‘Thermal Marking as an Indicator of Hatchery Salmon Straying and as a Key to Defining Hatchery Contribution and Estimating Harvestable Surpluses’.
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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 to induce the required mark. A 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 an intended 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) They 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. Thermal marks are now unique to their release facilities within DFO’s Pacific Region. Any marked otoliths recovered from high seas and non terminal areas can therefore be identified back to their hatchery of origin. Some facilities are however using the same mark to release fish at more than one release location within a system or even to multiple systems. Fish age is still required to determine hatchery of origin for some high seas recoveries as there are some duplicate marks from different facilities in different NPAFC member countries from different brood years.

In BC’s terminal areas age data is not required to identify hatchery of origin as there are no duplication of marks among BC hatcheries. This has the benefit of providing insight into the straying of stocks from one system to another without having to know the age of the fish.

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 and 2004 showed that many chinook originated from Robertson Creek hatchery near Port Alberni. Continued sampling of chinook returns to WCVI in 2005 was to provide further data to evaluate the extent of chinook straying in both distance and magnitude.

Sampling of chinook in both ‘enhanced’ and ‘wild’ rivers on WCVI was to provide data for evaluation of hatchery and naturally spawning contributions.

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 (23% to 31% from 2000 to 2004) of swim-ins to Robertson Creek Hatchery. Further sampling of returns to Stamp River and Robertson Creek Hatchery in 2005 was to provide additional data to compare CWT and thermal mark estimates of hatchery contribution.

Assess the distribution of thermally marked stocks in different fisheries with a view to using the results as a management tool to refine open and closed areas.

Assess the viability of applying thermal marks at facilities on Vancouver Island which are currently not using this mass marking technique.

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

Methods

Sample Collection

2864 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. Some additional systems were sampled when opportunities arose, including Salmon, Nanaimo and Cowichan Rivers on ECVI and Chilliwack River in the Lower Fraser along with San Juan and Sooke on WCVI (Table 2).

554 samples were collected from gillnet and purse seine commercial fisheries in Alberni Inlet and 200 gillnet samples were taken from Tlupana Inlet (Nootka Sound). A further 752 were taken from the First Nations fisheries in Alberni Inlet, Nitinat and San Juan.

Sport caught samples comprised a total of 601 samples. 581 of 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 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 then heads were removed and frozen before being extracted in the otolith lab at Robertson Creek Hatchery.

Lab Procedures

A group of otoliths recovered from 1 sampling program is termed a ‘sample’ and is assigned a ‘lab number’. Each otolith within that sample is also assigned a fish number to enable tracking of each otolith within that sample. This information is recorded on each glass slide prior to otolith mounting. Otoliths from adults are mounted on the labelled glass slides 'sulcus down' using crystals of thermoplastic cement which are melted using a hotplate. The otolith is placed in the melted cement on the slide which is then removed from the hotplate to allow the cement to harden. The 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.

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 which had been sampled 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 2005 harvest or escapement samples are shown in Table 1.

Results

A total of 4971 otolith samples were collected, processed and analysed as described above. All 4971 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 new database was not ready to enter the 2005 data so it was entered into Excel to permit analysis of results and comparison of readings. Comparison of the original reading and their corresponding verifications indicated a 98.8% agreement on whether a sample was marked or not (for 4739 samples when both readings agreed that the sample could be read i.e. that it either ‘was a thermal mark’ or ‘not a thermal mark’). When both readings agreed that the sample was marked there was an agreement of 98.8% on the RBr code being observed and of 99.7% on the hatchery of origin (3550 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. They were categorised into 26 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 and 25. In area 13 releases from both Quinsam River and sea-pens off Campbell Estuary were recovered in Campbell and Quinsam Rivers and 1 Quinsam fish was recovered in Salmon River near Sayward. Area 25 appears to have both limited localised straying within most of the systems surveyed and more significant straying from Robertson Creek hatchery. A small sample from Zeballos River indicated 96% of the fish were of hatchery origin including small components from Muchalaht/Gold, Conuma River/Estuary, Sarita R/Poett Nook and Nitinat/Sooke. A sample of 50 in the Burman River indicated 22% hatchery origin despite no thermal mark releases from the Burman River (marking began with the 2002 brood) itself. The limited sample (20) obtained from the Muchalaht/Gold had 55% hatchery origin of which 50% were Robertson and 5% Muchalaht/Gold. The 50% recovery rate of Robertson fish in the Muchalaht /Gold follows a similar pattern to that seen from 2002 to 2004. Robertson Creek hatchery also had strays recovered from other locations. 3 recoveries (6% of total) were made in the Burman River (adjacent to Gold River), 1 in Zeballos (2% of total), 1 in Port Renfrew (17% of total, 1 in San Juan River (1% of total) and 1 recovery (1% of total) was made in the Cowichan River.

Results in table 3 indicate that returns to some systems have very high hatchery components to them. Swim-ins to major facilities at Quinsam, Robertson and Chilliwack are, not surprisingly, very nearly 100% hatchery origin. Deadpitch and/or broodstock samples taken from systems with major facilities (including Conuma) also have a 94-97% first generation hatchery component to them. Some systems that have smaller broodstock releases also indicate a high hatchery component including Sarita, Zeballos and San Juan. It should be noted that some systems (Gold, Tahsis, Burman, Sooke and San Juan) 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 2 or 3 years. Nanaimo, Cowichan and Salmon River have not had thermal marking on them to this point. 1 stray was found in each of Salmon River (11% of total) and Cowichan (0.3% of total).

Thermal Marking and CWT Comparison

Comparison of thermal marking results and cwt analysis from both Stamp River and Robertson Creek Hatchery swim-ins in 2005 updates the results obtained from 2000 to 2004. 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.

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. 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 2005 from cwt's indicated a range of 58-79% hatchery origin in the deadpitch compared with 86-96% from thermal marks. Hatchery contribution to hatchery swim-ins from the same time period varied widely from 58-88% for cwt's but was consistent for thermal marks (98-100%).

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 1999 and 2000. 1996 and 1997 are only slightly underestimated as a result of poor age 2 and 3 returns in 1998 and 1999 whereas 2001, 2002 and 2003 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.

Thermal Marking Viability at other Vancouver Island Enhancement Facilities.

Thermal marking of chinook has been conducted at six facilities on Vancouver Island prior to 2005. However, only one facility on ECVI (Quinsam River Hatchery) has been using this marking technique on a large scale basis. A second smaller program on ECVI has involved thermal marking of Englishman River chinook at Big Qualicum Hatchery. Concerns over the status of ECVI chinook and our inability to assess hatchery production due to the low incidence of recovered cwt's in Cowichan means an alternative assessment method is desirable.

Thermal marking has the potential to improve our understanding of hatchery contribution to some ECVI stocks. There are currently no large scale otolith sampling program in place for ECVI fisheries but sampling of some broodstock collection and dead pitch programs does take place. In future this could provide hatchery contribution to escapement as well as the straying information it currently provides. This Endowment Fund Proposal was the catalyst that led to discussions on the feasibility of marking at Nanaimo River Hatchery.

Discussions with the hatchery manager regarding the status of the two water sources at Nanaimo indicated that marking could take place with minimal cost. Both summer run and fall run chinook were assigned unique marks and these were successfully applied to the 2005 brood.

Cowichan River Hatchery only has one water source so was not a viable candidate for thermal marking without some engineering. A proposal was submitted to and funded by the Southern Endowment Fund to install a chiller system. The chiller was engineered and installed in summer and fall 2006 and marking of Cowichan chinook began with the 2006 brood.

Budget

Funding for this project was nearly all earmarked for sample collection and sample preparation and analysis. $38.5k 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 4.3k 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 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 three 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.

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 only Robertson stock should be this significant to Gold River when there is a much lower level of it across the Inlet in Burman River. Burman has some straying from Conuma, Gold, Sucwoa/Tlupana/Zeballos and Robertson stocks 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 2005 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 swim-ins shows a consistent hatchery contribution across all age classes, 100% for each of age 3 to age 6 (100% overall) and 88% for age 2 (jacks). Hatchery contribution to the same 2005 hatchery returns based on cwt analysis shows variability from 87% to 167% (88% overall) for adults and 43% 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 95% to 100% for each of age 3 to age 6 (96% overall) and 84% for jacks. Cwt's indicate a hatchery variability from 36-66% for age 3 to age 6 (60% overall) and just 8% for jacks. Good sample sizes and the 100% thermal mark rate on hatchery releases contributed to the 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.

There are two potential sources of error resulting in a portion of the difference between the two methods. 2005 recoveries of cwt's from Stamp River had a 'no pin' rate of approximately 7%. 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 2005) 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 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 only approached in 1998,1999 and 2003 of the study period, in other years egg deposition fell well short. Table 4 shows that for the 3 years which have fully returned (1998-2000), total escapement of 47,000 (25,500 females) resulted in an egg deposition of 88 million in the Stamp River. Cwt analysis shows a resultant 'natural' escapement from this of 50,000 adults. Thermal marking estimates the natural production (escapement only) from those 3 years to be just 12,000. 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 questionable policy given that hatchery production appears to be generating the majority of the returns. If the policy is to continue 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 1.
Chinook Thermal Marks Available for Recovery During 2005 Fisheries and Escapement Sampling.

Facility	Release Site(s)	Statistical Area	Brood Year	Thermal Mark : RBr Code
Quinsam River Hatchery	Elk Falls Spawning Channel - Campbell River. (Egg Outplants to incubation boxes).	13	2000	1:1.3-2.4
			2001	1:1.3-2.4
			2002	1:1.3-2.4
			2003	1:1.3-2.4
	Upper Quinsam River (fed fry outplants).	13	2003	1:1.2-2.4
	Quinsam River & Lake	13	1999	2:1.2/2.2/3.2
			2000	2:1.2/2.2/3.2
			2001	2:1.2/2.2/3.2
			2002	2:1.2/2.2/3.2
			2003	2:1.2/2.2/3.2
	Seapens off Campbell Estuary	13	1999	2:1.2/2.2
			2000	2:1.2/2.2
			2001	2:1.2/2.2
			2002	2:1.2/2.2
			2003	2:1.2/2.2
Big Qualicum	Englishman River	14	2003	2:1.6n
San Juan River Hatchery	San Juan River	20	2001	2:1.4,2.2
	San Juan River, Estuary & Harris Creek	20	2002	2:1.3n
			2003	2:1.3n
Nitinat River Hatchery	Sarita River & Poett Nook Seapens	23	1999	2:1.3,2.2,3.3
			2000	2:1.3,2.2/3.3
			2001	2:1.3,2.2,3.3
			2002	2:1.3,2.2,3.3
			2003	2:1.3,2.2,3.3
	Nitinat River & Lake	22	1999	2:1.2,2.3,3.2
			2000	2:1.2,2.3,3.2
			2001	2:1.2,2.3,3.2
			2002	2:1.2,2.3,3.2
			2003	2:1.2,2.3,3.2
	Sooke Harbour	20	2001	2:1.2,2.3,3.2
			2002	2:1.2,2.3,3.2
			2003	2:1.2,2.3,3.2
	Sooke River	20	2002	1: 1.4-2.1
			2003	1:1.4
	Esquimault Harbour	19	2002	1: 1.4,2.1
			2003	1:1.4
	Toquart Lake	23	2002	1: 1.4
Robertson Creek Hatchery	Henderson Lake	23	1999	1: 1.5
			2000	1:1.5
			2001	1: 1.5
			2002	1: 1.5
			2003	1:1.5
	Nahmint River	23	1999	2:1.4
			2001	1:1.3-2.2
			2003	1:1.3,2.2
	Nahmint River & Estuary	23	2002	2:1.4-2.2
	Harbour Quay - Port Alberni	23	2000	1: 1.3
			2001	1: 1.3
			2002	1: 1.3
			2003	1:1.3,2.1-3.2
	Robertson Creek	23	1999	1: 1.3 and 2:1.2-2.3 and 3:1.3+2.2-3.3
			2000	1:1.2,2.1 and 1:1.3
			2001	1: 1.3
			2002	1: 1.3
			2003	1: 1.3
	Robertson Creek (Super smolts)	23	2002	1: 1.3
			2003	1:1.3,2.1,3.3

Table 1cont.

Chinook Thermal Marks Available for Recovery During 2005 Fisheries and Escapement Sampling.

Facility	Release Site(s)	Statistical Area	Brood Year	Thermal Mark : RBr Code
Conuma River Hatchery	Burman River	25	2002	2:1.4,2.2
			2003	2:1.4,2.2
	Conuma River, Estuary & Seapens	25	1999	2: 1.5
			2000	2:1.3,2.2
			2001	2: 1.5
			2002	2: 1.5
			2003	2: 1.5
	Gold River	25	2003	2:1.2,2.2,3.2
	Muchalat Lake & Gold River Estuary	25	2002	2:1.2,2.4
	Tahsis River	25	2003	2:1.9
	Sucwoa River	25	2000	2: 1.3
			2001	2: 1.3
			2002	2: 1.3
	Tlupana River	25	2000	2: 1.3
			2001	2: 1.3
			2002	2: 1.3
			2003	2: 1.3
	Zeballos River	25	1999	2: 1.3
			2000	2: 1.3
			2001	2: 1.3
			2002	2: 1.3
			2003	2: 1.3
Chilliwack River Hatchery	Chilliwack River	29	1999	2: 1.7
			2000	2: 1.7
			2001	2: 1.7
			2002	2: 1.7
			2003	2: 1.7
Spius Creek Hatchery	Coldwater River	29	2003	2:1.3+2.4

Table 2. **Summary of Samples Collected and Thermal Marks Recovered During 2005.**

											Hatchery: Quinsam	Quinsam	Quinsam	San J.	Nitinat	Nitinat	Nitinat	Nitinat	Robertson	Robertson	Robertson	Robertson	Robertson	Conuma	Conuma	Conuma	Chwk.	Unk.
										Release Locations & Stat Area(s)	13	13	13	20	22/20	23	23	20	23	23	23	23	23	25	25	25	29	?
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	San Juan River	Nitinat River & Lake+Sooke Harbour	Sarita River & Poett Nook Seapens	Toquart Lake	Sooke River	Henderson Lake	Nahmint River	Nahmint River & Estuary	Robertson Creek	Robertson Creek & Harbour Quay Seapens	Conuma River, Estuary & Seapens	Muchalaht Lake & Gold River Estuary	Sucwoa+Tlupana+Zeballos Rivers	Chilliwack River	Unknown
Quinsam River	13	Escapement	Deadpitch	Adult	1		3	96	100	97%		63	33															
Quinsam R. Hatchery	13	Escapement	Swim-ins	Adult			1	31	32	97%		21	10															
Quinsam R. Hatchery	13	Escapement	Swim-ins	Adult	2		1	103	106	99%		87	16															
Campbell River	13	Escapement	Deadpitch	Adult	1		27	17	45	39%	8	3	6															
Salmon River	13	Escapement	Beach seine	Adult			11	1	12	8%		1																
Campbell River	13	Sport	Sport rod	Adult	1		2	17	20	89%		11	6															
Nanaimo River	17	Escapement	Beach seine	Adult	4	5	181		190	0%																		
Nanaimo River	17	Escapement	Deadpitch	Adult	1		99		100	0%																		
Cowichan River	18	Escapement	Beach Seine	Adult	4		196		200	0%																		
Cowichan River	18	Escapement	Deadpitch	Adult	6	1	92	1	100	1%													1					
San Juan River	20	Escapement	Fence	Adult	5		36	65	106	64%				63	1								1					
Sooke River	20	Escapement	Beach seine	Adult	3	4	40	14	61	26%					10			4										
Port Renfrew. East Pt.	20	First Nations	Gillnet	Adult			5	1	6	17%													1					
San Juan River	20	First Nations	Beach seine	Adult	2		37	57	96	61%				54	3													
Port Renfrew	20	Sport	Sport rod	Adult	3	3	16	1	23	6%													1					
Port Renfrew. East Pt.	20	Sport	Sport rod	Adult			6	1	7	14%													1					
Nitinat Lake	22	First Nations	Gillnet	Adult	5	2	40	203	250	84%					203													
Alberni Inlet	23	Commercial	Gillnet	Adult	4	3	6	87	100	94%												7	80					
Alberni Inlet	23	Commercial	Purse Seine	Adult	4	3	1	92	100	99%												3	89					
Alberni Inlet	23	Commercial	Purse Seine	Adult	3		7	90	100	93%					1					1	3	3	81		1			
Alberni Inlet	23	Commercial	Gillnet	Adult	4	4	7	85	100	92%												9	76					
Alberni Inlet	23	Commercial	Purse Seine	Adult	5	7	3	85	100	97%						1	1		1	2	2	2	76					
Alberni Inlet	23	Commercial	Gillnet	Adult	1			53	54	####									1			1	50				1	
Nahmint River	23	Escapement	Deadpitch	Adult			9	8	17	47%										6	2							
Robertson C. Hatchery	23	Escapement	Swim-ins	Adult	4	1	1	169	175	99%												2	167					
Robertson C. Hatchery	23	Escapement	Swim-ins	Adult	7			171	178	####												10	161					
Robertson C. Hatchery	23	Escapement	Swim-ins	Jack			6	44	50	88%													44					
Stamp River	23	Escapement	Deadpitch	Adult			1	4	5	80%													4					
Stamp River	23	Escapement	Deadpitch	Jack	1		19	116	136	86%													116					
Stamp River	23	Escapement	Deadpitch	Female	3		3	169	175	98%												7	162					
Stamp River	23	Escapement	Deadpitch	Male	4		5	166	175	97%												4	162					
Sarita River	23	Escapement	Beach seine	Adult	3		15	140	158	90%						140												
Alberni Inlet	23	First Nations	Gillnet	Adult	4	3	1	92	100	99%												10	82					
Alberni Inlet	23	First Nations	Gillnet	Adult	3	1	2	94	100	98%												4	90					
Alberni Inlet	23	First Nations	Gillnet	Adult			3	97	100	97%												3	94					
Alberni Inlet	23	First Nations	Gillnet	Adult	5		3	92	100	97%												3	89					
Barkley Sound (23C-M)	23	Sport	Sport rod	Adult	2		23	4	29	15%						1							1				1	1
Barkley Sound (23C-M)	23	Sport	Sport rod	Adult			13	5	18	28%													3				2	
Barkley Sound (23C-M)	23	Sport	Sport rod	Adult	2	3	27	58	90	68%					7	4					1		45				1	
Alberni Inlet (23A-B)	23	Sport	Sport rod	Adult			1	22	23	96%												2	20					
Barkley Sound (23C-M)	23	Sport	Sport rod	Adult			2	11	13	85%					3								8					
Clayoquot Sound	24	Sport	Sport rod	Adult		1	15		16	0%																		
Clayoquot Sound	24	Sport	Sport rod	Adult			4	4	8	50%													3	1				
Clayoquot Sound	24	Sport	Sport rod	Adult			1	3	4	75%													2			1		
Tlupana Inlet	25	Commercial	Gillnet	Adult	1	3	2	94	100	98%														93		1		
Tlupana Inlet	25	Commercial	Gillnet	Adult			3	97	100	97%														96		1		
Burman River	25	Escapement	Beach seine	Adult	4		39	11	54	22%													3	6	1	1		
Conuma River	25	Escapement	Beach seine	Adult			1	99	100	99%														99				
Tahsis River	25	Escapement	Beach seine	Adult			8	1	9	11%																1		
Sucwoa River	25	Escapement	Beach seine	Adult			2	5	7	71%												1		4				
Gold River	25	Escapement	Beach seine	Adult			1	2	3	67%													2					
Muchulaht River	25	Escapement	Beach seine	Adult			6	8	14	57%													7		1			
Muchulaht River	25	Escapement	Deadpitch	Adult			2	1	3	33%													1					
Zeballos River	25	Escapement	Sport rod	Adult		2	2	43	47	96%					2	1							1		2	37		
25A	25	Sport	Sport rod	Adult			8	32	40	80%														32				
25B	25	Sport	Sport rod	Adult			10	26	36	72%					1									25				
25C	25	Sport	Sport rod	Adult	2		6	43	51	88%											1			41			1	
25 E-G	25	Sport	Sport rod	Adult	2		3	19	24	86%														19				
25A	25	Sport	Sport rod	Adult			6	5	11	45%													1	4				
25B	25	Sport	Sport rod	Adult			6	20	26	77%					1									18		1		
25C	25	Sport	Sport rod	Adult			4	40	44	91%													1	39				
Kyuquot	26	Sport	Sport rod	Adult	5	3	83	27	118	25%					2								8	13			4	
Chilliwack R. Hatchery	29	Escapement	Swim-ins	Adult	7	1		198	206	####																	198	
Chilliwack River	29	Escapement	Deadpitch	Adult	6	13	16	265	300	94%																	265	
Totals					124	63	1179	3605	4971	75%	7	186	71	117	234	147	1	4	2	10	9	71	###	490	5	43	473	1

Table 3

2005. Hatchery Contribution & Straying in Escapement & Terminal Area Recoveries As Indicated by Thermal Marks.

					Hatchery																
					Quinsam			San J.	Nitinat				Robertson					Conuma			Chwk.
					Release Locations & Stat Area(s)																
					13	13	13	20	22/20	23	23	20	23	23	23	23	23	25	25	25	29
Recovery Location	Statistical Area	Thermally Marked	Not Thermally Marked	% Hatchery	Elk Falls Spawning Ch - Campbell River	Quinsam River & Lake	Seapens off Campbell Estuary	San Juan River	Nitinat River & Lake+Sooke Harbour	Sarita River & Poett Nook Seapens	Toquart Lake	Sooke River	Henderson Lake	Nahmint River	Nahmint River & Estuary	Robertson Creek	Robertson Creek & Harbour Quay Seapens	Conuma River, Estuary & Seapens	Muchalaht Lake & Gold River Estuary	Sucwoa+Tlupana+Zeballos Rivers	Chilliwack River
Quinsam River	13	96	3	97%		64%	33%														
Quinsam R. Hatchery	13	103	1	99%		84%	15%														
Campbell River	13	17	27	39%	18%	7%	14%														
Salmon River	13	1	11	8%		8%															
Nanaimo River	17		280	0%																	
Cowichan River	18	1	288	0.3%													0.3%				
San Juan River	20	65	36	64%				62%	1%								1%				
Sooke River	20	14	40	26%					19%			7%									
Port Renfrew. East Pt.	20	1	5	17%													17%				
San Juan River	20	57	37	61%				57%	3%												
Nitinat Lake	22	203	40	84%					84%												
Nahmint River	23	8	9	47%										35%	12%						
Robertson C. Hatchery	23	340	1	100%												4%	96%				
Robertson C. Hatchery Jacks	23	44	6	88%													88%				
Stamp River	23	339	9	97%												3%	94%				
Stamp River Jacks	23	116	19	86%													86%				
Sarita River	23	140	15	90%						90%											
Alberni Inlet	23	375	9	98%												5%	92%				
Burman River	25	11	39	22%													6%	12%	2%	2%	
Conuma River	25	99	1	99%														99%			
Tahsis River	25	1	8	11%																11%	
Sucwoa River	25	5	2	71%												14%		57%			
Gold + Muchalaht Rivers	25	11	9	55%													50%		5%		
Zeballos River	25	43	2	96%					4%	2%							2%		4%	82%	
Chilliwack R. Hatchery	29	198		100%																	100%
Chilliwack River	29	265	16	94%																	94%

Table 4.

Stamp River Enhanced and 'Natural' Escapement from Thermal Mark and CWT Analysis (includes escapement recoveries from 2000 to 2005).

	Return				Brood Year Production			
Brood Year	Stamp River Adult Spawners	Stamp River Female Spawners	Stamp River Egg Deposition (million)	Hatchery Releases (million)	Total 'Natural' Return from Thermal Marking	Total 'Hatchery' Return from Thermal Marking	Total 'Natural' Return from Expanded CWT	Total 'Hatchery' Return 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	2522	41071	16619	26974
2001	8221	1305	4.95	6.38	1469	84448	23303	62614
2002	24714	7585	27.30	7.59	432	10900	4840	6492
2003	36246	11234	40.50	8.17	934	5294	5031	1197
Total	138238	50759	184.45	59.64	15246	287197	88175	214268

The following charts show Enhanced production from hatchery releases (dashed lines) and 'Natural' production from in river spawning (solid lines). Note that only brood years 1998-2000 currently have had a full complement of returns.

Chart 1.

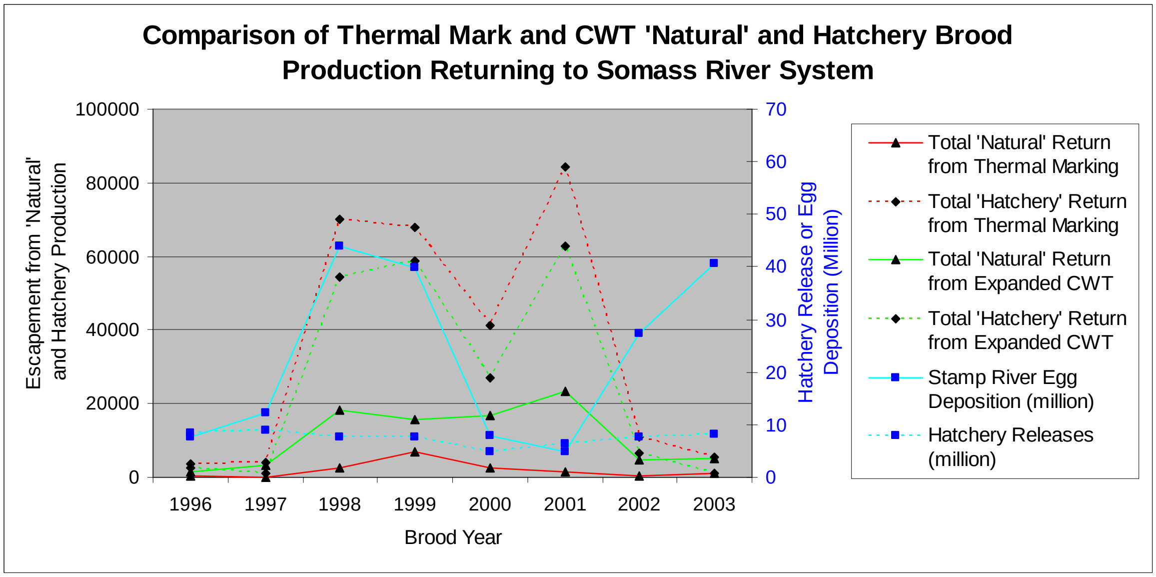
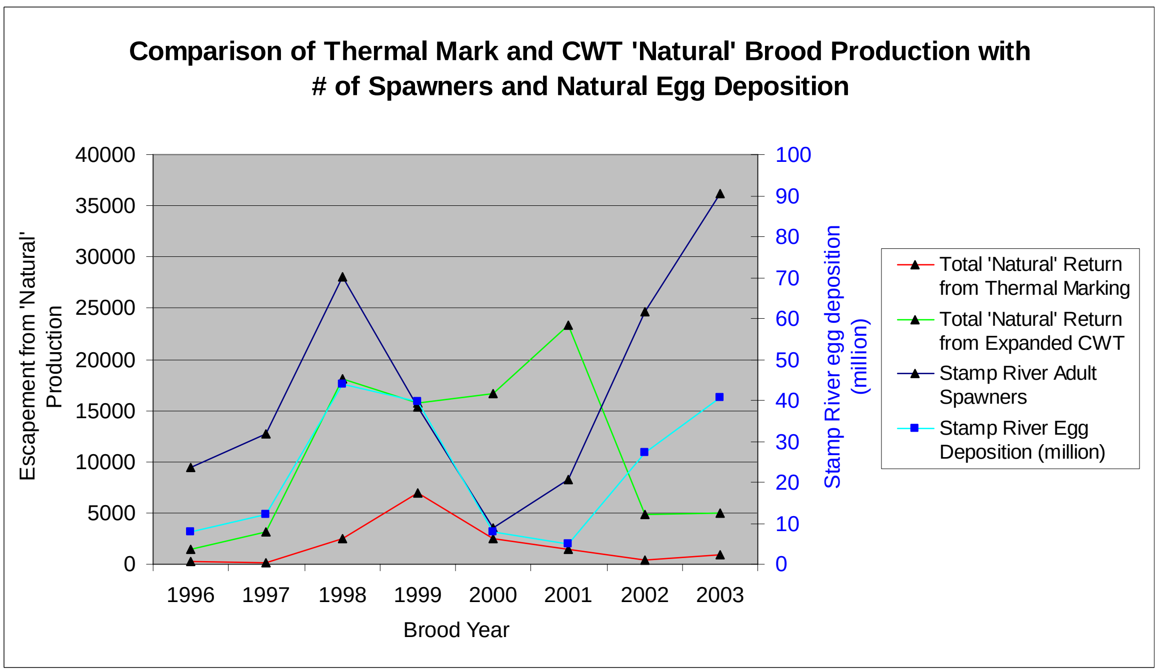


Chart 2.



Financial Account

Table 5. **Summary of costs**

Category	PSC Cost
Labour (Proj mgmt, lab co-ordination, data entry)	
Labour (Subcontractors & consultants)	$ 38,118.17
Sample Collection	$ 444.00
Repairs & Maintenance	$ 728.86
Supplies	$ 3,530.97
Equipment	
Travel	
Grand Total	**$ 42,822.00**

Table 6. **Breakdown of expenses**

Date	Supplier	Item	Cost	Category
30-Jun-06	Hupacasath First Nation	dissect juvenile & adult salmonids	$ 5,400.00	Labour
30-Jun-06	Hupacasath First Nation	dissect juvenile & adult salmonids	$ 4,104.00	Labour
21-Sep-05	Uchucklesaht Tribe	Prepare & Read Otoliths	$ 139.17	Labour
21-Sep-05	Ditidaht First Nation	Prepare & Read Otoliths	$ 27,720.00	Labour
20-Sep-05	Greyhound Bus	courier	$ 8.88	Supplies
3-Oct-05	Petty Cash	index cards	$ 6.14	Supplies
21-Sep-05	Pacfic Net & Twine	knives	$ 116.92	Supplies
20-Sep-05	Pacfic Net & Twine	supplies	$ 118.20	Supplies
11-Oct-05	Uchucklesaht Tribe	Thermal Marking	$ 675.00	Labour
25-Oct-05	Al Eden	Burman River bio-sample	$ 444.00	Sample collection
17-Oct-05	Emerson	carb discs	$ 184.73	Supplies
25-Nov-05	Zotec Services	organizing & entering thermal marking data	$ 80.00	Labour
25-Nov-05	Emerson	grinding wheels & plates for otolith grinder	$ 675.43	Repairs & Maintenance
22-Nov-05	Emerson	parts for grinder repairs	$ 53.43	Repairs & Maintenance
15-Nov-05	Emerson	grinding paper	$ 136.52	Supplies
17-Nov-05	Surgipath Canada	slides for otolith lab	$ 1,647.40	Supplies
16-Nov-05	Canada Wide Scientific	slide boxes for otolith lab	$ 824.04	Supplies
30-Nov-05	Surgipath Canada	slides for otolith lab	$ 334.10	Supplies
6-Jan-06	Nanaimo Home Hardware	plumbing hardware	$ 23.71	Supplies
9-Jan-06	Home Depot	plumbing hardware	$ 32.43	Supplies
7-Feb-06	Ono Trading	lab supplies	$ 97.90	Supplies
Total			$ 42,822.00	