT detection.

As with the other high volume buying stations/processing plants, a customized table would increase the efficiency of handling and processing of coho at the plant. This could take the form of an elevated sorting table designed to receive a tote-full of fish delivered by a fork lift. This would eliminate the need to bend over, pick up, and place each fish into the tube, and would allow the sampler to simply slide fish down a ramp into the tube.

Hatcheries

A total of 3,199 fish were sampled at nine tribal and USFWS hatcheries. Sampling included both sorted and non-sorted groups. Both pieces of equipment were tested, and both proved to be accurate at detecting CWTs with low false detection rates. It is assumed that the low rate of false detections is correlated with clean carcasses containing little sediment. The only exceptions were at the Makah NFH and Salmon River (discussed under Detection Rates), where sediment was an obvious factor. The only R-8 tube false detections registered at a hatchery site (aside from testing at the Tulalip Creek Pond) occurred at the Lummi Bay Hatchery. The circumstances surrounding these false detections were also sediment related and discussed under Detection Rates.

The appropriate equipment for specific hatcheries will be dependent on the volume of fish being processed. In general, the R-8 tube with a diverter gate would probably require less physical effort than the Wand and would therefore be more desirable at most production facilities. However, on days when relatively few fish are being spawned, or at sites with low return numbers, a Wand may be more convenient.

Lower Tulalip Creek Pond: Sampling with the R-8 tube was attempted on one day at the site. The hill was too steep to transport the machine down to the water's edge and there was no feasible area to sample the fish near the shore. Fish were moved up the hill and placed in a truck but were too muddy and dry to easily slide down the R-8 tube. A water supply was not readily available so it was decided that sampling should be moved to the hatchery (2 miles away) where a hose was available. At the hatchery, a trickle of water was directed at the R-8 tube entrance to lubricate the equipment so the fish could slide down the R-8 tube at the recommended minimum velocity (1.5 meters per second). The sediment on the fish caused enough friction that a board was needed under the wheels of the gurney to increase the angle of the slide to achieve the necessary velocity.

A total of 233 coho were sampled, and the R-8 tube registered 29 detections of which only 9 were adipose clipped. The 29 detected fish were washed under strong water pressure and rubbed

by the sampler's hands. The fish were again passed through the R-8 tube. This time 11 were detected, two of which were unmarked. The 2 non marked fish were scanned over the entire body with the Wand and did not register a detection. Although it is unknown why the R-8 tube detected these 2 fish, it is assumed that enough magnetic sediment remained on or in the carcass for the R-8 tube to register a tag. The sediment particles and their associated magnetism may not have been individually large or strong enough to register with the Wand but as a whole caused the R-8 tube to register a detection.

With the current sampling scheme involving seining fish from the pond, washing of fish would be required for effective use of the R-8 tube. Although further testing may be necessary for this site, the Wand appears to be the only potentially feasible equipment for the current situation.

Salmon River Spawning Surveys: A Wand was carried on the field surveys and used to sample carcasses. Sampling occurred on two day and 55 coho were sampled. Snouts were removed from all marked fish for laboratory analysis. Three tags were correctly detected and there were no false detections. Staff did not experience any problems with the operation of the Wand.

Queets, Quinault, Humptulips and Chehalis Rivers Spawning Surveys: QFiD staff collected 99 heads from marked coho carcasses sampled during routine spawning surveys on streams in these coastal river systems. Surveys were performed from October 21 through December 27, 1996. The Wand was used to test the snouts for tags at the QFiD CWT lab. Eighty two of the snouts contained tags, two of which were missed by the Wand.

Timed Tests For Comparing Sampling Rates Between Equipment

Results of timed sampling rates are presented in Table 9. The low fish numbers, and the unpredictable availability of fish, hampered efforts to conduct the paired test design at many of the sites. Comments on these tests listed below.

Puyallup River Truck Buyers: Numerous tests of the Wand were conducted but no comparative visual tests were achieved. Timed visual tests were conducted by WDFW crews working in the vicinity and may be appropriate for comparison.

Arcadia Truck Buyer: Both visual and wand tests were achieved. Results indicated that the visual sampling rate was approximately twice as fast as sampling with the wand.

Tulalip Bay Buyer Boat: The timed test of the R-8 tube test was performed with the use of two people. Unfortunately, fish buying stopped before a comparative visual test could be timed. The result of the R-8 tube test revealed that this site had the fastest sampling rate recorded of all the sites timed for the R-8 tube (12.1 fish per minute). This was partly a result of having the diverting gate operational for this test.

Table 9. Results of 1996 Timed Tests for Comparing Sampling Rates for Different Methods of CWT Detection.

Sampling Site	Sampling Method	Number Sampled	Sampling Time (Minutes)		Sampling Rate (Fish per Minute)
Puyallup River Truck Buyer	Wand	107	8.58		12.47
		90	7.26		12.40
		104	8.53		12.19
		162	17.51		9.25
		75	10.36		7.24
		61	6.76		9.02
				Mean	10.43
Arcadia Truck Buyer	Visual	313	10.88		28.77
		118	4.52		26.11
				Mean	27.44
	Wand	164	12.04		13.62
Tulalip Bay Buyer Boat	R-8[a]	346	30		11.53
		202	16		12.63
				Mean	12.08
Olympic Fish - Neah Bay	Visual	94	5.93		15.85
		103	7.48		13.77
		147	12.00		12.25
				Mean	13.96
	Wand	40	8.00		5.00
		65	13.00		5.00
				Mean	5.00
	R-8	25	5.00		5.00
		100	14.31		6.99
		107	13.58		7.88
		23	6.00		3.83
		6	2.00		3.00
				Mean	5.34
Clear Creek Fish Hatchery	Wand	353	35.38		9.98
	R-8	183	24.25		7.55
Makah NFH	Wand	12	2.06		5.83
		19	2.15		8.84
				Mean	7.33
	R-8	19	2.80		6.79
Quilcene NFH	Wand	176	19.31		9.11
Quinault NFH	Wand	336	33.58		10.01
		475	47.50		10.00
				Mean	10.00
Grovers Creek Fish Hatchery	Visual	129	12.00		10.75
	Wand	129	17.00		7.59
Tulalip Creek Pond	R-8[a]	222	30.88		7.19

[a] Fish sampled by R-8 with diverter gate

Olympic Fish: Timed tests were conducted for visual, Wand, and R-8 tube sampling rates (Table 9). Fish were visually sampled at an average of 11.5 fish per minute, "wanded" at an average of 5.0 fish per minute, and "tubed" at an average of 5.3 fish per minute. Timed tests were conducted for visual, Wand, and R-8 tube sampling rates (Table 9). Fish were visually sampled at an average of 11.5 fish per minute, "wanded" at an average of 5.0 fish per minute, and "tubed" at an average of 3.4 fish per minute. Although the R-8 tube was only slightly faster than the Wand, the tube tests included washing and re-sampling of falsely detected fish. The average rate recorded for the R-8 tube was also influenced by three tests with small sample sizes. Sampling with the tube requires more calibrations and adjustments, and the small sample sizes reflect the decreases in efficiency when using the equipment on small groups.

Hatcheries: At most of the hatcheries, CWT sampling is currently incorporated into the spawning process. After spawning, marked fish are tossed to a separate area. The time required to sort out marked fish is almost negligible. The results of timed sampling rate tests (Table 9) can therefore be considered as the additional time required to use electronic sampling equipment. Exceptions were the Grovers Creek Hatchery and the Tulalip Creek Pond. At the Grovers Creek Hatchery, fish are sorted prior to spawning and comparative visual and Wand tests were conducted.

Tulalip Creek Pond: The use of the R-8 tube at the Tulalip Creek Pond was problematic (see description under Feasibility), and the fish were transported to the hatchery site where running water was available. Although the setting was artificial, a timed test was conducted on the 233 fish. The initial sample took 23 minutes and 23 seconds with many false detections. The washing and re-sampling of the fish took an additional 7 minutes and 30 seconds.

CONCLUSIONS

Detection Rates: Field tests revealed high detection rates for both types of equipment. Detection rates for the R-8 tube ranged from 82.1 to 100 % with a mean of 96.9 % for all tests combined. Detection rates for the Wand tests ranged from 88.9 to 100 % with a mean of 99.3% for all tests combined. There were two sampling situations where a relatively high percentage of tags were missed with the R-8 tube: sampling on a buyer boat in Tulalip Bay, and during one day of sampling at the Olympic Fish processing plant. The reason for missing tags at these apparently isolated incidents was not identified. One possibility is that the sensitivity of the equipment was not adjusted appropriately for the environment. Calibrating the sensitivity (gain) is critical for both detecting tags and avoiding false detections. Suggestions for improving the calibration process have been discussed with the manufacturer. Standardized calibration procedures will also need to be developed and implemented on a regional basis.

False detection rates for all tests combined was 2.0 % for the R-8 tube and 0.5 % for the Wand. It was found that fish that had sediment on the skin (e.g. fish that had been in contact with a river bank, truck bed, or pavement) could cause false detections with the R-8 tube, and to a lesser extent with the Wand. Under current hatchery operations it is common for spawned carcasses to be in contact with the ground prior to sampling. At some sites this may require that fish be placed into totes prior to sampling, or that fish that register a detection are washed and re-tested.

The rates of false electronic detection were compared with false detection rates from visual sampling (adipose marked but untagged fish). Although the results were inconclusive, these rates seem comparable.

Durability: Two equipment failures and moisture problems occurred with the wand. The manufacture indicated that the moisture problem has been fixed in the current model. No mechanical problems occurred with the R-8 tube and the manufacturer is currently refining the design to improve its use. Numerous problems occurred with the prototype gate, but the manufacture has indicated that the unit will be substantially changed. Battery longevity was good for both units. A list of recommended improvements for all equipment was discussed with the manufacturer.

Feasibility: Practical use of the R-8 tube seems limited to sites with level surfaces and clean, wet fish (e.g., processing plants, buying stations, and hatcheries). The equipment is cumbersome and requires a truck for transport. The use of a hospital gurney made on-site movement practical. Use of the current tube did not seem feasible at truck buyer sites for in-river fisheries. These fish were often dryer, and some of these fish had sediment on the skin. These factors hindered the fish from sliding through the tube. Relatively small amounts of sediment on a fish can also cause an increase in the rate of false detections. The use of a diverting gate with the tube seems essential to realize any significant advantages over the Wand.

The Wand, although slower, can be more universally used. The Wand requires no set up time or calibration and would probably be the method of choice in most situations with low numbers of

fish. Although the Wand would be the logical choice for sampling at many undeveloped sites, fish that come in contact with the ground may still need to be washed to avoid high rates of false detections. In many commercial sampling situations fish volumes and buyer locations may change daily. In these situations it would be desirable for a sampler to have both types of equipment available, so the most efficient method could be selected.

Time and Effort: Replacing the current method of visual sampling with electronic sampling will involve significant increases in time and effort. Under the current method of visual sampling, fish can often be inspected with minimal handling. In electronic sampling each fish has to be lifted, and often moved, to be tested. This will also make sampling a more physically demanding job. Adaptations in processing plants (e.g. customized tables) should be considered to eliminate the need to lift and move each fish. The increases in time, handling, and movement of fish will undoubtedly be met with some resistance by commercial buyers, processors, and hatchery managers. Although limited paired testing was conducted, due to low fish numbers, it appears that use of the R-8 tube may approximately double the time required to sample fish and use of the Wand may double or triple the amount of time required for sampling. In order to maintain current sampling rates, increases in sampling staff will be required in many situations. Projected increases in manpower have not been estimated and would vary by location and fish volume. If a transition is made to electronic sampling, it would be an appropriate time to review sampling programs and sampling rates in an attempt to increase efficiency and assure that the desired levels of precision are achieved.

Future Research: The manufacturer of the equipment has indicated that several modifications are being made to the R-8 tube. Additional research would be useful to determine the feasibility of an improved R-8 tube, with diverter gate, at numerous commercial sampling sites. Additional work will also be required to estimate the logistical and financial impacts to tribal sampling programs, i.e.: 1) determine specific equipment needs and modifications in sampling procedures, 2) determine impacts on staffing levels, and 3) determine additional costs to tribal programs.

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