TCCOHO 8901

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PACIFIC SALMON COMMISSION
JOINT COHO TECHNICAL COMMITTEE

REPORT TCCOHO (89)-1

REPORT TO THE SOUTHERN PANEL ON COHO STOCK COMPOSITION ESTIMATES IN THE SOUTHERN PANEL AREA

September 29, 1989

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EXECUTIVE SUMMARY

In the fall of 1987, the Pacific Salmon Commission identified a need for estimates of the stock composition of Southern Panel area fisheries. The Coho Technical Committee (CoTC) was assigned the task of estimating stock composition for these fisheries for catch years 1984 through 1987.

This report provides estimates of stock composition for Southern Panel area fisheries for catch years 1984 through 1986. Washington CWT recovery data for 1987 were not available in the appropriate format and, therefore, only analyses for 1984 through 1986 were conducted. This report discusses the strengths and weaknesses of the analytical methods used and makes recommendations for further analysis. Results presented should be considered preliminary since the methods developed by the work group to estimate stock composition have not yet been fully evaluated and alternative methods (e.g., non-linear models) are under development.

Stock composition for Southern Panel area fisheries for 1984 through 1986 has been estimated using two methods; 1) the production factor expansion (PFE) method; and 2) the linear programing (LP) method. Contributions to catches from each stock production area (single stock or aggregate of stocks within a geographic area represented by a single coded-wire-tag distribution) were estimated. Within each fishery, these contributions were aggregated by country of origin to provide the required stock composition estimates.

The PFE method involves expansion of CWT recoveries to account for total production from a given area. This generally involves using hatchery CWT groups to represent both the hatchery and wild production from a particular watershed or geographic area, although both hatchery and wild CWT groups were used for some production areas. Most U.S. production was accounted for in this way. Apart from hatchery releases, the Fraser River was the only Canadian production area for which a production factor could be calculated.

The LP method is a mathematical optimization approach that relies upon reported catch and CWT recoveries to estimate the contribution to catch of fish originating from a particular production area. These data are generally available and are not as subject to large error as other data such as escapements, which may be required for the PFE method.

Tables 1 and 2 present stock composition estimates (by country of origin) for 29 Southern Panel area fisheries (9 in Canada and 20 in the United States) for the LP and PFE methods, respectively. Figure 1 shows the stock composition originating in each country for seven fisheries of concern to the Southern Panel using the LP method. Table 3 provides a comparison of estimates produced by the two methods. Figures 2 and 3 compare the proportions of the catch attributed to stocks originating in each country by the two estimation methods for the seven fisheries depicted in Figure 1. The greatest difference between the estimates is the proportion of catch attributed to Canadian production. This may reflect the lack of adequate data to estimate production factors for most Canadian wild stocks. In reviewing these results, it is important to recognize that methods to estimate stock composition are still under development; improved methods which may be developed may could yield different estimates of stock composition.

Since true stock compositions are unknown, there is no way to determine the accuracy of the estimates produced by the two methods. Nevertheless, the LP method likely produces the best better available estimates of stock composition than the PFE method. The LP method requires fewer assumptions and much of the data necessary to compute Canadian production using the PFE method are unavailable. However, an evaluation of the LPM by Canada indicates that biases may potentially be introduced when stocks are not adequately represented by tags.

The following discussions for major coho fisheries of concern to the Southern Panel are based upon estimates produced by the LP method.

NWVI and SWVI Troll Fisheries

The estimated Canadian contribution to the NWVI troll fishery was highly variable and declining during the period 1984 to 1986 (54% to 26%). The U.S. contribution ranged from 36% to 62% for the same period. In the SWVI troll fishery, Canadian contributions were approximately one-half of those in the NWVI troll fishery (30% to 14%) and U.S. contributions ranged from 70% to 86%. The portion of the catch which was not attributed to either U.S. or Canadian stocks ranged from 0% to 13%.

Canadian Juan de Fuca Net Fishery

The stock composition of the Canadian Juan de Fuca net fishery (Area 20) catch of coho ranged from 16% to 22% Canadian and 69% to 83% U.S.. The portion of the catch which was not attributed to either U.S. or Canadian stocks ranged from 1% to 11% for this fishery.

Georgia Strait Sport and Troll

The majority of the coho catch in these fisheries is of Canadian origin. The proportion of the troll catch comprised of Canadian stocks ranged from 68% to 88%. U.S. contributions ranged from 10% to 32%. The proportion of the sport catch comprised of Canadian stocks ranged from 73% to 77%, and the proportion of U.S. stocks ranged from 13% to 23%. The portion of the catch which was not attributed to either U.S. or Canadian stocks ranged from 0% to 14%.

U.S. Area 7 and 7A Net Fishery

The stock composition in these fisheries was highly variable. U.S. contributions ranged from 22% to 38% in Area 7A (Point Roberts) and 31% to 47% in Area 7 (San Juan Islands). Canadian contributions ranged from 22% to 53% in Area 7A and 22% to 47% in Area 7. A large portion of the catch was unassigned by both the PFE (18% to 45%) and the LP analyses (22% to 40%). This may be explained by low sampling rates in the Area 7A fishery and/or large amounts of production not represented by CWT groups (perhaps from the Fraser River) in both Areas 7 and 7A.

U.S. Juan de Fuca Sport/Troll and Net

The combined troll and sport catch in this area is estimated to be comprised of from 65% to 91% U.S. stocks and 5% to 9% Canadian stocks. The portion unassigned in the troll and sport fisheries ranged from 0% to 30%. For the Juan de Fuca net fishery, the catch is estimated to consist of 78% to 86% U.S. stocks and 14% to 20% Canadian stocks; virtually all the catch was accounted for. The composition for the Canadian Juan de Fuca net fishery was similar in all three years to estimates for the U.S. net fishery in the Strait, with the exception of the 1985 estimates of U.S. and unassigned percentages.

Other Puget Sound All Gear

Virtually no Canadian coho stocks were estimated in the catch by all gear types in other Puget Sound fisheries. With the exception of the 1986 Hood Canal fishery, nearly all the commercial catch by net fisheries was assigned. There are high rates of unassigned catch in the sport fisheries (as high as 100%). Small size of catches, low sampling rates, and low numbers of CWT recoveries (where voluntary returns and problems of catch estimation are known) may explain this result.

Recommendations:

1) Of the two approaches used in this report, the LP estimates of stock composition in Southern Panel area fisheries should be considered as the best technically supportable estimates available at this time.

2) Preliminary analytical work directed at evaluating the LP method and developing other estimation techniques has been conducted. Work on continuing that analysis for both LP and non-linear models should be supported and given a high priority.

3) Annual CWT releases which represent the distribution of all major stocks contributing to U.S. and Canadian boundary area fisheries are required if stock composition estimates are needed on a routine basis. In particular, increased annual tagging of Canadian stocks from the west coast of Vancouver Island, Juan de Fuca Strait, and southeast Vancouver Island is recommended.

4) Research programs designed to test the validity of the assumption that tagged hatchery coho adequately represent the catch distribution of wild stocks from the same geographic area should be undertaken. Wild tagging programs on the Salmon River in the lower Fraser, and on the Black, Trent, and French stocks on the east coast of Vancouver Island, and on Puget Sound and Washington coastal river systems will provide critical data over the next few years. Additional tagging programs may be required after further analysis.

5) Further research should be directed towards evaluating the accuracy and precision of CWT-based stock composition estimates using alternative stock identification methodologies.

6) We recommend a thorough review of the CWT tagging and tag recovery programs in Canada and the U.S., with emphasis on the quantification of error and bias.

7) We recommend that the stock composition working group of the CoTC continue efforts to develop improved methods for estimating stock composition.

TABLE 1. PRELIMINARY STOCK COMPOSITION ESTIMATES FROM LINEAR PROGRAMMING MODEL (ROUNDED).

FISHERY/AREA	1984 CAN	1984 US	1984 UNASSD	1985 CAN	1985 US	1985 UNASSD	1986 CAN	1986 US	1986 UNASSD
CANADIAN FISHERIES									
Georgia Strait Troll	88%	10%	2%	68%	32%	0%	76%	24%	0%
NW Vancouver Is Troll	54%	36%	10%	38%	62%	0%	26%	61%	13%
SW Vancouver Is Troll	30%	70%	0%	17%	71%	12%	14%	86%	0%
Johnstone Strait Net	91%	9%	0%	95%	5%	0%	84%	6%	10%
Georgia Strait Net	70%	30%	0%	87%	13%	0%	99%	1%	0%
Fraser Net	90%	10%	0%	47%	18%	35%	61%	2%	37%
Juan De Fuca Net (Area 20)	22%	73%	5%	20%	69%	11%	16%	83%	1%
WC Vancouver Is Net	97%	3%	0%	83%	17%	0%	93%	7%	0%
Georgia Strait Sport	73%	13%	14%	77%	23%	0%	77%	23%	0%
PUGET SOUND FISHERIES									
Juan De Fuca Troll/Sport	9%	91%	0%	5%	65%	30%	7%	73%	20%
Juan De Fuca Net (4B,5,6C)	20%	78%	2%	15%	85%	0%	14%	86%	0%
San Juan Islands Net (Area 7)	29%	47%	24%	22%	42%	36%	47%	31%	22%
Point Roberts Net (Area 7A)	22%	38%	40%	33%	38%	29%	53%	22%	25%
Nooksack/Samish Marine Net	5%	95%	0%	1%	99%	0%	2%	98%	0%
Skagit/Prt Gardner Marine Net	1%	99%	0%	0%	100%	0%	0%	97%	3%
South Puget Sound Marine Net	0%	100%	0%	0%	100%	0%	0%	100%	0%
Hood Canal Net	0%	100%	0%	0%	100%	0%	0%	28%	72%
San Juan Islands Sport	0%	8%	92%	4%	50%	45%	9%	16%	75%
Skagit/Prt Gardner Sport	0%	25%	75%	0%	68%	32%	0%	42%	58%
Admiralty Inlet Sport	2%	66%	32%	0%	65%	34%	0%	42%	58%
South Puget Sound Sport	1%	39%	60%	0%	39%	61%	0%	42%	58%
Hood Canal Sport	0%	25%	75%	0%	33%	67%	0%	0%	100%
WA/OR OCEAN FISHERIES									
Cape Flattery Troll/Sport	29%	71%	0%	11%	89%	0%	11%	89%	0%
Quillayute Troll/Sport	0%	0%	100%	16%	83%	1%	5%	66%	29%
Grays Harbor Troll/Sport	1%	18%	81%	8%	92%	0%	1%	76%	23%
Columbia River Troll/Sport	2%	98%	0%	3%	94%	3%	0%	100%	0%
Southern Oregon Troll/Sport	2%	98%	0%	0%	100%	0%	0%	100%	0%
WASHINGTON COASTAL & COLUMBIA RIVER FISHERIES									
Washington Coastal Net	0%	100%	0%	0%	100%	0%	0%	100%	0%
Columbia River Net	0%	66%	34%	0%	98%	2%	0%	84%	16%
Columbia River (Buoy 10) Spt	0%	100%	0%	0%	100%	0%	0%	100%	0%

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TABLE 2. PRELIMINARY STOCK COMPOSITION ESTIMATES FROM PRODUCTION FACTOR ANALYSIS (ROUNDED).

FISHERY/AREA	1984 CAN	1984 US	1984 UNASSD	1985 CAN	1985 US	1985 UNASSD	1986 CAN	1986 US	1986 UNASSD
CANADIAN FISHERIES									
Georgia Strait Troll	64%	10%	26%	100%	18%	-19%	48%	22%	30%
NW Vancouver Is Troll	17%	17%	66%	18%	39%	43%	11%	33%	56%
SW Vancouver Is Troll	13%	51%	36%	17%	61%	22%	10%	63%	27%
Johnstone Strait Net	30%	9%	61%	40%	3%	57%	35%	3%	62%
Georgia Strait Net	46%	15%	38%	61%	7%	32%	75%	1%	24%
Fraser Net	44%	12%	44%	92%	11%	-3%	37%	2%	61%
Juan De Fuca Net (Area 20)	12%	64%	25%	18%	66%	16%	9%	83%	8%
WC Vancouver Is Net	20%	5%	75%	9%	18%	74%	12%	7%	81%
Georgia Strait Sport	40%	12%	48%	69%	14%	18%	43%	19%	38%
PUGET SOUND FISHERIES									
Juan De Fuca Troll/Sport	5%	55%	40%	8%	62%	30%	4%	63%	33%
Juan De Fuca Net (4B, 5, 6C)	6%	63%	31%	16%	86%	-2%	9%	71%	21%
San Juan Islands Net (Area 7)	18%	45%	37%	28%	29%	43%	26%	29%	45%
Point Roberts Net (Area 7A)	14%	41%	45%	61%	20%	18%	41%	17%	41%
Nooksack/Samish Marine Net	4%	85%	11%	2%	57%	41%	1%	98%	1%
Skagit/Prt Gardner Marine Net	0%	97%	3%	0%	122%	-22%	0%	111%	-11%
South Puget Sound Marine Net	0%	90%	10%	0%	121%	-21%	0%	102%	-2%
Hood Canal Net	0%	85%	15%	0%	101%	-1%	0%	96%	4%
San Juan Islands Sport	0%	7%	93%	7%	30%	63%	6%	14%	80%
Skagit/Prt Gardner Sport	0%	30%	70%	0%	62%	38%	0%	33%	67%
Admiralty Inlet Sport	0%	61%	39%	0%	72%	28%	0%	56%	44%
South Puget Sound Sport	0%	36%	64%	0%	46%	53%	0%	40%	60%
Hood Canal Sport	0%	23%	77%	0%	35%	65%	0%	17%	83%
WA/OR OCEAN FISHERIES									
Cape Flattery Troll/Sport	15%	66%	19%	13%	76%	11%	8%	90%	2%
Quillayute Troll/Sport	0%	0%	100%	16%	84%	0%	3%	64%	33%
Grays Harbor Troll/Sport	0%	28%	72%	8%	88%	4%	1%	91%	8%
Columbia River Troll/Sport	0%	100%	0%	3%	114%	-17%	0%	114%	-14%
Southern Oregon Troll/Sport	NA	NA	NA	NA	NA	NA	NA	NA	NA
WASHINGTON COASTAL & COLUMBIA RIVER FISHERIES									
Washington Coastal Net	NA	NA	NA	NA	NA	NA	NA	NA	NA
Columbia River Gillnet	0%	86%	14%	0%	97%	3%	0%	105%	-5%
Columbia RIver (Buoy 10) Spt	0%	104%	-4%	0%	113%	-13%	0%	91%	9%

TABLE 3. COMPARISON OF STOCK COMPOSITION ESTIMATES FROM LINEAR PROGRAMMING (LP) AND PRODUCTION FACTOR (PF) ANALYSIS (ROUNDED).

	PERCENT CANADIAN						PERCENT U.S.						PERCENT UNASSIGNED					
	1984		1985		1986		1984		1985		1986		1984		1985		1986	
FISHERY/AREA	LP	PF	LP	PF	LP	PF	LP	PF	LP	PF	LP	PF	LP	PF	LP	PF	LP	PF
CANADIAN FISHERIES																		
Georgia Strait Troll	88%	64%	68%	100%	76%	48%	10%	10%	32%	18%	24%	22%	2%	26%	0%	-19%	0%	30%
NW Vancouver Is Troll	54%	17%	38%	18%	26%	11%	36%	17%	62%	39%	61%	33%	10%	66%	0%	43%	13%	56%
SW Vancouver Is Troll	30%	13%	17%	17%	14%	10%	70%	51%	71%	61%	86%	63%	0%	36%	12%	22%	0%	27%
Johnstone Strait Net	91%	30%	95%	40%	84%	35%	9%	9%	5%	3%	6%	3%	0%	61%	0%	57%	10%	61%
Georgia Strait Net	70%	46%	87%	61%	99%	75%	30%	15%	13%	7%	1%	1%	0%	38%	0%	32%	0%	24%
Fraser Net	90%	44%	47%	92%	61%	37%	10%	12%	18%	11%	2%	2%	0%	44%	35%	-3%	37%	61%
Juan De Fuca Net (Area 20)	22%	12%	20%	18%	16%	9%	73%	64%	69%	66%	83%	83%	5%	25%	11%	16%	1%	8%
WC Vancouver Is Net	97%	20%	83%	9%	93%	12%	3%	5%	17%	18%	7%	7%	0%	75%	0%	74%	0%	81%
Georgia Strait Sport	73%	40%	77%	69%	77%	43%	13%	12%	23%	14%	23%	19%	14%	48%	0%	18%	0%	38%
PUGET SOUND FISHERIES																		
Juan De Fuca Troll/Sport	9%	5%	5%	8%	7%	4%	91%	55%	65%	62%	73%	63%	0%	40%	30%	30%	20%	33%
Juan De Fuca Net (4B, 5, 6C)	20%	6%	15%	16%	14%	9%	78%	63%	85%	86%	86%	71%	2%	31%	0%	-2%	0%	21%
San Juan Islands Net (Area 7)	29%	18%	22%	28%	47%	26%	47%	45%	42%	29%	31%	29%	24%	37%	36%	43%	22%	45%
Point Roberts Net (Area 7A)	22%	14%	33%	61%	53%	41%	38%	41%	38%	20%	22%	17%	40%	45%	29%	18%	25%	41%
Nooksack/Samish Marine Net	5%	4%	1%	2%	2%	1%	95%	85%	99%	57%	98%	98%	0%	11%	0%	41%	0%	1%
Skagit/Prt Gardner Marine Net	1%	0%	0%	0%	0%	0%	99%	97%	100%	122%	97%	111%	0%	3%	0%	-22%	3%	-11%
South Puget Sound Marine Net	0%	0%	0%	0%	0%	0%	100%	90%	100%	121%	100%	102%	0%	10%	0%	-21%	0%	-2%
Hood Canal Net	0%	0%	0%	0%	0%	0%	100%	85%	100%	101%	28%	96%	0%	15%	0%	-1%	72%	4%
San Juan Islands Sport	0%	0%	4%	7%	9%	6%	8%	7%	50%	30%	16%	14%	92%	93%	45%	63%	75%	80%
Skagit/Prt Gardner Sport	0%	0%	0%	0%	0%	0%	25%	30%	68%	62%	42%	33%	75%	70%	32%	38%	58%	67%
Admiralty Inlet Sport	2%	0%	0%	0%	0%	0%	66%	61%	65%	72%	42%	56%	32%	39%	34%	28%	58%	44%
South Puget Sound Sport	1%	0%	0%	0%	0%	0%	39%	36%	39%	46%	42%	40%	60%	64%	61%	53%	58%	60%
Hood Canal Sport	0%	0%	0%	0%	0%	0%	25%	23%	33%	35%	0%	17%	75%	77%	67%	65%	100%	83%
WA/OR OCEAN FISHERIES																		
Cape Flattery Troll/Sport	29%	15%	11%	13%	11%	8%	71%	66%	89%	76%	89%	90%	0%	19%	0%	11%	0%	2%
Quillayute Troll/Sport	0%	0%	16%	16%	5%	3%	0%	0%	83%	84%	66%	64%	100%	100%	1%	0%	29%	33%
Grays Harbor Troll/Sport	1%	0%	8%	8%	1%	1%	18%	28%	92%	88%	76%	91%	81%	72%	0%	4%	23%	8%
Columbia River Troll/Sport	2%	0%	3%	3%	0%	0%	98%	100%	94%	114%	100%	114%	0%	0%	3%	-17%	0%	-14%
Southern Oregon Troll/Sport	2%	NA	0%	NA	0%	NA	98%	NA	100%	NA	100%	NA	0%	NA	0%	NA	0%	NA
WASHINGTON COASTAL & COLUMBIA RIVER FISHERIES																		
Washington Coastal Net	0%	NA	0%	NA	0%	NA	100%	NA	100%	NA	100%	NA	0%	NA	0%	NA	0%	NA
Columbia River Net	0%	0%	0%	0%	0%	0%	66%	85%	98%	97%	84%	105%	34%	15%	2%	3%	16%	-5%
Columbia River (Buoy 10) Spt	0%	0%	0%	0%	0%	0%	100%	104%	100%	113%	100%	91%	0%	-4%	0%	-13%	0%	9%

Linear Programming Estimates of Stock Composition For Southern Panel Fisheries

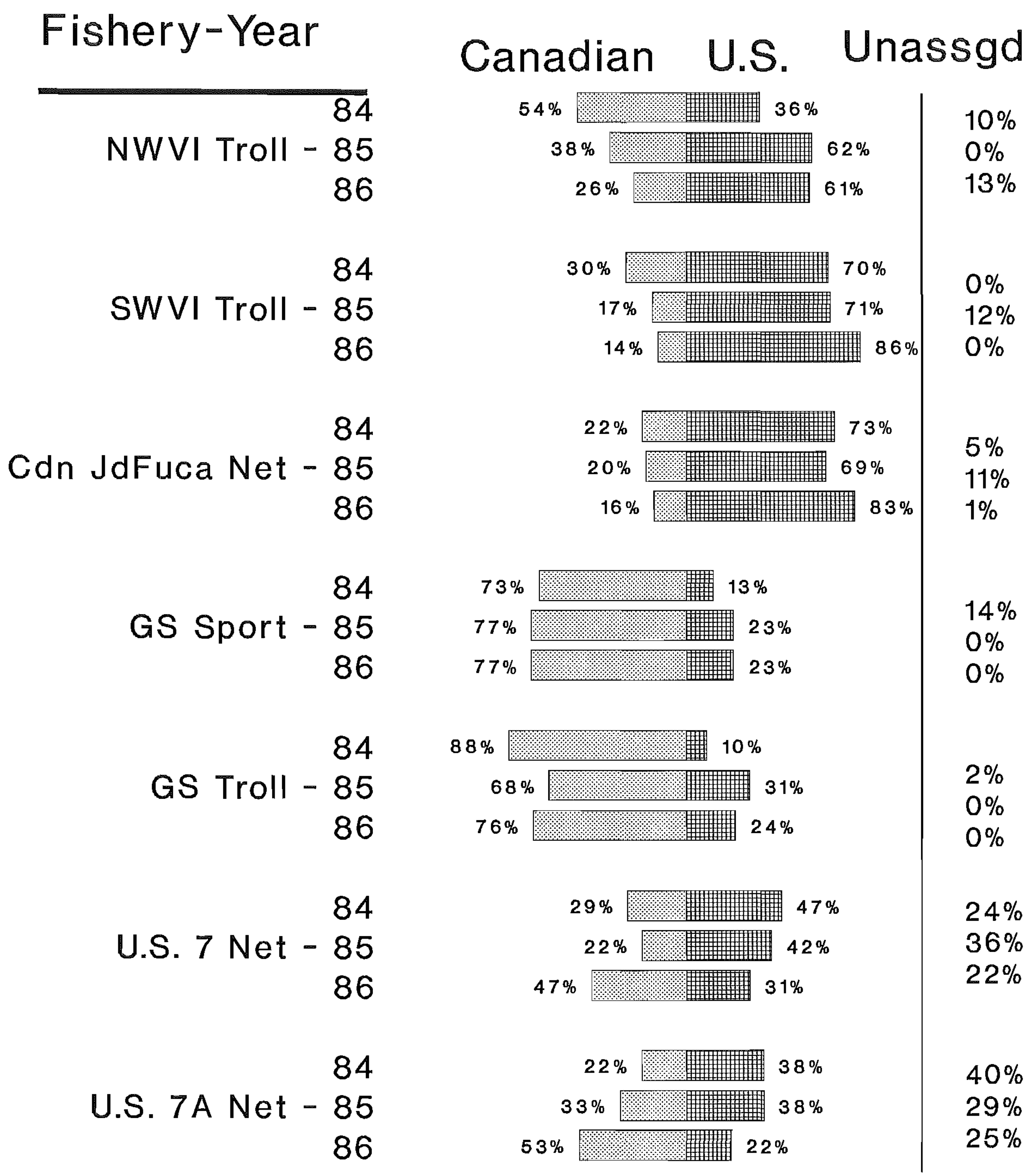

Figure 1

Comparison of LP and PFE Estimates of % Of Catch Comprised of U.S. Stocks

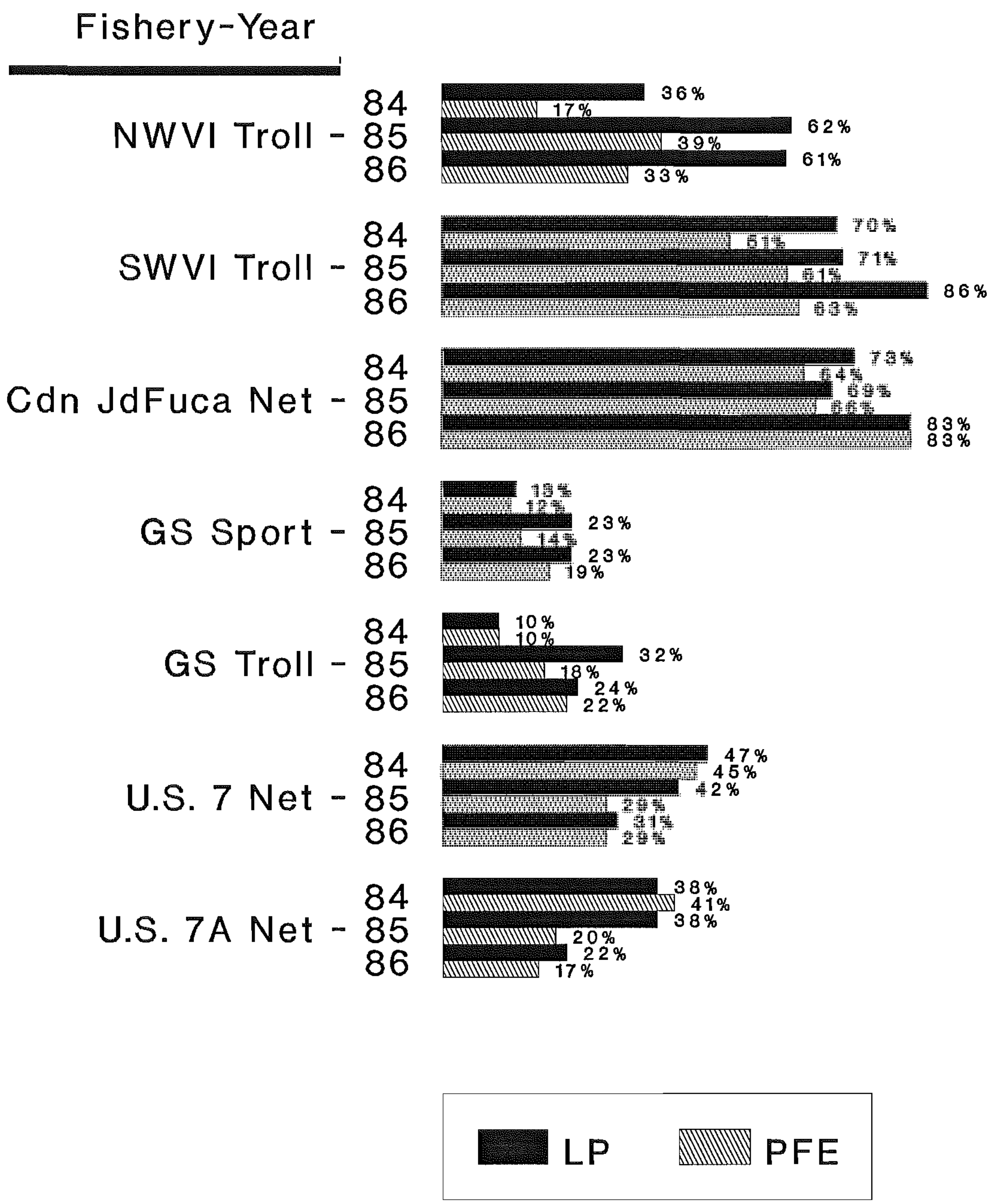

Figure 2

Comparison of LP and PFE Estimates of % Of Catch Comprised of Canadian Stocks

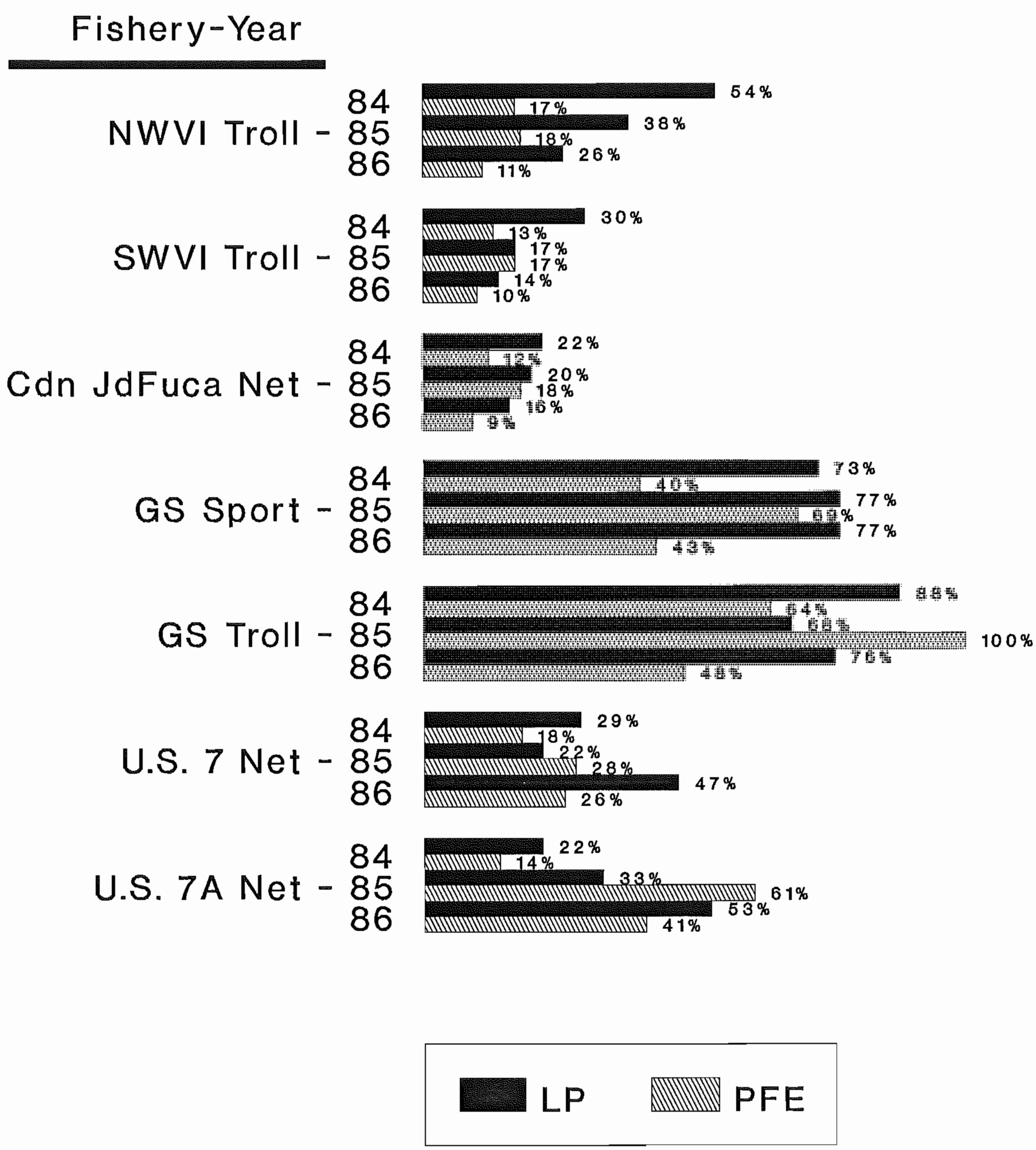

Figure 3

INTRODUCTION

In the fall of 1987, the Pacific Salmon Commission identified a need for estimates of the stock composition of Southern Panel area fisheries. The Coho Technical Committee (CoTC) was assigned the task of estimating stock composition for these fisheries for catch years 1984 through 1987.

The CoTC formed a stock composition working group[1] to perform the required analysis and to report back to the full committee for review. As per instructions of the Southern Panel (November, 1987), the CoTC prepared a time-schedule and general description of methodology for the development of coho stock composition estimates for Southern Panel area fisheries for the years 1984 through 1987 (January 21, 1988).

In preparation for the assignment, the work group reviewed coho stock identification techniques and methods to estimate stock composition. Results from the reviews are included as Appendices 1 and 2. Based on the review of stock identification techniques, the work group concluded that coded-wire-tag (CWT) analysis was the best technique available at this time. Two methods, linear programming and production factor analysis, were selected to estimate stock composition using CWT data.

The CoTC's time-schedule called for a progress report in November, 1988 and a final report in February, 1989. The progress report, released in November of 1988, provided an update of the work that had been accomplished to that date and a prognosis for completion of the assignment. Due to unanticipated problems in obtaining CWT recovery data and workloads placed upon CoTC members during the 1989 negotiation cycle, it was not possible to produce a final stock composition report in February, 1989.

Coho stock composition in southern boundary area fisheries has long been a contentious issue for both U.S. and Canadian fishermen and scientific staff. The CoTC report of February 7, 1987 (Coho Technical Report 87-1, Response to Southern Panel Questions) summarized the available stock composition estimates developed by both Parties and outlined the assumptions and limitations of the various methodologies used. In contrast to those stock composition estimates, this report describes the first bilaterally agreed upon technical analysis and estimates of stock composition in Southern Panel area fisheries.

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1 The work group members consist of Bob Hayman, Ron Kadowaki, Louis Lapi, Gary Morishima, Jane Ramonda-Powell, Jim Scott, and Ken Wilson.

METHODS

Analytical Approach

Two basic approaches were identified for estimating stock compositions. The first approach, which has been used previously by both U.S. and Canadian analysts, involves the expansion of coded wire tag recoveries by "production factors."

The second approach involves the analysis of catch and CWT recovery distribution data using a linear programing technique. This approach was pursued to provide an independent analysis which attempts to overcome problems associated with the lack of sufficient data to estimate production factors for all stocks.

Work on both approaches proceeded in parallel. Both have their own strengths and weaknesses and must contend with limitations in data availability and reliability. Both methods depend upon the following assumptions:

1) CWT groups selected accurately reflect the distribution of untagged fish from a production area.

2) Catches are accurately estimated and attributed to area/gear strata.

3) Catches are adequately sampled and the recoveries accurately estimated.

Aggregation of Stocks Based on CWT Distribution Patterns

The process of estimating stock composition by either production factors or linear programming relies upon the assumption that tagged and associated untagged fish have similar catch distributions. Production from Southern Panel area coho stocks were grouped into production areas which could be represented by an individual coded wire tag code or group of codes.

Cluster analysis was used to determine whether the tagged groups within a production area had similar catch distributions in preterminal fisheries. The catch distribution of stocks was estimated from coded wire tag recoveries of tagged groups which originated from southeast Alaska to California. Input to the cluster analysis consisted of the estimated recoveries of each tag group in 26 fisheries ranging from California to southeast Alaska[2]. Several types of clustering (unweighted pair-group and weighted pair-group) and measures of similarity (Bray-Curtis Index, Euclidean distance, and a correlation coefficient) were tried initially and found to give similar results. Cluster analysis results confirmed that fish released from a region generally had similar patterns of harvest. Regional similarity was evident in both releases from a single site (such as the Quinsam Hatchery) and from different sites within a region (such as the Quinsam and Puntledge Hatcheries). The

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2 CWT recovery data for Canadian fisheries were extracted from the Mark Recovery Database maintained by the Canadian Department of Fisheries and Oceans in Nanaimo. CWT recovery data for U.S. fisheries were extracted from the database maintained by the Pacific Marine Fisheries Commission in Portland. Only recovery records which had estimated recoveries were employed in the analysis (this may pose a potential problem, particularly for sport fisheries, since recoveries with problems in expansion were not included). Agency estimates of recoveries were employed with several exceptions: 1) An average awareness factor was computed for the Georgia Strait sport fishery for the months May through September. The average awareness factor was used for the months of January through April and October through December. 2) For the Georgia Strait sport fishery, an awareness factor of 4.0 was used if no estimated awareness factor was available. 3) Expansion factors were set equal to 1.0 for commercial fisheries in which the estimated expansion factor was less than 1.0.

presence of similarities within a region suggests that tagged stocks can be used to represent the untagged production within a region.

Production areas were not defined in the same manner in the two countries. In Canada, most production areas were identical to those used in the CWT recovery program. In the U.S. , production areas were defined according to geographic proximity and their status as domestically managed stock units. This, in combination with the larger number of stocks with associated tag releases, resulted in the physical size of production areas in the State of Washington being generally much smaller than those in British Columbia.

Definition of Fisheries

A list of Southern Panel area fisheries for which stock composition of catch would be estimated was approved by Southern Panel co-chairs. Annual stock compositions were estimated by the work group. Finer time resolutions were not possible because of the small number and higher uncertainty of CWT recoveries in bi-weekly or monthly strata.

Production Factor Expansion (PFE) Method

A production factor is the ratio of total production from an area divided by the tagged production and is used as a multiplier to expand CWT recoveries to estimate total contribution to a fishery from a production area. These contribution estimates are then aggregated by country of origin to derive national stock composition estimates. A production factor is dependent upon the amount of CWT tagging done on a stock or groups of stocks in one year. It is not a characteristic that is inherent to a particular stock nor is it related to productivity.

Observed CWT recoveries representing a particular production area must be expanded by two factors to provide an estimate of that area's contribution to a fishery. The first factor is the sampling rate; i.e. the observed recoveries must be divided by the proportion of the catch that was sampled for CWT's, to provide an estimate of the total number of tags caught by a fishery. These estimated recoveries are then multiplied by a production factor to estimate the total contribution to the fishery.

In some cases, a CWT code might represent only the specific group of fish with which it was released (if all fish are tagged then the production factor would be one). This is not generally the case, however. In our analysis, many coded wire tag groups were combined to represent the distribution of untagged stocks within a geographic area.

The catch in a fishery that is not assigned to a production area represented by a CWT group is attributed to those production areas not represented by a CWT group. In the Southern Panel area, this unassigned catch is made up of Canadian wild stocks other than those originating in the Fraser River, and some U.S. stocks originating in Admiralty Inlet, the Point Roberts area, and independent drainages on the Washington coast and California.

The general methods used to derive production factors where at least a part of the production is untagged or not directly associated with a tag group are described below. The method used was dependent upon the data available and the subjective evaluation of the biologists most familiar with the stock of concern. Details concerning data and methodologies employed to estimate production factors for each stock unit are presented in Appendix 3.

Method 1

The first method involves the estimation of a tag rate in a terminal location for a particular stock (fishery or test fishery). This tag rate is expressed as the proportion of the sample comprised of the representative CWT group. The production factor is then simply the inverse of the tag rate, e.g. a tag rate of 0.25 would give a production factor of 4.0. There are several assumptions and limitations of this method which must be considered.

Assumptions:

1) Coded wire tagged fish are distributed spatially and temporally in a similar manner to the fish they are representing. The production factor will be inaccurate (high or low) if tagged fish are mis-represented in the terminal fishery samples relative to the true proportion in the production area.

2) All fish from other production areas can be identified and removed from the terminal sample. If this cannot be done, the production factor will be biased high (which would overestimate the contributions of that stock) because of the presence of extra fish associated with the CWT group.

Limitations:

1) Timing of tagged fish (from hatcheries) through terminal areas can be more compressed than that of wild fish (e.g. Fraser River) and fisheries may target on the wild or hatchery portion of the run.

2) Passing stocks are known to be present even in extremely terminal tidal fishing areas (e.g. Skagit Bay, Willapa Bay). Although some non-local stocks represented by a CWT group can be subtracted out of the sample, this process relies on knowing the production factors for these stocks, and these may themselves be highly uncertain or unknown.

Method 2

The second method uses an estimate of tagged escapement (through spawning ground and/or hatchery sampling, or the tagged fraction of the smolt release) and untagged hatchery and wild escapement to calculate a production factor. With this approach, the production factor is equal to the total escapement divided by the tagged escapement. Although this method avoids some of the problems encountered with Method 1, it relies very heavily upon accurate escapement data (which are available for very few coho stocks).

Assumptions:

1) Hatchery and wild stock escapement estimates are accurate. Coho are probably the most difficult salmon species to enumerate in the wild because of their protracted spawning timing during periods of inclement weather and preference for numerous small streams with lots of cover.

2) The tagged escapement is estimated accurately. Wild CWT groups may mostly spawn in one tributary and this distribution must be accounted for in the sampling of spawning grounds.

3) Straying of fish from hatcheries to wild spawning grounds or vice versa is insignificant or accounted for. Violation of this assumption could result in an over-estimate of the production factor.

Limitations:

1) Observations in some Canadian and U.S. hatcheries have shown that CWT's can be missed by samplers at a rate of 2 to 50 percent of the tags present. This could cause a serious over-estimate of production factors.

2) Inaccurate wild escapement estimates are a problem. Uncorrected mark-recapture estimates are known to over-estimate escapement while visual methods usually under-estimate the actual numbers present. Accuracy of index methods can be variable due to inter-annual variability in distribution of spawners.

Canadian Production Factors

Production factors have presently been calculated for only one Canadian stock aggregate, the Fraser River, and for Canadian hatchery production (Appendix 3). For the Fraser River, the terminal gillnet fishery and in-river test fisheries provide estimates of the terminal area CWT incidence for the entire Fraser River. There are no terminal fisheries on the remaining tagged production in southern B.C. which would permit the calculation of a production factor that would account for Canadian wild stock production outside the Fraser River. Terminal fisheries are either highly localized (freshwater sport and Indian food fisheries) or are not strictly stock specific (Big Qualicum chum net fishery). Even for the particular river systems upon which hatcheries are located, production factors cannot be calculated for the natural spawning component of the run because terminal area fisheries are not sampled and escapements are not rigorously quantified.

U.S. Production Factors

Production factors were estimated for the following Washington and Oregon stocks (Appendix 3): Nooksack/Samish, Skagit, Stillaguamish/Snohomish, South Puget Sound, Hood Canal, Strait of Juan de Fuca tributaries, Quillayute summers, Quillayute falls, Queets, Quinault, Grays Harbor wild, Grays Harbor hatchery, Willapa Bay, Columbia River early, Columbia River late, Oregon coastal hatchery and wild stocks and Oregon private hatcheries.

Production factors sometimes varied widely even for the same stock and year, depending upon the CWT groups selected and the data and assumptions employed to estimate associated production. Estimated production factors for individual production areas varied by as much as a multiple of nearly 5.

Linear Programming (LP) Method

Linear programming techniques have been used extensively in industrial and resource management applications for several decades. The technique involves the optimization (maximization or minimization) of a linear objective function under a set of linear constraints. For the Linear Programming Model (LPM) developed for estimating stock composition, the objective function to be minimized is the weighted difference between the reported catch and the catch that can be accounted for by the stocks included in the model.

Use of a Linear Programming model (LPM) to address the stock composition problem provides a means of estimating stock compositions directly from CWT recoveries and catch statistics. The approach avoids problems associated with the lack of recoveries in escapements or terminal fisheries.

The validity of stock composition estimates derived through a LPM depends critically upon three major factors: (1) the degree to which CWT contribution profiles for stock units of interest represent untagged production; (2) the degree of differentiation between contribution profiles[3]; and (3) error in estimation of catch and recoveries.

Shaul and Clark (In Press) have described a method for estimating the abundance of stock aggregates within a fishery from CWT recovery and catch data. Their technique provided a means of estimating contribution levels without having to undertake the tedious and uncertain process of attempting to derive production factors. Shaul and Clark's technique relied upon the solution of a set of simultaneous linear equations where the number of stock aggregates exactly equals the number of fisheries. At a CWT workshop held in late June 1988, Shaul and Clark presented a paper in which they explored some of the properties of their approach. They reported a number of potential problems concerning the robustness of the technique, including: (1) the potential for negative contributions of some stocks to the catch; (2) the limitation that the number of fisheries must equal the number of stock aggregates; (3) general problems related to use of CWT data, such as tagging and sampling rates; and (4) the interdependence of the proportions of the total catch accounted for by various strata.

The general approach outlined by Shaul and Clark has been extended and formulated as a LPM. Such a formulation has several distinct advantages:

(1) A LPM has greater flexibility than the approach formulated by Shaul and Clark because it is not restricted to equality constraints. It is not necessary for estimated catches to equal reported catches. Rather, estimated catch can be equal to or less than reported catches (Shaul and Clark have discussed the use of an iterative technique which does not require the use of equality constraints.);

(2) There is no requirement for the number of stock units to equal the number of fisheries or even for the number of stocks to exceed the number of fisheries;

(3) Programs to solve LPM's are readily available (for example, "What's Best" is an add-in program to LOTUS 123) so results can be quickly generated once raw catch and CWT recovery data are collated;

(4) A LPM is more likely to produce a solution;

(5) Additional information concerning the structure of the model can be readily obtained; for instance, the value of relaxing constraints can be examined - if the catch level in a given stratum or a production factor constraint is uncertain, then the value of changing the constraint to provide a better fit can be explored; and

(6) The objective function can be weighted to place different emphasis on fisheries for which stock composition estimates are most important or for which data are most reliable.

A simple example of a LPM designed to estimate stock compositions is presented in Appendix 4.

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3 The ability of LP to accurately estimate stock composition is improved as differences in stock contribution profiles increase. The technique is unable to differentiate between stocks with identical distribution patterns since any combination of production can be assigned to these stocks. Problems decrease as distribution patterns become more distinct. The significance of these limitations to the work group assignment has yet to be determined. however, Stock distribution profiles for most U.S. and Canadian stocks are likely to be dissimilar given the fishery strata selected; however, problems may exist in Juan de Fuca Strait where stocks in both countries have similar catch distributions.

The LPM formulation of the stock composition estimation problem is described as follows:

MINIMIZE: $\sum_{k} \{ W(k) * [ACATCH(k) - ECATCH(k)] \}$

SUBJECT TO:

(a) a set of equations and relationships for catch for each fishery:

$$\sum_{i} \{REC(i,k) * PF(i)\} = ECATCH(k)$$

$$ECATCH(k) <= ACATCH(k)$$

(b) a set of relationships for each stock:

$$PF(i) >= K(i)$$

where:

k	=	fishery
i	=	stock
ACATCH(k)	=	actual catch of fishery k (constant).
ECATCH(k)	=	estimated catch of fishery k.
K(i)	=	constant; can be set to zero so that all populations are non-negative, or to some externally estimated production factor for stock i.
REC(i,k)	=	constant; total estimated recoveries of stock unit i in fishery k.
PF(i)	=	production factor for stock i; estimated.
W(k)	=	constant; weighting factor for reliability of catch data or relative importance of estimating stock composition for fishery k.

The PF(i) are the variables to be estimated. The contribution of stock group i to fishery k can then be estimated by simply multiplying the REC(i,k) * PF(i). The LP model finds the set of PF(i)'s which best explain the reported catches when applied to estimated CWT recoveries.

If the W(k) are set to 1, the value of the objective function indicates the amount of catch that remains unaccounted for in the optimum solution. The catch that is not accounted for can be examined on a fishery-by-fishery basis by simple subtraction [ACATCH(k)-ECATCH(k)].

The LPM generates only the solutions that produce the best value of the objective function. There may be many combinations of PF(i) which may yield results which are close to the "best", but these cannot easily be found. However, it should be noted that alternative "best" solutions for some LPMs are possible. That is, it is possible that different combinations of production factors can yield the same value of the objective function (see footnote 3 for related concerns). In these cases, alternative solutions can be found to provide an indication of uncertainty about the result.

A LP model of the above form was developed to estimate stock compositions in Southern Panel area fisheries. Note that one fishery outside the Southern Panel area is included, but only to provide greater distinction between stock distribution patterns. Fisheries used in the LPM are:

SE Alaska all areas and gear

Canadian Fisheries
- South/Central Troll
- NWVI Troll
- SWVI Troll
- WCVI Net
- Georgia Strait Troll
- Georgia Strait Sport
- Johnstone Strait Net
- Georgia Strait Net
- Fraser River Net
- Juan de Fuca Net

Southern U.S. Fisheries
- Juan de Fuca (4B,5,6C) Troll/Sport
- Juan de Fuca (4B,5,6C) Net
- San Juan Islands (Area 7) Sport
- San Juan Islands (Area 7) Net
- Point Roberts (Area 7A) Net
- Lummi Bay (Area 7B) Net
- Skagit/Port Susan (Area 8) Sport
- Skagit Net
- Stillaguamish/Snohomish Net
- Admiralty Inlet (Area 9) Sport
- South Puget Sound Net
- South Puget Sound - Areas 10,11,13 Sport
- Hood Canal - Area 12 Sport
- Hood Canal Net
- Washington Area 4 (Neah Bay) Troll & Sport
- Washington Area 3 (LaPush) Troll & Sport
- Washington Area 2 (Grays Harbor) Troll & Sport
- Washington Area 1 (Ilwaco & Astoria) Troll & Sport
- Washington Coastal Net
- Oregon (South of Cape Falcon) & California Troll & Sport
- Columbia River Gillnet
- Buoy 10 Sport

Stock complexes used in the LPM are listed below. A detailed list of CWT codes used to represent stock distribution profiles is presented in Appendix 4. Stock distribution profiles were developed by summing CWT recoveries for each production area and fishery stratum.

Canadian Stock Units
- Johnstone/Georgia Strait-Vanc Island (North)
- Georgia Strait-Vanc Island (South)
- Thompson
- Lower Fraser
- Georgia Strait Mainland
- West Coast Vancouver Island
- Canadian Juan de Fuca Strait

Southern U.S. Stock Units
Puget Sound
- Nooksack/Samish
- Skagit
- Stillaguamish/Snohomish
- South Puget Sound
- Hood Canal
- Strait of Juan de Fuca

Washington Coastal
- North Washington Coast
- Grays Harbor
- Willapa Bay

Columbia River, Oregon, and California
- Columbia River Washington
- Columbia River Oregon
- Private Aquaculture (Oregon)
- California/Oregon Coast

Stock composition estimates were generated using the LPM without production factor constraints and with weight factors set equal to 1.0.

RESULTS

Estimates of stock composition for Southern Panel area fisheries in 1984, 1985 and 1986 were generated using both the PFE and LP methods. Tables 1 and 2 present stock composition estimates (by national origin) for 29 Southern Panel area fisheries, 9 in Canada and 20 in the United States for LP and PFE methods, respectively. Estimates from both methods are compared in Table 3.

Stock Composition Estimates From the Production Factor Method:

Detailed results of the PFE analysis are presented in Appendix 3.

The production factor method can produce estimates of contributions which exceed reported catches. This is because production factors are calculated independently of the actual catch in fisheries and may indicate either overestimates of production factors, underestimates of total catch, or overestimates of tagged catch.

Stock composition estimates generated by this approach can also produce substantial differences in interceptions, depending upon the assumptions, data, and methodologies employed to estimate production factors. Only a single production factor estimate was generated for each Canadian stock for each year while maximum, minimum, and "best" production factors were generated for U.S. stocks. The "best" estimate reflects the informed judgement of the work group member most familiar with the conduct of the fishery and collection of data. Three estimates of stock composition are presented for each year to indicate the range of possible values resulting from this approach: (1) the minimum production factors for U.S. stocks combined with the production factor estimates for Canadian stocks produces a "high" Canadian stock composition estimate; (2) the maximum production factors for U.S. stocks combined with the production factor estimates for Canadian stocks produces a "high" U.S. stock composition estimate; and (3) the "best" estimate combines the "best" U.S. production factors with the Canadian production factors.

Production factors are unavailable for many key production areas (mostly in Canada) and the data that they are derived from (terminal catch and escapement mark rates and mark rates at release) are less reliable than the catch and CWT recoveries which provide the data necessary for the linear programing approach.

Stock Composition Estimates From Linear Programming:

Stock compositions and contributions to catch by production area estimated through the LP analysis are presented in Appendix 4. These results reflect the best solutions to the LP model; no alternative solutions were found in our analysis.

The catch accounted for by the LPM cannot exceed the reported catch because of the structure of the model. The LP model does not necessarily account for all reported catch. Catch unaccounted for by the LP model may be due to a number of factors, principal among them: (1) lack of or inadequate CWT representation of contributing stock groups; (2) overestimation of catch; and (3) catch sampling problems.

Detailed results from the LP analysis frequently indicate production factor estimates of zero (for example North Washington Coastal in 1984). These results stem from similarities in stock contribution profiles; the LP model simply assigns production to the stock with the profile that best explains the reported catches. Also, note that although stock composition estimates are generated by the LP model the South/Central B.C. troll fishery, no attempt was made in the analysis design to produce reliable stock composition estimates for this fishery; should LP be used to generate estimates for this and other northern fisheries, more detailed fishery and stock production strata will be required.

Estimates of stock composition generated with the LP model are determined by catch distribution patterns from CWT recoveries. However, there are some major production areas which are not consistently represented. These include the Canadian side of Juan de Fuca Strait and southeast Vancouver Island which could contribute to many of the same fisheries as U.S. stocks just over the border. Other untagged production areas include the mainland inlets of Georgia Strait and Johnstone Strait.

DISCUSSION

Potential Sources of Error and Bias

Estimates of stock composition derived from both the LP model and the PFE method depend on reasonably accurate and precise CWT data.

The PFE method requires an accurate estimate of terminal mark rate either at the hatchery or in a terminal fishery. Where the mark rate in a terminal fishery is used, it must be possible to account for and remove any catch contributed by non-local stocks. Where hatchery mark rates are used, production factors will be affected by:

1) straying of marked fish to natural spawning areas when straying is not assessed,

2) errors in estimating escapement when fish spawning in natural spawning areas are associated with hatchery production, and

3) errors in detecting tagged fish at the hatchery racks. (Errors in detecting tagged fish can be a significant problem at Canadian and U.S. hatcheries and could cause major errors in production factor estimates.)

Both LP and PFE analyses require reliable estimates of the number of tagged fish harvested in each fishery. Only a relatively small percentage (approximately 20%) of the fish caught in each commercial fishery is examined for tags. The catch by tag code is estimated by multiplying the number of tags observed in the sample by the sampling rate (total catch/number sampled). Low sampling rates (< 20%) can result in large errors in estimates of the number of tagged fish present. Errors in estimating total commercial catch or failure to detect tagged fish in the sample may occur. Catch estimation errors can be caused by non-reporting of catch or by allocating catch to fisheries incorrectly.

Both LP and PFE analyses are also based on the assumption that tagged and associated untagged fish within each production region have the same ocean distribution and are equally vulnerable to all fisheries. In large production regions, it is likely that not all stocks have the same patterns of ocean distribution, and hatchery stocks may not have the same run timing and vulnerability to fisheries (particularly terminal fisheries) as associated wild stocks.

Sport fisheries harvest a substantial proportion of the total coho catch of many stocks and pose unique sampling problems. In Georgia Strait, the total sport catch and the catch of marked fish are estimated by a creel survey stratified by month and region within Georgia Strait, but the heads of sport caught coho are not sampled in the creel survey to recover tags. Tagged catch is allocated to the various tag codes based on the relative proportions of each tag code in the voluntary head recovery program for all of Georgia Strait combined each month. It is likely however, that the probability of a tagged coho in the catch entering the voluntary sample depends in part on where it was caught. In other words, areas with different populations of tagged fish may be represented differently in the tags that are turned in. Washington State sport fisheries data are subject to similar biases. For example, catch is estimated by punch cards, but punch card estimates are reduced by 20% for assumed bias.

While we know that error and bias may significantly influence our analysis of stock composition, most of the sources of error and bias have not been quantified. As a result, while we recognize numerous sources of potential bias and error, we have no basis for incorporating their effects into our estimates of stock composition at this time.

Comments on Linear Programming Method

The strength of the LP analysis method lies in its exclusive use of what the CoTC considers to be the most reliable data available for coho salmon in the Pacific Salmon Treaty area; CWT catch distribution and total catch by fishery. In addition to CWT catch distribution data, the PFE method which was used to develop independent stock composition estimates requires terminal catch, spawning escapement or mark rate at release data which the CoTC considers to be less reliable; furthermore, they are unavailable for most Canadian and some U.S. wild stocks.

Although the LP model estimates are considered to be the best stock composition estimates developed to date, there remain a number of concerns regarding the assumptions of this analytical approach and the possible sources of error and bias which might influence the results. This analytical approach uses catch and CWT data as model inputs. The accuracy of these data is usually assumed to be very high; however, neither country routinely evaluates the quality of these data in a statistically rigorous fashion. Recent examinations of hatchery CWT sampling procedures in both countries have shown that significant errors in tag detection can occur. CWT's in the catch may not be uniformly sampled across all area and time strata. There are numerous unassessed sources of error and bias that could affect the quality of CWT data. The CoTC strongly believes that these should be investigated. The quality of catch estimates is also of importance to the LP analysis and there is some concern that these data are not of uniform quality; this is particularly the case for sport fisheries.

In addition to our basic concerns about the quality of the input data, the CoTC has some specific concerns with respect to the LP model outputs.

1) The large unassigned catch in the U.S. Area 7 and Area 7A net fisheries for both the LP and PFE methods is very disturbing since these have been very contentious fisheries within the PSC. It is not clear at this time as to the source of this problem. However, steps should be taken to investigate the cause and rectify any deficiencies where possible.

2) There were no CWT releases which returned to the Canadian side of Juan de Fuca Strait in 1986. This could lead to an underestimate of Canadian production in that year. This situation has not changed, nor it is likely to change, in the foreseeable future.

3) The LP model tends to allocate catch to only one of two or more stocks with similar catch distribution. This is not a problem if the similar stocks are within one country, however, it can be of some significance if stocks on opposite sides of the border have very similar distribution patterns. Stocks on the U.S. and Canadian side of Juan de Fuca Strait may be of particular concern in this regard. Evaluation of this problem is on-going.

4) The precision of the LP stock composition estimates is unknown. The LP model assigns catch to provide the "best" solution and cannot generate confidence intervals around those estimates, making it impossible to quantitatively evaluate the reliability of the estimates.

5) Based on simulation results conducted by Canada (Fournier and Sibert, 1989), the LP model appears to underestimate the contribution from stocks that are poorly represented by CWTs and is prone to occasional extreme errors. Poor representation by CWTs is a particular concern for wild production generally and some Canadian production regions.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

The stock composition of fisheries in the PSC Southern Panel area has been a constant source of concern to both Parties, even prior to the signing of the current treaty. A bilateral interception committee prepared annual reports from 1971 to 1980 and more recently both countries exchanged their estimates of the interception balances for all salmon species. The stock composition estimates generated by the LP and PFE methods presented in this report are the result of the first attempt by the Parties to develop mutually agreed upon estimates for coho in the Southern Panel area.

The representativeness of CWT tag groups is of concern for many production areas during the 1984 through 1986 period. Recent returns to many of these areas should improve the situation.

In spite of the concerns outlined above, the CoTC believes that the LP method should produce superior results to the analytical methods used in the past. Previous estimates of stock composition were based upon the data and technology available at that time. Differences could result not only from the change in methods, but also from changes in the production of hatchery and wild stocks, annual variability in the ocean distribution of stocks, and changes in management of ocean fisheries. These factors may also account for the inter-annual variability in stock composition evident in most fisheries for the years 1984 to 1986 in the current analysis.

Because of data limitations and uncertainties associated with the production factor approach, estimates derived from the LP method should be considered as the best estimates of stock composition available at this time. Analytical models which use catch and CWT catch distribution data have the greatest potential to provide reliable stock composition estimates for coho in the foreseeable future. We have used a LP model in this analysis and preliminary work has been completed on a non-linear model (Fournier and Sibert, 1989). These models may also be able to provide estimates of coho stock composition in Northern Panel area fisheries for recent years.

Production factor analysis is unlikely to provide useful stock composition estimates for Canadian and Alaskan fisheries. Production factors cannot presently be estimated for any Southern Canadian wild stock except the Fraser. Even where production factors can be calculated, they are highly sensitive to errors in estimating terminal mark rates and escapements of both CWT's and unmarked fish. The kind and quality of data required to estimate production factors for most Canadian stocks will probably never be available.

Recommendations:

1) Of the two approaches used in this report, the LP estimates of stock composition in Southern Panel area fisheries should be considered as the best technically supportable estimates available at this time.

2) Preliminary analytical work directed at evaluating the LP method and developing other estimation techniques has been conducted. Work on continuing this analysis for both LP and non-linear models should be supported and given a high priority.

3) Annual CWT releases which represent the distribution of all major stocks contributing to U.S. and Canadian boundary area fisheries are required if stock composition estimates are needed on a routine basis. In particular, increased annual tagging of Canadian stocks on the west coast of Vancouver Island, Juan de Fuca Strait, and southeast Vancouver Island is recommended.

4) Research programs designed to test the validity of the assumption that tagged hatchery coho adequately represent the catch distribution of wild stocks from the same geographic area should be undertaken. Wild tagging programs on the Salmon River in the lower Fraser, and on the Black, Trent, and French stocks on the east coast of Vancouver Island, and on Puget Sound and Washington coastal river systems will provide critical data over the next few years. Additional tagging programs may be required after further analysis.

5) Further research should be directed towards evaluating the accuracy and precision of CWT-based stock composition estimates using alternative stock identification methodologies.

6) We recommend a thorough review of the CWT tagging and tag recovery programs in Canada and the U.S., with emphasis on the quantification of error and bias.

7) We recommend that the stock composition working group of the CoTC continue efforts to develop improved techniques for estimating stock composition.

LITERATURE CITED

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APPENDIX 1[1]
A REVIEW OF COHO STOCK IDENTIFICATION METHODOLOGIES FINDINGS AND RECOMMENDATIONS FOR FURTHER RESEARCH

I. SUMMARY AND RECOMMENDATIONS

The joint Coho Technical Committee (CoTC) established a work group in August 1986 to provide recommendations concerning current and potential future methodologies for estimating stock composition in coho fisheries. This is a report of the workgroup's recommendations and findings concerning the subject of stock identification methodologies and their utility for estimating stock composition. The workgroup has not completed its review of stock composition estimation methodology, which involves a range of statistical and database management issues, rather than the field and laboratory procedures of tagging and identifying stocks.

Each stock identification method has been evaluated for strengths and limitations in resolution, accuracy, precision, cost, stage of development, tag application, tag recovery, applicability to wild stocks, and statistical interpretation. Each stock identification method has different strengths and limitations. Some methods are under development, and their potential utility is uncertain. Stock identification methodologies are not necessarily competing methodologies; concurrent application of two or more methods may best satisfy management needs.

Resolution is an important criteria for assessing different methodologies. For purposes of estimating interceptions, resolution may only be required to separate stocks by national origin. For other purposes, such as the conservation of individual stocks, greater resolution is required. Accuracy, precision and cost are other important criteria.

Findings and recommendations:

A) Coded Wire Tags. For the short term, analysis of Coded Wire Tags (CWTs) is the most promising method for identifying stocks and estimating stock composition. CWTs are the current standard tool available for hatchery stock identification. They have also been applied to wild stocks, but use for tagging and identifying all wild stocks is not practical. CWT stock identification can be improved by consistent tagging of all hatchery indicator stocks and, if possible, all representative hatchery releases. Resources directed at improving CWT-derived stock composition estimates can be best invested in improving sampling to provide greater accuracy in catch, escapement, and terminal run estimates, developing a means of verifying association of wild stock production to CWT releases, and improving hatchery production enumeration. Expanded tagging of wild stocks is recommended for Canada and SE Alaska.

B) Scales and Otoliths. Scales and otoliths are body parts that accrete layers of tissue as the fish grows. Stocks are identified by induced or natural patterns by the circuli pattern of scales or the growth rings in otoliths. Otolith and scale mark identification methods utilize similar techniques and tools; it is recommended that future research be conducted concurrently whenever possible. These methods and their potential utility are described below.

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1 This report summarizes research activities through December, 1987. Mark Hunter, WDF, was a primary contributor to appendices 1 and 2.

1) Induced Otolith Marks. Preliminary research suggests that otolith marking could become an inexpensive way to mark hatchery stocks and achieve moderate resolution and high precision in contribution estimates. An evaluation of intra and inter-experimental variability from recent laboratory experiments will help resolve questions about the potential of this method. If these concerns are resolved favorably, continued research is recommended.

2) Induced Scale Marks. Scale marking, like otolith marking, could provide an inexpensive way of marking hatchery fish. Only continued research can determine if the resolution and precision of these methods are sufficient for application.

3) Natural Scale Marks. Identification of natural scale marks is a technique that has been used with considerable success with sockeye salmon, however the method will probably lack the resolution necessary for preterminal management applications for coho in the Southern Boundary area. Scale analysis could provide a quick means of evaluating wild fish contribution in a catch, and perhaps assist in estimating wild stock production factors needed for CWT-derived stock composition estimates. Application in terminal fisheries with a limited number of stocks is possible. Discrimination of broader stock classifications, such as 'Puget Sound', 'Southern US Ocean' and 'Canadian Ocean', has not been examined for coho stocks under PST jurisdiction. Only continued research will resolve remaining questions regarding the utility of this method to meet the needs of the PSC.

4) Natural Otolith Marks. No formal research has been done on the identification of natural otolith marks. Initial research would be required to determine the potential utility of this method.

C) Chemical Tagging. Chemical tagging, using either strontium, tetracycline, or other elements has potential for complete tagging and precise identification of hatchery fish by national origin at a low cost. For applications requiring higher resolution (identification of individual stocks), no current chemical tagging method appears to be satisfactory.

D) Genetic Stock Identification (GSI). It is unclear whether electrophoretic analysis will provide sufficient resolution for determining coho stock composition. Current information indicates that coho stocks are more difficult to distinguish than chinook stocks or chum stocks. Expansion of stock baselines and identification of additional polymorphic loci should be emphasized in future research on coho salmon. Nuclear DNA Analysis holds potential for higher resolution than electrophoretic analysis. However, this method is currently in a very preliminary phase of research, and it is difficult to speculate on the utility and costs of this method.

E) Adult Tagging. Adult tagging is expensive and statistical requirements are extremely difficult to satisfy. Its use is not recommended, except some extreme terminal areas and to identify ocean migration, dispersal patterns and run timing.

F) Electronic Tagging. Electronic tagging has potentials for research on migration, run timing and dam passage. However, for evaluating marine stock identification and stock composition, these methods have the same limitations as adult tagging.

G) Fin-Clipping. Fin-clipping of juvenile fish has been made partially obsolete by the development of the more versatile coded wire tag. Applicability is limited by differential mortality of fin-clipped fish, fin regeneration, and the limited number of different marks.

II. INTRODUCTION

The Principles of the Pacific Salmon Treaty identify objectives that require dependable and statistically sound estimates of stock identification, stock distribution and stock composition. Article III.1. states that:

".... each party shall conduct its fisheries and its salmon enhancement programs so as to:

(a) prevent overfishing and provide for optimal production, and

(b) provide each Party to receive benefits equivalent to the production of salmon originating in its waters.

In order to prevent overfishing as directed in (a), the distribution of weak stocks and strong stocks need to be known so that stocks can be protected and fishery harvest optimized. Objective (b) will require stock composition estimates in all fisheries, a more complicated task than preventing overfishing.

Article III.3 expands upon the guidelines above, stating that:

"In fulfilling their obligations pursuant to paragraph 1, the Parties shall take into account:

(a) the desirability in most cases of reducing interceptions [of stocks from the other nation]:"

This objective too requires accurate, bilaterally acceptable stock composition estimates.

The December 1984 coho annex (Annex IV.5.1.a.) assigned the CoTC the responsibility of 'presenting historical catch data, associated fishing regimes, and information on stock composition in fisheries harvesting these (trans-boundary) stocks' and 'identify information and research needs, including future monitoring programs for stock assessments.' These objectives where reiterated in the March 1987 coho annex. In August 1986, the CoTC established a workgroup to review current and emerging stock composition methodologies.

This report reviews the field and laboratory aspects of different stock identification methods, and makes basic comparisons of the utility of each method for stock composition estimation. A second report, will address the statistical methodologies and database management procedures for making actual stock composition estimates.

Each method has its own strengths and limitations. Some techniques can effectively distinguish between individual groups of fish raised in a hatchery facility, while others are only capable of separating hatchery from wild fish. Resolution requirements will often dictate the most appropriate methodology. For purposes of estimating interceptions, stock identification methods must, at a minimum, be capable of providing estimates of the number of coho produced in one country which are harvested by the other.

This report discusses the following stock identification techniques: Coded wire tagging, otolith marking, scale marking, scale analysis, otolith analysis, chemical marking, genetic stock identification, adult tagging, electronic tagging, fin-clipping and run reconstruction techniques. The discussion of each technique is organized in three major sections: (1) description, (2) current status of research and (3) implementation.

III. DEFINITION OF TERMS

Accuracy: An accurate estimate, if repeatedly generated, will average very closely to the true value.

Baseline: Whenever mark recognition is not perfectly reliable, a baseline sample of known stock origin needs to be collected to establish the average or typical characteristics of the stock.

Bias: An estimate, if repeatedly generated, that averages either above or below the true value.

Catch/Sample Factor: The total catch divided by the sampled catch. The catch/sample factor must be computed for every sample strata when the tagging method tags less than 100% of each stock.

Precision: A precise estimate, if repeatedly generated, will produce values in a narrow range.
Production Factor: The total stock production divided by the tagged production. This factor is necessary for making stock composition estimates when only part of a stock is tagged.

Resolution: The level of detail that can be provided by a stock identification method. Coded wire tags can distinguish more than 200,000 different groups, thus this method has a high degree of resolution. Other methods may discriminate only two different classifications and thus have a very low resolution.

Variability: A measure of the dispersion about the mean of a particular estimate.

IV. SUMMARY OF STOCK IDENTIFICATION METHODOLOGIES.

Stock identification methodologies fall into one of three categories. These categories, and the basic advantages and disadvantages of each, are listed in table below.

Method	Advantages	Disadvantages
Artificially marked adults	- Can provide data on run timing and migration	-Very Expensive. -Potentially serious biases.
Artificially marked juveniles	- High stock resolution - Discrimination assured.	-Often impractical to mark all fish. Production factors must be estimated. -Wild stock application difficult or impractical.
Natural Marks	- All fish are marked. Production factors need not be estimated. - Wild stocks can be Identified.	-Poor stock resolution -Stock discrimination not always assured

Artificially marked juveniles provide the most suitable method for identifying hatchery stocks. It is impractical to apply artificial marks to all wild stocks on a routine basis for the purpose of making direct wild stock composition estimates. Natural marks can be used; however, these methodologies generally exhibit lower resolution, accuracy and precision. If the direct identification of wild stocks proves to be impractical using natural marks, the alternative is associating the distribution of each wild stock with that of a hatchery stock. CWT experiments are currently being conducted to determine the degree to which the distribution of wild stocks can be represented by hatchery stocks.

A more detailed evaluation of the available stock identification methods is shown in following table. This summary does not adequately address the advantages and disadvantages of each method, which includes characteristics such as accuracy, precision, costs, and inseason application potential. It simply summarizes the suitability of each method for certain stock identification needs.

Suitability Table. The suitability of different stock identification methods for handling four types of stock identification needs is summarized in the table below. This table does not attempt to address the full range of issues needed in selecting an appropriate methodology for a specific need.

	ARTIFICIAL MARKS					NATURAL MARKS		
Type of Identification Need	CWTS	Oto- liths	Scales	Adult Tags	Fin Clips	Oto- liths	Scales	GSI
(1) Distinguish Hatchery Fish From Wild Fish	Y	P	P	N	N	?	Y	N
(2) Distinguish Between Stocks in Terminal or Near-terminal Fisheries (Few Stocks)	Y	H	H	Y	N	?	P	?
(3) Distinguish Nationality in Preterminal Fisheries. (ie, US or Canadian Origin?)*	H	H	H	N	N	?	N	?
(4) Distinguish Specific Stocks in Preterminal Fisheries. (Many Stocks)*	H	H	H	N	N	?	?	?

KEY

Y - Has been successfully applied
P - Potentially feasible
H - Potentially feasible for hatchery stocks only
? - Unknown feasibility: Further research is necessary.
N - Not Recommended

* These applications are of particular interest to the Pacific Salmon Treaty objectives.

V. STATISTICAL REQUIREMENTS AND SOURCES OF ERROR

The estimation procedure for each stock identification methodology has statistical properties that will result in biased estimates of stock distribution and stock composition if specific requirements are not satisfied. Although in some instances, these requirements can be satisfied by experimental verification, a common procedure is to state assumptions concerning the characteristics of the data. Of course, this leaves the conclusions of the study open for question if some future research suggests that the underlying assumptions may not be valid. The use of assumptions is a necessity in most modern research, because satisfying all statistical requirements by experimental evaluation can be expensive and is not always possible. Further, explicit validation of assumptions may not always be necessary when previous experience and judgment indicate that the assumptions are likely to be valid or don't significantly affect the results.

These statistical requirements fall into five general categories: (A) Requirements that apply to all categories; (B) Requirements that apply to artificial marks; (C) requirements that apply to artificial marks when the entire hatchery production is not marked; (D) requirements when mark recognition is imperfect; and (E) adult tagging. Sections describing specific methodology may list additional requirements or may elaborate on the requirements listed here.

Those requirements marked with an asterisk (*) apply to stock composition estimates only.

A. Requirements Common to All Methods.

The following statistical requirements apply to all direct stock identification methods.

1. The mixed stock fishery or escapement must be sampled randomly.

2. Each stock must have unique mark or tag characteristics.

B. Artificial Marks.

The following statistical requirements apply to all artificial marks.

* 1. The percent of the total production of each stock that is wild must be known. This information is needed to compute the wild production factor (not required for linear programming).

2. The hatchery and wild components of each stock must have the same time and area distributions.

C. Artificial Marks When There is Incomplete Marking of Production.

The following statistical requirements apply to artificial tags and induced marks when only part of a hatchery stock is tagged. For coded wire tags tagging entire hatchery stocks is impossible or impractical. For some methods, such as induced otolith marks, induced scale marks and fin-clipping, tagging the entire hatchery stock is possible. Incomplete tagging if production will substantially increase variability of derived stock composition estimates. Thus, complete tagging of production is desirable when possible.

1. The number of fish caught and the number of fish sampled must be available for every sample strata. This information is needed to compute the catch/sample factor.

* 2. The percentage of marked fish in each hatchery stock must be known. This information is needed to compute the hatchery production factor. If this information is derived from hatchery release statistics, marked and unmarked components must have the same mortality rate. If this information is derived from hatchery rack statistics, there must be no straying of non-local stocks into the rack.

3. Marked and unmarked hatchery components of each stock have the same time and area catch distribution.

D. Imperfect Tag Recognition: Baseline Data Requirements.

This set of statistical requirements applies to all natural marks, such as GSI, natural scale marks, and natural otolith marks. These requirements might apply to some artificial marks where tag recognition may be imperfect, such as induced scale marks and induced otolith marks.

1. Baseline characteristics need to be established for all stocks that might be intercepted. This requires terminal area samples for all stocks potentially intercepted by the fishery being sampled.

2. Each set of baseline samples must be composed of one stock. The presence of strays will result in inaccurate baseline samples.

3. The terminal area must be sampled randomly. Each set of baseline samples must represent the full range of mark characteristics typical for the stock it represents.

4. The variation of baseline characteristics must be greater between stocks than within stocks.

E. Adult Tagging and electronic tagging of adults.

Requirements listed here are unique for adult tagging, and electronic tagging.

1. The fish that are tagged must represent a random sample of the actual catch of the fishery of interest.

* 2. All potential terminal fisheries, escapements and preterminal fisheries between the tagging site and the terminal area must be sampled for tags.

* 3. The tagging mortality rate must be an assessable and known value.

* 4. The natural mortality rate must be an assessable and known value.

* 5. The tag loss rate must be an assessable and known value.

* 6. The harvest rate by intercepting preterminal and terminal fisheries must be the same for tagged fish and the untagged fish in each stock.

7. Terminal area samples must be in single stock areas. The occurrence of tagged strays into the terminal area will cause misidentification.

VI. CODED WIRE TAGS

A. Description of Method

1. History and Description

The development of the coded-wire tags (CWT) revolutionized juvenile tagging programs, quickly replacing fin-clipping in the early 1970's. A standard 1mm long, the full sized stainless steel wire tag is injected in the nose cartilage of juveniles with nominal mortality (Jefferts et al 1963). Normally, hatchery stocks are tagged but limited tagging of wild stocks has occurred. Since the CWT is an internal tag, an external identifying mark is required. The adipose fin was chosen because its removal results in less mortality than other fin clips and has little effect on swimming control. In addition, the adipose is less subject to regeneration. The adipose fin-clip has been adopted exclusively as the flag indicating the presence of a CWT in salmon.

Initially, the tags were coded with bands of colored epoxy ink. Problems in differentiating colors, with the limited number of colors available, and with bands being chipped off led to preference for the binary coded tag. Etching unique binary codes onto wire eliminated the problems associated with color codes, and the binary coded tag is the most widely employed type of wire tag.

Applications in which CWT data are used include stock composition estimates, hatchery research, productivity evaluation, harvest rate evaluations and stock distribution estimates.

2. Analysis.

Observed CWT recoveries are routinely converted to estimated recoveries using a catch/sample factor, thus avoiding the need to sample entire catches. There are some differences in procedures employed by agencies to generate catch/sample factors. These differences involve treatment of unsampled strata and imputed tag recoveries, stratification of fisheries and areas, and the distribution of landings over time and area strata. However, these differences are relatively small and can be alleviated through the establishment of common procedures and databases.

3. Requirements and Sources of Error.

The requirements necessary for artificial marks are listed in section V.B. apply to CWTs. It is impractical to mark entire hatchery productions with CWTs on a routine basis. Thus, requirements in Section V.C. are also relevant here.

4. Resolution

Both the potential and realized resolution of CWTs is far greater than any other method (64^3 = 262144 unique codes). There are plans to expand the coding field, resulting in yet greater resolution.

5. Accuracy and Precision

A number of factors affect the accuracy of the catch/sample factor. First, about 10% of the adipose clipped fish recovered by samplers are without CWTs. Some of these tagless adipose clipped fish are tagged fish that have lost their tags, some are untagged fish that have lost their adipose fins naturally, some result from adipose fin-clip markings (although the adipose clip is currently reserved for CWT applications), and some may result from errors in sorting during sampling. Partial assessment of loss from tag retention is made at the time of tagging, but this does not account for losses after release. Other sources of uncertainty affect estimated recoveries: tag detection by samplers is imperfect and a small percentage of tags are lost during laboratory extraction, or are unreadable. Adipose fin regeneration may occur, although this is believed to be quite infrequent. On the whole, 'estimated' tag recoveries are believed to generate a relatively accurate recovery pattern of tagged groups.

6. Inseason Application

Inseason data could be made available for several key fisheries. Catch sampling and interpretation of the data could be achieved in one week for small fisheries. The coastwide decoding of heads and data verification of CWT recoveries in a short time period would be expensive. Post-season analysis for a large fishery (ie., B.C. troll) can be completed by the end of the calendar year and several months later for large terminal fisheries (ie., Puget Sound net fisheries.)

7. Wild Stock Applications.

CWTs have been used successfully to identify wild stocks in mixed stock fisheries. However, routine application of CWTs to wild stocks is expensive and sometimes impossible because of the difficulty of trapping and tagging sufficient numbers of wild juvenile fish.
However, CWTs have been used to assess the similarity of marine distributions of adjacent hatchery and wild stocks, by tagging both hatchery and wild stocks the same system.

8. Applicability to Stock Composition Estimation.

CWT data have been used by both United States (Hunter 1985) and Canada (Swain unpublished) to identify stocks and estimate stock composition in Southern Boundary fisheries. These unilateral efforts have not been found satisfactory to both nations. If future management needs continue to require high resolution for stock composition estimates, CWTs will continue to be the primary stock identification and stock composition estimation tool. However, if low costs and precise stock composition estimates become higher priorities, other methods may be more cost-effective. Precision can be substantially improved by tagging all hatchery production, rather than a small portion; such tagging on a routine basis would be expensive for both marking and recovery operations.

If CWTs are to be used routinely for stock composition estimates, improvement and verification of hatchery production estimates and/or escapement estimates will be necessary.

B. Current Status of Research

1. What is Known Now

The application of CWTs to coho salmon is widespread in both Canada and the U.S. Sampling programs have been instituted in all major fisheries. It is the established means of tagging coho for hatchery research, wild stock research, marine distribution evaluations and stock composition estimates.

2. Current Research Activity

The Pacific Salmon Commission Data Sharing Committee has formed a workgroup on CWT statistics to examine a number of issues, including the estimation of variance of CWT-derived stock composition estimates. This committee has not yet addressed these issues, however, research has been ongoing in these areas. Recent research (DeLibero 1986) has recommended the use of replicate samples to evaluate variability in the tag recovery rate and distribution. Theoretical estimates of the variance of estimated recoveries and stock composition have been addressed by Webb (1986) and Clark and Bernard (1987).

The Department of Fisheries and Oceans-Canada (DFO) and is in the process of designing and building a computer information retrieval system that will facilitate the application of CWT data and production statistics. This tool can facilitate estimation of catch sample factors, hatchery production factors, and contributions of marked stocks.

3. Research Needed

Additional research is needed to improve and verify the quality of hatchery release data, hatchery rack recoveries, catch sampling error, and escapement (terminal run) estimation.

4. Funding

Current funding for CWT studies appears to be stable. Funding in Southern Border areas needs to be allocated to see that all indicator stocks (ie., stocks that will be subjected to long term annual tagging for the purpose of identifying and monitoring the coho resource status) are adequately tagged every year. Tagging in Northern Border areas needs to be expanded. If higher rates of tagging are anticipated, additional funding is necessary to maintain a 20% catch sampling rate.

C. Implementation

1. Tagging.

Tagging is typically done in mechanized mobile tagging trailers that are transported from hatchery to hatchery. Fish from a hatchery pond are pumped into a holding tank where they are sedated for easier handling. They are then routed into the trailer where fish are tagged and the adipose fin clipped. The fish are then routed back to the hatchery pond for eventual release. A subsample of the tagged fish are isolated and evaluated for tag retention and mortality. Criteria for tag retention studies are not consistent. For example, the Washington Department of Fisheries (WDF) holds about 2000 tagged fish from every tag code in a tank for three weeks before estimating tag retention and tagging mortality. Typically, about 50,000 to 100,000 coho are tagged for each indicator stock, or about 2% to 5% of a hatchery stock. In Canada, procedures to assess tag retention vary between hatcheries and release types.

2. Sampling.

Sampling is conducted in all major commercial and most sport fisheries in both countries. Sampling may occur at the ports, buyer docks or tenders, or in fish processing plants away from the ports. When an ad-clipped salmon is encountered in a sample of the catch, the snout is removed, labelled and preserved in alcohol or a saline solution. The snouts are collected and transported to a laboratory (headlab) where the tag is dissected and its binary code deciphered. Laboratory dissection may take place within a few days or many months after sample collection. A 20% minimum sampling rate has been agreed upon as a coastwide objective. Tag recovery data are decoded, reported by the recovering agency, and later verified by the tagging agency. The tag recovery data are exchanged through the Regional Mark Processing Center in Portland, Oregon, which currently handles about 70,000 observed coho tag recoveries coastwide each year.

3. Costs.

Tagging costs, as estimated by WDF, are about 8 cents per fish. Tag collection, extraction and data processing cost about $4 per fish head.

VII. Induced Otolith Marks.

A. Description of Method

1. Description and History.

Otolith marking is currently being evaluated as a method of artificially tagging juveniles. As with scales, otoliths were originally used to determine age in individual fish, however recent developments have made it possible to detect daily growth bands in these structures (Campana and Neilson 1985). This method requires a very fine polish of a transect through the center of the otolith. Under magnification, bands are evident, and unlike scale circuli, there is often a clear one to one association between time intervals and bands. Otoliths are located inside the skull and are insulated from some unintended disturbances that might mark scales and distort stock identifying characteristics. Salmon stock identification using otoliths is currently in a preliminary phase of development. Distinct, identifiable marks in the otolith circuli pattern have been successfully induced in several species of salmon.

The width and optical density of daily growth rings in salmon otoliths can be altered by changes in water temperature, feeding regime, photoperiod, stress and other factors. Systematically varying water temperature by as little as two degrees C can produce distinctive patterns in otoliths even before fish begin to feed. The otoliths of very large groups of hatchery fish can be marked efficiently by varying water temperatures in the incubation trays. The fish are never handled or stressed, and negative effects from the marking process are extremely unlikely.

While mass marking of the otoliths of hatchery fish is simple and inexpensive, catch sampling and bulk processing of adult salmon otoliths presents several technical challenges. Otoliths of adults are not uniform in size or shape. The marked zone of a salmon otolith marked as an alevin is extremely small and it is this section of the otolith that must be examined for marks. Grinding otoliths into thin sections containing the marked center of the otolith requires very precise control. This level of precision may prove difficult to achieve when large numbers of otoliths of varying size and shape are processed together. Processing otoliths in bulk will probably be necessary if full scale fishery sampling is undertaken.

2. Analysis.

Because this tagging method is likely to be applied to entire hatchery productions, it may offer a direct estimate of hatchery stock distribution, thus simplifying analysis. However, there is a possibility that tag recognition will be imperfect, thus requiring multivariate analysis methods (See Appendix A)

3. Requirements and Sources of Error.

The requirements listed in section V.A. and V.B. apply to induced otolith marking under all circumstances. Requirements in section V.C. would apply if only part of a hatchery's production is tagged. If mark recognition is imperfect, requirements in section V.D. also apply.

4. Resolution.

Preliminary research suggests that a moderate number of unique marks or 'codes' are possible. It is conceivable that between 10 and 100 distinguishable codes could be applied to each species. A better understanding of the resolution potential will be available pending analysis of inter-experimental variability from recent WDF otolith studies.

5. Accuracy and Precision.

If entire hatchery stocks can be marked, which is likely to be feasible with this method, the same level of precision can be achieved with a much lower sample size than with partial tagging. The classification success of the mark identification process is not yet known, but is probably between 95 and 100%.

6. In-season Application.

Inseason interpretation is possible for otolith tags. It may take three days to a week to collect, prepare and interpret otolith samples. A smolt baseline sample is necessary if in-season stock identification is being considered. As with CWTs or GSI, attempting coastwide in-season evaluation would be expensive.

7. Wild Stock Application.

This method has little or no potential for direct wild stock identification. Indirect estimates of wild distribution is possible by associating wild stocks with tagged hatchery stocks.

8. Applicability to Stock Composition Estimation.

This method holds promise for stock composition estimation. The strongest point is the relative ease in which entire hatcheries might be tagged, which would improve precision and reduce bias. This method will not have the realized resolution of the CWT.

B. Current Status of Research

1. What is Known Now.

Identifiable induced otolith marks have been observed on coho, chum and chinook salmon subjected to water temperature treatments and periods of starvation. The prolonged fresh water rearing period for coho salmon makes this species ideal for this method. Several simple experiments have demonstrated that coho can also retain marks from this process. Mark retention in adult fish has not been formally evaluated, but normal adults exhibit growth bands much like normal juveniles, so no major problem is anticipated in recognizing marks in experimental adults.

2. Current Research Activity.

The laboratory rearing of 17 chum salmon groups and 16 chinook salmon groups has been completed, and the extraction of the otoliths and the interpretation of the banding patterns is currently underway. A report on these experiments might be available in the future (Schroder and Volk, pers. comm.).

A simple experiment on coho smolts has been conducted to see if a starvation period effectively induces marks. Initial results appear promising. A series of tests are planned to see if coho otoliths can be marked at the egg and fry stage. The logistics of mass collection, processing and interpretation of otoliths is being evaluated. A method of cutting and polishing up to forty otoliths at a time is under development. It is anticipated that otolith banding patterns will be interpreted using an optical pattern recognition system (Biosonics 1985), the same mechanical device used for interpreting scales. The entire 1986 coho brood from the Dungeness Hatchery (300,000 smolts) were successfully marked. Afterwards, a sample of the smolts indicated unique and consistent mark retention. This effort will be repeated for the 1987 Dungeness Hatchery coho brood.

3. Research Needed.

Additional research is needed to resolve many details about the potential use of this method for stock identification. The best means of marking otoliths remain to be determined, although starvation and temperature manipulation appear promising. Other methods, such as photoperiod control and dietary supplements (specifically phosphate) are to be evaluated in the near future. A standard operational procedure for sampling, processing and interpreting otoliths needs to be developed. Application of this method would require a time lag for research; if it were decided to experimentally tag several ponds of coho at a hatchery and wait for adult returns to evaluate mark retention, this would take three years when coho are marked as eggs or fry. If a subsequent decision was made to apply the method to actual management activities, the first management application of this method would be available three years later. Thus, a hypothetical time table for proceeding from secondary research activities to a widespread application of this method could be as much as seven years, or the mid-1990's. This development period could be shortened by tagging smolts prior to release, and examining jack returns.

4. Funding.

Currently, there is no direct funding of otolith research, although some research continues at the WDF as time and resources permit.

C. Implementation

1. Marking

Salmon have three otoliths on each side of the head. Two otoliths, the sagitta and lapillus, are of potential use in stock identification. Most research work has been done with the sagitta because of its larger size and easier handling. However, the sagitta exhibits a greater degree of calcification, which makes preparation of high-quality sections more difficult. There may be some advantage to using the lapillus, because it ceases growth at about one year of age. The transect image of the adult lapillus more directly resembles that of the juvenile lapillus, and the task of finding the true center of the otolith is easier. This latter consideration is important because marking may take place early in life. Sampling the sagitta is a matter of making a precise cut in to the skull, finding the 'large' otolith, placing it in small envelope and properly labeling the envelope. Collecting the lapillus may require removal of the entire inner ear or the entire upper head, and preserving it for laboratory extraction.

Marking can take place anytime during hatchery cultivation, either as egg, fry, fingerling or smolt. The best life stage for doing this remains to be determined. Baseline samples must be collected after the last tagging and preferably just before release. Because of the prolonged rearing of coho salmon, it may be possible to correct accidental duplicates in the tagging process. For example, if preliminary evaluation showed that marks induced on salmon fry from two hatchery were indistinguishable, this error could be corrected with additional marks applied at the smolt stage of development.

2. Sampling.

A new sampling system and mark recovery system would be required.

Baseline samples must be collected from each tagged stock to assure the uniqueness of the tags. If identification is imperfect, multivariate analysis methods may be needed to identify stocks.

Fishery samples can be collected at either the ports or processing plants. Otoliths could be extracted by the sampler, either with a knife or by taking a core section of the head. Should this be difficult, the head could be removed, preserved and its otolith extracted in a laboratory. Either way, the collection of otoliths would result in the mutilation of some marketable fish, a problem shared with CWTs and GSI. The collected otoliths are embedded into a clear plastic resin, sliced, polished and evaluated with an optical scanner.

2. Sample size.

About 100 otolith samples for each stock in the baseline would be desirable. When two to four stocks are in the baseline, between 50 to 150 fishery samples per time/area/fishery strata would be an approximate goal. Discrimination of 10 to 20 different hatchery stocks might require larger fishery samples (Schroder, pers. comm.).

3. Costs

The cost of tagging otoliths is likely to be substantially less than other methods of marking juveniles, and in some cases (ie., starvation) could be absorbed into the normal operational expenses of a hatchery.

The start-up costs of establishing a coastwide otolith collection system can not be estimated at this time, however, samplers would have to be trained, and a system for recording and exchanging sample data would be established. The sampling network is already in place as part of the coastwide CWT recovery and catch estimation system. However, some extra labor would be necessary to process otoliths.

The start-up costs of processing otoliths would probably require each sampling agency to establish a laboratory which would include an optical pattern recognition system, and yet-to-be-defined equipment for extracting, embedding, slicing and polishing otoliths.

The operation costs of collecting and processing otoliths would probably be similar to CWTs, but less than GSI.

VIII. INDUCED SCALE MARKS.

A. Description

1. Description and History.

Scales of juvenile salmonids can be artificially marked by manipulating the water temperature, photoperiod and/or diet of hatchery fish. These marks can be identified later with various degrees of success.

Scale tagging of the circuli is still in a preliminary phase of evaluation. WDF is currently in the process of rearing fall chinook that have been subjected to a range of dietary and environmental manipulations to induce scale and otolith marks, and preliminary evaluation of this method for inducing scale marks should be forthcoming, although otolith marks appear to be getting the emphasis in this research program. Several other pilot studies on chum and coho salmon are being conducted at the Hood Canal Hatchery.

2. Analysis.

Multivariate analysis methods are used to distinguish stocks based on characteristics identified in baseline samples representing each stock. An individual characteristic from a scale may not be unique to a specific stock. However, in association with other characteristics, it often is possible to assess the most likely stock of origin. A description of these methods is given in Appendix A.

3. Requirements and Sources of Error

The generalized requirements that apply to artificially tagged juveniles in sections V.A and V.B. apply to scale marking. Note that assumptions in section V.C. apply if only part of each hatchery stock is tagged. However, complete hatchery tagging may be both possible and economically feasible. Tag recognition is not likely to be perfect, in which case assumptions in section V.D. will apply to scale tagging.

4. Resolution

There is a tradeoff between precision and resolution. The more stock units that are identified in the mixed stock fishery, the lower the precision of the stock distribution estimate.

At this time, there is not much evidence that induced scale marks can achieve a resolution of more than 5 or 10 stocks. However, new methods for marking fish and interpreting scales (ie, optical pattern recognition system) have not been utilized yet.

5. Accuracy and Precision.

The external environment in which scales grow does not provide a uniform medium for development. The most serious problem is that scales can get absorbed, confounding mark identification. Thus, scale marks will likely exhibit a lower classification success than otolith marks.

6. In-season Application.

Scale marking can be applied to inseason analysis, provided baseline samples were collected prior to release of juveniles. Time lag between scale sampling and stock composition estimates could be as little as one or two days, because of the relative simplicity of collecting samples, delivering them to the laboratory, and processing the samples.

7. Wild Stock Applications.

There is no potential for this method to be used for direct wild stock identification.

8. Application to Stock Composition Estimation.

This method is similar to induced otolith analysis in that entire hatcheries might be tagged with relative ease. The classification accuracy and precision of circuli marks would probably be lower than otolith induced marks.

B. Current Status of Research

1. What is Known Now.

Preliminary studies on scale marking using circuli patterns (Pitre, pers comm) have suggested a low resolution potential, however, more recent tagging techniques and the use of optical recognition systems have not been applied to this method.

2. Current Research Activity.

Some analyses can be performed on scales currently available from the WDF otolith marking experiments, however scale marking does not have a high priority at this time (Schoeder and Volk, pers comm).

3. Research Required.

Since marking techniques, tools and analytical techniques for otolith marking and circuli scale marking are similar, research can be done concurrently. If this method is to see any application, more work is needed to examine the resolution and classification accuracy.

4. Funding.

There are no plans or funding currently planned for scale marking.

C. Implementation

1. Marking, Sampling and Data Analysis.

Actual field sampling for scales is simply a matter of plucking several scales in a precisely defined area on every fish sampled, applying the scale to a scale card which has an adhesive side, and recording information such as species, sex, length, date and location. Two sets of scales need to be collected for every application. One set of scales are random samples from the fisheries being examined, and the second set of scales, known as baseline samples, are collected from each of the hatchery stocks tagging.

In the laboratory, the scale cards are placed face down on a hard plastic sheet, and compressed in a scale press, which etches an image onto the plastic sheet. The methodology up to this point has not changed much for the last 30 years. The plastic images are placed in an optical scanner and key characteristics are automatically measured and recorded.

2. Sample Size.

Standard WDF procedures for natural scale marks recommend 100 samples for every stock to be entered into the baseline, and 50 to 150 samples per week in every fishery being evaluated.

3. Costs

The cost of marking the scales of hatchery populations would be slight to insignificant. Collecting baseline samples could be handled by on-station hatchery staff or by full time samplers traveling from station to station.

The primary capital investments are the optical scanner and scale press, about $30,000 per laboratory unit. Operational costs would be less than any other stock identification method. It would be comprised of mostly labor and transportation, with scale cards, plastic molds, field sampling equipment and computer expenses being minor items. The labor and transportation expenses would be less than any other method, as the actual removal of scales is relatively simple, and samples are easy to deliver to the laboratory. Mail delivery is possible, whereas samples in other methods other methods are bulky, delicate and/or preserved in noxious chemicals and thus require more labor to deliver.

IX. NATURAL SCALE MARKS

A. Description of Method

1. Description and History

Natural scale marks identify stocks using circuli characteristics that occur naturally. Different phases of the life history tend to produce different types of circuli and lay different frequencies of circuli. Circuli are not laid down in discrete time intervals, but are controlled by a variety of environmental and biological factors such as growth and temperature. However, when circuli accumulate over a period of years, the pattern shows seasonal changes and changes upon entering salt water. Thus, these patterns have been used to determine the age and fresh water residency of salmon for several decades. More recently, scale analysis has been used to discriminate hatchery and wild reared coho on the coast of Oregon (Murphy and Van Dyke 1983) using differences in the freshwater growth patterns on the scale. There has also been success in applying scale analysis to very broad stock classifications in the Central North Pacific for identification of several North American and Asian stock groups. This type of stock identification is dependent on recognition of early ocean growth characteristics on the scales (Harris, pers. comm.). Biologists from the International Pacific Salmon Fisheries Commission (Henry 1961), the Fisheries Research Institute (Cook and Lord 1978), the Alaska Department of Fish and Game and the Canadian Department of Fisheries and Oceans have all had success in identifying scale characteristics to distinguish regional sockeye stocks, and have applied this method in management.

Stock-specific scale characteristics are not necessarily the same from year to year. Thus, a baseline of scales for each stock needs to be established for every brood year. Furthermore, there is no control over the uniqueness of scale characteristics; thus, discrimination between key stocks may not be guaranteed every year. Coho, like sockeye, have an extended period of freshwater rearing during which stock-specific scale patterns could develop, and attempts are being made to identify individual stocks from scale patterns.

Scale reading for stock-specific characteristics has been a time-consuming, subjective, and tedious task. Interpretation of life history zones on scales has varied among scale readers, necessitating standardization of scale pattern measurement techniques. Crude wild stock composition estimates of Oregon Coastal coho needed revision because of new insights on scale reading subjectivity (e.g. Murphy and Van Dyke 1983, Solazzi, Johnson and Van Dyke 1983). Analysis of sockeye scale characteristics to identify specific stocks was a painstaking process of counting and measuring exact characteristics in an attempt to remove all subjectivity.

Recently, an optical scanner (optical pattern recognition system) has been developed that will automatically measure many scale characteristics (Biosonics 1985), thus reducing the time and subjectivity from the chore of reading scales.

2. Analysis.

Multivariate analysis methods are used to distinguish stocks based on characteristics identified in baseline samples representing each stock. An individual characteristic from a scale may not be unique to a specific stock. However, in association with other characteristics, it often is possible to assess the most likely stock of origin. A description of these methods is given in Appendix A.

3. Requirements and Sources of Error

See section V.A. and V.D. on requirements applicable to this method.

4. Resolution

There is a tradeoff between precision and resolution. The more stock units that are identified in the mixed stock fishery, the lower the precision of the stock composition estimate.

Studies to date have not achieved resolutions of greater than five. (Sneva, pers. comm., Harris, pers. Comm.)

5. Accuracy and Precision.

The external environment in which scales grow does not provide a uniform medium for development, and variation can be expected between fish representing the same stock. Classification accuracies of 85% to 95% where reported in preliminary research involving three stocks (Sneva, pers comm).

6. In-season Application.

Scale analysis cannot be applied to inseason management if the baseline scales are collected from adult fish at the hatchery racks and spawning grounds. Smolt samples might serve as a source of baseline scales that can be collected prior to the fishery, thus making inseason management possible. However it has not been proven that a random sample of smolt scales truly represents the scales of returning adults. Another possibility is that stock characteristics from a previous brood can adequately serve as a baseline for inseason stock identification. It has been observed in one study that the inter-brood variation of one stock was less than the inter-stock variation of one brood (Sneva pers. comm.)

7. Wild Stock Application.

Natural scale marks are a suitable methodology for distinguishing wild stocks from hatchery stocks, but resolution may not be sufficient to distinguish individual wild stocks. Preliminary research failed to find any difference between Snohomish River and Stillaguamish River wild stocks (Sneva, pers. comm.).

8. Application to Stock Composition Estimation.

Because of the low resolution potential, the most promising application of this identification method to stock composition estimation is in near-terminal fisheries, especially where wild stocks are abundant.

B. Current Status of Research

1. What is Known Now.

In 1985, this tool was used to discriminate scales of adult coho collected from the Snohomish and Stillaguamish rivers and in nearby terminal net fisheries (Sneva, pers. comm.). Random testing of the baseline samples (samples from hatcheries and streams which are of known origin) successfully classified two hatchery stocks (ie. the Snohomish and Tulalip hatcheries). However, wild stocks in the two adjacent river systems were not distinguished. Success was reported for distinguishing Skagit River Hatchery and Wild fish. (Sneva and Knudsen, Per. Comm.)

2. Current Research Activity.

Currently, scales are being collected from net fisheries throughout areas 8 and 8A to determine the interception of different hatchery and wild stocks returning to the Skagit, Stillaguamish and Snohomish rivers. Additional research to improve resolution of stock composition estimates and use a historical scale library to test and refine techniques are planned. Initial capital investment in this research is largely complete and operational expenses appear to be covered for several years.

Canadian research in the use of natural scale marks to identify coho stocks appears to be dormant.

3. Research Needed.

Present research activities aimed at identifying stocks in an expanding number of Puget Sound net fisheries should be continued to determine the upper limit of the number of stocks that can be discriminated using this method. Some research could also be directed at attempting to identify substantially broader stock classifications (eg. Puget Sound hatchery and wild, Georgia Strait hatchery and wild, Coastal hatchery and wild).

4. Funding.

Funding is committed for an undetermined period for two full time WDF researchers.

C. Implementation

1. and 2. Marking and Sampling.

A routine sampling program is essentially the same for natural scale marks as it is for induced scale marks. See section on induced scale marks.

3. Costs

Operation costs for a natural scale mark identification system would be similar to that for a induced scale mark identification system, except that the collection of stock baseline data would be considerably more costly for wild stocks. Trapping devices for capturing either outmigrating smolts or returning adults would have to established in many remote areas, or samples from spawning ground carcasses and terminal fishery catches would have to be used.

X. NATURAL OTOLITH MARKS.

Natural otolith marks could be used to identify stocks in a manner similar to natural scale mark identification described in Section IX. However, little formal research has been performed on natural otolith marks. If induced otolith marks (Section VII) becomes widely implemented as a stock identification method, wild stock otoliths will be collected as a byproduct of the sampling program. Under these circumstances, the prospects of using natural otolith marks to identify wild stocks would be worth exploring.

XI. Chemical Marking.

1. Description and History.

Chemical tagging involves adding chemicals or minerals to the diet of hatchery salmon. The chemical must be assimilated into a tissue of the fish which is extracted several years later and the assimilated chemical can be detected in trace amounts. Scales are the most desirable tissue to use for this purpose, because they are easy to extract, preserve and store, and sampling does not mutilate the fish. However, otoliths, bones and soft tissues have also been examined for this purpose.

There has been experimental success in tagging chum fry with the rare earth element europium in Japan (Kato 1981) and tagging coho with strontium in Canada (Yamada and Mulligan 1982). Several tetracycline compounds have also been used to use to tag coho (Syndel 1985). The trace chemical detection methods used in each of these experiments were different. Other methods trace chemical detection methods may be developed in the future.

2. Analysis.

Assuming that entire hatchery stocks would be tagged, stock distribution and composition can be estimated directly.

3. Requirements and Sources of Error.

Chemical tags must be readily detectable several years after tagging, and the tag recognition must be perfect. A chemical tagging method that does not satisfy these latter two assumptions would be of little value. Requirements in V.A. and V.B. would apply to these methods.

4. Resolution.

Current experimental resolution is limited. The resolution of the tagging methods described by Kato (ibid) and Yamada and Mulligan (ibid) was two. The method described by Syndel (ibid) had a resolution of six.

The hypothetical resolution is difficult to determine, as there are potentially many undeveloped trace detection methods and many chemicals and combinations of chemical tags.

5. Accuracy and Precision.

These methods would likely be applied to entire hatcheries, thus the accuracy and precision of these could be quite high. A potentially serious source of error is the failure to recognize some of the tag recoveries.

6. In-season Application.

Some methods of chemical tagging are amenable to in-season application, subjected to the added costs of the extra labor and equipment that would be needed. The neutron activation analysis method described by Kato (ibid) required six months to identify tags.

7. Wild Stock Application.

Chemical tagging of wild stocks does not appear to hold any prospects at this time.

However, a variation of this method, the identification of natural minerals, has been examined. Mineral contents of rivers and lakes differ, and these differences have detected in the scale tissues of returning adult sockeye to three West Coast of Vancouver Island lakes (Lapi and Mulligan 1981). The low precision and costs of laboratory analysis did not justify further research or application of this method, however new detection technology or management needs could justify another look.

8. Application to Stock Composition Estimates.

These methods could provide hatchery stock composition estimates. However, the methods developed to date would suggest that applications would have to be applied to situations where resolution needs are low.

B. Current Research.

1. What is known now.

Three chemical marking methods have seen experimental application to Pacific salmon. In all three of these methods, fish are tagged by adding the chemical to the diet.

a. Strontium is leached from the scales, and the looked is subjected to atomic emission spectroscopy. (Yamada and Mulligan ibid)

b. Europium has been detected by neutron activation analysis. (Kato ibid) It has been detected in the scales, soft tissues and bones of outmigrating juveniles. Only the scales of returning adults have been examined for europium traces, which were successful detected.

c. Tetracycline was detected using fluorescent spectroscopy.

2. Current Research Activity.

Currently there are two chemical marking experiments underway in Canada. In one experiment, salmon are being fed with food laced with trace elements to determine the rate at which these elements are taken up by the fish and to see if they are retained in the scales and otoliths. In the other experiment, rear-earth elements are being added to the water to induce a chemical mark in the scales and otoliths. A joint U.S./Canada workshop on chemical marking was held in Vancouver on May 3, 1989.

3. Research Needed.

There are currently several possible methods for low resolution chemical tagging, and if low resolution (say, distinguishing just the national origin of hatchery fish) is acceptable, one of the current methods could be utilized. Research into chemical tagging methods with higher resolution awaits the development of series of non-toxic chemicals that are incorporated into the scale tissue, along with a detection method that is accurate, simple and inexpensive.

4. Funding.

Research proposals for further development of strontium and tetracycline tagging are under consideration at the Department of Fisheries and Oceans - Canada.

C. Implementation.

1. Marking.

Marking is accomplished by introducing the tagging chemical in some form to the hatchery feed.

2. Sampling.

To date, the most suitable tissue for chemical tagging has been the scale. A description of scale sampling is described in Section VIII.C.1.

3. Costs.

The major capital cost would be a laboratory with trace detection equipment. Sampling costs are identical to other scale collection systems. Laboratory costs depend on the method involved.

XII. GENETIC STOCK IDENTIFICATION.

A. Description of Method

1. Description and History.

Genetic Stock Identification (GSI) is a natural mark identification method. The basic premise of genetic stock identification is that variations in the genetic structure of stocks can be used to identify fish of unknown stock origin. Electrophoresis is the most widely used GSI method, and is currently applied to the management of salmon species other than coho (primarily chum and chinook). Electrophoresis is a method of identifying protein variation in genes that code for specific protein enzymes. Other methods, nuclear DNA analysis and mitochondrial DNA analysis using restriction enzymes, is currently in the preliminary phase of research. Still other GSI methods could come on the scene as a by-product of current medical technology advances. The discussion herein is limited to electrophoresis, with some brief remarks on DNA methods.

The following description is condensed from May (1975), who provides a good introduction to the genetic basis of electrophoresis. All genetic information for an organism is stored in DNA molecules found in the nucleus of every cell. A segment of DNA which codes for a single amino acid sequence is called a gene. The locus of a gene is the location of the gene on the DNA molecule. Different forms of genes that occur at the same locus are called alleles. The instructions within DNA are used within a cell to construct protein. Protein consists of a sequence of amino acids. Differences in alleles result in the presence of different amino acids in the protein molecule.

Some of the amino acids that comprise protein molecules carry an electrical charge which results in a charge on the protein molecule itself. When placed in an electrical field, the charge on the protein molecules causes them to migrate toward the oppositely charged terminal. The rate of migration is related to the charge, size, and shape of the molecule.

Electrophoresis relies upon the migration of the electrically-charged protein molecules to distinguish genetic structures. DNA analysis recognizes certain sequences of nucleotides in the chromosome itself.

2. Analysis

The objective of the statistical analysis is to identify stocks in a sample from a mixed stock fishery (the mixed sample) given information on allelic frequencies for all stocks (the baseline data) which contribute to the fishery.

Two statistical techniques (or variants) have been used in the majority of studies involving Pacific salmon. Milner et al. (1981) developed an approach based on maximum likelihood estimates which has been used in most recent studies in British Columbia and Washington. Alternatively, discriminant analysis has been used for a wide range of salmon stock identification problems since the early 1960's. The application of these methods will be discussed in only a general manner in Appendix A. Readers interested in a more mathematical exposition are referred to Milner et al. (1981), Fournier et al. (1984), and Cook (1983).

3. Requirements and Sources of Error

See Sections V.A. and V.D. for a general summary of requirements.

The major requirement specific to electrophoretic analysis is that a genetic basis must exist for observed variations in the electrophoretic profiles. The genetic variant must be a stable attribute which is expressed throughout the lifetime of the individual. Nongenetic variants caused by environmental conditions or changes caused by storage, dissection, or extraction procedures must be ruled out prior to making any comparisons among populations. Evidence of a genetic basis is provided by the breeding history or parallel expression of the variant in a number of different types of tissue.

Allelic frequencies within a stock must be stable from generation to generation or annual baseline samples need to be taken. Consistent allelic expression negates the need to collect baseline data on an annual basis and to conduct analysis on a brood year basis. Most studies indicate that allelic frequencies are stable in the absence of human disturbances of the gene pool (Utter et al. 1980; Beacham et al. 1985a). Hatchery practices like egg transfers between facilities and transplanting fish could have significantly disrupt the stability of baseline gene pools in some areas. Natural straying may contribute to genotypic uniformity among stocks.

4. Resolution

The level at which coho stocks can be distinguished on the basis of genetic characteristics will not be known until an extensive baseline database has been collected. Some speculation is possible based on the results obtained from other species of Pacific salmon.
Electrophoretic studies of chinook salmon, chum salmon, and pink salmon have shown that variations between geographic regions (which include several river systems) is usually greater than the variation within a region between river systems (Milner et al. 1983; Beacham et al. 1985a; Beacham et al. 1985b). The limited studies of coho which have been conducted to this time indicate that genetic differences between coho stocks are less than for chinook and chum salmon (Milner, pers. comm.). In Washington and Oregon, this may be in part due to the large number of hatchery stock transfers which have occurred in the 1960's and 1970's.

Recent research on mitochondrial DNA suggests that this method may have potential for identifying regional stocks, but not coho stocks on a river by river basis. Nuclear DNA has a hypothetical potential for detecting much more genetic variation than either GSI or mitochondrial DNA.

5. Accuracy and Precision

GSI is an imperfect stock identification method, thus some level of imprecision will exist concerning the origin of any individual fish. Expansion of the number of heterozygous loci will probably improve accuracy and precision.

Electrophoretic analysis has seen several years of application in Southern Boundary chum fisheries. It was found that for stocks that make up less than 10% of the catch, the standard deviation of the estimate exceeds the estimate, and may be biased towards stocks that have genetic patterns similar to those of other more abundant stocks (Graves pers. comm.). As a result of these concerns analytical results of electrophoresis studies were considered inappropriate to apply to PSC management negotiations in 1988. While these analytical problems are considered surmountable (Lincoln pers. comm.), it is typical of problems encountered with the application of electrophoretic data in recent years.

6. In-season Application

Electrophoretic analysis can be used for inseason management as well as postseason assessment of catch composition. Electrophoretic analysis has been used inseason to monitor the stock composition of catches from chum test fisheries in "terminal" areas along the east coast of Vancouver Island and in Johnstone Strait. Samples from weekly test fisheries in "terminal" areas were used to estimate the abundance of nontarget stocks prior to commercial fisheries. Estimates of chum stock composition were generally available within 48 hours of sample collection (Beacham, pers. comm.).

7. Wild Stock Applications.

This method holds better prospects for direct identification of wild stocks than any other method. The application of this method to wild stocks of other salmonid species has been extensively explored and utilized in Washington, British Columbia and Alaska. Current coho research has been limited to hatchery stocks. However, wild stocks can reasonably be expected to have least as much genetic uniqueness as hatchery stocks. Extensive baseline samples need to be taken from numerous rivers to identify stock categories and determine the resolution. The costs of GSI and the possibility of low resolution may result in indirect methods being used (eg., assuming similarity in distribution between wild stocks and nearby hatchery stocks).

8. Application to Stock Composition Estimation.

This method provides a direct means of estimating stock composition. The presence of stocks in the fishery samples that don't exist in the baseline samples are a potentially serious source of bias.

B. Current Status of Research

1. What is Known Now

Electrophoretic studies conducted during the 1970's found little variation in the genetic structure of coho populations on the west coast of North America. Utter et al. (1980) summarized the results of these studies. "The coho salmon has the lowest average heterozygosity value of the five Pacific salmon species in North America with only a single polymorphic locus - transferrin - among 24 loci examined in a broad survey of populations from California through Alaska." They concluded that this phenomena could be attributed to one of two opposing hypotheses:" 1) the level of genetic variation currently indicated by protein loci is not a valid reflection of genetic variation over the remainder of the coho salmon genome; and 2) the coho salmon has evolved a genome possessing little genetic variation but a highly adaptable phenotype."

2. Current Research

Research by the National Marine Fisheries Service- United States (NMFS) and WDF has identified 12 genetically varying loci (ADA-1, GAP-3, GAP-4, GL-1, GL-2, GPI-2, GPI-3, IDH-4, MPI, NP-1, PGM-2, SOD-1) which may be more useful in identifying stocks. In a pilot project initiated in 1984, baseline samples were collected from 8 hatchery stocks from widely separate regions, with an equal number of test samples from each stock. The ability of these loci to discriminate among 8 stocks was assessed by blind testing of test samples. Utter (1985) reported that "Significant discrimination was demonstrated among all eight stocks. There was a strong correlation between geographic and genetic distances, indicating that populations within a region formed genetically cohesive units. The precision of GSI estimates of stock composition was good.". While these results are encouraging, this test design does not adequately imitate an actual fishery sample where genetically similar stocks could be present, and several stocks not in the baseline data could also be present. It is anticipated that an additional 12 stocks will be screened during the next year.

Sampling of juvenile coho salmon in many streams in British Columbia indicated that identifiable differences existed between the genetic structure of stocks in northern and southern British Columbia, but not between streams within a region (Wareham, pers. comm.). Polymorphic loci identified were ME-1, LDH-4, and a form of esterase. No further electrophoretic studies of coho salmon in British Columbia have been proposed (Beacham, pers. comm.).

Nuclear and mitochondrial DNA analysis is in the preliminary phase of research. The methods are similar. Restriction enzymes are used to cut DNA at every location a specific sequence of nucleotides is identified. Different restriction enzymes cut different sequences of nucleotides, and many different restriction enzymes are currently available. Allelic differences are detected by differences in the length of DNA fragments when subject to a specific restriction enzyme (Beecham pers. comm., Bermingham pers. comm.). In theory, the number of loci available for identifying stocks using nuclear DNA analysis is far greater than electrophoresis. Mitochondrial DNA is maternally inherited, and is not subjected to meiosis and the process of recombination. Thus, less variation can be expected, and characteristics might be more stable within a population.

Currently, DFO has contracted a private firm to evaluate the potential of nuclear DNA analysis in identifying chinook and coho stocks. The first phase of this work, establishing 'libraries' of information as to how chromosomes break up in response to different restriction enzymes, is nearly complete. The next phase is to identify stock specific differences in loci from differences in length of DNA fragments. The current contract should be completed by December 1988.

3. Research Needed.

Additional stocks and loci need to be added to the baseline database before the utility of this method for coho can be demonstrated.

Preliminary nuclear DNA analysis research for coho needs to be continued.

Mitochondrial DNA analysis may not have the genetic variability needed for application to coho. Under these circumstances it would be difficult to recommend more research.

4. Funding

Currently, there is no coho electrophoresis research funded for the Southern Boundary coho resource, although additional baseline samples have been collected in Washington State, and may be analyzed if time and resources permit it (Lincoln, pers. comm.).

C. Implementation

1 and 2. Marking and sampling.

The collection and processing of samples for electrophoretic analysis consists of five basic steps:

a) Tissue samples from the brain, heart, liver, eye, or muscle are collected and, if not used immediately, frozen at -20C. Tissue samples must be kept at a very low temperature to avoid alteration of the proteins.

b) Tissue extracts are prepared by squashing the tissue sample in water. This process breaks the cell membranes and releases the enzymes into the water.

c) The tissue extract is placed within a starch gel and an electrical current is applied to opposite ends of the gel. (See Utter et al. 1974 for additional information on gel techniques.)

d) The gel is sliced horizontally and stained. The stain forms a visible band on the gel which reveals the migration of the proteins. (See Shaw and Prasad 1970 for additional information on histochemical staining methods.)

e) The migration of the proteins is used to determine the allele present.

Samples of 100 adults or more per stock have been shown to provide adequate information for the baseline for other species. No criteria have been established for fishery sample sizes. If juveniles are used to establish the baseline, research is needed to demonstrate that the juvenile samples are representative of a random sample of returning adult population.

3. Costs

Estimating the cost of implementing electrophoretic analysis is difficult at this time because of the lack of: 1) defined resolution objectives and 2) baseline information on the genetic structure of coho populations. Laboratory costs are dependent on the number of loci that need to be screened and on the number of gels which must be used to identify the allele. Electrophoretic and statistical analysis of the chum salmon sampled in the study discussed above cost approximately 5 dollars (Canadian) per fish (Beacham, pers. comm.). The WDF estimates costs at roughly 50 cents per allele examined, or 7 to 15 dollars per fish. GSI should be regarded as a moderately expensive method.

The costs of nuclear DNA analysis is expected to be similar or greater than that of electrophoretic analysis (Beecham pers. comm.).

XIII. ADULT TAGGING

A. Description of Method

1. Description and History.

Adult tagging consists of capturing fish at the same time and area of the fishery of interest, attaching an external tag and releasing the fish alive. Then all subsequent fisheries and all potential terminal areas are sampled for tag recoveries. The tags must be uniquely coded, so that when a tagged fish is recovered, the date and location of tagging can be traced. Standard tags used in adult tagging are spaghetti tags, which are thin tubular tags passed through the muscle under the anterior base of the dorsal fin, Peterson disk tags, which are coin-sized tags attached by a wire under the dorsal fin, and jaw tags, which are metal bands or rings attached around the lower jaw bone (Stott 1971).

Prior to the 1970's, adult tagging was utilized to provide information on migration routes and migration timing. While this type of information cannot be directly utilized in stock distribution estimates, it does have important simulation model applications that are not available from any other stock identification methods. For example, the resident behavior of coho residing throughout their life in Georgia Strait and Puget Sound could have only been determined by adult tagging.

Adult coho salmon were first tagged in 1925 (Milne et al. 1958). Troll-caught coho were tagged and released from 1925-1930 off British Columbia and in Georgia Strait (Milne 1958), during the late 1940's off California, Oregon, and Washington (Fry and Hughes 1951; Van Hyning 1951; Kauffman 1951), and during the 1950's in Georgia Strait (Milne 1958) and the Strait of Juan de Fuca (Joint Report 1959).

2. Analysis.

Stock distribution estimates must be determined from terminal area adult recovery data that has been expanded by catch/sample factors. If intervening mixed stock fisheries occur between the tagging area and the terminal area, cohort reconstruction is necessary to estimate stock composition in the fishery.

3. Requirements and Sources of Error

A lengthy list of assumptions are needed to be satisfied for adult tagging to be seriously utilized to estimate stock identification. This is a serious limitation with the method. These assumptions are described in section V.E.

4. Resolution.

Adult tagging can identify stocks down to the level of the smallest terminal sample stratum. However, as the level of stock resolution becomes greater, the precision decreases. For practical applications, resolution is under ten stocks.

5. Accuracy and Precision.

This method has a potential for serious biases, because several requirements are difficult to satisfy.

The precision of a stock composition estimate derived from adult tag recoveries is highly dependent on the actual contribution rate of that stock. For stocks that make up less than about 10% of the mixed-stock area catch, the variability of the contribution rate estimate would generally be greater than 100% of the estimate, even with relatively high sampling rates and a few dozen tag recoveries in the terminal area. Conversely, for stocks that make up more than about 20% of the mixed-stock area catch, the variability of the estimate could be less than 10% of the estimate, even with a relatively low terminal area sampling rate and low numbers of tag recoveries. Thus, for a stock composition estimate to be reliable, different terminal areas would have to be grouped together until, combined together, they make up more than about 10% of the mixed-stock area catch. This combination of terminal areas would be the smallest stock unit that could be reliably identified from adult tagging.

6. In-season Application.

Since adult tagging requires spawning ground recoveries in order to identify stocks in the tagging area, this is the only direct method that does not have the potential for in-season assessment. Analysis of adult tagging data can be done after the end of each season.

7. Wild Stock Applications.

This method can be applied to wild stock identification, however, spawning surveys and terminal run estimates are essential. In some areas, adverse conditions of weather, accessibility and water visibility make spawning ground surveys impossible.

8. Application to Stock Composition Estimation.

Stock composition estimates would be difficult to derive from Adult Tag recovery data. The requirements that need to be satisfied would require several verification tests and adjustments.

Adult tagging is most suited for estimating stock composition in near terminal areas where potential intervening fisheries are absent and resolution need is low.

Adult tagging data have been used to make coho stock composition estimates. Adult coho were tagged during 1968-1971 off West Coast Vancouver Island (Wright 1968; Bourque and Pitre 1972) and during 1969 in Georgia Strait (Argue and Heizer 1971), and stock composition estimates derived from these studies were used to modify somewhat the then-assumed composition estimates. However these estimates used observed recoveries to estimate stock composition, and thus did not satisfy requirement C.1. described in section V.

The only serious effort to satisfy all statistical requirements for stock composition estimates occurred in 1982 through 1985. Intensive adult tagging studies were conducted to estimate stock composition of sockeye and pink, and evaluate the migration routes of chum in Northern Boundary region (SE Alaska and Northern BC). High costs have made continuation of this program questionable (Seibel, pers. comm.)

B. Current Status of Research.

1. What Is Known Now.

Adult tagging has been utilized for decades, primarily for tracing migration routes. It remains a useful method for studying marine dispersal, migration and migration timing. In general, the method is too expensive and potentially biased for routine evaluation of distribution and stock composition.

2. Current Research Activity.

No research activities are currently in progress.

3. Research Needed.

No addition research activities are recommended.

4. Funding.

For coho, none has been committed.

C. Implementation.

1. Marking, Sampling, Data Analysis.

If an adult tagging study were implemented, marking should be done in the mixed-stock area of interest, and if there are intervening mixed-stock fisheries, then tagging should also be done in these areas. Adults could be caught by normal fishing gear -- either purse seines, small-mesh gillnets (to tangle fish, rather than gill them), or by troll gear. The fish would be held in tanks on board the fishing vessel, until being tagged and released.

Sampling would have to be done in all terminal regions that contribute to the mixed-stock area catch. This should be done in terminal region fisheries, at hatchery racks, and on the spawning grounds.

The information would be compiled post-season. In order to do the analysis, it would be necessary for the terminal regions to coordinate exchange of recovery information.

2. Sample Sizes.

The number of fish to be tagged from an area depends on the precision desired, the number of tagged fish expected to be recovered, and the contribution percentage of the stock unit. In order to get an estimate within 20% of the actual contribution percentage, or stock units that make up at least 20% of the catch, it would be necessary to tag enough fish to get about 100 terminal area recoveries from each mixed-stock fishery. About 10% of every terminal run should be sampled. The number actually tagged would, therefore, depend on the expected tag loss, mortality, and mixed-stock fishery removal.

3. Costs.

The major costs to tag fish would be the costs of chartering a fishing vessel, and the salaries of the tagging personnel. Fishing vessels typically cost $500 to $1,000/day in the U.S. during fisheries closures, and as much as $5,000 to $10,000/day during openings in Canada. Past tagging projects have tagged about 50 coho/vessel-day; thus, it would require about 20 days to tag 1,000 coho at a cost of $10,000 to $20,000 during closed seasons and as much as $100,000 to $200,000 during the fishing season. Personnel costs would add about $200/day to the cost. Tagging costs are a severe limitation of this method. Routine annual tagging would be prohibitively expensive.

Sampling costs could be incorporated into on-going catch sampling and spawner survey programs; however, increased sampling rates would be needed in all terminal fisheries and rivers where tagged fish are expected to return. If there are regions that do not have such programs currently, the costs of implementing them must be added to the overall costs.

XIV. ELECTRONIC TAGS: RADIO, ACOUSTICAL AND 'PIT' TAGS.

Several recent tagging developments show promise as research tools, but are given a brief discussion herein because of their lack of potential for analysis of marine distribution and stock composition. These methods have the same limitations as adult tagging when applied to adult fish, but have similar advantages in studying migration and timing. Mass marking of juveniles is impractical with radio and acoustical tags and, given current tag costs, prohibitively expensive with any electronic tags.

Radio tags are large tags that carry their own transmitter and power source. Typically, they are embedded in the gut or fastened to the base of the dorsal fin. Since migration can be continuously traced with a portable radio unit, it is ideal for studying short term movement and migration. Battery life of these transmitters is dependent on the strength and frequency of the signal desired. For some adult tags, battery life can be 60 days. In one study where tags were applied to juvenile chinook and steelhead, battery life was 10 days and initial signal distance was from 50 to 150 meters (Faurot et al 1982). Signal distance is substantial less when the tagged fish dives deep or when the tag is in salt water. Radio tags cannot be used for marine tagging. Different tags can emit different signals; however, keeping track of several signals simultaneously is difficult and impractical under some circumstances (Stuehrenberg pers comm). Tracking can be done from a boat or at on-shore stations using a directional radio antenna. directional vectors from two sources are required to determine the location of a fish.

Acoustical tags are similar to radio tags in that the tag carries its own power source, only the tag releases a acoustical beacon. This tag is especially suitable for salt water applications. Typically, two boats are required to track a fish and the location is determined by the intersection of two directional vectors, much as with radio tags. Battery life is limited to several days (Stuehrenberg, pers comm)

'PIT' (Passive Integrated Transponder) tags are internal tags, measuring 10 mm by 2.1 in diameter, that are embedded with a microchip, but has no transmitter or power source. Several methods of applying this tag are possible, however injecting the tag into the visceral cavity has been the most successful method to date. This tag can be activated by an external radio wave emission, which causes it to emit a radio message giving a tag code. This message is detected and recorded automatically without killing or handling the fish, thus multiple recoveries of the same tag are possible. Up to 35 billion different codes are possible with the current coding standard. The tag can last the lifetime of the fish. This tag holds great promise for monitoring downstream passage of juveniles and upstream passage of adults in the Columbia River, because dam passage facilities collect migrating fish where they can be routed through detection devices. Experimental tag accountability has been very high to date (Prentice et al 1985).

XV. FIN CLIPPING

A. Description of Method

1. Description and History.

Fin-clipping was the first method of artificially marking juvenile salmonids. The first large-scale efforts to mark salmonids were conducted on chinook and coho from Columbia River and Puget Sound hatcheries during the late 1800's by U.S. Fisheries Agencies. In the late 1960's and early 1970's, Columbia River, Puget Sound and Washington Coastal hatchery stocks were marked as juveniles by clipping unique combinations of fins that identified the region of origin. Samplers attempted to sample 20% of all fishery catches for marks.

2. Analysis

Analysis of Fin-clipped Recovery data is similar to that of CWT recoveries.

3. Requirements and Sources of Error.

Requirements and sources of error are similar to those that apply to CWTs. Key sources of error include fin regeneration resulting in tag loss, and natural fin loss resulting in misidentification of unmarked fish as marked fish. Fin-clipping can also result in higher mortality of tagged fish and different mortality rates for different clips. Either of these sources of error need to be measured experimentally, or assumptions must be made. Other assumptions are listed in Section V.A., V.B. and V.C.

4. Resolution

The maximum number of usable fin-clip combinations is about 15. Some of the fin clips can cause excessive mortality (i.e. pectoral, anal); and should be avoided when possible., thus reducing resolution.

5. Accuracy and Precision.

Problems related to fin regeneration, natural tag loss, and tagging mortality affect the accuracy of estimates. Sampling for multiple fin clips, and recording this information properly is a tedious, and potentially error-prone process. Evaluation of these sources of error are necessary.

6. In-season Application.

Stock distinctive marks are readily identifiable at the time of sampling, so that the turn around time for applying data to inseason management could be less than a day. Because of this, fin-clips are uniquely suited for regulations requiring the hook and release of wild fish by fishermen. In this situation, all hatchery fish are clipped, so that wild fish can be identified by the absence of a clip. Thus, fishermen can that immediately identify and release wild fish. This wild stock preservation method has been applied to steelhead in Washington State. However, the application of this method to coho in Oregon and Georgia Strait has been rejected, because the assumed rate of hooking mortality for released fish would substantial negate the benefits to wild stocks.

7. Wild Stock Application.

As with other induced or applied juvenile marking methods, the task of capturing large numbers of wild juveniles for tagging is typically difficult or impossible, making widespread application to wild stocks impractical.

8. Application to Stock Composition Estimation.

Routine fin-clipping of entire hatchery stocks would be expensive in terms of labor and tagging mortality , thus accurate and verifiable hatchery production estimates are necessary to estimate production factors. The resolution potential is much lower than CWTs and different clips will have different tagging mortality rates. It is unlikely that fin-clipping will see major applications in the future.

B. Current Status of Method

1. What is Known Now

Fin-clip data have been historically used by both Canada and the United States to determine stock composition in almost every coho fishery in the Southern Boundary area. Tagging programs in the mid- to late 1960's demonstrated that fin clips can be used to estimate hatchery stock composition, however these programs have been largely replaced by CWT analyses. The entire 1983 brood Georgia Strait coho hatchery production was fin-clipped, providing an opportunity for a moderately precise estimate of Georgia Strait hatchery stock contributions to all fisheries sampled for fin clips.

2. Current Research Activity

None.

3. Research Needed.

None recommended

4. Funding.

None planned.

C. Implementation

1. Marking, Sampling and Data Analysis.

Marking is done at the hatchery facility. Fish are sedated and the proper fins are clipped using small scissors nail clippers. A sub- sample of fish are retained for at least several days to assess marking mortality. Tagging rates have varied from 7% to 100% of a hatchery's production.

2. Sampling

The use of fin-clips would require implementing a system of sampling, data collection and data interpretation. This could be integrated with CWT sampling, however, sampling of fin clips for the 1983 brood Georgia Strait coho was quite incomplete, suggesting that this is easier said than done. As with CWTs, the sample number always needs to be recorded to compute the catch/sample factor. Typically a 20% sampling rate is the objective of a fin-clipped sampling program.

2. Costs.

It costs approximately $600 to $1,000/day to operate a fin clipping crew. An experienced, average-sized crew might be able to clip about 50,000 fish per day.

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APPENDIX 1-A

STATISTICAL METHODS FOR IDENTIFYING STOCKS WHEN TAG RECOGNITION IS IMPERFECT

Marks involving two or more naturally occurring characteristics are not always perfect identifiers of a particular stock, but can be statistically associated with the specific stock that it most closely resembles using multivariate statistical methods. Stock classification will be in error some of the time. Typically, samples of known origin are used to test the 'classification success' of the mark recognition process. This is an important measure of the usefulness of an identification method, but it can be deceptive under some circumstances.

'Baseline' samples are collected for the purpose of determining a set of characteristics that can be used to identify each stock. These samples are collected from adult or juvenile fish taken in the freshwater habitat, or in a single stock terminal fishery. Failure to establish a baseline for all stocks that are actually intercepted in a particular fishery generates a bias in that fishery's stock composition estimate. This occurs because multivariate statistical methods will automatically place each fishery sample with an existing baseline stock. It is sometimes possible to find the presence of non-baseline stocks in a fishery sample using cluster analysis.

There is a trade-off between bias and precision (i.e. classification success) in multivariate methods. Classification success typical declines when a large number of stocks are included in the baseline. In addition, stocks making a small contribution to a fishery often have standard deviations greater than the percentage of contribution. It is a temptation for researchers to improve their classification success by arbitrarily limiting the number of baseline stocks or by creating a 'fishery sample' from a random sample of existing baseline data. Both of these practices allow potential biases to go unmeasured. Thus, it is important that methods using multivariate statistics are evaluated under circumstances that normally occur in sampling mixed stock fisheries.

Two multivariate statistical methods are currently used. These are the Maximum Likelihood Analysis and the Discriminant Analysis methods.

The maximum likelihood approach is somewhat analogous to the problem of estimating the parameters of a multinomial model. Maximum likelihood estimates for the probability that a fish from the mixed sample is of a specific characteristic can be obtained by maximizing the function

$$L = \prod_{i=1}^{G} p_i^{y} \qquad (1)$$

where p_i = the probability that a randomly chosen fish from the mixed sample will be of characteristic i;

y_i = the number of fish in the mixed sample with characteristic i;

G = number of characteristics.

The probability that a fish is of characteristic i can be written as a function of the stock composition and the probability that a fish from stock j has characteristic i,

$$p_i = \sum_{j=1}^{S} x_{ij} O_j \qquad (2)$$

x_{ij} = probability that a randomly chosen fish from stock j is of characteristic i;

O_j = probability that a randomly chosen fish from the mixed population is from stock j;

S = number of stocks.

Substituting equation 2 into equation 1 gives

$$L = \prod_{i=1}^{G} \sum_{j=1}^{S} x_{ij} O_j{}^{y} \qquad (3)$$

The probability that a fish from a given stock is of characteristic i (x_{ij}) can be estimated from the baseline data. Conditional on the estimated x_{ij}, the maximum likelihood estimates of O_j are found by maximizing the function L. Two techniques have been used, the EM Algorithm (Milner et al. 1981) and a generalized nonlinear optimization routine (Fournier et al. 1984).

Discriminant analysis utilizes the baseline data to define a set of rules by which each fish from the mixed sample can be assigned to a particular stock. If y_i fish are classified as stock i, then the composition of the mixed sample can then be estimated by maximizing the function

$$L = \sum_{i=1}^{S} \sum_{j=1}^{S} c_{ij} O_j{}^{y}$$

where

c_{ij} = the probability that a randomly chosen fish from stock j is classified as stock i;

Bias in estimates provided by either method may be estimated and corrected using simulation studies with known stock proportions.

Millar (1985) reviewed both methods of estimating stock composition and made the following general comments.

a) Discriminant analysis is a two step procedure in which each fish from the mixed sample is considered in isolation from the remainder of the sample. The maximum likelihood method is potentially more powerful in that information is gained by considering the mixture as a whole. (See also Fournier et al. 1984)

b) There has been insufficient experimentation with the two methods, under conditions likely to be found in practice, to recommend one method over the other.

APPENDIX 2
A REVIEW OF METHODS FOR ESTIMATING STOCK COMPOSITION IN COHO FISHERIES

I. INTRODUCTION

Stock composition estimates are needed for two fundamental management applications: (1) To plan harvest management and production strategies; and (2) To quantify interceptions by various fisheries.

A previous report of the joint Coho Technical Committee reviewed the methods for identifying different coho stocks in mixed-stock areas (Appendix 1). This report is the follow-up report that describes the statistical methods for making the actual stock composition estimates. It reviews the stock composition estimation methods derived from the stock identification methods previously discussed -- coded wire tagging, otolith marking, scale marking, scale analysis, otolith analysis, chemical marking, genetic stock identification, adult tagging, electronic tagging, and fin-clipping -- as well as reviewing stock composition estimates derived from simulation models that vary stock sizes and fisheries catches.

The stock composition estimation methods can be grouped into two general categories: those derived from perfect stock identification methods (coded wire tagging, adult tagging, and electronic tagging), and those derived from imperfect stock identification methods (everything else).

II. DEFINING THE PROBLEM

Before making a stock composition estimate, it is first necessary to define what the problem is; i.e., what are the fisheries, the time strata, and the stock strata for which the estimates will be made? Defining the problem thus involves three general steps: 1) Determining the appropriate years; 2) Determining the stock strata; and 3) Determining the time and area sample strata.

STEP 1. Determine the appropriate year or years you want to make stock composition estimates for. If an assessment of stock composition in previous years is desired, typically the years are defined as part of the assignment, and the results are reported as discrete annual estimates.

STEP 2. Determination of stock strata. Stock strata can be determined by statistical procedures or by previously defined management units. Usually, statistical and management approaches to identifying stock units are complementary, because management stock classifications are typically based on earlier evaluations of distributions, usually derived from tagging studies.

Distributions of different groups of coho are most easily estimated from CWTs, although theoretically any stock identification method can be used. However derived, the distributions for a single brood year can be organized into stocks using statistical methods. The statistical testing for differences in distributions can be performed using non-parametric methods on observed recoveries (see Hunter 1986, 1988) or parametric methods on the estimated recovery distributions (Webb 1986, Clark and Bernard 1987). No single method has gained usage as a standard tool for estimating variation. Most biologists are more comfortable with the use of estimated recoveries, since they represent a fundamental indication of stock contributions to catch. However, parametric estimates of variation for estimated recoveries are quite complicated and time consuming. By comparison, non- parametric procedures such as the

Chi-Square Test for Homogeneity and the Smirnov's Test for Two Independent Distributions (Conover 1980) are simple and easy to perform using observed recoveries. Hierarchial cluster analysis can also be used, although it is a measure of similarity rather than hypothesis testing.

Release groups can by grouped into stocks using any of the above mentioned methods on recovery distributions from the same brood year. Unless two release groups represent the same hatchery, differences in terminal time and area distribution can be expected. Usually it is the difference in preterminal area and time distribution that determines whether two release groups should be classified into the same stock. Hypothesis testing could identify too many stock strata for meaningful application. An alternate, and perhaps a superior statistical approach, is to run a hierarchial cluster analysis, or dendrogram, on the preterminal tag recovery distributions of release groups representing the same brood years. This method can identify appropriate clusters of groups with similar distributions that would best serve as stock units.

Previously defined management units can also be used to classify stocks. Many agencies already have defined stock definitions that are entrenched into the management process, and are inflexible to change. An obvious case where previous stock definitions would override observed similarity in distribution, is where tag codes representing stocks from two nations exhibit sufficiently similar distributions to justify placing them into the same stock unit; however, the application intent of the data precludes this action.

Step 3. Determination of Time and Area Sample Strata. To maximize accuracy and precision of an estimate derived from samples of unevenly distributed populations, stratification of samples should be determined with the intent of maintaining the uniformity of stock composition within each sample stratum.

Area sample strata are, to a large extent, already defined by the fishery catch areas, although it is possible to consolidate the existing area definitions. In a few cases, area strata can be expanded with subarea coding. Weekly, monthly and annual time periods can be used. Annual stock composition estimates could be biased, because stock composition in most marine areas changes over a period of several months, and, in the case of terminal areas, over a period of weeks. Similarly, stock composition estimates for large areas may be biased if the stock composition changes significantly within the area, and catch sampling rates are not uniform throughout the area. This would be a consideration in deciding whether, for example, the WCVI region should be examined as two areas (SWVI and NWVI), or as six areas (for the statistical catch reporting areas).

III. CWT-DERIVED[1] STOCK COMPOSITION METHODS

Coded wire tags (CWTs) provide perfect stock identification, because stock identification can be determined precisely for all fish with that tag (unless the tags are misread). For this method, stock composition for a stock is estimated generally as:

$$\% = (R * PF) / C$$

where % is the percentage of the catch made up of that stock, R is the number of tag recoveries for that stock in a fishery, PF is an expansion factor to account for untagged production attributed to that stock, and C is the catch of all stocks in that fishery.

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1 To the extent that fin clipping and chemical marking can identify stocks precisely, this section also applies to those stock identification methods.

The expansion factor PF (usually called the "production factor") can be calculated in different ways, depending on the stock identification method, and the method of analysis chosen.

A. Direct Calculation of Production Factors.

One way to generate CWT-derived stock composition estimates is by estimating production factors directly from production or sample data. Production factors are values that expand the tag recoveries in a fishery for the untagged production attributed to that stock, thereby converting the distribution of estimated tag recoveries into stock catch distributions. In its simplest form, the production factor (PF) for stock (i) is the sum of the tagged production (t) and untagged production (u) divided by the tagged production.

$$PF_i = (t_i + u_i)/t_i \qquad \text{Eq. 1}$$

The catch of stock i in fishery stratum j is:

$$c_{ij} = r_{ij} * PF_i \qquad \text{Eq. 2}$$

Where r is the number of estimated tag recoveries.

Five methods of estimating production factors are described herein. The first four methods rely on tagged and untagged production statistics; the last method does not. Stock composition estimates must often rely on two or more of these methods because the available data resources differ from stock to stock and from year to year. These methods are discussed in sections 1 through 5 below, with adjustments to the estimates described in 6 below:

1. Association and Allocation. This method applies primarily to hatchery production, and, as described here, would be used when the preterminal distributions vary for each tag group in a stock. Association is the process of assigning untagged production to the tagged production (ie., a specific CWT code) that is assumed to best resembles it in terms of marine catch distribution and survival. The concept of association has been used in many stock composition estimates (ie., Swain unpublished, Hunter 1985), however the equations herein represent detailed approach developed by Lapi (unpublished) to facilitate computer-based construction of stock composition estimates and minimize subjectivity. Allocation, which should not be confused with allocation as it applies to dividing resource shares among competing fisheries, is the process of dividing an untagged production unit to more than one associated tagged production unit for representation of distribution and survival.

    Association. The untagged production must be associated with a tagged production unit with the same primary criteria, in another words, the same species, stock and brood year. If an untagged release cannot be associated with a tagged release of the same primary criteria, then the production of this untagged release cannot be represented by association methods. Secondary criteria, specifically hatchery of origin, release site, size at release, date of release, run type (ie., Spring or Fall, Early or Late) and release size are known to affect marine distribution and survival.

    To put the problem in numerical form, assign these secondary criteria to an array (k; k = 1 through 6, where 1 represents hatchery of origin, etc). The difference between a tagged release and an untagged release is defined by six distance functions $d_k(M_k,L_k)$, where M designates a specific marked release group and L represents a specific unmarked release group. The exact formulation of these distance functions must be determined by the user of the program. In addition, each criteria are assigned relative weights (Wt_k) which represent the relative degree of importance in how each criteria affects marine distribution and/or survival. Determining W can be aided by comparisons of tag codes representing the same species, stock and brood year, but with different criteria. However, numerical determination of W will be subjective in most cases.

The total distance (D) between a tagged release (m) and an untagged release (l) is:

$$D_{ml} = \sum_{k} Wt_k d_k(M_k, L_k) \qquad \text{Eq. 3}$$

Untagged releases are associated with the tagged release with which it has the lowest distance index (D). If there is only one tagged release to represent all production for a stock, then all the untagged releases will be associated to it. Given an array of untagged releases (l), the production factor (PF) is:

$$PF = (t + \sum_{l} u_l)/t \qquad \text{Eq. 4}$$

A variation of this equation assumes that different survival rates between the tagged release and the untagged release exist, and the relative difference in survival rates are known. S is a survival factor and s_m and s_l are the survival rates of associated tagged and untagged productions respectively:

$$S_{ml} = s_l/s_m \qquad \text{Eq. 5}$$

The production factor becomes modified as:

$$PF = [t + \sum_{l} (S_l * u_l)]/t \qquad \text{Eq. 6}$$

The advantage of implementing the survival factor (S) is that association can be made on the basis of similarities in marine catch distributions alone, rather than both distribution and survival. Survival rates of untagged release groups cannot be assessed directly, however historical CWT data may allow reasonable estimates of survival rates. For example, Hunter (1985) noted that the survival rates of coho released from hatcheries in the lower Columbia River (Grays River, Elokomin) were typically less than those hatcheries further from the mouth of the River (Cowlitz, Washougal, Lewis) and weighed the production of untagged releases from the lower river facilities by half.

More typical is a situation of a stock represented by multiple tagged releases and multiple untagged releases. In this case, there will be an array of tagged releases (m) and arrays of untagged releases (l) associated with each element of the m array. The production factor for each tag code is:

$$PF_m = [t_m + \sum_{l} (S_l * u_l)]/t_m \qquad \text{Eq. 7}$$

And the total catch of stock i in stratum j is:

$$c_{ij} = \sum_{m} r_{jm} * p_m \qquad \text{Eq. 8}$$

The composition of stock i in stratum j would then be simply the c_{ij} divided by the total catch in that stratum.

Allocation. Simple association of the each untagged release to a single tagged release will satisfy most applications. However association of each untagged release to more than one tagged release can be desirable under some circumstances. When one tagged release is associated with a large number of untagged releases, a high production factor is generated, and the distribution of one tag code is given excessive weight in representing the overall catch distribution of the stock. As a result, the high variability affects the final stock catch distribution, and is desirable to associate the untagged unit to more than one tagged unit.

Another situation is where a cluster of tag codes are so similar that there is no basis for assigning them different production factors and weighing them differently in generating a final catch distribution. Some determination of criteria for what the minimum distance (D) or maximum production factor (p) warrants multiple allocation of untagged releases to tagged releases. A formula for allocated production factor is:

$$PF_m = [t_m + \sum_l (A_{ml} * S_{ml} * u_{ml})] / t_m \qquad \text{Eq. 9}$$

Where l is an array of all untagged releases of stock i, and A is the allocation fraction. Each untagged release must be fully allocated to tagged releases. In other words, for every untagged release l;

$$\sum_m A_{ml} = 1. \qquad \text{Eq. 10}$$

For unassociated tagged and untagged releases, A = 0. Three ways of allocating untagged production to associated tagged production were discussed by Lapi (ibid). First, allocate each untagged group on the basis of the number of tagged releases in each of the associated tagged groups. The array n is a subset of m representing only those tagged releases associated with untagged release l:

$$A_{ml} = t_m / \sum_n t_n \qquad \text{Eq. 11}$$

Secondly, allocate on the basis of the tagged release group production. In other words, the sum of the tagged release and the untagged releases that represent identical production units (D = 0). T_n and U_n represent those tagged production units associated with untagged release l:

$$A_{ml} = (t_l + u_l) / \sum_n (t_n + u_n) \qquad \text{Eq. 12}$$

Finally, allocate by equally weighing each tagged release regardless of the number of fish tagged in each, or the production of each. Let N be the number of tagged groups that are associated to untagged group l.

$$A_{ml} = 1/N \qquad \text{Eq. 13}$$

The A_{ml} would be substituted into Eq. 9 above to estimate the production factor, and the stock contribution to the fishery catch would be estimated from Eq. 8 above.

2. Uniform production factors. Is there really enough variation in preterminal distribution of different tagged releases of a stock to justify a detailed association analysis? If not, the maximum precision in the stock distribution estimate is achieved by weighing every tag recovery equally. This method is simple to apply when there is a credible estimate of the total terminal run and the tagged terminal run (ie., Eq. 1). This method could be used for wild and/or hatchery stocks. If hatchery release statistics are used to estimate a uniform hatchery production factor, and realistic assumptions concerning the survival of each tagged and untagged production unit can be made, then it is still possible to compute a uniform production factor. The uniform production factor for stock i is:

$$PF_i = (\sum_m t_m + \sum_l u_l) / \sum_m t_m \qquad \text{Eq. 14}$$

And the catch of stock i in fishery stratum j is:

$$c_{ij} = PF_i * \sum_m r_{ijm} \qquad \text{Eq. 15}$$

3. Add-on Wild stock production factors. Often, a stock unit is composed of a hatchery release groups, some of which are tagged, and untagged wild production. Wild production is often assumed to have a similar distribution to hatchery production, but it is desirable to verify this by concurrent tagging of the hatchery and wild components for one or two brood years. Production factors for the hatchery component (PF_H) can be estimated by techniques described in sections 1 and 2 above using hatchery release data. Untagged wild production is usually associated with tagged hatchery releases with a second production factor. Since wild production is typically measured in terminal runs or escapement, and the hatchery production must be measured in the same units to estimate PF_{H+W}:

$$PF_{H\&W} = PF_H * (H + W)/H \qquad \text{Eq. 16}$$

Where H and W are units of hatchery and wild production, respectively.

The catch of stock i in stratum j can then be recomputed to include wild production:

$$c'_{ij} = c_{ij} * PF_{H\&W} \qquad \text{Eq. 17}$$

4. Production Factors estimated by subtraction. This method is a means of estimating production factors when there are virtually no reliable production statistics by which to derive direct production factor estimates. This method assumes that production factors and catch distributions for all nearby stocks have been estimated. By selecting an appropriate fishery, preferably a terminal area fishery where the catch is predominately of the stock of concern, the tag recoveries of other stocks recovered in this fishery can be expanded and the catch attributable to these other stocks can be subtracted out of the catch. The assumption is that the remaining fish in the catch are of the stock of concern. By taking the total estimated tag recoveries in this fishery and dividing into the remaining catch, a uniform production factor is derived. Lets say that stock i is intercepted in large numbers in terminal fishery j. A limited number of tag recoveries of other stocks (o) have been expanded using methods in sections 1, 2 and 3 above, thus the estimated catches of these other stocks have already been computed. A uniform production factor for a stock can be computed as:

$$PF_i = (c_j - \sum_o c_{oj}) / \sum_m r_{ijm} \qquad \text{Eq. 18}$$

c_j is the true total catch in stratum j, as derived by fish ticket estimates. In this equation m is the set of CWT codes representing stock i. The contribution of stock i to the catch would then be estimated from Eq. 8.

In situations where there are no CWTs from a region, production factors cannot be estimated for that stock. In such cases, if there are no other stocks without CWT groups in the catch, then the contribution of the untagged stock would have to be estimated by subtracting out the contributions associated with all the tagged stocks. This subtraction method is obviously a last resort, and has the drawback that contributions estimated by subtraction (which could be estimated as negative numbers) cannot be independently confirmed.

5. Exploitation Rate Evaluation. When there is no terminal sampling for coded wire tag recoveries representing a particular stock, or data on tagged fractions in the smolt out-migration of that stock, it is impossible to use any of the above techniques. However if an estimate of the total stock terminal run is available, and the adult survival rate (ie, survival from the time of from stock recruitment to the time the stock enter terminal areas) can be estimated or extrapolated from adjacent and similar stocks that are tagged and have terminal fisheries, it is possible to make an assumption about the exploitation rate of the stock of concern. As with the previous method, this method should be regarded as a last resort. Given a terminal run (TR) and a adult survival rate (AS), and an estimate of all the preterminal estimated tag recoveries for the stock of concern ($\Sigma \Sigma R_{jm}$), the production factor can be derived as:

$$PF = TR((1/AS)-1)/\sum_j \sum_m r_{jm} \qquad \text{Eq. 19}$$

6. Adjustments to Stock Composition Estimates. When stock composition is estimated by any method except subtraction, the contribution of each stock to a fishery should be summed, in order to determine how much of the catch is accounted for (it may be more than the actual catch), and whether there may be biases in the production factors used. If unexplainable results are obtained, it may be necessary to adjust the stock composition estimates as follows:

Evaluation and Revision. Evaluation can be done for any time and area stratum where it can be assumed that all stocks that are intercepted in the fishery are accounted for in the stock composition estimates. When this assumption can be made, an independent estimate of the total catch is derived for each stratum by summing the individual stock catches for that stratum. By comparing this derived total catch with the actual total fishery catch the credibility of the model can be examined.

Because stock composition estimates have many potential sources of error and variation, the derived catch should normally deviate above or below the true total. These sources of error and variation include random variation in the frequency of tagged recoveries, catch/sample variability, error in handling of the sample and tag recovery data, bias as a result of non-random fishing within a stratum, bias as a result of non-random sampling of a catch, and error in the estimate of production factors.

When a whole series of derived catches from adjacent time and area strata are consistently above or consistently below the actual catches, errors probably exist in the production factors of one or more stocks present, and re-evaluation and corrections are in order. If a substantial deviation occurs in an individual stratum, a singular error in the sampling count or catch estimate might be suspected. When concurrent fisheries with similar stock composition show consistently different deviations (let's say the sport fishery had $e_i >> 0$ for several adjacent areas and time strata and the troll fishery had $e_i << 0$ for the same time and area strata), a systematic bias in the sampling procedure or catch estimate procedure can be suspected.

Scaling derived catches to match the true catches. The production factors may also be adjusted in order to scale the stock catches in each stratum such that the derived total catch of each stratum is equal to the true total catch. This is an optional step, and cannot be performed in time and area strata for which untagged or unaccounted stocks are believed to be present. This step does not change stock composition estimates in any transformed strata, but does change the stock distributions. Models such as the 1976-8 Brood coho model (Hunter 1985) did not transform the data in this manner. Other models, such as the Puget Sound Run Reconstruction database (Zilges 1975), do make these adjustments.

The advantage of this step is that the total catch in each stratum reflects the actual catch in the base period, resulting in consistent catch figures between the model and the catch database. It could be argued that transforming the data to match the actual catch would result in more accurate estimates of stock distributions, because the derived catch is an estimate that is the product of many sources of variability and bias, whereas the actual catch is usually a real value derived from fish ticket information. Thus, transforming the data may reduce the error in the stock distribution estimates. The case against transforming the data is that stock catch distributions, as estimated from CWT data, are changed. If a model is reviewed at a later time for its validity, the consistency of the stock distribution in the model with the actual CWT data it was derived from would be examined.

In summary, computing production factors for each separate CWT group by using Association and Allocation is a time-consuming procedure that provides improved precision only when different components within a stock have significant differences in preterminal distributions. If this is not the case, the Uniform Production Factor would be a sensible approach, because the maximum precision in distribution would be achieved by weighing each representative tag recovery equally. The Chi-Square Test For Homogeneity applied to the observed recoveries can be used to decide which technique to use. Methods 4 and 5 may need to be applied as deficiencies in the production data arise.

B. Simultaneous Linear Equations.

This is one of several mathematical methods for estimating production factors. These methods differ from previous methods in that they require only the tag recovery data, the sample data and the catch data. These methods are ideal for situations where information necessary to estimate production factors is non-existent or of poor quality.

In the first method, modified slightly from an proposal by Shaul and Clark (1987), production factors are determined by simultaneous linear equations. The following requirements must be satisfied for this method:

i) All stocks caught in any of the sample strata (eg., fishery) must have representative tagging (or assumptions must be made to associate untagged production with tagged production).

ii) Stocks must be uniformly distributed within each sample stratum or the sampling rate must be uniform for all sub- components within each sample stratum.

iii) The sample data and catch data for each sample stratum must be unbiased.

iv) All tag codes representing a single stock should have similar distributions.

v) There must be an equal number of fisheries strata and stocks.

This method calculates a production factor for each stock, defined simply as PF_i. Production factors can be estimated through the use of simultaneous linear equations:

$$[R] * [PF] = [C] \qquad \text{Eq. 20}$$

The solution for [PF] is:

$$[PF] = [R]^{-1} * [C] \qquad \text{Eq. 21}$$

Where $[R]^{-1}$ is the inverse matrix of [R].

The computation of inverse matrices is best done by computer. Most microcomputer spreadsheets have functions for inverting and multiplying matrices. Those who need an introduction to matrices should consult a textbook on the subject, such as Searle (1980).

The computed values of [PF] can be applied to other sample stratum for which all intercepted stocks are not tagged to get a partial estimate of stock composition.

C. Multiple Linear Regression.

The Shaul and Clark (ibid) method is limited to problems were the number of fisheries strata are equal to the number of stocks. For most applications, this would call for a substantial consolidation of sample strata, potentially introducing sufficient bias that requirement ii) cannot be satisfied.

However, Shaul and Clark's concept can be extended in a multiple linear regression form. The requirements are the same as in the simultaneous linear equation method, except for (v), which would change to "there must be a greater number of sample stratum than stocks". The basic equation for a multiple linear equation is (Draper and Smith 1966):

$$Y = b_0 + b_1X_1 + \ldots + b_nX_n + e \qquad \text{Eq. 22}$$

Where Y is the dependent variable, X_i are the independent variables, and e is the error.

The equivalent expression for sample strata i using terms established in the previous sections is:

$$c_j = PF_0 + PF_1r_{1j} + \ldots + PF_zr_{zj} + e_j \qquad \text{Eq. 23}$$

Where z = the total number of stocks.

When there are no recoveries in a sample stratum (ie., all values of r = 0), then $c_i = 0$, because all stocks are supposed to be tagged. Thus, by definition, $PF_0 = 0$:

$$c_j = PF_1r_{1j} + \ldots + PF_zr_{zj} + e_j \qquad \text{Eq. 24}$$

In regression jargon, this is called "forcing the y-intercept through the origin".

An estimate of [PF] can be solved for by the following matrix equation (Draper and Smith ibid, p. 44):

$$[PF] = [R]'[R]^{-1} * [R]'[C] \qquad \text{Eq. 25}$$

Where [R]' is the transpose matrix of [R].

Unlike the simultaneous linear equation method, this solution is imperfect. If the estimated values of [PF] are applied to Eq. 24 for sample stratum i, and e_i were solved for, we would find that, with few exceptions, $e_i <> 0$. For the simultaneous linear equation solution, variability is not measured and must be estimated by experimental methods (DeLibero 1986) or by sampling theory methods (see Shaul and Clark ibid, Clark and Bernard 1987). Multiple linear regression allows for a measure of error about the production factor estimate (i.e., standard error of slope).

Application of the multiple linear regression method can be subjected to several refinements:

1) Evaluation of the sample strata. There is a potential for error in the tag recovery, sample and catch data. It is generally impractical for stock composition estimators to familarize themselves with the problems and potential errors in every sampling program from California to Alaska. However, it is possible to review the data for anomalies. Perhaps a criteria for detecting suspicious data (eg., when $ABS(e_i/c_i) > 30\%$) should be established, such that the sample stratum data would be discarded from further analysis, or undergo review for errors.

2) Weighting of sample strata. In conventional regression, each observation (ie., sample stratum) is weighed equally. Draper and Smith (ibid, Sec 2.11) discusses a means of weighing observations. The concept could be applied to this situation in the following manner. A diagonal matrix S, where the diagonal elements $\{s_1 \ldots s_n\}$ are the actual sample sizes of sample strata 1 through n:

$$[PF] = [R]'[S][R]^{-1} * [R]'[S][C] \quad \text{Eq. 26}$$

D. Linear Programming.

Methods for estimating stock composition by linear programming are described in Appendix 4. Basically, linear programming estimates stock composition by finding the set of production factors that, when applied to the observed tag recoveries in all fisheries, minimizes the total difference between the observed catch and the calculated catch, subject to the constraints specified (e.g., production factors can't be negative, or catch cannot exceed the reported catch). The contribution of each stock to a fishery catch is estimated by multiplying the estimated production factors for each stock by the estimated tag recoveries for that stock in the particular fishery.

Because the application of linear programming to stock composition estimation is described in detail in Appendix 4, and in the text of the report, it will not be covered further in this appendix.

E. Simulation Modelling.

When stock composition for a particular year cannot be estimated directly from available data, or when it is desired to analyze the stock compositions that would be expected to result under different combinations of fisheries and stock abundances, stock composition can be calculated from simulation models. These models use, as input values, historical estimates of stock composition or fishery exploitation rates from years when sufficient data existed to use direct estimation methods.

The models rely on assumptions concerning migration, natural mortality, shaker mortality, and growth. The models can also provide a means of estimating stock compositions particularly for years that are different from the years used for calibration.

The models entail two distinct processes: (1) backwards calculation (a form of cohort analysis), often called the calibration phase; and (2) forward calculation (often called the regulation phase).

The backward calculation phase reconstructs the exploitation pattern, migration, and population size from the time of spawning backwards to the time of recruitment for the base input year(s) of the model. By expanding the estimated CWT recoveries of each stock in each fishery by the production factor for that stock, the catch of each stock in each fishery, the escapement, and estimates of natural mortality and fishery-induced mortality can be calculated and summed to get the population at the end of the previous time interval. From this process, exploitation rates (defined here as the catch divided by the total population alive during a particular time interval, not as the catch divided by population present in that area) for every stock in every time and area stratum can be computed by dividing the total catch by the population by the population at the end of the previous time interval. The number of exploitation rates that are computed from this process is the product of the number of areas, time intervals, and stocks.

The forward calculation phase is the application phase. The effects of changes in stock recruitment can be evaluated by scaling the initial population size up or down to match the estimated recruitment for a selected season. The effects of changes in the fishing effort, or changes in fishing quotas can be modelled by scaling the exploitation rates up or down. Given this control over the initial population of every stock and the exploitation rate in every time and area stratum, many potential management scenarios for the season can be tested.

Stock compositions would be estimated from results of forward calculations. Since the model would calculate the catch of each stock in each fishery for each time period, the stock composition for a particular time period would be calculated by dividing the modelled stock-specific catch in a fishery, by the total catch during the time period for that fishery.

The Model Base Period. The model base period is the period of years from which the stock composition data and fishery effort patterns are modelled. The model base period is an important concept, because changes in effort in every time and area stratum must be estimated in terms of the relative change from the base period average effort.

However, if a simulation model is the intended application of the stock composition estimates, a picture of stock distribution that will give you the best base period for future years must be developed. Typically, a multiple year average is desired. The following criteria should be considered:

A. Years of abnormal stock distributions should be avoided. The 1983 catch year, when the 'El Nino' current skewed the ocean distribution of many southern coho stocks, should be omitted from most multiple year base periods.

B. Each year included in the base period should have representative CWT releases from every stock. This is not always possible, but years in which many stocks are not tagged should be avoided.

C. It is desirable to choose base period years with long fishery seasons to get representative tag recoveries for as many strata as possible. This will make the resultant simulation model flexible to more season options.

D. In the absence of other guiding criteria, a large number of years should be included into the base period to achieve the best representation of stock composition.

In most cases, it is advisable to use an average of more than one year as the model base period, in order to smooth out normal variability between years. The averaging would be done by calculating the average stock-specific catch for each fishery, and calculating the exploitation rates that would result from average stock abundance. An average stock catch can be based on stock composition averages (SC_{ij}) or over the entire base period (SI_{ij}). Let c_{ijy} represent the catch of stock i in stratum j in year y, and c_{jy} represent the total catch in stratum j in year y:

$$SC_{ij} = (1/y)^2 * (\sum_y (c_{ijy}/c_{iy})) * (\sum_y c_{jy}) \quad \text{Eq. 27}$$

$$SI_{ij} = (\sum_y c_{ijy}) / (\sum_y c_{jy}) \quad \text{Eq. 28}$$

The first expression weights the stock composition estimates in each year equally regardless of the total catch, and the second expression weights the stock composition estimate of each year according to the size of the catch in that year. SI is most appropriate for long-term evaluations, because it reflects a average annual rate of interception. SC is most appropriate for simulation model applications, because it projects the best estimate of stock composition for future applications.

A complication may arise in the computation of SC when the sample in one year is either lacking or deficient as a result of poor sampling or the absence of catch. One solution is to simply average the years in which sample does exist for that stratum. Another solution is to utilize stock composition estimates from an adjacent sample stratum in the year where sampling was deficient, preferable the same area, but a different time or gear.

Model Requirements. Some major requirements need to be satisfied by assumptions, because it is difficult to measure and model migratory behavior, or to predict the future environmental conditions and regulatory regimes. Fishing fleet dynamics can also be unpredictable; for example, the effort levels may be different from what was anticipated, or the fleet may concentrate in different parts of a catch area. Major assumptions would be:

a. Stock recruitment can be accurately predicted.

b. Fishing patterns can be accurately predicted.

c. Stock catch distributions can be derived from the same base periods. Difficulties arise when a stock is untagged during the model base period. For some applications, it would be sufficient to say that the composition of the untagged stock in each of the fisheries being examined is unknown, and each of the fisheries would have catch remaining after all the tagged stocks are subtracted out, which is identified as of unknown origin. However, some management applications require an estimate of stock composition for every brood year. There are several options:

   1. Merging Stocks. The untagged stock is merged with another stock that is most similar in distribution, and the production factors are computed for the combined stocks. This, however, may not be a reasonable alternative for some applications. Distributions, especially in the terminal areas, may differ significantly between the untagged and tagged stocks.

   2. Utilizing the distributions from another year. If the untagged stock is tagged in another brood year, data from this other brood year could be utilized. However, fishery patterns invariably change from year to year and unrealistic estimates of the stock catch distribution result by directly utilizing tag data from another brood year. A variation of this approach is to 'simulate' the CWT data from another brood so that the catch distribution reflects fishery patterns in the untagged brood year. This is a complicated procedure that requires a number of assumptions.

   3. Interpolating the distribution from similar stocks. Tag distribution data from similar or adjacent stocks in the same brood year would be used to serve as a template to the untagged stock. With some exceptions, coho stocks of similar or adjacent geographic origin have similar time and area distributions. If the similar or adjacent stocks and the untagged stocks are represented by tagged releases in one or more other brood years, cluster analysis can be used to identify the combination of other stock distributions that best resemble the untagged stock. Then the untagged stock can be represented by same year stock distributions of adjacent and similar stocks by using the combination formula identified by cluster analysis. Stock composition of the untagged stock in terminal areas cannot be accurately estimated by this method. Terminal area stock composition is best estimated by subtraction. This template approach proved to be satisfactory in constructing a distribution to represent Skagit River coho (Hunter 1986) and is recommended for other applications as well.

   4. Estimating Stock Distributions By Using Consistent Differences or Similarities Between Stocks. This approach is a corollary to that described in (3), but would be more complex. First, stock distributions would be examined to identify consistently observed relationships between the distributions of the stock in question and those of other stocks. Available data on the distribution of adjacent stocks could then be employed to develop a distribution for the stock of interest by inference.

d. Stock migration behavior is accurately modelled, and does not vary from that observed in the base years. Even if it did not vary from year to year (which it seems to do), our understanding of stock migration would still be inadequate because most tag recovery data has one point of capture. Adult tagging data often yield two points of capture, providing limited insight on the migration, dispersal, and speed of migration for coho salmon. Systematic quantification of migration behavior is beyond current data resources; however, some general inferences can be derived from existing adult tagging data. For instance, we know that coho tagged in Puget Sound and Georgia Strait were inclined to remain in those areas until they migrate to the rivers, whereas coho tagged in the Juan de Fuca Strait during the winter were often captured in the ocean fisheries the next summer.

The accuracy of model estimates, and its degree of adherence to the assumptions, can be tested by comparing modelled stock composition estimates to stock composition estimates derived by independent means. Variability, however, is not practical to calculate directly because of the complexity of most models. Monte Carlo methods can be used to test the effects of variability about each input variable or about all input variables simultaneously. Sets of input values can be generated randomly within the range of variation believed to be typical for those values, and iteratively tested in the model to see how much the output variables are affected. This procedure can be time consuming, and it is not likely to be performed on a routine basis; however, it has been applied to test long-term model sensitivity of exploited chinook stocks (Reidinger 1987).

<u>Current Simulation Model Applications.</u> Two major coho models are currently in use in the Southern U.S. region. The Puget Sound Net Fishery Run Reconstruction model has been used to model the net fisheries since 1974 (Zillges 1974, 1977). It reconstructs the commercial run size of coho stocks entering the Juan de Fuca Strait, but does not attempt to model the impact of the ocean fisheries, Canadian fisheries, or the Puget Sound Sports fishery. The model is based on stock composition data from fin-clipping from the 1969-1971 period and adult tagging studies. Despite the antiquity of the original input data and some concerns about the quality of that data, it is still used for preseason and inseason management and allocation planning for the Puget Sound Net fisheries. A form of this model, called "The Coho Minimodel", includes input ocean and Puget Sound sports catches, and is used to model inseason allocations.

The other major model used in Southern U.S. coho management is the NBS/WDF 1976-78 brood coho model (Hunter 1985), and its microcomputer derivatives. These models incorporate 25 stocks from Central Vancouver Island to Northern California and all major marine fisheries from SE Alaska to Central California. These models have been used for ocean preseason management planning since the early 1980's. They have also been applied to Puget Sound fisheries. A number of microcomputer derivatives of the WDF/NBS model have been developed (Hunter 1986); the WDF/NBS model has been converted from a mainframe FORTRAN program to a microcomputer spreadsheet program called CAM (Coho Assessment Model). Special application models that are offshoots of CAM include a tribal allocation model for South Puget Sound called SPS (Morishima and Mobrand 1986), a minimodel to assess the effects of directed net fishery harvest regimes in North Puget Sound and the Canadian Juan de Fuca Strait (Hunter 1987), and a coho rebuilding and allocation model (CARE, Scott 1989).

<u>Potential PSC Applications.</u> If the Pacific Salmon Commission needs a model for evaluating prospective Southern Boundary management options in the near future, there will be a need for developing the input data and programming for a new simulation model. The new model should be a bilateral effort, to maximize acceptability of its applications. Research is needed to improve and verify the quality of data utilized by the models. Many of the research needs discussed for CWTs (Appendix 1) apply equally to simulation model development. Techniques for determining and verifying production factors and associating untagged production to tagged production need to be developed. Hook and release mortality rates, natural mortality rates, drop-off mortality rates, and net drop-out mortality rates are imprecisely known. Currently some management fora have negotiated assumed values for these mortality rates; however, there is no coastwide consensus on

them. More research would be desirable; however, past research has found mortality rates difficult to estimate, and further research should be attempted only if experimental designs can be improved over previous efforts.

The cost of constructing a model would vary depending on the size of the model (i.e., the number of stock strata and fishery/time strata), and the number of individuals and agencies participating in the development of the model. The development of a PSC-formatted database that can quickly retrieve catch data, CWT sample data, CWT recovery data, and hatchery release data will greatly facilitate the model development and reduce costs. The costs of constructing the model program is primarily the labor of one individual or a small group. Spreadsheet models can be constructed in a few days to several weeks, once the program structure has been agreed upon. The cost of using the model would be insignificant if the model were based in a microcomputer. Models based on a main frame program can be more costly; for example, the 1976-78 brood WDF/NBS coho model cost as much as $10,000 per year in computer expenses, and a substantial amount of labor to operate and maintain (Hunter, pers. comm.).

IV. ADULT TAGGING

Adult tagging (Appendix 1) was originally used to determine migration routes of salmon, but has also been used to estimate stock composition in mixed-stock fisheries (Anon. 1963; Bourque and Pitre 1972; Fiscus and Jewell 1973). In general, however, these analyses used only raw recovery numbers to estimate stock composition, and did not consider sampling rates.

In order to estimate stock composition from an adult tagging study, all terminal regions that produced fish that were caught in the tagging area should be sampled. The simplest case would be where all terminal regions are adjacent to the tagging area. In this case, the contribution of one region to the tag area catch would be the number of tags that reach that terminal region, divided by the total number of tags that reach all terminal regions. Since the number of tagged fish that reach one terminal region would be given by:

$$T_1 = m_1 * N_1 / n_1$$

where T_1 is the number of tagged fish reaching region 1, m_1 is the number of tags recovered in that region, N_1 is the run size to region 1, and n_1 is the number of fish sampled in region 1

Then the contribution of region 1 to the tagging area ($\%_1$) would be:

$$\%_1 = T_1 / \sum_i T_i$$

The stock composition in the tag area could be further broken down by time period by substituting into this equation the recoveries only of fish tagged during the designated time period:

$$\%_{1t} = T_{1t} / \sum_i T_{it}$$

where t is the period of concern in the tagging area. Note that the sampling expansions remain the same.

To avoid bias, the general sampling assumptions described in Appendix 1 apply to adult tagging. The assumptions that run sizes are estimated consistently, and that sampling is done randomly in all contributing regions, are especially critical for adult tagging, because the stock composition estimate is nearly a direct proportion of the run size estimate and the tagged fraction in the sample. Additional requirements critical to adult tagging are:

1) The gear used to capture fish for tagging must capture the same composition of stocks as the gear used in the actual fishery.

2) There must not be any region-specific differences in mortality or tag loss as fish migrate from the tagging area to the recovery areas. Tag loss is an especially acute problem for adult tagging studies. A high rate of random tag loss may not bias the estimate (although it would increase the variability and cost of the study), but differential tag loss would cause underestimates of the contribution of the stock that differentially loses its tags. Peterson disk tags are especially prone to removal in gillnet fisheries, which would cause bias against stocks that migrate through these fisheries.

3) Tagged fish must move to their terminal areas without being differentially harvested in other mixed-stock areas, or, if they are, then the catch in the intervening mixed-stock areas must be sampled for tags, and the tags recovered (and the untagged fish represented by those tags) must be apportioned reasonably accurately to the appropriate terminal region. In such a case, the N_1 given in the above equations would represent the stock's run size entering the adjacent mixed-stock area, not the terminal run size. Violation of this requirement would cause the same bias as differential tag loss (described above). This requirement creates particular problems with stock composition estimates derived from adult tagging, because most areas where composition data are desired are adjacent to intervening mixed-stock fishing areas, for which the stock composition is not accurately known.

V. ELECTRONIC TAGGING

Electronic tags include radio tags, acoustical tags, and PIT tags (Appendix 1).

Because radio tags and acoustical tags must be applied to adult salmon, stock composition estimation from these tags would use the same methods as are used for adult tagging. Radio tags, however, do not transmit in salt water, and acoustical tags, which have relatively short battery lives, would be difficult to track in streams.

PIT tags (Passive Integrated Transponder tags, which are embedded with a microchip - see Appendix 1) can be applied to either smolts or adults, and last the lifetime of the fish. If applied to smolts, stock composition would be estimated by using the same methods as are used for CWTs. If applied to adults, the stock composition estimation method would be the same as that used for adult tagging.

VI. IMPERFECT METHODS OF STOCK IDENTIFICATION

With CWTs and adult tagging, it is possible to identify the stock of each tagged fish that is recovered. With many other stock identification methods, however, it is possible only to compute the probability that a fish belongs to a particular stock. Because these methods do not identify the stock of individual fish with certainty, they are classified as imperfect methods of stock identification.

Imperfect methods of stock identification include Genetic Stock Identification (GSI), scale analysis, and otolith analysis. It may be that at some future date, otolith patterns will be induced that are uniquely distinct for each stock (which would make induced otolith marking a method of perfect stock identification), but at the present time, stocks cannot be identified with certainty for any of these methods.

For all of these stock identification methods, stock composition would be estimated by using multivariate statistical analysis. The two multivariate statistical methods currently used are Maximum Likelihood Analysis and Discriminant Analysis. Both of these methods estimate stock composition as the probability that a randomly chosen fish from the catch sample is from a given stock. These methods are described in more detail in Appendix 1.

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Glossary of Algebraic Expressions.

A — Allocation Factor. The proportion of an untagged production unit (l) allocated to a tagged production unit (m).

AS — Adult survival rate. Survival from the time of recruitment to the time a stock enters the terminal area. Eq. 19 only.

b — Generalized y-intercept or slope terms for a multiple linear equation. Eq. 25.

c — Catch in a specific sample stratum. A single subscript refers to the total catch in a sample stratum (j), and a second subscript refers to the catch of one stock (i) in stratum (j). Eq. 2.

c' — Stock Catch adjusted for wild production only. Eq. 17 only.

[C] — Catch vector with elements of c_j. Eq. 20.

d — Distance functions for association criteria. Eq. 3.

D — Distance index for associating untagged production with tagged production. Eq. 3.

e — Error term for a multiple linear equation. Eq. 22. In an applied situation, it is the difference between the total catch in a sample stratum and the sum of the computed stock catches for that stratum. Eq. 24.

H — Total hatchery production. Eq. 13.

i — Stock subscript Eq. 2.

j — Sample stratum subscript. Eq. 2.

l — Untagged production subscript or the array of untagged production units for stock i. Eq. 3.

m — Tagged production subscript or the array of CWT production units representing stock i. Eq. 3.

n — The array of CWT codes associated with untagged production unit l. n is a subset of m. Eq. 11.

N — Total number of CWT codes associated with untagged production unit l. Eq. 13.

o — Array of 'other' stocks, excluding the stock for which production factors are estimated. Eq. 18 only.

PF — Production Factor. Subscript may refer to a specific CWT code (m) or stock (i). Eq. 1.

[PF] — Vector of production factor variables, with elements of PF_i. Eq. 20.

r — Estimated tag recoveries. The (i) subscript represents the stock, the (j) subscript represents the sample stratum, and the (m) subscript represents the array of tag codes representing stock (i). Eq. 2.

[R] Tag recovery matrix. A matrix of r_{ij} elements, were i represents stocks and j represents sample stratum. Eq. 20.

s The smolt to adult survival rate of a tagged (m) or untagged (l) production unit. Eq. 5.

S Survival rate ratio between tagged and untagged production units. Eq. 5.

[S] A diagonal matrix of sample sizes for each sample stratum. Eq. 26 only.

SC Stock catch averaged over several years with the stock composition in each year given equal weight. Eq. 27.

SI Stock compositions averaged over several years. Eq. 28.

t Numbers of fish in a tagged production unit: Subscript (m) refers to a specific CWT code. Eq. 1.

TR Terminal Run. Eq. 19 only.

u Numbers of fish in an untagged production unit: Subscript (l) refers to a an element in an array of untagged releases representing a stock.

W Total wild production for a specific stock. Eq. 16 only.

Wt Weight factors for association criteria. Eq. 3 only.

X Generalized independent variables for a multiple linear equation. Eq. 22.

Y Generalized dependent variable for a multiple linear equation. Eq. 22.

z The total number of independent variables in a multiple linear equation. Eq. 22.

APPENDIX 3
Detailed Descriptions of Production Factor Calculations

Fraser River

Virtually all 1986 adult (1983 brood) hatchery coho returning to the Fraser river were fin clipped with either an adipose clip (and a CWT), a right ventral clip, or both. The incidence of these fin clips observed in the terminal Fraser River test fishery provides an estimate of total escapement. Since 34% of the test fishing catch was fin clipped, and the fin clipped escapement to Fraser river hatcheries (including estimated sport catches of fin clipped catch taken above the test fishery) was 107,000 an estimated 315,000 coho returned to the Fraser river in 1986. An estimated 5,900 CWT's were included in the 107,000 escapement, for a production factor of 53.39 (315,000/5,900) applied to CWT's from Chilliwack and Chehalis hatcheries.

No direct estimate of total coho escapement to the Fraser is available for 1985, but terminal commercial gillnet fisheries and the Fraser river gillnet test fishery were sampled for CWT's. The sample from the test fishery each week is small because only 20% of the catch was sampled on average. Larger samples are available from the commercial fisheries, but these fisheries were directed at sockeye, pink and chum salmon and are not evenly distributed throughout the coho run. In addition, non-Fraser tags were common in commercial catch samples prior to mid-September (statistical week 9-2).

The terminal mark rate for 1985 was estimated from the combined commercial and test fishing samples for each two week period between statistical week 9-2 and the end of the season. Where no sample was available for any week, samples from adjacent weeks were used. Because these samples were not evenly distributed throughout the coho run, the mark rate for each two week period was weighted by the proportion of the total coho run which entered the river during the period (based on the test fishing index). The weighted average mark rate for 1985 was 0.03504 for a production factor of 28.25 (1/0.03504) applied to all Fraser River tag codes.

In 1984, most samples of the terminal Fraser River commercial coho catch contained non-Fraser tags and cannot be used to estimate terminal mark rate. While no mark-recapture data are available to estimate total terminal run size (as in 1986), test fishing catches provide an index of total return. Assuming that the harvest rate of the test fishery was the same in both 1984 and 1986, the total terminal run can be estimated by:

1984 terminal run	=	1984 index * (1986 terminal run/1986 index)
	=	253.57 * (315,000/245.49)
	=	325,000

Escapement can be accurately estimated only for those tag codes released from the hatchery site (not those that were outplanted to natural spawning areas). Within the Fraser, only three tag codes from Chilliwack hatchery 1981 brood releases were released and recovered at the hatchery. Escapement of these three tag codes was estimated at 1613, for a production factor of 201.49 (325,000/1613) applied to the three tag codes released from Chilliwack hatchery. This assumes that the distribution of these three tag codes accurately represents the distribution of the entire Fraser River coho run.

Nooksack/Samish

The Nooksack/Samish region has a terminal bay in which an intensive net fishery occurs (Area 7B). Two rivers (the Nooksack and the Samish), both of which have escapement enumeration facilities enter into the bay. Significant numbers of hatchery coho are also released into Lummi Bay (Area 7D), a small inlet just north of Area 7B.

The Nooksack/Samish production factor would be calculated most easily by determining the CWT mark rate of the Area 7B net catch; however, this fishery also catches significant numbers of CWT's from non-local stocks, and there is not a clear distinction between bay and Nooksack River catches in the mark samples.

Alternatively, the production factor could be estimated from the tagged fraction in the catch. Because much of the escapement is counted at racks or weirs, escapement data for this region are probably fairly accurate. The main problems with using these data to estimate production factors are that rack samplers may miss tags, which would bias the estimate high. In addition, since the tagged fish returning to the Nooksack River are harvested at a higher rate than the untagged stocks returning to other systems, the resulting CWT mark rate for the entire production area will be underestimated.

For the years 1984-1986, a wide range of production factors could be estimated for the Nooksack/Samish, depending on the method used. For 1984 and 1985, use of the tagged fraction in the escapement resulted in estimates of 71 in 1984, and 89 in 1985. By contrast, estimating the tagged fraction by using the tagged fraction in the smolt release and the hatchery proportion of the adult return gave production factors of 151 in 1984, and 126 in 1985.

For 1986, the estimated tag return to the rack was much lower than would have been expected from the tagged fraction of the smolt release, indicating either that many tags were missed at the rack, or that the data are still incomplete. Applying the smolt release data and the hatchery proportion of the adult run gave a production factor of 133, while applying the smolt release data to the hatchery rack return gave a production factor of 75. Another alternative production factor for 1986 was estimated by subtracting an estimate of non-local catches from the Area 7B net catch, and determining the tagged fraction in the remaining Area 7B net catch. This resulted in a production factor estimate of 102.

Skagit

The Skagit Region has one terminal bay and one river. Some outside stocks are caught in the bay, but the number is relatively low. There is a hatchery return, but a large portion of the run spawns in the wild, where it is difficult to estimate escapement.

For this region, the most reliable estimates of production factors would likely come from the terminal area net catch. The major assumption in using the catch data is that the catch must be representative of the run composition. There were season-long test fisheries in the Skagit in 1984-86, and effort was reasonably consistent between weeks, particularly at the river set sites. There is an on-going study in the Skagit that can be used to evaluate whether future production factors estimated from catch composition are realistic.

By using the tagged fraction in the terminal net catch, Skagit production factors were estimated at approximately 28 in 1984, 25 in 1985, and 10 in 1986. Alternatively, if production factors were estimated from the tagged fraction in the estimated escapement, the estimates would be approximately 12 in 1984, 18 in 1985, and 11 in 1986.

Stillaguamish/Snohomish

The Stillaguamish/Snohomish Region has a terminal bay fishery (Area 8A) and two rivers (the Stillaguamish and Snohomish), one of which (the Stillaguamish) has a net fishery. A large portion of the region's escapement is wild. Starting in 1985, an intensive net fishery has been held on hatchery coho in Tulalip Bay (Area 8D), a small inlet off Area 8A.

Because the Area 8A fishery catches a significant number of outside tags, production factors would probably be estimated most accurately from estimated river run sizes. Because of changing conditions during the years 1984-1986, production factors for those years could be calculated by a variety of methods.

In 1984, the estimate of tagged escapement was in question because, in this year only, a number of adults that were tagged at Sunset Falls as smolts were observed in other parts of the system. By making different assumptions about the tagged escapement estimate, a range of production factors could be estimated. By using the ratio of total escapement to tagged escapement, production factors of 31 and 24 could be estimated. By using the tagged fraction in the Area 8A catch of local stocks, production factors ranging from 20 to 28 could be estimated.

In 1985, coho returned for the first time to Area 8D, but mark samples for this area were apparently lumped with the Area 8A samples. By using the tagged fraction in the Area 8A catch of local stocks, production factors of 15 and 17 could be estimated, depending on different assumptions about the tagged fraction in Area 8D. By using the tagged fraction in the escapement, the production factor was estimated at 24.

For 1986, the tagged fraction in the escapement gave a production factor estimate of 29. By using the tagged fraction in the Area 8A catch of local stocks, production factors of 21 and 36 could be estimated, depending on the method used to calculate the catch of local stocks.

South Puget Sound

South Sound is a large region with many river systems, and mostly hatchery production. An intensive net fishery occurs in Area 10, at the entrance to this region.

Production factors for this region could be estimated either by using the tagged fraction in the Area 10 fishery, or by using the tagged fraction in the smolt release and the hatchery proportion in the adult return.

The problems with using the Area 10 catch data to estimate production factors are that significant numbers of outside stocks are caught in this area, and that some South Sound stocks may be caught selectively in the fishery. Using the tagged fraction in the Area 10 catch gave production factors of 32 in 1984, 49 in 1985, and 34 in 1986. By comparison, the tagged fraction in the smolt release gave production factor estimates of 37 in 1984, 57 in 1985, and 34 in 1986.

Hood Canal

Hood Canal is a long finger-like marine bay, into which many rivers flow. It has both hatchery and wild production. An intensive net fishery occurs in Area 12, at the entrance to Hood Canal. As with South Sound, production factors could be estimated from either the tagged fraction in the Area 12 fishery, or by using the tagged fraction in the smolt release and the hatchery proportion in the adult return. The problems with the Area 12 data are similar to those of the Area 10 data.

By using the tagged fraction in the Area 12 catch production factors were estimated at 15 in

1984, 12 in 1985, and 17 in 1986. In comparison, by using the tagged fraction in the smolt release, production factors were estimated at 15 in 1984, 15 in 1985, and 18 in 1986.

U.S. Strait of Juan de Fuca

The U.S. side of the Strait of Juan de Fuca has several small streams flowing into it, two of which (the Elwha and the Dungeness) have significant hatchery coho production. There were CWT groups put out from either the Elwha or the Dungeness (not from both in any one year) during 1984 to 1986. There is no terminal area through which all the Strait stocks pass, so production factors were estimated only from the tagged fraction in the smolt release and the hatchery proportion in the adult run.

For the U.S. Strait of Juan de Fuca tributaries production factors were estimated at 34 in 1984; 20 in 1985; and 12 in 1986.

Quillayute Summers and Falls

The Quillayute is a Washington north coastal river system that has two different run timings of coho: a summer run that spawns naturally above a cascade in one of the major tributaries, and a fall run that spawns everywhere else. Both runs have a hatchery component.

Because both runs return to the same hatchery and are distinguished somewhat arbitrarily by time of entry, the estimates of hatchery escapement may not be accurate for each component. Thus, hatchery escapement would probably be estimated most accurately by expanding each run's tagged hatchery return by the tagged fraction in the smolt release, and adjusting the expansions, as necessary (under the assumption that differential tagging mortality was the same for both runs), to make the result equal to the actual hatchery return.

Production factors for summers and falls were estimated separately, from estimates of the tagged fraction in the escapement. In 1985 and 1986, there were tagged wild fall coho returning to the system, which required separate estimates of tagged escapement.

For summer coho, the production factors were estimated at 11 in 1984, 21 in 1985, and 18 in 1986. For Quillayute fall coho, the production factors were estimated at 13 in 1984, 52 in 1985, and 10 in 1986.

Queets River

Production factors were estimated for Queets wild stocks by dividing the estimated total Queets wild smolt yield (estimated from a smolt tag-recapture project) by the number of tags released in each of the three years. The resulting wild Queets production factors are 9.32 for 1984, 7.72 for 1985, and 9.31 for 1986. The hatchery component was estimated by dividing the total number of releases with the number of tagged fish. This produced values of 11.70, 9.78, and 5.88 for the years 1984-86 respectively.

Quinault River

Estimates of Quinault production factors were obtained by first dividing total hatchery releases by the number of tagged releases to yield a hatchery production factor. This was then expanded to take into account wild stocks by multiplying the hatchery production factor by the ratio of total terminal run/hatchery terminal run values. This produced production factors of 39.10 for 1984, 48.01 for 1985, and 31.94 for 1986.

Grays Harbor

The Grays Harbor stock includes Chehalis and Humptulips drainage hatchery and wild stocks. For purposes of estimating production factors the hatchery and wild components were estimated separately. The wild component of the Grays Harbor stock proved difficult to estimate due to the extremely low number of spawning ground recoveries of tagged wild stocks and the high amount of straying of these wild stocks into the Willapa and Columbia River gillnet catches. In this case, independent estimates of mark incidence for wild Grays Harbor stocks were provided by Dave Seiler of WDF. The resulting production factors are 21.07 for 1984, 19.97 for 1985, and 15.09 for 1986. These values were calculated by dividing wild escapement estimates by the survival to escapement to estimate total smolts produced. The total smolts were then divided by the number tagged to yield the production factor.

Hatchery estimates were generated by combining the individual hatchery data and estimating the pooled ratio of total escapement/tagged escapement. This yielded values of 20.01, 19.94, and 12.35 for 1984-86 respectively. Another estimate was achieved by multiplying the wild production factor by the total wild estimated gillnet recoveries to yield an estimate of the wild component of the catch. Subtracting that from the total gillnet catch estimated the hatchery component. The hatchery gillnet catch divided by the hatchery estimated recoveries produced production factors of 33.28 for 1984, 22.97 for 1985, and 15.28 for 1986.

Willapa Bay

In the case of Willapa coho, the tagcodes can either be lumped or separated, depending upon the similarity of the preterminal distributions between the three hatcheries which comprise the vast majority of the total Willapa production. Using escapement ratios for each hatchery yields production factors of 20.00, 14.30 and 12.90 for the Willapa hatchery, 17.87, 23.03, and 22.39 for the Nemah facility, and 26.87, 27.50, and 26.49 for the Naselle hatchery in each of the years 1984-86. Applying these production factors to the terminal gillnet recoveries only accounts for 71% , 85%, and 28% of the total catch in the years 1984-86 respectively, which greatly overestimates the wild contribution in this system based upon personal communications with regional biologists. Pooling the terminal area data produces production factors based upon the ratio of terminal catch/terminal catch recoveries of 30.40, 27.89, and 73.42 for each of the three years. Production factors based on the ratio of terminal run/terminal recoveries yield values of 26.08, 24.89, and 35.82 respectively.

Columbia River - Early Stock

In order to estimate production factors for the Columbia early stock, the number of CWT recoveries and total catch in the terminal gillnet fishery (zone 1-6) and in the escapement were compiled for years 1984-86. The gillnet catch was broken into early and late stock components based on historical timing data. An analysis done by WDF Columbia River staff determined that in 1984 the contributions of early and late stocks in the gillnet fishery were identical using the timing method and CWT analysis. Therefore the timing method estimates were used in all subsequent years. Estimates of associated gillnet catch for individual tagcodes were estimated by multiplying the terminal gillnet recoveries by the unmarked/marked ratio in the escapement. However, the sum of these associated catches exceeded the actual gillnet catch in all three years indicating that the variability between escapement recovery rates was very large. Therefore the terminal data was pooled across all tagcodes to compute one production factor for all Columbia early stocks in each year. This pooling makes sense given the common Toutle ancestry of these stocks and is supported by the large amount of straying among sites and the similarity of preterminal distributions of all early stocks. Pooling is also necessitated in years like 1985 and 86 where major production facilities did not release tagged fish. Using the ratio of terminal gillnet catch/terminal gillnet recoveries yields production factors of 17.70, 16.74, and 12.77 for the years 1984-86 respectively. Using the ratio of terminal run/terminal catch and escapement recoveries yields estimates of 15.08, 15.64, and 13.49 for each of the three years.

Columbia River - Late Stock

The Columbia River late stock represents a situation where in 1984, 1985, and 1986 several major hatcheries did not release any tagged coho. In this situation the terminal area information has to be pooled to include the escapement at these sites in the total area production or else the total escapement mark rate will be overestimated. Similarly, the total associated gillnet catch will be underestimated by expanding individual tagcodes whereas the pooled associated gillnet catch takes into account untagged production. Pooling the terminal area data is also supported by the common Cowlitz ancestry of the stock and the similarity of preterminal distributions of all Columbia late stocks. Production factors based on the ratio of terminal gillnet catch/terminal gillnet recoveries yield values of 36.34 for 1984, 24.36 for 1985, and 57.54 for 1986. The ratio of terminal run/terminal catch and escapement recoveries gives values of 31.93, 24.55, and 69.25 for each of the three years respectively.

Oregon Coastal

Estimates of production factors were computed for an aggregate of coastal stocks that show some northern migration patterns and would, to some extent, enter into PSC fisheries. Those stocks that do not migrate north were not included (primarily Cole Rivers Hatchery stock). For this analysis both wild (OCN) and coastal hatchery stocks are aggregated into a single production unit. Only stocks reared in hatcheries have been tagged; no wild coho tagging programs are underway in Oregon. The stocks making up this aggregation represent both established hatchery stocks and native non-hatchery stocks from a variety of rivers along the entire coast north of Cape Blanco. Therefore, for this analysis, we assume that these tagged groups represent both natural and hatchery production. Total terminal coho returns were determined by summing hatchery rack returns and estimates of OCN spawning escapements. Terminal tag recoveries were enumerated at hatchery racks or river weirs (freshwater sport fishery returns or tag recoveries were not used). Production factors (total terminal run/terminal tag recoveries) were 54.22, 130.08, and 51.80 for 1984-86, respectively.

Oregon Private Hatcheries

Production factors for Oregon private hatchery stocks were estimated by dividing the total number of smolts released from each facility by the number of tags released (data from Jacobs, 1988). For the Anadromous facility the production factors were 5.04, 12.47, and 11.12 for the years 1984-86. Estimates for the Oregon Aqua-Foods facility were 20.77, 27.30, and 6.42 for each of the three years. The Domsea Farms site only had releases for the 1981 brood. The production factor for the 1984 return year for this site was 2.53.

Appendix Table 3-2. Estimates of the U.S., Canadian, and unassigned components of coho salmon catches in 1985 in fisheries of concern to the Southern Panel of the Pacific Salmon Commission (based on Production Factor Expansions).

FISHERY	1985 Catch (1000's)	Min. U.S./Max Canadian % US	% Can	% Unasng	Max. U.S./Min Canadian % US	% Can	% Unasng	"Best" Estimates % US	% Can	% Unasng
CANADIAN FISHERIES										
NWVI Troll	377	34%	18%	48%	43%	18%	39%	39%	18%	43%
SWVI Troll	1,012	53%	17%	30%	68%	17%	15%	61%	17%	22%
NW/SWVI Net	7	15%	9%	77%	21%	9%	71%	18%	9%	74%
Georgia Strait Troll	200	18%	100%	-18%	29%	100%	-30%	18%	100%	-19%
Georgia Strait Sport	728	13%	69%	19%	20%	69%	11%	14%	69%	18%
Johnstone Net	147	2%	40%	57%	4%	40%	56%	3%	40%	57%
Georgia Strait Net	32	7%	61%	32%	11%	61%	28%	7%	61%	32%
Fraser Net	18	10%	92%	-2%	17%	92%	-8%	11%	92%	-3%
Juan de Fuca Net	224	57%	18%	25%	77%	18%	5%	66%	18%	16%
U.S. FISHERIES										
Puget Sound										
Juan de Fuca Sport/Troll	91	54%	8%	38%	70%	8%	22%	62%	8%	30%
Juan de Fuca Net	85	74%	16%	10%	97%	16%	-13%	86%	16%	-2%
San Juan Sport	9	26%	7%	67%	44%	7%	48%	30%	7%	63%
San Juan Net	100	26%	28%	46%	39%	28%	33%	29%	28%	43%
Pt. Roberts Net	43	19%	61%	19%	32%	61%	6%	20%	61%	18%
Nooksack/Samish Term. Net	162	57%	2%	41%	94%	2%	4%	57%	2%	41%
Skagit Bay/Pt. Gardner Sport	9	50%	0%	50%	76%	0%	24%	62%	0%	38%
Skgt/Stlly/Snoho Term. Net	108	103%	0%	-3%	163%	0%	-63%	122%	0%	-22%
Admiralty Inlet Sport	40	60%	0%	39%	80%	0%	19%	72%	0%	28%
South Sound Sport	38	40%	0%	60%	48%	0%	52%	46%	0%	53%
South Sound Term. Net	496	104%	0%	-4%	123%	0%	-23%	121%	0%	-21%
Hood Canal Sport	2	28%	0%	72%	38%	-0%	62%	35%	0%	65%
Hood Canal Term. Net	45	82%	0%	18%	102%	0%	-2%	101%	0%	-1%
Washington Ocean Fisheries										
Cape Flattery Sport/Troll	75	68%	13%	20%	84%	13%	3%	76%	13%	11%
Quillayute Sport/Troll	66	75%	16%	9%	97%	16%	-13%	84%	16%	0%
Grays Harbor Sport/Troll	160	79%	8%	12%	95%	8%	-3%	88%	8%	4%
Columbia River Sport/Troll	132	110%	3%	-13%	118%	3%	-21%	114%	3%	-17%
Columbia River										
Buoy 10 Sport	25	113%	0%	-13%	118%	0%	-18%	113%	0%	-13%
Gillnet	195	96%	0%	4%	100%	0%	-0%	97%	0%	3%

Appendix Table 3-1. Estimates of the U.S., Canadian, and unassigned components of coho salmon catches in 1984 in fisheries of concern to the Southern Panel of the Pacific Salmon Commission (based on Production Factor Expansions).

FISHERY	1984 Catch (1000's)	Min. U.S./Max Canadian % US	% Can	% Unasng	Max. U.S./Min Canadian % US	% Can	% Unasng	"Best" Estimates % US	% Can	% Unasng
CANADIAN FISHERIES										
NWVI Troll	504	14%	17%	69%	21%	17%	62%	17%	17%	66%
SWVI Troll	1,668	42%	13%	45%	64%	13%	23%	51%	13%	36%
NW/SWVI Net	11	3%	20%	77%	6%	20%	74%	5%	20%	75%
Georgia Strait Troll	117	9%	64%	27%	18%	64%	18%	10%	64%	26%
Georgia Strait Sport	443	10%	40%	50%	20%	40%	40%	12%	40%	48%
Johnstone Net	119	7%	30%	63%	14%	30%	55%	9%	30%	61%
Georgia Strait Net	14	8%	46%	46%	20%	46%	33%	15%	46%	38%
Fraser Net	9	9%	44%	47%	18%	44%	38%	12%	44%	44%
Juan de Fuca Net	75	51%	12%	37%	83%	12%	6%	64%	12%	25%
U.S. FISHERIES										
Puget Sound										
Juan de Fuca Sport/Troll	61	45%	5%	50%	73%	5%	22%	55%	5%	40%
Juan de Fuca Net	46	54%	6%	41%	81%	6%	14%	63%	6%	31%
San Juan Sport	4	7%	-0%	93%	14%	-0%	86%	7%	-0%	93%
San Juan Net	12	38%	18%	45%	71%	18%	11%	45%	18%	37%
Pt. Roberts Net	13	35%	14%	51%	76%	14%	10%	41%	14%	45%
Nooksack/Samish Term. Net	133	85%	4%	12%	180%	4%	-84%	85%	4%	11%
Skagit Bay/Pt. Gardner Sport	7	19%	-0%	81%	37%	-0%	63%	30%	-0%	70%
Skgt/Stlly/Snoho Term. Net	46	65%	0%	35%	126%	0%	-26%	97%	0%	3%
Admiralty Inlet Sport	36	50%	0%	50%	77%	0%	23%	61%	0%	39%
South Sound Sport	34	31%	-0%	69%	38%	-0%	62%	36%	0%	64%
South Sound Term. Net	426	78%	0%	22%	95%	0%	5%	90%	0%	10%
Hood Canal Sport	2	23%	-0%	77%	39%	0%	61%	23%	0%	77%
Hood Canal Term. Net	49	83%	0%	17%	139%	0%	-39%	85%	0%	15%
Washington Ocean Fisheries										
Cape Flattery Sport/Troll	53	56%	15%	29%	82%	15%	3%	66%	15%	19%
Quillayute Sport/Troll	10	0%	0%	100%	0%	0%	100%	0%	0%	100%
Grays Harbor Sport/Troll	12	19%	0%	81%	32%	0%	68%	28%	0%	72%
Columbia River Sport/Troll	55	72%	0%	28%	112%	0%	-12%	100%	0%	0%
Columbia River										
Buoy 10 Sport	74	65%	0%	35%	119%	0%	-19%	104%	0%	-4%
Gillnet	203	47%	0%	53%	100%	-0%	-0%	86%	0%	14%

Appendix Table 3-3. Estimates of the U.S., Canadian, and unassigned components of coho salmon catches in 1986 in fisheries of concern to the Southern Panel of the Pacific Salmon Commission (based on Production Factor Expansions).

FISHERY	1986 Catch (1000's)	Min. U.S./Max Canadian % US	% Can	% Unasng	Max. U.S./Min Canadian % US	% Can	% Unasng	"Best" Estimates % US	% Can	% Unasng
CANADIAN FISHERIES										
NWVI Troll	611	29%	11%	60%	45%	11%	44%	33%	11%	56%
SWVI Troll	1,546	57%	10%	33%	88%	10%	2%	63%	10%	27%
NW/SWVI Net	11	7%	12%	81%	9%	12%	79%	7%	12%	81%
Georgia Strait Troll	219	17%	48%	35%	64%	48%	-12%	22%	48%	30%
Georgia Strait Sport	572	15%	43%	42%	47%	43%	10%	19%	43%	38%
Johnstone Net	127	3%	35%	62%	6%	35%	58%	3%	35%	61%
Georgia Strait Net	16	1%	75%	24%	1%	75%	24%	1%	75%	24%
Fraser Net	34	1%	37%	62%	4%	37%	59%	2%	37%	61%
Juan de Fuca Net	203	75%	9%	16%	99%	9%	-7%	83%	9%	8%
U.S. FISHERIES										
Puget Sound										
Juan de Fuca Sport/Troll	154	58%	4%	38%	70%	4%	26%	63%	4%	33%
Juan de Fuca Net	71	65%	9%	27%	79%	9%	12%	71%	9%	21%
San Juan Sport	12	12%	6%	82%	22%	6%	72%	14%	6%	80%
San Juan Net	43	22%	26%	52%	81%	26%	-7%	29%	26%	45%
Pt. Roberts Net	61	13%	41%	45%	49%	41%	10%	17%	41%	41%
Nooksack/Samish Term. Net	137	73%	1%	26%	303%	1%	-204%	98%	1%	1%
Skagit Bay/Pt. Gardner Sport	12	29%	0%	71%	36%	-0%	64%	33%	0%	67%
Skgt/Stlly/Snoho Term. Net	163	90%	0%	10%	130%	0%	-30%	111%	0%	-11%
Admiralty Inlet Sport	45	52%	0%	48%	59%	0%	41%	56%	0%	44%
South Sound Sport	48	40%	0%	60%	41%	0%	59%	40%	-0%	60%
South Sound Term. Net	578	100%	0%	-0%	104%	0%	-4%	102%	0%	-2%
Hood Canal Sport	1	15%	0%	85%	18%	-0%	82%	17%	0%	83%
Hood Canal Term. Net	99	88%	0%	12%	104%	0%	-4%	96%	0%	4%
Washington Ocean Fisheries										
Cape Flattery Sport/Troll	74	76%	8%	16%	116%	8%	-24%	90%	8%	2%
Quillayute Sport/Troll	43	53%	3%	43%	81%	3%	16%	64%	3%	33%
Grays Harbor Sport/Troll	93	60%	1%	39%	102%	1%	-3%	91%	1%	8%
Columbia River Sport/Troll	198	74%	0%	26%	122%	0%	-22%	114%	0%	-14%
Columbia River										
Buoy 10 Sport	120	77%	-0%	23%	95%	0%	5%	91%	0%	9%
Gillnet	998	73%	0%	27%	105%	0%	-5%	105%	0%	-5%

Appendix Table 3-4. Production factors and associated tag codes for 1984 (H - hatchery; N - natural).

Stock	- Production Factor - Min	Max	Best	Codes
Southwest Vancouver Island (H)	7.8	7.8	7.8	022314-16
Johnstone Strait (H)	4.2	4.2	4.2	021762, 021960, 0211962-63, 022007-14, 022323
Georgia Strait - Mainland (H)	2.8	2.8	2.8	021819, 022015, 022102-03, 022162, 022334 022348, 022350-52, 022423
Georgia Strait - Vancouver Island (H)	19.1	19.1	19.1	022133, 022327, 022329, 022408
Fraser (H, N)	201.5	201.5	201.5	021957, 022006, 022210
Nooksack/Samish (H, N)	71.0	151.0	71.0	632356
Skagit (H, N)	7.0	32.0	28.0	632236, 632563, 632723
Stillaguamish/Snohomish (H, N)	20.0	31.0	20.0	632452, 632552, 632727, 632730
South Puget Sound (H, N)	32.0	37.0	37.0	632344, 632419, 632451, 632543, 632554-58 632560, 632601, 632718, 632720, 632729, 632731
Hood Canal (H, N)	15.0	26.0	15.0	051119, 632561, 632562, 632724, 632725
Juan de Fuca Tributaries (H, N)	34.0	34.0	34.0	051127-29
Quillayute Summer (H, N)	10.0	12.0	11.0	632643
Quillayute Fall (H, N)	12.0	17.0	13.0	632644
Queets (N)	9.3	9.3	9.3	051126, 051420-22, 632315, 632343, 632545
Queets (H)	11.7	11.7	11.7	051355
Quinault (H, N)	39.1	39.1	39.1	051261, 051362
Grays Harbor (N)	21.1	21.1	21.1	632230, 632418, 632559, 632719, 632726, 632728
Grays Harbor (H)	20.0	33.3	20.0	632646, 632647, 632648, 632736
Willapa (H, N)	18.5	30.4	26.1	632649-50, 632734
Columbia Early (H, N)	6.8	17.7	15.1	050928-45, 051133-38, 072447-49, 072451, 072606-07, 072643, 072731-36, 072742-47, 632645, 632733, 632735
Columbia Late (H, N)	20.8	36.3	31.9	632605, 632613-42, 632651-63, 632701-17
Oregon Coastal (H, N)	54.2	54.2	54.2	072442-44, 072450, 072559-61, 072608-11 072627-30, 072639-41, 072644-45
Anadromous (Oregon Private Hatchery)	5.0	5.0	5.0	621520-24, 621526-39, 621547-50, 621562-63, 621651-52, 624608 624708, 621547-50, 621562-63, 621651-52, 624608, 624708
Aqua-Foods (Oregon Private Hatchery)	20.8	20.8	20.8	600547-48, 600563, 600616-27, 603550-63 603601-14, 603616, 603618, 603622-26
DOMSEA (Oregon Private Hatchery)	2.5	2.5	2.5	624834

Appendix Table 3-5. Production factors and associated tag codes for 1985 (H - hatchery; N - natural).

Stock	- Production Factor - Min	Max	Best	Codes
Southwest Vancouver Island (H)	10.8	10.8	10.8	022458, 022539-40, 022605
Johnstone Strait (H)	5.2	5.2	5.2	022349, 022448, 022548-50
Georgia Strait - Mainland (H)	2.3	2.3	2.3	022502-03, 022617, 022629, 022638-42, 022649-51, 022808
Georgia Strait - Vancouver Island (H)	20.3	20.3	20.3	022615-16, 022643-45, 022723
Fraser (H, N)	28.3	28.3	28.3	022211, 022441, 022443, 022450, 022461, 022462 022532, 022542, 022606-14, 022619, 022627, 022721
Nooksack/Samish (H, N)	89.0	147.0	89.0	632850
Skagit (H, N)	15.0	31.0	25.0	211630, 632205, 632206
Stillaguamish/Snohomish (H, N)	15.0	24.0	17.0	211601, 632854, 632909, 633023, 633029
South Puget Sound (H, N)	49.0	57.0	57.0	111704-07, 632229, 632544, 632851-52, 632904-06, 633022, 633024, 633036-37
Hood Canal (H, N)	12.0	15.0	15.0	632204, 633021, 633026, 633028
Juan de Fuca Tributaries (H, N)	20.0	20.0	20.0	051430-32, 051516-23
Quillayute Summer (H, N)	21.0	21.0	21.0	632739
Quillayute Fall (H, N)	52.0	52.0	52.0	632740, 632907-08
Queets (N)	7.7	7.7	7.7	211624-26
Queets (H)	9.8	9.8	9.8	211607, 211614
Quinault (H, N)	48.0	48.0	48.0	051455, 211608
Grays Harbor (N)	20.0	20.0	20.0	632453, 632547, 632910-11, 633027, 633046-48, 633061-62, 633107
Grays Harbor (N)	13.3	23.0	19.9	632743-46, 632861-62, 633017-18
Willapa (H, N)	19.0	27.9	24.9	632741-42, 633012-14
Columbia Early (H, N)	15.6	16.7	15.6	051224-41, 072637, 072725, 072817-19, 072821-22, 072906-13 072944-49, 073014-15, 073141-42, 633011, 633015-16
Columbia Late (H, N)	24.5	24.6	24.6	632912-63, 633001-08
Oregon Coastal (H, N)	130.1	130.1	130.1	072653, 072655, 072738-39, 072748, 072806-10, 072812-16, 072823-25, 072939
Anadromous (Oregon Private Hatchery)	12.5	12.5	12.5	621721-25, 621733-46, 621749, 621752, 621757
Aqua-Foods (Oregon Private Hatchery)	27.3	27.3	27.3	603615, 603627, 603630-38, 603643-47, 603649-50, 603706-10

Appendix Table 3-6. Production factors and associated tag codes for 1986 (H - hatchery; N - natural).

Stock	- Production Factor - Min	Max	Best	Codes
Central Coast (H)	5.9	5.9	5.9	022910-11, 022952-55
Northwest Vancouver Island (H)	1.4	1.4	1.4	022706
Southwest Vancouver Island (H)	30.7	30.7	30.7	023006-07
Johnstone Strait (H)	13.9	13.9	13.9	022916-23, 022949-51
Georgia Strait - Mainland (H)	5.8	5.8	5.8	022809-11, 022843-44, 022846, 022862, 022931-36, 023008-09, 023056, 023137
Georgia Strait - Vancouver Island (H)	16.9	16.9	16.9	022912-15, 022943-46, 022957-60, 082251
Fraser (H, N)	53.4	53.4	53.4	022832, 022907-09, 022947-48, 022956, 023420
Nooksack/Samish (H, N)	75.0	321.0	102.0	632753-54
Skagit (H, N)	10.0	12.0	10.0	211703-05, 632755-58, 633154-55
Stillaguamish/Snohomish (H, N)	21.0	35.0	30.0	211634, 633051, 633141, 633203, 633429-30
South Puget Sound (H, N)	34.0	34.0	34.0	111714-17, 632454, 632759-63, 632801-07, 632855-56, 633057-59, 633140, 633204-05, 633552, 633426-27
Hood Canal (H, N)	17.0	18.0	17.0	632749-52, 632832-34
Juan de Fuca Tributaries (H, N)	12.0	12.0	12.0	B10408-12, B10414-15, B10508-10
Quillayute Summer (H, N)	18.0	18.0	18.0	633255-56
Quillayute Fall (H, N)	10.0	10.0	10.0	633257-58, 633417-18
Queets (N)	9.3	9.3	9.3	211710-11, 211713-15, 211718
Queets (H)	5.9	5.9	5.9	211642-43, 211648, B50802-03, B50807-08
Quinault (H, N)	31.9	31.9	31.9	211635-36
Grays Harbor (N)	15.1	15.1	15.1	633010, 633035, 633209, 633423-25, 633443-44
Grays Harbor (H)	5.0	15.3	12.4	632817-33, 633345-48, H10504, H10506-07, H10601-07, H10701
Willapa (H, N)	35.8	81.4	35.8	632808-16, 633341-44
Columbia Early (H, N)	12.8	13.5	13.5	072654, 072801-02, 072804, 072811, 073029-32, 073045-50, 073105-08 073204-09, 073343-44, 633030-31, 633132-35, 633259-63, 633301
Columbia Late (H, N)	37.9	69.3	69.3	633156-57, 633161-62, 633232-33, 633249-54
Oregon Coastal (H, N)	51.8	51.8	51.8	072754-55, 072757-61, 072763, 072958, 072722, 073025-28, 073033-35
Anadromous (Oregon Private Hatchery)	11.1	11.1	11.1	621610-13, 621616-19, 621631, 623023-42, 623047-54, 623120-35, 623140-417
Aqua-Foods (Oregon Private Hatchery)	6.4	6.4	6.4	603628, 603658-63, 603701-05 603712-13, 603716-48, 603750-63, 603801-10

1984 NOOKSACK/SAMISH PRODUCTION FACTOR DATA

MARKED & UNMARKED HATCHERY RELEASES

	MARKED	UNMARKED			TOTAL
CWT GROUP	63-23/56	-----	-----	-----	
FACILITY	NOOKSACK	SKOOKUM	LUMMI	EASTSOUND	
STOCK	NOOKSACK	NOOKSACK	LUMMI	MXD LOCAL	
RELEASE SITE	KENDALL	SKOOKUM	7D	7E	
RELEASE DATE	4/22/83	5/9/83	5/23/83	4/30/83	
FISH/LB	18	18	18.7	20	
# TAGGED	30096	0	0	0	30096
LOST TAGS	465	0	0	0	465
# UNMARKED	942439	1150000	926000	52500	3070939
TOTAL RELEASE	973000	1150000	926000	52500	3101500
HATCHRY TAG %					0.97%

AREA 7B CATCH	1524
RIVER CATCH	51
ESCPMT RECS	426

TERMINAL CATCH & ESCAPEMENT DATA

AREA	CATCH	LOCAL TAGS	HATCHERY ESCPMT	TAGS IN ESCPMT	WILD ESCPMT	TOTAL ESCPMT	RUN SIZE ENTERING
7B	91026	1524	-----	-----	-----	-----	162596
NOOKSACK RIV	41292	51	16000	426	1000	17000	58292
7C	5	0	-----	-----	-----	-----	8505
SAMISH RIVER	0	0	0	0	8500	8500	8500
7D	73	0	2600	0	0	2600	2673
7E	0	0	2000	0	100	2100	2100
TOTAL	132396	1575	20600	426	9600	30200	162596

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 30200 / 426
= 71

#2: PROD FACTOR = INVERSE OF % OF RUN TAGGED = 1/(% H TAGGED * H % OF RUN)
= 1/(.97% * 20600/30200)
= 151

#3: PROD FACTOR = TOTAL LOCAL CATCH (derived by subtracting non-local production)/LOCAL TAGGED CATCH
= (132396 - 19823) / 1575 (See attached page)
= 71

1984 AREA 7B

SOURCE	# TAGS	EXPANSN	TOTAL
CHILLIWK	89.66	201.49	18066
OTHER FSR	36.97	0	0
QUINSAM	8.29	10	83
PUNTLEDGE	7.28	10	73
CAPILANO	46.72	10	467
BIG QUAL	2.01	10	20
SKAGIT	31.51	28	882
SOUTH SND	2.51	37	93
HOOD CNL	6.32	15	95
COL EARLY	2.93	15.1	44
TOTAL	234.2		19823

7B + NOOK CATCH =	132396
NON-LOCALS =	19823
LOCAL TOTAL =	112573
LOCAL TAGS =	1575
PRODUCTN FACTOR =	71

1985 NOOKSACK/SAMISH PRODUCTION FACTOR DATA

MARKED & UNMARKED HATCHERY RELEASES

	MARKED	UNMARKED						TOTAL
CWT GROUP	63-28/50	-----	-----	-----	-----	-----	-----	
FACILITY	NOOKSACK	DRAYTON	SKOOKUM	SKOOKUM	BLHM HER	LUMMI	GLENWOOD	
STOCK	NOOKSACK	SKAGIT	NOOKSACK	SKYKOMSH	WHATCOM	LUMMI	LOCAL	
RELEASE SITE	KENDALL	BLAN RES	SKOOKUM	SKOOKUM	WHATCOM	7D	7E	
RELEASE DATE	5/15/84	5/15/84	6/4/84	6/4/84	1/10/84	6/13-22	5/8/84	
FISH/LB	19.0	27.0	23.0	23.0	15.3	16.8	20.0	
# TAGGED	30571	0	0	0	0	0	0	30571
LOST TAGS	494	0	0	0	0	0	0	494
# UNMARKED	1260935	200000	400000	464500	13984	800000	105120	3244539
TOTAL RELEASE	1292000	200000	400000	464500	13984	800000	105120	3275604

7B RECOVERIES	925	TAG % = 0.93%
NOOK RIV RECS	96	
ESCPMT RECS	437	

TERMINAL CATCH & ESCAPEMENT DATA

AREA	CATCH	LOCAL TAGS	HATCHERY ESCPMT	TAGS AT RACK	WILD ESCPMT	TOTAL ESCPMT	EXTREME TERM RS
7B	122221	925	-----	-----	-----	-----	-----
NOOKSACK RIV	33533	96	20900	437	2000	22900	56433
7C	222	0	-----	-----	-----	-----	-----
SAMISH RIVER	0	0	0	0	3700	3700	3700
7D	53	0	11100	0	0	11100	11153
7E	5473	0	900	0	100	1000	6473
TOTAL	161502	1021	32900	437	5800	38700	200202

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 38700/437
= 89

#2: PROD FACTOR = INVERSE OF % OF RUN TAGGED = 1/(% H TAGGED * H % OF RUN)
= 1/(.93% * 32900/38700)
= 126

#3: PROD FACTOR = TOTAL LOCAL CATCH (derived by subtracting non-local production)/7B LOCAL TAGS
= [(122221+33533) - 5587] / 1021
= 147

1986 NOOKSACK/SAMISH PRODUCTION FACTOR DATA

MARKED & UNMARKED HATCHERY RELEASES

	MARKED		UNMARKED						TOTAL
CWT GROUP	63-27/53	63-27/54							
FACILITY	NOOKSACK	NOOKSACK	NOOKSACK	NOOKSACK	LUMMI	LUMMI	LUMMI	DRAYTON	
STOCK	NOOKSACK	NOOKSACK	SKAGIT	SKAGIT	SKAGIT	SKOOKUM	LUMMI	SKAGIT	
RELEASE SITE	KENDALL	KENDALL	KENDALL	KENDALL	NOOKSACK	NOOKSACK	7D	BLAN RES	
RELEASE DATE	5/16-24	5/16-24	5/16/85	5/24/85	5/31/85	6/18/85	6/1-4/85	5/15/85	
FISH/LB	18.0	18.0	18.5	17.8	22.0	18.5	27.0	27.0	
# TAGGED	16526	16147	0	0	0	0	0	0	32673
LOST TAGS	132	130	0	0	0	0	0	0	262
# UNMARKED	486756	475613	94633	189200	386000	900000	550815	200000	3283017
TOTAL RELEASE	503414	491890	94633	189200	386000	900000	550815	200000	3315952
								TAG % =	0.99%
7B RECOVERIES	527	758							1285
NOOK RIV RECS	0	0							0
ESCPMT RECS	40	50							90

TERMINAL CATCH & ESCAPEMENT DATA

AREA	CATCH	LOCAL TAGS	HATCHERY ESCPMT	TAGS AT RACK	WILD ESCPMT	TOTAL ESCPMT	EXTREME TERM RS
7B	136753	1285	-----	-----	-----	-----	-----
NOOKSACK RIV	43655	0	15150	90	500	15650	59305
7C	7	0	-----	-----	-----	-----	-----
SAMISH RIVER	0	0	0	0	6200	6200	6200
7D	507	0	6899	0	0	6899	7406
7E	0	0	0	0	100	100	100
TOTAL	180922	1285	22049	90	6800	28849	209771

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 28849/90
= 321

#1a: PROD FACTOR = TOTAL ESCPMT/ESTD TAGGED ESCPMT
= 28849/(15150*TAG % IN RELEASE)
= 75

#2: PROD FACTOR = INVERSE OF % OF RUN TAGGED = 1/(% H TAGGED * H % OF RUN)
= 1/(.99% * 22049/28849)
= 133

#3: PROD FACTOR = AREA 7B CATCH/TAGGED CATCH
= 136753/1285
= 106

#4: PROD FACTOR = TOTAL LOCAL CATCH (derived by subtracting non-local production)/7B LOCAL TAGS
= (136753 - 5282) / 1285 (See attached page)
= 102

1985 AREA 7B

SOURCE	# TAGS	EXPANSN	TOTAL
FRASER	104	28.25	2938
TENDERFOOT	27	28.25	763
SKAGIT	20	25	500
SOUTH SOUND	23	57	1311
HOOD CANAL	5	15	75
TOTAL	179		5587

7B + NOOK CATCH =	155754
NON-LOCALS =	5587
LOCAL TOTAL =	150167
LOCAL TAGS =	1021
PRODUCTION FACTOR =	147

1986 AREA 7B

SOURCE	# TAGS	EXPANSN	TOTAL
CHEHELIS	49.64	53.39	2650
CHILLIWACK	21.49	53.39	1147
OTHER FRSR	77.17	0	0
CAPILANO	17	5.28	90
SWINMSH SL	203.16	1.28	260
OTHER SKAGIT	9.53	10	95
SOUTH SND	12.51	34	425
HOOD CANAL	29.74	17	506
OREGON COAST	2.09	51.8	108
	422.33		5282

AREA 7B CATCH = 136753
NON-LOCALS = 5282

LOCAL TOTAL = 131471

LOCAL TAGS = 1285

PRODUCTION FACTOR = 102

1984 SKAGIT PRODUCTION FACTOR DATA

MARKED & UNMARKED HATCHERY RELEASES

	MARKED			UNMARKED	TOTAL
CWT GROUP	63-22/36	63-27/23	63-25/63	-----	
FACILITY	PUGET	MARBLMT	MARBLMT	OAK HRBR	
STOCK	BAKER	BAKER	CLARK	SKYKOMSH	
RELEASE SITE	BAKER	MARBLMT	MARBLMT	OAK HRBR	
RELEASE DATE	5/10/83	5/21/83	5/21/83	6/15/83	
FISH/LB	17.3	23.0	23.0	7.0	
# TAGGED	89554	30334	30573	0	150461
LOST TAGS	1456	368	371	0	2195
# UNMARKED	0	171752	182722	30000	384474
TOTAL RELEASE	91010	202454	213666	30000	537130
HATCHRY TAG %					28.0%
AREA 8A CATCH	12	14	30		56
RIVER CATCH	35	59	100		194
ESCPMT RECS*	1227	1905	3078		6210

* CWT sampling at Baker was inconsistent in 1984. The 1227 was estimated by assuming the same terminal exploitation rate as the Marblemount Baker group (63-27/23).

TERMINAL CATCH & ESCAPEMENT DATA

AREA	CATCH	LOCAL TAGS	HATCHERY ESCPMT	TAGS IN ESCPMT	WILD ESCPMT	TOTAL ESCPMT	RUN SIZE ENTERING
AREA 8	923	56	-----	-----	-----	-----	84245
SKAGIT RIVER	6222	194	41500	6210	35600	77100	83322
TOTAL	7145	250	41500	6210	35600	77100	84245

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = RIVER CATCH/TAGS IN RIVER CATCH
= 6222 / 194
= 32

#2: PROD FACTOR = (TOTAL TERMINAL CATCH - NON-LOCAL PRODUCTION)/TAGS IN TERMINAL CATCH
= (7145 - 92) / 250
= 28

#3: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 77100 / 6210
= 12

#4: PROD FACTOR = INVERSE OF % OF RUN TAGGED (from tag rate at release and published escapement estimates)
= 1/(% H TAGGED * H % OF RUN)
= 1/(28% * 41500/77100)
= 7

1984 AREA 8 & SKAGIT RIVER

ORIGIN	# RECS	EXPNSN	CATCH
ST/SNO	2	20	40
SOUTH SND	1	37	37
HOOD CNL	1	15	15
	4		92

AREA 8&RIV CATCH =	7145
NON-LOCALS =	92
LOCAL TOTAL =	7053
LOCAL TAGS =	250
PRODUCTN FACTOR =	28

1985 SKAGIT PRODUCTION FACTOR DATA

MARKED & UNMARKED HATCHERY & WILD RELEASES

	MARKED			UNMARKED	TOTAL
CWT GROUP	21-16/30	63-22/5	63-22/6	-----	
FACILITY	WILD	MARBLMT	MARBLMT	OAK HRBR	
STOCK	NOOKCHMPS	BAKER	CLARK	CLARK	
RELEASE SITE	NOOKCHMPS	MARBLMT	MARBLMT	OAK HRBR	
RELEASE DATE	4/23-6/10	5/21/84	5/21/84	5/25/84	
FISH/LB	14.4	17.0	17.0	5.0	
# TAGGED	10058	22781	26488	0	59327
LOST TAGS	137	441	106	0	684
# UNMARKED	0	15781	173406	29987	219174
TOTAL RELEASE	10195	39003	200000	29987	279185
HATCHERY TAG %			18.3%		21.3%
AREA 8 CATCH	34	64	74		172
SKGT RIV C	66	103	129		298
ESCPMT RECS*	311	412	682		1405
TOTAL	411	579	885		1875

* There were 39 actual recoveries for 21-16/30. 311 estimated by assuming same average river exploitation rate (17.5%) as other two groups.

TERMINAL CATCH & ESCAPEMENT DATA

AREA	CATCH	LOCAL TAGS	HATCHERY ESCPMT	TAGS IN ESCPMT	WILD ESCPMT	TOTAL ESCPMT	RUN SIZE ENTERING
AREA 8	3958	172					38286
SKAGIT RIVER	9128	298	7200	1405	18000	25200	34328
TOTAL	13086	470	7200	1405	18000	25200	38286

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = RIVER CATCH/TAGS IN RIVER CATCH
= 9128 / 298
= 31

#2: PROD FACTOR = TOTAL TERMINAL LOCAL CATCH (derived by subtracting non-local production)/TAGS IN TERMINAL CATCH
= (13086 - 1274) / 470
= 25

#3: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 25200 / 1405
= 18

#4: PROD FACTOR = INVERSE OF % OF RUN TAGGED (from tag rate at release and published escapement estimates)
= 1/((% H TAGGED * H % OF RUN)+(% W TAGGED * W % OF RUN))
= 1/[(18.3% * 7200/25200) + ((311/18000)*(18000/25200))]
= 15

1985 AREA 8 & SKAGIT RIVER

ORIGIN	# RECS	EXPNSN	CATCH
TENDERFOOT	1	28.25	28
CHEHELIS	6	28.25	170
TULALIP	124	5.93	735
OTHER ST/SN	12	17	204
FINCH	12	6.67	80
SOUTH SND	1	57	57
	156		1274

AREA 8+78C&D CATCH =	13086
NON-LOCALS =	1274
LOCAL TOTAL =	11812
LOCAL TAGS =	470
PRODUCTION FACTOR =	25

1986 SKAGIT PRODUCTION FACTOR DATA

MARKED & UNMARKED HATCHERY & WILD RELEASES

	MARKED									UNMARKED	TOTAL
CWT GROUP	21-17/03	21-17/04	21-17/05	63-27/55	63-27/56	63-27/57	63-27/58	63-31/54	63-31/55	-----	
FACILITY	WILD	WILD	SWIN SL	MARBLMT	MARBLMT	MARBLMT	MARBLMT	PUGET	PUGET	OAK HRBR	
STOCK	SKAGIT	NOOKCHMPS	CLARK	CLARK	CLARK	BAKER	BAKER	CLARK	CLARK	CLARK	
RELEASE SITE	SKAGIT	NOOKCHMPS	SWIN SL	MARBLMT	MARBLMT	MARBLMT	MARBLMT	BAKER	BAKER	OAK HRBR	
RELEASE DATE	4-6/85	4-6/85	6/14/85	6/1/85	6/1/85	6/1/85	6/1/85	6/85	6/85	6/1/85	
FISH/LB	47.1	10.0	15.0	20.5	20.5	20.5	20.5	NA	NA	10.0	
# TAGGED	5218	7799	49532	12554	12586	15208	15407	60857	61609	0	240770
LOST TAGS			2827	101	102	92	93			0	3215
# UNMARKED			11111	110329	110328	40650	40650	0	0	29800	342868
TOTAL RELEASE	5218	7799	63470	122984	123016	55950	56150	60857	61609	29800	586853
HATCHRY TAG %											41.9%
AREA 8 CATCH	11	20	510	19	18	24	28	16	19		665
SKGT RIV C	73	122	878	236	229	226	211	218	218		2411
ESCPMT RECS*	108	181	1305	304	387	574	568	1004	1215		5647
TOTAL	192	323	2693	559	634	824	807	1238	1452		8723

* There were 17, 12, and 33 actual recoveries for 21-17/03, 04, & 05. The 108, 181, & 1305 were estimated by assuming same average river exploitation rate (40.2%) as Marblemount Clark stock groups.

TERMINAL CATCH & ESCAPEMENT DATA

AREA	COMM CATCH	LOCAL TAGS	HATCHERY ESCPMT	TAGS IN ESCPMT	WILD ESCPMT	TOTAL ESCPMT	RUN SIZE ENTERING	TEST CATCH	TAGS IN TEST
AREA 8	4943	665					94063	767	123
SKAGIT RIVER	28374	2411	13146	5647	47600	60746	89120	2434	201
TOTAL	33317	3076	13146	5647	47600	60746	94063	3201	324

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = RIVER CATCH/TAGS IN RIVER CATCH
= 28374 / 2411
= 12

#1A: PROD FACTOR = RIVER TEST CATCH/TAGS IN RIVER TEST CATCH
= 2434 / 201
= 12

#2: PROD FACTOR = LOCAL TERM CATCH/TAGS IN TERM C
= (33317 - 1780) / 3076
= 10

#2A: PROD FACTOR = TOTAL TEST CATCH/TAGS IN TEST CATCH
= 3201 / 324
= 10

#3: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 60746 / 5647
= 11

#4: PROD FACTOR = INVERSE OF % OF RUN TAGGED (from tag rate at release and published escapement estimates)
= 1/(% H TAGGED * H % OF RUN)+(% W TAGGED * W % OF RUN))
= 1/[(41.9% * 13146/60746) + (((108+181)/47600)*(47600/60746))]
= 10

1986 AREA 8 & SKAGIT RIVER

ORIGIN	# RECS	EXPNSN	CATCH
CHILLIWACK	1.46	53.39	78
CAPILANO	1.83	5.28	10
NOOK/SAM	15.89	102	1621
TULALIP	9.17	7.83	72
	28.35		1780

AREA 8&RIV CATCH = 33317
NON-LOCALS = 1780

LOCAL TOTAL = 31537

LOCAL TAGS = 3076

PRODUCTN FACTOR = 10

1984 STILLAGUAMISH/SNOHOMISH PRODUCTION FACTOR DATA

HATCHERY & WILD RELEASE GROUPS

	MARKED				UNMARKED	TOTAL
CWT GROUP	63-24/52	63-27/27	63-25/52	63-27/30	-----	
FACILITY	WILD	WILD	WILD	SKYKOMSH	SKYKOMSH	
STOCK	STILLY	STILLY	SKYKOMSH	SKYKOMSH	SKYKOMSH	
RELEASE SITE	STILLY	STILLY	SUNSET	WALLACE	WALLACE	
RELEASE DATE	5/25-6/3	5/2-5/24	4/19-5/27	4/29/83	4/21/83	
FISH/LB	45.0	45.0	60.0	27.0	34.0	
# TAGGED	5143	28861	18520	31300	0	83824
LOST TAGS	282	1360	120	100	0	1862
# UNMARKED	0	0	0	297000	34000	331000
TOTAL RELEASE	5425	30221	18640	328400	34000	416686
HATCHRY TAG %						8.6%
AREA 8A CATCH	30	374	136	282		822
RIVER CATCH	0	67	0	0		67
ESCPMT RECS*	0	1418	741	1536		3695
	30	1859	877	1818	0	4584

* There were 348 actual recoveries for 63-25/52. However, there were several strays observed below Sunset Falls, and it is likely that the actual escapement was higher. The 741 was estimated by assuming the same 8A exploitation rate as for the Wallace group. If the rack missed tagged fish, and the tag % at the rack were the same as at smolt release, the Skykomish CWT rack escapement would have been 2237, and the Sunset escapement would have been 1079.

TERMINAL CATCH & ESCAPEMENT DATA

AREA	CATCH	LOCAL TAGS	HATCHERY ESCPMT	TAGS IN ESCPMT	WILD ESCPMT	TOTAL ESCPMT	RUN SIZE ENTERING
AREA 8A	38496	822	-----	-----	-----	-----	154994
AREA 8D	0	0	0	0	0	0	0
STILLY RIVER	1593	67	0	1418	18000	18000	19593
SNOHOMISH R	5	0	25900	2277	71000	96900	96905
TOTAL	40094	889	25900	3695	89000	114900	154994

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 114900 / 3695 (observed rack return)
= 31

#1A PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 114900/(1418+1079+2237) (see note above)
= 24

#2: PROD FACTOR = AREA 8A LOCAL CATCH (derived by expanding local tags in catch by % in escapement)/8A LOCAL TAGS
= [(282*25900/1536)+(136*71000/741)+((30+374)*18000/1418)]/822
= 28

#2A: PROD FACTOR = AREA 8A LOCAL CATCH/8A LOCAL TAGS (with term expansions from smolt release data - see note above)
= [(282*25900/2237)+(136*71000/1079)+((30+374)*18000/1418)]/822
= 21

#3: PROD FACTOR = AREA 8A LOCAL CATCH (derived by subtracting non-local production)/8A LOCAL TAGS
= (38496 - 21836) / 822 (see calculations below)
= 20

1984 AREA 8A

SOURCE	# TAGS	EXPANSN	TOTAL
CHILLIWK	4.02	201.49	810
CAPILANO	2.75	10	28
NOOK/SAM	4.02	71	285
SKAGIT	407.77	28	11418
SOUTH SND	216.09	37	7995
HOOD CNL	86.67	15	1300
	721.32		21836

AREA 8A CATCH =	38496
NON-LOCALS =	21836
LOCAL TOTAL =	16660
LOCAL TAGS =	822
PRODUCTN FACTOR =	20

1985 STILLAGUAMISH/SNOHOMISH PRODUCTION FACTOR DATA

HATCHERY & WILD RELEASE GROUPS (None were unmarked)

CWT GROUP	21-16/1	63-30/23	63-28/54	63-29/9	63-30/29	TOTAL
FACILITY	TULALIP	SKYKOMSH	WILD	WILD	WILD	
STOCK	SKYKOMSH	SKYKOMSH	SKYKOMSH	SKYKOMSH	SKYKOMSH	
RELEASE SITE	8A	WALLACE	SUNSET	HARRIS	L PILCHUCK	
RELEASE DATE	6/15/84	6/1/84	4/30-6/2	4/25-6/1	4/25-6/11	
FISH/LB	18.0	17.0	30.0	35.0	30.0	
# TAGGED	124439	29750	10566	25895	22226	212876
LOST TAGS	8084	270	179	0	225	8758
# UNMARKED	605977	267580	0	0	0	873557
TOTAL RELEASE	738500	297600	10745	25895	22451	1095191
HATCHRY TAG %	16.9%	10.0%				19.4%
AREA 8A CATCH	3491	894	183	566	502	5636
RIVER CATCH	0	0	0	0	0	0
ESCPMT RECS*	253	1423	354	976	866	3872
TOTAL	3744	2317	537	1542	1368	9508

* There were no actual recoveries for the Harris and Little Pilchuck groups. The 976 and 866 were estimated by assuming the same average 8A exploitation rate (36.7%) as for the Sunset Falls and Wallace groups.

TERMINAL CATCH & ESCAPEMENT DATA

AREA	CATCH	TAGS IN CATCH	HATCHERY ESCPMT	TAGS IN ESCPMT	WILD ESCPMT	TOTAL ESCPMT	RUN SIZE ENTERING
AREA 8A	93333	5636	-----	-----	-----	-----	200135
AREA 8D	11000	**	2385	253	0	2385	13385
STILLY RIVER	2016	0	0	0	15000	15000	17016
SNOHOMISH R	1	0	11400	3619	65000	76400	76401
TOTAL	106350	5636	13785	3872	80000	93785	200135

** Area 8D tag recoveries were probably included within Area 8A catch samples in 1985. If 21-16/1 contributed to 8D at same rate as to escapement, then 11000*253/2385 = 1167 tags from that group should be moved from 8A to 8D.

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 93785 / 3872
= 24

#2: PROD FACTOR = AREA 8A LOCAL CATCH (derived by expanding local tags in catch by % in escapement)/8A LOCAL TAGS
= [(3491*2385/253)+(894*11400/1423)+((183+566+502)*(80000/(354+976+866)))]/5636
= 15 (Area 8A local catch would be 85643)

#3: PROD FACTOR = Same as above, except subtract from 8A the estimated recoveries of 21-16/1 in 8D (see note above).
= [((3491-1167)*2385/253)+(894*11400/1423)+((183+566+502)*(80000/(354+976+866)))]/(5636-1167)
= 17

#4: PROD FACTOR = AREA 8A & 8D LOCAL CATCH (derived by subtracting non-local production) / LOCAL TAGS
= [(93333 + 11000) - 17701] / 5636
= 15

1985 AREA 8A

ORIGIN	# RECS	EXPNSN	CATCH
TENDERFOOT	17	28.25	480
SKAGIT	443	25	11075
AGATE	240	6.54	1569
OTHER SSND	62	57	3534
FINCH	17	6.67	113
OTHER HOOD C	62	15	930
	841		17701

AREA 8A+8D CATCH =	104333
NON-LOCALS =	17701
LOCAL TOTAL =	86632
LOCAL TAGS =	5636
PRODUCTION FACTOR =	15

1986 STILLAGUAMISH/SNOHOMISH PRODUCTION FACTOR DATA

HATCHERY & WILD RELEASE GROUPS

	MARKED						UNMARKED	TOTAL
CWT GROUP	63-30/51	63-34/29	63-34/30	21-16/34	63-31/41	63-32/03	-----	
FACILITY	WILD	WILD	WILD	TULALIP	SKYKOMSH	SKYKOMSH	SKYKOMSH	
STOCK	SKYKOMSH	SKYKOMSH	SKYKOMSH	SKYKOMSH	SKYKOMSH	SKYKOMSH	SKYKOMSH	
RELEASE SITE	SUNSET	HARRIS	L PILCHK	8D	WALLACE	WALLACE	WALLACE	
RELEASE DATE	4-5/85	4-6/85	4-6/85	6/5/85	6/1/85	6/1/85	3/19/85	
FISH/LB	45.0	35.0	30.0	20.0	20.0	20.0	35.0	
# TAGGED	12412	24259	23770	62293	15174	15191	0	153099
LOST TAGS				693	310	310	0	1313
# UNMARKED				424517	133016	132999	3500	694032
TOTAL RELEASE	12412	24259	23770	487503	148500	148500	3500	848444
HATCHRY TAG %								11.8%
AREA 8A CATCH	241	308	281	1086	252	333		2501
RIVER CATCH	0	0	0	1118	0	0		1118
ESCPMT RECS*	1058	1151	1050	229	1011	1009		5509
TOTAL	1299	1459	1331	2433	1263	1342	0	9128

* There were no actual recoveries for the Harris and Little Pilchuck groups. The 895 and 817 were estimated by assuming the same average 8A exploitation rate (25.5%) as for the Sunset Falls and Wallace groups.

TERMINAL CATCH & ESCAPEMENT DATA

AREA	COMM CATCH	LOCAL TAGS	HATCHERY ESCPMT	TAGS IN ESCPMT	WILD ESCPMT	TOTAL ESCPMT	RUN SIZE ENTERING
AREA 8A	114345	2501					302788
AREA 8D	16004	1118	2063	229	0	2063	18067
STILLY RIVER	5784	0	462	0	23000	23462	29246
SNOHOMISH R	0	0	24130	5509	117000	141130	141130
TOTAL	136133	3619	26655	5738	140000	166655	302788

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = TOTAL ESCAPEMENT/TAGGED ESCAPEMENT
= 166655 / 5509
= 29

#2: PROD FACTOR = AREA 8A LOCAL CATCH (derived by expanding local tags in catch by % in escapement)/8A LOCAL TAGS
= [(1086*2063/229)+(252+333)*24130/(1011+1009)+(241+308+281)*140000/(1058+1151+1050)]/2501
= 21 (Area 8A local catch would be 52420).

#3: PROD FACTOR = AREA 8A LOCAL CATCH (derived by subtracting non-local production)/8A LOCAL TAGS
= (114345 - 25472) / 2501 (See attached page)
= 36

1986 AREA 8A

SOURCE	# TAGS	EXPANSN	TOTAL
INCH	13.24	0	0
SWIN SL	166.51	1.28	213
OTHER SKAGIT	924.22	10	9242
AGATE	181.35	9.38	1701
OTHER S SND	345.95	34	11762
HOOD CANAL	142.2	17	2417
QUEETS	14.56	9.31	136
	1788.03		25472

AREA 8A CATCH =	114345
NON-LOCALS =	25472
LOCAL TOTAL =	88873
LOCAL TAGS =	2501
PRODUCTION FACTOR =	36

1984 SOUTH SOUND PRODUCTION FACTOR DATA

HATCHERY YEARLING RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL
ISSAQUAH	965531		965531
ELLIOTT B	125082	24939	150021
GREEN	519361	50539	569900
CRISP CK	471500		471500
SEAHURST	9738		9738
POVERTY B	30000		30000
BOISE CK	51000		51000
PUYALLUP	988687	42613	1031300
COMMENCEMT	19450		19450
MURRAY CK	97000		97000
TABOTON	51000		51000
TANAWAX	112200		112200
BEAVER	51000		51000
SEQUALICHEW	939800		939800
PONCIN	29950		29950
PEALE	1020466	60919	1081385
MINTER	1432983	32370	1465353
GROVERS	79970		79970
AGATE	167955	30029	197984
TOTAL	7162673	241409	7404082

HATCHERY TAGGED FRACTION = 3.26%

TAGGED WILD RELEASES:

SITE	# TAGGED	CWT GROUP	TERMINAL RETURNS
DESCHUTES	7085	63-27/18	750
MINTER	15836	63-24/19	960
MINTER	8736	63-24/51	410
	31657		2120

1984 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL	AREA 10 CATCH
HATCHERY	418396	71.0%	
WILD	170569	29.0%	
TOTAL	588965		171761

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = INVERSE OF % OF RUN TAGGED (from tag rate at release and escapement estimates)
= 1/[(% H TAGGED * H % OF RUN)+(% W TAGGED * W % OF RUN)]
= 1/[(3.26% * 71%)+(2120/170569*29%)]
= 37

#2: PROD FACTOR = AREA 10 LOCAL CATCH (derived by subtracting non-local production)/AR 10 LOCAL TAGS
= (171761 - 26214) / 4509 (See below)
= 32

1984 AREA 10

SOURCE	# TAGS	EXPANSN	TOTAL
CHILLIWK	10	201.49	2015
OTHER CDN	11	10	110
HOOD CNL	1021	15	15315
SKAGIT	106	28	2968
NOOK/SAM	22	71	1562
STILL/SNO	207	20	4140
QUILL F	4	13	52
WILLAPA	2	26.1	52
	1383		26214

AREA 10 CATCH =	171761
NON-LOCALS =	26214
LOCAL TOTAL =	145547
LOCAL TAGS =	4509
PRODUCTN FACTOR =	32

1985 SOUTH SOUND PRODUCTION FACTOR DATA

HATCHERY YEARLING RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL	CWT GROUP
ISSAQUAH	959,500	0	959,500	
LK WASH	30,531	16,054	46,585	11-17/04
UNIV WASH	1,226	57,650	58,876	11-17/5-7
EDMONDS	30,000	0	30,000	
ELLIOTT	1,405	0	1,405	
GREEN	568,916	25,745	594,661	63-28/51
CRISP CK	486,000	0	486,000	
ELLIOTT	124,300	0	124,300	
GREEN	19,244	0	19,244	
SEAHURST	8,978	0	8,978	
POVERTY	32,200	0	32,200	
BOISE	60,500	0	60,500	
PUYALLUP	355,091	19,586	374,677	63-29/04
PUYALLUP	165,921	17,422	183,343	63-29/05
PUYALLUP	305,800	0	305,800	
COMMENCEMENT	26,000	0	26,000	
MURRAY	93,600	0	93,600	
TABOTON	93,600	0	93,600	
BEAVER	60,500	0	60,500	
WRIGHTS	4,200	0	4,200	
SEQUALICHEW	901,000	0	901,000	
GOLF COURSE	4,200	0	4,200	
PONCIN	29,500	0	29,500	
PEALE	824,713	19,787	844,500	63-28/52
PEALE	363,968	8,732	372,700	63-28/52
PEALE	1,142,213	30,587	1,172,800	63-30/24
PEALE	98,900	0	98,900	
MINTER	1,457,395	16,684	1,474,079	63-29/06
GROVERS	81,899	0	81,899	
FOX ISLAND	411,100	0	411,100	
AGATE	164,717	29,843	194,560	63-30/22
TOTAL	8,907,117	242,090	9,149,207	

HATCHERY TAGGED FRACTION = 2.6%

TAGGED WILD RELEASES:

SITE	# TAGGED	CWT GROUP	TERMINAL RETURNS
DESCHUTES	9,804	63-22/29	726
DESCHUTES	4,651	63-25/44	484
MINTER	10,044	63-30/36	321
MINTER	16,532	63-30/37	354
TOTAL	41,031		1,885

1985 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL
HATCHERY	364,464	55.2%
WILD	296,236	44.8%
TOTAL =	660,700	

continued on next page

1985 SOUTH SOUND PRODUCTION FACTOR DATA cont'd

PRODUCTION FACTOR CALCULATION:

% OF RUN HATCHERY TAGGED = % H TAGGED * H % OF RUN =	1.46%
% OF RUN WILD TAGGED = % W TAGGED * W % OF RUN =	0.29%

TOTAL % OF RUN TAGGED =	1.74%
#1 PRODUCTION FACTOR = INVERSE OF % OF RUN TAGGED =	57

#2 PROD FACTOR = (AREA 10 CATCH - NON-LOCAL CONTRIBUTION)/AR 10 LOCAL TAGS
= (285425 - 40640) / 4999
= 49

1985 GRAYS HARBOR PRODUCTION FACTOR ANALYSIS 17-May-89
01:15 PM

***********************************RELEASE INFORMMATION***********************************

TAGCODE	632852	632453	632547	632910	632911	633027	633046
HATCHERY	SKOOKUMCHUCK	WILD	WILD	WILD	WILD	WILD	WILD
STOCK	CLARK CREEK	WILD	WILD	WILD	WILD	WILD	WILD
RELEASE SITE	SKOOKUMCHUCK	BLACK/WADD	STILLMAN	NEWAUK R	ELK/9 MILE	BINGHAM	BEAVER
RELEASE DATE	FEB 84	APR 84	APR 84	APR 84	APR 84	APR 84	APR 84
FISH/LB	28	25.0	25.0	25.0	30.0	25.0	20.0
# TAGGED	9800	7424	9166	10272	858	31602	10760
TOTAL RELEASE	9800	7424	9192	10690	858	31985	10770
RELEASE/TAGGED	1.00	1.00	1.00	1.04	1.00	1.01	1.00

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

TOTAL RELEASED/ # TAGGED		1.00	1.00	1.04	1.00	1.01	1.00

***INDEPENDENT ESTIMATE: (WILD ESCAPEMENT/SURVIVAL TO ESC)=TOTAL SMOLTS. TOTAL SMOLTS/NUMBER TAGGED=19.97
(15801/.006)=2633500 SMOLTS 2633500/(131842)= 19.97

***********************************TERMINAL INFORRMATION***********************************

TOTAL ESCAPEMENT	5998	20643	20643	20643	20643	20643	20643
TAGGED ESCAPEMENT	3	0	0	0	7	111	0
GILLNET CATCH	10567	10567	10567	10567	10567	10567	10567
GILLNET RECOVERIES	0	0	0	0	0	2	0
TOTAL/TAGGED ESCAPEMEN	26.66	173.47	173.47	173.47	173.47	173.47	173.47

POOLED HATCHERY TOTAL/TAGGED ESCAPEMENT	19.94
WILD PROD FACTOR * WILD GILLNET RECOVS	3355
POOLED TOTAL TERM RUN/TAGGED	22.97

****

1985 AREA 10

SOURCE	# TAGS	EXPANSN	TOTAL
INCH	8	28.25	226
SQUAMISH	5	10	50
CHEHELIS	24	28.25	678
QUINSAM	5	10	50
COL EARLY	9	16	144
STRAITS	18	20	360
TULALIP	245	5.93	1454
OTHER ST/SNO	320	17	5440
SKAGIT	158	25	3950
HOOD CANAL	1380	15	20700
NOOKSACK/SAM	80	89	7120
QUILLAYUTE F	9	52	468
TOTAL	2261		40640

AREA 10 CATCH =	285425
NON-LOCALS =	40640
LOCAL TOTAL =	244785
LOCAL TAGS =	4999
PRODUCTION FACTOR =	49

1986 SOUTH SOUND PRODUCTION FACTOR DATA

HATCHERY YEARLING RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL	CWT GROUP
ISSAQUAH	967,000	0	967,000	
CRISP CK	528,300	0	528,300	
ELLIOTT	145,614	0	145,614	
SEAHURST	7,410	0	7,410	
POVERTY	26,000	0	26,000	
GREEN	279,654	17,163	296,817	63-28/06
GREEN	276,607	16,976	293,583	63-28/07
U OF WASH	310	10,033	10,343	11-17/14
U OF WASH	301	9,738	10,039	11-17/15
U OF WASH	307	9,919	10,226	11-17/16
U OF WASH	23,808	9,947	33,755	11-17/17
PUYALLUP	359,549	15,769	375,318	63-27/59
PUYALLUP	351,022	15,370	366,392	63-27/60
PUYALLUP	92	15,390	15,482	63-27/63
PUYALLUP	94	15,649	15,743	63-28/01
PUYALLUP	167,026	15,837	182,863	63-27/61
PUYALLUP	167,024	15,599	182,623	63-27/62
PUYALLUP	123	15,246	15,369	63-28/02
PUYALLUP	120	14,881	15,001	63-28/03
COMMENCEMENT	24,700	0	24,700	
MURRAY	108,000	0	108,000	
TABOTON	108,000	0	108,000	
TANAWAX	126,900	0	126,900	
BEAVER	43,200	0	43,200	
SEQUALICHEW	499,900	0	499,900	
DESCHUTES	1,000	0	1,000	
PONCIN	56,500	0	56,500	
PEALE	1,159,143	13,645	1,172,788	63-32/04
PEALE	182,643	13,668	196,311	63-32/05
PEALE	364,655	13,228	377,883	63-30/57
PEALE	335,931	12,186	348,117	63-30/58
PEALE	232,196	12,393	244,589	63-30/59
PEALE	226,331	12,080	238,411	63-31/40
MINTER	1,473,391	7,766	1,481,157	63-24/54
MINTER	71	7,780	7,851	63-28/56
MINTER	70	7,722	7,792	63-28/55
FOX ISLAND	386,700	0	386,700	
AGATE	124,591	14,870	139,461	63-28/05
AGATE	127,522	15,219	142,741	63-28/04
TOTAL	8,881,805	328,074	9,209,879	

HATCHERY TAGGED FRACTION = 3.6%

TAGGED WILD RELEASES:

SITE	# TAGGED	CWT GROUP	TERMINAL RETURNS
DESCHUTES	5,126	63-33/52	612
MINTER	13,040	63-34/26	1,002
MINTER	21,090	63-34/27	1,396
	39,256		3,010

continued on next page

1986 South Sound Production Factor continued

1986 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL	AR 10 CATCH	AREA 10 LOCAL TAGS
HATCHERY	562,311	71.2%		
WILD	227,762	28.8%		
TOTAL =	790,073		293,775	7,770

PRODUCTION FACTOR CALCULATIONS:

#1: % OF RUN HATCHERY TAGGED = % H TAGGED * H % OF RUN = 2.54%
% OF RUN WILD TAGGED = % W TAGGED * W % OF RUN = 0.38%

TOTAL % OF RUN TAGGED = 2.92%

PRODUCTION FACTOR = INVERSE OF % OF RUN TAGGED = 34

#2: PROD FACTOR = (AREA 10 LOCAL CATCH-NON LOCAL PRODUCTION)/AR 10 TAGS
= (293775 - 31953) / 7770 (See attached page)
= 34

1986 AREA 10

SOURCE	# TAGS	EXPANSN	TOTAL
CHEHELIS, BC	13.55	53.39	723
CHILLIWACK	4.85	53.39	259
OTHER FRASER	26.1	0	0
CAPILANO	8.18	5.28	43
QUINSAM	8.7	1.66	14
STRAIT JDF	36.65	12	440
NOOK/SAM	13.55	102	1382
SWINMSH SL	32.8	1.28	42
OTHER SKAGIT	183.33	10	1833
TULALIP	130.88	7.83	1024
OTHER ST/SNO	335.66	30	10070
HOOD CANAL	945.32	17	16070
GRAYS HARBOR	4.09	12.5	51
	1743.66		31953

AREA 10 CATCH =	293775
NON-LOCALS =	31953
LOCAL TOTAL =	261822
LOCAL TAGS =	7770
PRODUCTION FACTOR =	34

1984 HOOD CANAL PRODUCTION FACTOR DATA

HATCHERY RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL	CWT GROUP	AREA 12 RECOVS	ESCPMNT RECOVS*	ESCPMNT TO SITE**
PT GAMBLE	369939	30061	400000	63-25/62	317	491	10574
GEO ADAMS	321413	30061	351474	63-25/61	214	925	13643
FINCH	147219	30781	178000	63-27/24	132	862	7286
QUILCENE	323213	29085	352298	05-11/19	272	375	10116
TOTAL	1161784	119988	1281772		935	2653	41619

* Pt Gamble & Quilcene are extreme terminal catch recoveries (Areas 9A & 12A) because rack data unavailable.
** Pt Gamble & Quilcene are extreme terminal (Areas 9A & 12A) catches.

HATCHERY % TAGGED = 9.36%

TAGGED WILD RELEASES:

SITE	# TAGGED	CWT GROUP	TERMINAL RETURNS	AREA 12 RECOVS	ESCPMNT RECOVS	ASSOCIATED ESCAPEMENT*
BIG BEEF	30846	63-30/26	1328	372	878	37000

* Total Hood Canal wild escapement.

1984 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL	AREA 12 CATCH
HATCHERY	49720	54.2%	
WILD	41982	45.8%	
	91702		23481

PRODUCTION FACTOR CALCULATIONS:

#1: PROD FACTOR = INVERSE OF % OF RUN TAGGED (from tag rate at release and escapement estimates)
= 1/[(% H TAGGED * H % OF RUN)+(% W TAGGED * W % OF RUN)]
= 1/[(9.36% * 54.2%)+(45.8% * 1328/41982)]
= 15

#2: PROD FACTOR = AREA 12 LOCAL CATCH (derived by expanding local tags in catch by % in escapmt)/AR 12 LOCAL TAGS
= [(317*10574/491)+(214*13643/925)+(132*7286/862)+(272*10116/375)+(372*37000/878)]/(935+372)
= 34113 / 1307
= 26

#3: PROD FACTOR = AREA 12 LOCAL CATCH (derived by subtracting non-local production)/AREA 12 LOCAL TAGS
= (23481 - 3781) / (935+372)
= 15

1984 AREA 12

SOURCE	# TAGS	EXPANSN	TOTAL
BIG QUAL	2	10	20
SKAGIT	2	28	56
ST/SNO	2	20	40
SOUTH SND	94	37	3478
JDF STR	4	34	136
GRAYS HBR	1	25.1	25
WILLAPA	1	26.1	26
	106		3781

AREA 12 CATCH = 23481
NON-LOCALS = 3781

LOCAL TOTAL = 19700

LOCAL TAGS = 1307

PRODUCTN FACTOR = 15

1985 HOOD CANAL PRODUCTION FACTOR DATA

HATCHERY RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL	CWT GROUP
PT GAMBLE	366,422	27,578	394,000	63-30/28
GEO ADAMS	334,127	29,873	364,000	63-30/21
FINCH	168,201	29,799	198,000	63-22/04
QUILCENE	271,035	0	271,035	
TOTAL	1,139,785	87,250	1,227,035	

HATCHERY TAGGED % = 7.1%

TAGGED WILD RELEASES:

SITE	# TAGGED	CWT GROUP	TERMINAL RETURNS
BIG BEEF	30,846	63-30/26	2,364

1985 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL
HATCHERY	39,009	52.0% (incl Pt Gamble Pens)
WILD	35,981	48.0%
TOTAL	74,990	

PRODUCTION FACTOR CALCULATION #1:

% OF RUN HATCHERY TAGGED = % H TAGGED * H % OF RUN = 3.70%
% OF RUN WILD TAGGED = % W TAGGED * W % OF RUN = 3.15%

TOTAL % OF RUN TAGGED = 6.85%

PRODUCTION FACTOR = INVERSE OF % OF RUN TAGGED = 15

PRODUCTION FACTOR CALCULATION #2 & #3:

AREA 12 TAG RECOVERIES:

	HC TAGS	TOTAL C	P FACTOR
ALL AREA 12 CATCH	2,024	27,522	14
SUBTRACT OUTSIDE P	2,024	25,172	12

1985 AREA 12

SOURCE	# TAGS	EXPANSN	TOTAL
STRAIT	5	20	100
SKAGIT	2	25	50
TULALIP	9	5.93	53
OTHER ST/SNO	4	17	68
SQUAXIN	15	43.48	652
AGATE	9	6.54	59
OTHER S SND	24	57	1368
TOTAL	68		2350

AREA 12 CATCH =	27522
NON-LOCALS =	2350
LOCAL TOTAL =	25172
LOCAL TAGS =	2024
PRODUCTION FACTOR =	12

1986 HOOD CANAL PRODUCTION FACTOR DATA

HATCHERY YEARLING RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL	CWT GROUP
PT GAMBLE	278,272	14,928	293,200	63-27/52
PT GAMBLE	278,273	14,927	293,200	63-27/51
GEORGE ADAMS	140,816	15,584	156,400	63-28/32
GEORGE ADAMS	138,415	15,285	153,700	63-28/33
FINCH	73,299	15,801	89,100	63-27/50
FINCH	74,396	16,104	90,500	63-27/49
QUILCENE	223,128	0	223,128	
	1,206,599	92,629	1,299,228	

HATCHERY TAGGED % = 7.1%

TAGGED WILD RELEASES:

SITE	# TAGGED	CWT GROUP	TERMINAL RETURNS
BIG BEEF	21,309	63-30/34	2,891

1986 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL	AR 12 CATCH	AREA 12 LOCAL TAGS
HATCHERY	93,256	54.3%	(incl Pt Gamble Pens)	
WILD	78,590	45.7%		
TOTAL =	171,846		59,497	2,533

PRODUCTION FACTOR CALCULATIONS:

#1: % OF RUN HATCHERY TAGGED = % H TAGGED * H % OF RUN = 3.87%
% OF RUN WILD TAGGED = % W TAGGED * W % OF RUN = 1.68%

TOTAL % OF RUN TAGGED = 5.55%

PRODUCTION FACTOR = INVERSE OF % OF RUN TAGGED = 18

#2: PROD FACTOR = (AREA 12 LOCAL CATCH-NON LOCAL PRODUCTION)/AR 12 TAGS
= (59497 - 16189) / 2533 (See attached page)
= 17

1986 AREA 12

SOURCE	# TAGS	EXPANSN	TOTAL
STRAIT JDF	18.22	12	219
NOOK/SAM	6.57	144	946
SKAGIT	22.41	10	224
TULALIP	2.54	7.83	20
OTHER ST/SNO	54.15	30	1625
AGATE	148.6	9.38	1394
OTHER S SND	335.24	34	11398
QUEETS	10.6	9.31	99
GRAYS HARBOR	21.2	12.5	265
	619.53		16189

AREA 12 CATCH =	59497
NON-LOCALS =	16189
LOCAL TOTAL =	43308
LOCAL TAGS =	2533
PRODUCTION FACTOR =	17

1984 STRAIT OF JUAN DE FUCA TRIBS PRODUCTION FACTOR DATA

HATCHERY RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL	CWT GROUP
ELWHA	0	9618	9618	05-11/27
ELWHA	568700	9843	578543	05-11/28
ELWHA	0	9637	9637	05-11/29
PT ANGELE	4991	0	4991	
	573691	29098	602789	

HATCHERY % TAGGE 4.83%

1984 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL
HATCHERY	9412	61.5%
WILD	5897	38.5%
TOTAL	15309	

PRODUCTION FACTOR CALCULATION:

% OF RUN TAGGED = % H TAGGED * H % OF RUN = 2.97%

PRODUCTION FACTOR = INVERSE OF % OF RUN TAGGED 34

1985 STRAIT OF JUAN DE FUCA TRIBS PRODUCTION FACTOR DATA

HATCHERY RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL	CWT GROUP
DUNGENESS	188,000	0	188,000	
ELWHA	1,470	7,720	9,190	05-14/32
ELWHA	0	4,934	4,934	05-15/16
ELWHA	0	3,601	3,601	05-15/20
ELWHA	0	5,053	5,053	05-15/19
ELWHA	636,000	3,847	639,847	05-15/23
ELWHA	0	5,134	5,134	05-15/18
ELWHA	1,439	7,781	9,220	05-14/31
ELWHA	0	3,518	3,518	05-15/22
ELWHA	0	3,625	3,625	05-15/21
ELWHA	0	4,370	4,370	05-17/17
ELWHA	1,282	8,145	9,427	05-14/30
ELWHA	53,091	0	53,091	AR?,AL?,PL5
PT ANGELES	29,758	0	29,758	
TOTAL	911,040	57,728	968,768	

HATCHERY TAGGED % = 6.0%

1985 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL
HATCHERY	16,958	83.0%
WILD	3,481	17.0%
TOTAL	20,439	

PRODUCTION FACTOR CALCULATION:

% OF RUN TAGGED = % H TAGGED * H % OF RUN = 4.94%

PRODUCTION FACTOR = INVERSE OF % OF RUN TAGGED = 20

1986 STRAIT OF JUAN DE FUCA TRIBS PRODUCTION FACTOR DATA

HATCHERY YEARLING RELEASES:

SITE	# UNTAGGED	# TAGGED	TOTAL	CWT GROUP
DUNGENESS	10,094	19,481	29,575	1B-04/08
DUNGENESS	10,193	19,676	29,869	1B-04/09
DUNGENESS	10,518	20,314	30,832	1B-04/10
DUNGENESS	10,154	19,599	29,753	1B-04/11
DUNGENESS	10,332	19,948	30,280	1B-04/12
DUNGENESS	10,070	19,364	29,434	1B-04/14
DUNGENESS	10,108	19,438	29,546	1B-04/15
DUNGENESS	10,111	19,444	29,555	1B-05/08
DUNGENESS	10,073	19,370	29,443	1B-05/09
DUNGENESS	10,164	19,549	29,713	1B-05/10
ELWHA	645,414	0	645,414	
PT ANGELES	46,270	0	46,270	
	793,501	196,183	989,684	

HATCHERY TAGGED % = 19.8%

1986 TERMINAL RUN SIZE:

	RUN SIZE	% OF TOTAL
HATCHERY	9,984	43.0%
WILD	13,215	57.0%
TOTAL =	23,199	

PRODUCTION FACTOR CALCULATION:

% OF RUN TAGGED = % H TAGGED * H % OF RUN = 8.53%

PRODUCTION FACTOR = INVERSE OF % OF RUN TAGGED = 12

1984 QUILLAYUTE SUMMER AND FALL COHO PRODUCTION FACTOR DATA

RELEASE DATA:

CWT GROUP	RACE	STOCK	# TAGGED	# UNTAGGED	TOTAL RELEASE	% TAGGED
63-26/43	SUMMER	SOLEDUCK	23048	177852	200900	11.5%
63-26/44	FALL	SOLEDUCK	22073	64045	86118	25.6%

1984 SPAWNING ESCAPEMENT:

	WILD FALL	WILD SUMMER	HATCHERY TOTAL
ESTIMATED ESCAPEMENT	10508	1573	11307

			ESTIMATED RETURN	
RACE	TAGS AT RACK	HATCHERY % TAGGED	RACK RETURN	ADJUSTED FOR ACTUAL
SUMMER	787	11.5%	6860	6838
FALL	1149	25.6%	4483	4469
	1936		11343	11307

PRODUCTION FACTOR CALCULATION:

```
SUMMERS: PROD FACTOR = TOTAL SUMMER ESCAPEMENT/TAGGED ESCAPEMENT
--------             = (1573 + 6838) / 787
                     =         11

FALLS:   PROD FACTOR = TOTAL FALL ESCAPEMENT/TAGGED ESCAPEMENT
------               = (10508 + 4469) / 1149
                     =         13
```

1985 QUILLAYUTE SUMMER AND FALL COHO PRODUCTION FACTOR DATA

RELEASE DATA:

CWT GROUP	RACE	STOCK	# TAGGED	# UNTAGGED	TOTAL RELEASE	% TAGGED
63-27/39	SUMMER	SOLEDUCK	34849	454251	489100	7.1%
63-27/40	FALL	SOLEDUCK	34122	240978	275100	12.4%
63-29/7	FALL	DICKEY WILD	14170	0	14170	
63-29/8	FALL	BOGY WILD	11226	0	11226	

1985 SPAWNING ESCAPEMENT:

	WILD FALL	WILD SUMMER	HATCHERY (ALL)
ESTIMATED ESCAPEMENT	7500	300	1415

RACE	TAGS AT RACK	HATCHERY % TAGGED	ESTIMATED RACK RETURN	RETURN ADJUSTED FOR ACTUAL
SUMMER	59	7.1%	828	946
FALL	51	12.4%	411	469
TOTAL	110		1239	1415

PRODUCTION FACTOR CALCULATION:

SUMMERS: PROD FACTOR = TOTAL SUMMER ESCAPEMENT/TAGGED ESCAPEMENT
= (300 + 946) / 59
= 21

FALLS: No data exist on escapement of wild tag groups. Thus, escapement will be calculated by assuming that the ratio between Washington ocean catch and escapement is the same as for the hatchery group (63-27/40):

CWT GROUP	WASHINGTON OCEAN CATCH	ESCAPEMNT	
63-27/40	35	51	(Actual)
63-29/7	21	31	(Calculated)
63-29/8	49	71	(Calculated)
TOTAL	105	153	

PROD FACTOR = TOTAL FALL ESCAPEMENT/TAGGED ESCAPEMENT
= (7500 + 469) / 153
= 52

1986 QUILLAYUTE SUMMER AND FALL COHO PRODUCTION FACTOR DATA

RELEASE DATA:

CWT GROUP	RACE	STOCK	# TAGGED	# UNTAGGED	TOTAL RELEASE	% TAGGED
63-22/55	SUMMER	SOLEDUCK	21076	317331	338407	6.7%
63-32/56	SUMMER	SOLEDUCK	22200	330293	352493	
63-32/58	FALL	SOLEDUCK	24520	142275	166795	17.2%
63-32/57	FALL	SOLEDUCK	24226	141579	165805	
63-34/17	FALL	QUILL W	7078		7078	
63-34/18	FALL	DICKEY	34990		34990	

1986 SPAWNING ESCAPEMENT:

	WILD FALL	WILD SUMMER	HATCHERY (ALL)
ESTIMATED ESCPMT	10600	700	9800

RACE	TAGS AT RACK	HATCHERY % TAGGED	ESTMTD RACK RETURN	RETURN ADJUSTED FOR ACTUAL
SUMMER	412	6.7%	6166	6576
FALL	519	17.2%	3022	3224
TOTAL	931		9188	9800

PRODUCTION FACTOR CALCULATION:

SUMMERS: PROD FACTOR = TOTAL SUMMER ESCAPEMENT/TAGGED ESCAPEMENT
= (700 + 6576) / 412
= 18

FALLS: No data exist on escapement of wild tag groups. Thus, escapement will be calculated by assuming that the ratio between prior interceptions and escapement is the same as for the hatchery groups (63-32/57 & 63-32/58):

CWT GROUP	PRIOR CATCHES	ESCPMT	
63-32/57	314	225	(Actual)
63-32/58	342	289	(Actual)
63-34/17	172	134	(Calculated)
63-34/18	866	676	(Calculated)
TOTAL	1694	1324	

PROD FACTOR = TOTAL FALL ESCAPEMENT/TAGGED ESCAPEMENT
= (10600 + 3224) / 1324
= 10

PRODUCTION FACTOR ESTIMATES FOR QUEETS AND QUINAULT STOCKS

QUEETS HATCHERY STOCK

Year	No. tags released	No. untagged released	Production factor
1984	40686	435260	11.70
1985	81410	714781	9.78
1986	244513	1194175	5.88

QUEETS WILD STOCK

Year	No. tags released	Total Queets smolt yield	Productio Factor *
1984	34900	284685	9.32
1985	27026	183183	7.72
1986	16433	133394	9.31

* survival rate of tagged wild fish estimated at 0.86 that of untagged fish.

QUEETS HATCHERY TAGCODES

Year	Tagcode	Facility	Stock
1984	51355	Quinault Lake	Quinault
1985	211607	Quinault Lake	Quinault
1985	211614	Quinault Lake	Quinault
1986	211642	Quinault Lake	Quinault
1986	211643	Quinault Lake	Queets
1986	211648	Quinault Lake	Quinault
1986	B50802	Quinault	Quinault
1986	B50803	Quinault Lake	Queets
1986	B50807	Quinault Lake	Soleduck
1986	B50808	Quinault Lake	Soleduck

QUEETS WILD TAGCODES

Year	Tagcode	Facility	Stock
1984	51126	wild	Osprey
1984	51420-21	wild	Queets
1984	51422	wild	Snahapish
1984	632315	wild	
1984	632343	wild	Queets
1984	632545	wild	Clearwate
			Clearwate
1985	211624-26	wild	
			Queets
1986	211710-11	wild	
1986	211713-15	wild	Queets
1986	211718	wild	Queets
			Queets

QUINAULT STOCK

Year	No. tags released	No. untagged released	Hatchery prod fact	Hatchery term run	Wild/off stat run	Total run/ hatch run	Queets hatch&wild prod fact
1984	54258	900303	17.59	15300	18700	2.22	39.10
1985	54592	819044	16.00	4000	8000	3.00	48.01
1986	50236	735318	15.64	16500	17200	2.04	31.94

QUINAULT HATCHERY TAGCODES

Year	Tagcode	Facility	Stock
1984	51261	Quinault	Quinault
1984	51362	Quinault Lake	Quinault
1985	51455	Quinault	Quinault
1985	211608	Quinault Lake	Quinault
1986	211635-36	Quinault	Quinault

NON-LOCAL PRODUCTION RECOVERED IN THE GRAYS HARBOR GILLENT CATCH
ADJUSTMENT OF TERMINAL GILLNET CATCH TO EXCLUDE NON-LOCAL STOCKS

1984 GRAYS HARBOR GILLNET CATCH TOTAL =13200

NON-LOCAL STOCKS	EST REC	PROD FACT	EST PROD
632734 WILLAPA	1.58	26.1	41.2
TOTAL NON-LOCAL PRODUCTION			41
TOTAL LOCAL PRODUCTION			13159

1985 GRAYS HARBOR GILLNET CATCH TOTAL =10600

NON-LOCAL STOCKS	EST REC	PROD FACT	EST PROD
211625 WILD QUEETS	4.30	7.7	33.2
TOTAL NON-LOCAL PRODUCTION			33
TOTAL LOCAL PRODUCTION			10567

1986 GRAYS HARBOR GILLNET CATCH TOTAL =51000

NON-LOCAL STOCKS	EST REC	PROD FACT	EST PROD
72759 NEWHALEM	1.49	51.8	77.2
211643 QUEETS	3.36	5.9	19.8
211718 WILD QUEETS	3.36	9.3	31.3
603734 OR-AQUA	1.21	6.4	7.8
632808 NASELLE	3.36	35.8	120.3
632812 NASELLE	1.84	35.8	65.9
632813 NASELLE	1.50	35.8	53.7
632814 NEMAH	4.89	35.8	175.1
632816 NEMAH	1.84	35.8	65.9
633342 WILLAPA	1.84	35.8	65.9
633343 WILLAPA	6.35	35.8	227.3
NO TAGS	72.10	10.0	721.0
TOTAL NON-LOCAL PRODUCTION			1631
TOTAL LOCAL PRODUCTION			49369

1984 GRAYS HARBOR PRODUCTION FACTOR ANALYSIS 17-May-89 01:15 PM

********************************RELEASE INFORMATION********************************

TAGCODE	632647		632648	632736	632646	
HATCHERY	SIMPSON		SATSOP SPR	SKOOKUMCHUCK	SIMPSON	
STOCK	SIMPSON		SIMPSON	SIMPSON	LATE SATSOP	
RELEASE SITE	BINGHAM CR		MISC GH	MISC GH	BINGHAM CR	
RELEASE DATE	APR-MAY 83		APR 83	MAY 83	APR-MAY 83	
FISH/LB	18.0		27.0	24.0	18.0	
# TAGGED	49483		51230	51945	35155	
TOTAL RELEASE	1118541		1136437	895160	35388	
RELEASE/TAGGED	22.60		22.18	17.23	1.01	

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	SATSOP SPR	COOP				
STOCK	SATSPO SPR	WISHKAH				
TYPE RELEASE	FING-ON	FRY-ON				
# RELEASED	52125	80000				
SMOLT EQUIVALENTS	3128	521				
HATCHERY	HUMPTULIPS	HUMPTULIPS				
STOCK	HUMPTULIPS	HUMPTULIPS				
TYPE RELEASE	FING-OFF	SMOLTS-ON				
# RELEASED	5570133	643545				
SMOLT EQUIVALENTS	167104	643545				
HATCHERY	SIMPSON	HUMPTULIPS				
STOCK	SIMPSON	HUMPTULIPS				
TYPE RELEASE	FRY&FING-OFF	SMOLTS-OFF				
# RELEASED	3984975	603700				
SMOLT EQUIVALENTS	173473	301850				
HATCHERY	HUMP/COOP	WSTPT PENS				
STOCK	HUMPTULIPS	HUMPTULIPS				POOLED
TYPE RELEASE	FRY&FING-OFF	SMOLTS-OFF				HATCHERY
# RELEASED	300437	98600				RELEASE
SMOLT EQUIVALENTS	5226	98600				INFO
TOTAL RELEASED/ # TAGGED	50.76		22.18	17.23	1.01	24.38

********************************TERMINAL INFORMATION********************************

						HUMTULIPS
TOTAL ESCAPEMENT	24125		24125	177	24125	12449
TAGGED ESCAPEMENT	1451		43	5	338	
GILLNET CATCH	13159		13159	13159	13159	
GILLNET RECOVERIES	13		62	68	141	
TOTAL/TAGGED ESCAPEMEN	13.17		13.17	35.40	13.17	

POOLED HATCHERY TOTAL/TAGGED ESCAPEMENT	20.01
WILD PROD FACTOR * WILD GILLNET RECOVS	3708
HATCH GILLNET CATCH/HATCH GILLNET RECOVS	33.28

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1984 GRAYS HARBOR PRODUCTION FACTOR ANALYSIS 17-May-89
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**********************************RELEASE INFORMATION**

TAGCODE	632418	632559	632719	632726	632230	632728
HATCHERY	WILD	WILD	WILD	WILD	WILD	WILD
STOCK	STILLMAN CR	NEWAKUM	STEVENS CR	BINGHAM CR	BEAVER/BLACK	BEAVER/BLACK
RELEASE SITE	STILLMAN CR	NEWAKUM	STEVENS CR	BINGHAM CR	BEAVER/BLACK	BEAVER/BLACK
RELEASE DATE	APR-MAY 83	APR-MAY 83	APR-JUN 83	APR-JUN 83	MAY-JUN 83	APR-MAY 83
FISH/LB	-	-	-	-	-	-
# TAGGED	5844	7599	20578	23824	9382	32013
TOTAL RELEASE	6344	8595	20784	23833	9408	33121
RELEASE/TAGGED	1.09	1.13	1.01	1.00	1.00	1.03

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

							POOLED WILD RELEASE INFO
TOTAL RELEASED/ # TAGGED	1.09	1.13	1.01	1.00	1.00	1.03	1.03

***INDEPENDENT ESTIMATE: (WILD ESCAPEMENT/SURVIVAL TO ESC)=TOTAL SMOLTS TOTAL SMOLTS/NUMBER TAGGED =21.07
(165010/.0789)=2091381 SMOLTS 2091391/(99240) = 21.07

**********************************TERMINAL INFORMATION**

							HUMP/HOQUIAM
TOTAL ESCAPEMENT	74202	74202	74202	74202	74202	74202	30955
TAGGED ESCAPEMENT	1	0	42	1578	2	1	
GILLNET CATCH	13159	13159	13159	13159	13159	13159	
GILLNET RECOVERIES	17	2	99	24	12	22	
TOTAL/TAGGED ESCAPEMEN	45.69	45.69	45.69	45.69	45.69	45.69	

POOLED HATCHERY TOTAL/TAGGED ESCAPEMENT	20.01
WILD PROD FACTOR * WILD GILLNET RECOVS	3708
HATCH GILLNET CATCH/HATCH GILLNET RECOVS	33.28

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1985 GRAYS HARBOR PRODUCTION FACTOR ANALYSIS 17-May-89
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********************************RELEASE INFORMATION********************************

TAGCODE	632861	633017-018 632744	632745	632745	632862	632743	632746
HATCHERY	SIMPSON	HUMPTULIPS	HUMPTULIPS	WP COOP PENS	SATSOP SPR	SKOOKUMCHUCK	SIMPSON
STOCK	SIMPSON	HUMPTULIPS	HUMPTULIPS	HUMPTULIPS	SIMPSON	SIMPSON	LATE SATSOP
RELEASE SITE	BINGHAM CR	STEVENS	MISC/OFF	SOUTH BAY	MISC GH	MISC GH	BINGHAM CR
RELEASE DATE	MAY 84	MAR/MAY	MAR 84	MAY 84	MAR 84	MAR 84	MAY 84
FISH/LB	20	21-30	30	12	26-29	22	22
# TAGGED	45404	146899	44457	6081	50231	48935	49676
TOTAL RELEASE	1085270	1009321	741000	100400	963510	831160	321924
RELEASE/TAGGED	23.90	6.87	16.67	16.51	19.18	16.98	6.48

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	SIMPSON	HUMPTULIPS	HUMPTULIPS		MINIMODS	WILLAPA	
STOCK	SIMPSON	NASELLE	HUMPTULIPS		WILLAPA	WILLAPA	
TYPE RELEASE	FING-OFF	FING-ON	FING-OFF		FING/MISC	FING-OFF	
# RELEASED	1783400	69600	2157200		205737	168700	
SMOLT EQUIVALENTS	107004	4176	107004		12344	10122	
HATCHERY	SIMPSON		WISHKAH HS		MINIMODS		
STOCK	NASELLE		HUMPTULIPS		NASELLE		
TYPE RELEASE	FING-OFF		FRY		FING/MISC		
# RELEASED	121000		150000		385650		
SMOLT EQUIVALENTS	7260		1500		23139		
HATCHERY			GRS HRB COLL				
STOCK			HUMPTULIPS				
TYPE RELEASE			FRY/MISC				
# RELEASED			298000				
SMOLT EQUIVALENTS			2980				
HATCHERY			GRS HARB GILNT				
STOCK			NASELLE				
TYPE RELEASE			FING/MISC				
# RELEASED			185800				
SMOLT EQUIVALENTS			11148				
TOTAL RELEASED/ # TAGGED	26.42	6.90	19.43	16.51	19.89	17.19	6.48

POOLED HATCHERY RELEASE INFO 13.32

********************************TERMINAL INFORMATION********************************

TOTAL ESCAPEMENT	5998	1920	1920	1920	5998	5998	5998
TAGGED ESCAPEMENT	220	170	2	(2)	2	0	0
GILLNET CATCH	10567	10567	10567	10567	10567	10567	10567
GILLNET RECOVERIES	0	239	44	(44)	0	23	8
TOTAL/TAGGED ESCAPEMEN	26.66	11.16	11.16	11.16	26.66	26.66	26.66

POOLED HATCHERY TOTAL/TAGGED ESCAPEMENT	19.94
WILD PROD FACTOR * WILD GILLNET RECOVS	3355
POOLED TOTAL TERM RUN/TAGGED	22.97

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1985 GRAYS HARBOR PRODUCTION FACTOR ANALYSIS 17-May-89
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**********************************RELEASE INFMATION***

TAGCODE	633047	633048	633061	633062	633107
HATCHERY	WILD	WILD	WILD	WILD	WILD
STOCK	WILD	WILD	WILD	WILD	WILD
RELEASE SITE	BLACK	STEVENS	BEAVER	BEAVER	STEVENS
RELEASE DATE	APR 84	APR 84	APR 84	MAY 84	MAY 84
FISH/LB	20.0	25.0	18.0	20.0	25.0
# TAGGED	20910	18055	10717	7663	4415
TOTAL RELEASE	20910	18023	10727	7671	4415
RELEASE/TAGGED	1.00	1.00	1.00	1.00	1.00

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

TOTAL RELEASED/ # TAGGED	1.00	1.00	1.00	1.00	

***INDEPENDENT ESTIMATE: (WILD ESCAPEMENT/SURVIVAL TO ESC)=TOTAL SMOLTS. TOTAL SMOLTS/NUMBER TAGGED=19.97
(15801/.006)=2633500 SMOLTS 2633500/(131842)= 19.97

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TOTAL ESCAPEMENT	20643	20643	20643	20643	20643
TAGGED ESCAPEMENT	0	1	0	0	0
GILLNET CATCH	10567	10567	10567	10567	10567
GILLNET RECOVERIES	111	37	15	0	3
TOTAL/TAGGED ESCAP	173.47	173.47	173.47	173.47	173.47

POOLED HATCHERY TOTAL/TAGGED ESCAPEMENT	19.94
WILD PROD FACTOR * WILD GILLNET RECOVS	3355
POOLED TOTAL TERM RUN/TAGGED	22.97

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1986 GRAYS HARBOR PRODUCTION FACTOR ANALYSIS 27-Sep-89 02:31 PM

RELEASE INFORMATION

TAGCODE	H10504-505 H10601-604	632820-822	632817-819 632823-628	632829-831	633032-33	H10605-07&701 H10506-07	633345-348
HATCHERY	HUMPTULIPS	HUMPTULIPS	HUMPTULIPS	SATSOP SPR	SKOOKUMCHUCK	SIMPSON	SIMPSON
STOCK	HUMPTULIPS	HUMPTULIPS	HUMPTULIPS	SATSOP SPR	SATSOP SPR	SIMPSON	SIMPSON
RELEASE SITE	MISC/OFF	MISC/OFF	STEVENS	MISC/OFF	CHEHALIS	MISC/OFF	BINGHAM
RELEASE DATE	MAR 84	APR 85	APR/MAY 85	MAR 85	MAR 85	APR-MAY 84	MAR/MAY 85
FISH/LB	425-442	406	23-33	23	18	488-550	20-27
# TAGGED	190171	51201	1039742	49021	44211	199346	103939
TOTAL RELEASE	300400	924500	1140882	821100	688824	3102397	983748
RELEASE/TAGGED	1.58	18.06	1.10	16.75	15.58	15.56	9.46

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	HUMPTULIPS	WESTP PENS		MARICUL	GRS HARB COLLE		
STOCK	HUMPTULIPS	HUMPTULIPS		WILLAPA	SIMPSON		
TYPE RELEASE	FING-OFF	SMOLT		FING/MISC	FING		
# RELEASED	154200	99800		317363	98637		
SMOLT EQUIVALENTS	9252	99800		19042	5918		
HATCHERY	HUMPTULIPS	WILLAPA		MARICUL			
STOCK	SIMPSON	WILLAPA		NEMAH			
TYPE RELEASE	FING-OFF	FING/MISC		FING/MISC			
# RELEASED	1066811	532000		558287			
SMOLT EQUIVALENTS	64009	31920		33497			
HATCHERY	GRS HARB GILNT	MINIMODS		MARICUL			
STOCK	SIMPSON	NEMAH		NASELLE			
TYPE RELEASE	FING	FING/MISC		FING/MISC			
# RELEASED	7000	490455		920899			
SMOLT EQUIVALENTS	420	29427		55254			
HATCHERY							
STOCK							
TYPE RELEASE							
# RELEASED							
SMOLT EQUIVALENTS							
TOTAL RELEASED/ # TAGGED	1.97	21.20	1.10	18.95	15.71	15.56	9.46

POOLED RELEASE INFORMATION 4.95

TERMINAL INFORMATION

TOTAL ESCAPEMENT	24469	24469	24469	15979	15979	15979	15979
TAGGED ESCAPEMENT	2	0	2446	2	15	46	764
GILLNET CATCH	49369	49369	49369	49369	49369	49369	49369
GILLNET RECOVERIES	0	10	1485	70	35	57	69
TOTAL/TAGGED ESCAPEMEN	10.00	10.00	10.00	19.32	19.32	19.32	19.32

POOLED HATCHERY TOTAL/TAGGED ESCAPEMENT 12.35
WILD PROD FACTOR * WILD GILLNET RECOVS 22997
HATCH GILLNET CATCH/HATCH GILLNET RECOVS 15.28

1986 GRAYS HARBOR PRODUCTION FACTOR ANALYSIS 27-Sep-89 02:31 PM

******************************RELEASE INFORMATION******************************

TAGCODE	633010	633035	633209	633423	633424	633425	633443	633444
HATCHERY	WILD	WILD	WILD	WILD	WILD	WILD	WILD	WILD
STOCK	WILD	WILD	WILD	WILD	WILD	WILD	WILD	WILD
RELEASE SITE	STEVENS CR	BINGHAM CR	WADDWLL CR	BEAVER CR	STEVENS CR	BLACK R	STILLMAN CR	NEWAUKUM R
RELEASE DATE	MAY 85	APR 85	APR 85	APR 85	APR 85	APR 85	APR 85	APR 85
FISH/LB	25.0	30.0	20.0	20.0	25.0	20.0	25.0	25
# TAGGED	3530	21369	4830	23998	21914	28142	7242	10942
TOTAL RELEASE	3534	21429	5906	24222	21936	28142	7278	10990
RELEASE/TAGGED	1.00	1.00	1.22	1.01	1.00	1.00	1.00	1.00

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

HATCHERY
STOCK
TYPE RELEASE
RELEASED
SMOLT EQUIVALENTS

TOTAL RELEASED/ # TAGGED	1.00	1.00	1.22	1.01	1.00	1.00	1.00	1.00

***INDEPENDENT ESTIMATE: (WILD ESCAPEMENT/SURVIVAL TO ESC)=TOTAL SMOLTS. TOTAL SMOLTS/NUMBER TAGGED=15.09
(76767/.0417)=1840935 SMOLTS. 1840935/(121967) = 15.09

* T E R M I N A
INFORMATION**

TOTAL ESCAPEMENT	33683	33683	33683	33683	33683	33683	33683	33683
TAGGED ESCAPEMENT	0	775	0	24	25	19	12	2
GILLNET CATCH	49425	49369	49369	49369	49369	49369	49369	49369
GILLNET RECOVERIES	29	388	27	45	678	185	28	144
TOTAL/TAGGED ESCAPEM	39.30	39.30	39.30	39.30	39.30	39.30	39.30	39.30

POOLED HATCHERY TOTAL/TAGGED ESCAPEMENT	12.35
WILD PROD FACTOR * WILD GILLNET RECOVS	22997
HATCH GILLNET CATCH/HATCH GILLNET RECOVS	15.28

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NON-LOCAL PRODUCTION RECOVERED IN THE WILLAPA GILLENT CATCH
ADJUSTMENT OF TERMINAL GILLNET CATCH TO EXCLUDE NON-LOCAL STOCKS

1984 WILLAPA BAY GILLNET CATCH TOTAL = 50700

NON-LOCAL STOCKS		EST REC	PROD FACT	EST PROD
051355	QUEETS	2.47	11.7	28.9
072744	CASCADE	2.47	15.1	37.3
072745	CASCADE	10.07	15.1	152.1
632230	WILD BEAVER/BLACK	5.32	21.1	112.1
632418	WILD STILLMAN CR	2.47	21.1	52.0
632618	COWLITZ	2.47	32.0	79.0
632628	COWLITZ	2.47	32.0	79.0
632634	COWLITZ	2.47	32.0	79.0
632647	SIMPSON	30.05	20.0	601.0
632648	SATSOP SPRINGS	26.06	20.0	521.2
632719	WILD STEVENS CR	13.87	21.1	292.2
632726	WILD BINGHAM CR	17.59	21.1	370.6
632736	WILD BEAVER/BLACK	29.26	21.1	616.5
632735	SPEELYAI	4.94	15.1	74.6
632736	SKOOKUMCHUCK	2.85	21.1	60.0
TOTAL NON-LOCAL PRODUCTION				3156
TOTAL LOCAL PRODUCTION				47544

1985 WILLAPA BAY GILLNET CATCH TOTAL = 35300

NON-LOCAL STOCKS		EST REC	PROD FACT	EST PROD
51519	LOWER ELHWA	2.15	20.0	43.0
72907	SANDY	2.92	15.6	45.6
72944	CASCADE	2.92	15.6	45.6
72946	CASCADE	5.61	15.6	87.5
72947	CASCADE	2.69	15.6	42.0
72949	CASCADE	2.69	15.6	42.0
211624	WILD QUEETS	2.15	7.7	16.6
621725	ANADRAMOUS	2.92	12.5	36.4
632743	SKOOKUMCHUCK	14.80	19.9	294.5
632744	HUMPTULIPS	13.44	19.9	267.5
632745	HUMPTULIPS	11.52	19.9	229.2
632861	SIMPSON	21.18	19.9	421.5
632918	COWLITZ	2.15	24.6	52.9
632932	COWLITZ	2.15	24.6	52.9
632958	WASHOUGAL	2.69	24.6	66.2
633018	HUMPTULIPS	4.30	19.9	85.6
633024	SQUAXIN ISLAND	2.92	57.0	166.4
633027	WILD BINGHAM CR	7.50	20.0	149.8
633028	PORT GAMBLE PENS	2.92	15.0	43.8
633047	WILD BLACK R	4.30	20.0	85.9
633048	WILD STEVENS CR	7.46	20.0	149.0
633107	WILD STEVENS CR	3.00	20.0	59.9
NO TAGS		102.22	10.0	1022.2
TOTAL NON-LOCAL PRODUCTION				3506
TOTAL LOCAL PRODUCTION				31794

1986 WILLAPA BAY GILLNET CATCH TOTAL = 116900

NON-LOCAL STOCKS		EST REC	PROD FACT	EST PROD
H10606	SIMPSON	1.03	12.5	12.9
H10701	SIMPSON	3.11	12.5	38.9
73029	CASCADE	1.03	13.5	13.9
73205	CASCADE	2.08	13.5	28.1
73206	CASCADE	3.14	13.5	42.4
73209	CASCADE	1.06	13.5	14.3
621618	ANADRAMOUS	1.03	11.1	11.5
632755	SKAGIT	1.03	10.0	10.3
632805	SUQUAMISH PENS	2.00	34.0	68.0
632817	HUMPTULIPS	3.11	12.5	38.9
632818	HUMPTULIPS	5.17	12.5	64.6
632819	HUMPTULIPS	7.24	12.5	90.5
632820	HUMPTULIPS	1.06	12.5	13.3
632823	HUMPTULIPS	7.25	12.5	90.6
632824	HUMPTULIPS	2.04	12.5	25.5
632825	HUMPTULIPS	5.12	12.5	64.0
632826	HUMPTULIPS	3.11	12.5	38.9
632827	HUMPTULIPS	5.13	12.5	64.1
832828	HUMPTULIPS	1.06	12.5	13.3
632829	SATSOP SPRINGS	1.03	12.5	12.9
632831	SATSOP SPRINGS	1.03	12.5	12.9
633010	WILD STEVENS CR	0.17	15.1	2.5
633032	SKOOKUMCHUCK	3.07	12.5	38.4
633033	SKOOKUMCHUCK	2.05	12.5	25.6
633035	WILD BINGHAM CR	6.17	15.1	93.0
633345	SIMPSON	5.19	12.5	64.9
633346	SIMPSON	7.24	12.5	90.5
633423	WILD BEAVER CR	3.10	15.1	46.7
633424	WILD STEVENS CR	2.05	15.1	30.9
633425	WILD BLACK R	8.25	15.1	124.3
633444	WILD NEWAKUM R	1.03	15.1	15.5
NO TAGS		224.23	10.0	2242.3
TOTAL NON-LOCAL PRODUCTION				3544
TOTAL LOCAL PRODUCTION				113356

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1984 WILLAPA PRODUCTION FACTOR ANALYSIS 01:19 PM

*********************************RELEASE INFORMATION ************************************

TAGCODE	632734	632650	632649
HATCHERY	WILLAPA	NEMAH	NASELLE
STOCK	WILLAPA	NEMAH	JOHNSON CR
RELEASE SITE	FORK CREEK	N NEMAH	NASELLE
RELEASE DATE	APRIL 83	MAY 83	MAY 83
FISH/LB	19.0-20.0	20.0	20.0
# TAGGED	52796	50783	51293
TOTAL RELEASE	711837	750900	1089000
RELEASE/TAGGED	13.48	14.79	21.23

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	WILLAPA	NEMAH	NASELLE	
STOCK	HUMPTULIPS	NEMAH	NEMAH	
TYPE RELEASE	FRY	FINGERLING	FRY	
# RELEASED	498800	970752	624000	
SMOLT EQUIVALENTS	4988	58245	6240	
HATCHERY	WILLAPA	SEA RESOURCES	NASELLE	
STOCK	WILLAPA	NEMAH	NASELLE	
TYPE RELEASE	FRY	FRY	FINGERLING	
# RELEASED	1018460	1150036	668417	
SMOLT EQUIVALENTS	10185	11500	40105	
HATCHERY	WILLAPA	SEA RESOURCES	NASELLE	
STOCK	WILLAPA	NEMAH	JOHNSON CR	
TYPE RELEASE	FINGERLING	FINGERLING	FRY	
# RELEASED	604258	636550	226200	
SMOLT EQUIVALENTS	36255	38193	2262	
HATCHERY			NASELLE	
STOCK			JOHNSON CR	
TYPE RELEASE			FINGERLING	
# RELEASED			1626071	
SMOLT EQUIVALENTS			97564	POOLED RELEASE INFORMATION
TOTAL RELEASED/ # TAGGED	14.46	16.91	24.08	18.45
EXPANDED 5% WILD	15.18	17.76	25.28	19.37

*********************************TERMINAL INFORMATION***

					POOLED ESTIMATE
TOTAL ESCAPEMENT	10098	8955	14374		33427
TAGGED ESCAPEMENT	505	501	535		1552
GILLNET CATCH	47544	47544	47544		47544
GILLNET RECOVERIES	741	406	417	TOT ASSOC CATCH	1564
ASSOCIATED TERM CATCH	14817	7257	11204	33278	33685
TOTAL/TAGGED ESCAPEMENT	20.00	17.87	26.87		21.54

POOLED TERM CATCH/TERM RECOVS	30.40
POOLED CATCH & ESC/RECOVS	26.08

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17-May-89
1985 WILLAPA PRODUCTION FACTOR ANALYSIS 01:19 PM

**********************************RELEASE INFORMATION ************************************

TAGCODE	633013-14	633012	632741-2
HATCHERY	WILLAPA	NEMAH	NASELLE
STOCK	WILLAPA	NEMAH	NASELLE
RELEASE SITE	FORK CREEK	N NEMAH	NASELLE
RELEASE DATE	MAR/APR 84	MAY 84	APR/MAY 84
FISH/LB	17-19	19	16-19
# TAGGED	102492	51125	101892
TOTAL RELEASE	727370	1064014	3003515
RELEASE/TAGGED	7.10	20.81	29.48

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	PAC TROLRS		NASELLE	
STOCK	WILLAPA		HUMPTULIPS	
TYPE RELEASE	FRY		FRY	
# RELEASED	140400		475000	
SMOLT EQUIVALENTS	1404		4750	
HATCHERY	WILLAPA		MINIMODS	
STOCK	WILLAPA		NASELLE	
TYPE RELEASE	FINGERLING		FINGERLING	
# RELEASED	239800		577000	
SMOLT EQUIVALENTS	14388		34620	
HATCHERY			SEA RESOURCES	
STOCK			NASELLE	
TYPE RELEASE			FRY	
# RELEASED			1650000	
SMOLT EQUIVALENTS			16500	
HATCHERY				
STOCK				
TYPE RELEASE				
# RELEASED				
SMOLT EQUIVALENTS				POOLED RELEASE INFORMATION
TOTAL RELEASED/ # TAGGED	7.25	20.81	30.03	19.05
EXPANDED 5% WILD	7.61	21.85	31.53	20.00

**********************************TERMINAL INFORMATION***

					POOLED ESTIMATE
TOTAL ESCAPEMENT	5504	6771	12621		24896
TAGGED ESCAPEMENT	385	294	459		1141
GILLNET CATCH	31794	31794	31794		31794
GILLNET RECOVERIES	272	253	615	TOT ASSOC CATCH	1140
ASSOCIATED TERM CATCH	3889	5827	16910	26626	24874
TOTAL/TAGGED ESCAPEMENT	14.30	23.03	27.50		21.82

POOLED TERM CATCH/TERM RECOVS 27.89
POOLED CATCH & ESC/RECOVS 24.89
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17-May-89
1986 WILLAPA PRODUCTION FACTOR ANALYSIS 01:19 PM

**********************************RELEASE INFORMATION ************************************

TAGCODE	633341-344	632814-816	632808-813
HATCHERY	WILLAPA	NEMAH	NASELLE
STOCK	WILLAPA	NEMAH	NASELLE
RELEASE SITE	FORK CREEK	N NEMAH	NASELLE
RELEASE DATE	APR/MAY 85	MAR/APR/MAY 85	MAR/APR/MAY 85
FISH/LB	19-21	18-23	16-17
# TAGGED	104311	50633	100136
TOTAL RELEASE	733141	864955	18233172
RELEASE/TAGGED	7.03	17.08	182.08

ASSOCIATED RELEASES (ASSUMES A 6% FINGERLING-TO-SMOLT AND 1% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	WILLAPA		NEMAH	
STOCK	WILLAPA		NASELLE	
TYPE RELEASE	FINGERLING		SMOLT	
# RELEASED	35000		170775	
SMOLT EQUIVALENTS	2100		170775	
HATCHERY			NASELLE	
STOCK			NASELLE	
TYPE RELEASE			SMOLT	
# RELEASED			693000	
SMOLT EQUIVALENTS			693000	
HATCHERY			NASELLE	
STOCK			NASELLE	
TYPE RELEASE			FINGERLING	
# RELEASED			1242000	
SMOLT EQUIVALENTS			74520	
HATCHERY				
STOCK				
TYPE RELEASE				
# RELEASED				
SMOLT EQUIVALENTS				POOLED RELEASE INFORMATION
TOTAL RELEASED/ # TAGGED	7.05	17.08	191.45	81.43
EXPANDED 5% WILD	7.40	17.94	201.03	85.50

**********************************TERMINAL INFORMATION**

					POOLED ESTIMATE
TOTAL ESCAPEMENT	19806	18945	32687		71438
TAGGED ESCAPEMENT	1535	846	1234		3708
GILLNET CATCH	113356	113356	113356		113356
GILLNET RECOVERIES	662	160	722	TOTAL ASSOC CATCH	1544
ASSOCIATED TERM CATCH	8542	3583	19125	31250	29747
TOTAL/TAGGED ESCAPEMENT	12.90	22.39	26.49		19.27

POOLED TERM CATCH/TERM RECOVS	73.42
POOLED CATCH & ESC/RECOVS	35.82

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NON-LOCAL PRODUCTION RECOVERED IN THE COLUMBIA RIVER GILLNET CATCH (ZONE 1-5)
ADJUSTMENT OF TERMINAL GILLNET CATCH TO EXCLUDE NON-LOCAL STOCKS

1984 COLUMBIA RIVER GILLNET CATCH TOTAL =203100

NON-LOCAL STOCKS		EST REC	PROD FACT	EST PROD
072560	NEWHALEM	3.12	54.2	169.1
072609	TRASK	3.12	54.2	169.1
072629	SALMON RIVER-OR	3.12	54.2	169.1
072630	SALMON RIVER-OR	3.12	54.2	169.1
072641	FALL CREEK	2.36	54.2	127.9
600617	OR-AQUA	3.79	20.8	78.8
632551	WILD SOLEDUCK	3.12	13.1	40.9
632646	SIMPSON	3.79	20.0	75.8
632647	SIMPSON	3.12	20.0	62.4
632648	SATSOP SPRINGS	3.12	20.0	62.4
632649	NASELLE	3.12	26.1	81.4
632728	WILD BEAVER/BLACK	4.56	21.1	96.1
632734	WILLAPA	3.12	26.1	81.4

TOTAL NON-LOCAL PRODUCTION	1384
TOTAL LOCAL PRODUCTION (EARLY)	115910
TOTAL LOCAL PRODUCTION (LATE)	85807

1985 COLUMBIA RIVER GILLNET CATCH TOTAL= 195200

NON-LOCAL STOCKS		EST REC	PROD FACT	EST PROD
603710	OR-AQUA	4.21	27.3	114.9
632741	NASELLE	4.21	24.8	104.4
632742	NASELLE	4.21	24.8	104.4
632745	HUMPTULIPS	4.17	19.9	83.0
632904	PUYALLUP	4.76	57.0	271.3
633012	NEMAH	3.93	24.8	97.5
633024	SQUAXIN ISLAND	4.17	57.0	237.7
633026	WILD BIG BEEF CR	1.58	15.0	23.7

TOTAL NON-LOCAL PRODUCTION	1037
TOTAL LOCAL PRODUCTION (EARLY)	110423
TOTAL LOCAL PRODUCTION (LATE)	83740

1986 COLUMBIA RIVER GILLNET CATCH TOTAL =997800

NON-LOCAL STOCKS		EST REC	PROD FACT	EST PROD
72761	ROCK CREEK	4.6	51.8	238.3
73028	SILETZ	5.70	51.8	295.3
73035	TRASK	7.20	51.8	373.0
603628	OR-AQUA	4.60	6.4	29.5
630704	OR-AQUA	4.60	6.4	29.5
630713	OR-AQUA	5.60	6.4	36.0
603747	OR-AQUA	7.20	6.4	46.2
603750	OR-AQUA	4.60	6.4	29.5
603761	OR-AQUA	4.60	6.4	29.5
603762	OR-AQUA	7.20	6.4	46.2
603820	OR-AQUA	4.20	6.4	27.0
603821	OR-AQUA	7.20	6.4	46.2
603822	OR-AQUA	7.20	6.4	46.2
623024	ANADRAMOUS	7.20	11.1	80.1
623034	ANADRAMOUS	4.60	11.1	51.2
623036	ANADRAMOUS	5.60	11.1	62.3
632750	HOOD CANAL	4.60	17.0	78.3
632807	GREEN RIVER	4.60	34.0	156.4
632808	NASELLE	5.10	35.8	182.6
633057	SQUAXIN ISLAND	4.30	34.0	146.2
633256	SOLEDUCK	8.50	18.0	153.0
633425	WILD BLACK R	5.60	15.1	84.4

TOTAL NON-LOCAL PRODUCTION	2267
TOTAL LOCAL PRODUCTION (EARLY)	372576
TOTAL LOCAL PRODUCTION (LATE)	622957

1984 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (EARLY STOCK) 27-Sep-89
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********************************RELEASE INFORMATION************************************

TAGCODE	050928-050945	051133-051138	72447	72448	72743-72745	72449	72451
HATCHERY	WILLARD	EAGLE CREEK	BIG CREEK	BIG CREEK	BIG CREEK	KLASKANINE	VANDERVLT PND
STOCK	TOUTLE	EAGLE CREEK	BIG CREEK	BIG CREEK	COL EARLY	COL EARLY	COL EARLY
RELEASE SITE	LIT WHITE SALM	EAGLE CREEK	BIG CREEK	BIG CREEK	OCEAN	KLASKANINE	TUCKER CREEK
RELEASE DATE	JUNE 83	MAY 83	MAY 83	JUNE 83	JUNE 83	APRIL 83	APRIL 83
FISH/LB	18.5-20.9	13.3-15.5	15.2	15.9	13.5-13.9	15.5	15.0
# TAGGED	406576	244740	26125	26858	127630	25466	27404
TOTAL RELEASE	417829	253386	302366	439702	129570	1378338	216490
RELEASE/TAGGED	1.03	1.04	11.57	16.37	1.02	54.12	7.90

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY		EAGLE CREEK				KLASKANINE	
STOCK		EAGLE CREEK				BIG CREEK	
TYPE RELEASE		SMOLT				FINGERLING	
# RELEASED		185001				158360	
SMOLT EQUIVALENTS		185001				23754	
HATCHERY						KLASKANINE	
STOCK						BIG CREEK	
TYPE RELEASE						SMOLTS	
# RELEASED						146735	
SMOLT EQUIVALENTS						146735	
HATCHERY						KLASKANINE	
STOCK						KLASKANINE	
TYPE RELEASE						FRY	
# RELEASED						353950	
SMOLT EQUIVALENTS						10619	
HATCHERY						KLASKANINE	
STOCK						KLASKANINE	
TYPE RELEASE						FINGERLING	
# RELEASED						157320	
SMOLT EQUIVALENTS						23598	
TOTAL RELEASED/ # TAGGED	1.03	1.79	11.57	16.37	1.02	62.16	7.90
EXPANDED 10% WILD	1.13	1.97	12.73	18.01	1.12	68.38	8.69

********************************TERMINAL INFORMATION************************************

TOTAL ESCAPEMENT	6619	2166	5950	5950	5950	4228	177
TAGGED ESCAPEMENT	1213	670	302	116	5	49	17
GILLNET CATCH	115910	115910	115910	115910	115910	115910	115910
GILLNET RECOVERIES	245	524	243	61	226	679	635
ASSOCIATED TERM CATCH*	1337	1694	7455	(7455)	(7455)	58588	6611
TOTAL/TAGGED ESCAPEMEN	5.46	3.23	14.07	14.07	14.07	86.29	10.41

POOLED RELEASE INFORMATION (EARLY STOCKS)		POOLED TERMINAL INFORMATION (EARLY STOCKS)	
TOTAL RELEASED/# TAGGED	6.76	TERM CATCH/TERM RECOVS	17.70
EXPANDED 10% WILD	7.44	CATCH & ESC/RECOVS	15.08

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* TOTAL ASSOCIATED TERMINAL CATCH GREATER THAN ACTUAL CATCH. HAVE TO POOL ESTIMATES FOR ALL EARLY STOCKS.

1984 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (EARLY STOCK) 27-Sep-89
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**********************************RELEASE INFORMATION**********************************

TAGCODE	72643	72742,46,47	72606-72607	72731-72736	632733	632735	632645
HATCHERY	CASCADE	CASCADE	BONNEVILLE	SANDY	GRAYS RIVER	SPEELYAI	WASHOUGAL
STOCK	COL EARLY	COL EARLY	COL EARLY	COL EARLY	COL EARLY	COL EARLY	COL EARLY
RELEASE SITE	KLASKANINE	COL RIVER	TANNER CREEK	CLEAR CREEK	GRAYS RIVER	LEWIS RIVER	WASHOUGAL
RELEASE DATE	JUNE 83	JUNE 83	MAY 83	APRIL 83	APRIL 83	JUNE 83	APRIL 83
FISH/LB	16.5	13.0-18.5	15.0-16.2	16.2-17.2	20.0	20.0	18.0
# TAGGED	26065	127630	54196	163049	50086	50985	50852
TOTAL RELEASE	824817	129890	1802207	327837	396200	115500	906300
RELEASE/TAGGED	31.64	1.02	33.25	2.01	7.91	2.27	17.82

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY			BONNEVILLE	SANDY		LEWIS RIVER	SPEELYAI
STOCK			SANDY	SANDY		COL EARLY	COL EARLY
TYPE RELEASE			FINGERLING	SMOLT		FRY	SMOLT
# RELEASED			1854988	115292		480000	1003220
SMOLT EQUIVALENTS			278248	115292		14400	1003220
HATCHERY						KALAMA FALLS	
STOCK						COL EARLY	
TYPE RELEASE						FINGERLIN	
# RELEASED						406000	
SMOLT EQUIVALENTS						60900	
HATCHERY						SPEELYAI	
STOCK						COL EARLY	
TYPE RELEASE						FRY	
# RELEASED						336000	
SMOLT EQUIVALENTS						10080	
HATCHERY						EGG BOXES	
STOCK						COL EARLY	
TYPE RELEASE						FRY	
# RELEASED						204000	
SMOLT EQUIVALENTS						6120	
TOTAL RELEASED/ # TAGGED	31.64	1.02	38.39	2.72	7.91	4.06	37.55
EXPANDED 10% WILD	34.81	1.12	42.23	2.99	8.70	4.47	41.31

**********************************TERMINAL INFORMATION**********************************

								POOLED
TOTAL ESCAPEMENT	15311	15311	15311	12290	2688	2532	7341	65252
TAGGED ESCAPEMENT	28	96	426	1847	369	6	317	5461
GILLNET CATCH	115910	115910	115910	115910	115910	115910	115910	115910
GILLNET RECOVERIES	182	414	397	2333	329	18	264	6550
ASSOCIATED TERM CATCH*	27643	(27643)	(27643)	15524	2397	7596	6114	78264
TOTAL/TAGGED ESCAPEMEN	29.33	29.33	29.33	6.65	7.28	422.00	23.16	11.95

POOLED RELEASE INFORMATION (EARLY STOCKS)		POOLED TERMINAL INFORMATION (EARLY STOCKS)	
TOTAL RELEASED/# TAGGED	6.76	TERM CATCH/TERM RECOVS	17.70
EXPANDED 10% WILD	7.44	CATCH & ESC/RECOVS	15.08

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* TOTAL ASSOCIATED TERMINAL CATCH GREATER THAN ACTUAL CATCH. HAVE TO POOL ESTIMATES FOR ALL EARLY STOCKS.

1984 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (LATE STOCK) 27-Sep-89 02:33 PM

**************************************RELEASEINFORMATION**************************************

TAGCODE	632605	632613-632642	632651-632717
HATCHERY	LOWER KALAMA	COWLITZ	WASHOUGAL
STOCK	COL LATE	COL LATE	COL LATE
RELEASE SITE	FALLERT CREEK	COWLITZ	WASHOUGAL
RELEASE DATE	MAY 83	MAY 83	MAY 83
FISH/LB	16.6	16.6-20.0	18.8-19.3
# TAGGED	52002	311009	293034
TOTAL RELEASE	536800	2809361	402013
RELEASE/TAGGED	10.32	9.03	1.37

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	LOWER KALAMA	ELOKOMIN	WASHOUGAL	
STOCK	COL LATE	COL LATE	COL LATE	
TYPE RELEASE	FRY	FINGERLING	FINGERLING	
# RELEASED	71344	145256	303468	
SMOLT EQUIVALENTS	2140	21788	45520	
HATCHERY	KALAMA FALLS	COWLITZ	KLICKITAT	
STOCK	COL LATE	COL LATE	COL LATE	
TYPE RELEASE	FRY	FRY	SMOLT	
# RELEASED	653414	120000	1456910	
SMOLT EQUIVALENTS	19602	3600	1456910	
HATCHERY	LEWIS RIVER	COWLITZ	ROCKY REACH	
STOCK	COL LATE	COL LATE	COL LATE	
TYPE RELEASE	SMOLT	FINGERLING	SMOLT	
# RELEASED	2767410	2154007	515605	
SMOLT EQUIVALENTS	2767410	323101	515605	
HATCHERY		COW/ELOKOM		
STOCK		COL LATES		
TYPE RELEASE		SMOLT		
# RELEASED		4731000		
SMOLT EQUIVALENTS		4731000		POOLED ESTIMATE
TOTAL RELEASED/ # TAGGED	63.96	25.37	8.26	20.78
EXPANDED 10% WILD	70.35	27.90	9.08	22.86

**************************************TERMINALINFORMATION**************************************

	LOWER KALAMA	COWLITZ	WASHOUGAL	ELOKOMIN	LEWIS RIVER	POOLED ESTIMATE
TOTAL ESCAPEMENT	1482	26166	6384	3094	12504	49630
TAGGED ESCAPEMENT	125	1460	292			1880
GILLNET CATCH	85807	85807	85807			85807
GILLNET RECOVERIES	434	1444	483		TOT ASSOC CATCH	2361
ASSOCIATED TERMINAL C	5146	25879	10560		41585	62328
TOTAL/TAGGED ESCAPEME	11.86	17.92	21.86			26.40

POOLED TERM CATCH/TERM RECOVS 36.34

POOLED CATCH & ESC/TERM RECOVS 31.94

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1985 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (EARLY STOCK) 17-May-89
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********************************RELEASE INFORMATION**

TAGCODE	051224-241	72725	72817-819	72944-947	072906-913	073014-15	072948-94
HATCHERY	WILLARD	KLASKANINE	BIG CREEK	BIG CREEK	SANDY	BONNEVILLE	CASCADE
STOCK	WILLARD	COL EARLY	BIG CREEK	TANNER CR	SANDY	TANNER CR	TANNER CR
RELEASE SITE	LIT WHITE SALM	KLASKANINE	BIG CR/TUALA	COLUMBIA	SANDY	TANNER CR	TANNER/CO
RELEASE DATE	JUNE 84	APRIL 84	MAY/JUNE 84	MAY 84	APRIL 84	MAY/APR/JN 84	MAY 84
FISH/LB	12-16	10	12-15	12	17	11-15	13.0
# TAGGED	339183	20018	81639	167860	209408	44275	87236
TOTAL RELEASE	1081558	1264230	788739	167860	1038938	1740253	87236
RELEASE/TAGGED	3.19	63.15	9.66	1.00	4.96	39.31	1.00

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	WILLARD	KLASKANINE	BIG CREEK	GNAT CREEK	SANDY	OXBOW	CASCADE
STOCK	LIT WHITE SALM	KLASKANI	BIG CREEK	SANDY	SANDY	TANNER	SANDY
TYPE RELEASE	SMOLT	FRY	FRY	FRY	FRY	FRY	FRY
# RELEASED	1845456	462880	258420	790775	1652239	499473	160995
SMOLT EQUIVALENTS	1845456	13886	7753	23723	495672	14984	4830
HATCHERY	EAGLE CR	KLASKANINE			SANDY		CASCADE
STOCK	CLACKAMAS	KLASKANI			SANDY		SANDY
TYPE RELEASE	SMOLT	SMOLT			FINGERLING		FINGERLIN
# RELEASED	1021403	1264234			80597		1967412
SMOLT EQUIVALENTS	1021403	1264234			12090		29511
HATCHERY	LITTLE WHITE	KLASKANINE					CASCADE
STOCK	COL EARLY	TANNER CR					TANNER
TYPE RELEASE	FRY	SMOLT					FRY
# RELEASED	247500	1174199					1075240
SMOLT EQUIVALENTS	7425	1174199					32257
HATCHERY	LITTLE WHITE						
STOCK	COL EARLY						
TYPE RELEASE	FINGERLING						
# RELEASED	326026						
SMOLT EQUIVALENTS	48904						
TOTAL RELEASED/ # TAGGED	11.81	185.66	9.76	1.14	7.39	39.64	1.76
EXPANDED 10% WILD	12.99	204.23	10.73	1.26	8.12	43.61	1.94

********************************TERMINAL INFORMATION**

TOTAL ESCAPEMENT	10591	4152	9124	9124	8145	24630	24630
TAGGED ESCAPEMENT	1144	25	299	82	1744	579	749
GILLNET CATCH	110423	110423	110423	110423	110423	110423	110423
GILLNET RECOVERIES	180	602	718	1143	704	74	1124
ASSOCIATED TERM CATCH*	1666	99980	44566	(44590)	3288	54137	(54158)
TOTAL/TAGGED ESCAPEMEN	9.26	166.08	23.95	23.95	4.67	17.61	17.61

POOLED RELEASE INFORMATION (EARLY STOCKS)		POOLED TERMINAL INFORMATION (EARLY STOCKS)	
TOTAL RELEASED/# TAGGED	16.74	TERM CATCH/TERM RECOVS	16.74
EXPANDED 10% WILD	18.42	CATCH & ESC/RECOVS	15.64

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* TOTAL ASSOCIATED TERMINAL CATCH GREATER THAN ACTUAL CATCH. HAVE TO POOL ACROSS ALL EARLY STOCKS

1985 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (EARLY STOCK) 17-May-89 01:13 PM

*****RELEASE INFORMATION*****

TAGCODE	72821-22	73141-142	633011	633015-016	72637
HATCHERY	CASCADE	CASCADE	GRAYS RIVER	SPEELYAI	WAHKEENA P.
STOCK	COL EARLY	COL EARLY	COL EARLY	COL EARLY	COL EARLY
RELEASE SITE	KLASK/TROJAN	PTUCKER CR	GRAYS RIVER	LEWIS RIVER	COLUMBIA
RELEASE DATE	APR/MAY 84	APRIL 84	APRIL 84	JUNE 84	JUNE 83
FISH/LB	13-16	13-16	18.0	17-19	60
# TAGGED	46202	53240	48594	100595	27120
TOTAL RELEASE	1450151	301374	405600	1127623	2787122
RELEASE/TAGGED	31.39	5.66	8.35	11.21	102.77

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	GRAYS RIVER	SPEELYAI	KLICKITAT
STOCK	COL EARLY	COL EARLY	COL EARLY
TYPE RELEASE	FINGERLING	FINGERLING	SMOLT
# RELEASED	225400	154600	799300
SMOLT EQUIVALENTS	33810	23190	799300
HATCHERY	SEA REAS	WASHOUGAL	
STOCK	CHINOOK R	COL EARLY	
TYPE RELEASE	FINGERLING	FINGERLING	
# RELEASED	7725	1001800	
SMOLT EQUIVALENTS	1159	150270	
HATCHERY		L KALAMA	
STOCK		COL EARLY	
TYPE RELEASE		SMOLT	
# RELEASED		209000	
SMOLT EQUIVALENTS		209000	
HATCHERY		WASHOUGAL	
STOCK		COL EARLY	
TYPE RELEASE		SMOLT	
# RELEASED		1062570	
SMOLT EQUIVALENTS		1062570	

TOTAL RELEASED/ # TAGGED	31.39	5.66	9.07	33.52	102.77
EXPANDED 10% WILD	34.53	6.23	9.97	36.87	113.05

*****TERMINAL INFORMATION*****

						WASH	EAGLE	L KAL CED
TOTAL ESCAPEMENT	24630	24630	828	724	0	4489	4461	961
TAGGED ESCAPEMENT	70	1	73	50	5			
GILLNET CATCH	110423	110423	110423	110423	110423			
GILLNET RECOVERIES	954	923	90	17	68			
ASSOCIATED TERM CATCH*	(54158)	(54158)	1021	246	0			
TOTAL/TAGGED ESCAPEMENT	17.61	17.61	11.34	14.48	0.00			

POOLED RELEASE INFORMATION (EARLY STOCKS)		POOLED TERMINAL INFORMATION (EARLY STOCKS)	
TOTAL RELEASED/# TAGGED	16.74	TERM CATCH/TERM RECOVS	16.74
EXPANDED 10% WILD	18.42	CATCH & ESC/RECOVS	15.64

*****

* TOTAL ASSOCIATED TERMINAL CATCH GREATER THAN ACTUAL CATCH. HAVE TO POOL ACROSS ALL EARLY STOCKS

1985 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (LATE STOCK) 17-May-89 01:13 PM

RELEASE INFORMATION

TAGCODE	632942-963 633001-008	632912-941
HATCHERY	WASHOUGAL	COWLITZ
STOCK	COL LATE	COL LATE
RELEASE S	WASHOUGAL	COWLITZ
RELEASE DATE	MAY 84	MAY 84
FISH/LB	18	17-20
# TAGGED	296897	308343
TOTAL RELEASE	2035630	5002800
RELEASE/TAGGED	6.86	16.22

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	KLICKITAT	ELOKOMIN	ELOKOMIN	
STOCK	COL LATE	COL LATE	COL LATE	
TYPE RELEASE	SMOLT	FINGERLING	SMOLT	
# RELEASE	540000	321500	2507000	
SMOLT EQUIVALENTS	540000	48225	2507000	
HATCHERY	WASHOUGAL	COWLITZ	L KALAMA	
STOCK	COL LATE	COL LATE	COL LATE	
TYPE RELEASE	FINGERLING	FRY	SMOLT	
# RELEASE	600000	8000	453000	
SMOLT EQUIVALENTS	90000	240	453000	
HATCHERY	LEWIS RIVER	COWLITZ		
STOCK	COL LATE	COL LATE		
TYPE RELEASE	SMOLT	FINGERLING		
# RELEASE	3266000	4176400		
SMOLT EQUIVALENTS	3266000	626460		
HATCHERY		L KALAMA		
STOCK		COL LATES		
TYPE RELEASE		FINGERLING		
# RELEASED		1526000		POOLED RELEASE
SMOLT EQUIVALENTS		228900		INFORMATION
TOTAL RELEASED/ # TAGGED	19.98	28.76		24.45
EXPANDED 10% WILD	21.98	31.63		26.90

TERMINAL INFORMATION

			LEWIS	L KAL	K FAL	ELOKO	POOLED
TOTAL ESCAPEMENT	2743	18610	9529	123	1030	5563	37598
TAGGED ESCAPEMENT	752	754					1506
GILLNET CATCH	83740	83740					83740
GILLNET RECOVERIES	2082	1355			TOT ASSOC CATCH		3437
ASSOCIATED GILLNET CA	7594	33444			41038		85806
TOTAL/TAGGED ESCAPEME	3.65	24.68					

POOLED TERM CATCH/TERM RECOVS	24.36
POOLED CATCH & ESC/TERM RECOVS	24.55

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1986 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (EARLY STOCK) 27-Sep-89
02:32 PM

******************************RELEASE INFORMATION******************************

TAGCODE	073030-032	073205-07&09	072802 & 04	72654	73343-44	073204 & 08	073105-08 073045-50
HATCHERY	BIG CREEK	BIG CREEK	BONNEVILE	BONNEVILLE	CASCADE	CASCADE	SANDY
STOCK	BIG CREEK	TANNER CR	TANNER CR	COL EARLY	COL EARLY	TANNER CR	SANDY
RELEASE SITE	BIG CREEK	PACIFIC OC	TANNER CR	WAHKENNA POND	TUCKER CR	COLUM/TANNER	SANDY
RELEASE DATE	JUNE 85	MAY 85	MAY/JUNE 85	AUG 84	APRIL 85	MAY 85	APRIL 85
FISH/LB	10-15	14	15	80.0	13-16	15	12
# TAGGED	82079	158824	52115	25862	50264	79740	263690
TOTAL RELEASE	703941	158824	2072986	2110395	302226	79740	683356
RELEASE/TAGGED	8.58	1.00	39.78	81.60	6.01	1.00	2.59

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY						OXBOW	SANDY
STOCK						SANDY	SANDY
TYPE RELEASE						FINGERLING	FINGERLING
# RELEASED						42966	14129
SMOLT EQUIVALENTS						6445	2119
HATCHERY							EAGLE
STOCK						WILLARD	CLACKAMAS
TYPE RELEASE						SMOLT	SMOLT
# RELEASED						999538	1026105
SMOLT EQUIVALENTS						999538	1026105
HATCHERY							
STOCK							
TYPE RELEASE							
# RELEASED							
SMOLT EQUIVALENTS							
HATCHERY							
STOCK							
TYPE RELEASE							
# RELEASED							
SMOLT EQUIVALENTS							
TOTAL RELEASED/ # TAGGED	8.58	1.00	39.78	81.60	6.01	13.62	6.49
EXPANDED 10% WILD	9.43	1.10	43.75	89.76	6.61	14.98	7.14

******************************TERMINAL INFORMATION******************************

TOTAL ESCAPEMENT	18425	18425	57162	57162	57162	57162	25872
TAGGED ESCAPEMENT	1567	146	1306	36	59	861	7271
GILLNET CATCH	372576	372576	372576	372576	372576	372576	372576
GILLNET RECOVERIES	1897	4776	1055	1542	925	3786	8763
ASSOCIATED TERM CATCH*	71775	(72635)	64805	(65148)	(65148)	(65148)	31193
TOTAL/TAGGED ESCAPEMEN	10.76	10.76	25.27	25.27	25.27	25.27	3.21

POOLED RELEASE INFORMATION (EARLY STOCKS)		POOLED TERMINAL INFORMATION (EARLY STOCKS)	
TOTAL RELEASED/# TAGGED	13.33	TERM CATCH/TERM RECOVS	12.77
EXPANDED 10% WILD	14.66	CATCH & ESC/RECOVS	13.49

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* TOTAL ASSOCIATED TERMINAL CATCH GREATER THAN ACTUAL CATCH. HAVE TO POOL ESTIMATES FOR ALL EARLY STOCKS.

1986 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (EARLY STOCK) 27-Sep-89 02:32 PM

********RELEASE INFORMATION********

TAGCODE	72811	73029	72801	633259-301	633132-135	633030-031
HATCHERY	SANDY	KLASKANINE	KLASKANINE	GRAYS RIVER	WASHOUGAL	KLICKITAT
STOCK	SANDY	TANNER	KLASKANINE	COL EARLY	COL EARLY	COL EARLY
RELEASE SITE	SANDY/CEDAR	KLASKANI	KLASKANI	GRAYS RIVER	WASHOUGAL	KLICKITAT
RELEASE DATE	APRIL 85	MAY 85	APRIL 85	APR/MAY 85	MAY 85	MAY/JUNE 85
FISH/LB	12.0	14.0	11.0	16.0	17-18	12-13
# TAGGED	25590	27960	27177	146660	102758	44923
TOTAL RELEASE	213248	1397990	1358852	147996	1064760	1163488
RELEASE/TAGGED	8.33	50.00	50.00	1.01	10.36	25.90

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY				SEA RESOUR	KALAMA FALLS	
STOCK				CHINOOK	COL EARLY	
TYPE RELEASE				FINGERLIN	SMOLT	
# RELEASED				832	328400	
SMOLT EQUIVALENTS				125	328400	
HATCHERY					LEWIS RIVER	
STOCK					COL EARLY	
TYPE RELEASE					SMOLT	
# RELEASED					678500	
SMOLT EQUIVALENTS					678500	
HATCHERY						
STOCK						
TYPE RELEASE						
# RELEASED						
SMOLT EQUIVALENTS						
HATCHERY						
STOCK						
TYPE RELEASE						
# RELEASED						
SMOLT EQUIVALENTS						
TOTAL RELEASED/ # TAGGED	8.33	50.00	50.00	3.25	20.16	25.90
EXPANDED 10% WILD	9.17	55.00	55.00	3.57	22.18	28.49

********TERMINAL INFORMATION********

							EAGL	K FAL	LEWIS
TOTAL ESCAPEMENT	25872	19462	19462	1983	16999	25014	13394	5578	1385
TAGGED ESCAPEMENT	790	166	95	15	0	2			
GILLNET CATCH	372576	372576	372576	372576	372576	372576		SPEEL	CEDC
GILLNET RECOVERIES	956	809	1069	1225	1598	768		1529	347
ASSOCIATED TERM CATCH*	(31389)	140037	(141379)	161945	0	9605376			
TOTAL/TAGGED ESCAPEMEN	3.21	74.57	74.57	132.20	0.00	12507			

POOLED RELEASE INFORMATION (EARLY STOCKS)		POOLED TERMINAL INFORMATION (EARLY STOCKS)	
TOTAL RELEASED/# TAGGED	13.33	TERM CATCH/TERM RECOVS	12.77
EXPANDED 10% WILD	14.66	CATCH & ESC/RECOVS	13.49

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* TOTAL ASSOCIATED TERMINAL CATCH GREATER THAN ACTUAL CATCH. HAVE TO POOL ESTIMATES FOR ALL EARLY STOCKS.

1986 COLUMBIA RIVER PRODUCTION FACTOR ANALYSIS (LATE STOCK) 27-Sep-89 02:32 PM

RELEASE INFORMATION

TAGCODE	633253-254	633161-162 633249-252	633232-233 633156-157
HATCHERY	ELOKOMIN	COWLITZ	KALAMA FALLS
STOCK	COL LATE	COL LATE	COL LATE
RELEASE SITE	ELOKOMIN	COWLITZ	KALAMA
RELEASE DATE	MAY 85	MAY 85	APR/MAY 85
FISH/LB	25	17-21	17
# TAGGED	51767	140444	204454
TOTAL RELEASE	1703000	4278200	502379
RELEASE/TAGGED	32.90	30.46	2.46

ASSOCIATED RELEASES (ASSUMES A 15% FINGERLING-TO-SMOLT AND 3% FRY-TO-SMOLT SURVIVAL RATE)

HATCHERY	ELOKOMIN	OXBOW	COWLITZ	L KALAMA	
STOCK	COL LATE	COWLITZ	COL LATE	COL LATE	
TYPE RELEASE	FINGERLING	FRY	FINGERLINGS	SMOLT	
# RELEASED	531800	1986856	5796300	533500	
SMOLT EQUIVALENTS	79770	59606	869445	533500	
HATCHERY		LEWIS RIVER	SPEELYAI		
STOCK		COL LATE	COL LATE		
TYPE RELEASE		SMOLT	FINGERLING		
# RELEASE		4664100	150300		
SMOLT EQUIVALENTS		4664100	22545		
HATCHERY		SPEELYAI	WASHOUGAL		
STOCK		COL LATE	COL LATE		
TYPE RELEASE		SMOLT	FINGERLING		
# RELEASE		151300	302000		
SMOLT EQUIVALENTS		151300	45300		
HATCHERY		WASHOUGAL	TOLEDO HI		
STOCK		COL LATES	COWLITZ		
TYPE RELEASE		SMOLT	FINGERLING		
# RELEASED		2118900	320		POOLED RELEASE
SMOLT EQUIVALENTS		2118900	48		INFORMATIO
TOTAL RELEASED/ # TAGGED	34.44	86.93		5.07	37.89
EXPANDED 10% WILD	37.88	95.63		5.57	41.67

TERMINAL INFORMATION

				LEWIS	WASH	POOLED ESTIMAT
TOTAL ESCAPEMENT	10934	54685	6921	48001	10443	130984
TAGGED ESCAPEMENT	3	57	0			60
GILLNET CATCH	622957	622957	622957			622957
GILLNET RECOVERIES	910	3642	6275			10827
ASSOCIATED GILLNET CA	3316647	3494084	0.00			23636063
TOTAL/TAGGED ESCAPEME	3644.67	959.39	0.00			2183

POOLED TERM CATCH/TERM RECOVS	57.54
POOLED CATCH & ESC/TERM RECOVS	69.25

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PRODUCTION FACTOR ESTIMATES FOR OREGON COASTAL HATCHERY AND WILD COHO STOCKS

Year	Escapements Hatchery	Natural	Total	CWT recoveries at fixed sites	Production Factor
1984	28300	210700	239000	4408	54.22
1985	19200	196600	215800	1659	130.08
1986	42200	200400	242600	4683	51.80

OREGON COASTAL HATCHERY TAGCODES

YEAR	TAGCODE	FACILITY	STOCK
1984	72442-44	Fall Creek	Fall Creek
1984	72450	Siletz	Siletz
1984	72559	Newhalem	Newhalem R
1984	72560-61	Newhalem	Fishhawk Cr
1984	72608-11	Trask	Trask
1984	72627	Butte Falls	Coquille R
1984	72628	Butte Falls	Eel Lake
1984	72629-30	Salmon River	Salmon River
1984	72639-40	Rock Creek	Umpqua
1984	72641	Fall Creek	Fall Creek
1984	72644-45	Siletz	Siletz
1985	72653	Rock Creek	Umpqua
1985	72655	Salmon River	Salmon River
1985	72738	Butte Falls	Eel lake
1985	72739	Bandon	Coquille
1985	72748	Newhalem	Newhalem
1985	72806	Newhalem	Newhalem
1985	72807-9	Newhalem	Fishhawk
1985	72810	Fall Creek	Fall Creek
1985	72812-15	Siletz	Siletz
1985	72816	Trask	Trask
1985	72823-25	Trask	Trask
1985	72939	Fall Creek	Fall Creek
1986	72754	Butte Falls	Coquille
1986	72755	Butte Falls	Eel Lake
1986	72757-59	Newhalem	Newhalem
1986	72760	Newhalem	Fishhawk Cr
1986	72761	Rock Creek	Umpqua
1986	72763	Salmon River	Salmon River
1986	72958	Fall Creek	Fall Creek
1986	73022	Fall Creek	Fall Creek
1986	73025-28	Siletz	Siletz
1986	73033-35	Trask	Trask

APPENDIX 4
LINEAR PROGRAMMING MODEL
FOR ESTIMATION OF STOCK COMPOSITION

A Linear Programming Model (LPM) was used to estimate coho stock composition for fisheries of interest to the Southern Panel for catch years 1984 through 1986. Tabulated results of that analysis and CWT codes used for the generation of stock distribution profiles are attached for reference.

A brief description of LPM's and a simple example follow.

WHAT IS LINEAR PROGRAMMING?

Linear Programming is a mathematical optimization technique which was initially developed in the 1950's. It is a cornerstone of modern Operations Research and has been extensively applied to a wide variety of industrial, military, and natural resource allocation problems.

LPM's are comprised of two basic elements:

1. a linear objective function to be optimized (maximized or minimized); and

2. a set of linear constraints which defines the "solution space."

The goal of LP techniques is to find the set of variables that optimizes the value of the objective function within the solution space. All feasible solutions must lie within the LPM's solution space. If there is no set of variables which satisfies all constraints, the techniques employed to solve LPM's will indicate that no feasible solution is possible.

Several readily available computer programs can be used to solve LPM's through well-defined computational algorithms. For technical details regarding these algorithms, the interested reader should consult the references listed in the attached bibliography.

Since linear programming is a mathematical optimization technique, estimates of confidence intervals about solutions to LPM's are not available. There may be several sets of variables which produce values of the objective function which are "close" to the best solution. In some respects, the existence of sets of variables which produce values of the objective function which are "close" to the optimum provides an indication of the sensitivity of the LPM solution; however, most readily available LP computer programs do not have the capability to identify sets of variable values which produce an objective which is arbitrarily "close" to the best possible solution.

A simple example is presented to illustrate how the LPM approach can be used to generate stock composition estimates.

EXAMPLE

The LPM under development depends upon only two types of information: CWT recoveries and catch statistics.

Given: Three stocks (A, B, and C) with the following catch distribution patterns derived from CWT recoveries (e.g. 60% of the total fishery recoveries of Stock A were observed in Fishery 1).

	FISHERY			
STOCK	1	2	3	4
A	.60	.10	.20	.10
B	.30	.40	.10	.20
C	.10	.10	.80	.00

And the catch by the four fisheries (1, 2, 3, 4) for which stock composition is to be estimated:

FISHERY	REPORTED CATCH		
1	2300	=	ACATCH(1)
2	2200	=	ACATCH(2)
3	4600	=	ACATCH(3)
4	900	=	ACATCH(4)

Find: The set of estimates for the total contributions of each of the three stocks that best explains catches in the four fisheries.

LPM STRUCTURE FOR ESTIMATING STOCK COMPOSITION

OBJECTIVE:

In mathematical terms, the objective of the LPM is to minimize the weighted difference between the catch accounted for by the three stocks and the reported catch for the four fisheries.

$$\text{Minimize} \quad \sum_i [ACATCH(i) - ECATCH(i)] * W(i)$$

where: i = the fishery
ACATCH(i) = Reported Catch in Fishery i
ECATCH(i) = Estimated Contribution of the three stocks to fishery i
W(i) = Weight for Fishery i

Weights are used to place different levels of importance upon the estimation of catch in various fisheries. For this example, assume that all weights are set equal to 1. The value of the objective function then represents the total catch from these four fisheries that cannot be accounted for by these stocks.

SOLUTION SPACE:

The solution to the problem is constrained by a requirement that the estimated contributions of the three stocks cannot exceed the reported catch in any of the four fisheries (there is, of course, the possibility that other stocks may contribute to the fishery catches). The catch contribution profiles of the individual stocks and the reported catch statistics create a set of linear fishery constraints that define a "solution space".

Fishery Constraints Comprising the Solution Space:

```
1         (.60 * PFA) + (.30 * PFB) + (.10 * PFC) <= 2300
2         (.10 * PFA) + (.40 * PFB) + (.10 * PFC) <= 2200
3         (.20 * PFA) + (.10 * PFB) + (.80 * PFC) <= 4600
4         (.10 * PFA) + (.20 * PFB) + (.00 * PFC) <=  900
```

where PFx is the Production Factor for stock x and the PF's must not be less than zero.

The basic form of LPM described above can be readily modified to further define the solution space. For example, a set of production factor constraints can be employed to establish a minimum TC for individual stock groups. A minimum production factor constraint for stock A would take the form:

PFA > minimum estimate of production factor for stock A

VARIABLES TO BE ESTIMATED:

The PF's are the variables to be estimated by the LPM.

RESULTS:

The LPM estimates for total catch by stock are:

PFA = 10
PFB = 40
PFC = 50

Substituting these estimates in the fishery constraints defining the solution space yields:

```
Fishery

1         (60*10) + (30*40) + (10*50) = 2300 = C(1)
2         (10*10) + (40*40) + (10*50) = 2200 = C(2)
3         (20*10) + (10*40) + (80*50) = 4600 = C(3)
4         (10*10) + (20*40) +  (0*50) =  900 = C(4)
```

The value of the LPM objective function is:

```
    [ACATCH(1) - ECATCH(1)] * W(1)    =    [2300-2300] * 1
+   [ACATCH(2) - ECATCH(2)] * W(2)    =    [2200-2200] * 1
+   [ACATCH(3) - ECATCH(3)] * W(3)    =    [4600-4600] * 1
+   [ACATCH(4) - ECATCH(4)] * W(4)    =    [ 900- 900] * 1
--------------------------------      ------------------------
                                      =          0
```

Since the value of the objective function is zero in this example, the LP solution indicates that all the catch in these four fisheries can be accounted for by these three stocks.

ESTIMATES OF STOCK COMPOSITION

Stock composition can now be estimated as the proportion of the reported catch accounted for by each stock. For instance, the stock composition for Fishery 1 of this example is:

Stock A	60*PFA/ACATCH(1)	=	60*10/2300	=	26%
Stock B	30*PFB/ACATCH(1)	=	30*40/2300	=	52%
Stock C	10*PFC/ACATCH(1)	=	10*50/2300	=	22%

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PRELIMINARY STOCK COMPOSITION ESTIMATES
FROM LINEAR PROGRAMMING MODEL
28-Sep-89 1984
09:08 AM UNCONSTRAINED

FISHERY/AREA	ACCTD FOR CATCH		REPORTED CATCH	UNASSGD CATCH	LP STOCK COMP EST % CAN	% US	% UNASSGD
South/Central BC Troll	142239	<	210116	67877	50%	18%	32%
Georgia Strait Troll	114489	<	116907	2418	88%	10%	2%
NW Vancouver Is Troll	451035	<	503781	52746	54%	36%	10%
SW Vancouver Is Troll	1668254	<	1668254	0	30%	70%	0%
Johnstone Strait Net	119116	<	119116	0	91%	9%	0%
Georgia Strait Net	13585	<	13585	0	70%	30%	0%
Fraser River Net	9192	<	9192	-0	90%	10%	0%
Can Juan De Fuca Net	70768	<	74859	4091	22%	73%	5%
WC Vancouver Is Net	10561	<	10561	-0	97%	3%	0%
Georgia Strait Sport	380868	<	443000	62132	73%	13%	14%
US Juan De Fuca Str Troll/Sport	60599	<	60599	0	9%	91%	0%
Cape Flattery Troll/Sport	53445	<	53445	0	29%	71%	0%
Quillayute Troll/Sport	0	<	10049	10049	0%	0%	100%
Grays Harbor Troll/Sport	2349	<	12381	10032	1%	18%	81%
Columbia River Troll/Sport	54700	<	54700	-0	2%	98%	0%
Southern Oregon Troll/Sport	178400	<	178400	-0	2%	98%	0%
San Juan Islands Net	8384	<	11005	2621	29%	47%	24%
Point Roberts Net	7973	<	13334	5361	22%	38%	40%
Nooksack/Samish Net	132874	<	132874	-0	5%	95%	0%
Skagit/Port Gardner Net	45647	<	45647	0	1%	99%	0%
South Puget Sound Net	426216	<	426216	0	0%	100%	0%
Hood Canal Net	49172	<	49172	0	0%	100%	0%
U.S. Juan De Fuca Strait Net	45647	<	46495	848	20%	78%	2%
Washington Coastal Net	91100	<	91100	-0	0%	100%	0%
Columbia River Gillnet	133664	<	203100	69436	0%	66%	34%
San Juan Islands Sport	320	<	4226	3906	0%	8%	92%
Skagit/Port Gardner Sport	1611	<	6575	4964	0%	25%	75%
Admiralty Inlet Sport	24531	<	36032	11501	2%	66%	32%
South Puget Sound Sport	13772	<	34235	20463	1%	39%	60%
Hood Canal Sport	526	<	2110	1584	0%	25%	75%
Columbia River Buoy 10 Sport	74400	<	74400	-0	0%	100%	0%

STOCK	PF EST	- CONTRIBUTION TO - SO. PANEL AREA CANADIAN FISHERIES	U.S. FISHERIES
Johnstone Str	26.29	301899	3102
Georgia Str	23.54	85882	1577
Thompson	0.00	0	0
Lower Fraser	65.82	600379	33566
Geo St Mnlnd	0.00	0	0
WCVI	37.12	206269	2635
Canadian JDF	543.81	156072	9245
Nksack/Samish	80.03	139015	145098
Skagit	0.00	0	0
Stilly/Sno	41.93	186621	73877
S Puget Snd	40.76	437438	488837
Hood Canal	16.44	113728	84441
US JDF Str	665.00	266000	35910
No WA Coast	0.00	0	0
Grays Harbor	166.79	252850	201479
Willapa Bay	30.73	47994	75955
Columbia R WA	15.15	16616	91077
Columbia R OR	0.00	0	0
Prvt Aqua.	8.05	8624	5951
Calif/Oregon	49.81	18481	152578

INTERCEPTIONS BY SOUTHERN PANEL
AREA FISHERIES

U.S. OF CANADIAN STOCKS	50,126
CANADIAN OF U.S. STOCKS	1,487,368

	CAN	U.S.
TOTAL CATCH	2,959,255	1,546,095
UNASSIGNED	121,387	140,767
PERCENT	4%	9%

PRELIMINARY STOCK COMPOSITION ESTIMATES
FROM LINEAR PROGRAMMING MODEL
28-Sep-89 1985
09:09 AM UNCONSTRAINED

FISHERY/AREA	ACCTD FOR CATCH		REPORTED CATCH	UNASSGD CATCH	LP STOCK COMP EST % CAN	% US	% UNASSGD
South/Central BC Troll	74299	<	83128	8829	60%	29%	11%
Georgia Strait Troll	199889	<	199889	0	68%	32%	0%
NW Vancouver Is Troll	377035	<	377035	0	38%	62%	0%
SW Vancouver Is Troll	893866	<	1012020	118154	17%	71%	12%
Johnstone Strait Net	147276	<	147276	0	95%	5%	0%
Georgia Strait Net	31764	<	31764	0	87%	13%	0%
Fraser River Net	11826	<	18229	6403	47%	18%	35%
Can Juan De Fuca Net	198228	<	223939	25711	20%	69%	11%
WC Vancouver Is Net	7394	<	7394	0	83%	17%	0%
Georgia Strait Sport	728000	<	728000	0	77%	23%	0%
US Juan De Fuca Str Troll/Sport	63738	<	90890	27152	5%	65%	30%
Cape Flattery Troll/Sport	75244	<	75244	0	11%	89%	0%
Quillayute Troll/Sport	65795	<	66374	579	16%	83%	1%
Grays Harbor Troll/Sport	159947	<	159947	0	8%	92%	0%
Columbia River Troll/Sport	128139	<	132300	4161	3%	94%	3%
Southern Oregon Troll/Sport	222000	<	222000	-0	0%	100%	0%
San Juan Islands Net	64324	<	100405	36081	22%	42%	36%
Point Roberts Net	30202	<	42623	12421	33%	38%	29%
Nooksack/Samish Net	161770	<	161770	0	1%	99%	0%
Skagit/Port Gardner Net	108291	<	108291	0	0%	100%	0%
South Puget Sound Net	495890	<	495890	0	0%	100%	0%
Hood Canal Net	45204	<	45204	-0	0%	100%	0%
U.S. Juan De Fuca Strait Net	84834	<	84834	0	15%	85%	0%
Washington Coastal Net	71000	<	71000	0	0%	100%	0%
Columbia River Gillnet	186467	<	190000	3533	0%	98%	2%
San Juan Islands Sport	4705	<	8612	3907	4%	50%	45%
Skagit/Port Gardner Sport	6109	<	8941	2832	0%	68%	32%
Admiralty Inlet Sport	26017	<	39535	13518	0%	65%	34%
South Puget Sound Sport	14621	<	37667	23046	0%	39%	61%
Hood Canal Sport	677	<	2077	1400	0%	33%	67%
Columbia River Buoy 10 Sport	25400	<	25400	-0	0%	100%	0%

STOCK	PF EST	- CONTRIBUTION TO - SO. PANEL AREA CANADIAN FISHERIES	U.S. FISHERIES
Johnstone Str	16.31	494584	14580
Georgia Str	62.23	186934	12508
Thompson	0.00	0	0
Lower Fraser	12.55	338817	45894
Geo St Mnlnd	4.73	72867	9360
WCVI	26.89	104879	1049
Canadian JDF	207.73	46948	9971
Nksack/Samish	154.60	312910	265603
Skagit	66.24	228189	150824
Stilly/Sno	8.98	60552	86913
S Puget Snd	47.06	367726	647167
Hood Canal	15.68	58536	104781
US JDF Str	0.00	0	0
No WA Coast	0.00	0	0
Grays Harbor	281.92	276003	170282
Willapa Bay	32.38	24741	62046
Columbia R WA	16.87	7508	150304
Columbia R OR	15.24	2469	172970
Prvt Aqua.	0.00	0	0
Calif/Oregon	39.38	11616	136123

INTERCEPTIONS BY SOUTHERN PANEL
AREA FISHERIES

U.S. OF CANADIAN STOCKS	93,362
CANADIAN OF U.S. STOCKS	1,350,250

	CAN	U.S.
TOTAL CATCH	2,745,546	2,169,004
UNASSIGNED	150,268	128,631
PERCENT	5%	6%

PRELIMINARY STOCK COMPOSITION ESTIMATES
FROM LINEAR PROGRAMMING MODEL
28-Sep-89 1986
09:10 AM UNCONSTRAINED

FISHERY/AREA	ACCTD FOR CATCH		REPORTED CATCH	UNASSGD CATCH	LP STOCK COMP EST % CAN	% US	% UNASSGD
South/Central BC Troll	287733	<	441927	154194	43%	22%	35%
Georgia Strait Troll	218894	<	218894	-0	76%	24%	0%
NW Vancouver Is Troll	530255	<	610502	80247	26%	61%	13%
SW Vancouver Is Troll	1546331	<	1546331	-0	14%	86%	0%
Johnstone Strait Net	114070	<	126711	12641	84%	6%	10%
Georgia Strait Net	16237	<	16237	-0	99%	1%	0%
Fraser River Net	21806	<	34394	12588	61%	2%	37%
Can Juan De Fuca Net	199690	<	202501	2811	16%	83%	1%
WC Vancouver Is Net	10581	<	10581	-0	93%	7%	0%
Georgia Strait Sport	572000	<	572000	-0	77%	23%	0%
US Juan De Fuca Str Troll/Sport	123004	<	153516	30512	7%	73%	20%
Cape Flattery Troll/Sport	74416	<	74416	-0	11%	89%	0%
Quillayute Troll/Sport	30520	<	42885	12365	5%	66%	29%
Grays Harbor Troll/Sport	72169	<	93142	20973	1%	76%	23%
Columbia River Troll/Sport	198300	<	198300	-0	0%	100%	0%
Southern Oregon Troll/Sport	621000	<	621000	-0	0%	100%	0%
San Juan Islands Net	33552	<	43239	9687	47%	31%	22%
Point Roberts Net	45704	<	60984	15280	53%	22%	25%
Nooksack/Samish Net	137295	<	137295	-0	2%	98%	0%
Skagit/Port Gardner Net	159176	<	163377	4201	0%	97%	3%
South Puget Sound Net	577981	<	577981	0	0%	100%	0%
Hood Canal Net	27668	<	99035	71367	0%	28%	72%
U.S. Juan De Fuca Strait Net	71071	<	71071	-0	14%	86%	0%
Washington Coastal Net	217500	<	217500	-0	0%	100%	0%
Columbia River Gillnet	822521	<	981000	158479	0%	84%	16%
San Juan Islands Sport	3060	<	12420	9360	9%	16%	75%
Skagit/Port Gardner Sport	4916	<	11698	6782	0%	42%	58%
Admiralty Inlet Sport	19013	<	45419	26406	0%	42%	58%
South Puget Sound Sport	20381	<	48457	28076	0%	42%	58%
Hood Canal Sport	0	<	1254	1254	0%	0%	100%
Columbia River Buoy 10 Sport	120400	<	120400	-0	0%	100%	0%

STOCK	PF EST	- CONTRIBUTION TO - SO. PANEL AREA CANADIAN FISHERIES	U.S. FISHERIES
Johnstone Str	20.27	401624	10478
Georgia Str	0.00	0	0
Thompson	0.00	0	0
Lower Fraser	32.97	526623	69047
Geo St Mnlnd	5.96	127157	14013
WCVI	15.44	114764	772
Canadian JDF	0.00	0	0
Nksack/Samish	98.65	194633	158824
Skagit	31.61	250709	223049
Stilly/Sno	0.00	0	0
S Puget Snd	35.47	506474	768296
Hood Canal	0.00	0	0
US JDF Str	164.44	303225	78437
No WA Coast	0.00	0	0
Grays Harbor	164.79	690984	738445
Willapa Bay	5.08	28443	45173
Columbia R WA	41.53	54026	899837
Columbia R OR	3.83	3310	166791
Prvt Aqua.	0.00	0	0
Calif/Oregon	54.37	27890	206485

INTERCEPTIONS BY SOUTHERN PANEL AREA FISHERIES

U.S. OF CANADIAN STOCKS	94,310
CANADIAN OF U.S. STOCKS	2,059,695

	CAN	U.S.
TOTAL CATCH	3,338,151	3,774,389
UNASSIGNED	108,287	394,742
PERCENT	3%	10%

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

JOHNSTONE STRAIT

Hatchery 1984	Code
QUINSAM RIVER	021762
QUINSAM RIVER	021960
QUINSAM RIVER	021962
QUINSAM RIVER	021963
QUINSAM RIVER	022007
QUINSAM RIVER	022008
QUINSAM RIVER	022009
QUINSAM RIVER	022010
QUINSAM RIVER	022011
QUINSAM RIVER	022012
QUINSAM RIVER	022013
QUINSAM RIVER	022014
PUNTLEDGE RIVER	022133
QUINSAM RIVER	022323
PUNTLEDGE RIVER	022327
PUNTLEDGE RIVER	022329
PUNTLEDGE RIVER	022362
PUNTLEDGE RIVER	022363
PUNTLEDGE RIVER	022401
QUINSAM RIVER	082116
QUINSAM RIVER	082117
QUINSAM RIVER	082118
QUINSAM RIVER	082155
QUINSAM RIVER	082156
QUINSAM RIVER	082157
QUINSAM RIVER	082158
QUINSAM RIVER	082159
QUINSAM RIVER	082160
QUINSAM RIVER	082161
QUINSAM RIVER	082162
QUINSAM RIVER	082163
QUINSAM RIVER	082201
QUINSAM RIVER	082202
QUINSAM RIVER	082203
QUINSAM RIVER	082204
QUINSAM RIVER	082205
QUINSAM RIVER	082206

Hatchery 1985	Code
QUINSAM RIVER	022349
QUINSAM RIVER	022413
PUNTLEDGE RIVER	022447
QUINSAM RIVER	022448
QUINSAM RIVER	022548
QUINSAM RIVER	022549
QUINSAM RIVER	022550
PUNTLEDGE RIVER	022603
PUNTLEDGE RIVER	022604
PUNTLEDGE RIVER	022643
PUNTLEDGE RIVER	022644
PUNTLEDGE RIVER	022645
PUNTLEDGE RIVER	022723
QUINSAM RIVER	082229
QUINSAM RIVER	082230
QUINSAM RIVER	082231
QUINSAM RIVER	082232
QUINSAM RIVER	082233
QUINSAM RIVER	082234
QUINSAM RIVER	082235
QUINSAM RIVER	082236
QUINSAM RIVER	082237
QUINSAM RIVER	082238
QUINSAM RIVER	082239
QUINSAM RIVER	082240
QUINSAM RIVER	082241
QUINSAM RIVER	082242
QUINSAM RIVER	082243
QUINSAM RIVER	082244
QUINSAM RIVER	082245
QUINSAM RIVER	082246

Hatchery 1986	Code
PUNTLEDGE RIVER	022762
PUNTLEDGE RIVER	022763
PUNTLEDGE RIVER	022801
PUNTLEDGE RIVER	022902
PUNTLEDGE RIVER	022903
PUNTLEDGE RIVER	022904
PUNTLEDGE RIVER	022905
PUNTLEDGE RIVER	022906
PUNTLEDGE RIVER	022912
PUNTLEDGE RIVER	022913
PUNTLEDGE RIVER	022914
PUNTLEDGE RIVER	022915
QUINSAM RIVER	022916
QUINSAM RIVER	022917
QUINSAM RIVER	022918
QUINSAM RIVER	022919
QUINSAM RIVER	022920
QUINSAM RIVER	022921
QUINSAM RIVER	022922
QUINSAM RIVER	022923
PUNTLEDGE RIVER	022943
PUNTLEDGE RIVER	022944
PUNTLEDGE RIVER	022945
PUNTLEDGE RIVER	022946
QUINSAM RIVER	022949
QUINSAM RIVER	022950
QUINSAM RIVER	022951
QUINSAM RIVER	022962
QUINSAM RIVER	022963
QUINSAM RIVER	023001
QUINSAM RIVER	023002
BLACK CREEK	023119
BLACK CREEK	023120
BLACK CREEK	023121
TRENT RIVER	023122
TRENT RIVER	023123
QUINSAM RIVER	082313
QUINSAM RIVER	082314

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

NOOKSACK/SAMISH REGION

Hatchery	1984 Code
NOOKSACK RIVER	632356

Hatchery	1985 Code
NOOKSACK RIVER	632850

Hatchery	1986 Code
NOOKSACK RIVER	632753
NOOKSACK RIVER	632754

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

CANADIAN JUAN DE FUCA STRAIT

Hatchery	1984 Code
SOOKE RIVER PIP	022420
SOOKE RIVER PIP	022421

Hatchery	1985 Code
SAN JUAN RIVER CDP	022463

Hatchery	1986 Code

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

WEST COAST VANCOUVER ISLAND

Hatchery	1984 Code
THORNTON CR CDP	022142
ROBERTSON CREEK	022314
ROBERTSON CREEK	022315
ROBERTSON CREEK	022316

Hatchery	1985 Code
THORNTON CR CDP	021911
THORNTON CR CDP	021933
CONUMA RIVER	022261
SCOTT COVE PIP	022451
THORNTON CR CDP	022458
ROBERTSON CREEK	022539
ROBERTSON CREEK	022540
NITINAT RIVER	022547
CONUMA RIVER	022560
ROBERTSON CREEK	022605

Hatchery	1986 Code
CONUMA RIVER	022705
CONUMA RIVER	022706
P.HARDY/QUATSE CDP	022838
P.HARDY/QUATSE CDP	022839
P.HARDY/STEPHENS CD	022840
ROBERTSON CREEK	023006
ROBERTSON CREEK	023007

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

GEORGIA STRAIT MAINLAND

Hatchery	1984 Code
CAPILANO RIVER	021819
SECHELT CDP	022015
WEST VANCOUVER LAB	022102
WEST VANCOUVER LAB	022103
CAPILANO RIVER	022162
SECHELT CDP	022334
CAPILANO RIVER	022343
CAPILANO RIVER	022350
CAPILANO RIVER	022351
CAPILANO RIVER	022352
L.CAMPBELL RIVER	022359
CAPILANO RIVER	022406
CAPILANO RIVER	022407
CAPILANO RIVER	022423

Hatchery	1985 Code
SEYMOUR RIVER CDP	022502
SEYMOUR RIVER CDP	022503
N VAN OUT SCHOOL PI	022546
TENDERFOOT CREEK	022561
SECHELT CDP	022617
SLIAMMON RIVER CDP	022629
CAPILANO RIVER	022638
CAPILANO RIVER	022639
CAPILANO RIVER	022640
CAPILANO RIVER	022641
CAPILANO RIVER	022642
TENDERFOOT CREEK	022649
TENDERFOOT CREEK	022650
TENDERFOOT CREEK	022651
WEST VANCOUVER LAB	022808

Hatchery	1986 Code
VANCOUVER BAY SPU	022445
TENDERFOOT CREEK	022809
TENDERFOOT CREEK	022810
TENDERFOOT CREEK	022811
SECHELT CDP	022843
SECHELT CDP	022844
SLIAMMON RIVER CDP	022845
SECHELT CDP	022846
SLIAMMON RIVER CDP	022853
L.CAMPBELL RIVER PI	022862
CAPILANO RIVER	022931
CAPILANO RIVER	022932
CAPILANO RIVER	022933
CAPILANO RIVER	022934
CAPILANO RIVER	022935
CAPILANO RIVER	022936
CAPILANO RIVER	023008
CAPILANO RIVER	023009
TENDERFOOT CREEK	023056
CAPILANO RIVER	023137
CAPILANO RIVER	082249
CAPILANO RIVER	082250

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

LOWER FRASER RIVER

Hatchery	1984 Code
CHILLIWACK RIVER	021957
CHILLIWACK RIVER	022006
BRUNETTE RIVER PIP	022132
BIRKENHEAD RIVER	022209
CHILLIWACK RIVER	022210
INCH CREEK	022249
INCH CREEK	022251
BIRKENHEAD RIVER	022326
CHILLIWACK RIVER	022335
CHILLIWACK RIVER	022336
NOONS CREEK PIP	022348
CHILLIWACK RIVER	022353

Hatchery	1985 Code
CHILLIWACK RIVER	022211
CHILLIWACK RIVER	022441
ALOUETTE RIVER SPU	022443
CHILLIWACK RIVER	022450
CHILLIWACK RIVER	022462
INCH CREEK	022542
CHEHALIS RIVER/BC	022606
CHEHALIS RIVER/BC	022607
CHEHALIS RIVER/BC	022608
CHEHALIS RIVER/BC	022609
CHEHALIS RIVER/BC	022610
INCH CREEK	022611
INCH CREEK	022612
INCH CREEK	022613
INCH CREEK	022614
CHILLIWACK RIVER	022619
CHILLIWACK RIVER	022627
CHILLIWACK RIVER	022721

Hatchery	1986 Code
QUESNEL RIVER	022630
CHILLIWACK RIVER	022832
CHEHALIS RIVER/BC	022907
CHEHALIS RIVER/BC	022908
CHEHALIS RIVER/BC	022909
INCH CREEK	022924
INCH CREEK	022925
INCH CREEK	022926
INCH CREEK	022927
INCH CREEK	022928
INCH CREEK	022929
INCH CREEK	022930
CHEHALIS RIVER/BC	022942
CHILLIWACK RIVER	022947
CHILLIWACK RIVER	022948
CHILLIWACK RIVER	022956
INCH CREEK	022961
CHEHALIS RIVER/BC	023003
CHEHALIS RIVER/BC	023004
BIRKENHEAD RIVER	023005
CHILLIWACK RIVER	023420

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

THOMPSON RIVER

Hatchery	1984	Code
WIRE CACHE CREEK		022328
LOUIS CREEK		022330
LOUIS CREEK		022331
LEMIEUX CREEK		022332
LION CREEK		022337
LION CREEK		022341
WIRE CACHE CREEK		022342

Hatchery	1985	Code
LOUIS CREEK PIP		022461
THOMPSON R N	CDP	022532

Hatchery	1986	Code
EAGLE RIVER		022828
EAGLE RIVER		022829
EAGLE RIVER		022830
THOMPSON R N	CDP	022848
THOMPSON R N	CDP	022850

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

GEORGIA STRAIT - SOUTH VANCOUVER ISLAND

Hatchery	1984 Code
NANAIMO RIVER CDP	022030
NANAIMO RIVER CDP	022344
NANAIMO RIVER CDP	022345
NANAIMO RIVER CDP	022346
NANAIMO RIVER CDP	022347
BIG QUALICUM RIVER	022408

Hatchery	1985 Code
NANAIMO RIVER CDP	022455
NANAIMO RIVER CDP	022456
NANAIMO RIVER CDP	022457
NANAIMO RIVER CDP	022507
BIG QUALICUM RIVER	022615
BIG QUALICUM RIVER	022616

Hatchery	1986 Code
LITTLE QUALICUM R	022937
LITTLE QUALICUM R	022938
LITTLE QUALICUM R	022939
BIG QUALICUM RIVER	022957
BIG QUALICUM RIVER	022958
BIG QUALICUM RIVER	022959
BIG QUALICUM RIVER	022960
BIG QUALICUM RIVER	082251
BIG QUALICUM RIVER	082252

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

SKAGIT REGION

Hatchery	1984 Code
PUGET POWER	632236
SKAGIT RIVER	632563
SKAGIT RIVER	632723

Hatchery	1985 Code
SKAGIT RIVER	211630
SKAGIT RIVER	632205
SKAGIT RIVER	632206

Hatchery	1986 Code
SKAGIT RIVER	211705
SKAGIT RIVER	632755
SKAGIT RIVER	632756
SKAGIT RIVER	632757
SKAGIT RIVER	632758
PUGET POWER	633154
PUGET POWER	633155

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

STILLAGUAMISH/SNOHOMISH REGION

Hatchery 1984	Code
STILLAGUAMISH RIVER	632452
SKYKOMISH RIVER S F	632552
STILLAGUAMISH RIVER	632727
SKYKOMISH RIVER	632730

Hatchery 1985	Code
TULALIP CREEK	211601
SKYKOMISH RIVER	632854
HARRIS CREEK/WA	632909
SKYKOMISH RIVER	633023
LITTLE PILCHUCK CR	633029

Hatchery 1986	Code
TULALIP CREEK	211634
SKYKOMISH RIVER S F	633051
SKYKOMISH RIVER	633141
SKYKOMISH RIVER	633203
HARRIS CREEK/WA	633429
LITTLE PILCHUCK CR	633430

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

SOUTH PUGET SOUND REGION

Hatchery	1984 Code
MINTER CREEK	632344
MINTER CREEK	632419
MINTER CREEK	632451
MINTER CREEK	632543
GREEN RIVER/PUGET	632554
GREEN RIVER/PUGET	632555
PUYALLUP RIVER	632556
PUYALLUP RIVER	632557
MINTER CREEK	632558
MINTER CREEK	632560
SQUAXIN ISLAND	632601
DESCHUTES RIVER-WA	632718
ELLIOTT BAY	632720
SUQUAMISH PENS	632729
SQUAXIN ISLAND	632731

Hatchery	1985 Code
UNIV OF WASH F.R.I.	111704
UNIV OF WASH F.R.I.	111705
UNIV OF WASH F.R.I.	111706
UNIV OF WASH F.R.I.	111707
DESCHUTES RIVER-WA	632229
DESCHUTES RIVER-WA	632544
GREEN RIVER/PUGET	632851
SQUAXIN ISLAND	632852
PUYALLUP RIVER	632904
PUYALLUP RIVER	632905
MINTER CREEK	632906
SUQUAMISH PENS	633022
SQUAXIN ISLAND	633024
MINTER CREEK	633036
MINTER CREEK	633037

Hatchery	1986 Code
COLL FISHERIES	111714
COLL FISHERIES	111715
COLL FISHERIES	111716
COLL FISHERIES	111717
MINTER CREEK	632454
PUYALLUP RIVER	632759
PUYALLUP RIVER	632760
PUYALLUP RIVER	632761
PUYALLUP RIVER	632762
PUYALLUP RIVER	632763
PUYALLUP RIVER	632801
PUYALLUP RIVER	632802
PUYALLUP RIVER	632803
SUQUAMISH PENS	632804
SUQUAMISH PENS	632805
GREEN RIVER/PUGET	632806
GREEN RIVER/PUGET	632807
MINTER CREEK	632855
MINTER CREEK	632856
SQUAXIN ISLAND	633057
SQUAXIN I. PENS	633058
SQUAXIN I. PENS	633059
SQUAXIN I. PENS	633140
SQUAXIN I. PENS	633204
SQUAXIN I. PENS	633205
DESCHUTES RIVER-WA	633352
MINTER CREEK	633426
MINTER CREEK	633427

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

U.S. JUAN DE FUCA STRAIT

Hatchery	1984 Code
ELWHA RIVER LOWER	051127
ELWHA RIVER LOWER	051128
ELWHA RIVER LOWER	051129

Hatchery	1985 Code
ELWHA RIVER LOWER	051430
ELWHA RIVER LOWER	051431
ELWHA RIVER LOWER	051432
ELWHA CHANNEL	051516
ELWHA RIVER LOWER	051517
ELWHA RIVER LOWER	051518
ELWHA CHANNEL	051519
ELWHA RIVER LOWER	051520
ELWHA CHANNEL	051521
ELWHA RIVER LOWER	051522
ELWHA RIVER LOWER	051523

Hatchery	1986 Code
DUNGENESS RIVER	B10408
DUNGENESS RIVER	B10409
DUNGENESS RIVER	B10410
DUNGENESS RIVER	B10411
DUNGENESS RIVER	B10412
DUNGENESS RIVER	B10414
DUNGENESS RIVER	B10415
DUNGENESS RIVER	B10508
DUNGENESS RIVER	B10509
DUNGENESS RIVER	B10510

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

NORTH WASHINGTON COAST

Hatchery	1984 Code
QUEETS SYSTEM	051126
QUINAULT LAKE	051261
HOH SYSTEM	051341
HOH SYSTEM	051342
HOH SYSTEM	051343
QUINAULT LAKE	051355
QUINAULT LAKE	051361
QUINAULT LAKE	051362
QUEETS SYSTEM	051420
QUEETS SYSTEM	051421
QUEETS SYSTEM	051422
CLEARWATER RIVER/WA	632315
CLEARWATER RIVER/WA	632343
SOLEDUCK RIVER	632348
CLEARWATER RIVER/WA	632545
DICKEY RIVER E FK	632550
SOLEDUCK RIVER	632551
SOLEDUCK RIVER	632643
SOLEDUCK RIVER	632644

Hatchery	1985 Code
QUINAULT RIVER NFH	051455
QUINAULT LAKE	211607
QUINAULT LAKE	211608
HOH RIVER	211609
HOH RIVER	211610
HOH RIVER	211612
QUINAULT LAKE	211614
SNAHAPISH RIVER	211624
QUEETS SYSTEM	211625
CLEARWATER RIVER/WA	211626
SOLEDUCK RIVER	632739
SOLEDUCK RIVER	632740
DICKEY RIVER E FK	632907
SOLEDUCK RIVER	632908

Hatchery	1986 Code
QUINAULT RIVER NFH	211635
QUINAULT RIVER NFH	211636
HOH RIVER	211638
HOH RIVER	211639
HOH RIVER	211640
QUINAULT LAKE	211642
QUINAULT LAKE	211643
QUINAULT LAKE	211647
QUINAULT LAKE	211648
COPPERMINE/BOTTOM C	211710
NORTH CREEK	211711
SUALIAPISU R	211713
SALMON R/WA	211714
HURST CREEK	211715
MUD CREEK	211718
SOLEDUCK RIVER	633255
SOLEDUCK RIVER	633256
SOLEDUCK RIVER	633257
SOLEDUCK RIVER	633258
QUILLAYUTE TRIBS	633417
DICKEY RIVER	633418
QUINAULT RIVER NFH	B50802
QUINAULT LAKE	B50803
QUINAULT LAKE	B50807
QUINAULT LAKE	B50808

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

GRAYS HARBOR

Hatchery	1984 Code
BLACK/BEAVER/WADDEL	632230
NEWAUKUM RIVER	632559
SIMPSON	632646
SIMPSON	632647
SATSOP SPRINGS	632648
STEVENS CREEK	632719
BINGHAM CREEK	632726
BLACK/BEAVER/WADDEL	632728
GRAYS RIVER	632733
SKOOKUMCHUCK RIVER	632736

Hatchery	1985 Code
BLACK R/WADDELL CR	632453
SKOOKUMCHUCK RIVER	632743
HUMPTULIPS RIVER	632744
HUMPTULIPS RIVER	632745
SIMPSON	632746
SIMPSON	632861
SATSOP SPRINGS	632862
NEWAUKUM RIVER	632910
ELK CR 9 MILE CR	632911
GRAYS RIVER	633011
HUMPTULIPS RIVER	633017
HUMPTULIPS RIVER	633018
BINGHAM CREEK	633027
BEAVER CREEK/WA	633046
BLACK RIVER	633047
STEVENS CREEK	633048
BEAVER CREEK/WA	633061
BEAVER CREEK/WA	633062
STEVENS CREEK	633107

Hatchery	1986 Code
HUMPTULIPS RIVER	632817
HUMPTULIPS RIVER	632818
HUMPTULIPS RIVER	632819
HUMPTULIPS RIVER	632820
HUMPTULIPS RIVER	632821
HUMPTULIPS RIVER	632822
HUMPTULIPS RIVER	632823
HUMPTULIPS RIVER	632824
HUMPTULIPS RIVER	632825
HUMPTULIPS RIVER	632826
HUMPTULIPS RIVER	632827
HUMPTULIPS RIVER	632828
SATSOP SPRINGS	632829
SATSOP SPRINGS	632830
SATSOP SPRINGS	632831
STEVENS CREEK	633010
SKOOKUMCHUCK RIVER	633032
SKOOKUMCHUCK RIVER	633033
BINGHAM CREEK	633035
WADDELL CREEK	633209
GRAYS RIVER	633259
GRAYS RIVER	633260
GRAYS RIVER	633261
GRAYS RIVER	633262
GRAYS RIVER	633263
GRAYS RIVER	633301
SIMPSON	633345
SIMPSON	633346
SIMPSON	633347
SIMPSON	633348
BEAVER CREEK/WA	633423
STEVENS CREEK	633424
BLACK RIVER	633425
NEWAUKUM RIVER	633444
HUMPTULIPS RIVER	H10504
HUMPTULIPS RIVER	H10505
SIMPSON	H10506
SIMPSON	H10507
HUMPTULIPS RIVER	H10601
HUMPTULIPS RIVER	H10604
SIMPSON	H10605
SIMPSON	H10606
SIMPSON	H10607
SIMPSON	H10701

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

WILLAPA BAY

Hatchery	1984	Code
NASELLE RIVER		632649
NEMAH RIVER		632650
WILLAPA RIVER		632734

Hatchery	1985	Code
NASELLE RIVER		632741
NASELLE RIVER		632742
NEMAH RIVER		633012
WILLAPA RIVER		633013
WILLAPA RIVER		633014

Hatchery	1986	Code
NASELLE RIVER		632808
NASELLE RIVER		632809
NASELLE RIVER		632810
NASELLE RIVER		632811
NASELLE RIVER		632812
NASELLE RIVER		632813
NEMAH RIVER		632814
NEMAH RIVER		632815
NEMAH RIVER		632816
WILLAPA RIVER		633341
WILLAPA RIVER		633342
WILLAPA RIVER		633343
WILLAPA RIVER		633344

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

WASHINGTON COLUMBIA RIVER (LATE TYPE)

Hatchery	1984 Code
WILLARD NFH	050928
WILLARD NFH	050929
WILLARD NFH	050930
WILLARD NFH	050931
WILLARD NFH	050932
WILLARD NFH	050933
WILLARD NFH	050934
WILLARD NFH	050935
WILLARD NFH	050936
WILLARD NFH	050937
WILLARD NFH	050938
WILLARD NFH	050939
WILLARD NFH	050940
WILLARD NFH	050941
WILLARD NFH	050942
WILLARD NFH	050943
WILLARD NFH	050944
WILLARD NFH	050945
KALAMA RIVER LOWER	632605
COWLITZ RIVER	632613
COWLITZ RIVER	632614
COWLITZ RIVER	632615
COWLITZ RIVER	632616
COWLITZ RIVER	632617
COWLITZ RIVER	632618
COWLITZ RIVER	632619
COWLITZ RIVER	632620
COWLITZ RIVER	632621
COWLITZ RIVER	632622
COWLITZ RIVER	632623
COWLITZ RIVER	632624
COWLITZ RIVER	632625
COWLITZ RIVER	632626
COWLITZ RIVER	632627
COWLITZ RIVER	632628
COWLITZ RIVER	632629
COWLITZ RIVER	632630
COWLITZ RIVER	632631
COWLITZ RIVER	632632
COWLITZ RIVER	632633
COWLITZ RIVER	632634
COWLITZ RIVER	632635
COWLITZ RIVER	632636
COWLITZ RIVER	632637
COWLITZ RIVER	632638
COWLITZ RIVER	632639
COWLITZ RIVER	632640
COWLITZ RIVER	632641
COWLITZ RIVER	632642
WASHOUGAL RIVER	632645
WASHOUGAL RIVER	632651
WASHOUGAL RIVER	632652
WASHOUGAL RIVER	632653
WASHOUGAL RIVER	632654
WASHOUGAL RIVER	632655
WASHOUGAL RIVER	632656
WASHOUGAL RIVER	632657
WASHOUGAL RIVER	632658
WASHOUGAL RIVER	632659
WASHOUGAL RIVER	632660

Hatchery	1985 Code
WILLARD NFH	051224
WILLARD NFH	051225
WILLARD NFH	051226
WILLARD NFH	051227
WILLARD NFH	051228
WILLARD NFH	051229
WILLARD NFH	051230
WILLARD NFH	051231
WILLARD NFH	051232
WILLARD NFH	051233
WILLARD NFH	051234
WILLARD NFH	051235
WILLARD NFH	051236
WILLARD NFH	051237
WILLARD NFH	051238
WILLARD NFH	051239
WILLARD NFH	051240
WILLARD NFH	051241
COWLITZ RIVER	632912
COWLITZ RIVER	632913
COWLITZ RIVER	632914
COWLITZ RIVER	632915
COWLITZ RIVER	632916
COWLITZ RIVER	632917
COWLITZ RIVER	632918
COWLITZ RIVER	632919
COWLITZ RIVER	632920
COWLITZ RIVER	632921
COWLITZ RIVER	632922
COWLITZ RIVER	632923
COWLITZ RIVER	632924
COWLITZ RIVER	632925
COWLITZ RIVER	632926
COWLITZ RIVER	632927
COWLITZ RIVER	632928
COWLITZ RIVER	632929
COWLITZ RIVER	632930
COWLITZ RIVER	632931
COWLITZ RIVER	632932
COWLITZ RIVER	632933
COWLITZ RIVER	632934
COWLITZ RIVER	632935
COWLITZ RIVER	632936
COWLITZ RIVER	632937
COWLITZ RIVER	632938
COWLITZ RIVER	632939
COWLITZ RIVER	632940
COWLITZ RIVER	632941
WASHOUGAL RIVER	632942
WASHOUGAL RIVER	632943
WASHOUGAL RIVER	632944
WASHOUGAL RIVER	632945
WASHOUGAL RIVER	632946
WASHOUGAL RIVER	632947
WASHOUGAL RIVER	632948
WASHOUGAL RIVER	632949
WASHOUGAL RIVER	632950
WASHOUGAL RIVER	632951
WASHOUGAL RIVER	632952
WASHOUGAL RIVER	632953

Hatchery	1986 Code
WASHOUGAL RIVER	633132
WASHOUGAL RIVER	633133
WASHOUGAL RIVER	633134
WASHOUGAL RIVER	633135
KALAMA FALLS	633156
KALAMA FALLS	633157
COWLITZ RIVER	633161
COWLITZ RIVER	633162
KALAMA FALLS	633232
KALAMA FALLS	633233
COWLITZ RIVER	633249
COWLITZ RIVER	633250
COWLITZ RIVER	633251
COWLITZ RIVER	633252
ELOKOMIN RIVER	633253
ELOKOMIN RIVER	633254

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

WASHINGTON COLUMBIA RIVER (LATE TYPE)

Hatchery 1984	Code
WASHOUGAL RIVER	632661
WASHOUGAL RIVER	632662
WASHOUGAL RIVER	632663
WASHOUGAL RIVER	632701
WASHOUGAL RIVER	632702
WASHOUGAL RIVER	632703
WASHOUGAL RIVER	632704
WASHOUGAL RIVER	632705
WASHOUGAL RIVER	632706
WASHOUGAL RIVER	632707
WASHOUGAL RIVER	632708
WASHOUGAL RIVER	632709
WASHOUGAL RIVER	632710
WASHOUGAL RIVER	632711
WASHOUGAL RIVER	632712
WASHOUGAL RIVER	632713
WASHOUGAL RIVER	632714
WASHOUGAL RIVER	632715
WASHOUGAL RIVER	632716
WASHOUGAL RIVER	632717
SPEELYAI	632735

Hatchery 1985	Code
WASHOUGAL RIVER	632954
WASHOUGAL RIVER	632955
WASHOUGAL RIVER	632956
WASHOUGAL RIVER	632957
WASHOUGAL RIVER	632958
WASHOUGAL RIVER	632959
WASHOUGAL RIVER	632960
WASHOUGAL RIVER	632961
WASHOUGAL RIVER	632962
WASHOUGAL RIVER	632963
WASHOUGAL RIVER	633001
WASHOUGAL RIVER	633002
WASHOUGAL RIVER	633003
WASHOUGAL RIVER	633004
WASHOUGAL RIVER	633005
WASHOUGAL RIVER	633006
WASHOUGAL RIVER	633007
WASHOUGAL RIVER	633008
SPEELYAI	633015
SPEELYAI	633016

Hatchery 1986	Code

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

OREGON COLUMBIA RIVER (EARLY TYPE)

Hatchery	1984 Code
EAGLE CREEK NFH/OR	051133
EAGLE CREEK NFH/OR	051134
EAGLE CREEK NFH/OR	051135
EAGLE CREEK NFH/OR	051136
EAGLE CREEK NFH/OR	051137
EAGLE CREEK NFH/OR	051138
BIG CREEK	072447
BIG CREEK	072448
KLASKANINE RIVER	072449
BONNEVILLE DAM	072606
BONNEVILLE DAM	072607
CASCADE /OR	072643
SANDY RIVER	072731
SANDY RIVER	072732
SANDY RIVER	072733
SANDY RIVER	072734
SANDY RIVER	072735
SANDY RIVER	072736
CASCADE /OR	072742
CASCADE /OR	072743
CASCADE /OR	072744
CASCADE /OR	072745
CASCADE /OR	072746
CASCADE /OR	072747

Hatchery	1985 Code
KLASKANINE RIVER	072725
BIG CREEK	072817
BIG CREEK	072818
BIG CREEK	072819
CASCADE /OR	072821
CASCADE /OR	072822
SANDY RIVER	072906
SANDY RIVER	072907
SANDY RIVER	072908
SANDY RIVER	072909
SANDY RIVER	072910
SANDY RIVER	072911
SANDY RIVER	072912
SANDY RIVER	072913
CASCADE /OR	072944
CASCADE /OR	072945
CASCADE /OR	072946
CASCADE /OR	072947
CASCADE /OR	072948
CASCADE /OR	072949
BONNEVILLE DAM	073014
OXBOW	073015
CASCADE /OR	073141
CASCADE /OR	073142

Hatchery	1986 Code
BONNEVILLE DAM	072654
KLASKANINE RIVER	072801
BONNEVILLE DAM	072802
BONNEVILLE DAM	072804
SANDY RIVER	072811
CASCADE /OR	073029
BIG CREEK	073030
BIG CREEK	073031
BIG CREEK	073032
SANDY RIVER	073045
SANDY RIVER	073046
SANDY RIVER	073047
SANDY RIVER	073048
SANDY RIVER	073049
SANDY RIVER	073050
SANDY RIVER	073105
SANDY RIVER	073106
SANDY RIVER	073107
SANDY RIVER	073108
CASCADE /OR	073204
CASCADE /OR	073205
CASCADE /OR	073206
CASCADE /OR	073207
CASCADE /OR	073208
CASCADE /OR	073209
CASCADE /OR	073343
CASCADE /OR	073344
KLICKITAT RIVER	633030
KLICKITAT RIVER	633031

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

OREGON PRIVATE AQUACULTURE

Hatchery 1984	Code
OREGON AQUA-FOODS	600547
OREGON AQUA-FOODS	600548
OREGON AQUA-FOODS	600549
OREGON AQUA-FOODS	600563
OREGON AQUA-FOODS	600616
OREGON AQUA-FOODS	600617
OREGON AQUA-FOODS	600618
OREGON AQUA-FOODS	600619
OREGON AQUA-FOODS	600620
OREGON AQUA-FOODS	600623
OREGON AQUA-FOODS	600624
OREGON AQUA-FOODS	600625
OREGON AQUA-FOODS	600626
OREGON AQUA-FOODS	600627
OREGON AQUA-FOODS	603550
OREGON AQUA-FOODS	603551
OREGON AQUA-FOODS	603552
OREGON AQUA-FOODS	603553
OREGON AQUA-FOODS	603554
OREGON AQUA-FOODS	603555
OREGON AQUA-FOODS	603556
OREGON AQUA-FOODS	603557
OREGON AQUA-FOODS	603558
OREGON AQUA-FOODS	603559
OREGON AQUA-FOODS	603560
OREGON AQUA-FOODS	603561
OREGON AQUA-FOODS	603562
OREGON AQUA-FOODS	603563
OREGON AQUA-FOODS	603601
OREGON AQUA-FOODS	603602
OREGON AQUA-FOODS	603603
OREGON AQUA-FOODS	603604
OREGON AQUA-FOODS	603605
OREGON AQUA-FOODS	603606
OREGON AQUA-FOODS	603607
OREGON AQUA-FOODS	603608
OREGON AQUA-FOODS	603609
OREGON AQUA-FOODS	603611
OREGON AQUA-FOODS	603612
OREGON AQUA-FOODS	603613
OREGON AQUA-FOODS	603614
OREGON AQUA-FOODS	603616
OREGON AQUA-FOODS	603618
OREGON AQUA-FOODS	603622
OREGON AQUA-FOODS	603623
OREGON AQUA-FOODS	603624
OREGON AQUA-FOODS	603625
OREGON AQUA-FOODS	603626
ANADROMOUS INC	621520
ANADROMOUS INC	621521
ANADROMOUS INC	621522
ANADROMOUS INC	621523
ANADROMOUS INC	621524
ANADROMOUS INC	621526
ANADROMOUS INC	621527
ANADROMOUS INC	621528
ANADROMOUS INC	621529
ANADROMOUS INC	621530
ANADROMOUS INC	621532
ANADROMOUS INC	621533
ANADROMOUS INC	621534

Hatchery 1985	Code
OREGON AQUA-FOODS	603615
OREGON AQUA-FOODS	603627
OREGON AQUA-FOODS	603630
OREGON AQUA-FOODS	603631
OREGON AQUA-FOODS	603632
OREGON AQUA-FOODS	603633
OREGON AQUA-FOODS	603634
OREGON AQUA-FOODS	603635
OREGON AQUA-FOODS	603636
OREGON AQUA-FOODS	603637
OREGON AQUA-FOODS	603638
OREGON AQUA-FOODS	603643
OREGON AQUA-FOODS	603644
OREGON AQUA-FOODS	603645
OREGON AQUA-FOODS	603646
OREGON AQUA-FOODS	603647
OREGON AQUA-FOODS	603649
OREGON AQUA-FOODS	603650
OREGON AQUA-FOODS	603706
OREGON AQUA-FOODS	603707
OREGON AQUA-FOODS	603708
OREGON AQUA-FOODS	603709
OREGON AQUA-FOODS	603710
ANADROMOUS INC	621721
ANADROMOUS INC	621722
ANADROMOUS INC	621723
ANADROMOUS INC	621724
ANADROMOUS INC	621725
ANADROMOUS INC	621733
ANADROMOUS INC	621734
ANADROMOUS INC	621735
ANADROMOUS INC	621736
ANADROMOUS INC	621737
ANADROMOUS INC	621738
ANADROMOUS INC	621739
ANADROMOUS INC	621740
ANADROMOUS INC	621741
ANADROMOUS INC	621742
ANADROMOUS INC	621743
ANADROMOUS INC	621744
ANADROMOUS INC	621745
ANADROMOUS INC	621746
ANADROMOUS INC	621749
ANADROMOUS INC	621757

Hatchery 1986	Code
OREGON AQUA-FOODS	603628
OREGON AQUA-FOODS	603633
OREGON AQUA-FOODS	603658
OREGON AQUA-FOODS	603659
OREGON AQUA-FOODS	603660
OREGON AQUA-FOODS	603661
OREGON AQUA-FOODS	603662
OREGON AQUA-FOODS	603663
OREGON AQUA-FOODS	603701
OREGON AQUA-FOODS	603702
OREGON AQUA-FOODS	603703
OREGON AQUA-FOODS	603704
OREGON AQUA-FOODS	603705
OREGON AQUA-FOODS	603712
OREGON AQUA-FOODS	603713
OREGON AQUA-FOODS	603716
OREGON AQUA-FOODS	603717
OREGON AQUA-FOODS	603718
OREGON AQUA-FOODS	603719
OREGON AQUA-FOODS	603720
OREGON AQUA-FOODS	603721
OREGON AQUA-FOODS	603722
OREGON AQUA-FOODS	603723
OREGON AQUA-FOODS	603724
OREGON AQUA-FOODS	603725
OREGON AQUA-FOODS	603726
OREGON AQUA-FOODS	603727
OREGON AQUA-FOODS	603728
OREGON AQUA-FOODS	603729
OREGON AQUA-FOODS	603730
OREGON AQUA-FOODS	603731
OREGON AQUA-FOODS	603732
OREGON AQUA-FOODS	603733
OREGON AQUA-FOODS	603734
OREGON AQUA-FOODS	603735
OREGON AQUA-FOODS	603736
OREGON AQUA-FOODS	603737
OREGON AQUA-FOODS	603738
OREGON AQUA-FOODS	603739
OREGON AQUA-FOODS	603740
OREGON AQUA-FOODS	603741
OREGON AQUA-FOODS	603742
OREGON AQUA-FOODS	603743
OREGON AQUA-FOODS	603744
OREGON AQUA-FOODS	603745
OREGON AQUA-FOODS	603746
OREGON AQUA-FOODS	603747
OREGON AQUA-FOODS	603748
OREGON AQUA-FOODS	603749
OREGON AQUA-FOODS	603750
OREGON AQUA-FOODS	603751
OREGON AQUA-FOODS	603752
OREGON AQUA-FOODS	603753
OREGON AQUA-FOODS	603754
OREGON AQUA-FOODS	603755
OREGON AQUA-FOODS	603756
OREGON AQUA-FOODS	603757
OREGON AQUA-FOODS	603758
OREGON AQUA-FOODS	603759
OREGON AQUA-FOODS	603760
OREGON AQUA-FOODS	603761

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

OREGON PRIVATE AQUACULTURE

Hatchery 1984	Code
ANADROMOUS INC	621535
ANADROMOUS INC	621536
ANADROMOUS INC	621537
ANADROMOUS INC	621538
ANADROMOUS INC	621539
ANADROMOUS INC	621549
ANADROMOUS INC	621563
DOMSEA FARMS	624834

Hatchery 1985	Code

Hatchery 1986	Code
OREGON AQUA-FOODS	603762
OREGON AQUA-FOODS	603763
OREGON AQUA-FOODS	603801
OREGON AQUA-FOODS	603802
OREGON AQUA-FOODS	603803
OREGON AQUA-FOODS	603804
OREGON AQUA-FOODS	603805
OREGON AQUA-FOODS	603806
OREGON AQUA-FOODS	603807
OREGON AQUA-FOODS	603808
OREGON AQUA-FOODS	603809
OREGON AQUA-FOODS	603810
OREGON AQUA-FOODS	603820
OREGON AQUA-FOODS	603821
OREGON AQUA-FOODS	603822
OREGON AQUA-FOODS	603823
OREGON AQUA-FOODS	603825
ANADROMOUS INC	621610
ANADROMOUS INC	621611
ANADROMOUS INC	621612
ANADROMOUS INC	621613
ANADROMOUS INC	621616
ANADROMOUS INC	621617
ANADROMOUS INC	621618
ANADROMOUS INC	621619
ANADROMOUS INC	621631
ANADROMOUS INC	623023
ANADROMOUS INC	623024
ANADROMOUS INC	623025
ANADROMOUS INC	623026
ANADROMOUS INC	623027
ANADROMOUS INC	623028
ANADROMOUS INC	623029
ANADROMOUS INC	623030
ANADROMOUS INC	623031
ANADROMOUS INC	623032
ANADROMOUS INC	623033
ANADROMOUS INC	623034
ANADROMOUS INC	623035
ANADROMOUS INC	623036
ANADROMOUS INC	623037
ANADROMOUS INC	623038
ANADROMOUS INC	623039
ANADROMOUS INC	623040
ANADROMOUS INC	623041
ANADROMOUS INC	623042
ANADROMOUS INC	623047
ANADROMOUS INC	623048
ANADROMOUS INC	623049
ANADROMOUS INC	623050
ANADROMOUS INC	623051
ANADROMOUS INC	623052
ANADROMOUS INC	623053
ANADROMOUS INC	623054
ANADROMOUS INC	623121
ANADROMOUS INC	623122
ANADROMOUS INC	623123
ANADROMOUS INC	623124

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

OREGON PRIVATE AQUACULTURE

Hatchery	1984 Code

Hatchery	1985 Code

Hatchery	1986 Code
ANADROMOUS INC	623125
ANADROMOUS INC	623126
ANADROMOUS INC	623127
ANADROMOUS INC	623128
ANADROMOUS INC	623129
ANADROMOUS INC	623130
ANADROMOUS INC	623131
ANADROMOUS INC	623132
ANADROMOUS INC	623133
ANADROMOUS INC	623134
ANADROMOUS INC	623135
ANADROMOUS INC	623140
ANADROMOUS INC	623141

CWT Codes Used For Linear Programming Model
For Estimation of Coho Stock Composition

OREGON, CALIFORNIA COASTAL

Hatchery	1984 Code
IRON GATE	064903
TRINITY RIVER	065602
TRINITY RIVER	065603
TRINITY RIVER	065604
TRINITY RIVER	065605
TRINITY RIVER	065606
IRON GATE	065952
IRON GATE	065953
IRON GATE	065954
IRON GATE	065955
FALL CREEK/ALSEA	072435
FALL CREEK/ALSEA	072436
FALL CREEK/ALSEA	072437
FALL CREEK/ALSEA	072438
FALL CREEK/ALSEA	072439
FALL CREEK/ALSEA	072440
FALL CREEK/ALSEA	072441
FALL CREEK/ALSEA	072442
FALL CREEK/ALSEA	072443
FALL CREEK/ALSEA	072444
FALL CREEK/ALSEA	072445
FALL CREEK/ALSEA	072446
SILETZ RIVER	072450
VANDERVELDT PONDS	072451
NEHALEM RIVER	072559
NEHALEM RIVER	072560
NEHALEM RIVER	072561
TRASK RIVER	072608
TRASK RIVER	072609
TRASK RIVER	072610
TRASK RIVER	072611
COLE RIVERS	072625
COLE RIVERS	072626
BUTTE FALLS	072627
BUTTE FALLS	072628
SALMON RIVER-OR	072629
SALMON RIVER-OR	072630
ROCK CREEK-UMPQUA	072638
ROCK CREEK-UMPQUA	072639
ROCK CREEK-UMPQUA	072640
FALL CREEK/ALSEA	072641
FALL CREEK/ALSEA	072642
SILETZ RIVER	072644
SILETZ RIVER	072645
COLE RIVERS	072712
STILLMAN CR/LOST	632418
BANDON	H70107
FALL CREEK/ALSEA	H70206
TRASK	H70207

Hatchery	1985 Code
TRINITY RIVER	065645
TRINITY RIVER	065646
TRINITY RIVER	065647
TRINITY RIVER	065648
TRINITY RIVER	065649
IRON GATE(KLAMATH)	065956
IRON GATE(KLAMATH)	065957
IRON GATE(KLAMATH)	065958
IRON GATE(KLAMATH)	065959
COLE RIVERS	072615
WAHKEENA POND	072637
ROCK CREEK-UMPQUA	072652
ROCK CREEK-UMPQUA	072653
SALMON RIVER-OR	072655
BUTTE FALLS	072737
BUTTE FALLS	072738
BANDON	072739
NEHALEM RIVER	072748
NEHALEM RIVER	072806
NEHALEM RIVER	072807
NEHALEM RIVER	072808
NEHALEM RIVER	072809
FALL CREEK/ALSEA	072810
SILETZ RIVER	072812
SILETZ RIVER	072813
SILETZ RIVER	072814
SILETZ RIVER	072815
TRASK RIVER	072816
TRASK RIVER	072823
TRASK RIVER	072824
TRASK RIVER	072825
COLE RIVERS	072854
FALL CREEK/ALSEA	072938
FALL CREEK/ALSEA	072939
FALL CREEK/ALSEA	072940
FALL CREEK/ALSEA	072941
FALL CREEK/ALSEA	072942
FALL CREEK/ALSEA	072943
STILLMAN CR/LOST	632547

Hatchery	1986 Code
TRINITY RIVER	065650
TRINITY RIVER	065651
IRON GATE(KLAMATH)	065930
BUTTE FALLS	072754
BUTTE FALLS	072755
BUTTE FALLS	072756
NEHALEM RIVER	072757
NEHALEM RIVER	072758
NEHALEM RIVER	072759
NEHALEM RIVER	072760
ROCK CREEK-UMPQUA	072761
ROCK CREEK-UMPQUA	072762
SALMON RIVER-OR	072763
FALL CREEK/ALSEA	072958
FALL CREEK/ALSEA	072959
FALL CREEK/ALSEA	072960
FALL CREEK/ALSEA	072961
FALL CREEK/ALSEA	072962
FALL CREEK/ALSEA	072963
COLE RIVERS	073011
FALL CREEK/ALSEA	073022
SILETZ RIVER	073025
SILETZ RIVER	073026
SILETZ RIVER	073027
SILETZ RIVER	073028
TRASK RIVER	073033
TRASK RIVER	073034
TRASK RIVER	073035
STILLMAN CR/LOST	633443

CWT Codes Used For Linear Programming Model
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HOOD CANAL REGION

Hatchery	1984 Code
QUILCENE RIVER NFH	051119
GEORGE ADAMS RIVER	632561
PORT GAMBLE PENS	632562
HOOD CANAL	632724
BIG BEEF CREEK	632725

Hatchery	1985 Code
GEORGE ADAMS RIVER	621752
HOOD CANAL	632204
GEORGE ADAMS RIVER	633021
BIG BEEF CREEK	633026
PORT GAMBLE PENS	633028

Hatchery	1986 Code
HOOD CANAL	632749
HOOD CANAL	632750
PORT GAMBLE PENS	632751
PORT GAMBLE PENS	632752
GEORGE ADAMS RIVER	632832
GEORGE ADAMS RIVER	632833
BIG BEEF CREEK	633034