Estimates of the Abundance of Hatchery Chinook in Wild Spawning Populations - 2008.
SF-2008 –I- 20

Introduction

Thermal marking is a method of imparting a mass mark in the form of a series of dark rings on the otoliths of fish. It is accomplished by manipulating water temperatures during incubation or early rearing to induce the required mark. A single thermal ring is induced onto the otolith through any rapid temperature drop of $2^{o}C$ or greater, and usually left for a 24 hour period. By manipulating temperatures in a pre-determined sequence of temperature drops and rises it is possible to induce a consistent mark pattern on the otoliths of all eggs or fish being so marked.

Marking protocols are overseen by the North Pacific Anadromous Fish Commission's (NPAFC) 'Working Group on Salmon Marking (WGSM). The WGSM require that mark releases in any given brood year be unique to a particular release facility for any given species. In recent years most release facilities have used a standard thermal mark to identify their 'production' releases and additional unique marks for experimental or new release strategies. Consequently most thermal marks are now unique to their release facilities within DFO's Pacific Region though some have multiple release locations. A few identical marks have been applied at different facilities in different brood years. Most marked otoliths recovered from high seas and non terminal areas can therefore be identified back to their hatchery of origin without the need for ageing structures but a few samples still require an age to pinpoint their hatchery of origin.

Project Objectives

Data obtained in recent years from the Pacific region thermal marking program has indicated varying degrees of straying of chinook along WCVI. Otolith analysis from Gold River on the WCVI from 2002 to 2006 showed that many Chinook originated from Robertson Creek hatchery near Port Alberni. Limited straying has also been observed to other WCVI systems. Continued sampling of chinook returns to WCVI in 2008 was to provide further data to evaluate the extent of chinook straying in both distance and magnitude.

Comparisons of thermal mark and cwt data from Robertson Creek Hatchery and Stamp River in recent years have resulted in significant differences in hatchery contribution between the two methods. Hatchery contributions based on CWT's have been considerably lower than otolith based estimates. CWT estimates also indicate that progeny from 'natural' spawners comprise a significant portion (22% to 5% from 2000 to 2005) of swim-ins to Robertson Creek Hatchery. Sampling of returns to Stamp River and Robertson Creek Hatchery in 2008 was to provide additional data to compare CWT and thermal mark estimates of hatchery contribution.

Continue to increase First Nations expertise in sample collection, preparation and thermal mark analysis.

Methods

Sample Collection

4443 escapement samples were collected from a total of 27 sites on 21 different systems on Vancouver Island and 1 on the Lower Mainland. Samples were taken during ongoing DFO programs wherever possible, including broodstock collection, escapement enumeration at fences and from dead pitches and river swims.

Some proposed systems were unable to be sampled due to logistical problems, including both poor escapements and poor availability of carcasses due to high water and low escapements. However, broodstock were collected from the Gold/Muchalaht system in 2008 and resulted in a good otolith sample being obtained from this system. Supporting funding to the 'Friends of Marble River' resulted in the first good sized sample from that system which was expecting age 2 and 3 thermal marks back in 2008. Some additional systems were sampled when opportunities arose, including Salmon, Englishman, Nanaimo and Cowichan Rivers on ECVI and Zeballos on WCVI (Table 2).

Sport caught samples comprised a total of 1586 samples. Nearly all these came from the main sport fishing hot spots off WCVI including Port Renfrew, Alberni Inlet/Barkley Sound, Clayoquot Sound, Nootka Sound

and Kyuquot Sound. A small sample of 11 was also obtained from the Campbell River tyee club. These were sampled during routine DFO creel surveys.

Whenever possible otoliths were extracted in the field and stored in boxes with individually numbered vials. Additional biological data including, length, sex, and scales were collected when time permitted. Samples were checked for missing adipose fins. Samples and data were submitted to the project coordinator to organise and assign lab numbers for identification. If time did not allow for otolith extraction in the field then heads were removed and frozen before being extracted in the otolith lab at the Hupacasath First Nation offices in Port Alberni.

Lab Procedures

Each 'sample' or group of otoliths recovered from 1 sampling program is assigned a 'lab number'. Each pair of otoliths within that sample are also assigned a fish number to enable tracking within that sample. This information is recorded on each glass slide prior to otolith mounting. Otoliths from adults are mounted on labelled glass slides 'sulcus down' using crystals of thermoplastic cement which are melted using a hotplate. Each otolith is placed in the melted cement on a labelled slide which is then removed from the hotplate to allow the cement to harden. The left otolith is ground down to the midplane using a precision Buehler grinder and a dissecting scope to look for the primordia (the points from which cells originally coalesce to start forming the otolith). This confirms the correct amount of material has been removed. The slide is then placed back on the hotplate to melt the cement and the otolith is turned over before again being removed from the hotplate to allow the cement to re-set. The otolith is then ground down to a thin section before being viewed on a compound microscope at between 100X and 400X power. Final preparation is achieved by polishing with a diamond polishing paper to bring out any mark. If a satisfactory reading cannot be obtained from the left otolith the right one is processed using the same procedure.

A thermal mark is apparent by a series (or multiple series) of equidistant rings that differ from any natural rings by their dark appearance and uniformity. Lab technicians are able to compare any marks with baseline or 'reference' samples received from hatcheries and obtained prior to release of the group. Comparisons are made using either the RBr or the Hatch code coding system, utilised in thermal marking programs throughout the Pacific Northwest, along with the relative and absolute spacing of the Bands and Rings which comprise the thermal mark. All chinook marks from BC which could have been present in 2008 harvest or escapement samples are shown in Tables 1a and 1b.

Results

A total of 6161 otolith samples were collected, processed and analysed as described above. 4104 of these otoliths were re-read a second time to enable a comparison with the original reading. Readings agreed 99.4% of the time on whether an otolith was thermally marked or not. Agreement was reached 97.0% of the time on the Hatch Code observed and of the 2414 otoliths in which both readings agreed that a thermal mark was present only 1 sample had a disagreement as to the Hatchery of origin. Time constraints have meant the readings have not currently been compared to determine a 'final' result. Results presented here are from readings carried out by our most consistent/experienced reader. The thermal marking program is now using a new database obtained from ADF&G for ongoing lab readings. This database will shortly be populated with standardised historical readings and updated baseline data prior to full operation and generation of reports. Data for this report was entered into Excel to permit analysis of results.

Straying and Hatchery Component

Samples from broodstock recovery, deadpitch sampling and hatchery swim-ins were looked at in terms of straying from one location to another and in terms of hatchery contribution to escapement. It should be noted that the hatchery % indicated is biased low for some recovery locations as not all years contributing to the escapement were thermally marked (tables 1a and 1b).

Recoveries were categorised into 25 different sampling locations by statistical area (Table 3). Stray rates appear to be relatively low across statistical areas but do occur on a local scale. This localised straying occurs mostly in areas 13 and 25. In area 13, releases from both Quinsam River and Campbell Estuary sea-pens were recovered in Campbell and Quinsam Rivers. Salmon River also saw 3 recoveries from Quinsam releases and 1 from Robertson Creek Hatchery near Port Alberni. Area 25 appears to have both localised straying within most of the systems surveyed and some straying from further a-field. Recoveries in the Conuma River included 4 fish from Sucwoa/Tlupana/Zeballos. 3 thermal marks from Conuma River/Estuary releases were recovered from the Tahsis River. Zeballos River saw 1 recovery from Burman

River. No samples were recovered from the Leiner in 2008 which observed significant local straying in 2007.

Straying over longer distances appears to be limited to the Esquimalt/Sooke/Toquart release from Nitinat River Hatchery and from some Robertson Creek Hatchery releases. Esquimalt/Sooke/Toquart samples were recovered from both the Englishman River (1 recovery) and the Lower Nanaimo River (4 recoveries). Henderson River fish from Robertson Creek Hatchery were recovered in escapement samples from Cowichan River (2) and Sooke River (9). Robertson Creek fish were recovered from the Salmon River (1) in Area 13 and, more significantly, from Gold River. 56% of the 105 samples recovered from Gold River were determined to be of Robertson Creek origin.

Results in table 3 indicate that returns to some systems have very high hatchery components to them. Swim-ins to major facilities at Robertson and Chilliwack not surprisingly had very high hatchery components from 98%-99%. The swim-ins to Quinsam had a much lower hatchery component than in 2007 (75% to 98%). It is unclear at this point why this is so. Deadpitch and/or broodstock samples taken from systems with major facilities also have a high first generation hatchery component to them. This ranged from 60% in Quinsam to 96% in Conuma. Some systems with smaller broodstock releases also indicate a high hatchery component including Sarita which showed 88% hatchery origin from the 229 samples read and Burman River with 77% of its 100 samples being hatchery origin. 81% of the 16 samples read from Tlupana River and 79% of the 28 samples from Tahsis River were also of hatchery origin. Thermal Marking began on the Nanaimo and Salmon Rivers in 2005. There were 2 recoveries of Salmon River otoliths in the 44 deadpitch samples recovered from the Salmon River. There were also 3 strays from Quinsam River recovered. A very high hatchery contribution was observed to the Nanaimo River where only the 2 and 3 year old components are thermally marked. The Lower River beach seine and deadpitch samples contained mostly Fall run returns in its 66% hatchery component (sample size 299) but did include 4 summer run fish. 44 of the 147 samples read from the Upper River deadpitch were thermally marked. 8 of these were from Fall run fish and 36 were from Summer run.

Thermal Marking and CWT Comparison

Comparison of thermal marking results and cwt analysis from both Stamp River and Robertson Creek Hatchery swim-ins in 2008 updates the results obtained from 2000 to 2007. Cwt analysis was conducted using MRP standards and PSARC approved methods for the Somass River Keystream assessments.

Preparing and reading otoliths requires the ability to pick out a thermal pattern from the ‘noise’ around it. Because it is easier to look for something that is present rather than for the absence of something there can be a tendency (especially with new technicians) to grind too far into an otolith and therefore render it impossible to read. This lends itself to a possible bias towards ‘unmarked’ fish in those samples that are classed as ‘destroyed’. Thermal marking results can be reported in two ways to account for this. Firstly, by excluding the ‘destroyed’ samples and secondly by including ‘destroyed’ samples as ‘not marked’. The first method gives a maximum hatchery component (and therefore minimum natural contribution) and the second minimises hatchery component and maximises any natural contribution. The thermal mark data set reported here includes ‘destroyed’ samples classed as ‘not marked’, thereby maximising ‘natural’ contribution and minimising ‘hatchery’ contribution.

All First Nations, commercial and sport caught salmonids and any escapements which are sampled should be checked for adipose clips. Heads (containing the otoliths) from ad clipped fish are submitted to the head lab for dissection and removal of any cwt. Most samples of otoliths therefore exclude any ad clipped fish. This biases the results towards natural production by reducing hatchery contribution. The underestimate of hatchery contribution is relatively small in cases where hatchery component is high and the proportion of ad clipped fish is relatively low, as is the case with Robertson Creek Hatchery (approx. 3%).

Despite biases away from ‘hatchery’ production the results obtained continue to indicate a higher proportion of hatchery production in the Stamp River system from thermal marks than are indicated by cwt’s. Hatchery contribution between 2000 and 2008 from cwt’s indicated a range of 58-84% (77% in 2008) hatchery origin in the deadpitch compared with 86-96% (83% in 2008) from thermal marks. Hatchery contribution to hatchery swim-ins from the same time period varied widely from 55-89% (83% in 2008) for cwt’s. Hatchery contribution to swim-ins from thermal marks (including ‘destroyed’ samples as ‘not marked’ has been consistent over all years (98-100%) until 2006 and 2007 when it dropped to 88% and 94% respectively. In 2008 this was back up to 97%. The reduction in the 2006 hatchery contribution (from thermal marks) was primarily due to unmarked (or destroyed) 3 year old samples (2003 brood year) observed both in the deadpitch and swim-in samples and could be indicative of either good natural

production from the 2003 brood or difficulty in observing the applied thermal mark. Additional unmarked and/or destroyed samples from the 2003 brood year were also observed in 2007 and 2008.

Table 4 and Fig 1 show the contribution of both 'natural' and enhanced production to chinook escapement in the Stamp River system using both thermal mark analysis and cwt recoveries. Total returns are underestimated for all brood years except 1998 to 2003. 1996 and 1997 are only slightly underestimated as a result of poor age 2 and 3 returns in 1998 and 1999 whereas 2004, 2005 and 2006 broods still have significant portions of their cohorts to return. The data does however accurately portray the relative returns for those years between the two assessment methods.

Budget

Funding for this project was nearly all earmarked for sample collection and sample preparation and analysis. $63.5k of the original 64.0k budget was spent on preparation and reading by members of the Hupacasath, Uchucklesaht and Ditidaht First Nations who gained valuable additional expertise. The remaining $0.5k in the budget was spent on sample collection by the 'Friends of the Marble'. The majority of the sample collection and all the management and coordination of the project was in the form of in-kind contribution from DFO, primarily South Coast Stock Assessment. The project was completed on budget - see tables 5 and 6 for budget details.

Discussion

Straying and Hatchery Component

Straying percentages are shown in Table 3. Both recovery locations and release locations are grouped together by statistical area. This helps to show the extent of localised straying compared with that over greater distances. Most straying that does occur appears to be localised and minor and the sample sizes and numbers of observations are low. Patterns of straying observed in 2008 were similar to those in 2007. Most straying occurred from releases around Nootka Sound. As expected, the collection of samples from the Gold/Muchalaht resumed in 2008 and continued to show significant straying from Robertson Creek Hatchery near Port Alberni. Of the 105 readable samples 62 were thermally marked and 43 were not marked. The 62 thermally marked samples comprised 59 Robertson Creek fish, 1 Gold River fish and 2 Burman River fish.

Results from Chilliwack deadpitch indicate that 'natural' production can be variable. 'Natural' production from 2000 to 2006 returns was shown to be 11% or less but this increased to 38% in 2007 and dropped back to 22% in 2008. Swim-ins are consistently 99-100% hatchery contribution so the change is unlikely to be due to a marking/reading error. The improved 'natural' production is likely due to better survival from 1 brood year (either 2003 or 2004). A less likely possibility is that there was significant straying to Chilliwack River from other unmarked systems in both 2007 and 2008.

Comparison of Thermal Mark and CWT Results

The data obtained from the 2008 program continues to show that thermal marking indicates a greater proportion of returning fish to both Stamp River and Robertson Creek Hatchery are of hatchery origin than is indicated by cwt's. These differences could be due to error in determining presence/absence of thermal marks, error associated with the cwt methodology and/or analysis or both. Large consistent error in thermal mark analysis appears unlikely because whilst Robertson Creek Hatchery's main thermal mark could occasionally be misidentified (it is single band of 3 rings so it could be misidentified with a natural occurrence of a similar mark), similar results (and discrepancies with cwt results) have been reported (pers. comm. Roberta Cook) from Chilliwack River where the thermal mark consists of a band of 7 rings and cannot be easily misidentified. Furthermore, thermal marking is a mass marking technique and all fish subject to the same temperature changes are subject to the same mark. Therefore sample sizes do not need to be large to get a representative sample and no expansions are required. Cwt's are usually applied at rates of 2-5% but expansion values can vary from 1 to >100. Because the recovery of a cwt is a rare event any error or bias associated with the sampling methodology (e.g. missed adipose clips) or in the analysis becomes magnified.

Thermal mark analysis of Robertson Creek Hatchery adult swim-ins in 2008 shows a hatchery contribution of 92%-100%. Overall hatchery contribution for adults was 97% (99% when excluding 'destroyed' samples) and 100% for jacks. The lower hatchery contribution of 92% from the 2003 brood confirms similar results obtained in 2005 (2 year old jacks) and 2006 (3 year olds) and 2007 (4 year olds) which also

showed a higher 'natural' contribution from the 2003 brood. Hatchery contribution to the same 2008 hatchery returns based on cwt analysis indicates a more variable hatchery contribution ranging from 0% (from the small population of 6 year olds) to 109% (83% overall) for adults and 76% for jacks. These results for cwt's are similar to those obtained in previous years except for 2007 when the cwt results were more consistent and much closer to those obtained from the thermal marks. Similar results are shown in recoveries from the dead pitch program from 'natural' spawners in the Stamp River. Thermal marks show a hatchery component of 73% to 90% for each of age 3 to age 5 (83% overall – no age 6 returns) and 91% for jacks. Cwt's indicate a hatchery variability from 50-105% for age 3 to age 5 (77% overall) and 69% for jacks. Good sample sizes and the 100% thermal mark rate on hatchery releases contributed to the relative consistency of the thermal mark results. Conversely the low sample sizes and large expansions required of the cwt data resulted in variable results from that data set. Results obtained in 2008 continue to indicate that CWT's provide highly variable hatchery contribution estimates on a year by year basis and that overall they are underestimating hatchery contribution to escapement in the Stamp River.

The lower hatchery percentage obtained from the thermal mark results for 2003 brood samples may be indicative of good natural production from that brood which had good spawning numbers (estimated 40 million egg deposition in the Stamp River). Alternatively it is possible that the thermal marks from 1 or more production groups are not being recognised. The 2003 brood reference samples obtained by the lab were missing 2 groups where the heaters were started up part way through application of the mark. In theory this should not have affected the mark but without the reference samples the marks appearance and overall 'look' cannot be confirmed.

There are two potential sources of error resulting in a portion of the difference between the two methods. 2006 recoveries of cwt's from Stamp River had a 'no pin' rate of approximately 3.4% for swim-ins and 5.9% for dead pitch samples (4.6% overall). Expansion factors associated with cwt recoveries allow for 'no pins' at a rate determined during holdover and re-testing of smolts post tagging and pre-release. Mortality of these test fish over the short holding period is usually low (0.3% from 1996 to 2005 brood year releases). Recent years (including 2008 rate of 5.1%) recovery of 'no pins' indicate the no pin rate can be much greater than that allowed for in the expansions. A further small component of the difference (in previous returns) is from 'unassociated' releases of fish; that is releases with no cwt's as part of the group and not associated to releases with cwt's because they are too dissimilar. Robertson had one such release of 126,000 fish from brood year 1996. These fish were thermally marked but are not expanded for in the cwt analysis.

The Stamp River keystream program has an annual target of 50 million eggs deposited into Stamp River plus an additional 20% allowance for pre-spawn mortality. In addition Robertson Creek Hatchery brood requirements are for 6 to 7 million eggs. The egg target was approached in 1998, 1999, and each year from 2003 to 2006 of the study period, in other years egg deposition fell well short. Table 4 shows that for the 6 years which have fully returned (1998-2003), total escapement of 116,000 (45,600 females) resulted in an egg deposition of 164 million in the Stamp River. Cwt analysis shows a resultant 'natural' escapement (excluding catch) from this of 112,400 adults. Thermal marking estimates the natural production (escapement only) from those 6 years to be just 25,500 (23% of the cwt estimate). The thermal marking results (Fig 2) continue to call into question from a production standpoint whether it is worthwhile striving to reach the 50 million in-river egg target. While 'natural' production does appear to follow the trends shown by egg deposition it is at a low level. Foregoing potential catch and reducing economic benefits to some segments of the fishery in order to reach the current egg target is of questionable benefit, unless required for genetic diversity, given that hatchery production appears to be generating the majority of the returns. If this egg target is to remain and 'natural production' is important enough to justify such high escapement levels in this system the low natural productivity in the Stamp River needs to be analysed and actions taken to remedy the situation.

Appendix

Table 1a. **Chinook Thermal Marks Available for Recovery During 2008 Fisheries and Escapement Sampling.** (by Release Facility).

			Brood Year				
Facility	**Release Site**	**Hatch Code**	**2002**	**2003**	**2004**	**2005**	**2006**
Big Qualicum River	Englishman River	H6		Yes	Yes	Yes	
Chilliwack River Hatchery	Chilliwack River + Alouette River South	H7	Yes	Yes	Yes	Yes	Yes
Conuma River Hatchery	Burman River + Burman Estuary	H4,2	Yes	Yes	Yes	Yes	Yes
	Conuma River + Conuma Estuary	H5-2				Yes	Yes
		H5-3				Yes	Yes
		H5	Yes	Yes	Yes		
	Gold River + Gold Estuary + Muchalat Lake	H2,4	Yes		Yes	Yes	
	Gold River	H2,1,2					Yes
		H2,2,2		Yes			
	Sucwoa River + Sucwoa Estuary + Tlupana River + Tlupana Estuary + Zeballos River	H3	Yes	Yes	Yes	Yes	Yes
	Tahsis River	H9		Yes	Yes	Yes	
Cowichan River Hatchery	Cowichan River	4-1H					Yes
		1,3,1H					Yes
		3,2wH					Yes
Marble River Hatchery	Benson River + Marble River + Quatsino Sound	3,2,2H				Yes	Yes
Nanaimo River Hatchery	Nanaimo First Lake/GSVI - Summer run.	H2,3				Yes	
		H5					Yes
	Nanaimo River - Fall run	H2/3				Yes	
		H6					Yes
	Nanaimo River + Napoleon Creek - Fall run	H2-3					Yes
Nitinat River Hatchery	Esquimalt Harbour	4,1H	Yes				
	Esquimalt Harbour + Sooke River	4H		Yes	Yes	Yes	Yes
	Nitinat River + Nitinat Lake + Klanawa River + Sooke Harbour	H2,3,1				Yes	
		H2,3,2	Yes	Yes	Yes		Yes
	Nitinat Lake	H2,3,2,2				Yes	Yes
	Poett Nook	H2/2,3+4					Yes
		H2W,3,2+4					Yes
		H3				Yes	
	Poett Nook + Sarita River	H3,2,3	Yes	Yes	Yes		Yes
	Sooke River	4-1H	Yes				
	Toquart Lake	4H	Yes				
Quinsam River Hatchery	Campbell River + Elk Falls Channel 1 + Second Island Slough + Quinsam River	3-4H	Yes	Yes	Yes	Yes	Yes
	Campbell River + Quinsam River + Quinsam Lake + Cold Creek	2-4H		Yes	Yes	Yes	Yes
	Discovery Passage	H2/2	Yes	Yes	Yes	Yes	Yes
	Quinsam River	H2/2/2	Yes	Yes	Yes	Yes	Yes
	Salmon River/JNST	H2/2/2/2				Yes	Yes
Robertson Creek	Great Central Lake + Harbour Quay	3,1,2H		Yes	Yes		
	Henderson River + Henderson Lake	5H	Yes	Yes	Yes	Yes	Yes
	Nahmint River	3,2H		Yes	Yes		
		3,2H4					Yes
		3-2H					Yes
	Nahmint Estuary	3-2H5					Yes
	Nahmint River + Nahmint Estuary	H4-2	Yes				
	Robertson Creek	2H				Yes	
		3,1,3H		Yes	Yes		
	Robertson Creek + Stamp River + Harbour Quay + Great Central Lake	3H	Yes	Yes	Yes	Yes	Yes
San Juan River Hatchery	San Juan River + San Juan Estuary + Back Pond + Harris Creek/SWV	H3	Yes	Yes	Yes	Yes	Yes
Spius Creek Hatchery	Coldwater River	H3/4		Yes			

Table 1b. **Chinook Thermal Marks Available for Recovery During 2008 Fisheries and Escapement Sampling.** (by Hatch Code).

			Brood Year				
Hatch Code	**Facility**	**Release Site**	**2002**	**2003**	**2004**	**2005**	**2006**
1,3,1H	Cowichan River Hatchery	Cowichan River					Yes
2-4H	Quinsam River Hatchery	Campbell River + Quinsam River + Quinsam Lake + Cold Creek		Yes	Yes	Yes	Yes
2H	Robertson Creek Hatchery	Robertson Creek				Yes	
3,1,2H	Robertson Creek Hatchery	Great Central Lake + Harbour Quay		Yes	Yes		
3,1,3H	Robertson Creek Hatchery	Robertson Creek		Yes	Yes		
3,2,2H	Marble River Hatchery	Benson River + Marble River + Quatsino Sound				Yes	Yes
3,2H	Robertson Creek Hatchery	Nahmint River		Yes	Yes		
3,2H4	Robertson Creek Hatchery	Nahmint River					Yes
3,2wH	Cowichan River Hatchery	Cowichan River					Yes
3-2H	Robertson Creek Hatchery	Nahmint River					Yes
3-2H5	Robertson Creek Hatchery	Nahmint Estuary					Yes
3-4H	Quinsam River Hatchery	Campbell River + Elk Falls Channel 1 + Second Island Slough + Quinsam River	Yes	Yes	Yes	Yes	Yes
3H	Robertson Creek Hatchery	Robertson Creek + Stamp River + Harbour Quay + Great Central Lake	Yes	Yes	Yes	Yes	Yes
4,1H	Nitinat River Hatchery	Esquimalt Harbour	Yes				
4-1H	Cowichan River Hatchery	Cowichan River					Yes
	Nitinat River Hatchery	Sooke River	Yes				
4H	Nitinat River Hatchery	Esquimalt Harbour + Sooke River		Yes	Yes	Yes	Yes
		Toquart Lake	Yes				
5H	Robertson Creek Hatchery	Henderson River + Henderson Lake	Yes	Yes	Yes	Yes	Yes
H2,1,2	Conuma River Hatchery	Gold River					Yes
H2,2,2	Conuma River Hatchery	Gold River		Yes			
H2,3	Nanaimo River Hatchery	Nanaimo First Lake/GSVI - Summer run.				Yes	
H2,3,1	Nitinat River Hatchery	Nitinat River + Nitinat Lake + Klanawa River + Sooke Harbour				Yes	
H2,3,2	Nitinat River Hatchery	Nitinat River + Nitinat Lake + Klanawa River + Sooke Harbour	Yes	Yes	Yes		Yes
H2,3,2,2	Nitinat River Hatchery	Nitinat Lake				Yes	Yes
H2,4	Conuma River Hatchery	Gold River + Gold Estuary + Muchalat Lake	Yes		Yes	Yes	
H2/2	Quinsam River Hatchery	Discovery Passage	Yes	Yes	Yes	Yes	Yes
H2/2,3+4	Nitinat River Hatchery	Poett Nook					Yes
H2/2/2	Quinsam River Hatchery	Quinsam River	Yes	Yes	Yes	Yes	Yes
H2/2/2/2	Quinsam River Hatchery	Salmon River/JNST				Yes	Yes
H2/3	Nanaimo River Hatchery	Nanaimo River - Fall run				Yes	
H2-3	Nanaimo River Hatchery	Nanaimo River + Napoleon Creek - Fall run					Yes
H2W,3,2+4	Nitinat River Hatchery	Poett Nook					Yes
H3	Conuma River Hatchery	Sucwoa River + Sucwoa Estuary + Tlupana River + Tlupana Estuary + Zeballos River	Yes	Yes	Yes	Yes	Yes
	Nitinat River Hatchery	Poett Nook				Yes	
	San Juan River Hatchery	San Juan River + San Juan Estuary + Back Pond + Harris Creek/SWV	Yes	Yes	Yes	Yes	Yes
H3,2,3	Nitinat River Hatchery	Poett Nook + Sarita River	Yes	Yes	Yes		Yes
H3/4	Spius Creek Hatchery	Coldwater River		Yes			
H4,2	Conuma River Hatchery	Burman River + Burman Estuary	Yes	Yes	Yes	Yes	Yes
H4-2	Robertson Creek Hatchery	Nahmint River + Nahmint Estuary	Yes				
H5	Conuma River Hatchery	Conuma Estuary + Conuma River	Yes	Yes	Yes		
	Nanaimo River Hatchery	Nanaimo First Lake/GSVI - Summer run.					Yes
H5-2	Conuma River Hatchery	Conuma River + Conuma Estuary				Yes	Yes
H5-3	Conuma River Hatchery	Conuma River + Estuary				Yes	Yes
H6	Big Qualicum River Hatchery	Englishman River		Yes	Yes	Yes	
	Nanaimo River Hatchery	Nanaimo River - Fall run					Yes
H7	Chilliwack River Hatchery	Chilliwack River + Alouette River South	Yes	Yes	Yes	Yes	Yes
H9	Conuma River Hatchery	Tahsis River		Yes	Yes	Yes	

Table 2. **Summary of Samples Collected and Thermal Marks Recovered During 2008.**

											Hatchery																							
											Quinsam					Big Qualicum	Nanaimo		Nitinat				Robertson			Conuma					Marble	Chilliwack	Unknown
											Release Locations & Stat Areas																							
											13	13	13	13	13	14	17	17	19/20/23	20	20/21/22	23	23	23	23	25	25	25	25	25	27	29	
Catch Location	Statistical Area	Sample Type	Gear Type	Development Stage	Destroyed	No Sample	Not Thermally Marked	Yes Thermally Marked	Effective Sample Size	% Hatchery																								
Campbell River	13	Escapement	Deadpitch	Adult	5	22	51	22	73	30%	10	3		9																				
Quinsam River	13	Escapement	Deadpitch	Adult	2		1	9	10	90%	3	6																						
Quinsam River	13	Escapement	Deadpitch	Adult	3		39	58	97	60%	24	31	2	1																				
Quinsam Hatchery	13	Escapement	Swim-in	Adult	2			38	38	100%	10	26	2																					
Quinsam Hatchery	13	Escapement	Swim-in	Adult			25	75	100	75%	19	47	9																					
Gillards Pass/Phillips River	13	Escapement	Deadpitch	Adult			1		1	0%																								
Menzies Creek	13	Escapement	Beach	Adult			1		1	0%																								
Salmon River	13	Escapement	Deadpitch	Adult		1	38	6	44	14%		2	1		2									1									
Tyee Pool	13	Sport	Sport Rod	Adult			6	5	11	45%	4	1																						
Englishman River	14	Escapement	Deadpitch	Adult		1	24	9	33	27%						8			1															
Lower Nanaimo River	17	Escapement	Beach	Adult	2		40	59	99	60%							58	1																
Lower Nanaimo River	17	Escapement	Deadpitch	Adult	1		63	137	200	69%							129	4	4															
Upper Nanaimo River	17	Escapement	Deadpitch	Adult	7	7	79	20	99	20%							6	14																
Upper Nanaimo River	17	Escapement	Gillnet	Adult	2		24	24	48	50%							2	22																
Cowichan River	18	Escapement	Beach	Adult	4	1	192	3	195	2%							1							2										
Sooke River	20	Escapement	Beach	Adult	6	5	47	37	84	44%									12	7	9			9										
San Juan River	20	Escapement	Fence /	Adult		6	83	1	84	1%											1													
Juan de Fuca/Nitinat	20/21	Sport	Sport Rod	Adult		1	37	9	46	20%											1				5									3
Juan de Fuca/Nitinat	20/21/121	Sport	Sport Rod	Adult	5		148	14	162	9%									1		1				5		1					3	3
Nitinat River	22	Escapement	Beach	Adult	2	3	80	316	396	80%											316													
Nitinat River	22	Escapement	Swim-in	Adult	4	2	76	318	394	81%											317	1												
Nitinat Lake	22	Escapement	Purse Seine	Adult	2		9	69	78	88%											67	1												1
Nahmint River	23	Escapement	Beach	Adult	2		7	5	12	42%													5											
Sarita River	23	Escapement	Beach	Adult	3	6	27	202	229	88%												202												
Stamp River	23	Escapement	Deadpitch	Adult	4	1	16	79	95	83%															79									
Stamp River	23	Escapement	Deadpitch	Adult	5	4	11	80	91	88%															80									
Stamp River	23	Escapement	Deadpitch	Adult	2	1	7	60	67	90%															60									
Stamp River	23	Escapement	Deadpitch	Adult	15	6	34	213	247	86%															213									
Robertson Creek Hatchery	23	Escapement	Swim-in	Adult	3		5	167	172	97%															167									
Robertson Creek Hatchery	23	Escapement	Swim-in	Adult	2		1	172	173	99%															172									
Robertson Creek Hatchery	23	Escapement	Swim-in	Adult				50	50	100%															50									
Robertson Creek Hatchery	23	Escapement	Swim-in / Deadpitch	Adult	3		1	118	119	99%															118									
Barkley	23/123	Sport	Sport Rod	Adult		1	14	12	26	46%											1				8	1						1	1
Barkley	23/123	Sport	Sport Rod	Adult			36	64	100	64%							1				2				57	1						3	
Barkley	23/123	Sport	Sport Rod	Adult		5	16	46	62	74%												1			45								
Barkley	23/123	Sport	Sport Rod	Adult	1	2	109	55	164	34%											3	4			31	1						8	8
Barkley/Clayoquot	3/24/123/124	Sport	Sport Rod	Adult	4	4	250	42	292	14%										4	3			1	8	1						9	16
Clayoquot	24/124	Sport	Sport Rod	Adult	5	1	104	16	120	13%											1				1	1						7	6
Conuma River	25	Escapement	Beach	Adult	4	1	4	94	98	96%																90				4				
Gold River	25	Escapement	Beach	Adult	2		43	62	105	59%															59		1		2					
Burman River	25	Escapement	Beach	Adult			23	77	100	77%																			77					
Tahsis River	25	Escapement	Beach	Adult			6	22	28	79%																3		19						
Tlupana River	25	Escapement	Beach	Adult		2	3	13	16	81%																8				5				
Zeballos River	25	Escapement	Beach	Adult	1		21	20	41	49%																			1	19				
Nootka	25/125	Sport	Sport Rod	Adult	1	3	90	147	237	62%											3	1			10	115		2	5	4			5	2
Nootka/Esperanza	25/125/126	Sport	Sport Rod	Adult	1	1	48	27	75	36%															2	17		1	3	2			2	
Kyuquot	26/126	Sport	Sport Rod	Adult		1	38	5	43	12%															1								2	2
Kyuquot	126	Sport	Sport Rod	Adult		1	130	20	150	13%							1								3	13	1		1					1
Kyuquot	126	Sport	Sport Rod	Adult	3	1	68	10	78	13%							1		1						1	2							2	3
Marble River	27	Escapement	Beach	Adult	1	10	187	2	189	1%																					2			
Chilliwack River	29	Escapement	Deadpitch	Adult	1	31	52	186	238	78%																						186		
Chilliwack River	29	Escapement	Swim-in	Adult			3	206	209	99%																						206		
											70	116	14	10	2	8	199	41	19	11	725	210	6	12	1176	253	3	22	89	34	2	434	46

Table 3. **Hatchery Contribution & Straying in Escapement & Terminal Area Recoveries As Indicated by Thermal Marks.**

											Hatchery																					
											Quinsam					Big Qualicum	Nanaimo		Nitinat				Robertson			Conuma					Marble	Chilliwack	Unknown
											Release Locations & Stat Areas																					
											13	13	13	13	13	14	17	17	19/20/23	20	20/21/22	23	23	23	23	25	25	25	25	25	27	29	
Catch Location	Statistical Area	Sample Type	Gear Type	Development Stage	Destroyed	No Sample	Not Thermally Marked	Yes Thermally Marked	Effective Sample Size	% Hatchery																							
Campbell River	13	Escapement	Deadpitch	Adult	5	22	51	22	73	30%	14%	4%		12%																			
Quinsam River	13	Escapement	Deadpitch	Adult	3		39	58	97	60%	25%	32%	2%	1%																			
Quinsam Hatchery	13	Escapement	Swim-in	Adult			25	75	100	75%	19%	47%	9%																				
Menzies Creek	13	Escapement	Beach Seine	Adult			1		1	0%																							
Salmon River	13	Escapement	Deadpitch	Adult		1	38	6	44	14%		5%	2%		5%										2%								
Englishman River	14	Escapement	Deadpitch	Adult		1	24	9	33	27%						24%			3%														
Lower Nanaimo River	17	Escapement	Deadpitch/ Beach Seine	Adult	3	0	103	196	299	66%							63%	2%	1%														
Upper Nanaimo River	17	Escapement	Deadpitch/ Gillnet	Adult	9	7	103	44	147	30%							5%	24%															
Cowichan River	18	Escapement	Beach Seine	Adult	4	1	192	3	195	2%							1%							1%								
Sooke River	20	Escapement	Beach Seine	Adult	6	5	47	37	84	44%									14%	8%	11%			11%									
San Juan River	20	Escapement	Fence / Trap	Adult		6	83	1	84	1%											1%												
Nitinat River	22	Escapement	Beach Seine/ Swim-in	Adult	6	5	156	634	790	80%											80%	0%											
Nitinat Lake	22	Escapement	Purse Seine	Adult	2		9	69	78	88%											86%	1%											1%
Nahmint River	23	Escapement	Beach Seine	Adult	2		7	5	12	42%													42%										
Sarita River	23	Escapement	Beach Seine	Adult	3	6	27	202	229	88%												88%											
Stamp River	23	Escapement	Deadpitch	Adult	26	12	68	432	500	86%															86%								
Robertson Creek Hatchery	23	Escapement	Swim-in	Adult	5	0	6	389	395	98%															98%								
Burman River	25	Escapement	Beach Seine	Adult			23	77	100	77%																			77%				
Conuma River	25	Escapement	Beach Seine	Adult	4	1	4	94	98	96%																92%				4%			
Gold River	25	Escapement	Beach Seine	Adult	2		43	62	105	59%															56%		1%		2%				
Tahsis River	25	Escapement	Beach Seine	Adult			6	22	28	79%																11%		68%					
Tlupana River	25	Escapement	Beach Seine	Adult		2	3	13	16	81%																50%				31%			
Zeballos River	25	Escapement	Beach Seine	Adult	1		21	20	41	49%																			2%	46%			
Marble River	27	Escapement	Beach Seine	Adult	1	10	187	2	189	1%																					1%		
Chilliwack River	29	Escapement	Deadpitch	Adult	1	31	52	186	238	78%																						78%	
Chilliwack River	29	Escapement	Swim-in	Adult			3	206	209	99%																						99%	

Table 4. **Stamp River Enhanced and 'Natural' Escapement from Thermal Mark and CWT Analysis (includes escapement recoveries from 2000 to 2008).**

	Escapement				Brood Year Production			
Brood Year	Stamp River Adult Spawners	Stamp River Female Spawners	Stamp River Egg Deposition (million)	Hatchery Releases (million)	Total 'Natural' Escapement from Thermal Marking	Total 'Enhanced' Escapement from Thermal Marking	Total 'Natural' Escapement from Expanded CWT	Total 'Enhanced' Escapement from Expanded CWT
1996	9410	1885	7.75	8.45	284	3723	1433	2574
1997	12785	3228	12.25	9.05	144	4076	3138	1082
1998	28044	13650	44.00	7.58	2515	69971	18083	54403
1999	15312	9964	39.80	7.68	6946	67714	15728	58932
2000	3506	1908	7.90	5.00	2528	41171	16619	27080
2001	8221	1305	4.95	6.42	2442	89266	24949	66759
2002	24714	7585	27.30	7.59	1100	32698	12334	21464
2003	36246	11234	40.50	8.17	9956	55679	24737	40899
2004	37472	12832	41.00	6.48	922	6069	3370	3621
2005	30815	15399	55.95	6.16	1131	18005	4457	14679
2006	37687	12930	52.30	6.25	87	1109	353	843
Total	244212	91920	333.70	78.83	26838	370367	120391	276814

The following charts show 'Enhanced Production' (dashed lines) from hatchery releases and 'Natural Production' (solid lines) from river spawners. Note that only brood years 1998-2003 currently have had a full complement of returns.

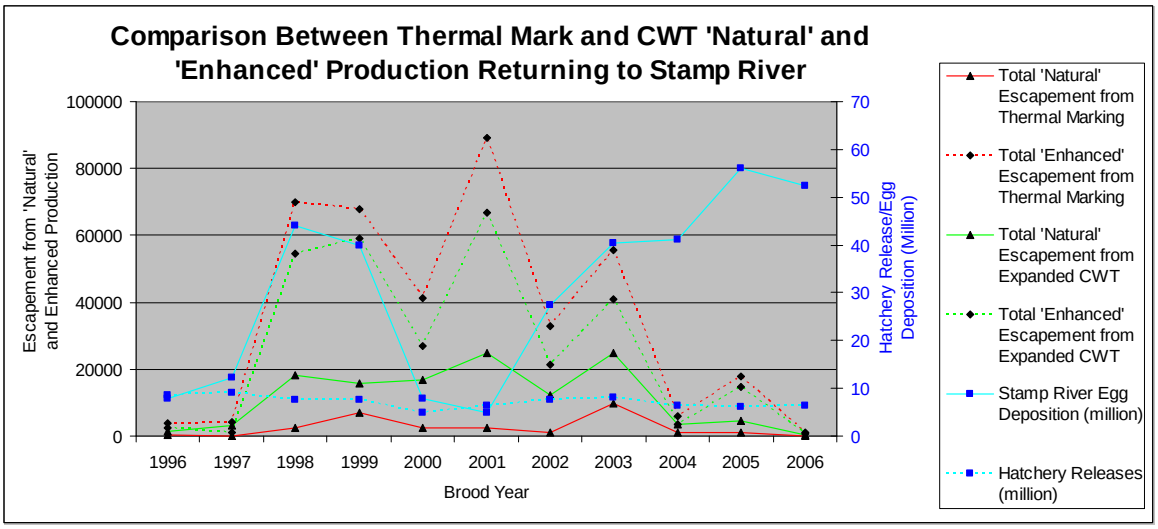

Fig. 1.

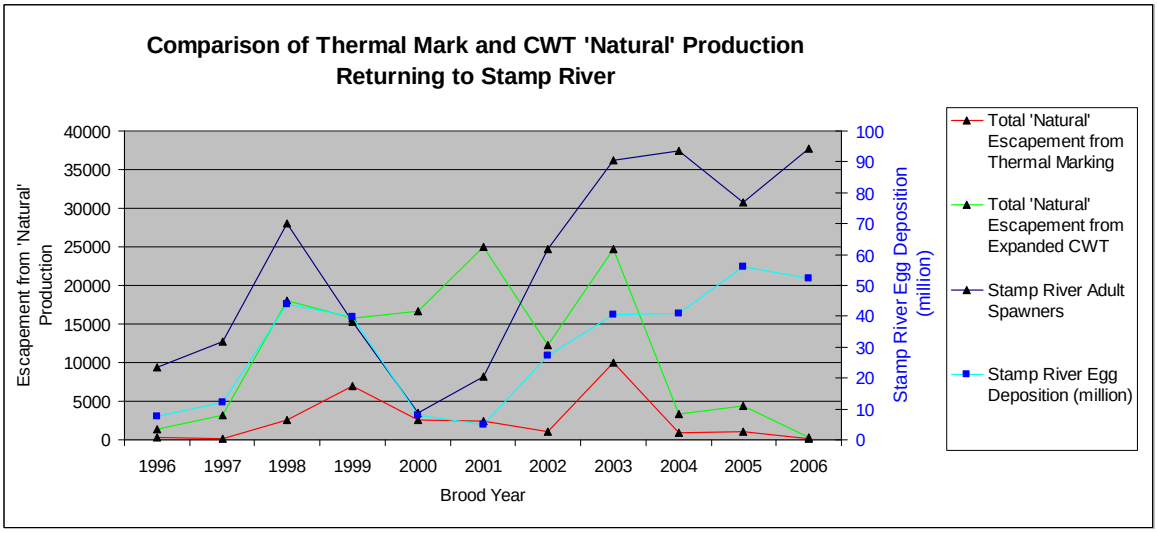

Fig. 2.

Financial Account

Table 5. **Summary of costs**

Category	PSC Cost
Labour (Proj mgmt, lab co-ordination, data entry)	
Labour (Subcontractors & consultants)	$ 59,958.00
Labour (Subcontractors & consultants). **	$ 3,542.00
Sample Collection	$ 500.00
Repairs & Maintenance	
Supplies	
Equipment	
Travel	
Grand Total	**$ 64,000.00**

Table 6. **Breakdown of expenses**

Invoice Date	Supplier	Item	Cost	Category
07-Nov-08	FRIENDS OF MARBLE RIVER	Sample Collection	$500.00	Sample Collection
08-Jan-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$1,620.00	Labour
08-Jan-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$3,726.00	Labour
24-Feb-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$3,564.00	Labour
23-Mar-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$3,240.00	Labour
08-May-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$3,564.00	Labour
11-Jun-09	HUPACASATH FIRST NATION	Thermal Mark lab services	$8,388.00	Labour
14-Jul-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$648.00	Labour
14-Jul-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$2,754.00	Labour
14-Jul-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$3,564.00	Labour
14-Jul-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$3,564.00	Labour
05-Aug-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$3,618.00	Labour
05-Aug-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$27.00	Labour
17-Aug-09	DITIDAHT	Thermal Mark lab services	$15,765.00	Labour
17-Aug-09	DITIDAHT	Thermal Mark lab services	$3,000.00	Labour
31-Aug-09	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$2,916.00	* Labour
Spring 2010	UCHUCKLESAHT BAND COUNCIL	Thermal Mark lab services	$3,542.00	** Labour
* Invoice paid thorugh different collator while awaiting payment of 'holdback'.				
** Remaining 'holdback' to be applied to reading services during Spring 2010 to process			**$64,000.00**	**Total**