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Coded-Wire Tag Sampling: The Case for Electronic-Field Detection

Abstract

A clipped adipose fin served as an effective external mark indicating presence of a coded-wire tag (CWT) in salmon (*Oncorhynchus* spp.) from the 1960s until the mid 1990s when hatcheries in the Pacific Northwest began mass marking released fish with an adipose fin clip, but not necessarily a CWT. Since then, many CWT sampling programs of commercial fisheries have transitioned to electronic-field detection, while others are still visual-field only, examining snouts from all adipose-clipped salmon, even those without CWTs. Because some CWT salmon are released from hatcheries without any external marks, visual-field only programs also fail to sample these CWTs. In 2012, we used electronic tag detection at a processing plant in Kodiak, Alaska, to scan 1,201 Chinook salmon (*O. tschawytscha*) caught as bycatch in the US North Pacific groundfish fisheries in the Gulf of Alaska (GOA). Chinook salmon bycatch were also electronically scanned in partnerships with private industry: 3,713 salmon in the 2013–2016 US rockfish fishery in the central GOA, and 611 salmon in testing of salmon excluder devices in 2013 in the central GOA groundfish fisheries. Electronic-field detection increased CWT recovery rates by 20–24% over visual-field detection of adipose-clipped Chinook salmon, and an estimated 64–74% of adipose-clipped Chinook salmon sampled had no CWTs. Visual-field only CWT sampling programs may unnecessarily process large numbers of untagged, adipose-clipped salmon while also recovering fewer CWTs than comparable electronic sampling programs.

Keywords: coded-wire tagging, Chinook salmon, electronic tag detection, Gulf of Alaska

Introduction

When Pacific salmon (*Oncorhynchus* spp.) were first released with coded-wire tags (CWTs) in the late 1960s in the Pacific Ocean region (Alaska, British Columbia, Washington, Idaho, Oregon, and California), a clipped adipose fin served as an external mark indicating presence of the tag (Nandor et al. 2010). Starting in 1996, however, Washington and Oregon initiated mass marking of all state hatchery coho salmon (*O. kisutch*) smolts, clipping the adipose fins of all fish released, regardless of the presence of a CWT (Nandor et al. 2010). Mass marking was primarily introduced as a way to implement mark-selective fisheries intended to increase the harvest of marked hatchery fish while limiting the effects on unmarked salmon (Zhou 2002, PSC 2005, Hoffman and Pattillo 2007, Nandor et al. 2010). In mark-selective fisheries, hatchery fish that are easily identified visually by their clipped adipose fins are retained, and unmarked fish are generally released (Zhou 2002, PSC 2005, Hoffman and Pattillo 2007, Nandor et al. 2010). These mass marking programs were later expanded to include Chinook salmon (*O. tschawytscha*) smolts. Idaho, British Columbia, Canada, and the Treaty Tribes of Washington, Oregon, and Idaho all followed suit with the mass marking of hatchery smolts (Vander Haegen and Blankenship 2010). Since 2003, all federal appropriations bills have included directives for mass marking in all federally operated or financed hatcheries (PSC 2005). In 2016, approximately 118 million Chinook salmon were proposed to be mass marked and released from British Columbia, Washington, Oregon, and Idaho (PSCSFEC 2017). This mass marking of millions of salmon has proven challenging for CWT sampling programs throughout the Pacific Ocean region. Visual methods alone cannot distinguish salmon with CWTs. Several types of electronic CWT detectors have been developed over the years, and within some states—Washington, Oregon, and Idaho—electronic tag detection is almost entirely used in their

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commercial fishery sampling programs (Nandor et al. 2010, PSCSFEC 2017). British Columbia uses electronic tag detection for sampling all Chinook salmon in commercial fisheries (PSCSFEC 2017). Alaska uses mostly visual-field detection in sampling state fisheries, but because of increased costs in sampling large numbers of adipose-clipped salmon with no CWTs, Alaska is making efforts to institute more electronic-field detection (PSCSFEC 2017). CWT sampling in California (PSCSFEC 2017) and by the National Marine Fisheries Service (NMFS) in US North Pacific groundfish fisheries in Alaska are currently visual-field only (AFSC 2017).

Previous studies demonstrated the effectiveness of electronic technology for CWT detection. Blankenship and Thompson (2003) reported 100% and 99.9% detection rates for tunnel detectors (Figures 1, 2) and handheld wand detectors (wands) (e.g., Figure 3), respectively, in coho salmon. Vander Haegen et al. (2002) showed wand detection rates of 89% and 98% for Chinook salmon, depending on the wanding technique and using an older-style wand that has long since been improved. Tunnel detectors are large devices suitable for use in hatcheries or fish processing plants and allow for more production-line type screening of whole fish for CWTs. Although wands are commonly used in hatcheries, they are also suitable for use in stream surveys and on vessels.

The CWT sampling programs that have not converted from visual- to electronic-field detection have cited concerns regarding "costs, accuracy, and practical feasibility" (PSCSFEC 2017). Given the millions of salmon that are mass marked in the Pacific Northwest region, though, relying on visual-field detection alone can result

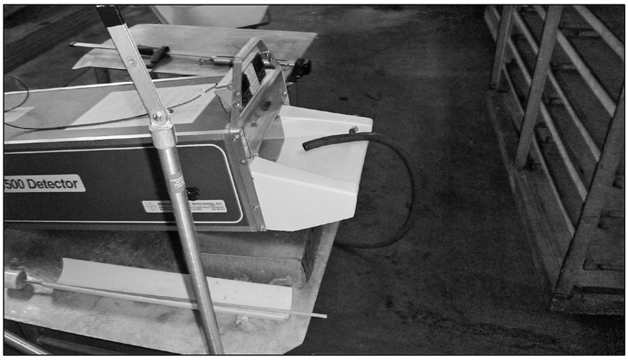

Figure 1. Northwest Marine Technology R9500 tunnel detector (41.4 cm long x 43.5 cm wide x 33.0 cm high with the inner chamber measuring 24.1 cm wide x 11.7 cm high) installed at a fish processing plant in Kodiak, Alaska. Water that flows from the hose facilitates passage of fish through the tunnel.

Figure 2. Northwest Marine Technology R9500 tunnel detector with the optional diverter gate for automated sorting of untagged and potentially coded-wire tagged fish. The tunnel detector was installed at a fish processing plant in Kodiak, Alaska.

Figure 3. Northwest Marine Technology T-Wand detector (30 cm long x 16 cm wide x 4 cm thick) used to scan Chinook salmon for coded-wire tags.

in the unnecessary sampling and processing of many untagged, adipose-clipped fish. Additionally, since tunnel detectors and wands directly detect CWTs, the use of electronic technology typically augments the number of CWTs recovered from visual-field detection alone by detecting tagged fish that are not externally marked or appear not externally marked due to an incomplete clip or regeneration of fin tissue (Thompson and Blankenship 1997). Some groups of salmon are purposely released from hatcheries and wild-stock tagging programs with a CWT but no external mark such as an adipose clip (PSCSFEC 2017) as part of double-index tagging in mark-selective fisheries (Zhou 2002, PSC 2005) or for the purposes of rebuilding populations (Yuen and Conrad 2011). In 2016, of the 29 million Chinook salmon proposed to be tagged in Washington and Oregon, 8 million (28%) were designated to be unmarked (PSCSFEC 2017).

In 2012, we installed a CWT tunnel detector at a fish processing plant in Kodiak, Alaska, as part of a feasibility study for increasing CWT recoveries in Chinook salmon bycatch of the US North Pacific groundfish fisheries in the Gulf of Alaska (GOA) (hereafter the GOA groundfish fisheries). In the following year, a cooperative genetics project between NMFS and private industry was initiated to gather more information about Chinook salmon bycatch in the US rockfish fishery in the central GOA (hereafter the central GOA rockfish fishery). One component of this genetics project, now ongoing for four years (2013–2016), involved scanning with portable wands the entire Chinook salmon bycatch from the fishery for CWTs. In a separate project, also with private industry, Chinook salmon caught in salmon excluder device testing were electronically scanned aboard vessels targeting Alaska walleye pollock (*Gadus chalcogrammus*) in 2013 in the central GOA. The recording in all three projects of adipose-clip status of scanned fish allowed us to quantify the numbers of CWT Chinook salmon that were not externally marked (i.e., tagged fish that would have otherwise gone undetected using visual-field detection only). We demonstrate the benefits of electronic tag detection by 1) calculating the increased CWTs recovered from electronic- over visual-field detection, and 2) estimating the percentage of untagged, adipose-clipped Chinook salmon that would have been collected unnecessarily in a visual-field only sampling program. The results of this study can be used to evaluate converting from visual- to electronic-field detection of CWTs.

Methods

Sampling Using the Tunnel Detector at a Fish Processing Plant

In a 2012 feasibility study, we cooperated with Western Alaska Fisheries to install in their Kodiak, Alaska, fish processing plant, a Northwest Marine Technology (NMT) R9500 CWT tunnel detector with a diverter gate (Figures 1, 2). The objective of the study was to determine if using electronic technology was a practical means of increasing the recovery rate of CWTs in Chinook salmon bycatch of the federally managed GOA groundfish fisheries. Chinook salmon are caught as bycatch primarily in the Alaska walleye pollock trawl fishery but are also caught in non-pollock (e.g., flatfish and Pacific cod [*G. microcephalus*]) fisheries (Witherell et al. 2002). The fish processing plant directly received offloaded catches from commercial fishing vessels and had onsite observers from the NMFS North Pacific Groundfish and Halibut Fisheries Observer Program (hereafter the Observer Program) that sub-sampled catches.

The rectangular tunnel detector, designed to accommodate large, whole fish, weighed 44.5 kg and measured 41.4 cm long x 43.5 cm wide x 33.0 cm high. The inner chamber itself measured 24.1 cm wide x 11.7 cm high. The detector was powered by AC power, although a 12-volt rechargeable battery was also available. The detector installed at the fish processing plant was placed on a stand with a steady stream of water flowing through the tunnel that facilitated passage of individual fish (Figure 1). The optional diverter gate attached to the detector automated the sorting of tagged and untagged fish by diverting fish to opposite sides of the tunnel and into separate receiving bins (Figure 2). The sensitivity of the detector was adjusted according to instructions in the user's manual, depending on any electronic noise in proximity of the detector.

The testing of the tunnel detector occurred during an approximate six-week portion of the GOA groundfish fisheries: 09–23 September and 02–29 October 2012. Observers of the Observer Program, stationed at the plant, conducted routine sub-sampling of Chinook salmon bycatch by visual detection only during vessel offloading as directed in the NMFS Observer Sampling Manual (AFSC 2012). Specifically, the observers sampled any adipose-clipped salmon in a sub-sample of the groundfish catch. Once the observers completed their sampling, including snout removal of Chinook salmon, the remaining salmon (headless or whole) were made available to the tunnel detector operator for sampling. The tunnel detector operator, in contrast to the observers, conducted a census of the Chinook salmon bycatch, recording total number of Chinook salmon and adipose-clip status of those fish and then screening all whole Chinook salmon through the detector for CWTs. For fish that tested positive for a CWT, the operator collected a portion of the salmon's snout thought to contain the CWT, according to protocols outlined in the NMFS Observer Sampling Manual (AFSC 2012). The operator entered biological information for the sampled salmon on a data card, bagged the snout sample with the data card, and preserved the sample with salt until shipment to the CWT lab at the Auke Bay Laboratories (ABL) for confirmation and extraction of the CWT. Observers also sent snout samples to the ABL for processing. In the CWT lab, a tag reader used a countertop NMT V-Detector to confirm presence of a CWT in the snout sample and then extracted the tag, if present, from the snout tissue. After extraction, the reader decoded the CWT tag under a dissecting microscope.

Sampling Using the Handheld Wand Detector at a Fish Processing Plant

In 2013, NMFS partnered with Alaska Groundfish Data Bank (AGDB) to gather more information on Chinook salmon bycatch in the central GOA rockfish fishery near Kodiak, Alaska. As part of the cooperative genetics and CWT project, NMFS provided sampling materials (data cards and plastic bags), a NMT handheld wand detector (e.g., Figure 3), and training in using the wand. AGDB provided technical staff who sampled Chinook salmon from offloaded fishery catches.

Wands designed for field use are waterproof, float if submerged, and can withstand varying temperatures. The newer T-Wand model weighs 0.68 kg, measures 30 cm long x 16 cm wide x 4 cm thick, operates on two AA batteries that supply about 100 hours of operation, and comes with a fabric holster. With a detection range of 5.5 cm for a standard-length CWT, the T-Wand, like the tunnel detector, detects CWT wire by sensing changes in magnetic fields (Vander Haegen et al. 2002).

Between 2013 and 2016, samplers from AGDB scanned Chinook salmon bycatch from the central GOA rockfish fishery. The sampler scanned Chinook salmon with the wand by picking up the fish, touching the back of the wand to the tip of the salmon snout, and sweeping the back of the head with a quick up and down motion. Audible (beep) and visual (indicator light) signals indicated a positive CWT signal. For fish with positive CWT signals, the sampler recorded biological information and collected a snout sample using the same method described previously. The snout samples were frozen or salted until shipment to the CWT lab at the ABL for extraction and decoding of CWTs. CWTs were extracted and decoded in the lab as described previously. Results are summarized for the four years of data combined.

Sampling Using the Handheld Wand Detector on Fishing Vessels

In the spring and fall of 2013, the North Pacific Research Foundation (NPRF) undertook testing under an Exempted Fishing Permit of salmon excluder devices on two catcher vessels targeting Alaska walleye pollock in the central GOA. Salmon excluder devices are intended to minimize salmon bycatch in trawl catches by allowing salmon to exit the trawl while groundfish are retained. For this project, NPRF partnered with NMFS to sample Chinook salmon bycatch for genetic analysis and CWTs. NMFS provided sampling materials (data cards and plastic bags), a NMT handheld wand detector (e.g., Figure 3), and training in using the wand. NPRF provided the staff who sampled Chinook salmon from catcher vessel hauls.

NPRF samplers, onboard the vessel, scanned Chinook salmon bycatch from hauls during testing of salmon excluder devices. Chinook salmon were scanned with wands as described previously. For fish with positive CWT signals, the sampler collected snout samples, salted, and shipped them to the CWT lab at the ABL using the methods described previously. CWTs were extracted and decoded in the CWT lab at the ABL also as described previously.

Results

Sampling Using the Tunnel Detector at a Fish Processing Plant

Use of the tunnel detector at a fish processing plant led to an increased number of CWT recoveries over visual-field only sampling. The tunnel detector operator electronically screened for CWTs 1,201 Chinook salmon delivered to the fish processing plant during a six-week portion of the 2012 GOA groundfish fisheries. Two additional Chinook salmon were not screened because their snouts were removed during visual-field sampling by observers; however, the adipose-clip status of the salmon were noted. Of the 1,201 Chinook salmon, 80 (7%) (Table 1) registered a positive signal with the tunnel detector, indicating the potential presence of a CWT. Of the 80 snout samples processed by the CWT lab, 59 were coded-wire tagged and adipose-clipped and 12 were coded-wire tagged but not adipose-clipped (Table 1). Since the 12 tagged salmon were not externally marked, their CWTs could only have been recovered using electronic tag detection, resulting in a 20% increase in the number of CWTs recovered using electronic- over visual-field detection (Table 1) or an overall 89% CWT recovery rate. In the lab, we determined a false positive rate of 11% for the tunnel detector (Table 1).

The tunnel detector screened out a large number of untagged but adipose-clipped Chinook salmon. Of the 1,201 Chinook salmon electronically scanned, 185 (15%) (Table 2) were determined visually to be adipose-clipped, representing the number of salmon that would have been identified as potentially coded-wire tagged under visual-field only sampling. Of the 185 salmon externally marked, however, most (68%) (Table 2) were untagged, assuming 100% electronic-field detection, and represents the percentage of salmon that would have been processed unnecessarily under visual-field only sampling. This is equivalent to an estimated 32% CWT recovery rate for visual-field detection (Table 2). The CWT recovery rate is an estimate of the CWT recovery rate in practice because snouts from all marked fish were not shipped to the CWT lab for processing; only those fish that returned a positive signal in the field were sampled and their snouts shipped to the CWT lab. Since electronic tag detection is not 100% accurate, some marked, tagged fish may have been missed in the field sampling.

Sampling Using the Handheld Wand Detector at a Fish Processing Plant

The use of a wand at a fish processing plant resulted in an increased number of CWT recoveries over visual-field only sampling. Samplers from AGDB scanned nearly all Chinook salmon bycatch from the central GOA rockfish fishery in 2013–2016; the sampling rate ranged 96.9% in 2014 to 99.6% in 2016. The total number of Chinook salmon scanned for CWTs over the four years was 3,713 and ranged from nearly 500 in 2014 to over 2,000 in 2013 (Table 1). The percentage of samples that registered a positive CWT signal, indicating the potential presence of a CWT, was consistently 6% annually (Table 1). Of the snout samples processed by the CWT lab, 0–27 (0–23%) (Table 1) were coded-wire tagged but not adipose-clipped and represent the numbers of CWTs that could only have been recovered using electronic tag detection. Therefore, the increase in the CWT recovery rate by using electronic- over visual-field detection ranged 0–31% with a 4-year combined rate of 24% (Table 1) or an overall 4-year CWT recovery rate of 87%. In the lab, we determined the false positive rate for the wand ranged from 3–35% (Table 1).

TABLE 1. Numbers of Chinook salmon sampled in the 2012 tunnel detector test at a fish processing plant in Kodiak, Alaska, during the Gulf of Alaska (GOA) groundfish fisheries, in 2013–2016 from offloaded catches in the central GOA rockfish fishery, and in 2013 from vessel hauls in salmon excluder device (SED) testing in the central GOA groundfish fisheries. Using electronic-field detection, the total number of Chinook salmon identified as potentially coded-wire tagged (i.e., have a positive signal). Of the Chinook salmon with a positive signal and examined in the laboratory for coded-wire tags (CWTs)—the number with no CWTs (i.e., false positives), the number with CWTs and clipped adipose fins (ad-clipped), and the number with CWTs and not ad-clipped are shown, along with percentages of the total number with a positive signal in parentheses. The last column is the percent increase in CWTs recovered by using electronic-field detection.

			Electronic Tag Detection (Positive Signal)				
Year	Fishery	Number Sampled	Total (% of the sample)	No CWT	CWT and Ad-Clipped	CWT and not Ad-Clipped	Increase in CWTs Recovered
Tunnel Detector							
2012	GOA groundfish	1,201	80 (7%)	9 (11%)	59 (74%)	12 (15%)	20%
Handheld Wand Detector							
2013	GOA rockfish	2,111	118 (6%)	4 (3%)	87 (74%)	27 (23%)	31%
2014	GOA rockfish	468	26 (6%)	9 (35%)	17 (65%)	0 (0%)	0%
2015	GOA rockfish	638	36 (6%)	8 (22%)	23 (64%)	5 (14%)	22%
2016	GOA rockfish	496	30 (6%)	6 (20%)	21 (70%)	3 (10%)	14%
2013–2016 (overall)		3,713					24%
2013	GOA groundfish[a] (SED)	611	54 (9%)	14 (26%)	33 (61%)	7 (13%)	21%

[a] SED testing occurred under an Exempted Fishing Permit.

By using the wand, samplers screened out large numbers of untagged but adipose-clipped Chinook salmon: 57–213 (Table 2). Assuming 100% electronic-field detection, the percentages of untagged, adipose-clipped salmon that would have been processed unnecessarily under a visual-field only sampling program were consistent over the years, 71–77%, with a combined percentage of 74 for the four years (Table 2). This is equivalent to an estimated CWT recovery rate of 26% for visual-field detection (Table 2).

Sampling Using the Handheld Wand Detector on Fishing Vessels

The use of wands on fishing vessels increased CWT recoveries over visual-field only sampling. Samplers from NPRF electronically scanned all Chinook salmon bycatch from the testing of salmon excluder devices in the central GOA groundfish fisheries in the spring and fall of 2013. Of the 611 Chinook salmon scanned for CWTs, 54 (9%) registered a positive signal (Table 1), indicating the potential presence of a CWT. Of the 54 snout samples processed by the CWT lab, 33 were coded-wire tagged and adipose-clipped and seven were coded-wire tagged but not adipose-clipped (Table 1). Since the seven tagged salmon were not externally marked, their CWTs could only have been recovered using electronic tag detection, resulting in a 21% increase in the number of CWTs recovered using electronic- over visual-field detection (Table 1) or an overall 74% CWT recovery rate. In the lab, we determined a false positive rate of 26% for the wand (Table 1).

By using the wand, samplers screened out 58 untagged salmon from the total 91 adipose-clipped Chinook salmon (Table 2). Assuming 100% electronic-field detection, the percentage of untagged, adipose-clipped salmon that would been processed unnecessarily under a visual-field only sampling program was 64% (Table 2) which is equivalent to an estimated 36% CWT recovery rate for visual-field detection (Table 2).

Discussion

Coded-wire tagging has proven a valuable tool in managing and studying Pacific salmon, and its versatility is evidenced by the variety of uses of

TABLE 2. Using visual-field detection, the total number of Chinook salmon identified as potentially coded-wire tagged (i.e., have a clipped adipose fin or is ad-clipped) in 2012 at a fish processing plant in Kodiak, Alaska, during the Gulf of Alaska (GOA) groundfish fisheries, in 2013–2016 from offloaded catches in the central GOA rockfish fishery, and in 2013 from vessel hauls in salmon excluder device (SED) testing in the central GOA groundfish fisheries. Of the Chinook salmon ad-clipped and examined in the laboratory for coded-wire tags (CWTs), the numbers and percent of sample (%) with and without CWTs.

		Visual Detection Only (i.e., Ad-Clipped)		
Year	Fishery	Total (% of the sample)	CWT[a]	No CWT[b]
Tunnel Detector				
2012	GOA groundfish	185 (15%)	59 (32%)	126 (68%)
Handheld Wand Detector				
2013	GOA rockfish	300 (14%)	87 (29%)	213 (71%)
2014	GOA rockfish	74 (16%)	17 (23%)	57 (77%)
2015	GOA rockfish	100 (16%)	23 (23%)	77 (77%)
2016	GOA rockfish	86 (17%)	21 (24%)	65 (76%)
2013–2016 (overall)			(26%)	(74%)
2013	GOA groundfish[c] (SED)	91 (15%)	33 (36%)	58 (64%)

[a] Only samples with a positive signal from electronic-field detection were examined in the laboratory for a CWT.

[b] The number of ad-clipped salmon with no CWTs is an estimate, assuming 100% electronic-field detection, since not all ad-clipped salmon were examined in the laboratory for CWTs.

[c] SED testing occurred under an Exempted Fishing Permit.

CWT data: evaluating hatchery and stock-specific contributions to mixed fisheries, estimating harvest and survival rates, studying ocean distribution, among many other uses (Nandor et al. 2010). Our study has shown that electronic-field detection was effective in increasing CWT recoveries over visual-field detection alone by detecting tagged fish not externally marked. Electronic-field detection was also effective in screening out untagged, adipose-clipped fish, saving labor in unnecessary sampling, shipping, and laboratory processing of untagged snouts.

Within some states and countries—Washington, Oregon, Idaho, and Canada—many CWT sampling programs for commercial fisheries employ electronic technology for recovering unmarked, tagged fish (PSCSFEC 2017). Agencies that rely only on visual-field detection have cited increased costs and practical infeasibility as prohibitive to converting from visual- to electronic-field detection. According to the Observer Program's 2016 annual report, 469 NMFS observers were deployed on 500 vessels and at seven fish processing plants in GOA and Bering Sea-Aleutian Islands (BSAI) groundfish and halibut fisheries (AFSCARO 2017). Implementation of electronic-field detection by the Observer Program would be costly in terms of additional training for observers and supplying processing plants with tunnel detectors and observers with wands. On the other hand, electronic-field detection could increase CWT recoveries, as well as reduce labor by observers (i.e., only salmon with a positive CWT signal would be sampled). We estimated in this study that 64–74% of adipose-clipped Chinook salmon sampled did not contain CWTs which is consistent with the 74% rate of adipose-clipped, untagged salmon reported by the Alaska Department of Fish and Game for the 2015 Southeast Alaska troll fishery (PSCSFEC 2017) and the approximate 70% rate of adipose-clipped, untagged salmon (average for 2014–2016) for the Observer Program in the GOA groundfish fisheries (unpublished data). Although using electronic-field detection can reduce the number of marked, untagged snouts that are processed, the increased costs of time and labor required to handle every fish (i.e., marked or unmarked) has led to reduced sampling by some agencies (PSCSFEC 2016). Also, since electronic tag detection is not 100%

accurate, some small percentage of tagged fish (both marked and unmarked) will be missed in the field. A visual-field only sampling program would presumably miss the same unmarked fish. In addition, the false positives from electronic-field detection still require processing and shipping to a CWT lab. The number of false positives in this study, however, was small compared to the number of marked, untagged fish that would have been processed under visual-field sampling.

When we calculated the increase in CWT recoveries from electronic- over visual-field detection, we assumed 100% visual detection of adipose-clipped salmon. This, however, may not be the case, and the tunnel detector project provided a unique opportunity to test the reasonableness of this assumption. Recall that at the fish processing plant, the tunnel detector operator sampled Chinook salmon after observers of the Observer Program completed their sub-sampling of salmon by visual detection, including the removal of snouts. The tunnel detector operator examined the adipose-clip status of 1,201 Chinook salmon during a six-week portion of the GOA groundfish fisheries, observing an adipose-clip rate of 15% (*n* = 185). Observers sub-sampled Seasons A–D (nearly 29 weeks) of GOA groundfish fisheries, reporting a total of 1,095 Chinook salmon (source: Fisheries Monitoring and Analysis Division of the Alaska Fisheries Science Center) with an adipose-clip rate of 3% (*n* = 29), far below what was observed by the tunnel detector operator. As a consequence, more CWTs were recovered in the tunnel detector sampling than in the observer sampling: 59 CWTs from adipose-clipped salmon (plus 12 CWTs from salmon not adipose-clipped) compared to nine CWTs. Using only the number of CWTs recovered from adipose-clipped salmon, we calculated a visual-field CWT detection rate for the tunnel detector operator of 5% (59 / 1,201) compared to 1% (9 / 1,095) for the observers.

This disparity in adipose-clip and visual-field CWT detection rates, however, cannot be explained definitively. The tunnel detector operator sampled Chinook salmon bycatch during only a portion of the time period sampled by observers, so rates may have simply differed by time periods sampled. Also, the tunnel detector operator focused solely on recovering CWTs whereas the observers have many sampling tasks and determine adipose-clip status of Chinook salmon as time permits (AFSC 2012). In addition, visual determination of a clipped adipose fin is subjective and can vary among samplers. Employing electronic technology itself (e.g., wanding or using a tunnel detector) with audible and visual cues of a CWT may lead to more CWT recoveries by eliminating the subjective, perhaps more difficult, visual adipose-clip determination, as well as freeing up time spent sampling untagged snouts. The time gained by not processing untagged snouts, however, is offset by the time required by samplers to electronically scan all fish—both marked and unmarked. If we applied to the observer sampling the same CWT occurrence rate (5.9% = 71 / 1,201) as the tunnel detector sampling that used both visual- and electronic-field detection, then we would expect the observers to recover 65 (5.9% x 1,095) CWTs compared to nine, equating to over seven times as many CWT recoveries. By assuming 100% visual detection of adipose-clipped salmon, the realized benefits of electronic- over visual-field detection may be underestimated.

The successful installation of a tunnel detector at a processing plant in Kodiak, Alaska, provided for the scanning of all Chinook salmon bycatch delivered to the plant during six weeks of the 2012 GOA groundfish fisheries. Not only did we gain valuable information about expected increased CWT recovery rates from using electronic- over visual-field detection, but we gained information on the feasibility of installing a tunnel detector in a fish processing plant. The tunnel detector operator provided helpful suggestions on installing and operating the tunnel detector such as locating the detector in an area that would not interfere with normal plant operations and that was large enough for a forklift to maneuver. The operator also suggested the area be sheltered from the wind and rain and have good lighting; AC power; a water supply via hose; two tables—one for dry and one for wet work; a stable, approximately 1.2 m high platform or table for the detector; two totes for receiving exiting salmon; and a rolling tote to transport small offloads of fish from the dock to the detector. The operator noted it was helpful to have an assistant with dry hands to record data during tunnel detector screening. The forklift operator for that project served as the data recorder while the operator screened fish through the tunnel, weighed and measured fish, and collected a snout sample if a positive signal was detected.

The false positive rates reported in this study for the tunnel detector and wands are higher than previously published rates. The false positive rate of 11% for the tunnel detector was much higher than 1.9% reported by Vander Haegen et al. (2002), and the discrepancy may be due to our setting the tunnel detector at an overly sensitive detection level, metal contaminants on the samples themselves, or electronic noise in the detection area. The false positive rates for the wands (3–35%) were also much higher than 1% or less reported by Vander Haegen et al. (2002), and the discrepancy may be due to the wanding technique by the samplers or possible metal contamination on the fish. Future research could examine the effects of sensitivity settings of electronic detectors on CWT detection rates.

Results for the three data sets—increased recovery rates from electronic tag detection (20%, 21%, and overall, 4-year 24%) and estimated percentages of marked but untagged salmon (64%, 68%, and overall, 4-year 74%)—were similar and provided corroborative information even though the data sets differed in location of detection (in a fish processing plant or on a vessel) and type of electronic tag detection used (tunnel detector or wand). In addition, the data sets were independently sampled by different entities (the Observer Program or private industry) and for different purposes. Chinook salmon sampled in bycatch of GOA (and also BSAI) groundfish fisheries by the Observer Program that originated from evolutionarily significant units, known as ESUs, listed under the US Endangered Species Act (ESA) are reported annually to the NMFS West Coast Region as part of an ESA Section 7 Consultation. Origins of CWTs sampled by private industry from the central GOA rockfish fishery have been reported to the North Pacific Fishery Management Council. CWTs recovered by private industry in salmon excluder device testing supplemented CWTs recovered in the same area by the Observer Program.

Clearly, electronic-field detection is an improvement over visual-field detection in terms of increased CWT recovery rates and decreased processing of untagged, adipose-clipped fish. The magnitude of the increase in CWT recovery rate by using electronic-field detection, however, likely depends on the specific stocks that contribute to the fisheries sampled and their fractions of releases that are unmarked but tagged. The value of the data obtained from additional CWTs that potentially would be recovered from electronic-field detection clearly depends on the specific objectives of the sampling program. Increasing recoveries would be especially important for those programs hampered by low numbers of recoveries in performing rigorous statistical analyses or for those programs that sample rare stocks such as those listed as endangered or threatened under the ESA. Increased CWT recoveries could also increase the accuracy and precision of estimates computed from CWT recoveries. The increased CWT recoveries and decreased processing by using electronic-field detection are important considerations in any decision to convert from visual- to electronic-field detection. Ultimately the decision to forego the benefits of electronic-field detection is a policy decision, but a cost-benefit analysis of such a changeover may be warranted.

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