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Patterns in the recapture rates among release locations of  
coded-wire tagged juvenile coho salmon in the  
Strait of Georgia

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## Abstract

In recent years, Canadian hatcheries have released an average of 9-12 million coho smolts into the Strait of Georgia, British Columbia. These hatchery coho (approximately 85% of which are released by 9 major hatcheries) represent about 70-75% of the total coho population entering the Strait. Approximately 5% of the hatchery-reared coho are marked with a small coded wire tag (CWT) implanted into the nasal region, which enables determination of release date and site as well as other pertinent information.

The analysis of CWT recoveries from research surveys during 1995 to 1998 indicated that, in September, the production from Fraser River hatcheries dominated the recaptures. Production from the Fraser River hatcheries may dominate in part due to slightly larger number of releases compared to the Vancouver Island hatcheries. However, recaptures from the Fraser River hatcheries also tend to exceed the expected adult returns, indicating that early marine survival is higher for Fraser River stocks than for coho released on the opposite side of the Strait. The relative proportions of CWT's from the 9 major hatcheries seen in the September surveys generally persisted until the next fall which indicated that the fall/winter mortality was non-selective across all of the hatcheries. We interpret the differences in early marine survival to be the result of persistent differences in predation at the time of ocean entry which was unexpected in this relatively small marine ecosystem.

Canadian hatcheries have released approximately 9-12 million coho into the Strait of Georgia annually. Approximately 5% of the hatchery coho from both countries have a coded wire tag (CWT) inserted in the anterior dorsal region of their head. These tags allow fisheries managers to study coho movements and survival during the marine phase of their life cycle. In most cases, the adipose fin is removed to indicate that the fish has been tagged. In 1997 and 1998, the percentage of Canadian hatchery reared coho entering the Strait of Georgia was estimated to be 76.3% and 71.8%, respectively, of the total population (Beamish et al. 1998, Sweeting et al. 1999). Using these estimates and the releases reported by Sweeting et al. 1999 (that include an estimate of fry), there would be 13.18 million hatchery and wild coho juveniles entering the Strait of Georgia in 1997 and 15.54 million in 1998. The wild coho in the population would represent the offspring of all naturally spawning coho, as well as the naturally spawning hatchery fish. In addition, a small percentage of hatchery-reared coho from United States hatcheries in the northern part of Puget Sound enter the Strait of Georgia.

The analysis of recaptured coho with CWT's is almost exclusive to fish recaptured in fisheries, in their second marine year or very late in their first year (Cormack and Skalski, 1992, Coronado and Hilborn, 1998) as it has been difficult to catch large enough numbers of these ocean age 0 juveniles with CWT's. Information on the behaviour of juvenile coho with CWT's in their early marine period is virtually absent, yet it is this period when the brood year strength is determined. Thus, we examined the pattern of hatchery recaptures to determine if there were persistent trends.

We also examined the possibility that recaptures from specific hatcheries may provide a method of forecasting returns in the next year.

The marine mortality of coho in the Strait of Georgia recently has increased to about 98% from approximately 85% in the late 1970s (Beamish et al. 1999a). Beamish and Mahnken (1999) have proposed that marine mortality can be separated into an early predation-based mortality and fall/winter growth-based mortality. Testing such ideas and understanding the natural processes that regulate brood year strength is necessary to provide a realistic expectation of coho production, particularly because management agencies spend massive amounts of money attempting to rebuild abundances to historic high levels. Failure to achieve these rebuilding targets frustrates the general public and even results in a belief of incompetence in management. If the marine habitat of coho (and other salmon) regulates abundance and if the capacity of this habitat fluctuates as climate changes, then expectations of returns must be based on the productive capacity of their marine habitats. Establishing this capacity, even in a relative sense, requires an improved appreciation of what kills coho in the ocean.

## Methods

Coho were captured using a large rope trawl (Beamish et al. 1999a), fished at a variety of depths, but with a concentration of tows in the surface 30 meters. All coho recaptured in the Strait of Georgia, Juan de Fuca Strait and off the west coast of Vancouver Island (Fig. 1) were used in the analysis. In addition, coho recaptured in Puget Sound (Fig. 1) in April, July, and September 1997 and July 1999 were included. The effort varied among these areas and at fishing depths, thus the recaptures are not

standardized for effort. For the 1995 to 1997 surveys, all coho were examined for missing adipose fins and those with the adipose fin clipped had their head removed and were preserved by freezing. Beginning in 1998, large numbers of hatchery coho were marked by removal of the adipose fin (i.e., whether a CWT had been implanted or not), so all recaptured coho were examined with a hand-held coded-wire tag detector (Northwest Marine Technology, Wash., USA). Only coho possessing a tag had the head removed. Tags were extracted in a laboratory and the CWT number determined. The release information for each tag code was retrieved from a CWT release database (MRP Database, Kuhn 1988).

## Results

Release and recapture information has been summarized by the major hatchery release sites and major recapture areas for each season of recapture (Tables 1 - 4, and Fig. 1). Recaptures of coho tagged in the United States were summarized by major release areas including Puget Sound, off Oregon and off Washington. Release and tagging numbers are also recorded separately for the 9 major hatcheries (Table 6). Recaptured coho in Puget Sound are also listed separately (Table 5).

In general, coho from the Fraser River drainage and Capilano hatchery were the first to enter the survey area in the Strait of Georgia and they dominated the catches throughout the year. No coho from off shore hatcheries were recaptured in the Strait of Georgia. Coho from Puget Sound were routinely found in the Strait of Georgia but they were not present until after April, and were dominated by coho released from hatcheries adjacent to the Canada-United States border. Small numbers of coho with tags from

Oregon hatcheries were found off Vancouver Island in the May/June surveys and again in November, but were not common.

In April surveys (Table 1), no ocean age 0 or ocean age 1 coho were captured in the Strait of Georgia. One ocean age 0 coho was captured in Puget Sound, one in Juan de Fuca Strait (Makah hatchery release) and 3 were captured on the west coast of Vancouver Island (Makah, Solduc and Aberdeen hatcheries).

In June/July (Table 2), the majority of recaptures in the Strait of Georgia were from hatcheries in the Fraser River drainage (Chilliwack, Inch Creek, Chehalis, Capilano and Spius), whereas Vancouver Island hatchery reared coho were less abundant. In 1996, recaptures of Fraser River hatchery coho were made in Juan de Fuca Strait, but not in other years. Two recaptures of ocean age 0 coho from Oregon hatcheries were made on the west coast in 1997 (May/June and June/July).

Catches were largest in the September surveys, as were the CWT recoveries (Table 3). While CWT's from Fraser River hatcheries continued to dominate the recapture, in two of the four years, coho from the Big Qualicum hatchery (Fig. 1) on Vancouver Island were the second most abundant in the catches.

In November (Table 4), the total number of tagged ocean age 0 recaptures in all years was 104, substantially lower than the total of 431 observed in Septembers of all years. Of the 104, 9 were identified as wild, virtually the same percentage (8.7%) as in September (37 of 431). In November, of all years there were 42 U.S. CWT's recovered or 40.4% of the total CWT's which is higher than the 32.3% U.S. CWT's observed in September. In November 1998, the sample sizes were small, but the percentage of U.S. CWT's was equal to the percentage of Canadian CWT's, substantially different from that

of previous years. In Puget Sound in 1997 and in July 1999 no Canadian tags were recaptured (Table 5).

Ocean age 1<sup>+</sup> coho were captured in the April surveys outside of the Strait of Georgia. Small numbers of ocean age 1<sup>+</sup> coho were captured in the June/July surveys (Tables 1, 2) and in the September surveys in 1995 and 1998 on the west coast.

The 9 major Canadian hatcheries that release coho into the Strait of Georgia accounted for 81 to 87% of the releases from 1995 to 1998 (Table 6). When the CWT recaptures for the larger September catches were expanded using the tagging percentages (number tagged/number released), recaptures from Chilliwack hatchery consistently were the largest (Table 7) even though other hatcheries released larger numbers of tagged coho (Table 6). Other hatcheries consistently contributing the largest returns were Chehalis, Big Qualicum, Inch Creek and Capilano. Quinsam contributed relatively large numbers only in 1996, the only year when a few recaptures were made outside of the Strait of Georgia in September. When the expanded numbers were standardized by relating expanded recaptures as a percentage of releases, the Fraser River hatcheries (Capilano, Chehalis, Inch, Spius and Chilliwack) dominated the recoveries in June and July (Table 8). Recaptures from the Tenderfoot hatcheries were more variable. By September, coho from almost all of these hatcheries were found in the catches, but Chilliwack, Capilano, Inch and Big Qualicum coho dominated the returns. By October/November, fewer CWT's were obtained, but coho from Capilano and Big Qualicum were the most common. No ocean age 1 coho with CWT's were recaptured in the Strait of Georgia, but coho with CWT's from all 9 hatcheries were found outside of the Strait of Georgia.

The observed recapture percentages were also compared to the marking percentages for each hatchery (Table 9). When this was done for the September catches, there was some variation among years for some hatcheries, but hatcheries such as Chilliwack and Chehalis always were either at, or exceeded expectations. Puntledge and Tenderfoot, on the other hand, were always less than expected. The differences between expected and observed catches in September could not be compared to total returns in the next year for all 9 hatcheries, but data were available for 7 hatcheries. The estimates that were available may underestimate total returns, as jacks (ocean age 0, mature males) may not be counted accurately and the accuracy of the counts of adults was not known. The comparison also assumed that fishing mortality was constant in 1996 and 1997 among hatcheries. There was no fishing permitted in 1998 on the Strait of Georgia stocks.

In all years, for all hatcheries, 16 of the 21 total returns were consistent with the observation of below average, or above average percentage of CWT recaptures observed in September of the previous year (Table 10). The relationship was clearest for the Chilliwack hatchery. In September of 1995 and 1996, recaptures of Chilliwack hatchery coho exceeded the expected among the 9 hatcheries and the returns in 1996 and 1997 were also proportionally higher than expected. In 1997, recaptures were slightly less than expected among the 9 hatcheries, and in 1998, the returns to Chilliwack were slightly less than the expected proportion among the 7 hatcheries that had estimates of total returns.

Recaptures of coho in the Strait of Georgia that were released from United States hatcheries all originated from Puget Sound hatcheries. Coho from the Skookum Creek, Kendall Creek and Marblemount hatcheries were the most abundant (Table 11). All of these hatcheries are at the northern end of Puget Sound, immediately adjacent of the



Canada-U.S. border and the southern end of the Strait of Georgia (Fig. 1). If the tagging percentages were on average about the same in the two countries over the survey period, the U.S. tags from hatchery releases were 16% of the combined U.S. and Canadian CWT's. A comparison of the contribution of U.S. hatchery coho expanded by tagging percentages was not made because of the small sample sizes. There were 4 recaptures from wild tagged coho during this period.

## Discussion

The actual number of CWT's recaptured were small, compared to the releases, thus it is possible that interpretations are affected by sample size. Accepting that this may be a problem, we concluded that there were differences in the recapture rates among hatcheries that were consistent for some hatchery releases and locations. Coho entering the Strait of Georgia from the Fraser River or close to the mouth of the Fraser River appeared in the catches earlier and appeared to have higher survival through to September than coho from the opposite side of the Strait on Vancouver Island. In about 75% of the returns, the proportion of the coho relative to that expected among the hatcheries was consistent with the relative catches in September. This indicates that the mortality from September through to the next fall was relatively non-selective. There was some variation over the study period and there were some years when coho from Big Qualicum (Vancouver Island side) were both above and below expectations. In general, Quinsam hatchery coho were below their expected percentage of capture and this may be explained by a northward migration out of the Strait as we seldom sampled the northern passage and Quinsam hatchery is close to this area (Johnston Strait, Fig. 1).

Nevertheless, there were distinctly different patterns in the percentages of recaptures from the 9 hatcheries that seemed to be related to the general location of ocean entry. One explanation is that the early mortality is greater in the near shore areas adjacent to Vancouver Island rather than adjacent to the Fraser River. We propose that this indicates that the early marine mortality is more site specific than the fall-winter mortality.

Beamish and Mahnken (1998, 1999) have proposed that there are two major periods which determine the number of coho that return to spawn or to the fishery. They proposed that the first mortality is predation based with a size-related component. The second mortality occurs in the fall/winter and is related to the amount of growth over the summer. Unless coho reach a minimum size by late September, they are unable to survive the changes in the ocean environment and food availability that occur in the fall and winter. Death is a result of physiological changes, but may be effected through predation.

A study of predation-based mortality in the immediate vicinity of the Big Qualicum River and hatchery by Beamish et al. (1992) showed that spiny dogfish (Squalus acanthias) abundance increased from an average of 125,000-175,000 to approximately 1.0-1.4 million just prior to the releases of coho and chinook from the hatchery. The percentage of the release eaten by dogfish varied from 20% to nearly 100% over the two years of study (Beamish et al. 1992). It was important to note that all this mortality was estimated to occur over a nine week period. Another major predator of coho in the Strait of Georgia is Lampetra ayresi (Beamish and Youson 1987). The total coho mortality caused by this parasitic lamprey was concentrated in the Fraser River plume and was estimated to be 78% of the combined coho and chinook population that

entered the Strait of Georgia in 1979. There probably are other predators on juvenile coho salmon within the Strait of Georgia (eg., seabirds), however, these two predators have been shown to account for a large percentage of the total marine mortality of coho and their behaviour may account for the differences in recapture rates on the east and west sides of the Strait. We can only speculate that dogfish predation is not evenly distributed as it has not been possible to study their behaviour throughout the Strait at the time coho enter the ocean.

We observed a sharp change in catches between mid-September and the end of October or early November. Coho were leaving the Strait of Georgia at this time, but we interpret the decline in catches and CWT recoveries to be an indication of a significant mortality in the late fall. The movement of virtually all coho out of the Strait of Georgia in the late fall in the 1990's has resulted in a collapse of the sports fishery (Beamish et al. 1999a). The persistent and complete movement out of the Strait in consecutive years since 1994 appears to be unique in this century and is related to climate induced physical changes in the Strait of Georgia. It appears that coho in Puget Sound are also leaving but the departure occurs between mid-July and mid-September. We have no explanation for the earlier movement of Puget Sound coho, but we believe a common mechanism is involved.

There are a number of other observations that are of specific importance to coho stocks in the study area. Coho in the Strait of Georgia do not move into Puget Sound. Coho from the most northern portion of Puget Sound move into the Strait of Georgia but coho from most Puget Sound hatcheries move directly out through Juan de Fuca Strait. Only very small numbers of ocean age 0 coho from Oregon were found off the west coast

of Vancouver Island, indicating that most coho in this area in their first marine year were from Puget Sound, the Strait of Georgia, or local. If the proportional relationships among hatchery recoveries observed in September continue, the percentages could be used to forecast deviations total returns from an average marine survival for specific hatcheries. The forecast that is most useful is the total marine survival. We propose that it may be possible to produce reliable marine survival estimates once we understand more about the reasons for the variability in hatchery survival in the spring and summer and the reasons for a non-selective fall/winter mortality.

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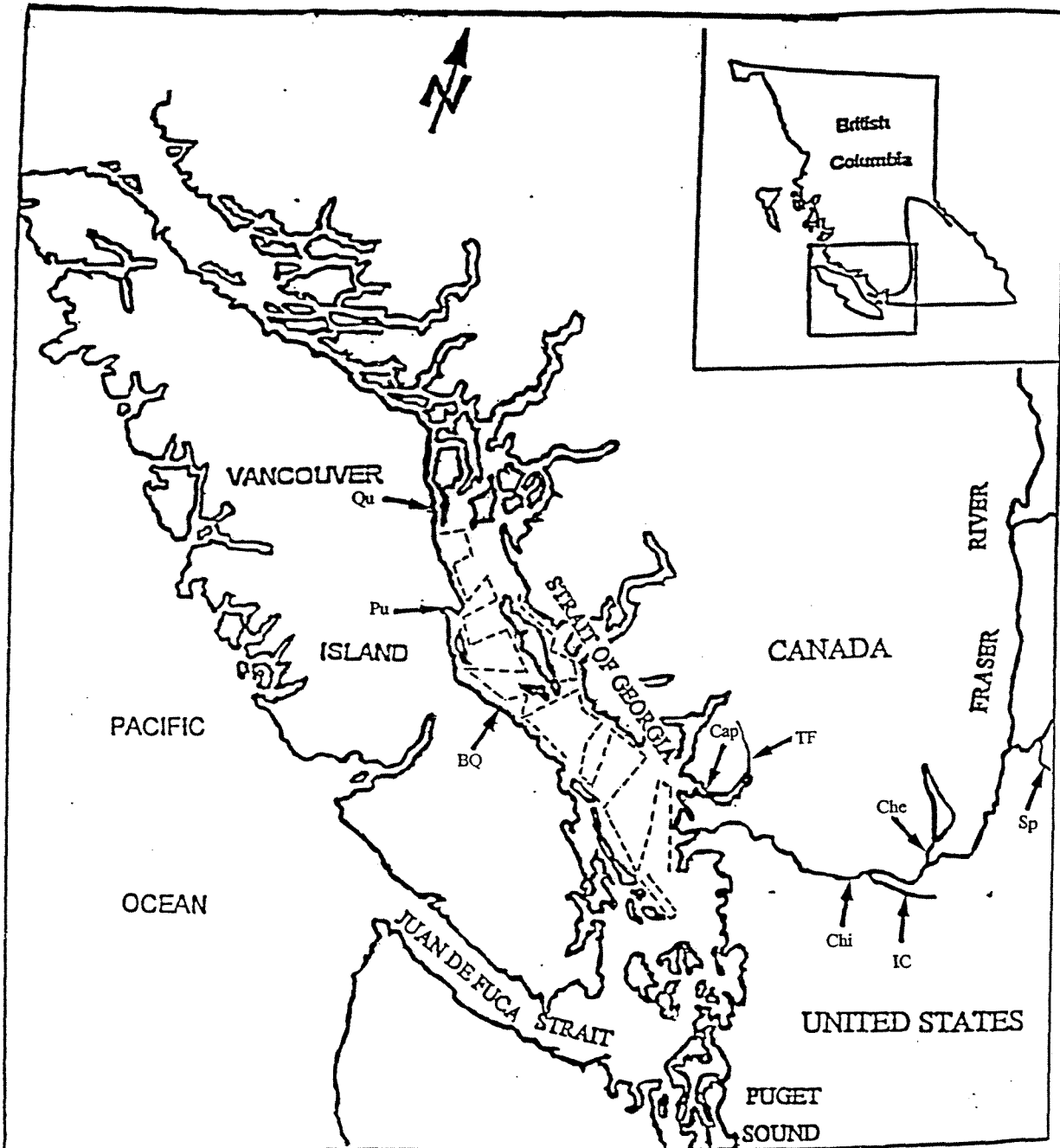


Figure 1. (Beamish and Sweeting) Map of Strait of Georgia and surrounding area. The track line for surveys in the Strait of Georgia is shown as a dashed line (---). The major British Columbia coho hatcheries discussed in the text are indicated by arrows and the accompanying letter codes: BQ – Big Qualicum; Cap – Capilano; Che – Chehalis; Chi – Chilliwack; IC – Inch Creek; Pu – Puntledge; Qu – Quinsam; Sp – Spius; and TF – Tenderfoot.

Table 1. Numbers of coho captured in the surveys summarised by major release areas. Summaries are for ocean age 0 and 1+. In April, no coho with CWT's were captured in the Strait of Georgia (SoG), Juan de Fuca Strait (JdeFS), or West Coast of Vancouver Island (WCVI). (note: one adult coho from the Skeena River hatchery on the north/central coast was recaptured in April 1996 in Juan de Fuca Strait)

Hatchery/Area	OCEAN AGE 0						OCEAN AGE 1+					
	APRIL, 1996		APRIL, 1997		APRIL, 1998		APRIL, 1996		APRIL, 1997		APRIL, 1998	
	JdeFS	WCVI	JdeFS	WCVI	JdeFS	WCVI	JdeFS	WCVI	JdeFS	WCVI	JdeFS	WCVI
<b>Lower Fraser Drainage:</b>												
Chilliwack	0	0	0	0	0	0	4	4	1	2	1	0
Inch Creek	0	0	0	0	0	0	2	2	0	0	0	4
Chehalis	0	0	0	0	0	0	0	0	1	1	0	0
Spius	0	0	0	0	0	0	0	1	1	1	0	0
Tenderfoot	0	0	0	0	0	0	1	0	0	0	0	0
Others	0	0	0	0	0	0	1	1	0	0	0	0
<b>WILD</b>	0	0	0	0	0	0	10	1	0	0	0	0
Upper Fraser	0	0	0	0	0	0	4	0	1	1	0	0
Coastal Mainland	0	0	0	0	0	0	2	1	0	0	0	0
Capilano Hatchery	0	0	0	0	0	0	1	0	3	1	0	1
<b>Vancouver Island:</b>												
Puntledge	0	0	0	0	0	0	2	1	1	0	0	0
Big Qualicum	0	0	0	0	0	0	3	0	0	0	0	0
Van. Is. - South	0	0	0	0	0	0	3	1	1	0	0	0
<b>Van. Is. - WILD</b>	0	0	0	0	0	0	0	0	0	0	0	1
Quinsam	0	0	0	0	0	0	6	0	0	0	0	0
West coast hatcheries	0	0	0	0	0	0	1	0	0	1	0	0
<b>US TAGS:</b>												
Washington (Puget Snd)	0	0	0	0	0	0	31	9	17	16	7	6
Washington	1	3	0	0	0	0	1	2				
Oregon	0	0	0	0	0	0	3	2	0	0	0	0
Idaho	0	0	0	0	0	0	0	0	0	0	0	0
California	0	0	0	0	0	0	0	0	0	0	0	0
<b>WILD US Tags</b>	0	0	0	0	0	0	5	1	3	0	1	1
<b>TOTAL CDN TAGS</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>39</b>	<b>12</b>	<b>9</b>	<b>6</b>	<b>1</b>	<b>6</b>
<b>TOTAL US TAGS</b>	<b>1</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>40</b>	<b>14</b>	<b>20</b>	<b>16</b>	<b>8</b>	<b>7</b>

Table 2. Numbers of coho salmon captured in the May-July surveys summarised by major release areas. Summaries are for ocean age 0 and 1+. In May-July, no adult coho with CWTs were recaptured in the Strait of Georgia (SoG) but adults were present in Juan de Fuca Strait (JdeFS) and West Coast Vancouver Island (WCVI).

Hatchery/Area	OCEAN AGE 0										OCEAN AGE 1+									
	June/July, 1996		May/June, 1997			June/July, 1997			June/July, 1998		June/July, 1996		May/June, 1997			June/July, 1997			June/July, 1998	
	WCVI	JdeFS	SoG	JdeFS	WCVI	SoG	JdeFS	WCVI	SoG	WCVI	WCVI	JdeFS	SoG	JdeFS	WCVI	SoG	JdeFS	WCVI	SoG	WCVI
Lower Fraser Drainage:																				
Chilliwack	2	0	3	0	0	4	0	0	2	0	0	0	0	0	0	0	1	2	0	0
Inch Creek	0	0	2	0	0	9	0	0	6	0	0	0	0	0	1	0	1	0	0	0
Chehalis	3	1	3	0	0	4	0	0	2	0	0	0	0	0	0	0	0	1	0	0
Spius	5	0	0	0	0	2	0	0	9	0	0	0	0	0	0	0	0	0	0	0
Tenderfoot	2	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Others	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WILD	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Upper Fraser	1	1	0	0	0	0	0	0	4	0	0	0	0	1	2	0	0	0	0	0
Coastal Mainland	1	1	2	0	0	6	0	0	4	0	0	0	0	0	1	0	0	0	0	0
Capilano Hatchery	5	4	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Vancouver Island:																				
Puntledge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Big Qualicum	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Van. Is. - South	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Van. Is. - WILD	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Quinsam	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
US TAGS:																				
Washington (Puget Snd)	6	3	0	0	0	4	13	5	8	0	0	0	0	10	6	0	8	9	0	2
Washington	0	0	0	0	13	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0
Oregon	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
California	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WILD US Tags	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0
TOTAL CDN TAGS	23	7	13	0	0	30	0	0	35	0	0	0	0	3	6	0	4	4	0	0
TOTAL US TAGS	6	3	0	0	15	4	14	10	8	0	0	0	0	10	7	0	11	9	0	2







Table 5. Number of coho salmon with CWT's captured in Puget Sound in 1997.<sup>1</sup>

MONTH	Number of CWTs	TOTAL CATCH	
		Ocean Age 1	Ocean Age 0
April/May	3	2	1
July	70	0	70
September	2	0	2

1. In 1997, no CWTs of Canadian origin were recaptured. In July 1999, ocean age 0 coho were sampled and 127 had CWTs. No CWTs from Canadian hatcheries were recaptured.

Table 6. Total number of smolts released and the number receiving a CWT for the major British Columbia hatcheries releasing coho into the Strait of Georgia from 1995 to 1998 (brood years 1993 to 1996). In 1998, coho receiving a CWT but not having the adipose fin removed are included. Capilano is included in Fraser River drainage group.

AREA	1995		1996		1997		1998	
	Released	CWT	Released	CWT	Released	CWT	Released	CWT
Fraser R. Drainage								
Chilliwack	1,795,181	39,808	1,702,085	36,256	1,973,961	114,100	1,857,069	75,598
Chehalis	1,088,726	39,843	1,044,907	38,537	886,578	85,155	1,171,184	35,696
Inch Creek	562,294	52,402	542,240	53,041	795,798	108,008	804,179	115,696
Spius Creek	162,569	39,174	184,964	66,537	149,760	40,022	135,757	86,506
Capilano	460,294	39,611	520,960	42,708	526,150	89,676	530,254	43,393
Mainland								
Tenderfoot	287,407	29,535	285,997	40,161	236,540	39,119	323,693	40,215
Vancouver Island								
Big Qualicum	1,508,383	38,917	1,738,986	37,616	1,278,697	78,138	1,322,872	81,686
Puntledge	838,649	41,623	748,982	39,526	695,186	82,688	686,773	37,626
Quinsam River	1,193,987	38,947	1,215,267	80,125	1,249,119	82,351	1,466,392	102,660
TOTAL	7,897,490	320,686	7,984,388	434,507	7,791,789	719,257	8,298,173	619,076

Table 7. The number of age 0 coho salmon captured during the September surveys, expanded by the percentages of fish tagged at the hatcheries. The larger numbers indicate the dominance of the specific hatchery in the catch for that year.

September, 1995	September, 1996	September, 1997	September, 1998
Chilliwack - 135	Chilliwack - 376	Chilliwack - 239	Chilliwack - 220
Chehalis - 109	Big Qualicum - 324	Chehalis - 198	Big Qualicum - 178
Inch Creek - 64	Capilano - 183	Inch Creek - 133	Chehalis - 98
Capilano - 47	Quinsam River - 182	Big Qualicum - 98	Inch Creek - 63
Big Qualicum - 39	Chehalis - 108	Capilano - 86	Tenderfoot - 25
Puntledge - 20	Puntledge - 76	Puntledge - 51	Puntledge - 53
Tenderfoot - 10	Tenderfoot - 29	Quinsam River - 46	Capilano - 24
Spius Creek - 4	Spius Creek - 29	Spius Creek - 38	Spius Creek - 9
Quinsam River - 0	Inch Creek - 0	Tenderfoot - 12	Quinsam River - 0

TABLE 8. Calculated number of recaptures of ocean age 0 coho salmon in the Strait of Georgia for each of the 9 major hatcheries, expanded by the tagging percentage. The calculated number is expressed as a percentage of the total release ( $\times 10^{-6}$ ). A larger percentage indicates a higher marine survival if there is no migration out of the sampling area and if there was no selection in the sampling.

HATCHERY	1995 Sampling				1996 Sampling						1997 Sampling								1998 Sampling					
	September		November		June		September		November		May/June		June/July		September		October		June/July		September		November	
	N <sup>1</sup>	% <sup>1</sup>	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Chilliwack	135	75	45	25	94	55	282	166	0	0	51	26	68	35	239	123	51	26	49	27	270	146	0	0
Chehalis	109	100	27	25	81	78	108	104	0	0	31	35	42	47	198	223	21	24	66	56	98	84	0	0
Inch Creek	64	114	11	19	0	0	0	0	0	0	15	19	67	84	133	167	22	28	42	52	63	78	7	9
Spius Creek	4	26	0	0	14	75	14	75	3	16	0	0	8	50	38	250	4	25	14	104	9	69	0	0
Capilano	47	101	35	76	61	117	183	351	77	149	0	0	6	11	86	164	24	45	49	92	24	46	0	0
Tenderfoot	10	34	0	0	14	50	29	100	7	25	6	26	6	26	12	51	0	0	0	0	25	77	0	0
Big Qualicum	40	26	39	26	0	0	324	186	0	0	0	0	0	0	98	77	49	38	16	12	178	134	16	12
Puntledge	20	24	0	0	0	0	76	101	0	0	0	0	8	12	51	73	34	48	0	0	37	53	0	0
Quinsam	0	0	0	0	30	25	182	150	46	37	0	0	0	0	46	36	15	12	14	10	0	0	0	0
TOTAL CATCH	1370		304		730		2572		451		228		523		2403		625		1238		1516		60	
TOTAL CWT	21		7		19		57		11		9		22		93		21		25		46		2	

<sup>1</sup> N is the number of recaptures adjusted for the tagging percentage, and the % is (N/Total releases) or the % of the total release, estimated to be present in the total catch in the survey. No Age 0 coho salmon were captured in April surveys.

Table 9. The percentage of CWT's expected from the percentage released from each of the 9 major British Columbia hatcheries compared to the actual percentage of CWT's observed in each September sample for Strait of Georgia catches. The actual number of CWT's is indicated (n) and the total catch of all age 0 coho in the Strait of Georgian portion of the survey is indicated.

HATCHERY	1995		1996		1997		1998	
	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual
Chilliwack	11.06	14.29	8.34	13.56	15.87	15.05	12.21	23.91
Chehalis	11.07	19.05	8.87	6.78	11.84	20.43	5.77	6.52
Inch Creek	14.56	28.57	12.21	00.0	15.02	19.35	18.69	19.57
Spius Creek	10.89	4.76	15.31	8.47	5.56	10.75	13.97	13.04
Capilano	11.01	19.05	9.83	25.40	12.47	16.13	7.01	4.35
Tenderfoot	8.21	4.76	9.24	6.78	5.44	2.15	6.50	4.35
Big Qualicum	10.81	4.76	8.66	11.86	10.86	6.45	13.19	23.91
Puntledge	11.57	4.76	9.10	6.78	11.50	6.45	6.08	4.35
Quinsam River	10.82	00.0	18.44	20.34	11.45	3.23	16.58	00.0
Total number of CWTs	-	21	-	59	-	93	-	46
TOTAL Coho Catch	-	1370	-	2572	-	2402	-	1516

Table 10. Numbers of juvenile coho salmon released into the Strait of Georgia by the major British Columbia hatcheries, with the expected and observed returns and percentages. The expected CWT recapture values are taken from Table 9. Chehalis and Spius hatcheries are not included, as total returns are not available.

	1993 Brood Year		1996 Adult Return Year			Obs/Exp CWT %
	Smolts Released	Expected Return %	Observed Return	Observed Return %	Observed/ Expected	
Chilliwack	1,795,181	27.0	49,588	41.5	153.7	129
Chehalis	-	-	-	-	-	-
Inch Creek	562,294	8.5	3,145	2.6	30.6	196
Spius Creek	-	-	-	-	-	-
Capilano	460,294	6.9	10,505	8.8	127.5	173
Tenderfoot	287,407	4.3	853	0.7	16.3	58
Big Qualicum	1,508,383	22.7	34,536	28.9	127.3	44
Puntledge	838,649	12.6	3,072	2.6	20.6	41
Quinsam	1,193,987	18.0	17,873	14.9	82.8	00
TOTALS	6,646,195	100.0	119,572	100.0		

	1994 Brood Year		1997 Adult Return Year			Obs/Exp CWT %
	Smolts Released	Expected Return %	Observed Return	Observed Return %	Observed/ Expected	
Chilliwack	1,702,085	25.2	48,316	37.4	148.4	163
Chehalis	-	-	-	-	-	-
Inch Creek	542,224	8.0	1,539	1.2	15.0	0.0
Spius Creek	-	-	-	-	-	-
Capilano	520,960	7.7	23,838	18.5	240.3	258
Tenderfoot	285,997	4.2	572	0.4	9.5	73
Big Qualicum	1,738,986	25.7	25,104	19.4	75.4	137
Puntledge	748,982	11.1	4,672	3.6	32.4	75
Quinsam	1,215,267	18.0	25,162	19.5	108.3	110
TOTALS	6,754,501	99.9	129,203	100.0		

	1995 Brood Year		1998 Adult Return Year			CWT %
	Smolts Released	Expected Return %	Observed Return	Observed Return %	Observed/ Expected	
Chilliwack	1,943,961	28.9	21,695	24.0	83	95
Chehalis	-	-	-	-	-	-
Inch Creek	795,798	11.8	2,886	3.2	271.2	129
Spius Creek	-	-	-	-	-	-
Capilano	526,150	7.8	11,613	12.8	164.1	129
Tenderfoot	236,540	3.5	993	1.1	31.4	59
Big Qualicum	1,278,697	19.0	9,789	10.8	56.8	56
Puntledge	695,186	10.3	4,901	5.4	524.3	28
Quinsam	1,249,119	18.6	38,693	42.7	2295.7	40
TOTALS	6,725,451	99.9	90,570	100.0		



Table 11. Recaptures of United States hatchery-reared coho salmon in the Strait of Georgia.

HATCHERY	1995		1996			1997			1998			TOTALS
	Sept.	Nov.	June	Sept.	Nov.	Jun/Jul	Sept.	Oct.	Jun/Jul	Sept.	Nov.	
Skookum Creek	2	2	5	7	1	2	4		2	1	1	27
Kendall Creek		2		4			1		4	3	2	16
Marblemount	1			3			2	1	1	1		9
Lummi Sea Pens						1	3		1	2	1	8
Agate Pass Sea Pens						1	1					2
South Sound Sea Pens							2					2
Kapowsin Lake							1					1
Red Creek			1		1							2
Anacortes Net Pens				1								1
Fairhaven Net Pens	2	1										3
Fidalgo Vay Net Pens	4											4
WILD - Big Beef Ck												1
WILD - Baker River							1					2
WILD - Airport Pond												1
TOTAL US Tags	9	5	6	15	2	4	15	1	8	9	5	79
TOTAL Canadian Tags	28	12	23	73	13	29	106	24	35	55	4	402
TOTAL Canadian WILD	8	0	0	10	1	1	9	3	1	3	1	37