Costs Associated with the Coded-Wire Tag Program in British Columbia, Canada

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Introduction

Since the 1970's, coded-wire tag (CWT) marking has been a cornerstone of coho and chinook stock assessment programs in British Columbia (B.C.). With the signing of the Pacific Salmon Treaty (PST) in 1985, the Canadian Department of Fisheries and Oceans (CDFO) augmented existing chinook and coho CWT marking and escapement sampling programs, and started additional programs on other B.C. stocks which were thought to be representative of stock types region-wide. These 'key' streams provide estimates of early marine survival, and exploitation rates through the recovery of CWTs in commercial, sport, and native fisheries, as well as in spawning escapements. In addition, they provided information on marine distribution.

With the signing of the 1999 Agreement, the number of key streams in Canada increased for both coho and chinook. With these new programs, the requirement for more CWT releases and the resources necessary to adequately sample fisheries and escapement increased. The cost of CWTs, a major cost component of the CWT program, has been steadily increasing. Furthermore, the advent of mass-marking of hatchery releases in the U.S. and Canada has further added to the cost of the Mark Recovery Program (MRP) in Canada. These increasing costs have been met with shrinking financial resources. This financial 'squeeze', in addition to the analytical challenges created by recent mark-selective fisheries, has led to questions regarding the cost-effectiveness and reliability of the current CWT program coastwide.

The intent of this paper is to provide a rough estimate of the cost of CWT programs in B.C., against which the cost of any proposed alternative approaches to managing coho and chinook stocks coastwide can be compared. Only the major component costs of the CWT program will be considered, namely the purchase price of tags, the cost of adipose-clipping and CWT-marking, the cost of collecting representative samples from commercial and sport catch, as well as from carcass-recovery programs, and the cost of dissecting heads and decoding retrieved CWTs. Other indirect costs of this program were not considered, including equipment and facility depreciation, hatchery maintenance costs, and CDFO staff salary costs for time spent collecting samples and managing CWT databases.

In order to estimate recent costs, I have used data for the years 2000-2003, where available. For estimating the cost of the CWT program in Canada, I have used the most recent cost estimates for such items as CWT purchases, their application costs, as well as the cost of commercial catch sampling and head dissection/CWT decoding. Tag requirements are based on the three year average for 2000-2002. Cost estimates for wild juvenile coho marking programs

are based on the most recent program costs, and are program specific. Costs of CWT recovery in spawning escapement were considered a fixed, incremental cost to adult enumeration programs already in place. Only costs for key stream escapement programs were included in this estimate. All cost are provided in Canadian dollars, unless otherwise stated.

Description of CWT-Marking Programs

CWT Marking

Most CWT-marking in B.C. occurs on juveniles reared in hatcheries. Currently, no tagging of wild chinook juveniles occurs in B.C. However, approximately 11 coho programs involve the capture and tagging of wild outmigrant smolts (Table 1). CDFO makes annual bulk purchases of CWTs, which are then distributed to CDFO-run marking programs. A small number of tags are purchased from outside DFO by non-governmental agencies. For this exercise, it is assumed that non-CDFO agencies paid the same price per tag as did CDFO.

Between 2000-2002, approximately 60-65% of all coho and chinook CWT-marking occurs on key stream stocks used by stock assessment for PST-related purposes. In 2004, this percentage will increase significantly, as most non-PST related marking will be discontinued by CDFO (S. Lehmann, pers. comm.). These non-PST releases are associated with other stock assessment programs, programs to evaluate hatchery production and release strategies, and non-CDFO release programs. About a third of adipose-clipping and CWT-marking at hatcheries is conducted by a single contractor (Streamline Consulting). The remainder are marked by CDFO staff, casual staff hired to assist CDFO personnel, or non-CDFO agencies. The cost of marking coho and chinook in B.C. was estimated by applying an average cost per fish from several facilities. The average cost used was that charged by Streamline Consulting for marking nine chinook and 17 coho stocks from 2002-2003. Table 1 provides a list of CWT-marked key stream programs that have previously been funded, are currently being funded, or would be funded if resources permitted. While the number of key streams being funded in B.C. has declined over the past several years, all key stream programs are assumed to be funded for the purpose of this costing exercise.

CWT Recovery Programs

Prior to the early 1980's, CDFO staff did most of the sampling of Canadian commercial and sport fisheries, as well as spawner escapement. However, since the early 1980's, annual contracts have been let to private contractors to sample all commercial fishery landings for CWTs. Up until 2002, a single contractor, J.O. Thomas and Associates (JOT), was contracted to sample all commercial

fisheries, and process all heads collected from adipose-clipped fish from all sources, i.e., commercial, sport and native fisheries, as well as escapement, and to decode all retrieved CWTs. In addition, heads from non-adipose clipped fish which tested positive for a CWT (Double Index Tagged, i.e., DIT, tags) during electronic detection in commercial and sport fisheries as well as escapement, were also to be dissected for CWTs. Target sampling rates are currently set at 20% of troll and 15% of commercial net harvest for chinook and coho. While sample rates for 2003 are not yet available, rates in 2002 were generally higher than target (Table 2) In the 2003/2004 fiscal year, JOT conducted commercial CWT sampling for all commercial B.C. salmon fisheries, with the exception of the WCVI troll and net fisheries. These latter fisheries were sampled by CDFO staff and casual hires.

Prior to 2000, sport recoveries were obtained through a voluntary head recovery program. Anglers would voluntarily remove the heads from adipose-clipped catch, and deposit them at one of the ~250 head depots in B.C. In 2000-2002, when mass-marked fish recruited to fisheries, creel surveyors sampling for effort and mark rate information electronically sampled the recreational catch for CWTs. Anglers interviewer by creel surveyors were encouraged to submit the head from any coho or chinook that tested positive for a CWT. Non-interviewed anglers continued to voluntarily submit heads from adipose-clipped fish. Since 2003, creel surveyors stopped electronically sampling, though they continue to encourage anglers to deposit heads from adipose-clipped catch. Currently, all sport recoveries are obtained through the voluntary program. Creel surveys still provide the adipose-clip rates used to expand CWT recoveries. Sport sample rates are difficult to quantify in B.C. with the recent decline in direct sampling of sport catch. However, sport sample rates are generally much lower than those of commercial gear; in 2002 they averaged 19.6% for chinook, but only 3.9% for coho (Table 2)

Only the costs of CWT escapement sampling for key streams were included in annual cost estimates. Because all such programs would proceed even if CWT recovery was not incorporated, CWT recovery costs were considered to represent an incremental cost to adult enumeration. This incremental cost was assumed to be ~$2,000, regardless of the program. While other escapement programs can include CWT recovery, they are not directly PST-linked, and their recovery costs were not included. However, the cost of head dissection and CWT decoding of samples from such systems are included, since separting the cost of decoding key stream versus non-key stream heads is problematic. That is because the contract to JOT covers the cost of maintaining the head recovery laboratory, a fixed cost that is not directly related to the number of heads processed. Nevertheless, the incremental per head labour cost of dissection is estimated to be ~$11 (M. Hamer, pers. comm.).

In an effort to quantify the impact that mark-selective fisheries have on Canadian stocks, both adipose-clipped and non-clipped CWT-marked fish from five

Canadian coho and three chinook stocks have been released since the late 1990's. Since 1999, Canada has directed efforts at electronic detection of CWTs from these Double Index Tag (DIT) releases, as well as those from Washington state, in commercial and some sport catch. At commercial landing points, all salmon, both with and without adipose fins, are passed through an electronic tag detector. Heads are removed only from those fish which test positive for a CWT. While wanding of sport catch encountered during creel surveys was implemented at the same time, little or no such screening of sport catch continues today. Some wanding of deadpitch also occurred in escapement programs for DIT-marked stocks. However, while some DIT sampling continues to occur in escapement programs (Quinsam R. and Inch Cr. coho, Chilliwack R. chinook), reductions in program funding have led to the curtailing of such sampling for other DIT-marked stocks.

Due to the electronic pre-screening that takes place when fish are landed, no-pin rates for commercial catch were relatively low in 2002, the most recent year for which data is available (Table 3). Rates for troll catch were 6.6% for Chinook and 14.8% for coho. No-pin rates in net catch for both species were <7%. However, no-pin rates for sport recoveries were much higher. This is due to the fact that most sport heads recovered in 2002 were from the voluntary head recovery program, and thus were not pre-screened electronically. In that year, no-pin rates for chinook were 50.6% among direct sampled heads, and 57.8% among voluntary recoveries. For coho, rates were 70.8 and 95.6%, respectively.

CWT-Marking and Recovery Program Costs

CWT-Marking

A summary of the number of CWT-marked and unmarked releases from 2000-2002 are provided in Table 4. Approximately 3.7 million CWT-marked chinook and 1.5 million CWT-marked coho are released annually in B.C. These marked releases represent approximately 6.5 and 7.0 %, respectively, of all hatchery and wild releases, which have averaged over 77.4 million annually. For chinook, 100% of all CWT marked releases are hatchery- reared. Wild CWT-marked coho comprise only 13% of all marked coho releases.

CDFO makes an annual bulk purchase of CWTs to cover the needs for all but non-DFO programs. Such volume buying reduces the cost of tags. Nevertheless, the price charged CDFO by Northwest Marine Technologies for CWTs has risen steadily since 2001. In 2001, the price of tags was $80.40/1000 tags, while in 2004, the quoted price is $93.83/1000 tags (U.S. prices converted to Cdn dollars at an exchange rate of $1U.S.=$1.34 Cdn). This represents an increase of ~17%. The cost of rearing CWT-marked releases was not included in

the cost of the CWT program, since the large majority of such releases would have occurred whether fish had been CWT-marked or not. Consequently, only the incremental costs of marking are included in CWT-marking estimates.

The average cost of adipose-clipping and CWT-marking coho and chinook juveniles charged by Streamline Consulting in 2002 and 2003 was 6.5 cents (S. Lehmann, pers. comm.), not including the cost of the tag. This was assumed to represent the average cost of marking all stocks. While most of this amount represents labour cost, a small portion covers the cost of annual maintenance of tagging machines, which are owned by the CDFO. The 2004 quoted per fish price of 9.4 cents was used to represent the cost of CWTs. Thus, it is estimated to annually cost approximately $475,000 to purchase tags, and $460,000 for clipping and tag application for hatchery fish (Table 5). This works out to a per fish cost for clipping and CWT-marking of hatchery-reared fish of ~16 cents (Table 5).

The cost of marking wild coho releases is program specific, depending on the remoteness of the stream location, and whether such marking is piggybacked onto other programs operating on the same system at the same time. Since wild coho juvenile programs are used to estimate freshwater survival as well as early marine survival and exploitation rates, most would proceed even if CWT-marking was discontinued (B. Holtby, pers. comm.). Consequently, only a portion of the total cost of such programs was attributed to CWT-marking. The estimated incremental cost of such marking was based upon discussions with biologists involved with these programs. Nevertheless, these estimates should be considered very approximate. When determining the total cost of wild coho marking programs to CDFO, it was assumed that all key stream programs were fully funded, even though such will not be the case for 2004. Thus, the total cost of CWT- marking of wild coho indicators was estimated to be approximately $150,000 (Table 5). This works out to an average per fish cost of marking wild coho (CDFO releases only) of ~84 cents. When added to the cost of marking hatchery-reared chinook and coho,the total estimated annual cost of clipping and CWT-marking of coho and chinook in B.C. is just over $950,000 (Table 5).

CWT Recovery

Due to the nature of the contract to JOT, it is difficult to break out the costs of catch sampling from the costs associated with dissecting heads and decoding CWTs. While final costs for the 2003/2004 season are still being finalized, it was estimated pre-season that JOT's portion of the commercial catch sampling, plus the cost of head dissection and tag decoding of <u>all</u> collected heads would be $825,000. The cost of sampling WCVI fisheries under CDFO direction was estimated to be $65,000. When these costs are added to the estimated cost of CWT recovery in spawner escapement (Table 1), the estimated total cost of the head recovery program in B.C. in 2003/2004 was approximately $966,000 (Table

6). Actual costs may be higher or lower, depending on the number of adipose-clipped fish encountered in catch and escapement that year.

Annual costs will vary with the size of landed catch and escapement; as abundance increases and fisheries expand, more heads will be recovered, thus increasing the cost of CWT retrieval. Between 2000 and 2002, the number of heads submitted to JOT increased over 72% from 18,469 to 31,788 (Table 7). This increase was due both to an increase in catch and a concurrent increase in the incidence of mass-marked, adipose-clipped fish. It is most likely that the increased abundance of chinook anticipated for 2004 and the continued release of mass-marked chinook and coho will result in a further increase in head recoveries, and hence cost, in 2004. In 2002, over 41% of recovered heads were from hatchery swim-ins and escapement programs, which constituted the single largest source of heads. This actually represents a decline from 2001, when such heads comprised 62% of the total number of heads submitted that year (JOT 2003). Commercial recoveries accounted for 31%, and sport recoveries 18% of the total in 2002.

Summary and Conclusions

When only the major cost components are considered, the estimated annual cost of the CWT program to CDFO is approximately $1.9 million (Table 8). Fifty percent of this amount can be attributed to the cost of marking juveniles, and the other 50% to the cost of sampling fisheries and spawning escapement, and decoding retrieved CWTs. Based on the average number of annual recoveries coastwide of Canadian CWT releases between 2000 and 2002 (14,944), the average cost of each recovered B.C.-released CWT is $154 for chinook, and $123 for coho (Table 9). This cost difference between species is primarily due to the fact that 2.4 times as many CWT-marked chinook than coho are released annually, while chinook recoveries constitute only 45% of the recoveries of the two species.

Due to the relatively short timeline for this assignment, no attempt was made to estimate the incremental cost to hatchery facilities of CWT-marking, i.e., electrical costs, hatchery maintenance, or cost of consumables such as paper towels, scissors, etc. Because hatcheries undertake a variety of programs, of which CWT-marking is one, it would have been problematic to estimate the incremental costs to hatcheries associated with CWT-marking. Also not considered were depreciation costs of equipment and facilities, nor the wages of CDFO staff involved in one capacity or another in CWT-marking and escapement recovery or catch sampling of WCVI fisheries. Finally, the cost of CWT data management was not included, as this is performed by CDFO staff.

Part of any proposal to replace CWT programs with alternative technologies should include a cost and benefits comparison. This paper should provide a reasonably accurate estimate of the cost of the CWT program in B.C. that should help facilitate such a comparison.

Acknowledgements

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References

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Table 1. Chinook and coho exploitation and survival indicators in B.C. Streams listed represent those programs which have either been operating within the past several years, or were originally intended to become indicator stocks. Programs proposed to be funded in 2004 are indicated by bold font. Reported costs represent the estimated incremental cost of CWT-marking for wild stocks, as well as the CWT escapement recovery costs for both hatchery and wild stocks. Costs of marking hatchery releases are provided in Table 6.

Chinook		**Coho**				
		Wild			Hatchery	
Stock (Hatchery)	Estimated CWT Recovery Cost[2]	Stock	Estimated Incremental CWT Marking Cost[1]	CWT Carcass Recovery Cost[2]	Stock	CWT Recovery Cost[2]
Kitsumkalum	**$2,000**	**Eagle R.**	**$15,000.00**	**$2,000.00**	**Louis Cr.**	**$2,000**
Atnarko	$2,000	Salmon R. (Lower Fraser)	$8,000.00	$2,000.00	**Lemieux Cr.**	**$2,000**
Quinsam	**$2,000**	Myrtle Cr.	$10,500.00	$2,000.00	**Salmon R. (Lower Thompson)**	**$2,000**
Big Qualicum	**$2,000**	Black Cr.	$5,500.00	$2,000.00	Coldwater R.	$2,000
Puntledge	**$2,000**	**Keogh R.**	**$9,500.00**	**$2,000.00**	**Dunn R.**	**$2,000**
Nanaimo	**$2,000**	Heydon Cr.	**$3,000.00**	**$2,000.00**	**Nicola R.**	**$2,000**
Cowichan	**$2,000**	**Carnation Cr.**	$4,000.00	$2,000.00	**Chilliwack R.**	**$2,000**
Robertson	**$2,000**	Martin R.	$20,500.00	$2,000.00	**Inch Cr.**	**$2,000**
Harrison	**$2,000**	**Drake Inlet**	**$18,000.00**	**$2,000.00**	**Big Qualicum R.**	**$2,000**
Chilliwack	**$2,000**	**Zolzap Cr.**	**$22,000.00**	**$2,000.00**	**Quinsam R.**	**$2,000**
Dome Cr.	$2,000	Lachmach Cr.	$12,000.00	$2,000.00	**Robertson Cr.**	**$2,000**
Lower Shuswap R.	$2,000				**Toboggan Cr.**	**$2,000**
Nicola R.	**$2,000**				**Babine R.**	**$2,000**
					Bulkley R.	$2,000
Totals	$26,000		$128,000	$22,000		$28,000

[1] Does not include the purchase cost of CWTs; this amount is provided in Table 5.

[2] Costs of CWT recovery were considered to be a fixed, incremental cost to adult enumeration programs. See text for further explanation.

Table 2. Average catch sample rates by gear for 2002. Commercial rates were obtained from JOT (2003); sport rates are from the MRP database.

Species	Gear	Year	Target Sample %	Average % of Catch Sampled[1]
Chinook	Troll	2002	20	59.9
	Net	2002	15	55.2
	Sport	2002	-	19.6
Coho	Troll	2002	20	45.7
	Net	2002	15	88.6[2]
	Sport	2002	-	3.9

[1] For commercial gear, values represent an arithmetic mean across catch regions. The sport sample rate is actually the inverse of the mean awareness factor (estimated CWTs/Observed CWTs) for Georgia St., Juan de Fuca St., and WCVI only.

[2] Coho net sample rates are biased high, as an unknown amount of landed catch was not reported (J.O. Thomas, pers. Comm.).

Table 3. Percentage of heads submitted for CWT dissection from fish caught in 2002 where no CWT was found (no-pins).

Species	Fishery	% No-pins
Chinook	Troll[1]	6.6%
	Net[1]	6.1%
	Sport[2] - direct sampled recoveries	50.6%
	- voluntary recoveries	57.8%
Coho	Troll[1]	14.8%
	Net[1]	4.4%
	Sport[2] - direct sampled recoveries	70.8%
	- voluntary recoveries	95.6%

[1] Commercial recoveries were pre-screened through a tube detector; for the most part, only heads that detected positive for a CWT were removed for dissection. However, an unknown number of heads from adipose-clipped fish that tested negative for a CWT were also submitted for dissection. Consequently, the no-pin rates are biased high to an unknown degree.

[2] No pre-screening of sport caught heads is performed prior to dissection. Because sport head recoveries represent voluntary samples, an unknown number of heads may have come from non-adipose clipped fish. Consequently, sport no-pin rates are likely biased high, but to an unknown degree.

Table 4. Numbers of juvenile chinook and coho salmon that were coded-wire-tagged in B.C. hatcheries from 2000-2002. Also shown are the total number of juvenile chinook and coho salmon released from hatchery facilities and the average percent of releases that are CWT-marked[1].

Species	Type	Tagging Agency	CWT Marked in 2000	Total Releases in 2000	CWT Marked in 2001	Total Releases in 2001	CWT Marked in 2002	Total Releases in 2002	2000-2002 Average CWT Marked	2000-2002 Average Releases	Average % Tagged
Chinook	Hatchery	CDFO (B.C.)	3,725,953	55,978,349	3,692,090	48,701,693	3,803,348	54,606,484	3,740,464	53,095,509	7.0%
Chinook	**Total**	-	**3,725,953**	**56,969,622**	**3,692,090**	**49,667,560**	**3,803,348**	**54,606,484**	**3,740,464**	**53,747,889**	**7.0%**
Coho	Hatchery	CDFO (B.C.)	1,293,602	25,091,922	1,313,810	24,174,582	1,374,388	20,720,322	1,327,267	23,328,942	5.7%
Coho	Wild	CDFO (B.C.)	211,605	448,915	119,652	293,887	183,681	234,888	171,646	325,897	52.7%
Coho	Wild	AFSP[2]	42,378	45,850	22,216	26,812	27,089	27,123	30,561	33,262	91.9%
Coho	**Total**	-	**1,547,585**	**25,586,687**	**1,455,678**	**24,495,281**	**1,585,158**	**20,982,333**	**1,529,474**	**23,688,100**	**6.5%**
Grand Total			**5,273,538**	**82,556,309**	**5,147,768**	**74,162,841**	**5,388,506**	**75,588,817**	**5,269,937**	**77,435,989**	**6.8%**

[1] Release data from the MRP database maintained at the Pacific Biological Station, Nanaimo, B.C.

[2] Aboriginal Fisheries Strategy Program

Table 5. Approximate costs associated with the coded-wire-tagging of wild and hatchery juvenile chinook and coho salmon released from hatcheries in B.C.

Species	Type of Release	Agency	Average No. Tagged 2000-2002	Approximate Cost per 1,000 CWTs (2004 Price)	Total Annual Purchase Cost of CWTs	Approximate Cost of Ad-clipping and CWT Marking per 1,000[2]	Total Annual Clipping/Marking Cost	Total Cost per 1,000	Total Cost[3]
Chinook	Hatchery	CDFO (B.C.)	3,740,464	$93.83	$350,968	$65.00	$243,130	$159	$594,098
Coho	Hatchery	CDFO (B.C.)	1,327,267	$93.83	$124,537	$65.00	$86,272	$159	$210,810
Coho	Wild	CDFO (B.C.)	171,646	$93.83	$16,106	-	$128,000	-	$144,106
Coho	Wild	AFSP[1]	30,561	$93.83	$2,868	$65.00	$1,986	$159	$4,854
Total			**5,269,937**		**$494,478**		**$459,389**		**$953,867**

[1] Aborginal Fisheries Strategy Programs; it is assumed that the per fish cost of marking/clipping for these programs was similar to the cost of marking hatchery-reared fish.

[2] Based on average 2002-2003 cost. Labour costs for individual stocks varies, with location and experience of the markers.

[3] Cost for CDFO wild releases from Table 1.

Table 6. Estimated annual cost of CWT recovery operations in B.C.

Recovery Component	Estimated Cost
WCVI Commercial Sampling	$65,000
Non-WCVI Commercial Sampling, All Head Dissecting/CWT Decoding	$825,000
Escapement Sampling (From Table 1)	$76,000
Total	**$966,000**

Table 7. Numbers of heads submitted for CWT decoding by sector from 2000-2002; data from JOT (2003).

	No. of Heads Dissected for CWTs		
Category	**2000**	**2001**	**2002**
Escapement[1]	12,244	14,032	13,012
Commercial	2,184	4,018	9,874
Sport	2,863	3,024	5,651
Misc./Small Projects	1,178	1,625	3,251
Total	18,469	22,699	31,788

[1] Does not include heads decoded by several hatcheries; the number of such heads would not normally amount to more than 300-400 annually in total.

Table 8. Estimated total cost of the CWT program to CDFO B.C.

		Cost	
Category	**Component**	**$Cdn**	**$ U.S.**
CWT Purchase	-	$494,478	$369,013
Clipping and CWT Marking	Hatchery Stocks	$329,402	$245,822
	Wild Stocks	$129,986	$97,004
Total Marking Costs		**$953,866**	**$711,840**
CWT Recovery	Fishery Sampling-JOT	$825,000	$615,672
	Fishery Sampling-CDFO	$65,000	$48,507
	Escapement	$76,000	$56,716
Total CWT Recovery Costs		**$966,000**	**$720,896**
Total Cost of CWT Program		**$1,919,866**	**$1,432,736**

Table 9. Observed CWT recoveries of Canadian stocks in all coastwide fisheries and escapement[1].

Species	Year	Fishery Recoveries	Escapement Recoveries[1]	Total Observed CWT Recoveries	Cost of Marking	Cost of Recovery[2]	Total Cost	Avg Cost per CWT Recovery
Chinook	2000	1,700	2,502	4,202				
	2001	2,273	4,756	7,029				
	2002	3,617	3,872	7,489				
Avg		**2,530**	**3,710**	**6,240**	**$594,098**	**$368,650**	**$962,748**	**$154**
Coho	2000	1,851	7,181	9,032				
	2001	1,864	7,044	8,908				
	2002	888	4,495	5,383				
Avg		**1,534**	**6,240**	**7,774**	**$359,977**	**$597,350**	**$957,327**	**$123**
Avg, Total		**4,064**	**9,950**	**14,014**	**$954,075**	**$966,000**	**$1,920,075**	

[1] Recovery data obtained from the MRP database maintained at the Pacific Biological Station, Nanaimo, B.C.

[2] Not all escapement recoveries have been inputted to the mark-recovery database.
However, these represent a small portion of total Canadian escapement recoveries.

[3] Cost is the sum of the cost of escapement sampling, plus the cost of the commercial sampling and head decoding contract to JOT, based on the proportion of recoveries for that species.