‘Analysis of Chinook Thermal Marking’.
SF-2006 –I- 18

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°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 indicated there is the possibility of extensive straying of chinook along WCVI. Otolith analysis from Gold River on the WCVI in 2002, 2003, 2004 and 2005 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 2006 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 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. Further sampling of returns to Stamp River and Robertson Creek Hatchery in 2006 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

3234 escapement samples were collected from a total of 16 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 dead pitches, from swims and from creel surveys. Samplers were sent in specifically to sample otoliths from commercial and native fisheries and for some escapement collections.

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. Some additional systems were sampled when opportunities arose, including Salmon and Nanaimo Rivers on ECVI and Leiner, San Juan and Sooke on WCVI (Table 2).

432 samples were collected from commercial gillnet fisheries in Alberni Inlet and 100 gillnet samples were taken from Tlupana Inlet (Nootka Sound). A further 202 were taken from the First Nations fisheries in Alberni Inlet and 199 by Scientific Permit from Nitinat Lake.

Sport caught samples comprised a total of 1612 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 46 was also obtained from the Campbell River tyee club.

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 the RBr 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 2006 harvest or escapement samples are shown in Tables 1a and 1b.

Results

A total of 5779 otolith samples were collected, processed and analysed as described above. All 5779 otoliths were re-read a second time to compare with the original reading. Where differences occurred these were reviewed and resolved. The thermal marking program is in the process of installing and adapting a new database obtained from ADF&G. This database is continuing to undergo further development and was not ready to enter the 2006 data. Data was therefore entered into Excel to permit analysis of results and comparison of readings. Some cleaning up of the data was required to standardise the results where the ‘delimiters’ recorded by the readers were inconsistent with those applied at the hatcheries e.g. if a code of 1:1.2,2.4 was recorded it would be standardised to 1:1.2-2.4 which is consistent with the code applied to fry releases from Quinsam. Comparison of the original reading and their corresponding verifications indicated a 97.6% agreement on whether a sample was marked or not (for 5550 samples when both readings agreed that the sample could be read i.e. that it either ‘was a thermal mark’ or was ‘not a thermal mark’). The remaining 229 samples had disagreements as to whether they could be read or not e.g. destroyed and ‘marked’, destroyed and ‘not marked’, whether there was a sample etc. When both readings agreed that the sample was marked there was an agreement of 98.6% on the RBr code being observed and of 99.4% on the hatchery of origin (3864 samples).

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 23 different sampling locations by statistical area (Table 3). Stray rates appear to be relatively low across statistical areas but do have some significance on a local scale. This localised straying occurs mostly in areas 13, 23 and 25. In area 13, releases from both Quinsam River and Campbell Estuary sea-pens were recovered in Campbell and Quinsam Rivers. Campbell River also saw 1 recovery from Nitinat and 2 from Robertson Creek. Area 23 recoveries in Nahmint River included samples released from Sarita, Henderson and Robertson. Additional recoveries in Nahmint from further a-field included 2 samples each from Nitinat and Conuma. Area 25 appears to have both localised straying within most of the systems surveyed and more significant straying from Robertson Creek hatchery to Gold River. A sample of 101 in the Burman River included 12 recoveries from Conuma, 4 from Gold/Muchalaht and 1 from Sucwoa/Tlupana/Zeballos. A sample of 108 obtained from the Gold/Muchalaht had 72% hatchery origin, 64% of which were Robertson, 1% Nahmint and 7% from the Gold/Muchalaht itself. The 64% recovery rate of Robertson fish in the Gold follows a similar pattern to that seen from 2002 to 2005. Additional local straying was also observed in the Leiner where 35% (14) of the 40 samples collected were from Conuma and from Tahsis where 1 Conuma recovery was observed in the sample of 17.

Results in table 3 indicate that returns to some systems have very high hatchery components to them. Swim-ins to major facilities at Nitinat, Robertson and Chilliwack are, not surprisingly, 100% hatchery origin and Quinsam is 96%. Deadpitch and/or broodstock samples taken from systems with major facilities (including Conuma) also have 89-100% first generation hatchery component to them. Some systems that have smaller broodstock releases also indicate a high hatchery component including Sarita and Nahmint. Difficulty in obtaining Nahmint broodstock in some years has resulted in intermittent releases but hatchery production still appears to dominate the returns (81%). It should also be noted that some systems (Gold, Tahsis and Burman) only have a limited number of thermally marked brood years contributing at present so the full impact of hatchery contribution will not be observed for another year or two. Thermal Marking began on the Marble, Nanaimo and Salmon Rivers in 2005 so no marks (local or strays) were recovered.

Thermal Marking and CWT Comparison

Comparison of thermal marking results and cwt analysis from both Stamp River and Robertson Creek Hatchery swim-ins in 2006 updates the results obtained from 2000 to 2005. 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. It is therefore expected that there is a bias towards ‘unmarked’ fish in those samples that are 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 fish 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 much higher proportion of hatchery production in the Stamp River system from thermal marks than from cwt’s Hatchery contribution between 2000 and 2006 from cwt’s indicated a range of 58-79% (61% in 2006) hatchery origin in the deadpitch compared with 86-96% (89% in 2006) from thermal marks. Hatchery contribution to hatchery swim-ins from the same time period varied widely from 55-88% (55% in 2006) for cwt’s and was consistent for thermal marks (98-100%) until 2006 when it dropped to 88%. The reduction in the 2006 hatchery contribution (from thermal marks) was primarily due to unmarked 3 year old samples 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.

Table 4 and Chart 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 2001. 1996 and 1997 are only slightly underestimated as a result of poor age 2 and 3 returns in 1998 and 1999 whereas 2002, 2003 and 2004 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. $42.25k of the original budget was spent on sample collection, preparation and reading by members of the Hupacasath, Uchucklesaht and Ditidaht First Nations who gained valuable additional expertise. The remaining 4.8k in the budget was spent on supplies and repairs and maintenance of equipment. A large part 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. Most straying occurs from the Robertson Creek Hatchery with some from Conuma and Nitinat. This pattern would be expected given the much greater releases from Robertson than other facilities.

Whilst the straying numbers appear to be low from any given facility the straying occurring to Gold River from Robertson is still of interest to local parties. The results confirm those observed over the previous four years. The Gold River broodstock program has developed to try and reduce the introgression of Robertson Creek fish on the Gold River population. This has resulted in a process whereby the fertilised eggs from each pair of spawned fish are kept in separate holding tanks. If both fish are found to be ‘non Robertson’ (from the otolith analysis) the eggs are reared and fed before release into the ocean. If one parent is found to be of Robertson origin the fry are released unfed and if both are found to be of Robertson origin they are destroyed. This resulted in very few fed fry being raised for this program from the 2006 brood and has put future collection in jeopardy due to the time and effort involved for the low number of resulting releases.

Other evidence of Robertson straying to Gold River comes from DNA analysis of scales which indicates a blending of Robertson and Gold stocks in the early 1980’s and there has been no separate distinct Gold stock recovered since that time. A few recoveries of Robertson cwt’s during sampling programs also indicate the presence of that stock.

There appears to be no clear reason why straying of Robertson stock should be this significant to Gold River when none were found across the Inlet in Burman River. Burman has some straying from Conuma, Gold/Muchalaht and Sucwoa/Tlupana/Zeballos whereas Gold River/Muchalat does not. One suggestion has been the presence of pulp mills at both Gold River (now closed down) and Port Alberni. The Robertson Creek fish may be homing in on traces of chemicals left by the Gold River pulp mill which they acclimatised to as they passed the Port Alberni mill as smolts.

Comparison of Thermal Mark and CWT Results

The data obtained from the 2006 program continues to show that thermal marking indicates a greater proportion of returning fish to some locations are of hatchery origin than do cwt’s. These differences could be due to either 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 2006 swim-ins shows a consistent hatchery contribution across all age classes from 93 to 100% for each age class (all were 100% if ‘destroyed’ samples were excluded) except for the age 3’s (2003 brood) which was 85% (89% when excluding ‘destroyed’). Overall hatchery contribution for adults was 88% (93% when excluding ‘destroyed’ samples) and 94% for jacks (100% excluding ‘destroyed’). The lower hatchery contribution from the 2003 brood confirms similar results obtained in 2005 from the 2 year old jacks which indicated hatchery contribution for 2003 brood was 88%. Hatchery contribution to the same 2006 hatchery returns based on cwt analysis indicates a much lower hatchery contribution with greater variability between age classes ranging from 0% to 58% (55% overall) for adults and 72% for jacks. 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 79% to 97% for each of age 3 to age 6 (89% overall) and 90% for jacks. Cwt’s indicate a hatchery variability from 48-233% for age 3 to age 6 (61% overall) and 0% 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 2006 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 5.8% for swim-ins and 7.5% for dead pitch samples (6.3% 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 2004 brood year releases). Recent years (including 2006) 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. In addition Robertson Creek Hatchery brood requirements are for 6 to 7 million eggs and there is an additional 20% allowance for pre-spawn mortality. The 50 million target was approached in 1998,1999, 2003 and 2004 of the study period, in other years egg deposition fell well short. Table 4 shows that for the 4 years which have fully returned (1998-2001), total escapement of 55,000 (26,800 females) resulted in an egg deposition of 97 million in the Stamp River. Cwt analysis shows a resultant ‘natural’ escapement from this of 75,000 adults (return rate of 1.4 to 1). Thermal marking estimates the natural production (escapement only) from those 4 years to be just 14,400 (return rate of 0.26 to 1). The thermal marking results (chart 2) call into question from a production standpoint whether it is worthwhile striving to reach the 50 million in-river egg target. 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 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 2006 Fisheries and Escapement Sampling.** (by Release Facility).

				Brood Year				
Facility	Release Site	Release Stat Area	Thermal Mark : RBr Code	2000	2001	2002	2003	2004
Quinsam River Hatchery	Quinsam River	13	2:1.2/2.2/3.2			Yes	Yes	
	Quinsam River & Lake	13	2:1.2/2.2/3.2	Yes	Yes			
	Quinsam/Campbell River	13	2:1.2,2.2,3.2					Yes
	Seapens off Campbell Estuary	13	2:1.2/2.2	Yes	Yes	Yes	Yes	
			2:1.2,2.2					Yes
	Elk Falls Spawning Channel - Campbell River. (Egg Outplants to incubation boxes).	13	1:1.3-2.4	Yes	Yes	Yes	Yes	
			1:1.3,2.4					Yes
	Quinsam River Upper - (Fed fry outplants)	13	1:1.2-2.4				Yes	
			1:1.2,2.4					Yes
Big Qualicum Hatchery	Englishman River	14	2:1.6n				Yes	Yes
San Juan River Hatchery	San Juan River	20	2:1.3n			Yes	Yes	Yes
			2:1.4,2.2		Yes			
Nitinat River Hatchery	Esquimault Harbour	19	1:1.4				Yes	Yes
			1:1.4,2.1			Yes		
	Sooke River	20	1:1.4				Yes	Yes
			1:1.4-2.1			Yes		
	Toquart Lake	23	1:1.4			Yes		
	Sarita River	23	2:1.3,2.2,3.3					Yes
	Sarita River & Poett Nook Seapens	23	2:1.3,2.2,3.3		Yes	Yes	Yes	
			2:1.3,2.2/3.3	Yes				
	Nitinat River	22	2:1.2,2.3,3.2					Yes
	Nitinat River & Lake	22	2:1.2,2.3,3.2	Yes	Yes	Yes	Yes	
	Sooke Harbour	20	2:1.2,2.3,3.2		Yes	Yes	Yes	Yes
Robertson Creek Hatchery	Stamp River	23	1:1.3					Yes
	Robertson Creek	23	1:1.2,2.1	Yes				
			1:1.3	Yes	Yes	Yes	Yes	
	Robertson Creek (Super smolts)	23	1:1.3			Yes		
			1:1.3,2.1,3.3				Yes	
	Stamp River (Super smolts)	23	1:1.3,2.1,3.3					Yes
	Harbour Quay	23	1:1.3	Yes	Yes	Yes	Yes	
	Port Alberni Harbour	23	1:1.3,2.1-3.2				Yes	
	Great Central Lake	23	1:1.3,2.1,3.2					Yes
	Nahmint River	23	1:1.3,2.2				Yes	Yes
			1:1.3-2.2		Yes			
	Nahmint River & Estuary	23	2:1.4-2.2			Yes		
	Henderson Lake	23	1:1.5	Yes	Yes	Yes	Yes	Yes
Conuma River Hatchery	Conuma River	25	2:1.5					Yes
	Conuma River & Estuary	25	2:1.5			Yes	Yes	
	Conuma River, Estuary & Seapens	25	2:1.3,2.2	Yes				
			2:1.5		Yes			
	Burman River	25	2:1.4,2.2			Yes	Yes	Yes
	Gold River	25	2:1.2,2.2,3.2				Yes	
			2:1.2,2.4					Yes
	Muchalat Lake & Gold River Estuary	25	2:1.2,2.4			Yes		
	Sucwoa River	25	2:1.3		Yes	Yes		Yes
			2:1.3	Yes				
	Tahsis River	25	2:1.9				Yes	Yes
	Tlupana River	25	2:1.3	Yes	Yes	Yes	Yes	Yes
	Zeballos River	25	2:1.3	Yes	Yes	Yes	Yes	
Chilliwack River Hatchery	Chilliwack River	29	2:1.7	Yes	Yes	Yes	Yes	Yes
Spius Creek Hatchery	Coldwater River	29	2:1.3+2.4				Yes	
			2:1.3,2.4					Yes

Table 1b. **Chinook Thermal Marks Available for Recovery During 2006 Fisheries and Escapement Sampling.** (by RBr Code).

				Brood Year				
Thermal Mark : RBr Code	Facility	Release Site	Release Stat Area	2000	2001	2002	2003	2004
1:1.2,2.1	Robertson Creek Hatchery	Robertson Creek	23	Yes				
1:1.2,2.4	Quinsam River Hatchery	Quinsam River Upper - (Fed fry outplants)	13					Yes
1:1.2-2.4	Quinsam River Hatchery	Quinsam River Upper - (Fed fry outplants)	13				Yes	
1:1.3	Robertson Creek Hatchery	Stamp River	23					Yes
		Robertson Creek	23	Yes	Yes	Yes	Yes	
		Robertson Creek (Super smolts)	23			Yes		
		Harbour Quay	23	Yes	Yes	Yes	Yes	
1:1.3,2.1,3.2	Robertson Creek Hatchery	Great Central Lake	23					Yes
1:1.3,2.1-3.2	Robertson Creek Hatchery	Port Alberni Harbour	23				Yes	
1:1.3,2.1,3.3	Robertson Creek Hatchery	Robertson Creek (Super smolts)	23				Yes	
		Stamp River (Super smolts)	23					Yes
1:1.3,2.2	Robertson Creek Hatchery	Nahmint River	23				Yes	Yes
1:1.3-2.2	Robertson Creek Hatchery	Nahmint River	23		Yes			
1:1.3,2.4	Quinsam River Hatchery	Elk Falls Spawning Channel - Campbell River. (Egg Outplants to incubation boxes).	13					Yes
1:1.3-2.4	Quinsam River Hatchery	Elk Falls Spawning Channel - Campbell River. (Egg Outplants to incubation boxes).	13	Yes	Yes	Yes	Yes	
1:1.4	Nitinat River Hatchery	Esquimault Harbour	19				Yes	Yes
		Sooke River	20				Yes	Yes
		Toquart Lake	23			Yes		
1:1.4,2.1	Nitinat River Hatchery	Esquimault Harbour	19			Yes		
1:1.4-2.1	Nitinat River Hatchery	Sooke River	20			Yes		
1:1.5	Robertson Creek Hatchery	Henderson Lake	23	Yes	Yes	Yes	Yes	Yes
2:1.2,2.2	Quinsam River Hatchery	Seapens off Campbell Estuary	13					Yes
2:1.2/2.2	Quinsam River Hatchery	Seapens off Campbell Estuary	13	Yes	Yes	Yes	Yes	
2:1.2,2.2,3.2	Quinsam River Hatchery	Quinsam/Campbell River	13					Yes
	Conuma River Hatchery	Gold River	25				Yes	
2:1.2/2.2/3.2	Quinsam River Hatchery	Quinsam River	13			Yes	Yes	
		Quinsam River & Lake	13	Yes	Yes			
2:1.2,2.3,3.2	Nitinat River Hatchery	Nitinat River	22					Yes
		Nitinat River & Lake	22	Yes	Yes	Yes	Yes	
		Sooke Harbour	20		Yes	Yes	Yes	Yes
2:1.2,2.4	Conuma River Hatchery	Gold River	25					Yes
		Muchalat Lake & Gold River Estuary	25			Yes		
2:1.3	Conuma River Hatchery	Sucwoa River	25	Yes	Yes	Yes		Yes
		Tlupana River	25	Yes	Yes	Yes	Yes	Yes
		Zeballos River	25	Yes	Yes	Yes	Yes	
2:1.3n	San Juan River Hatchery	San Juan River	20			Yes	Yes	Yes
2:1.3,2.2	Conuma River Hatchery	Conuma River, Estuary & Seapens	25	Yes				
2:1.3,2.2,3.3	Nitinat River Hatchery	Sarita River	23					Yes
		Sarita River & Poett Nook Seapens	23		Yes	Yes	Yes	
2:1.3,2.2/3.3	Nitinat River Hatchery	Sarita River & Poett Nook Seapens	23	Yes				
2:1.3,2.4	Spius Creek Hatchery	Coldwater River	29					Yes
2:1.3+2.4	Spius Creek Hatchery	Coldwater River	29				Yes	
2:1.4,2.2	San Juan River Hatchery	San Juan River	20		Yes			
	Conuma River Hatchery	Burman River	25			Yes	Yes	Yes
2:1.4-2.2	Robertson Creek Hatchery	Nahmint River & Estuary	23			Yes		
2:1.5	Conuma River Hatchery	Conuma River	25					Yes
		Conuma River & Estuary	25			Yes	Yes	
		Conuma River, Estuary & Seapens	25		Yes			
2:1.6n	Big Qualicum Hatchery	Englishman River	14				Yes	Yes
2:1.7	Chilliwack River Hatchery	Chilliwack River	29	Yes	Yes	Yes	Yes	Yes
2:1.9	Conuma River Hatchery	Tahsis River	25				Yes	Yes

Table 2. **Summary of Samples Collected and Thermal Marks Recovered During 2006.**

												Hatchery																								
												Quinsam				San Juan		Nitinat						Robertson					Conuma					Chilliwack	Conuma, Robertson, San Juan	Unknown
												Release Locations & Stat Areas																								
												13	13	13	13	20	20	19/20	19/20/23	22/20	23	20	23	23	23	23	23	23	25	25	25	25	25	29	25/23/20	Unknown
Lab Number	Catch Location	Statistical Area	Sample Type	Gear Type	Development Stage	Destroyed	No Sample	Not Thermally Marked	Yes Thermally Marked	Total Sample Size	% Hatchery	Elk Falls Spawning Ch - Campbell River	Quinsam River & Lake	Seapens off Campbell Estuary	Upper Quinsam - fed fry	San Juan River	San Juan River & Estuary	Esquimault Harbour & Sooke River	Esquimault Harbour, Sooke River & Toquart Lake	Nitinat River & Lake & Sooke Harbour	Sarita River & Poett Nook Seapens	Sooke River	Toquart Lake	Henderson Lake	Nahmint River	Nahmint River & Estuary	Robertson Creek	Robertson Creek & Harbour Quay Seapens	Burman River	Conuma River, Estuary & Seapens	Muchalaht Lake & Gold River Estuary	Sucwoa+Tlupana+Zeballos Rivers	Tahsis River	Chilliwack River	Burman River, Nahmint River & Estuary or San Juan River	Unknown
CN06-033	Salmon River	13	Escapement	Beach Seine	Adult			44		44	0%																									
CN06-047	Quinsam Hatchery	13	Escapement	Deadpitch	Adult	3	1	51	45	100	47%	20	13	9						1								2								
CN06-048	Quinsam Hatchery	13	Escapement	Deadpitch	Adult	4		9	88	101	91%		59	29																						
CN06-049	Quinsam Hatchery	13	Escapement	Swim-in	Adult			5	102	107	95%		85	16	1																					
CN06-050	Quinsam Hatchery	13	Escapement	Swim-in	Adult				34	34	100%		27	7																						
CN06-054	Quinsam Hatchery	13	Escapement	Deadpitch	Adult				8	8	100%		6	2																						
CN06-034	Nanaimo River Upper	17	Escapement	Deadpitch	Adult	1		99		100	0%																									
CN06-035	Nanaimo River Lower	17	Escapement	Deadpitch	Adult	3		97		100	0%																									
CN06-030	San Juan River	20	Escapement	Fence	Adult	2	1	131	67	201	34%					62	4			1																
CN06-062	Sooke R Hatchery	20	Escapement	Beach Seine	Adult	4		53	48	105	48%									17		31														
CN06-055	Nitinat Hatchery	22	Escapement	Swim-in	Adult	1			67	68	100%									67																
CN06-058	Nitinat Hatchery	22	Escapement	Beach Seine	Adult	1		13	186	200	93%									4	182															
CN06-059	Nitinat Hatchery	22	Escapement	Beach Seine	Adult	1	1	18	180	200	91%									180																
CN06-060	Leiner River	22	Escapement	Beach Seine	Adult			26	14	40	35%																			14						
CN06-061	Tahsis River	22	Escapement	Beach Seine	Adult			14	3	17	18%																			1			2			
CN06-039	Robertson Creek Hatchery	23	Escapement	Deadpitch	Adult	2		12	170	184	93%																	170								
CN06-040	Robertson Creek Hatchery	23	Escapement	Deadpitch	Adult	1		7	176	184	96%																	176								
CN06-041	Robertson Creek Hatchery	23	Escapement	Deadpitch	Jack	1		6	43	50	88%																3	40								
CN06-042	Robertson Creek Hatchery	23	Escapement	Swim-in	Adult	9			166	175	100%																	166								
CN06-043	Robertson Creek Hatchery	23	Escapement	Swim-in	Adult	5			170	175	100%																	170								
CN06-044	Robertson Creek Hatchery	23	Escapement	Swim-in	Jack	2			48	50	100%																2	46								
CN06-046	Nahmint River	23	Escapement	Beach Seine + Deadpitch	Adult		1	42	178	221	81%									2	6			5	25	133		5		2						
CN06-013	Conuma River	25	Escapement	Beach Seine	Adult				100	100	100%																			100						
CN06-014	Burman River	25	Escapement	Beach Seine	Adult	4	2	35	60	101	63%																		43	12	4	1				
CN06-032	Gold River	25	Escapement	Beach Seine	Adult	2		14	30	46	68%																	29			1					
CN06-037	Gold River	25	Escapement	Beach Seine	Adult			5	20	25	80%														1			19								
CN06-038	Gold River	25	Escapement	Beach Seine + Deadpitch	Adult			11	26	37	70%																	20			6					
CN06-045	Marble River	27	Escapement	Beach Seine	Adult		2	98		100	0%																									
CN06-052	Chilliwack Hatchery	29	Escapement	Swim-in	Adult				196	196	100%																							196		
CN06-053	Chilliwack River	29	Escapement	Deadpitch	Adult	5	17	16	127	165	89%																							127		
CN06-002	Alberni Inlet	23	Commercial	Gillnet	Adult		1	1	79	81	99%																	79								
CN06-006	Alberni Inlet	23	Commercial	Gillnet	Adult	2		6	92	100	94%									1								91								
CN06-010	Alberni Inlet	23	Commercial	Gillnet	Adult	4	5	6	35	50	85%													1				34								
CN06-012	Alberni Inlet	23	Commercial	Gillnet	Adult	5	4	10	82	101	89%															1		81								
CN06-016	Alberni Inlet	23	Commercial	Gillnet	Adult		1	7	92	100	93%													2				90								
CN06-001	Nootka	25	Commercial	Gillnet	Adult	2		3	95	100	97%																			93		2				
CN06-003	Alberni Inlet	23	First Nations	Gillnet	Adult	1	1		49	51	100%																	49								
CN06-011	Alberni Inlet	23	First Nations	Gillnet	Adult		2	1	47	50	98%																	47								
CN06-015	Alberni Inlet	23	First Nations	Gillnet	Adult	2	2	5	92	101	95%															1		91								
CN06-057	Ditidaht First Nation	22	Scientific Permit	Seine	Adult	5		11	183	199	94%									182								1								
CN06-051	Campbell River	13	Sport	Sport Rod	Adult		4	6	36	46	86%	2	25	9																						
CN06-022	Port Renfrew	20	Sport	Sport Rod	Adult	3		21		24	0%																									
CN06-017	Barkley Sound	23	Sport	Sport Rod	Adult	2	11	20	44	77	69%									2	3		1					38								
CN06-018	Barkley Sound	23	Sport	Sport Rod	Adult		2	23	59	84	72%		1					2		12	6							35							3	
CN06-019	Barkley Sound	23	Sport	Sport Rod	Adult	2		20	5	27	20%		1															1		1				1		1
CN06-020	Alberni Inlet	23	Sport	Sport Rod	Adult	2		9	135	146	94%									2			1		1	4		127								
CN06-021	Alberni Inlet	23	Sport	Sport Rod	Adult	8	1	12	35	56	74%										1				1	5		27		1						
CN06-031	Alberni Inlet	23	Sport	Sport Rod	Adult			7	45	52	87%																	45								
CN06-025	Offshore Barkley Sound	123	Sport - Offshore	Sport Rod	Adult	1		87	23	111	21%									1	1							5						14	1	1
CN06-026	Offshore Barkley Sound	123	Sport - Offshore	Sport Rod	Adult	1	1	24	7	33	23%									1								2						4		
CN06-027	Offshore Barkley Sound	123	Sport - Offshore	Sport Rod	Adult	7		107	19	133	15%																							17		2
CN06-023	Clayoquot Sound	24	Sport	Sport Rod	Adult		1	7	14	22	67%									2	1							7		2					1	1
CN06-024	Clayoquot Sound	24	Sport	Sport Rod	Adult	2		13	9	24	41%									1	2							1		5						
CN06-028	Offshore Clayoquot Sound	124	Sport - Offshore	Sport Rod	Adult	1		94	5	100	5%								1											2				1		1
CN06-029	Offshore Clayoquot Sound	124	Sport - Offshore	Sport Rod	Adult	5	1	67	19	92	22%			1						1	1							7		1	1			6		1
CN06-004	Nootka	25	Sport	Sport Rod	Adult	3		13	49	65	79%							1		2			1					1		44						
CN06-005	Nootka	25	Sport	Sport Rod	Adult	1		25	64	90	72%							2	1	7	3				1			20	2	26	1	1				
CN06-007	Nootka	25	Sport	Sport Rod	Adult	1		14	85	100	86%							1		1								3		78		2				
CN06-008	Nootka	25	Sport	Sport Rod	Adult	3		20	77	100	79%									3	1							7	1	65						
CN06-009	Kyuquot	26	Sport	Sport Rod	Adult	1		43	20	64	32%									1										19						
CN06-036	Kyuquot	26	Sport	Sport Rod	Adult	2	6	93	65	166	41%									7	4							24		20	2	2		5	1	
Total Sample Size						117	68	1581	4013	5779	72%	22	217	73	1	62	4	6	2	498	211	31	3	8	29	144	5	1756	46	486	15	8	2	371	6	7

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

						Hatchery																											
						Quinsam				San Juan		Nitinat						Robertson					Conuma					Chilliwack	Conuma, Robertson, San Juan	Unknown
						Release Locations & Stat Areas																								
						13	13	13	13	20	20	19/20	19/20/23	22/20	23	20	23	23	23	23	23	23	25	25	25	25	25	29	25/23/20	Unknown
Catch Location	Statistical Area	Not Thermally Marked	Yes Thermally Marked	Total Sample Size	% Hatchery	Elk Falls Spawning Ch - Campbell River	Quinsam River & Lake	Seapens off Campbell Estuary	Upper Quinsam - fed fry	San Juan River	San Juan River & Estuary	Esquimault Harbour & Sooke River	Esquimault Harbour, Sooke River & Toquart Lake	Nitinat River & Lake & Sooke Harbour	Sarita River & Poett Nook Seapens	Sooke River	Toquart Lake	Henderson Lake	Nahmint River	Nahmint River & Estuary	Robertson Creek	Robertson Creek & Harbour Quay Seapens	Burman River	Conuma River, Estuary & Seapens	Muchalaht Lake & Gold River Estuary	Sucwoa+Tlupana+Zeballos Rivers	Tahsis River	Chilliwack River	Burman River, Nahmint River & Estuary or San Juan River	Unknown
Campbell River	13	51	53	108	51%	19%	18%	11%						1%								2%								
Quinsam River	13	9	88	101	91%		61%	30%																						
Quinsam Hatchery	13	5	136	141	96%		79%	16%	1%																					
Salmon River	13	44		44	0%																									
Nanaimo River	17	196		200	0%																									
San Juan River	20	131	67	201	34%					31%	2%			1%																
Sooke R	20	53	48	105	48%									17%		31%														
Nitinat River	22	18	180	200	91%									91%																
Nitinat Hatchery	22		67	68	100%									100%																
Sarita River	22	13	186	200	93%									2%	91%															
Stamp River - Adult	23	19	346	368	95%																	95%								
Stamp River - Jack	23	6	43	50	88%																6%	82%								
Robertson Creek Hatchery - Adult	23		336	350	100%																	100%								
Robertson Creek Hatchery - Jack	23		48	50	100%																4%	96%								
Nahmint River	23	42	178	221	81%									1%	3%			2%	11%	60%		2%		1%						
Conuma River	25		100	100	100%																			100%						
Burman River	25	35	60	101	63%																		45%	13%	4%	1%				
Gold River	25	30	76	108	72%														1%			64%			7%					
Leiner River	25	26	14	40	35%																			35%						
Tahsis River	25	14	3	17	18%																			6%			12%			
Marble River	27	98		100	0%																									
Chilliwack River	29	16	127	165	89%																							89%		
Chilliwack Hatchery	29		196	196	100%																							100%		

Table 4. **Stamp River Enhanced and 'Natural' Escapement from Thermal Mark and CWT Analysis (includes escapement recoveries from 2000 to 2006).**

	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 'Hatchery' Escapement from Thermal Marking	Total 'Natural' Escapement from Expanded CWT	Total 'Hatchery' Escapement from Expanded CWT
1996	9410	1885	7.75	8.45	284	3723	1433	2574
1997	12785	3228	12.25	8.83	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	4.97	2528	41171	16619	27080
2001	8221	1305	4.95	6.38	2442	89266	24949	66759
2002	24714	7585	27.30	7.59	1100	31459	12297	20262
2003	36246	11234	40.50	8.17	6591	35992	22158	20425
2004	37472	12832	41.00	7.48	71	701	666	106
Total	175710	63591	225.45	67.12	22621	344073	115072	251622

The following charts show Enhanced production (dashed lines) from hatchery releases and 'Natural' production (solid lines) from in river spawning. Note that only brood years 1998-2001 currently have had a full complement of returns.

Chart 1.

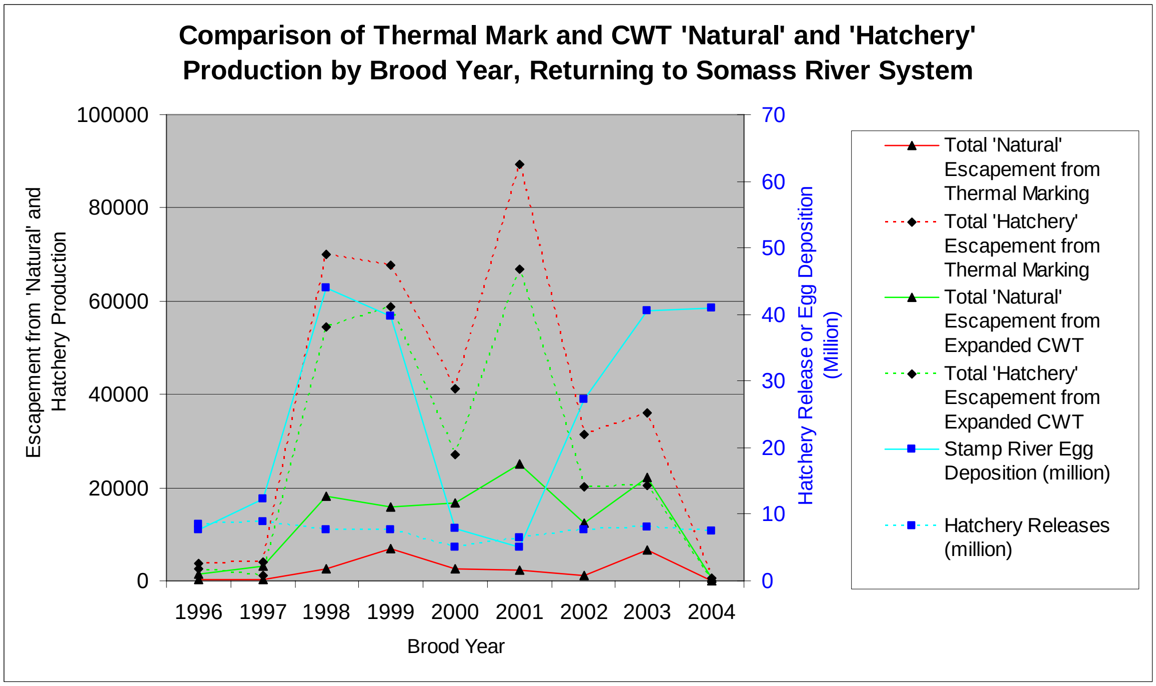
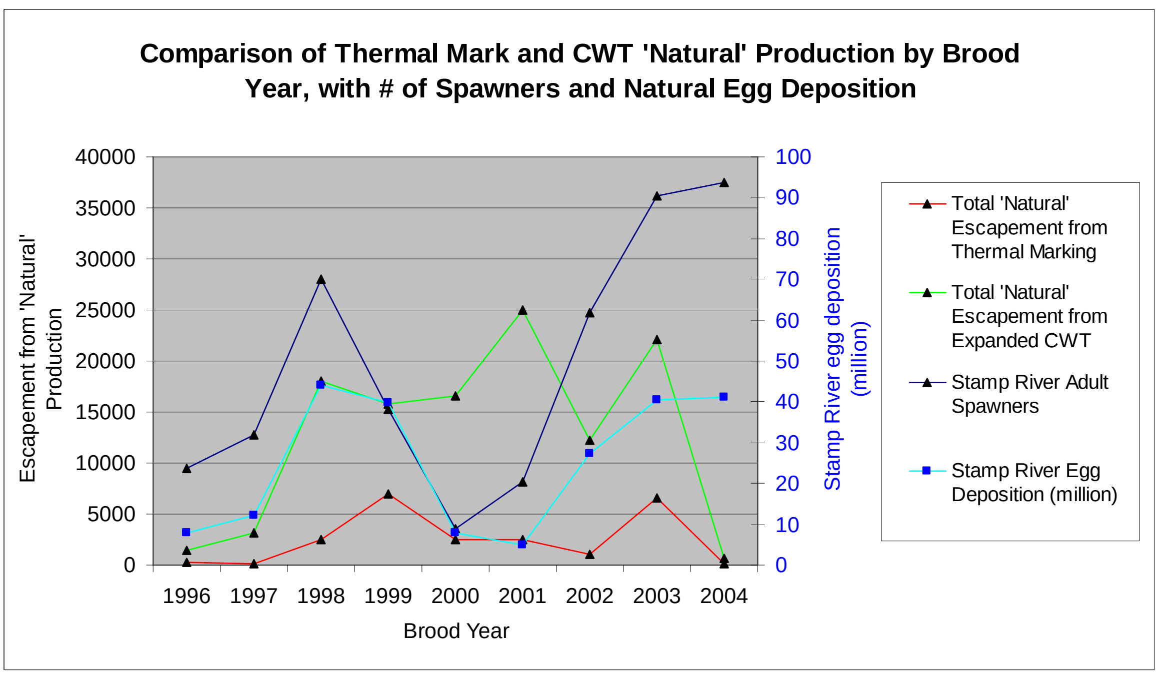


Chart 2.



Financial Account

Table 5. **Summary of costs**

Category	PSC Cost
Labour (Proj mgmt, lab co-ordination, data entry)	
Labour (Subcontractors & consultants)	$ 42,250.72
Sample Collection	
Repairs & Maintenance	$ 133.75
Supplies	$ 4,695.53
Equipment	
Travel	
Grand Total	**$ 47,080.00**

Table 6. **Breakdown of expenses**

Invoice Date	Supplier	Item	Cost	Category
31-Aug-06	Hupacasath First Nation	Thermal Mark lab services	$ 2,415.00	Labour
31-Aug-06	Hupacasath First Nation	Thermal Mark lab services	$ 483.00	Labour
14-Sep-06	Canadawide Scientific	Field supplies	$ 63.64	Supplies
18-Oct-06	Uchucklesaht Band Council	Thermal Mark lab services	$ 3,024.00	Labour
26-Oct-06	Staples Store	Supplies for otolith lab	$ 17.11	Supplies
31-Oct-06	Surgipath Canada	Glass slides	$ 1,322.40	Supplies
9-Nov-06	Jeff Till	Brass coupling & hose	$ 15.17	Supplies
23-Nov-06	Uchucklesaht Band Council	Thermal Mark lab services	$ 3,168.00	Labour
21-Dec-06	Uchucklesaht Band Council	Thermal Mark lab services	$ 3,168.00	Labour
17-Jan-07	Uchucklesaht Band Council	Thermal Mark lab services	$ 3,024.00	Labour
1-Feb-07	Electronic Imaging	Laser paper	$ 101.72	Supplies
6-Feb-07	Uchucklesaht Band Council	Thermal Mark lab services	$ 2,016.00	Labour
7-Feb-07	Canadawide Scientific	Slide boxes	$ 1,740.52	Supplies
8-Feb-07	UPS	Custom duties	$ 25.30	Supplies
8-Feb-07	Surgipath Canada	Slides	$ 1,226.31	Supplies
20-Feb-07	Emerson	Freight	$ 16.36	Supplies
20-Feb-07	Emerson	Grinding disks	$ 167.00	Supplies
26-Feb-07	Dididaht	Thermal Mark lab services	$ 13,500.00	Labour
23-Mar-07	Reichert Inc	Microscope replacement parts	$ 133.75	Repairs and Maintenance
20-Jul-07	Uchucklesaht Band Council	Thermal Mark lab services	$ 3,024.00	Labour
20-Jul-07	Uchucklesaht Band Council	Thermal Mark lab services	$ 3,312.00	Labour
20-Jul-07	Ditidaht Band Council	Thermal Mark lab services	$ 4,708.00	Labour - invoice paid from another collator but to be JV'd back when we've received 'holdback'
23-Jul-07	Ditidaht Band Council	Thermal Mark lab services	$ 256.00	Labour
27-Jul-07	Hupacasath First Nation	Thermal Mark lab services	$ 152.72	Labour
Total			**$ 47,080.00**	