Northwest Indian Fisheries Commission

6730 Martin Way E., Olympia, Washington 98506

Phone (206) 438-1180
FAX #753-8659

Phone (206) 753-9010
FTS #434-9476

To: Tribal Biologists Involved with PSC Indicator Stock Studies
From: Ron Olson, Fisheries Biologist Ron
Date: June 28, 1993
Subject: Review of CWT Spawning Escapement Estimates for Tribal PSC Chinook Indicator Stocks

****

Attached for your review is a draft report, *Review of Procedures used to Estimate Escapement of Tribal Chinook Exploitation Rate Indicator Stocks.* This report is the product of the CWT Spawning Escapement Estimation Project described in a previous memo (June 3, 1992). The intent of this report is to address the questions and concerns regarding CWT escapement estimation and reporting that were discussed in the report - *"Review of the Chinook Exploitation Rate Indicator Stock Program for the Washington Coast and Puget Sound"* (Scott, Moore and Moore, 1992).

This report provides information on the results of our efforts to develop methodologies for statistically acceptable escapement estimates of coded wire tagged chinook. For each Indicator stock we provide a purpose, a description of the program, a review of hatchery and stream survey sampling, a review of natural spawning escapement estimation, an examination of straying, the status of reporting of the data, and a summary of recommendations for future use as a PSC indicator stock.

This review, in conjunction with the review by Scott et al. (1992), will be used for improving and refining the list of tribal chinook indicator stocks to be tagged and used in PSC analysis and modelling efforts.

Please forward your comments to me by the end of July.

REVIEW OF PROCEDURES USED TO ESTIMATE ESCAPEMENT OF TRIBAL CHINOOK EXPLOITATION RATE INDICATOR STOCKS

(DRAFT)

by

Ron P. Olson
Pamela Goddard
Ken Phillipson

Northwest Indian Fisheries Commission

June 1993

TABLE OF CONTENTS

INTRODUCTION

Chinook and Coho Exploitation Indicator Stock programs were initiated to evaluate the effectiveness of management measures prescribed by the Pacific Salmon Commission (PSC). In 1985 the Northwest Indian Fisheries Commission (NWIFC), Washington Department of Fisheries (WDF), and the U.S. Fish and Wildlife Service (USFWS) instituted a comprehensive coded wire tagging (CWT) program in Washington State. The current chinook indicator stocks for Puget Sound and the Washington Coast are listed in Tables 1 - 4.

Washington State representatives of the PSC Chinook Technical Committee recently completed a report, *Review of the Chinook Indicator Stock Program for Western Washington* (Scott, Moore and Moore, in press). In summarizing their findings, the authors state: "Serious problems exist with the program that severely hamper the ability of technical staff to evaluate compliance with the objectives of the Pacific Salmon Treaty (PST)". The summary of recommendations from that report are listed in Table 5. A significant problem identified was: "Estimates of the escapement of tagged fish are lacking, are unreliable, or have not been provided to the Pacific States Marine Fisheries Commission (PSMFC)". The estimation of the spawning escapement component of the tag group must be reported for CWT studies to be useable for estimating fishery exploitation rates. This is necessary for both wild stock studies and for hatchery studies where a significant number of fish may "stray" onto the adjacent spawning grounds.

The NWIFC began tagging tribal chinook indicator stocks in 1986 (brood year 1985 fish). The program involves tagging and recovery of nine chinook stocks. Four of the chinook stocks (Stillaguamish summer/fall, Hoko fall, Quillayute summer, and Queets fall) are considered "wild broodstock" groups. These fish are derived from wild broodstocking efforts where returning adults are captured and brought to a hatchery for spawning, incubation, early rearing, and tagging. The fish are then transferred as pre-smolts to an acclimation/imprinting pond adjacent to the native river. An attempt is made to release the fish at a size and time consistent with the wild chinook smolt migration. All of the wild broodstock projects include spawning ground surveys to estimate escapement and sample carcasses to recover CWTs. The escapement estimation methodologies vary for each stock, and the estimates vary in their degree of statistical precision. Some of these projects have not been able to provide estimates of the CWT escapement (i.e. estimated recoveries from spawning ground carcass sampling). This has resulted from delays in analyzing escapement data and/or determinations that the quality of some escapement estimates does not warrant their use in expansion of recoveries.

The five hatchery stocks are sampled for CWTs upon return to their hatchery, and this sampling/recovery data has been reported. However, only two of these stocks (Grovers Creek and Lower Elwha) have associated stream sampling programs to accurately estimate straying to nearby spawning grounds. The lack of complete escapement data has precluded the usefulness of the other three hatchery stocks (Lummi Bay, Tulalip and Nisqually).

A concerted effort was made to review the status of CWT sampling, CWT recovery, data reporting and escapement estimation techniques for all tribal chinook PSC Indicator Stocks. Specific objectives of the review were:

For Hatchery Stocks:

- Determine the extent of straying of CWT fish to areas outside of the hatchery
- If straying appears significant, identify problems with current methods for sampling, estimating, and reporting of tagged straying.
- Make recommendations for improving CWT straying estimates.

For Wild Stocks:

- Review the status of spawning escapement estimates and CWT recoveries from stream surveys.
- Determine if the precision of escapement estimates will allow for CWT expansions.
- Where possible and/or needed, complete the task of compiling the sampling data, expanding the tag recoveries for the escapement estimates, documenting the estimation methods used, and reporting the CWT data to the PSMFC/PSC database.
- Identify any problems with current methods for sampling, estimating, and reporting of tagged escapement.
- Make recommendations for improving CWT escapement estimates.

The results of this review will be used in refining and improving NWIFC's program for tagging and recovery of tribal PSC chinook exploitation indicator stocks.

Table 1. Natural Puget Sound and Washington coastal spring chinook stocks and associated escapement and exploitation indicator stocks. (from Scott et al. 1992)

NATURAL STOCK	ESCAPEMENT INDICATOR STOCK	EXPLOITATION INDICATOR STOCK
Nooksack spring	None 1/	Nooksack Hatchery Skookum Creek Hatchery 3/
Skagit spring	Skagit spring	Skagit Hatchery
White River spring	None 1/	Hupp Springs Hatchery
None	None	Quilcene Hatchery 2/
Juan de Fuca Tributaries	None 1/	None
Grays Harbor spring	Grays Harbor spring	None

1/ Due to data limitations, this natural stock is not currently used as an escapement indicator stock.
2/ This stock is used as a harvest rate indicator stock an has no associated natural stock.
3/ Tagging of this stock was discontinued due to low abundance.

Table 2. Natural Washington coastal summer and spring/summer chinook stocks and associated escapement and exploitation indicator stocks.

NATURAL STOCK	ESCAPEMENT INDICATOR STOCK	EXPLOITATION INDICATOR STOCK
Quillayute summer	Quillayute summer	Quillayute Broodstock Program
Hoh spring/summer	Hoh spring/summer	Quillayute Broodstock Program
Queets spring/summer	Queets spring/summer	Quillayute Broodstock Program

Table 3. Natural Puget Sound and Washington coastal summer/fall and fall chinook stocks and associated escapement and exploitation indicator stocks.

NATURAL STOCK	ESCAPEMENT INDICATOR STOCK	EXPLOITATION INDICATOR STOCK
Nooksack/Samish Region 1/	None	Lummi Ponds Samish Hatchery
Skagit summer/fall	Skagit summer/fall	Skagit Hatchery 2/
Snohomish summer/fall	Snohomish summer/fall	Tulalip Hatchery Skykomish Hatchery 2/
Stillaguamish summer/fall	Stillaguamish summer/fall	Stillaguamish Broodstock Program
Green River Fall	Green River fall	Green River Hatchery
Mid-Puget Sound Region 1/	None	Green River Hatchery Grovers Creek Hatchery Issaquah Hatchery 3/
South Puget Sound Region 1/	None	Kalama Creek Deschutes Hatchery 3/
Hood Canal Region 1/	None	George Adams Hatchery
Juan de Fuca Tributaries	None 4/	Lower Elwha Hatchery Elwha Channel 3/ Hoko Broodstock Program
Queets fall	Queets fall	Soleduck Hatchery 3/ Queets Broodstock Program Makah Hatchery Quinault Hatchery
Quillayute fall	Quillayute fall	Soleduck Hatchery 3/ Queets Broodstock Program Makah Hatchery Quinault Hatchery
Hoh fall	Hoh fall	Soleduck Hatchery 3/ Queets Broodstock Program Makah Hatchery Quinault Hatchery
Grays Harbor fall	Grays Harbor fall	Humptulips Hatchery Satsop Hatchery 5/
Willapa Bay fall	None 4/	Willapa Bay Hatchery 3/

1/ This region is managed for hatchery chinook production.
2/ Tagging of this stock was discontinued because it was not representative of the natural stock.
3/ PSC tagging of this stock was discontinued.
4/ Due to data limitations, this natural stock is not currently used as an escapement indicator stock.
5/ Although recommended as an exploitation indicator stock by the CTC, this stock was never used.

Table 4. Natural Puget Sound fall yearling and accelerated chinook stocks and associated escapement and exploitation indicator stocks.

NATURAL STOCK	ESCAPEMENT INDICATOR STOCK	EXPLOITATION INDICATOR STOCK
Mid-Puget Sound Region 1/	None	U.W. Accelerated 2/ Icy Creek 3/
South Puget Sound Region 1/	None	Percival Cove Pens 4/ Squaxin Island Pens

1/ There are no natural fall yearling or accelerated chinook stocks.
2/ Tagging of this stock was discontinued.
3/ PSC tagging of this stock was discontinued.
4/ PSC tagging of this stock was moved to Squaxin Net Pens.

Table 5 Summary of recommendations for Puget Sound and Washington Coastal chinook exploitation rate indicator stocks.
(From Scott et al., 1992)

Stock	Consider Continuing PSC Tagging	Consider Establishing/ Resuming PSC Tagging	Consider Discontinuing PSC Tagging	IF TAGGING IS CONTINUED: Improve/Provide Escapements	Achieve Target Tagging	Evaluate Straying	Evaluate Stock Characteristics	Standardize Size/ Time at Release
Nooksack/Samish Region								
Nooksack Hatchery spring	X				X	X	X	
Skookum Cr. Hatchery spring			X					
Samish Hatchery fall	X			X				
Lummi Bay Hatchery fall			X					
Skagit River								
Skagit Hatchery spring	X			X	X		X	
Skagit Hatchery summer/fall		X		X			X	
Snohomish River								
Skykomish Hatchery summer		X		X			X	
Tulalip Hatchery fall			X					
Stillaguamish River								
Stillaguamish summer/fall	X			X	X		X	
Mid-Puget Sound Region								
Green River Hatchery fall	X							
Grovers Creek Hatchery fall	X							
U. of W. fall		X						
South Puget Sound Region								
White River Spring	X							

continued on next page

Table 5 continued.

Stock	Consider Continuing PSC Tagging	Consider Establishing/ Resuming PSC Tagging	Consider Discontinuing PSC Tagging	IF TAGGING IS CONTINUED: Improve/Provide Escapements	Achieve Target Tagging	Evaluate Straying	Evaluate Stock Characteristics	Standardize Size/ Time at Release
South Puget Sound Region cont.								
Kalama Creek fall fing. [1]	X					X		X
Squaxin Pens fall yearling [1]	X			X				
Hood Canal Region								
Quilcene Hatchery spring			X					
George Adams Hatchery fall	X							
Strait of Juan de Fuca Tributaries								
Lower Elwha Hatchery fall	X			X	X			X
Hoko River fall	X			X	X		X	
North Washington Coast Region								
Quillayute River summer			X					
Makah Hatchery fall			X					
Queets River fall [2]	X			X	X			
Quinault Hatchery fall			X					
Soleduck Hatchery fall [2]	X			X				
Grays Harbor Region								
Humptulips Hatchery fall			X					

[1] Consider moving this program to another facility.
[2] One of these two stocks could be chosen to represent Washington coastal production.

METHODS

The status of escapement estimation and CWT sampling and recovery was reviewed for tribal PSC Chinook Exploitation Rate Indicator Stocks. The process involved extensive contact with appropriate tribal and WDF biologists. Information was also obtained from the following documents: tribal annual reports on Pacific Salmon Treaty research projects, *Review of the Chinook Exploitation Rate Indicator Stock Program for the Washington Coast and Puget Sound* (Scott, Moore, and Moore, 1992), *Puget Sound Chinook Salmon Escapement Estimates and Methodology* (Smith and Castle, 1992), and WDF progress reports entitled *Results from Micro-Tagged Experimental Groups* (annual reports for years 1988 to 1991). Escapement estimation methodologies were reviewed for statistical design and precision of estimates.

CWT groups from brood years (BY) 1983 to 1987 were used in analyzing escapement data. Information on individual CWT recoveries was obtained from the PSMFC/PSC CWT database (PSMFC Regional Mark Processing Center, Portland). Complete recovery data sets (fisheries, hatchery returns and spawning ground surveys) were available through return year 1990. Recovery data for fisheries and hatchery returns were generally available through return year 1991, and was used when spawning ground data was not available for the stock. Recovery data were also verified by queries to CWT databases maintained by individual agencies. These included WDF, USFWS, NWIFC, and individual tribes. Estimates of survival rates and freshwater (terminal) return rates were obtained through reports generated by NWIFC's CRAS (Coded Wire Tag Retrieval and Analysis System) database. Unless noted, all references of CWT recoveries refer to "estimated recoveries" as reported in the PSMFC/PSC database. Estimated recoveries are derived by multiplying the number of observed recoveries by the inverse of the sampling rate (total catch / number sampled).

In order to assess the importance of obtaining accurate escapement estimates, the magnitude of freshwater escapement and the degree of straying were examined for each stock. This was done by calculating two statistics: *Freshwater Return Rates* and *Stray Rates*. These rates are defined as follows:

$$\text{Freshwater Return Rates} = \frac{\text{Total Freshwater CWT Recoveries}^{1}}{\text{Total CWT Recoveries}} \times 100\ \%$$

[1] Includes all freshwater fishery, hatchery, and spawning ground recoveries

Not all spawning grounds are sampled for CWT recoveries (carcass sampling). Additionally, many CWT recoveries from stream surveys are not expanded when reported because either an estimate of the escapement was not made, or the precision of the spawning escapement estimate is unknown. Because of these factors, the terminal return rates used in this report should be considered as minimum rates.

Stray Rates were calculated where adequate data were available. These rates were calculated differently depending on the stock. The Lummi Bay, Tulalip, and Grovers Creek hatchery stocks have hatchery racks located on or near saltwater with no adjacent spawning grounds. Hatchery stray rates for these stocks were calculated as:

$$\frac{F - H}{F}$$

Where: F = Total freshwater CWT recoveries
H = Total hatchery recoveries at the release hatchery

Five of the stocks do not rely on a hatchery rack and the spawning grounds are sampled for tag recovery and escapement estimation. These stocks include the Lower Elwha hatchery stock and the four stocks utilizing wild broodstock: Stillaguamish summer/fall, Hoko fall, Quillayute summer, and Queets fall. Stray rates for these stocks were calculated as:

$$\frac{F - R}{F}$$

Where: F = Total freshwater CWT recoveries
R = Total CWT recoveries within the native river (includes all in-river fishery, broodstocking, and spawning ground recoveries)

The term "stray rate" requires some clarification. This rate is used with respect to the freshwater escapement component of a tag group. The intention of this statistic is to estimate a rate at which fish "strayed" to other hatcheries, rivers, or spawning grounds; as compared with the number returning to their original hatchery or river of release. Straying may be a concern for hatchery stocks where either the hatchery rack does not provide good attraction or when an outside broodsource is used. Evidence for a hereditary component in chinook homing behavior has been presented by McIsaac and Quinn (1987). This stray rate should not, however, be interpreted as an estimate of the homing ability of the stock or tagged group, since many of the stocks are subjected to near-terminal marine fisheries, and recoveries in those fisheries were not used in calculating the rate. Additionally, only those recoveries from non-origin spawning grounds or hatcheries should be considered homing "strays" in the strictest sense.

With respect to the freshwater escapement component and the above definition, these stray rates should probably be considered as minimum rates. As mentioned above, not all spawning grounds are sampled for tagged fish, and even in the streams that are, carcasses are generally difficult to recover. Carcass recovery appears to be particularly difficult on larger rivers. Conversely, it is well documented that returning spawners may "test" or temporarily enter a non-native river prior to entering their river of origin (Ricker, 1972). In order to minimize the chance of these fish

being included as strays, no recoveries from marine or esturine fisheries were included, even if recoveries occurred in near-terminal marine fisheries well outside of the expected return migration route.

REVIEW OF STOCKS

LUMMI BAY FALL CHINOOK

Stock Type: Hatchery

Purpose of Indicator Stock: The primary purpose of the fall chinook exploitation rate indicator stocks within the Nooksack/Samish region is to monitor harvest rate indices in the West Coast Vancouver Island (WCVI) troll and Georgia Strait (GS) sport fisheries.

Program Description and History:
Hatchery: Lummi Bay Sea Ponds / Mamoya Pond (Lummi Tribe)

Broodsource: The program has generally relied on imported eggs or fry from northern Puget Sound hatcheries. These have been primarily Samish stock, although Green River stock was used in BY 1988, Kendall stock (N.F. Nooksack) was used in BY 1989 and a Kendall-Samish mix was used in BY 1991. Eggs from adults returning to Mamoya pond and Lummi Bay will be used to the extent they are available.

Rearing and Release: Samish stock eggs have generally been reared to fry at Kendall Hatchery before transfer to Lummi Bay. Mamoya Pond, a satellite rearing site, was added in 1989. This rearing pond is located on Kwina Slough near the mouth of the Nooksack river. The pond has a rearing capacity of 3 million fall chinook and is now the primary release site. Releases are of the fingerling type and occur in the May - June time period.

Tagging History: Fall chinook have been tagged intermittently at Lummi Bay Sea Ponds beginning with BY 1976 fish. Indicator stock tagging began with BY 1985 fish.

Hatchery Returns and Sampling: Returns of adult chinook to the Lummi Bay Sea Ponds hatchery rack have generally been low, with an average annual return of 164 fish for years 1982 to 1991. This has ranged from 23 in 1991 to 591 in 1985. For BY 1985 and 1987 tag groups there were no returns to the hatchery. The relatively low number of returns is undoubtedly highly influenced by local fisheries. Lummi Bay hatchery recoveries averaged only 0.13 % of the total recoveries for brood years 1985 to 1987 release groups. Recoveries in the Nooksack/Samish Net fisheries (WDF Areas 7B, 7C, 7D, 7E) averaged 41% of the total recoveries for the same tag groups. A similar pattern of recoveries occurred for a fall chinook release from WDF's Nooksack Hatchery; a brood year 1985 CWT group had hatchery recoveries of 0.6% and Nooksack/Samish net recoveries of 41% of the total. Conversely, a brood year 1985 Samish Hatchery CWT group had a hatchery escapement of 15% and Nooksack/Samish net recoveries of 34% (49% total). Sampling of the Lummi Bay hatchery returns has been inconsistent. Accurate sampling and adult return records are not available for 1988. The 1990 and 1991 releases of Lummi Bay CWT groups were from Mamoya Pond, which also has a

hatchery rack. It is anticipated that future releases of this stock will also be from Mamoya Pond. It is unknown how well these fish will return to the Mamoya Pond rack.

Stream Surveys and CWT Sampling: There is currently no spawning ground sampling program targeting the recovery of marked fall chinook carcasses on the Nooksack River. Current WDF sampling concentrates on spring chinook and coho. Tribal sampling is conducted for spring chinook.

Natural Spawning Escapement Estimation: Escapement estimates for chinook salmon returning to the Nooksack system are discussed in Smith and Castle (1992). Past estimates were based on using 15.6% of the Skagit escapement estimate. The authors state that they no longer believe this relationship adequately approximates the Nooksack escapement and efforts are underway to develop a system-specific estimate. The natural spawning escapement is believed to be low in recent years and a self sustaining run is questionable (Pete Castle, pers. comm.). Water quality characteristics of the Nooksack (i.e. glacial influence on the North Fork) restrict visibility and thereby limit the possibilities for stream survey based estimates.

Straying: Freshwater return rates and hatchery stray rates for the Lummi Bay Sea Ponds and Samish Hatchery are summarized in Tables 6 - 9. The data indicate that a significant problem with straying may exist for the Lummi Hatchery. Stray rates for the Lummi facility averaged 0.96 versus 0.06 for the Samish Hatchery. Since estimates of the tagged fish which spawn in the Nooksack River are not available, we would also expect the freshwater return rate to be lower than for the Samish Hatchery - if significant straying occurs from the Lummi Bay facility into the Nooksack River. An alternative hypothesis is that the fish mill in marine areas and are harvested. The high stray rate for the Lummi facility was due to the low number of hatchery returns, and the high number of recoveries in the Nooksack River net fisheries and at the Samish Hatchery rack (Table 7). This straying was particularly apparent for the BY 1986 groups, which had high survival rates (14.4% and 4.5%). In the 1989 returns there were more Lummi Bay CWTs recovered at the Samish hatchery (26) than were recovered at the Lummi Bay Sea Ponds rack (7). This straying may be related to the stock origin. The straying may also indicate poor attraction to the Lummi Bay rack site. The Lummi Bay hatchery rack is located directly on Lummi Bay. The hatchery also uses a mixture of saltwater and Nooksack River water for rearing. This combination may limit the attraction provided by the hatchery rack. The fact that tags are frequently recovered in the Nooksack in-river fishery indicates the possibility of significant straying to the Nooksack River natural spawning areas. However, interpretation of this data is difficult due to sampling complications. Sampling occurs at buyer stations, which often have fish from both Nooksack River and Bellingham Bay (7B) fisheries. There has been an attempt in recent years to separate out the two areas, but this separation is not consistently achieved. Nooksack River fisheries are often combined with 7B fisheries when sampling separations cannot be made, and sampling recorded as Nooksack River may include some fish caught in 7B fisheries (Lonnie Crumley, pers. comm.). No stream survey recoveries of Lummi Bay CWTs have been reported in recent years, but as previously mentioned there is no spawning

ground sampling program targeting the recovery of marked fall chinook carcasses on the Nooksack River.

Status of Reporting CWT Escapement Recoveries: Lummi Bay hatchery rack sampling and recoveries have been reported for all years. Non-expanded recoveries were reported for 1988 returns because the sample rate was unknown. Sampling and recoveries have been reported for the Samish Hatchery and the Samish River. The Samish River is sampled for carcasses and redd counts in the section of river below the hatchery weir. Tagged carcass recoveries are expanded based on a peak redd count escapement estimation method (Smith and Castle, 1992). The precision of these estimates is unknown because of the methodology used.

Summary and Recommendations: CWT escapement estimates for Lummi Bay fall chinook groups are currently limited to hatchery returns and strays to the Samish system. Because of the lack of escapement estimates and spawning ground surveys, the amount of straying to the Nooksack River is unknown. Substantial straying to the Samish Hatchery does occur. If tagging of this stock were to continue, a program to sample and estimate the fall chinook escapement to the Nooksack River would need to be implemented. Any stream sampling program on the Nooksack would need to address the visibility problems found on the north fork of the river. The use of stocks from outside of the region (e.g. Green River) may exacerbate the current straying rate and would also diminish the usefulness of Lummi Bay as a regional indicator stock. These escapement problems do not appear to occur with the Samish fall chinook indicator stock. As discussed in the review by Scott et al. (1992) the Samish Hatchery is providing a useful fall chinook exploitation rate indicator stock for the region. Cluster analysis of recovery distribution for all Western Washington chinook indicator stocks (Appendix A) reveals that the two hatcheries have very similar distribution patterns. We therefore concur with the recommendation that PSC indicator stock tagging of Lummi Bay fall chinook be discontinued.

Table 6. Estimates of Survival, Terminal Return Rates, and Hatchery Stray Rates For Lummi Bay Fall Chinook CWT Groups (recoveries through 1990).

Brood Year	Tag Code	Stock	Survival Rate	Freshwater Return Rate (% of total)	Hatchery Stray Rate
1985	211902	Samish	0.00418	2.1 %	1.00
1986	212232	Samish	0.14414	2.7 %	0.91
	212235	Samish	0.04516	3.3 %	0.84
1987	212538	Samish	0.00290	2.5 %	1.00
	212537	Samish	0.01570	5.0 %	1.00
Mean Brood Year Rate =			0.03600	3.7 %	0.96

Table 7. CWT Recoveries of Lummi Bay Hatchery Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1990).

Release Hatchery	Brood Year	Tag Code	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Lummi Bay Sea Ponds	1985	211902	100,719	1987		Samish / 1 / 1
				1988		Samish / 2 / 2
	1986	212232	93,683	1988		Samish / 12 / 12
				1988		Lummi Bay / 7 / 7 [c]
				1989	Samish R. / 1 / 2 [a]	Samish / 26 / 26
				1989		Lummi Bay / 4 / 4
				1989	Nooksack R. / 17 / 71 [b]	Nooksack / 1 / 1
				1990		Samish / 19 / 23
				1990		Chehalis B.C. / 1 / 1
				1990		Lummi Bay / 3 / 3
				1990		Samish / 7 / 7
		212235	98,550	1988		Lummi Bay / 2 / 2 [c]
				1989		Lummi Bay / 3 / 3
				1990	Samish R. / 1 / 2 [a]	Samish / 6 / 7
				1990	Nooksack R. / 8 / 29 [b]	Lummi Bay / 2 / 2
	1987	212538	92,987			
		212537	96,572	1990	Nooksack R. / 1 / 3 [b]	Samish / 1 / 1

[a] Spawning ground recoveries
[b] In-river fishery recoveries - Nooksack River may include some Bellingham Bay recoveries.
[c] Sampling rate unknown - recoveries not expanded

Table 8. Estimates of Survival, Terminal Recoveries, and Hatchery Stray Rates For Samish Hatchery Fall Chinook CWT Groups (recoveries through 1990).

Brood Year	Tag Code	Stock	Survival Rate	Freshwater Return Rate (% of total)	Hatchery Stray Rate
1985	633804	Samish	0.00775	16.1 %	0.0870
	633805	Samish	0.01010	14.5 %	0.1379
	633806	Samish	0.01117	14.9 %	0.0
	633807	Samish	0.01097	15.4 %	0.0
1986	634122	Samish	0.06062	17.2 %	0.0868
1987	634732	Samish	0.01347	23.9 %	0.0351
Mean Brood Year Rate =			0.02803	18.8 %	0.0594

Table 9. CWT Recoveries of Samish Hatchery Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1990).

Release Hatchery	Tag Code	Brood Year	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Samish	633804	1985	53,773	1987		Samish / 5 / 5
				1988	Samish R. / 1 / 2 [b]	Samish / 15 / 15
				1989		Samish / 1 / 1
	633805	1985	52,297	1988	Samish R. / 1 / 2 [b]	Samish / 7 / 7
				1989		Samish / 17 / 17
				1990	Samish R. / 1 / 2 [b]	Samish / 1 / 1
	633806	1985	52,297	1988		Samish / 14 / 14
				1989		Samish / 16 / 16
	633807	1985	52,506	1987		Samish / 1 / 1
				1988		Samish / 10 / 10
				1989		Samish / 19 / 19
	634122	1986	204,517	1988		Samish / 87 / 87
				1989	Samish R. / 2 / 4 [b]	Samish / 212 / 214
				1990	Samish R. / 29 / 49 [b]	Samish / 262 / 320
					Nooksack R. / 2 / 6 [a]	
	634732	1987	205,145	1989	Samish R. / 1 / 2 [b]	Samish / 10 / 10
				1990		Samish / 36 / 44

[a] In-river fishery recoveries
[b] Stream survey recoveries

STILLAGUAMISH SUMMER CHINOOK

Stock Type: Wild Broodstock

Purpose: The primary purpose of the indicator stock within this region is to provide estimates of exploitation rates that can be used to evaluate the effect of the rebuilding program on natural stocks of summer/fall chinook from the Stillaguamish River.

Program Description and History:
Broodsource: The Stillaguamish indicator stock relies upon natural broodstock for tagging. Broodstock are collected from the north fork of the river between RM 10.0 and RM 24.0. The fish are transported to the Stillaguamish Tribal Hatchery for mturation and spawning.

Rearing and Release: The resulting fry are reared and tagged at the Stillaguamish Tribal Hatchery. The tagged fish are then transported to an upstream acclimation facility. Beginning with BY 1990, the fish have been released at Washington Department of Wildlife's Whitehorse rearing ponds on the upper North Fork Stillaguamish River. This facility is located within an area where the majority of wild chinook spawning occurs. From 1988 - 1989 acclimation and releases occurred at Fortson Pond. In 1987 acclimation and release occurred at C-Post Pond. The tagged smolts are released as fingerlings in mid-May. The release time and size are based on native smolt data from the Stillaguamish, and ATPase studies of the hatchery fish.

Tagging History: Tagging of this wild broodstocking program has occured since BY 1980, except for BY 1984 and 1985. For most of these years the tag group size has been low, resulting from difficulties in collecting sufficient broodstock from the river.

Stream Surveys and CWT Sampling: The high freshwater escapement rates (Table 10) reveal the necessity of providing accurate CWT escapement estimates for this stock. Stillaguamish River spawning ground surveys for summer chinook are conducted by the Stillaguamish Tribe and WDF. The Stillaguamish Tribe conducts foot surveys for approximately 16 miles of the North Fork Stillaguamish, between Deer Creek and the Whitehorse Bridge (RM 14.2 to RM 30.0). WDF conducts foot surveys of the North Fork Stillaguamish between RM 30.0 and RM 34.0, as well as Boulder River and Squire Creek (two tributaries of the North Fork Stillaguamish). WDF also conducts foot surveys on Pilchuck Creek (a tributary of the mainstem) and Jim Creek (a tributary of the South Fork). In addition, WDF conducts aerial surveys of the North Fork from RM 0.0 to RM 30.0, of the South Fork from RM 17.8 to RM 34.6, and of the mainstem from RM 0.0 to RM 17.8. The South Fork aerial survey is checked by foot from RM 27.5 to RM 30.0. WDF conducts live and dead fish counts, redd counts, and notes the environmental conditions on their foot surveys. The Stillaguamish Tribal surveys are primarily for carcass sampling. Extensive carcass sampling began in 1989 and annual sampling has increased from 63 carcasses sampled with 10 CWTs recovered in 1989, to 139 carcasses with 82 CWTs in 1991. Broodstock sampling has been conducted at the 100% rate. Based on WDF escapement estimates, combined stream survey and broodstocking sampling account for total escapement sampling rates of 15.5% in 1989, 28.6% in 1990, and 23.2% in 1991 (Table 11).

Table 10. Estimates of Survival, Freshwater Return Rates, and Stray Rates For Stillaguamish Summer Chinook CWT Groups (recoveries through 1990).

Brood Year	Tag Code	Stock	Survival Rate	Freshwater Return Rate (% of total) [a]	Stray Rate [a]
1983	211618	Stillaguamish	N/A	N/A	N/A
1986	212221	Stillaguamish	N/A	47.5	0.1
1987	212555	Stillaguamish	N/A	46.0	0.002
Mean Brood Year Rate =			N/A	46.7	0.051

[a] Calculations based on expansions of unknown precision.

Table 11. Summary of Spawning Escapement Estimation and CWT Sampling for North Fork Stillaguamish Summer Chinook, 1988 - 1991.

Year	North Fork Stillaguamish Escapement Estimate	Broodstock Sampling		Stream Sampling		
		Adults	CWTs	Carcasses	CWTs	CWT Expansion
1988	591	14	1	0	0	
1989	587	27	9	72	2	8.15
1990	636	88	31	65	14	9.78
1991	1,492	118	67	187	63	7.97

Natural Spawning Escapement Estimation: WDF estimates the escapement of the Stillaguamish summer chinook using a variety of methods. The primary method used to estimate escapement is a linear redd count interpolation graph. This method uses redd counts obtained from one or two helicopter surveys conducted around peak spawning. These one or two points are used to construct a curve built around the estimated beginning and ending times of the run, an assumed 21-day redd life, and an assumed 2.5 fish per redd. Other methods used to estimate escapement are peak live and dead counts, peak redd counts, live count interpolation graphs, and various ratio combinations when no survey data are available. Recent escapement estimates are summarized in Table 11. The precision of these estimates is unknown because of the methodologies used; therefore, confidence intervals cannot be placed on these estimates. Until the precision of these estimates can be assessed, their use in expanding CWT carcass recoveries is not considered satisfactory for PSC indicator stock analysis. Annual summaries of the 1988

to 1991 escapement estimation methodologies are listed in Appendix B.

In the fall of 1992 the Stillaguamish Tribe experimented with an alternative field method to derive an independent escapement estimate. This method utilized a mark-and-recapture procedure which used chinook salmon carcasses and a Jolly-Seber estimation model. Carcasses were marked with individually numbered jaw tags. The methods and results of the experiment are described in a report by Bob Conrad (Appendix C). Results were compared with the WDF redd counting method for the same spawning ground area. The WDF estimate for this area was 410 chinook, as compared with the Jolly-Seber estimate of 132 chinook (95% confidence interval: 104 to 207). Unfortunately no confidence intervals are available for the WDF estimate. As discussed in Bob Conrad's report, two possible explanations for the substantial difference in estimates (279 fish) are: (1) the carcass surveys were not begun early enough and a portion of the escapement may have been missed; or (2) the redd count is in error.

Straying: Several recoveries of this stock have occured in the Skagit River (Table). These have included both fishery and spawning ground recoveries. Because all Skagit recoveries are expanded and reported, this should pose no analytical problems.

Status of Reporting CWT Escapement Recoveries to the PSMFC/PSC Database: Recoveries from broodstocking have been reported to the PSMFC/PSC database. Stream survey carcass recoveries have not yet been expanded for escapement estimation or reported.

Summary and Recommendations: Because of the estimated high escapement rates (47 %), accurate and precise CWT escapement estimates are imperative if this stock is to provide useful data as an indicator stock. Because of the high CWT sampling rates and percentage of CWTs found in the escapement, annual expansions of tag codes should be possible if accurate escapement estimates can be generated. The precision of recent escapement estimates is unknown because of the methodologies used. An alternative escapement estimation method is needed to either replace the current WDF method or to evaluate the precision of this method. Hydrological characteristics of the Stillaguamish River have been conducive to both redd counting and carcass recovery. For return year 1993, we recommend either repeating the Jolly-Seber method over an extended time period (to ensure that the entire period of chinook carcass availability is encompassed), or modifying the current redd counting method to incorporate index areas (weekly surveys) and escapement estimates based on index and supplemental area survey designs. In this later option, the existing aerial surveys may serve as convenient supplemental surveys.

Table 12. CWT recoveries of Stillaguamish summer chinook in freshwater fisheries and escapement areas (recoveries through 1991).

Release Site	Brood Year	Tag Code	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
North Fork Stillaguamish R.	1983	211618	26,915	1985		Cowlitz / 1 / 1
				1986	Skagit R. / 2 / 7 [b]	
				1987	Stillaguamish R. / 5 / 5 [a]	
	1986	212221	23,904	1988	Stillaguamish R. / 1 / 1 [a]	
					Stillaguamish R. / 0 / 42 [d]	
				1989	Skagit R. / 1 / 2 [b]	
					Stillaguamish R. / 4 / 4 [a]	
					Stillaguamish R. / 0 / 54 [d]	
					Skagit R. / 1 / 19 [c]	
				1990	Skagit R. / 1 / 2 [b]	
					Stillaguamish R. / 9 / 37 [c]	
					Stillaguamish R. / 7 / 7 [a]	
				1991	Stillaguamish R. / 8 / 8 [a]	
					Stillaguamish R. / 3 / 59 [c]	
	1987	212555	127,910	1989	Stillaguamish R. / 4 / 4 [a]	Skagit / 1 / 1
					Stillaguamish R / 0 / 42 [d]	
				1990	Stillaguamish R. / 24 / 24 [a]	
					Stillaguamish R. / 4 / 17 [c]	
				1991	Stillaguamish R. / 55 / 55 [a]	
					Stillaguamish R. / 49 / 261 [c]	

[a] Broodstocking recoveries
[b] In-river fishery recoveries
[c] Stream survey recoveries - preliminary expansions based on escapement estimates of unknown precision.
[d] Estimated CWT spawning escapement - preliminary expansions derived through combining broodstock and stream survey CWT sampling data, and based on escapement estimate of unknown precision.

TULALIP HATCHERY CHINOOK SALMON INDICATOR STOCK

Stock Type: Hatchery

Purpose: The primary purpose of the Tulalip Hatchery fall chinook indicator stock is to provide estimates of exploitation rates that can be used to evaluate the effect of the rebuilding program on the natural summer/fall chinook stock from the Snohomish region. The Snohomish stock has been assessed as "Probably Not Rebuilding" by the Chinook Technical Committee (CTC), and the Pacific Fisheries Management Council (PFMC) has designated the stock as "Overfished".

Program Description and History:
Hatchery: Tulalip Salmon Hatchery (Tulalip Tribes)

Broodsource: The hatchery chinook program relies on eggs provided by other facilities and the broodstock source varies annually and has included Samish, Green, and Skykomish fall chinook stocks. The Skykomish fall chinook stock originated from Green River stock. Because of this stock history, the tagged stock may not be representative of natural production from the region (Scott et al. 1992).

Rearing and Release: Incubation and rearing takes place at the Tulalip Salmon Hatchery. Final rearing and release occurs at a rearing pond located on Tulalip Bay. Releases are of the fingerling type and occur in May.

Tagging History: Tagging at the Tulalip Hatchery was initiated with the indicator stock program on BY 1986 fish.

Hatchery Returns and CWT Sampling: The hatchery program is managed to support an intensive terminal fishery with no hatchery escapement goal. As intended, the escapement to the hatchery is minimal. Adult returns to the rack have ranged from 1 fish in 1990 to 62 fish in 1987. All returns have been sampled for CWTs and a few tags have been recovered. Many potential hatchery returns are undoubtedly intercepted in the Tulalip Bay net fishery (Area 8D). This fishery has been sampled at an average rate of 27% for years 1988 to 1991.

Stream Surveys and CWT Sampling: The Tulalip Hatchery rack is located at the mouth of Tulalip Creek on Tulalip Bay. Tulalip Bay is located just north of the mouth of the Snohomish River, and approximately 10 miles south of the mouth of the Stillaguamish River. Because of this location, potential straying to either drainage is of concern. Stream surveys on the Snohomish system are conducted by WDF but primarily target coho. Chinook carcass sampling is generally limited to Wallace River below the Skykomish Hatchery (Pete Castle, pers. comm.). Summer chinook spawning ground surveys do occur on the Stillaguamish River and are described in the Stillaguamish summer chinook section of this report.

Natural Spawning Escapement Estimation: Stream surveys to estimate escapement for the Snohomish and Stillaguamish systems are described by Smith and Castle (1992). It is not possible to place confidence intervals on these escapement estimates, so their precision is unknown.

Straying: Because of the varied stock history, the location of the Tulalip Hatchery rack, and the limited hatchery returns, straying of Tulalip Hatchery chinook is a concern. However, the intensive terminal fishery may preclude straying. Perhaps due to this fishery, freshwater return rates average only 0.2% (Table 13). Alternatively, it might be hypothesized that tagged fish are straying to either the Snohomish River or the Stillaguamish River. The limited information available suggests that this hypothesis is incorrect. There have been no recoveries of Tulalip CWTs at other regional hatcheries, and there have been no recoveries from summer chinook spawning surveys in the Stillaguamish River (Table 14). The extent of straying to the Snohomish system in unknown. However, no recoveries have been reported at the Skykomish Hatchery and no recoveries have been reported for the limited chinook carcass sampling that does occur in the Snohomish system. The Tulalip Tribe is planning to address this issue through a PST research project. The purpose of the project is to determine straying levels of Skykomish and Tulalip hatchery origin chinook in the Snohomish River. Unique otolith marks will be given to developing fry at both hatcheries, beginning with BY 1993 fish. Spawning ground surveys will be conducted to recover marks and determine marked to unmarked ratios.

Table 13. Estimates of Survival and Freshwater Return Rates For Tulalip Creek Fall Chinook CWT Groups (recoveries through 1990).

Brood Year	Tag Code	Stock	Survival Rate	Freshwater Return Rate (% of total)
1986	212204	Snohomish	0.0316	0.002
1987	212544	Green R. / Tulalip	0.0080	0.002
Mean Brood Year Rate =			0.0200	0.002

Table 14. CWT Recoveries of Tulalip Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1990).

Release Hatchery	Brood Year	Tag Code	Number Tagged	Recovery Year	Freshwater Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Tulalip	1986	212204	191,825	1989	Ship Canal / 1 / 3 [a]	Tulalip / 1 / 1
	1987	212544	188,110	1989		Tulalip / 1 / 1

[a] In-river fishery recoveries

Status of Reporting CWT Escapement Recoveries: Tulalip Salmon Hatchery rack sampling and recoveries have been reported.

Summary and Recommendations: Because of the lack of fall chinook spawning ground sampling, the degree of Tulalip chinook straying to the Snohomish basin is unknown. The extent of this possible straying must be determined in order for this stock to provide useful information as a PSC indicator stock. As indicated in the review by Scott et al. (1992), the stock history calls into question its usefulness as an indicator of the natural summer/fall production for the region. Because of these factors the recommendations in Scott et al. (1992) were followed and indicator stock tagging of the is group has been discontinued. The appropriate indicator stock recommended for the region is the Skykomish summer stock at the WDF Skykomish Hatchery. Problems identified with the previous tagging program of the Skykomish stock should be addressed and tagging resumed.

GROVERS CREEK FALL CHINOOK

Stock Type: Hatchery

Purpose: The primary purpose of this stock is to monitor exploitation rates in PSC fisheries and is to represent production of fall chinook fingerlings from the mid-Puget Sound Region.

Program Description and History:
Hatchery: Grovers Creek (Suquamish Tribe)

Broodsource: Returns to the hatchery have been used since BY 1982. The hatchery run was started with the use of the following stocks: Finch Cr. (BY 1978), and Green River & Deschutes (BY 1979 to 1981).

Rearing and Release: Fish are reared and released on-station as fingerlings. Releases are volitional and occur in May.

Tagging History: Tagging has been conducted consistently at the Grovers Creek Hatchery since brood year 1981.

Hatchery Returns and Sampling: Escapement rates to the hatchery have been relatively high; averaging 37% of total CWT recoveries for brood year 1983 to 1987 CWT groups (Table 15). Adult chinook have returned to the hatchery in consistently high numbers. Annual returns have averaged 2,453 fish for return years 1983 to 1991. Grovers Creek has a permanent weir and no adults are allowed upstream of the hatchery. Sampling at the rack has been at 100%. The hatchery sampling has also included a program of carcass CWT sampling for fish stranded in the estuary below the rack at low tide.

Stream Surveys and CWT Sampling: There are no large drainages in the vicinity of the hatchery. The only local stream known to have escapements of spawning chinook is Dogfish Creek, in Sinclair Inlet. Websters Pond, a chinook rearing facility, is located on Dogfish Creek and supports a terminal net fishery. Returns to the creek are minimal, but the carcasses have not been sampled for CWT strays. All net fisheries in the vicinity (catch area 10E) have been well sampled in recent years, with an average sample rate of 32% for years 1988 - 1991. The only other stream on the east side of Kitsap Peninsula supporting a substantial population of spawning chinook is Burley Creek. Burley Creek is located substantially south of Grovers Creek in the uppermost portion of Henderson Bay. This stream is surveyed by WDF personnel, and all carcass CWT recoveries are expanded and reported.

Straying: Despite the rather small discharge of Grovers Creek, fish appear to return well to the hatchery. Hatchery stray rates have averaged 1% (Table 16). The probability of straying may be minimized by the shape of the bay, which tends to funnel fish toward the hatchery, and the

lack of larger streams in the vicinity. As revealed in Table 16, fish from this hatchery have strayed to other hatcheries and streams in the mid-Puget Sound area. These strays occurred on both sides of the Sound in areas south of Grovers Creek. Most of these recoveries occurred in 1989 and 1990. The fact that Grovers Creek has a very low discharge during dry falls may have contributed to this straying; 1987, 1989 and 1990 experienced droughts that extended well into the fall of the year. The mixed stock origin and the fact that there is no large river system nearby may also account for the widespread distribution of the strays.

Table 15. Estimates of Survival, Terminal Return Rates, and Stray Rates For Grovers Creek Fall Chinook CWT Groups (recoveries through 1990).

Brood Year	Tag Code	Stock	Survival Rate	Freshwater Return Rate (% of total)	Stray Rate
1983	211622	Grovers Creek	0.0203	36.4	0.01
1984	211657	Grovers Creek	0.0379	29.3	0.03
1985	211901	Grovers Creek	0.0191	49.7	0.01
1986	211961	Grovers Creek	0.0478	35.6	0.01
1987	212542	Grovers Creek	0.0136	36.2	0.01
Mean Brood Year Rate =			0.0277	37.4	0.01

Status of Reporting CWT Escapement Recoveries: Grovers Creek hatchery rack and esturine sampling and recoveries have been reported for all years.

Summary and Recommendations: The Grovers Creek Hatchery fall chinook stock is characterized by relatively high escapement rates and low stray rates. Straying of this stock occurred throughout mid-Puget Sound in 1989 and 1990, but the amount of straying does not appear to be significant in terms of numbers. No problems are foreseen in the sampling and reporting of the escapement component of this stock.

Table 16. CWT Recoveries of Grovers Creek Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1990).

Release Hatchery	Brood Year	Tag Code	Number Tagged	Recovery Year	Freshwater Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Grovers Creek	1983	211622	40,324	1985		Grovers / 4 / 4
				1986		Grovers / 44 / 44
				1987		Grovers / 24 / 25
						Green / 1 / 1
				1988		Grovers / 8 / 8
	1984	211657	45,907	1986		Grovers / 10 / 10
				1987		Grovers / 29 / 30
						Deschutes / 3 / 3
				1988		Grovers / 87 / 87
				1989		Grovers / 7 / 7
						Garrison 1 / 1
	1985	211901	207,155	1986		Grovers / 1 / 1
				1987		Grovers / 5 / 5
						Garrison / 1 / 3
				1988	Duwamish R. / 1 / 1 [c]	Grovers / 159 / 161
						Garrison / 1 / 1
				1989	Lk. Wa. Ship Canal / 1 / 3 [b]	Grovers / 449 / 449
					Nisqually R. / 1 / 3 [b]	Garrison / 1 / 1
					Burley Cr. / 1 / 3 [a]	Issaquah / 1 / 1
				1990		Grovers / 5 / 5
	1986	211961	187,757	1987		Grovers / 27 / 27
				1988		Grovers / 94 / 97
						Mcallister / 1 / 1
				1989	Nisqually R. / 1 / 2 [b]	Grovers / 523 / 523
					Lk. Wa. Ship Canal / 3 / 8 [b]	Green / 1 / 1
						Mcallister / 1 / 1
						Minter / 1 / 1
						Garrison / 1 / 1
				1990	Issaquah Cr. / 1 / 1 [a]	Grovers / 204 / 204
					Minter Cr. / 1 / ** [a]	Garrison / 1 / 1
					Duwamish R. / 1 / 2 [c]	Mcallister / 1 / 1
					Nisqually R. / 1 / 2 [b]	Green / 1 / 1
	1987	212542	193,906	1988		Grovers / 9 / 9
				1989		Grovers / 19 / 19
						Garrison / 1 / 1
				1990	Lk. Wa. Ship Canal / 4 / 6 [b]	Grovers / 88 / 88
						Minter / 1 / 1
						Deschutes / 1 / 1
				1991	Lk. Wa. Ship Canal / 4 / 8 [b]	Grovers / 189 / 189

[a] Stream survey recoveries
[b] In-river/freshwater fishery recoveries
[c] In-river fishery recoveries that may include some terminal marine/esturine recoveries

NISQUALLY FALL CHINOOK

Stock Type: Hatchery

Purpose: The purpose of the Nisqually fall chinook indicator stock is to monitor exploitation rates in PSC fisheries for fall chinook fingerling production from south Puget Sound. The Kalama Creek Hatchery is currently the only exploitation rate indicator stock for the stock aggregate.

Program Description and History:
Hatchery: Kalama Creek (Nisqually Tribe). Located on a tributary to the Nisqually River at R.M. 9.

Broodsource: Because of difficulties in achieving egg take goals for this facility, eggs have come from a number of Puget Sound Hatcheries (Table 17) in past years. Eggs from Kalama returns have been primarily used since BY 1988.

Rearing and Release: Fish are reared and released on-station as fingerlings. Releases are volitional and occur late May through late June.

Tagging History: Tagging has occurred at various levels since BY 1979. Indicator stock tagging began with BY 1985 fish.

Hatchery Returns and CWT Sampling: Chinook returns to the Kalama Creek Hatchery rack have averaged 476 fish for return years 1983 to 1990. This has ranged from 82 in 1985 to 1,142 in 1988. CWT sampling has been at the 100% level, and all recoveries have been reported to the PSMFC/PSC database.

Stream Surveys and CWT Sampling: The Nisqually Tribe conducts stream surveys for chinook redd counts and live fish counts in index sections of the Nisqually River. The river is glacial fed and poor water visibility can create survey difficulties in the mainstem (Smith and Castle, 1992). Carcasses have not been sampled for CWTs, but very few chinook carcasses are observed during surveys (Joan Minikin, pers. comm.).

Natural Spawning Escapement Estimation: The current escapement estimate involves an equation that combines peak redd counts and peak live fish counts from index sections within the basin (Nisqually Chinook Population Model, 1986; and Smith and Castle, 1992). Confidence intervals cannot be calculated for this method, so the precision of the estimates is unknown. The tribe is currently reviewing the technique. In 1992 the Nisqually Tribe and the NWIFC attempted to utilize a carcass mark-and-recapture procedure. The methodology is described in Appendix C. The attempt was unsuccessful as four weeks of stream surveys resulted in no carcass recoveries. The escapement for 1992 was predicted to be very low, and only 106 natural

spawners were estimated by the current escapement estimation calculation.

Table 17. Estimates of Survival and Freshwater Return Rates for Kalama Creek Fall Chinook CWT Groups (recoveries through 1991).

Brood Year	Tag Code	Stock	Survival Rate	Freshwater Return Rate (% of total)
1983	211628	Kalama Cr. / Green R.	0.0079	40.4
	211629	Kalama Cr. / Green R.	0.0076	25.7
1984	211706	Kalama Cr.	0.0095	22.7
	211707	Deschutes	0.0042	19.3
1985	211759	Deschutes	0.0118	51.3
	211761	Deschutes	0.0021	39.3
1986	211962	Kalama Cr. / Green R.	0.0377	35.9
1987	212541	Kalama Cr. / Green R. / McAllister	0.0011	37.9
Mean Brood Year Rate =			0.0102	34.1

Straying: Because of the lack of carcass sampling and recoveries, the degree of hatchery "straying" to the spawning grounds is unknown. Straying to areas outside of the basin does not appear to be a problem, with the only recoveries occurring in the nearby Puyallup River net fishery (Table 18). However, carcass sampling of South Sound streams is not comprehensive.

Status of Reporting CWT Escapement Recoveries: Kalama Creek hatchery rack sampling and recoveries have been reported for all years. As previously mentioned, stream survey carcasses have not been sampled for CWTs.

Summary and Recommendations: The lack of natural spawning escapement estimates for tagged fish has limited the usefulness of this stock as an indicator stock. The extent of straying to the Nisqually River spawning grounds must be assessed if tagging of this stock is to continue. For 1993 we recommend that intensive carcass sampling and the carcass mark-recapture technique be tried again. The results of carcass sampling may also prove useful in comparing straying rates between the two tribal hatcheries (Kalama Creek and Clear Creek). We further recommend that the possibility of installing a fish trap at the Centrailia power diversion dam be investigated. The dam is located at RM 26.2, and approximately 50% of the natural chinook

spawning occurs above the dam (Tim Wilson, pers. comm.). The dam has an operating fish ladder, although chinook are capable of leaping the spillway (Tim Wilson, pers. comm.). The operation of such a fish trap could potentially provide accurate CWT sampling and escapement data, for both chinook and coho, for a large portion of the natural spawning area. The operation of a trap could also serve in broodstocking if necessary.

Table 18. CWT Recoveries of Kalama Creek Hatchery Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1991).

Release Hatchery	Brood Year	Tag Code	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Kalama Creek	1983	211629	11,317	1985		Kalama / 1 / 1
				1986	Nisqually R. / 1 / 1 [a]	Kalama / 6 / 6
				1987	Nisqually R. / 3 / 5 [a]	Kalama / 1 / 1
		211628	37,541	1985		Kalama / 1 / 1
				1986	Nisqually R. / 4 / 6 [a]	Kalama / 4 / 4
				1987	Nisqually R. / 8 / 28 [a]	Kalama / 1 / 1 McAllister / 1 / 1
	1984	211706	38,605	1987	Nisqually R. / 3 / 12 [a]	
					Puyallup R. / 1 / 1 [a]	
				1988	Nisqually R. / 3 / 4 [a]	Kalama / 4 / 4
				1989	Nisqually R. / 2 / 3 [a]	Kalama / 2 / 2
		211707	44,898	1988	Nisqually R. / 1 / 1 [a]	Kalama / 1 / 1
				1989	Nisqually R. / 1 / 3 [a]	
				1990	Nisqually R. / 1 / 2 [a]	
	1985	211759	94,552	1987	Nisqually R. / 2 / 5 [a]	Kalama / 6 / 6
				1988	Nisqually R. / 7 / 12 [a]	Kalama / 20 / 20
					Puyallup R. / 1 / 1 [a]	Garrison / 1 / 1
				1989	Nisqually R. / 45 / 56 [a]	Kalama / 28 / 28
				1990	Nisqually R. / 2 / 4 [a]	Kalama / 1 / 1
		211761	85,934	1988		Kalama / 1 / 1
				1989	Nisqually R. / 6 / 10 [a]	Kalama / 11 / 11
	1986	211962	194,549	1987		Kalama / 5 / 5
				1988	Nisqually R. / 4 / 7 [a]	Kalama / 55 / 55
				1989	Nisqually R. / 90 / 157 [a]	Kalama / 39 /39
					Puyallup R. / 2 / 5 [a]	
				1990	Nisqually R. / 200 / 447 [a]	Kalama / 51 / 51
	1987	212541	195,101	1989		Kalama / 3 / 3
				1990	Nisqually R. / 2 / 5 [a]	
				1991	Nisqually R. / 7 / 11 [a]	Kalama / 4 / 4 Clear Cr. / 1 / 1

[a] In-river fishery recoveries

ELWHA RIVER FALL CHINOOK

Stock Type: Hatchery

Purpose: Provide estimates of exploitation rates that can be used to evaluate the effect of the rebuilding program on natural chinook stocks in tributaries to the Strait of Juan de Fuca.

Program Description and History:
Hatchery: Lower Elwha Hatchery (Lower Elwha Tribe)

Broodsource: Although production of this stock is dominated by artificial propagation, great care has been taken to maintain the genetic integrity of this native stock (Brannon and Hershberger, 1984). Eggs are obtained from WDF broodstocking and from returns to the Elwha Spawning Channel.

Rearing and Release: The Lower Elwha hatchery relies on receiving eggs from the WDF program. Fish are reared and released on-station as fingerlings. Releases are volitional and occur in June.

Tagging History: The chinook indicator stock program at the Lower Elwha Hatchery was initiated when WDF terminated a similar tagging program at the Elwha Channel in 1988. Tagging data is available from either the Channel or the Hatchery beginning with the 1982 brood.

Hatchery Returns and CWT Sampling: Very few adult chinook return to the Lower Elwha Hatchery rack, and those that do have been returned to the river for natural spawning (Larry Ward, pers. comm.). This scarcity of hatchery returns is believed to be due to the lack of a significant attraction outflow from the hatchery at the time of return. The hatchery program assumes that returning fish will contribute to natural spawning and the WDF broodstocking effort. Natural spawning from WDF Elwha Channel returns is also believed to be significant (Carol Smith, pers. comm.). Despite moderately high terminal return rates (Table 19) and substantial sampling, relatively few Lower Elwha CWTs have been recovered in the spawning ground surveys or at the Spawning Channel rack (Table 20). This reflects the relatively low survival observed for past Lower Elwha tag groups.

Stream Surveys and CWT Sampling: Substantial CWT sampling of the natural escapement does occur in the Elwha River. This includes WDF sampling of both carcasses and broodstock gaffed for WDF's Spawning Channel program. Sampling rates for 1987 to 1991 have ranged from 32% to 49% of the total estimated escapement (hatchery and spawning grounds). WDF normally conducts stream surveys on a weekly basis, but flooding river conditions allowed only one survey in 1991. Stream surveys are conducted by boat from RM 0.1 - 4.9, where total visible redds are counted and carcasses are sampled.

Table 19. Estimates of Survival, Freshwater Return Rates, and Stray Rates For Lower Elwha Fall Chinook CWT groups (recoveries through 1990).

Brood Year	Tag Code	Stock	Survival Rate	Freshwater Return Rate (% of total)	Stray Rate
1983	211616	Elwha	0.0096	9.4	0.0
1984	211658	Elwha	0.0097	14.0	0.0
1985	211919	Elwha	0.0004	60.0	0.0
	211920	Elwha	0.0030	0	0.0
	211921	Elwha	0.0021	35.7	0.0
1986	212208	Elwha	0.0029	22.2	0.0
Mean Brood Year Rate =			0.0046	23.6	0.0

Table 20. CWT Recoveries of Lower Elwha Hatchery Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1990).

Release Hatchery	Brood Year	Tag Code	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Elwha	1983	211616	40,592	1986		E.R.S.C. / 2 /2
				1987		E.R.S.C. / 5 / 5
				1988	Elwha R. / 1 / 5 [a]	
	1984	211658	41,550	1988	Elwha R. / 2 / 9 [a]	Lower Elwha / 1 / 1
	1985	211919	16,618	1988	Elwha R. / 1 / 5 [a]	
				1988		E.R.S.C. / 5 / 5
		211920	16,127			
		211921	16,108	1989	Elwha R. / 1 / 4 [a]	
	1986	212208	49,097	1989		E.R.S.C. / 3 / 3
				1990		E.R.S.C. / 5 / 5

[a] Stream survey recoveries

Natural Spawning Escapement Estimation: Methods for escapement estimation are described in Smith and Castle (1992). The preferred WDF method of calculating the Elwha River natural escapement is by plotting visible redds (counted weekly) versus the date and calculating the area under the curve. The area under the curve integration results in the number of redd days. The number of redd days is divided by an assumed 21 day redd life to derive the total number of redds for the season. The total redd estimate is then multiplied by an assumed 2.5 fish per redd to provide an estimate of total number of spawners for the season. Because of this methodology, the precision of the estimates are unknown. One potential source of error with the estimate involves the possibility of double counting fish due to broodstock removal from the spawning grounds (Carol Smith, pers. comm.). Broodstock are removed at a time when some of the females may have begun excavation of a redd. Counting such fish and their redds would obviously lead to double counting. Recent escapement estimates are listed in Table 21.

Table 21. Natural Spawning Escapement Estimates for Elwha River Fall Chinook.

Year	Escapement Estimate [a]
1991	2,499
1990	2,594
1989	4,352
1988	5,784
1987	4,610

[a] Includes fish removed for broodstock

As with any redd counting technique, visibility problems can occur after periods of rain. The Elwha River is subject to such visibility problems in the fall (Carol Smith, pers. comm.), and turbid waters prevented a direct redd count estimate in 1991. The 1991 escapement estimate was obtained using data on visible redds for the index area RM 3.2 to 4.4 for 1986-1990. Three of these years (1986, 1987, and 1989) were used to interpolate visible redd values for the sampling date of October 10, 1991. These visible redd values were divided by the total escapement for that particular year and averaged. The mean result was 0.0836. The number of visible redds for the index in 1991 was then divided by 0.0836 to provide an escapement estimate of 1,567 adults. The number of broodstock gaffed (857) and the number of fish placed upstream at the hatchery (75) were added to this estimate for a total of 2,499 adult natural spawners in 1991.

Straying: As would be expected, straying of this native stock outside of the Elwha River is not a problem. No strays were observed in other freshwater areas for the tag codes examined (Table 20). However, significant "straying" within the Elwha River occurs in that very few adults return to the Lower Elwha Hatchery. This has the potential to reduce the utility of the tagging program

since estimates of tagged escapement in natural spawning areas are generally of lower precision and accuracy than estimated returns to a hatchery rack.

Status of Reporting CWT Escapement Recoveries: Beginning in 1988, WDF has reported all CWT stream recoveries, with expansions for spawning estimates, to the PSMFC/PSC database.

Summary and Recommendations: CWT sampling, escapement estimation, and reporting appears to be comprehensive for this stock. The extensive sampling and the low number of terminal recoveries result in relatively low expansions for stream recoveries. However, the precision of the current method of escapement estimation is unknown, therefore confidence intervals cannot be placed on the estimates. The estimates involve three major assumptions: all redds are counted, an estimated redd life of 21 days, and an estimated 2.5 fish per redd. The accuracy of these assumptions should be assessed. At a minimum, an estimation of redd life should be experimentally determined on an annual basis, and possibly stratified by time or area if necessary.

HOKO FALL CHINOOK INDICATOR STOCK

Stock Type: Wild Broodstock

Purpose: The primary purpose of this exploitation rate indicator stock is to provide estimates of exploitation rates that can be used to evaluate the effect of the rebuilding program on natural stocks of fall chinook originating from tributaries to the Strait of Juan de Fuca.

Program Description and History:
Broodsource: Eggs are obtained from annual wild broodstocking efforts in the Hoko River. From BY 1952 to 1974 the Hoko River was sporadically planted with non-native stocks of fall and spring chinook. Planting of non-native stocks has not occurred since BY 1974 fish.

Rearing and Release: Beginning with BY 1990, fish are now reared, tagged and released on-station at the Makah Tribe's Hoko Hatchery. The hatchery is located at R.M. 10 on the Hoko River. Fish are released as fingerlings in June. BY 1985 to 1987 fish were incubated, reared and tagged at the Makah NFH prior to transportation to the Hoko Pond for final rearing and release. BY 1988 fish were destroyed when VHS was detected at the Makah NFH while the fish were rearing. BY 1989 fish were temporarily reared and tagged at the Quilcene NFH.

Tagging History: Tagging began with BY 1985 fish for the indicator stock program. Tagging has been continuous except for BY 1988.

Stream Surveys and CWT Sampling: The relatively high rate of freshwater escapement (Table 21) indicates the importance of accurate CWT escapement estimation for this stock. Stream surveys are conducted jointly by Makah Fisheries Management (MFM) and WDF crews. The sampling goal on the Hoko River is to survey all available chinook spawning habitat on a weekly basis during the spawning season. Generally, stream surveyors walk or float a stream section marking each new chinook redd on a weekly basis. Carcass surveys are conducted separately by MFM staff for CWT recovery and scales, sex, and length data. Carcass surveys for CWT recovery and CWT escapement estimation began in 1988 to sample for age 3 returns from the first year of tagging. Fish captured for broodstocking are sampled at the 100% level. Sampling has proved very successful for both carcass surveys and broodstocking. From 1988 to 1991 a total of 882 carcasses were sampled with 261 CWTs recovered (Table 22).

Natural Spawning Escapement Estimation: The redd count methodology used on the Hoko River has been determined to be an accurate census of all chinook salmon redds built during a spawning season. Therefore, expansions are usually unnecessary to obtain a total redd estimate. The annual chinook spawning escapement estimate is determined by summing the number of new redds recorded during each survey and multiplying by 2.5 fish per redd. Poor stream conditions have occasionally prevented surveys from being conducted as scheduled. If a significant period of time elapsed between surveys, redd counts were expanded for the period. Depending on the method and percentage of the estimate expanded for, the estimate may not be suitable for CWT

recovery expansions. Surveyor counting error and any error associated with using an assumed 2.5 fish per redd have not been evaluated for these estimates. MFM staff compiles all survey data which is sent to WDF staff to compute the annual escapement estimate. Annual escapement estimates for 1988 to 1991 are listed in Table 22. More detailed information on these estimates is listed in Appendix D.

Table 21 . Estimates of Survival, Terminal Return Rates, and Stray Rates For Hoko River Fall Chinook CWT Groups (recoveries through 1991).

Brood Year	Tag Code	Stock	Survival Rate	Freshwater Return Rate (% of total)	Stray Rate
1985	211935	Hoko R.	N/A	37.90	0.0
1986	212216	Hoko R.	0.0208	47.56	0.01
1987	211907	Hoko R.	0.0102	27.33	0.06
Mean Brood Year Rate =			0.0155	37.60	0.02

Table 22. Summary of Spawning Escapement Estimation and CWT Sampling for Hoko Fall Chinook, 1988 - 1991.

Year	Hoko River Escapement Estimate [a]	Broodstock Sampling		Stream Sampling		
		Adults	CWTs	Carcasses	CWTs	Expansion
1988	684	90	1	223	10	2.18
1989	775	90	14	113	11	3.81
1990	378	116	69	68	25	2.05
1991	1,005	112	79	70	52	5.52

[a] Estimate does not include fish removed for broodstock

Straying: An examination of escapement recoveries (Table 23) reveals few recoveries outside of the Hoko drainage. As would be expected, straying of this stock does not appear to be a problem. Chinook escapement surveys are sporadically conducted on the other local rivers: the Sekiu and the Pysht. The Sekiu River is surveyed by MFM and the Pysht River is surveyed by WDF. Chinook escapement to both rivers appears to be extremely low in recent years, i.e. a few redds per year (Ned Currence and Carol Smith, pers. comm.).

Table 23. CWT Recoveries of Hoko River Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1991).

Release Hatchery	Brood Year	Tag Code	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Hoko	1985	211935	123,563	1988	Hoko R. / 3 / 7 [d]	
				1989	Hoko R. / 2 / 12 [a]	
					Hoko R. / 6 / 6 [b]	
				1990	Hoko R. / 6 / 33 [a]	
					Hoko R. / 11 / 19 [b]	
				1991 [e]	Hoko R. / 1 / 5 [a]	
					Hoko R. / 1 / 1 [b]	
	1986	212216	144,482	1988	Hoko R. / 7 / 15 [a]	
				1989	Hoko R. / 8 / 47 [a]	
					Hoko R. / 8 / 8 [b]	
				1990	Hoko R. / 12 / 66 [a]	
					Hoko R. / 49 / 84 [b]	
					Soleduck R. / 1 / 2 [c]	
				1991 [e]	Hoko R. / 29 / 29 [b]	
					Hoko R. / 11 / 61 [a]	
	1987	211907	199,740	1990	Hoko R. / 4 / 17 [a]	Makah NFH / 1 / 1
					Hoko R. / 10 / 10 [b]	
					Soleduck R. / 1 / 2 [c]	
				1991 [e]	Hoko R. / 48 / 48 [b]	
					Hoko R. / 36 / 99 [a]	

[a] Stream survey recoveries
[b] Broodstocking recoveries
[c] In-river fishery recoveries
[d] 1988 Stream survey recoveries - preliminary expansions based on escapement estimate of unknown precision.
[e] 1991 data is preliminary

Status of Reporting CWT Escapement Recoveries: All broodstocking CWT recoveries have been reported. Spawning ground recoveries for 1989 to 1991 have been expanded for escapement estimates and have been reported. Spawning ground recoveries for 1988 have not yet been reported because of the indirect expansion methodology used to extrapolate 47% of the total escapement estimate (Appendix D).

Summary and Recommendations: Because of relatively high freshwater escapement rates (37.69%), accurate CWT escapement estimates are necessary for providing useful data from the Hoko indicator stock. The entire range of Hoko River chinook spawning habitat is now surveyed

for new redds throughout the spawning season. The resulting redd count is considered comprehensive and accurate. Relatively high levels of carcass sampling and CWT recoveries, combined with the escapement estimates, allow for precise estimates of CWT escapements. The only recommendations for improvement to the current sampling design are to ensure that stream surveys are conducted through the entire period of spawning activity (i.e. through the end of November), and to assess the accuracy of the estimated 2.5 spawners per redd.

QUILLAYUTE SUMMER CHINOOK INDICATOR STOCK

Stock Type: Wild Broodstock

Purpose: The primary purpose of this indicator stock is to provide estimates of exploitation rates that can be used to evaluate the effect of the rebuilding program on natural stocks of summer or spring/summer chinook from the Quillayute, Hoh, and Queets Rivers.

Program Description and History:
Broodsource: Broodstock for this program is collected from the Bogachiel and Soleduck Rivers by pulling a gillnet through suspected holding locations. The broodstock collection program has been in place since 1987; tagging of the 1985 and 1986 broods relied upon fish that returned to the hatchery. Because of the mixed origin of fish in the Quillayute program, there are concerns that the stock is not representative of the natural stocks (Scott et al., 1992). Using CWT recovery data and tagged to untagged ratios from CWT release records, the origin of broodstock used in 1990 and 1991 can be divided into three groups: wild-broodstock summer chinook, hatchery spring chinook, and wild chinook stocks (Table 24). Of the total 144 chinook salmon caught for the 1990 broodstock, an estimated 13.6% were summer chinook, 13.1% were hatchery spring chinook, and 73.3% were wild chinook stocks. Of the total 112 chinook salmon caught for the 1991 broodstock an estimated 12.7% were summer chinook, 46.8% were hatchery spring chinook, and 40.5% were wild chinook stocks. Beginning in 1992, the Quileute Fisheries Department began reading tag codes prior to spawning the broodstock to reduce cross breeding between spring and summer stocks.

Rearing and Release: After capture the fish are held at the Soleduck Hatchery until spawning. The fish are subsequently incubated, reared, and tagged at the Lonesome Creek Hatchery and moved to the Bear Spring Ponds for final rearing before release in the Soleduck River.

Tagging History: Tagging of this stock began with brood year 1985 fish.

Stream Surveys and CWT Sampling: The high freshwater return rates (Table 25) reveal the necessity of providing comprehensive CWT sampling and accurate escapement estimates for this stock. Returning fish are sampled for tags in the in-river gillnet fishery, in the broodstock collection, and on the spawning grounds. The gillnet fishery is sampled at a high rate (73% in 1992). Sampling of the wild broodstock collection began in 1990. Carcass sampling occurs during spawning surveys. Each fish is sexed, measured, scale sampled, and examined for an adipose clip. Carcass surveys conducted prior to 1992 provided limited CWT recovery information, as few carcasses were found and none of the fish were marked (Table 26). It is believed that the lack of observed carcasses is partially due to heavy predation by wildlife (Jeff Haymes, pers. comm.). In 1992 carcass surveys did result in CWT recoveries.

Spawning surveys are conducted to enumerate the total number of new and visible spawning redds in each index reach (designated stretches of stream surveyed on a weekly basis throughout the spawning season). Surveyors walk or float the index sections counting the number of new

chinook redds found, and the number of redds still visible from previous surveys. New redds are marked and labeled with plastic flagging. The index areas are selected as being representative of the types of spawning habitat and the relative spawning densities that occur in the Quillayute River system.

Supplemental spawning surveys are conducted during estimated peak spawning activity. Surveyors walk, float, or fly the majority of the river system utilized by summer chinook spawners. All visible chinook redds are enumerated. The mainstem supplemental reaches are surveyed by helicopter, and the tributaries are surveyed by foot or boat.

Table 24. Quillayute River Summer Chinook Broodstock Composition, From CWT Recoveries.

Year	Stock	Tag Code	Number Recovered	Expansion Factor [a]	Expanded Recoveries
1990	Summer	211760	7	1.35	9.5
		212214	2	1.30	2.6
		212552	4	1.88	7.5
		Subtotal	13		19.6
	Spring	633322	10	1.88	18.8
	Unmarked		121		105.6[b]
		TOTAL	144[c]		144.0
1991	Summer	211760	2	1.35	2.7
		212552	5	1.88	9.4
		213135	1	2.08	2.1
		Subtotal	8		14.2
	Spring	630426	1	3.24	3.2
		633322	14	1.88	26.3
		634707	3	3.27	9.8
		634759	4	3.27	13.1
		Subtotal	22		52.4
	Unmarked		82		45.4
		TOTAL	112[d]		112.0

[a] Tagged to untagged ratios obtained from CWT release records.
[b] Estimated wild stock component.
[c] Total broodstock collected, of which 103 were spawned.
[d] Total broodstock collected, of which 63 were spawned.

Table 25. Estimates of Survival, Freshwater Return Rates, and Stray Rates for Quillayute Summer Chinook CWT groups (recoveries through 1991).

Brood Year	Tag Code	Stock	Survival [a] Rate	Freshwater Return Rate (% of total)	Stray Rate
1985	211760	Quillayute	N/A	60.44	0
1986	212214	Quillayute	N/A	65.22	0
1987	212552	Quillayute	N/A	60.60	0
Mean Brood Year Rate =			N/A	62.08	0

[a] Complete data was not available in CRAS

Table 26. Summary of Spawning Escapement Estimation and CWT Sampling for Quillayute Summer Chinook, 1988 - 1992.

Year	Quillayute River Escapement Estimate	Broodstock Sampling		Stream Sampling		
		Adults	CWTs	Carcasses	CWTs	CWT Expansion
1988	1,291	50	?	4	0	
1989	2,242	?	?	31	0	
1990	1,484	144	26	16	0	
1991	1,191	112	30	0	0	
1992	1,008	186	24	61	21	16.52

Natural Spawning Escapement Estimation: Quillayute summer chinook escapement estimates are made using a redd count methodology. The estimation of the total number of summer chinook redds produced in the Quillayute River system has been calculated by the following process:

A) Index redd production:

1) Total index redd production = Sum of the new redds for the season;

and

B) Supplemental redd production:

1) Index visible ÷ Cumulative redd ratio =

$$\frac{\text{Total visible redds in the index during supplemental surveys}}{\text{Total cumulative redds in the index section}}$$

2) Total supplemental redds for the season =

$$\frac{\text{Total visible redds in supplemental section}}{\text{Equation B1}}$$

The sum of A and B gives the total redd estimate. The total redd estimate is multiplied by an assumed 2.5 fish per redd to obtain the total escapement estimate.

The index sections on the Quillayute River system were selected to provide visible to cumulative redd ratios for use in expanding the supplemental survey data. The expansion ratios for supplemental stream sections were determined by a qualitative assessment of the relationship of spawning activities in the supplemental sections to the index sections. Areas with known spawning habitat that were not surveyed were assigned a redds per mile estimate based on a representative index or supplemental stream reach.

Straying: An examination of escapement recoveries revealed no recoveries outside of the Quillayute drainage (Table 27). Straying of this stock does not appear to be a problem.

Status of Reporting CWT In-River Fishery and Escapement Recoveries: Reporting of Quillayute River recoveries is incomplete. In-river net fishery data has been reported for 1988, 1990 and 1991. Quileute Fisheries staff and NWIFC staff are currently in the process of validating and reporting the 1989 data. Broodstocking data has only been reported for 1990 and 1991, but sampling information is missing for the 1990 data. CWT spawning escapement data has not been estimated or reported.

Summary and Recommendations: Because of the lack of carcass recoveries it is unclear how CWT escapement estimation will be calculated for years prior to 1992. Additionally, it is not possible to place confidence intervals on the escapement estimates for run years 1988 - 1991, so the precision of the estimates is unknown. This is a result of the sampling design used to estimate the escapement. Specifically, only one index section was used to expand supplemental redd counts. The precision of estimates using only one index section for expansions are unknown. The Quileute Fisheries Department is considering modifying their sampling strategy for run year 1992 to obtain an escapement estimate with known precision. This could be accomplished by increasing the number of index sections used to expand the supplemental redd

counts. There is also a need to evaluate the factor used in estimating the number of spawners per redd (e.g., sex ratio), account for any surveyor error, and assess the correction factor used to adjust redd counts made from helicopter surveys. If carcass sampling remains a problem, alternative methods of determining the CWT component of the escapement would be needed. The tribal gillnet fishery and the broodstock sampling programs might provide alternative indirect sampling data. Use of these data sets would require additional considerations due to the following: both of these sampling programs may include fish destined to the hatchery, gillnets are generally size selective, and the composition of tagged fish within each sample group would need to be compared for similarities.

Although the difficulties with escapement estimation may be overcome, additional concerns remain with the use of this stock as a PST indicator group. As discussed in Scott et al. (1992), these concerns include: mixing of the stock with the non-native hatchery spring stock, difficulties in achieving the target tagging level, the possible need of increasing the tagging level to achieve sufficient recoveries, and the need for studies to compare the size and outmigration timing of natural and tagged fish. Cluster analysis of recovery distribution for all Western Washington chinook indicator stocks (Appendix A) reveals that the stock has similar distribution patterns to the other coastal indicator stocks. Because of these issues the recommendation by Scott et al. (1992) to discontinue PST indicator stock tagging of this group seems appropriate.

Table 27. CWT recoveries of Quillayute summer chinook in freshwater fisheries and escapement areas, 1988 - 1991.

Release Stock	Brood Year	Tag Code	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Quillayute	1985	211760	91,253	1988	Quillayute R. / 4 / 5 [a]	
				1989	Quillayute R. / 5 / 6 [a]	
				1990	Quillayute R. / 54 / 70 [a]	Soleduck / 6 / 6
					Quillayute R. / 7 / 7 [b]	
				1991	Quillayute R. / 15 / 20 [a]	
					Quillayute R. / 2 / 2 [a]	
	1986	212214	31,378	1989	Quillayute R. / 4 / 5 [a]	Soleduck / 6 / 6
				1990	Quillayute R. / 2 / 2 [b]	
					Quillayute R. / 10 / 12 [a]	
				1991	Quillayute R. / 8 / 11 [a]	
	1987	212552	171,456	1989		Soleduck / 1 / 1
				1990	Quillayute R. / 21 / 26 [a]	
					Quillayute R. / 4 / 4 [b]	
				1991	Quillayute R. / 49 / 65 [a]	
					Quillayute R. / 5 / 5 [b]	

[a] In-river fishery recoveries
[b] Broodstocking recoveries

QUEETS FALL CHINOOK (Review of this stock has not been completed at the time of this 6/28/93 draft - only partial information included)

Stock Type: Wild Broodstock

Purpose: The primary purpose of the exploitation indicator stocks within the North Washington Coast region is to provide estimates of exploitation rates that can be used to evaluate the effect of the rebuilding program on natural fall chinook stocks from the Quillayute, Hoh, and Queets Rivers.

Program Description and History:
Broodsource: Eggs are obtained from annual wild broodstocking efforts in the mainstem Queets and Clearwater Rivers. Fish are captured in gillnets and are immediately removed and placed in a PVC tube for transportation in a tank truck. The fish are transported to Shale Creek Pond where they are held for maturation and spawning.

Rearing and Release: Initial incubation occurs in the quarantine incubation unit at Lake Quinault Hatchery. Once the eggs are certified and have reached the eyed stage they are transferred to the Quinault National Fish Hatchery at Cook Creek for final incubation, early rearing and coded wire tagging. After a recuperation period tagged fish are transferred to the Salmon River Pond imprinting facility. Fish are held for six to seven weeks in the imprinting pond before volitional release in late July - August. Previous studies by QFiD have shown that fish handled in this manner migrate seaward at the same time as wild fish.

Tagging History: Tagging of Queets fall chinook releases from Salmon River Pond began with BY 1977 fish. Annual tagging of this stock has been continuous except for BY 1980 when Quinault stock was used.

Stream Surveys and CWT Sampling:

Natural Spawning Escapement Estimation:

Straying: Many recoveries of this stock have occurred in the nearby Quillayute and Hoh Rivers (Table 30). These have included a few recoveries in the Quillayute net fishery and numerous recoveries in both the Hoh net fishery and spawning ground sampling.

Status of Reporting In-River Fishery and CWT Escapement Recoveries: Reporting of Queets River CWT sampling/recoveries is conducted by QFiD. Reporting of all Queets River chinook recoveries (net fisheries, hatchery rack, and spawning escapement) have been reported to the PSMFC/PSC database through 1991. Hoh River CWT sampling data has not been expanded and reported to the PSMFC/PSC database since 1988. Staff from the Hoh Tribe and NWIFC are currently working on getting this data reported.

Summary and Recommendations:

Table 28. Estimates of Survival, Freshwater Return Rates, and Stray Rates For Queets Chinook CWT Groups (recoveries through 1991). [1]

Brood Year	Tag Code	Stock	Survival [2] Rate	Freshwater Return Rate (% of total)	Stray Rate
1983	211621	Queets	N/A	63.7	6.6
1985	211908	Queets	N/A	76.5	3.2
1986	212101	Queets	N/A	52.1	3.5
1987	212835	Queets	N/A	42.1	3.5
Mean Brood Year Rate =			N/A	58.6	4.2

[1] Rates are considered minimal due to lack of expansions on 1989 - 1991 Hoh recoveries.
[2] Data was not available in CRAS

Table 29. Summary of Spawning Escapement Estimation and CWT Sampling for Queets River Fall Chinook, 1988 - 1992.

Year	Queets River Escapement Estimate	Broodstock Sampling[a]		Stream Sampling		
		Adults	Adipose	Carcasses	CWT	CWT Expansion
1988	9,644	177	13	185	12	52
1989	9,466	172	4	584	19	16
1990	10,719	123	38	224	8	48
1991	4,945	165	18	210	26	24

[a] Adipose marked fish are released as CWT fish are generally not used for wild broodstock.

Table 30. CWT Recoveries of Queets River Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1991).

Release Site	Brood Year	Tag Code	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Salmon River	1983	211621	98,684	1986	Quinault R. / 1 / 2 [b]	
					Salmon R. / 1 / 17 [c]	
					Queets R. / 7 / 7 [a]	
					Queets R. / 10 / 12 [b]	
				1987	Queets R. / 4 / 4 [a]	
					Hoh R. / 14 / 19 [b]	
					Queets R. / 34 / 85 [b]	
					Queets R / 1 / 367 [c]	Salmon R. Pond / 1 / 1
					Quinault R. / 3 / 6 [b]	
					Matheny (Queets) / 2 / [c]	
					Hoh R. / 1 / [c]	
					Quillayute R. / 1 / 5 [b]	
					Salmon R. / 2 / 20 [c]	
				1988	Hoh R. / 17 / 25 [b]	
					Owl C. (Hoh) / 1/ [c]	
					Salmon R. / 8 / 275 [c]	
					Queets R. / 24 / 56 [b]	
					Quinault R. / 2 / 5 [b]	
				1989	Queets R. / 4 / 8 [b]	
					Hoh R. / 1 / [b]	
					Salmon R. / 1 / 12 [c]	
					Queets R. / 1 / 18 [c]	
	1985	211908	117,674	1988	Hoh R. / 2 / 3 [b]	Salmon R. Pond / 2 / 2
					Queets R. / 4 / 11 [b]	
					Queets R. / 1 / 1 [a]	
					Salmon R. / 4 / 137 [c]	
				1989	Queets R. / 31 / 77 [b]	Salmon R. Pond / 1 / 1
					Quinault R. / 1 / 4 [b]	
					Salmon R. / 12 / 141[c]	
					Queets R. / 2 / 36 [c]	
					Hoh R. / 3 / [b]	
					Hoh R. / 1 / [c]	
				1990	Hoh R. / 1 / [c]	
					Hoh R. / 6 / [b]	
					Salmon R. / 4 / 301 [c]	
					Queets R. / 1 / 84 [c]	
					Quinault R. / 1 / 3 [b]	
					Queets R. / 31 / 50 [b]	
					Quillayute R. / 1 / 1 [b]	
				1991	Salmon R. / 4 / 50 [c]	
					Queets R. / 1 / 30 [c]	
					Hoh R. / 2 / [b]	

Table 30. CWT Recoveries of Queets River Fall Chinook in Freshwater Fisheries and Escapement Areas (recoveries through 1991) (**continued**).

Release Site	Brood Year	Tag Code	Number Tagged	Recovery Year	Stream Recoveries Site / Obs. / Est.	Hatchery Recoveries Site / Obs. / Est.
Salmon River	1986	212101	199,013	1988	Queets R. / 1 / 1 [b]	
				1989	Hoh R. / 4 / [b]	
					Salmon R. / 2 / 24 [c]	
					Queets R. / 36 / 70 [b]	Salmon R. Pond / 1 / 1
					Quillayute R. / 1 / [b]	Salmon R. Pond / 1 / 1
				1990	Queets R. / 44 / 78 [b]	
					Quinault R. / 3 / 8 [b]	
					Salmon R. / 2 / 150 [c]	
					Hoh R. / 6 / [b]	
				1991	Salmon R. / 9 / 112 [c]	
					Queets R. / 5 / 149 [c]	
					Hoh R. / 2 / [b]	
	1987	212835	101,914	1990	Queets R. / 21 / 36 [b]	
					Hoh R. / 1 / [b]	
				1991	Salmon R. / 6 / 75 [c]	
					Hoh R. / 3 / [b]	

[a] Broodstocking recoveries
[b] In-river fishery recoveries
[c] Stream survey recoveries

REFERENCES

Brannon, E.L. and W.K. Hershberger. 1983. Elwha River fall chinook salmon. Pages 169-172 in J.M. Walton and D.B. Houston (eds.), Proceedings of the Olympic Wild Fish Conference, March 23-25, 1983.

McIssac, D.O. and T.P. Quinn. 1988. Evidence for a hereditary component in homing behavior chinook salmon (*Oncorhynchus tshawytscha*). Can. J. Fish. Aquatic. Sci. 45:2201-2205.

Quinault Department of Natural Resources Fisheries Division. 1987, 1988, 1989. Annual Reports on *Evaluation and Improvement of Escapement Estimation on the Washington Coast.*

Ricker, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations. Pages 19-160 in R.C. Simon and P.A. Larkin (eds.), The Stock Concept in Pacific Salmon. H.R. MacMillan Lectures in Fisheries.

Scott, J.B., S.D. Moore and R.A. Moore. 1992. Review of the Chinook Exploitation Rate Indicator Stock Program for the Washington Coast and Puget Sound. Northwest Indian Fisheries Commission and Washington Department of Fisheries.

Smith, C.J and P. Castle. 1992. Puget Sound chinook salmon escapement estimates and methodology. Washington Department of Fisheries (Draft Report).

Washington Department of Fisheries. 1988, 1989,1990. Results from Micro-Tagged Experimental Groups. State of Washington Department of Fisheries Progress Reports 282,294,301.

Appendix B. Spawning escapement estimates for Stillaguamish summer chinook, 1988 - 1991.

1988 Stillaguamish Summer Chinook Escapement Estimate

Stream Reach	Esc. Est.	Estimate Methodology
Mainstem	0	Unknown.
North Fork	516	Redd interpolation graph.
South Fork (RM 17.8 - RM 34.0) (RM 34.0 - RM 64.6)	67 5	Five year N.F. to S.F. proportion (509/3,934 = x/516). Unknown.
Squire	15	Redd interpolation graph and/or peak live & dead count X 2.5.
Boulder	60	Peak redd count X 2.5.
Jim	51	Live count interpolation graph.
Pilchuck	3	Peak live & dead count X 2.5.
TOTAL ESC. EST.	**717**	

1989 Stillaguamish Summer Chinook Escapement Estimate

Stream Reach	Esc. Est.	Estimate Methodology
Mainstem	106	Redd interpolation graph.
North Fork	537	Redd interpolation graph.
South Fork	101	Redd interpolation graph.
Squire	25	Peak live & dead count X 2.5.
Boulder	25	Peak live & dead count X 2.5.
Jim	17	Peak live & dead count X 2.5.
Pilchuck	0	Unknown.
TOTAL ESC. EST.	**811**	

Appendix B. Spawning escapement estimates for Stillaguamish summer chinook, 1988 - 1991. (continued).

1990 Stillaguamish Summer Chinook Escapement Estimate

Stream Reach	Esc. Est.	Estimate Methodology
Mainstem	88	No data, used 1989 proportion (91/784 = x/754).
North Fork (RM 0.0 - 14.3) (RM 14.3 - 30.0) (RM 30.0 - 34.4)	 49 488 38	 Used 10% of N.F. 14.3 - 30.0 est. Redd interpolation graph. Redd interpolation graph.
South Fork	108	Used 1989 proportion (116/693 = x/646).
Squire	18	Peak redd count X 2.5.
Boulder	43	Peak redd count X 2.5.
Jim	10	Peak redd count X 2.5.
Pilchuck	0	Redd count.
TOTAL ESC. EST.	**842**	

1991 Stillaguamish Summer Chinook Escapement Estimate

Stream Reach	Esc. Est.	Estimate Methodology
Mainstem	78	Redd interpolation graph.
North Fork	1,427	Redd interpolation graphs.
South Fork	50	Peak redd count X 2.5.
Squire	45	Peak redd count X 2.5.
Boulder	20	Peak redd count X 2.5.
Jim	12	Peak live & dead count X 2.5.
Pilchuck	0	Live, dead, and redd counts.
Total Escapement Estimate	**1,632**	

Appendix D. Hoko River fall chinook escapement estimates, 1988 - 1991.

The 1988 Hoko Fall Chinook Escapement Estimate

The stream surveys used to estimate escapement were conducted from 8 September 1988 through 30 November 1988. The total escapement estimate of 774 chinook salmon is not recommended for expanding CWT recoveries. This recommendation is a result of the expansion methodology used to extrapolate 47% of the total escapement estimate. Specifically, the escapement for stream section #4 was estimated using WDF's area under the curve methodology (Bill Graeber, pers. comm.). Also, redd estimates for stream sections #3 and #5 were expanded using the area under the curve estimate calculated for stream section #4. Since the precision of estimates derived by this method are unknown, CWT recovery expansions are not recommended if based on this escapement estimate. For a more detailed analysis see the Makah Fisheries Management's Annual Progress Report FY 89, "1988 Hoko River Fall Chinook Indicator Stock Study".

The 1988 Hoko fall chinook escapement estimate.

Stream Section	Total Redds	Escapement Estimate[a]	Broodstock Removals
1. RM 0.0 to 1.5	0	0	51
2. RM 1.5 to 3.4	1	3	--
3. RM 3.4 to 5.6[b]	21	52	--
4. RM 5.6 to 8.4[c]	101	252	29
5. RM 8.4 to 10.2[d]	25	62	10
6. RM 10.2 to 11.0	7	18	--
7. RM 11.0 to 15.3	30	75	--
8. RM 15.3 to 18.4	30	75	--
9. RM 18.4 to 20.4	10	25	--
10. Tributaries	49	122	--
TOTAL	274	684	90
TOTAL ESCAPEMENT ESTIMATE = 774			

[a] Assumes 2.5 fish per redd.
[b] Estimate is based on area under the curve estimate from RM 5.6 - 8.4.
[c] Calculated using WDF's area under the curve methodology.
[d] Estimate is based on area under the curve estimate from RM 5.6 - 8.4.

CWT Sampling: A total of 313 chinook stream survey and broodstock carcasses were recovered and sampled for CWT's. A total of 18 ad clipped chinook resulted in 10 CWT recoveries. These CWT's will not be reported with expansions.

Appendix D. Hoko River fall chinook escapement estimates, 1988 - 1991. (continued)

The 1989 Hoko Fall Chinook Escapement Estimate

The stream surveys used to estimate escapement were conducted from 14 September 1989 through 29 November 1989. The total redd estimate was obtained by summing the total number of redds counted during stream surveys, no expansions were deemed necessary. The total spawning escapement was estimated by multiplying the cumulative total redds counted during stream surveys by an assumed 2.5 fish per redd. The total spawning escapement was added to the total number of broodstock removals to obtain the total escapement estimate of 842 chinook salmon. The escapement estimate of 842 chinook salmon is sufficiently precise to use in CWT recovery expansions if expanding redd counts by an assumed 2.5 fish per redd is justified, and if not accounting for possible surveyor biases is acceptable. For a more detailed analysis see the Makah Fisheries Management's FY 90 Annual Report, "1989 Hoko River Fall Chinook Indicator Stock Study".

The 1989 Hoko fall chinook escapement estimate.

Stream Section	Total Redds	Escapement Estimate[a]	Broodstock Removals
1. RM 0.0 to 1.5	0	0	21
2. RM 1.5 to 3.4	20	50	--
3. RM 3.4 to 5.6	71	178	--
4. RM 5.6 to 8.4	120	300	22
5. RM 8.4 to 10.2	91	228	24
6. RM 10.2 to 12.0	0	0	--
7. RM 12.0 to 15.3	1	3	--
8. RM 15.3 to 18.4	2	6	--
9. RM 18.4 to 20.4	1	2	--
10. Tributaries	4	10	--
TOTAL	310	775	67
TOTAL ESCAPEMENT ESTIMATE = 842			

[a] Assumes 2.5 fish per redd.

CWT Sampling: During broodstocking and stream survey 98 chinook carcasses were recovered and sampled for CWT's . A total of 35 ad-clipped chinook resulted in 25 readable CWT's. 11 of these CWT's were recovered from stream survey carcasses and were reported with an expansion of 5.87 calculated from an escapement of 775. The broodstocking resulted in 14 readable tags with an expansion of 1.00. All CWT's have been reported to PSMFC.

Appendix D. Hoko River fall chinook escapement estimates, 1988 - 1991. (continued)

The 1990 Hoko Fall Chinook Escapement Estimate

The stream surveys used to estimate escapement were conducted from 28 August 1990 through 8 November 1990. The total redd estimate was obtained by summing the total number of redds counted during stream surveys, no expansions were deemed necessary. The spawning escapement was estimated by multiplying the cumulative total redds counted during stream surveys by an assumed 2.5 fish per redd. The total spawning escapement was added to the total number of broodstock removals to obtain the total escapement estimate of 493 chinook salmon. The escapement estimate of 493 chinook salmon is sufficiently precise to use in CWT recovery expansions if expanding redd counts by an assumed 2.5 fish per redd is justified, and if not accounting for possible surveyor biases is acceptable. It should be noted that the spawning ground surveys ended approximately three weeks earlier than in previous years, and there was still redd building activities recorded on the last survey completed. Even if some redd construction was unaccounted for, this would still be an accurate minimum escapement estimate. For a more detailed analysis see the Makah Fisheries Management's FY 91 Annual Report, "1990 Hoko River Fall Chinook Indicator Stock Study".

The 1990 Hoko fall chinook escapement estimate.

Stream Section	Total Redds	Escapement Estimate[a]	Broodstock Removals
1. RM 0.0 to 1.5	0	0	115
2. RM 1.5 to 3.4	0	0	--
3. RM 3.4 to 5.6	4	10	--
4. RM 5.6 to 8.4	67	168	--
5. RM 8.4 to 10.2	35	88	--
6. RM 10.2 to 11.0	1	3	--
7. RM 12.0 to 15.3	21	53	--
8. RM 15.3 to 18.4	14	35	--
9. RM 18.4 to 20.3	5	13	--
10. Tributaries	4	10	--
TOTAL	151	378	115
TOTAL ESCAPEMENT ESTIMATE = 493			

[a] Assumes 2.5 fish per redd.

CWT Sampling: A total of 289 broodstocking and stream survey chinook carcasses were recovered and sampled for CWT's . 108 ad-clipped chinook resulted in 93 readable CWT's. 25 of these CWT's were recovered from stream survey carcasses and were reported with an expansion of 5.48 calculated from an escapement of 378. The broodstocking resulted in 68 readable tags and an expansion of 1.00. All CWT's have been reported to PSMFC.

Appendix D. Hoko River fall chinook escapement estimates, 1988 - 1991. (continued)

The 1991 Hoko Fall Chinook Escapement Estimate

The stream surveys used to estimate escapement were conducted from 4 September 1991 though 10 November 1991. After updating WDF's 1991 total escapement estimate reported in "Puget Sound Chinook Salmon Escapement Estimates and Methodology", an escapement of 893 spawners + 112 broodstock = 1,005 chinook salmon has been agreed upon by Makah Fisheries and WDF as an accurate minimum total escapement (WDF's updated table is attached). This is a minimum estimate only, as the data indicate the last survey completed on the Hoko River was at or perhaps before peak spawning. The escapement estimate of 1,005 chinook salmon is sufficiently precise to use in CWT recovery expansions if expanding redd counts by an assumed 2.5 fish per redd is justified, and if not accounting for possible surveyor biases is acceptable. For a more detailed analysis see WDF's draft report, "Puget Sound Chinook Salmon Escapement Estimates and Methodology".

The 1991 Hoko fall chinook escapement estimate.

Stream Section	Total Redds	Escapement Estimate[a]	Broodstock Removals
1. RM 1.5 - 3.4	23	58	112
2. RM 3.4 - 5.6	123	308	---
3. RM 5.6 - 8.4	103	258	---
4. RM 8.4 - 10.2	85	213	---
5. RM 10.2 - 11.0	6	15	---
6. RM 13.0 - 15.3	6	15	---
7. RM 15.3 - 20.0	1	3	---
8. Brown's Cr.	10	25	---
TOTAL	357	893	112
TOTAL MINIMUM ESCAPEMENT ESTIMATE = 1,005			

[a] Assumes 2.5 fish per redd.

CWT Sampling: A total of 184 broodstocking and stream survey chinook carcasses were recovered and sampled for CWT's . 140 ad-clipped chinook resulted in 131 readable CWT's. 52 of these CWT's were recovered from stream survey carcasses and will be reported with an expansion calculated from an escapement of 893. The broodstocking resulted in 79 readable tags and an expansion of 1.00. All CWT's will be reported to PSMFC.

Appendix E. Spawning escapement estimates for Quillayute summer chinook, 1988 - 1991.

1988 Quillayute River Summer Chinook Escapement Estimate: (Specific details have not yet been compiled).

Drainage	Total Redds	Total Escapement
Quillayute	0	0
Sol Duc	289	723
Bogachiel	107	268
Calawah	120	300
Broodstock		50
TOTAL	516	1,341
BILL WOOD'S ESTIMATES WERE: 533 SYSTEM REDDS		

1989 Quillayute River Summer Chinook Escapement Estimate: (Specific details have not yet been compiled).

Drainage	Total Redds	Total Escapement
Quillayute	0	0
Sol Duc	463	1,158
Bogachiel	191	478
Calawah	264	659
Broodstock		
TOTAL	918	2,295
TOTAL AGREED TO BY BILL WOOD, 8 FEB 1990		2,242

Appendix E. Spawning escapement estimates for Quillayute summer chinook, 1988 - 1991. (continued)

1990 Quillayute River Summer Chinook Escapement Estimate: Stream surveys were conducted from 1 September 1990 through 15 October 1990 by Quileute Fisheries Management and the Washington Department of Fisheries. Adjustments were made to survey data collected during mid-October to account for the transition between summer and fall spawning stocks. For the mainstem outside of the indices, a redd estimate was made from an expansion of the supplemental aerial surveys. Other supplemental survey data was expanded using ratios derived from tributary indices. An estimated 536 chinook redds were calculated, assuming 2.5 spawners per redd, 1,340 chinook + 144 chinook taken for broodstock = 1,484 chinook estimated to be the total escapement. No confidence intervals can be placed on this estimate; therefore, it is not recommended for use in CWT recovery expansions.

Drainage	Total Redds	Total Escapement
Quillayute	5	13
Sol Duc	254	635
Bogachiel	96	239
Calawah	181	453
Broodstock		144
TOTAL	536	1,484

The 1991 Quillayute River Summer Chinook Escapement Estimate: Stream surveys were conducted from 1 September 1991 to 15 October 1991 by Quileute Fisheries Management and the Washington Department of Fisheries. A supplemental mainstem river helicopter spawning survey was conducted 30 September 1991 at the estimated peak spawning. Supplemental surveys were completed on tributary reaches accessible to summer chinook during late September. An estimated 431 chinook redds were calculated, assuming 2.5 spawners per redd, 1,078 chinook + 112 chinook taken for broodstock = 1,190 chinook estimated to be the total escapement. No confidence intervals can be placed on this estimate; therefore, it is not recommended for use in CWT recovery expansions.

Drainage	Total Redds	Total Escapement
Quillayute	1	3
Sol Duc	305	763
Bogachiel	13	32
Calawah	113	281
Broodstock		112
TOTAL	432	1,191