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FRAM Coho Model Development & Support
Final Report

by

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Abstract

Successful implementation of the Southern Coho Management Plan (JTC 2002) depends on the development of planning tools used to evaluate performance of fisheries regimes adopted by the parties to the Pacific Salmon Treaty. This project represents a large portion of the essential tasks that have been defined by the bilateral Coho Technical Committee and Southern Panel, intended to produce necessary components of the agreed upon planning tools (specifically the Fishery Regulation Assessment Model – FRAM) and the data needed as input for application of these planning tools and documentation of those products.

The three major objectives for this project are:

1. Develop an integrated system of computer programs to generate base period stock distribution profiles (annual estimates of fishery-specific exploitation rates for regional groups of coho salmon) for the Coho FRAM Model. This involves converting existing Mixed Stock Model (MSM) and other programs into MS Visual Basic (MSM-VB) for implementation on a personal computer (PC) platform. All components of the Unix-based MSM have been re-programmed into a single MS-Windows based program which allows the User to generate data to be readily incorporated into a selected FRAM base period.

2. Develop FRAM command files, provide documentation of all program code, and determine if the MSM-VB system functions correctly. The MSM-VB programs have undergone testing and the system has been validated using the 1991 catch year data. This report provides a general description of the new system and documentation of program code.

3. Develop an historical database for catch years 1992-1997. The coded-wire-tag (CWT) release groups for each production region have been identified for the 1992-1997 catch years and associated release, recovery and catch data compiled. Information required for terminal area run reconstruction (RRTERM) has been collected for all regions, and is undergoing review by regional managers. Estimates of production expansion factors (PEFs) are in the process of being generated for review by the Pacific Salmon Commission's Coho Technical Committee (PSC CoTC).

Introduction

There is a need to improve the information base available to the PSC Coho Technical Committee (PSC CoTC) for analysis of fishery exploitation and stock distribution profiles for use in regional fishery management planning models. This project, where an integrated system of PC programs (MSM-VB) was developed that can quickly generate annual estimates of exploitation rates for coho salmon from production regions coastwide, overcomes limitations of previous programs employed to generate these data. These older programs were written in several different languages on a UNIX platform, were time consuming, and error-prone. The MSM-VB system will provide the means to accelerate postseason evaluation of each catch year as the data become available. When results are routinely incorporated into an historical database, a convenient source of information will become available to support many types of analyses and facilitate tailoring input files for use in regional coho fishery planning models (e.g. Fishery Regulation Assessment Model - FRAM).

General Description of the Coho FRAM Base Period Devopment Process

The Coho FRAM is a preseason model used to assess the cumlative impacts of all fishery regulations on individual stocks. This assessment is done by scaling stock cohort sizes and total fishery landed catch relative to a base period average. The catch years used for the Coho FRAM base period are a complete cohort analysis of all stocks and all fisheries within the study region. The MSM-VB program is used to estimate stock composition in the mixed stock fisheries using expanded coded-wire-tag (CWT) recovery data, which is then combined with terminal run and escapement data from the terminal area run reconstrunction program (RRTERM) to complete the cohort analysis. Figure 1 shows the relationship between the various programs and the input data sources needed to compute the base period file.

MSM-VB system is comprised of an integrated set of programs. The User interacts with this system through input files that specify the data to be used and the analysis options to be employed (Figure 2).

Generally, the process of creating a new FRAM base period consists of the following steps (Figure 1):

For each Catch Year-

User Specification of Fishery and Stocks (MSM-VB system)-

> The User identifies: (a) the production regions and CWT codes selected to characterize fishery distribution profiles for selected production regions; and (b) the fishery strata to be used for estimation. All coho salmon stocks coastwide are represented by regional groupings of CWT data.

CWT and Catch Matrices by Stock (MSM-VB system)-

The MSM-VB System then extracts relevant CWT release and recovery information and maps recoveries and total catch into appropriate fishery strata (annual time strata), creating CWT and catch by stock and fishery matrices.

Production Expansion Factor (PEF) Estimation (MSM-VB system)-

The above files are then used as input to the MSM-VB to generate estimates of PEFs for each MSM stock. MSM-VB is an analytical tool that estimates PEFs from the stock distribution profiles and reported catches. Two MSM algorithms have been incorporated into the system. One is a simple unconstrained least squares model (ULS) that minimizes the difference in total expanded catch to total observed catch in mixed stock fisheries from California to Alaska. The second is a Bayesian estimation method developed under a separate project completed under the Southern Boundary Restoration & Enhancement Fund (Gazey 2005). PEFs are assumed to be constant across all fisheries for individual production regions.

Catch Adjustment (MSM-VB system)-

Once the PEFs are estimated, a Catch Adjustment Program (CAP) is used to adjust CWT recoveries so that the estimated and reported catches are equivalent.

Terminal Run Estimates (RRTerm and MSMSplit programs)-

The PEFs estimated by MSM-VB are employed for pre-teminal fishing areas. Because of the complexity of interactions between fisheries and individual stocks represented by regional production units, separate programs (RRTERM and MSMSplit) are employed for the terminal area fisheries. RRTERM uses data for terminal runsizes, harvest, and escapements plus user-specified fishery sequences (gauntlet) to generate estimates of escapement and terminal run sizes of individual coho populations (Management Units, or MUs) represented by a production region. MSMSplit generates estimates of catches by pre-terminal fisheries for each MU among the fishery-time strata desired for analysis and modeling (PEFs are estimated annually, but fishery-time strata can be finer).

Cohort Analysis-

Cohort analysis is then performed for individual MUs using estimates of terminal catch and escapement from RRTERM and Pre-Terminal catches from MSMSplit. Results of Cohort Analysis are then placed in a MS Access Database. Finally, MSM-VB includes a program to extract estimates for years specified by the user to generate stock distribution profile input files for FRAM.

Project Objectives

Problems experienced during the development of the 1986-1991 stock distribution input file currently used for FRAM and the length of time (nearly 10 years) it took to analyze the data served as the impetus for undertaking this project. The procedures employed to generate this file involved the use of programs written in “C”, “PERL”, and text editors. The “C” and “PERL” program code was fragmented into many separate programs and needed substantial user involvement to create and edit the input files needed for each program. The file editing process was prone to transcription errors. The formats of the various input files were undocumented and typically contained several disjointed sections

where parameter values had to be entered. Many of the fragmented programs were written in response to analytical problems that arose in the development process. This fragmentation is understandable because the focus of the original work was development of a new technique for analyzing CWT recovery information. In addition to program fragmentation, the "C" code itself was undocumented and key files needed for compilation were missing

The MS Visual Basic (VB) language was chosen for accomplishing the first objective of this project of creating an integrated analysis system because it is widely used in salmon management. Additionally, the use of VB will smoothly integrate with existing analytical tools, including RRTERM and FRAM. All of these programs use the MS Access database program for data input and output. VB is able to use the Access database files without having the user install the Access program and can use the "Active-X Data Object" (ADO) methodology to perform input and output functions for each of the various tables contained in the database file. The ADO method uses the "Standard Query Language" (SQL) for its core functions. This combination of language and database programs forms a seamless development environment that greatly simplifies development work and is easy to modify when necessary. The MSM-VB system combines seven previously separate programs into one and greatly simplifies the analytical process needed for cohort analysis.

Flowcharts depicting the general associations between major processes and data structures handled by the most important subroutines within the MSM-VB program are shown in Figures 3-9. The initialization of the fishery-related arrays is shown in Figure 3. This subroutine creates a temporary table of the selected fisheries combined with the input values for the terminal fisheries. The creation of the temporary stock table is shown in Figure 4. The temporary table of CWT recovery information uses the results from the stock and fishery initialization subroutines (Figure 5). The matrix used for the PEF estimation routines is compressed from the original data using the combinations selected by the user (Figure 6). The calculation of the sweep vector values is shown in Figure 7. The ULS method for PEF calculation is shown in Figure 8 and the general methodology for the Bayesian analysis is shown in Figure 9.

To accomplish the second objective of the project, system validation, MSM-VB was tested to insure accuracy and compatibility with the previous version of the MSM process. This evaluation was difficult because the old MSM programs could not be recompiled to yield values at intermediate steps of the calculation process. The calculation of PEF values involves association of CWT releases by stock, summarization of CWT recoveries by variable fishery definitions, user-defined PEF values, year-specific combinations of stocks and fisheries, and the addition of terminal run estimates. When errors occurred in the development process, it was difficult to compare input values because of the size and sorting of the input matrices. The most difficult process to test was summarization of the CWT recovery data. Some of the recovery data changed since the original catch years were analyzed and PSC recovery location codes used varied among catch years.

Two basic tests were performed to evaluate the MSM-VB program algorithms. First, the original input data for the 1986 to 1991 catch years were modified to be read by the program and the PEF calculations were done. This yielded results that were exactly the same as the original estimates. Second, the MSM-VB program was used to summarize

the latest available CWT data and calculate the PEFs. The PEF results were slightly different due to changes in CWT recovery information, which were primarily from Southeast Alaska net and Canadian Strait of Juan de Fuca troll and sport fisheries.

The third project objective was development of a historical database for all the catch years with adequate CWT recovery information. The priority of analysis was 1992-1997, followed by 1979-1985, and 1998-2005. The period 1992-1997 was given the highest priority because of interest in exploring different stock distribution patterns (inside vs. outside) and changes in fisheries that have occurred during these years. The period 1979-1985 was given the next highest priority because fishery harvest rates were relatively high, yielding better CWT recovery data for parameter estimation. The period 1998-2005 were assigned the lowest priority because the emergence of non-retention and mark-selective fisheries are problematic for the algorithms employed to estimate PEFs.

Development of the historical database required selection of CWT groups for each production region and year, gathering RRTERM data for each region and catch year and MSM-VB analysis of PEF values for each catch year. Contacts were made with the management agencies responsible for each region and the majority of necessary data was collected. Some important CWT-based estimates for the RRTERM fisheries using localized PEF values were not readily available and alternate estimates using landed catch and escapement numbers were derived from various agency publications. The CWT associations by stock and catch year have been made and is under review by affected agencies.

The preliminary PEF estimation process for the 1992-1997 catch years yielded some poor results that were very similar to those encountered in the 1986 to 1991 analyses. The initial calculations, without user-defined PEFs and terminal run data, resulted in many large positive and negative PEF values for some production regions due to poor CWT representation for some stocks and similar recovery distribution patterns among the stocks. Stocks with low numbers of recoveries can be more easily expanded by the MSM algorithms to estimate observed catch. Stocks with similar distribution patterns can be canceled out with large positive and negative PEF values. The pattern of problem stocks and fisheries for the 1992-1997 catch years was very similar to that from the 1986-1991 catch years.

Investigation on the use of user-defined PEFs and terminal run information to force the MSM-VB analysis to produce more plausible results was begun for the 1992-1997 catch years. Preliminary investigations showed that the PEF values were very unstable and small changes in one stock resulted in major changes in many other stocks. Production regions with poor initial PEF estimates were from the Puget Sound, Washington coast, and Canadian regions. The Puget Sound regions, including the Stillaguamish, Hood Canal, Strait of Juan de Fuca, and Makah production regions, were usually assigned user-defined PEFs. The Washington coastal regions were combined for PEF estimation and usually included Hoh, Quillayute, and Queets production regions. The Canadian regions from the Georgia Strait and Vancouver Island areas were always combined for PEF estimation. In addition to the use of user-defined PEFs, terminal run data was added for some stocks to help with the PEF estimation problems. Typically this data was either hatchery rack or wild smolt outmigration estimates of tagged to untagged ratios applied to terminal returns. Externally estimated PEF values were used when either the data was considered to be “good” or when overall PEF problems were confounded by a particular

stock grouping. A preliminary set of plausible PEF values for these catch years has been developed but will need to be reviewed by the CoTC.

The designation of stocks for the MSM-VB analysis generally follows a set of guidelines for regional groupings of production regions. The production regions defined in MSM-VB are the same as those used in the terminal run reconstruction. The production regions are collections of stock management units. The management units are typically the smallest groupings of coho stocks that enter into the negotiations for fishery regulation impacts and form the consistent link between MSM-VB estimation, terminal run reconstruction, cohort analysis, and development of fishery regulation models. Management unit groupings are used as MSM-VB stocks when PEF estimation problems occur for production regions or when good quality data is available for a particular management unit. The majority of the management units are designated as hatchery or natural production, rather than a combination of the two types of production.

The MSM-VB fishery groupings combine similar gear and adjacent areas, CWT recovery data, and generally follow the scheme used to estimate the sampling expansion factors for those fisheries. Larger fishery groupings are often made to address poor CWT sampling and for fisheries with similar CWT recovery patterns. The fishery groupings used for PEF estimation are generally different than the standardized groupings used for FRAM and cohort analysis. The differences are typically for smaller fisheries with inconsistent sampling and recovery data.

Estimation of PEFs Using the ULS

The Unconstrained linear Least Squares (ULS) model was developed with the assumption that the variance of the estimated catch does not vary with the size of the catch and only the PEF values are estimated. The ULS estimates can be found analytically and there are no constraints on the solution space. The model can be written as:

$$\min \sum_f (RC_f - TotalCatch_f)^2$$

where: RC = reported catch in fishery f and

$$TotalCatch_f = \sum_s (PEF_s \times CWTRec_{s,f}) + e_f$$

where:

$TotalCatch_f$	Total Landed Catch for year in fishery ***f***
PEF_s	Production Expansion Factor for stock ***s***
$CWTRec_{s,f}$	Coded Wire Tag Recoveries for stock ***s*** in fishery ***f***
e_f	Error in estimate of catch in fishery ***f***

Assumptions:

1) CWT recoveries are obtained from a random sample.
2) CWT groups represent all stocks caught in modeled fisheries.

3) CWT groups are representative of all untagged production within their release or production region (i.e. ocean distributions of tagged groups and untagged wild stocks are similar)
4) Harvest rates are the same for tagged and untagged stock components in all fisheries.
5) The PEFs are essentially constant across fisheries for each stock.
6) The CWT recovery profile for each stock or production region is distinct from the CWT recovery profile of other groups.

MSM-VB Development and Processes

The MSM-VB system was developed to replace a set of computer programs developed for the Unix operating system. The original programs were written in the "C" programming language and the "PERL" scripting language. These programs used all text-based input and output files that required many steps to create or change. In many cases the output from one program was used to create the input file for the next program in the estimation process. This system was cumbersome and fraught with many transcription errors. Any data or selection changes usually resulted in re-running of all components of the system. This typically required 2-3 days of intense work for 2 people. Some of the original code for the "C" programs could not be located so it was not possible to re-compile the programs for a new computer platform.

The decision to re-write the MSM estimation procedure into a PC-based system was done so that all the programs used for coho cohort analysis were in the same language and data could be easily and efficiently exchanged using PC database files. The terminal run reconstruction program (RRTERM) and the FRAM base period construction program are both written in MS Visual Basic and both use MS Access database files for data storage and retrieval. The MSM-VB program uses both these features as well. In addition, the basic data needed was retrieved from the PSMFC RMIS (Pacific Salmon Marine Fishery Council – Regional Mark Information System) internet site so that in the future, the data can be easily obtained and the database updated. The previous MSM estimation programs used truncated files of the same information obtained from a different source.

The MSM-VB estimation process for coho salmon is divided into two distinct procedures for use in cohort analysis. The first involves the estimation of production expansion factors (PEFs) for each stock or stock group selected using CWT data for each catch year analyzed. Each stock group must have CWT recovery data available that represents the relative distribution of fishery impacts. The PEF values are used to estimate all the production from the particular regions they represent, which includes both hatchery and wild production. In the second step, the PEFs are applied to CWT recovery data for a similar but standardized set of stocks that are used for management purposes. The selection of stocks and fisheries for the first step requires the user to make year-specific decisions based on the availability and quality of CWT data. The selection of CWT data to represent each stock is one of the most important steps that must be taken in the analytical procedure. The MSM-VB program was created to aid with the selection of stocks, fisheries, and CWT groups and to apply the MSM algorithms to those selections.

The CWT release, recovery, and catch-sample data were downloaded from the PSMFC RMIS site using the PSC standard format protocol. The decision to use this data source

and format was made because the data is readily available and the datafile formats are standardized, allowing for quick update of the data on a catch year basis for any data that changes and when new catch years become available.

The MSM-VB program is organized into 3 main sections (Figure 2). The first section deals with selection of the database file and the recordset within the database file for the catch year being analyzed. The second section involves the CWT release data and association to stock groups. The final section deals with the MSM-VB analysis and contains many functions. Both stocks and fisheries can be selected, combined, or deleted. Terminal fisheries can also be defined and estimated CWT recoveries entered. Summaries of total catch by time period and numbers of CWT recoveries by stock and fisheries can be displayed. The matrix of CWT recoveries is very important because it is used in the MSM-VB algorithms for estimating the PEF values. This matrix has always been very difficult to create because it summarizes multiple CWT release codes for each stock group and uses multiple recovery location codes in each fishery for the CWT recovery data. Summarizing the recovery location codes is further compounded by the use of variable length specification criteria for each area and differing codes among the gear types used (sport, troll, and net).

The MS Access database was constructed to hold multiple recordsets representing each catch year analyzed and/or multiple recordsets for each catch year. This was accomplished by having a unique identification number (RunID) for each recordset in the database. Each variable table in the database file contains records that are linked by the RunID value. Tables were created for the stock, fishery, CWT associations, terminal runs, and rejected CWT recoveries that were linked by the RunID values. Other tables in the database are static and are not linked by the RunID variable. These tables include the "Catch Area" and the "Management Unit" tables used in RRTERM and FRAM, and the CWT release, recovery, and catch-sample data from RMIS. The CWT recovery and catch-sample tables are arranged into separate tables by catch year to reduce size and to allow for quick updating. The RunID information is stored in a separate table and each record is linked to the individual catch year recovery and catch-sample information using the "year" variable in each table. The separation of the data into year-specific tables allows for multiple database files that do not need to retain all the data for all years. The large numbers of recovery records for each catch year required this table design structure. It also lets the user easily export analyses for an individual year or range of years into a single database. This database structure also aids in the sharing of the data and analyses with multiple users of the program.

The MSM-VB system allows the user to estimate PEF values using two different methodologies. The standard method for previous coho cohort analyses used the Unconstrained Least Squares (ULS) method described by Scott et al. (1995) for the PSC Coho Technical Committee. The committee accepted this algorithm after investigating several calculation techniques including constrained least squares and non-linear approaches. The second method of PEF estimation in the MSM-VB program was developed for this project using a Bayesian estimation technique (Gazey 2005). This method uses a Bayesian approach where weighting factors can be applied to the CWT recoveries by fishery. The estimated PEF values using this technique when all fisheries are weighted equally are identical to those produced by the ULS algorithm. The Bayesian approach using variable fishery weighting factors will be used in future work to allow the fisheries with the most recoveries to have the greatest effect on the PEF

estimation process. The production regions from the Columbia River, Puget Sound, and the Strait of Georgia have the highest production of hatchery fish and the highest CWT release and recovery rates. Using the Bayesian method with a fishery-weighting scheme proportional to CWT recovery rates will improve the PEF estimation for these production regions.

A bootstrap method is used to calculate the PEF variances estimated using the ULS algorithm. The Bayesian method also includes a variance calculation as described in Gazey (2005).

The final calculations done by the MSM-VB program are the catch adjustment factors by fishery and time step. These factors are the ratio between the total estimated catch and the observed total catch. The estimated catch is calculated by multiplying the PEF values times the CWT recoveries for each stock. The catch and CWT recovery data for this procedure are summarized by the standard definitions for fisheries and time steps used in the RRTERM and FRAM programs. The catch and CWT recovery data are summarized on an annual basis for estimation of the PEF values so they cannot be used in this step of the cohort analysis.

The general design of the MSM-VB program is illustrated in the flowcharts depicted in Figures 2-9. Figure 2 shows the processes available from the program's main menus. The other flowcharts illustrate the progression of steps and algorithms for each of the major processes. Table 1 is a list of the tables contained in the MS-Access datafile that are used by the MSM-VB program. Table 2 lists the variables in each of these tables.

Stocks used in MSM-VB PEF Estimation

The selection of stocks for the MSM-VB PEF estimation process closely follows the stock designation used in the coho FRAM model, but has some variation within each catch year analyzed. The list of FRAM stocks from each production region is listed in Table 3 in the Appendix. The stocks used in the MSM-VB process are usually aggregated at the production region level but can be specified for any of the FRAM management units listed in Table 3. The variations are the result of differences in the quality and availability of CWT recovery data for each of the stock groupings. The designation and description of production regions and the individual management units or stocks within the regions is the same for all the major processes used to analyze coho CWT data. These processes include the terminal run reconstruction program RRTERM, the MSM-VB and associated cohort analysis programs described in this report, the FRAM base period calculation program, and the FRAM program. The estimation of PEF values using the MSM-VB program is usually done for stock groupings on the production region level. Some management units have been estimated separately because of high quality CWT recovery data for that stock. Typically CWT data for the Puget Sound and Columbia River stocks allows for management unit use in some cases. In cases where the distribution data is well known and adequate numbers of CWT recoveries were available, the PEF values were fixed or "user-defined" for those stocks.

One of the more difficult problems to deal with for stock designations is the low CWT tagging rate in many years for some stocks, including those from Southeast Alaska, North and Central British Columbia coast, and California. Most of these areas have low

hatchery production and are so remote that it is logistically impractical to tag significant numbers of smolts. In addition, stock distributions for the Alaskan and Northern BC stocks are fairly similar and the PEF estimates are easily confounded in the ULS process, resulting in both high positive and high negative estimated PEF values for the stocks. This was often the case for Puget Sound stocks also with good CWT recovery data, but similar catch distribution patterns. The fixed PEF method could be used with the Puget Sound stocks because better information was available for escapement and total terminal run estimates. In contrast, escapement and terminal run estimates are typically not available for the stocks from remote areas and fixed PEF values could not be estimated and used. In the MSM-VB process, stocks with poor CWT data were usually combined with other production regions. The data availability was fairly similar for most years and the combinations of stocks were also similar between the catch years analyzed. This results in the same PEF value for each of the components of a combined stock grouping. This technique greatly helps in the estimation of total catch in the major marine mixed stock fisheries, but probably gives a somewhat biased view of the relative contribution rates within the combined stock groupings. This outcome is unavoidable given the poor quality and low tagging rates for these areas. This is not an unacceptable outcome because it reflects the low priority for assessment of these stocks.

Fisheries used in MSM-VB PEF Estimation

The selection of fisheries for the MSM-VB PEF estimation process is similar to the stock selection in that the description of fisheries follows the standardized lists used in the other coho CWT programs. The list of available fisheries is shown in Table 4 and is the same as that used for the coho FRAM program. One important difference for the MSM-VB process is the exclusion of many terminal area fisheries. One of the basic assumptions of the ULS estimation technique is that the grouping of CWT recoveries is uniform for all the tag codes used for each stock. This assumption is not satisfied for many terminal areas where the fish from individual tag codes have different migration routes. An example would be for the South Sound group for Puget Sound. This production region stretches from the Seattle area to Olympia and includes many management units. The fish originating from the northern portion of the production region would not be expected to contribute to fisheries in the southern portion. Terminal area fisheries are generally included in the PEF process if they have considerable non-local origin fish contributing to the catch. Estimates of non-local contribution are calculated for those fisheries and are used in the RRTERM program.

Some fisheries are combined for PEF estimation because of low CWT recovery rates or poor sampling rates. These fisheries are typically combined for the PEF estimation but the catch adjustment program and cohort analysis use a standardized set of fisheries for the FRAM base period (Table 4).

CWT Selection Process

The selection of CWT release groups to associate with the stocks used in the MSM-VB PEF estimation process is the most important first step taken in this analysis. Selection of CWT groups associated with each production region has been completed for Alaska, Canada, Washington, Oregon, and California. Tag group selection was accomplished using 4 steps: 1) Compilation of all coho CWT release information; 2) Compilation of all

CWT recovery data; 3) Assessment of tag recovery rates, tag recovery distributions, and other criteria; and 4) Review of draft CWT lists by state, tribal, and federal fisheries managers.

The CWT release information and CWT recovery records were downloaded from the PSMFC RMIS site using the PSC standard format protocol and placed in the MS-Access datafile for record retrieval and manipulation by the program. All coho release and recovery data available from RMIS was downloaded for all years in an attempt to avoid missing any data. Earlier versions of the MSM program used CWT release selection criteria for region-of-origin and a small range of brood years, but several problems were encountered and CWTs were missed. The program now provides all possible coho CWT releases to the program user during the CWT selection process.

The majority of coho salmon harvested in marine fisheries are 3 year-old fish, so the CWT groups considered for inclusion in the model are from the brood year 3 years previous to the catch year being analyzed. Exceptions were made for Alaskan and northern Canadian stocks that have significant fishery contributions and escapements of 4 year-old fish and from Oregon coastal ocean ranching facilities with primarily 2 year-old returns. The northern stocks have fish that reside in freshwater for two years, resulting in four year-old returns, while the Oregon ocean ranching facilities used accelerated rearing practices that reduced ocean residency time. Our data base development process has determined that very little information for these years is available for representing California coho production. While our intention was to include complete representation of coho CWT and production data, this discovery is not considered a serious shortcoming to the project's purpose.

To assess a CWT group for inclusion in the model, estimated tag recoveries were summed over all fisheries for each tag group by catch year and the tag recovery rate (estimated tag recoveries in fisheries / total tags released *100) was calculated. Mean tag recovery rates and standard deviations were then calculated for each management unit by age and catch year using all tag codes with at least 1 estimated recovery for that catch year. A CWT group was included in the lists of potential CWTs to use in the MSM-VB process if its tag recovery rate was above the lower confidence limit (alpha = 95%) of the mean. Regional biologists familiar with the stocks then reviewed the draft CWT selections and release data for each area and additional deletions to the list were made. CWT groups were removed from consideration if they were released early due to flooding, released diseased or the stock was transferred and released outside of the management unit area. The current CWT groups chosen to represent MSM-VB production regions and management units are listed in Table 5.

RRTERM Program

The RRTERM program was designed to calculate and store estimates of terminal runsize, terminal harvest, and escapement for all coho salmon populations defined in the MSM-VB/FRAM management system. It was created to accomplish two major objectives:

1) To serve as a repository for terminal area and escapement information;
2) Replace run reconstruction algorithms that had been used for terminal area runsize estimation for Puget Sound coho populations for the 1967 to 1996 catch

years. Those algorithms had several flaws and did not make use of CWT recovery information when it was available.

There are currently 34 production regions (PRs) on the Pacific Coast for which terminal runsize estimates are derived for the coho cohort reconstruction process. Terminal run reconstruction estimates are required for each of these PRs to estimate the abundance of the portion of the cohort not accounted for by the MSM-VB PEF analysis of stock composition in mixed stock fisheries. In addition, the MSMSplit program uses the relative abundance of the terminal runsize estimates to help estimate the MSM-VB user-defined PEF values.

The production regions were identified on the criteria of being geographically distinct freshwater/estuarine location nodes from which significant natural and or hatchery-origin salmon production originates. There are usually multiple individual Management Units (MUs) within each PR, each representing distinct major freshwater natural spawning streams, hatcheries, or net pens.

A terminal reconstruction consists of the sum of:

1) Spawning escapement(s) for each of the stock(s) being reconstructed, for year $_X$;
2) Portion of the terminal marine and freshwater fishery catch(es) assigned to each of the stock(s) being reconstructed for year $_X$, time period $_i$, and optionally;
3) Estimates of mortality from non-landed fishery losses, marine mammal predation, or other sources.

The RRTERM terminal runsize estimation program uses the following inputs to derive the terminal runsize estimates for each MU in each PR:

1) Adult (age 3 and or 4) escapement values for each MU;
2) Adult landed catch values for each sport and commercial fishery described in the RRTERM model (values typically constrained to Sept. 1-Dec. 31 in the estuarine fisheries, because landing prior to this time period often have significant numbers of non-local origin coho present, and the MSM-VB model itself allocates these catches to locations of origin);
3) PEFs (juvenile-release or adult-recovery based);
4) CWT recovery values from each sampled fishery (constrained to the same time period of the fishery catch inputs);
5) The non-local catch estimate for each MSM-VB fishery flagged for terminal area calculation (this estimate is not available until the initial MSM-VB run, which typically is done after the preliminary terminal runsize estimates are completed).

Escapement data used in this process were collected from the WDFW annual post season hatchery escapement reports, summaries provided by ODFW biologists, natural escapement estimates directly provided by regional state and tribal biologists, the PFMC 2004 Review of Ocean Salmon Fisheries report (PFMC 2005), and other sources. Catch data were retrieved from the WDFW commercial fish ticket database, WDFW annual post-season sport catch reports, summaries provided by ODFW biologists, PFMC 2004 Review of Ocean Salmon Fisheries report, and other sources.

Fishery catch allocation to the MUs of origin is conducted in the RRTERM model by a combination of CWT recovery expansions and proportional escapement-based catch

allocation. The CWT recoveries are used to estimate the portion of the catch belonging to each MU for which tag recovery data is provided by multiplication of the MU-of-origin-specific CWT recoveries for each fishery by the MU-of-origin-specific PEF value provided for each MU. The order of precedence for the allocation of catch in each fishery is to first allocate catch to MUs for which CWT recovery values were entered, then, the remainder of the catch is distributed among the MUs for which CWT data were not provided (or not used due to problems with the CWT recovery data and/or PEF) by the ratio of the MU escapement values. The raw CWT recovery data were extracted from the PSMFC RMIS database and imported into Microsoft Access for summarization and analysis. To expand the CWT recoveries for terminal fisheries, PEF values for the CWT grouping were calculated.

There are two types of terminal area PEFs:

1) Release PEF = Total number of smolts produced from MU / Number of tagged smolts released from MU.
2) Recovery PEF = Total adults recovered in hatchery rack or extreme terminal fishery / Number of tagged adults recovered in hatchery rack or extreme terminal fishery.

Release PEFs were used almost exclusively for the CWT recovery expansions in this process due to the consistent availability of information to derive these values. The historical hatchery release data for Washington was downloaded from the RMIS database to derive the values. The use of recovery PEFs was briefly examined, but the difficulty of finding "clean" fisheries that would allow calculation of an accurate terminal adult PEF was problematic, and apparent year-to-year inconsistencies in sampling/tag expansion accuracy at many hatchery rack locations made use of hatchery-rack derived PEFs difficult also.

Proportional-abundance based estimation of management unit catches is the default method used in the RRTERM program. This method assumes that a gauntlet of terminal fisheries can be defined for the management unit(s) in question based on knowledge of the migrational paths of the units. Then, as Starr and Hilborn (1988) describe, the terminal return is reconstructed working backwards from the escapement and last terminal (or extreme terminal) fishery. It is assumed that the management units present in each fishery are known and that the harvest rate in a fishery is equal on all management units present in the fishery. Then, for the last fishery in the gauntlet, the proportion of each management unit exiting the fishery is estimated using escapement estimates.

$$\hat{\pi}_{jkl} = \frac{\hat{E}_j}{\sum_{j \in l} \hat{E}_j}$$

and its variance,

$$V(\hat{\pi}_{jkl}) = \hat{\pi}^2_{jkl} \left[\frac{V(\hat{E}_j)}{\hat{E}_j^2} + \frac{\sum_{j \in l} V(\hat{E}_j)}{(\sum_{j \in l} \hat{E}_j)^2} \right]$$

where:

$\hat{\pi}_{jkl}$	MU proportion of escapement for stock ***j*** in production region ***k*** for fishery ***l***
E_j	Escapement for stock ***j***
V	Variance of parameter
C_{jkl}	Catch of stock ***j*** in production region ***k*** for fishery ***l***
N_{jl}	Cohort Size (Abundance) for stock ***j*** for fishery ***l***

Under the assumption of equal harvest rates on all management units present in the fishery, then this proportion can be used to apportion the terminal catch in the last fishery to each management unit by,

$$\hat{C}_{jkl} = C_l \ \hat{\pi}_{jkl}$$

with a variance of,

$$V(\hat{C}_{jkl}) = V(\hat{C}_l)\hat{\pi}^2_{jkl} + \hat{C}_l^2 V(\hat{\pi}_{jkl}) + V(\hat{C}_l)V(\hat{\pi}_{jkl})$$

The terminal area abundance of management unit *j* entering the last fishery will then be,

$$\hat{N}_{jl} = \hat{E}_j + \hat{C}_{jl}$$

where *l* indicates the last fishery. The variance of the abundance is the sum of the variances of the escapement and the estimated catches.

The combined abundance for all management units entering this last fishery is calculated similarly. The proportion of management unit *j* exiting the next to last fishery is,

$$\hat{\pi}_{jk(l1)} = \frac{\hat{E}_j + \hat{C}_{jkl}}{\sum_{j \in l} \hat{E}_j + \sum_{j \in l} \hat{C}_{jkl}}$$

and the variance is estimated as in equation above for the last fishery. This proportion is then used to apportion catches in the next to last fishery. In this manner the abundances of management units entering each fishery can be estimated and the proportion used to allocate the catch to each unit. The equation for estimation of this proportion for fisheries prior to the last fishery is,

$$\hat{\pi}_{jk(lx)} = \frac{\hat{E}_j + \sum_{\eta}^{x} \hat{C}_{jk(l\eta+1)}}{\sum_{j \in l} \hat{E}_j + \sum_{j \in l} \sum_{\eta}^{x} \hat{C}_{jk(l\eta+1)}}$$

where x indicates the location of the fishery away from the last fishery (e.g. x=1) for the second to last fishery. The variance of this ratio is estimated as described above.

As the process moves forward in the fishery gauntlet the number of management units assumed to be present in the terminal fishery might increase or decrease. The total terminal runsize of a management unit is then estimated by summing all the escapement and catch estimates for that unit and the variance estimated by summing their variances.

Overview of 1992-97 Terminal Runsize Estimation Process

It was our intent to prepare the terminal runsize estimates for the 1992-97 time period in a cooperative process with state and tribal biologists. An RRTERM/MSM overview meeting was held in July 2004 at the Northwest Indian Fisheries Commission (NWIFC) office in Olympia, Washington. Attendees included technical representatives from WDFW, NWIFC, Boldt Case area tribes, and CDFO. Presentations were conducted showing the basic theory and design of the MSM and RRTERM process and software tools that had been developed. A follow-up meeting to discuss coastal Washington terminal runsize estimation issues was held in December 2004 at the NWIFC office in Forks, Washington.

Over the course of winter-summer of 2005 a series of individual meetings were held between WDFW and technical representatives of the Nooksack, Swinomish, Upper Skagit, Tulalip, Quileute, and Quinault Tribes to discuss the terminal runsize estimation process for the Nooksack-Samish, Skagit, Stillaguamish-Snohomish, Quillayute, Queets, Quinault, and Grays Harbor production regions. Preliminary estimates of terminal runsize with co-manager technical agreement have been completed for the Skagit, Stillaguamish-Snohomish, Quillayute, and Queets productions regions. The remainder of the current production regions estimates presented in this report for Washington and Oregon are preliminary estimates to facilitate the MSM-VB model run process, and have not yet been subject to formal review or agreement by the co-managers in each production region. No estimates have had “non-local” catch removed yet, pending completion of the initial MSM-VB estimation process.

Appendix C contains summary tables of the terminal runsize estimates for each production region for the 1992-1997 time period, and relevant background information specific to each terminal estimate.

User-Defined PEF Values

The preliminary user-defined PEF values for coho stocks originating in Washington State are listed in Table 6. These values were calculated from hatchery release numbers of tagged and untagged fish and the estimated numbers of wild-origin smolts. The hatchery

release information was obtained from the PSMFC RMIS database. The estimated wild smolt numbers were obtained from the WDFW preseason forecast report. Actual estimated numbers were used from river systems that have wild smolt enumeration projects. The numbers for other areas were derived by formulas relating size of the watershed to expected production potential. These estimates are potentially biased by the wild smolt estimates but are reasonable for the expected rate of CWT returns for each of the stocks.

The only other production region where user-defined PEF values were used in these analyses was the Upper Fraser / Thompson River stock (FRSUPP). The management of this stock has been significantly important for Canada for several years because of low returns and is usually the focus of bi-lateral fishery management issues because of the constraints on overall exploitation rate due to it's critical status. Extensive analyses have been done on escapements and exploitation for recovery planning purposes. The user-defined PEF values were calculated using the CWT recovery data for the tag codes associated with this production region so that the MSM-VB analysis would exactly match the data used in the recovery planning process. This was accomplished by dividing the total marine landed catch by the number tags from the MSM-VB summary as shown in Table 7. The total marine landed catch was calculated by multiplying the escapement number times the ratio of total marine exploitation rate over the escapement rate. The escapement and exploitation rate numbers were obtained from the Canadian recovery planning documents.

A subjective evaluation of each user-defined PEF value was made and a flag of "good" or "poor" was assigned. The stocks assigned "good" PEFs were considered to have reasonable estimates of escapement, terminal run size, and CWT recovery rates.

Revised Canadian CWT Recoveries and Catch Data

The expansion of CWT recoveries for the Canadian fisheries in the Johnstone Strait and lower Fraser River areas were aggregated into large geographic areas for most of the catch years to be analyzed in this project. These fisheries are now managed at a finer scale than these larger aggregated areas and it was necessary to identify and expand the CWT recoveries by the new fisheries designations, and apportion the catch by the new fisheries. This work was done by the CDFO Southern Boundary Restoration and Enhancement Fund project (Tompkins 2005) and the updated information is stored in separate tables for record keeping in the MSM-Access datafile.

Catch Adjustment Procedure

The Catch Adjustment Procedure (CAP) is used to modify the summed estimated catch by stock to equal the observed total catch by fishery and time period. The same CWT release and recovery information used in the MSM-VB analysis to estimate PEFs are used in CAP, except that the catch and recovery data are summed using the standard FRAM definitions for fisheries and time periods. A catch adjustment factor is calculated for each fishery/time-period stratum and applied to the estimated catches by stock. This can be viewed as applying the stock composition estimated by CWT recoveries to total landed catch. The adjustment procedure insures that all catch is assigned to the contributing stocks in each stratum in the forwarding projecting FRAM program.

An exception to the adjustment procedure is made for stocks with "good" user-defined PEF values. The catch for these stocks is deleted from the total and estimated catches before the catch adjustment factor is calculated. The user-defined PEFs flagged as "poor" are included in the calculation.

CAP also generates estimates of "non-local" catch in terminal fisheries. Non-local refers to coho salmon originating from production regions outside of where the terminal fishery occurs. The non-local estimates are used by RRTERM to calculate stock composition in terminal fisheries with substantial non-local contribution. These terminal fisheries generally had more than 5% non-local contribution for more than half of the years analyzed.

$$CAPCatch_{f,t} = TotCatch_{f,t} - \sum_{s=s1}^{s2}\sum_{a}(PEF_{s,a} \times CWTRec_{s,a,f,t})$$

$$EstPEFCatch_{f,t} = \sum_{s=s3}^{s4}\sum_{a}(PEF_{s,a} \times CWTRec_{s,a,f,t})$$

$$CatAdjFact_{f,t} = CAPCatch_{f,t} \big/ EstPEFCatch_{f,t}$$

$$MSMCatch_{s,a,f,t} = MSMCatch_{s,a,f,t} \times CatAdjFact_{f,t}$$

$$NonLocal_{f,t} = \sum_{s=s5}^{s6}\sum_{a} MSMCatch_{s,a,f,t}$$

Where:

$CAPCatch_{f,t}$	Catch after deleting for MSM stocks with "good" PEF values
$TotCatch_{f,t}$	Total Catch for fishery ***f,*** at time step ***t***
$PEF_{s,a}$	Production Expansion Factor for stock ***s,*** age ***a***
$CWTRec_{s,a,f,t}$	Coded Wire Tag Recovery for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***
$EstPEFCatch_{f,t}$	Estimated Catch of remaining stocks for fishery ***f*** at time step ***t***
$MSMCatch_{s,a,f,t}$	Catch for MSM stock ***s,*** age ***a***, in fishery ***f*** at time step ***t***
$NonLocal_{f,t}$	Catch of NonLocal stocks in terminal fishery ***f*** at time step ***t***
Stocks s_1,s_2	List of stocks with "good" or user-defined PEF estimates
Stocks s_3,s_4	List of stocks with estimated PEF estimates (from MSM)
Stocks s_5,s_6	List of stocks from other regions in terminal fishery ***f*** at time step ***t***

MSMSplit Program Algorithms

The MSMSplit program divides the stock aggregations used for the MSM-VB process into the management unit components defined in the terminal run reconstruction program RRTERM. The MSM-VB stocks are generally defined as either production regions or management units. The production regions are groupings of MUs that are used for management purposes. The exceptions for MSM-VB stocks are aggregations of production regions for northern British Columbia in years without CWT representation and Columbia River late runs.

The program determines which MUs are included in each MSM-VB stock definition and uses the terminal run proportions from RRTERM to allocate the MSM catch estimates. The MSM-VB stock names must match either the PR or MU names from RRTERM. The

terminal run proportions from RRTERM are recalculated when MSM-VB stock corresponds to a MU name because that stock is longer included in the production region PEF estimate. A file containing catch estimates by MU is created for use in the cohort analysis program.

The MSM-VB stocks that are aggregations of production regions are allocated with user-defined proportions contained in the MSM-VB input file. These estimates are usually averages of recent years.

The Columbia River late run stock group is treated essentially like a separate production region for MSM-VB estimation. The MU components are lower river hatchery and Clackamas River wild. They are split using the RRTERM proportions separately from the early-timed MUs.

$$MSMProp_{s,a} = RRPct_{s,a} \Big/ \sum_{s=s1}^{s2} \sum_{a} RRPct_{s,a}$$

$$Catch_{s,a,f,t} = MSMCatch_{k,a,f,t} \times MSMProp_{s,a} \quad \textbf{where stock } s \textbf{ is subset of MSM stock } k$$

Columbia River Late Hatchery

$$Catch_{h,a,f,t} = ColLHW_{f,t} \times (RRPct_{h,a,s,a} \big/ (RRPct_{h,a,s,a} + RRPct_{w,a,s,a}))$$

Columbia River (Clackamas) Late Wild

$$Catch_{h,a,f,t} = ColLHW_{f,t} \times (RRPct_{w,a,s,a} \big/ (RRPct_{h,a,s,a} + RRPct_{w,a,s,a}))$$

Where:

$MSMProp_{s,a}$	MU proportion of MSM stock
$RRPct_{s,a}$	MU proportion of Terminal Run for stock ***s,*** age ***a*** from RRTERM
$Catch_{s,a,f,t}$	Landed Catch by MU for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***
$MSMCatch_{k,a,f,t}$	Catch for MSM stock ***k,*** age ***a***, in fishery ***f*** at time step ***t***
$ColLHW_{f,t}$	Catch for MSM stock Columbia River Late Hatchery/Wild
Stocks s_1,s_2	List of MU stocks contained in MSM grouping
Stock k	MSM stock grouping of MUs
Stocks h,w	Columbia River Late Hatchery and Clackamas River Late Wild

MSM Cohort Analysis Program Algorithms

The MSM Cohort Analysis Program calculates abundances by MU and time-step using catch data from the MSMSplit program, terminal catch and escapement data from RRTERM, and estimates of incidental fishing mortality and natural mortality. The cohort abundances are then used to calculate exploitation rates that can be used for fishery modeling purposes.

The cohort reconstruction starts with escapement and works backwards through time adding fishery impacts and natural mortality. Landed catch data comes directly from MSMSplit and RRTERM. Incidental fishery impacts include dropoff and non-retention. Dropoff is calculated as add-on mortality to landed catch. Non-retention estimates are input as numbers of dead fish and must be associated with the stock composition of

another fishery. The associated fishery is generally the same gear/area fishery in another time-step or an adjacent area fishery in the same time-step. A small group of fisheries with either no sampling or no CWT recoveries were handled in the same way as the non-retention estimates. These fisheries were typically in terminal areas with relatively small catches.

The exploitation rate calculations were done using either the initial cohort sizes or with the time-step cohort sizes. The non-retention mortalities were treated like landed catch for these computations. Exploitation rates using the initial abundances can be summed across time-steps but are not particularly useful for modeling of regulation impacts. The time-step exploitation rates are used to create the base period information for FRAM. They are calculated after natural mortality has been subtracted from the time-step cohort size to match the sequence of computations used in FRAM.

$$Cohort_{s,a,t} = Cohort_{s,a,t+1} + \left(\sum_{f}(Catch_{s,a,f,t} + IncMort_{s,a,f,t}) + Escape_{s,a,t}\right) \Big/ (1 - NatMort_t)$$

$$IncMort_{s,a,f,t} = Dropoff_{s,a,f,t} + CNR_{s,a,f,t}$$

$$Dropoff_{s,a,f,t} = Catch_{s,a,f,t} \times DropoffRate_{f,t}$$

$$CNR_{s,a,f,t} = CNRMort_{f,t} \times (Catch_{s,a,f',t} / TotCatch_{f',t})$$

$$Catch_{s,a,f,t} = NOSMort_{f,t} \times (Catch_{s,a,f',t} / TotCatch_{f',t})$$

$$ExplRate_{s,a,f,t} = Catch_{s,a,f,t} / (Cohort_{s,a,t} \times (1 - Natmort_t))$$

Where:

$Cohort_{s,a,t}$	MU Population Size for stock ***s,*** age ***a***, at time step ***t***
$Escape_{s,a,t}$	Escapement for stock ***s,*** age ***a***, at time step ***t***
$Catch_{s,a,f,t}$	Landed Catch by MU for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***
$IncMort_{s,a,f,t}$	Incidental Fishery Mortality for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***
$Dropoff_{s,a,f,,t}$	Dropoff Mortality for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***
$DropoffRate_{f,t}$	Dropoff Mortality Rate for fishery ***f,*** at time step ***t***
$CNRMort_{f,,t}$	Total Non-Retention Mortality for fishery ***f,*** at time step ***t***
$CNR_{s,a,f,,t}$	Non-Retention Mortality for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***
$NOSMort_{f,,t}$	Total Catch for fishery ***f,*** at time step ***t*** with No Sample or No CWT Recovery
Fishery *f'*	Associated Fishery for stock composition of CNR and NOS mortalities
$ExplRate_{s,a,f,,t}$	Exploitation Rate for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***

Coho FRAM Base Period Algorithms

The Coho FRAM Base Period file is generated by averaging cohort sizes and exploitation rates over a range of selected years. The base period file contains the initial cohort sizes by stock and age, plus the average exploitation rate by stock, age, fishery, and time-step.

The base period cohort size is an average of initial cohorts from all the years selected divided equally into marked and un-marked components. The two components are necessary for evaluating mark-selective fisheries. There were no mass-marked coho during the base period years. Each component uses the same, original MSM exploitation rate because the cohort split was weighted equally.

Four methods were evaluated for averaging exploitation rates: 1) Average over all years selected; 2) Average over years with a fishery occurring; 3) Average over all years selected weighted by cohort size; and 4) Average over years with fishery occurring weighted by cohort size. The second method was chosen by the PFMC Scientific and Statistical Committee (SSC) because it averaged actual rates without missing values. The only exception was for Thompson River coho, were the 1986 data was excluded because of poor escapement data.

The exploitation rates for troll and net fisheries in Washington State were split into Treaty Tribal and Non-Treaty fisheries so that sharing allocation summaries could be calculated. The MSM-VB fisheries for Washington State were combined Treaty and Non-Treaty to increase the number of CWT recoveries and decrease the variance of the exploitation rates. The exploitation rate split was made using the average Treaty proportion for the years selected. If either component was missing for all years it was arbitrarily set to 0.01 and no average was allowed to be lower than that value.

$$BPCohort_{s,a,t} = \left(\sum_{y=y1}^{y2} Cohort_{s,a,t,y}\right) \Big/ NumYears \times 0.5$$

Method 1- Average Exploitation Rate Over All Years Selected

$$BPER_{s,a,f,t} = \sum_{y=y1}^{y2} ExplRate_{s,a,f,t,y} \Big/ NumYears$$

Method 2- Average Exploitation Rate Over Years with Fishery Occurring

$$BPER_{s,a,f,t} = \sum_{y=y3}^{y4} ExplRate_{s,a,f,t,y} \Big/ NumYears \qquad \text{(except Thompson)}$$

Method 3- Average Exploitation Rate Over All Years Selected Weighted by Cohort size

$$BPER_{s,a,f,t} = \left(\sum_{y=y1}^{y2} (ExplRate_{s,a,f,t,y} \times Cohort_{s,a,f,t,y})\right) \Big/ NumYears \Big/ \left(\sum_{y=y1}^{y2} Cohort_{s,a,f,t,y}\right) \Big/ NumYears$$

Method 4- Average Exploitation Rate Over Years with Fishery Occurring Weighted by Cohort size

$$BPER_{s,a,f,t} = \left(\sum_{y=y3}^{y4} (ExplRate_{s,a,f,t,y} \times Cohort_{s,a,f,t,y}) \Big/ NumYears \right) \Big/ \left(\sum_{y=y3}^{y4} Cohort_{s,a,f,t,y} \Big/ NumYears \right)$$

$$AvgTreatyPct_{f,t} = \sum_{y=y1}^{y2} TreatyPct_{f,t,y} \Big/ NumYears$$

Where:

$BPCohort_{s,a,t}$	FRAM Base Period Cohort Size for stock ***s,*** age ***a***, at time step ***1***
$Cohort_{s,a,t1,y}$	MSM Cohort for stock ***s,*** age ***a***, at time step ***1***, year ***y***
$BPER_{s,a,f,t}$	FRAM Base Period Expl. Rate for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***
$ExplRate_{s,a,f,t,y}$	MSM Exploitation Rate for stock ***s,*** age ***a***, in fishery ***f,*** at time step ***t***, year ***y***
$AvgTreatyPct_{f,t}$	Average Treaty Percent for fishery ***f,*** at time step ***t***
$TreatyPct_{f,t,y}$	Treaty Percent for fishery ***f,*** at time step ***t***, year ***y***
NumYears	Number of Years in List Selected
Years y1, y2	List of Years Selected
Years y3, y4	List of Years Selected where fisheries occurred

Recommendations for Future Work

The future work for coho cohort analysis should include adding all years with adequate CWT recovery information, refinement of the techniques used to estimate PEF values by production region, and development of algorithms to estimate effects from mark-selective fishery regulations. Completion of this work would yield a historical database of fishery-related mortality that could be used in a variety of applications. The focus of the current work is development of a base period file for the FRAM program, which is used to estimate preseason fishery impacts so that appropriate regulations can be developed for stock conservation concerns and user-group allocation issues. Other uses of the historical database include stock recruitment analysis and preseason forecasting techniques.

The range of years available with adequate CWT recovery information is fairly limited. The MSM PEF estimation technique was first applied to the 1986 to 1991 catch years and was successfully incorporated into the FRAM base period development process. The current MSM-VB project focused on the 1992-1997 catch years because of the similarity to the previous range of years in terms of overall catch and stock exploitation rates and the absence of mark-selective regulations. During both these ranges of years there were CWT release and recovery information available for nearly all the production regions defined in the cohort analysis process and adequate sampling levels in all the major mixed stock fishery areas. The 1979-1981 catch years were previously used for the FRAM base period development, but did not include all the current production regions and stocks used in the current configuration. This is characteristic of the 1972-1978 catch years when fewer regions had representative CWT information. The 1982-1985 catch years have better CWT representation than the previous years, but are also missing data for some important regions.

The latest catch years (1998-2005) have an increasing number of fisheries with mark-selective regulations that will require an additional set of algorithms to estimate the differential effects by stock. The technique used in the FRAM program to assess mark-selective regulations was to split each model stock into marked and unmarked components and to use new algorithms and parameters to estimate the differential effects between the marked and unmarked groups. The MSM-VB PEF estimation program and the cohort analysis will need to be modified in a similar manner to analyze the 1998 to 2005 catch years.

The MSM-VB PEF program needs substantial user input and analysis for various stocks and fisheries to yield meaningful results. This is most likely due to low CWT tagging levels for large geographic regions within the range of this study, which results in low numbers of CWT recoveries for many of the large ocean mixed stock fisheries. The estimation algorithms typically yield nonsensical results such as large positive and negative PEF values for many of the stocks. The use of user-defined PEF values for stocks with low numbers of CWT recoveries, combining of stocks with similar catch distribution patterns, and estimation of terminal runs and associated CWT recoveries is needed to make plausible estimates for the remaining stocks with adequate CWT information. Estimation of these parameters is somewhat subjective and can greatly influence the PEF estimates of the other stocks.

User-defined PEF values were used for many stocks in the current analysis. This technique essentially removes a stock with PEF estimation problems from the analysis

and insures that the stock estimates are within a reasonable range of production and exploitation rate values. This technique was typically applied to stocks with low CWT recovery numbers. While this technique greatly improved the overall performance of the MSM-VB PEF estimation process, it most likely results in a poor representation of the overall contribution and distribution of the user-defined PEF stock. This result is unavoidable until better information becomes available for the stock in question.

The estimation of terminal run and associated CWT recovery numbers was used for some of the stocks in each of the years analyzed. This technique was generally used when the CWT recovery distribution pattern was similar to another stock and the PEF results between the two stocks were confounded. This occurred most often in the Puget Sound regions where the production regions are defined on a smaller geographic basis. The Puget Sound production regions typically have better CWT and escapement information because of higher hatchery production with CWT tagging levels and more extensive natural escapement estimation programs. These data can be used to estimate total terminal runs and the expected numbers of CWT recoveries much easier than for other production regions. The proportion of CWT recoveries to the total terminal run is essentially the inverse of the PEF value for that production region. This forces the estimation algorithm to make the PEF value for that region fairly close to the terminal run PEF estimate without removing the stock from the MSM-VB PEF process.

Future analysis of PEF estimation should include runs where some or all of the stocks with estimation problems use the terminal run technique instead of user-defined PEF values. This would allow those stocks to remain in the estimation process and let the resulting PEF value be modified slightly from the user-defined value. This may result in a better fit between the observed and estimated catch in the mixed stock fisheries where those stocks contribute the most.

The Bayesian estimation technique developed for the MSM-VB PEF program (Gazey 2005) has not been analyzed at this time. This technique uses an algorithm that incorporates weighting factors by fishery for the PEF values. Use of appropriate weighting factors could alleviate estimation problems for many of the stocks with poor CWT representation. In most years the stocks originating in Southeast Alaska and Northern Canada have very poor CWT release and recovery information and contribute to the largest fisheries, which also occur in these areas. The ULS algorithm minimizes the difference between observed and PEF estimated catch summed across all fisheries. This results in a default weighting of total catch by fishery. The result is the largest fisheries with the lowest CWT recovery rates have the largest weighting factor. This is not an overwhelming problem because the stock composition of these fisheries is primarily from the stocks in that region. Unfortunately, the default weighting can cause a problem for stocks in other regions by creating a “ripple effect” between the estimated PEF values. Changes in the large fisheries with low CWT recoveries can significantly change the PEF values for the stocks with minor contribution rates in those fisheries. This, in turn, changes the PEF values for all the other stocks that contribute to the fisheries where the original stock has a significant contribution rate.

Different fishery weighting factor schemes should be used in the MSM-VB PEF estimation process to investigate the importance of the weighting factors to the overall PEF estimation by stock. The weighting schemes could include sampling rate, sampling rate times catch, or CWT recovery rate for the total catch in a fishery. The CWT

recovery rate would seem to be the most likely candidate to weight fisheries because it would be a function of the CWT tagging rate for the stocks contributing to each fishery.

Literature Cited

Gazey, B. 2005. Development and Documentation of Coho Mixed Stock Model Component. Southern Boundary Restoration & Enhancement Fund 2004/2005 Project #A-022.

JTC (Joint Canada-US Coho Technical Committee). 2002. Joint Canada-US Coho Technical Committee Workplan. Pacific Salmon Commission.

PFMC (Pacific Fishery Management Council). 2005. Review of 2004 ocean salmon fisheries. Pacific Fishery Management Council, Portland, Oregon.

Scott, J.B., R.A. Moore, R.A. Comstock, M. Alexandersdottir and W. Tweit. 1995. A coded wire tag based methodology for reconstructing coho salmon (*Oncorhynchus kisutch*) cohorts. Draft Manuscript. Washington Department of Fisheries, Olympia, Washington.

Starr, P.J. and R. Hilborn. 1988. Reconstruction of harvest rates and stock contribution in gauntlet salmon fisheries. Canadian Journal of Fisheries and Aquatic Sciences 45:2216-2229.

Tompkins, A. 2005. Development and documentation of expanded Canadian FRAM base period for Coho. Pacific Biological Station, Canada Department of Fisheries and Oceans. Southern Boundary Restoration & Enhancement Fund 2004/2005 Project #A-050.

Figures

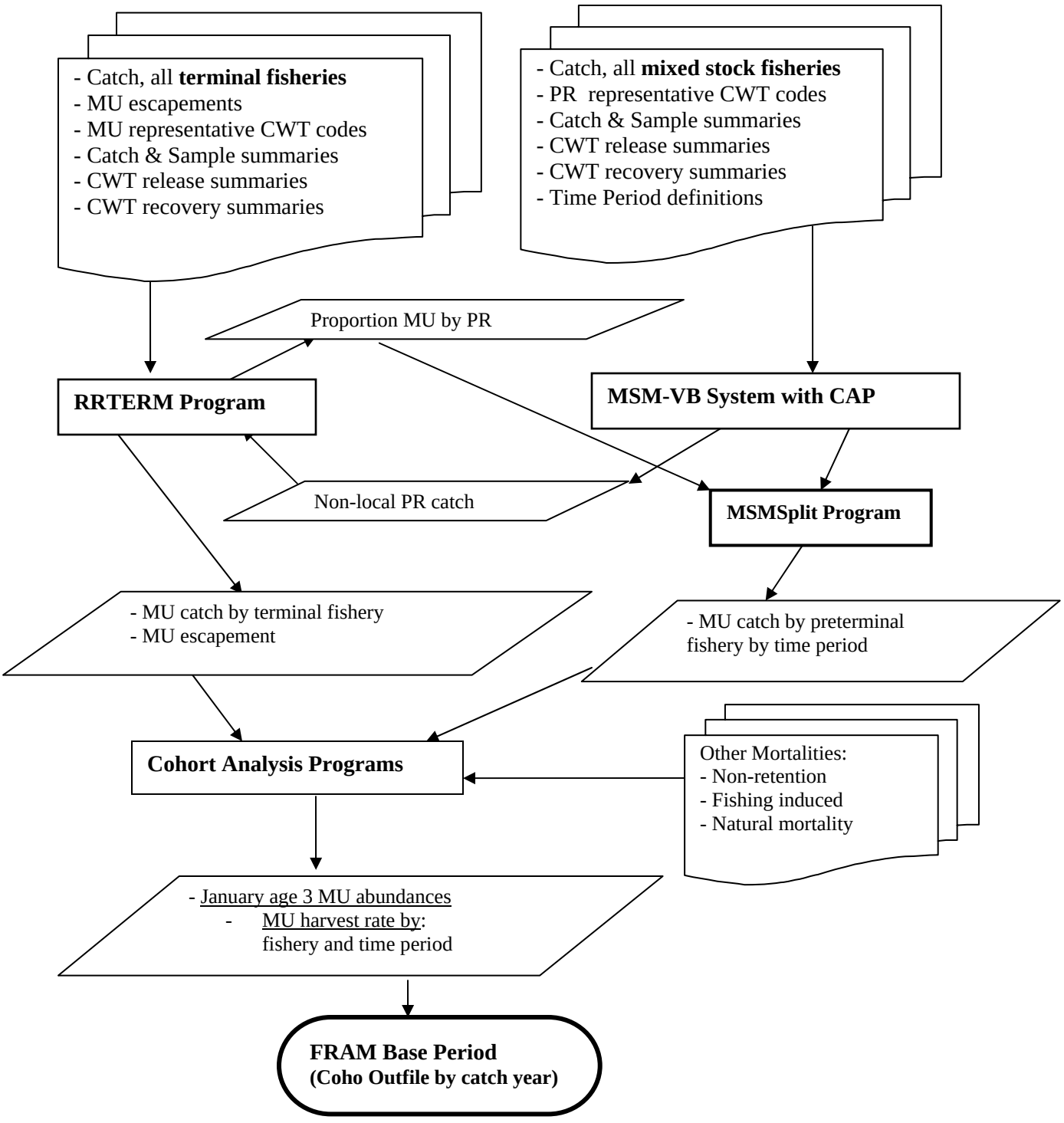

Figure 1. Flowchart of Coho FRAM base period development process.
MU = Management Unit; PR = Production Region.

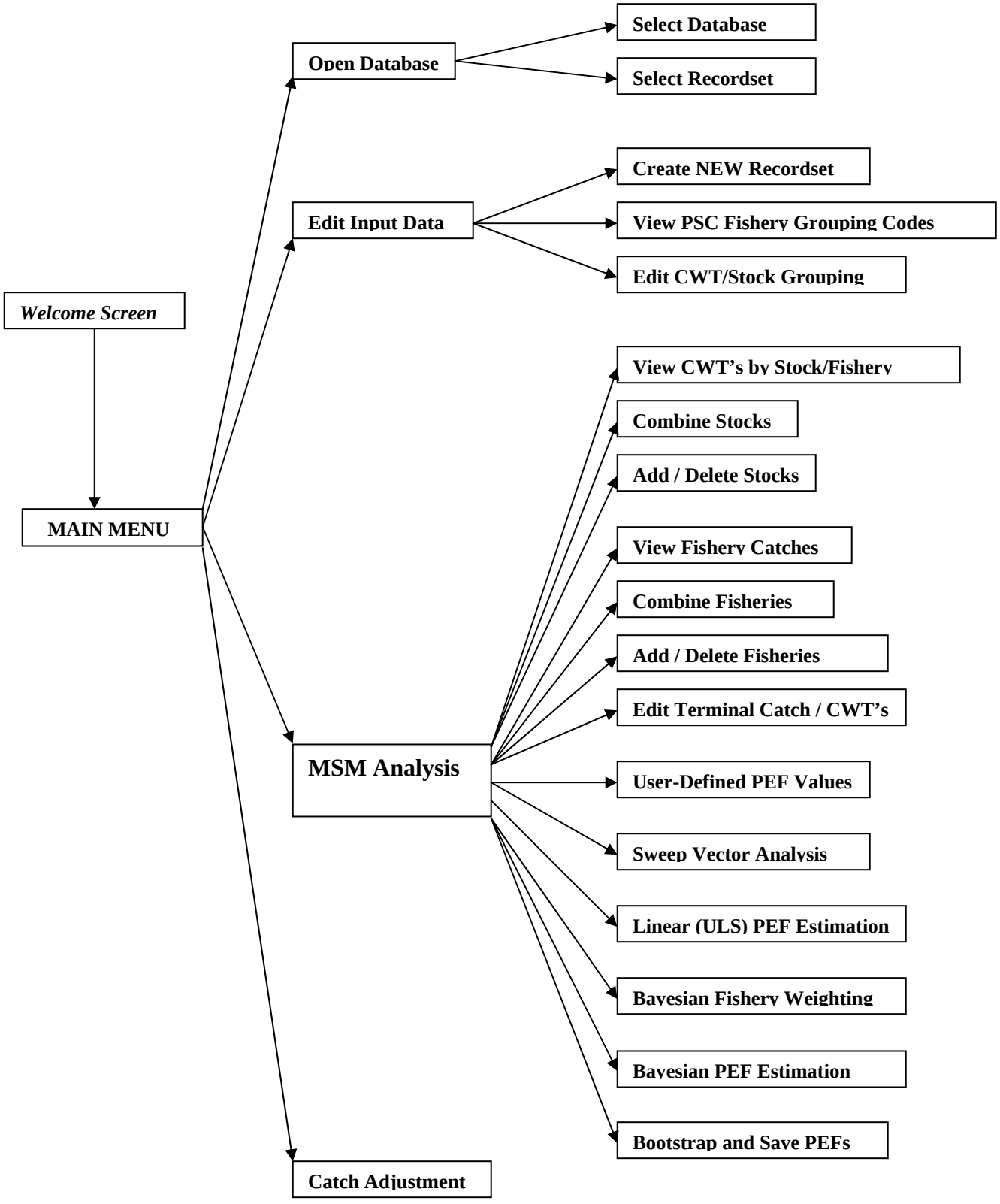

Figure 2. Flowchart of MSM-VB system.

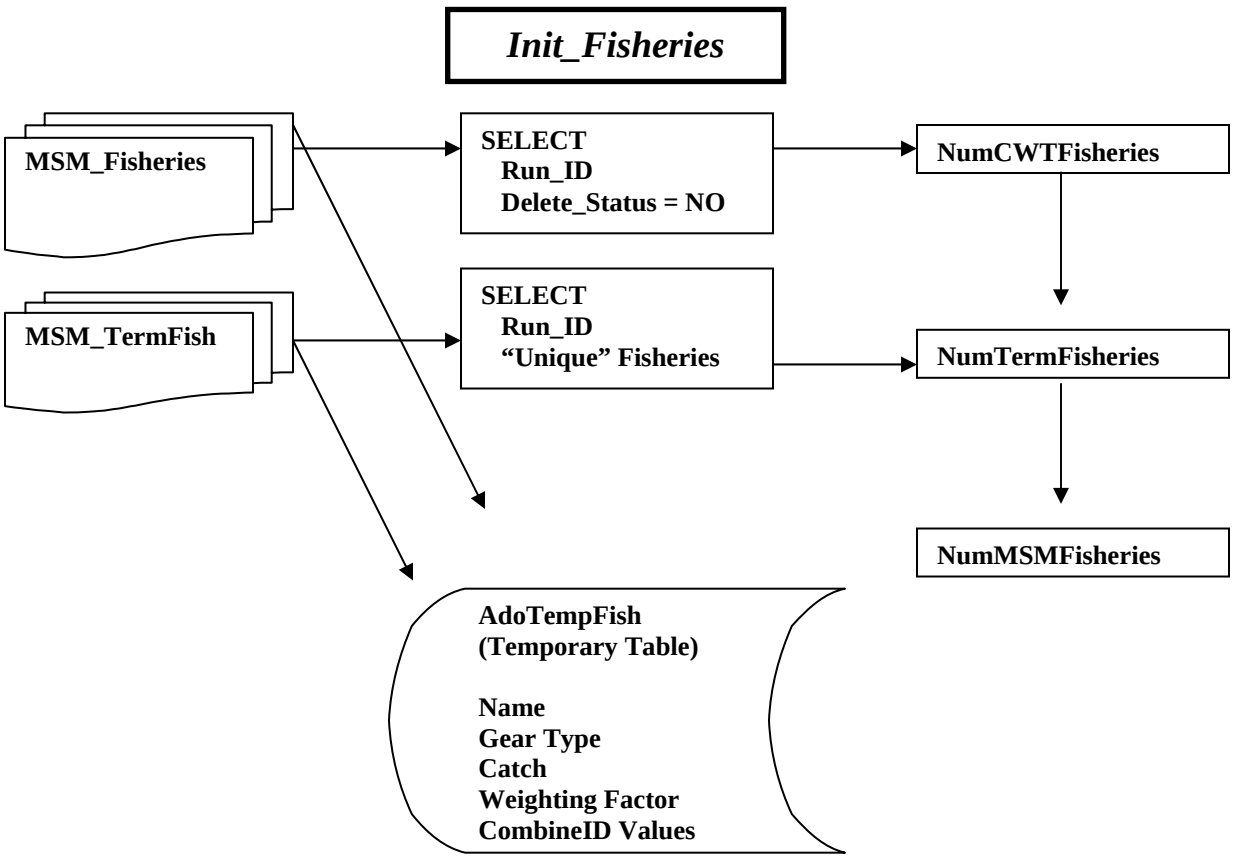

Figure 3. Flowchart of subroutine "Init_Fisheries" in MSM-VB program.

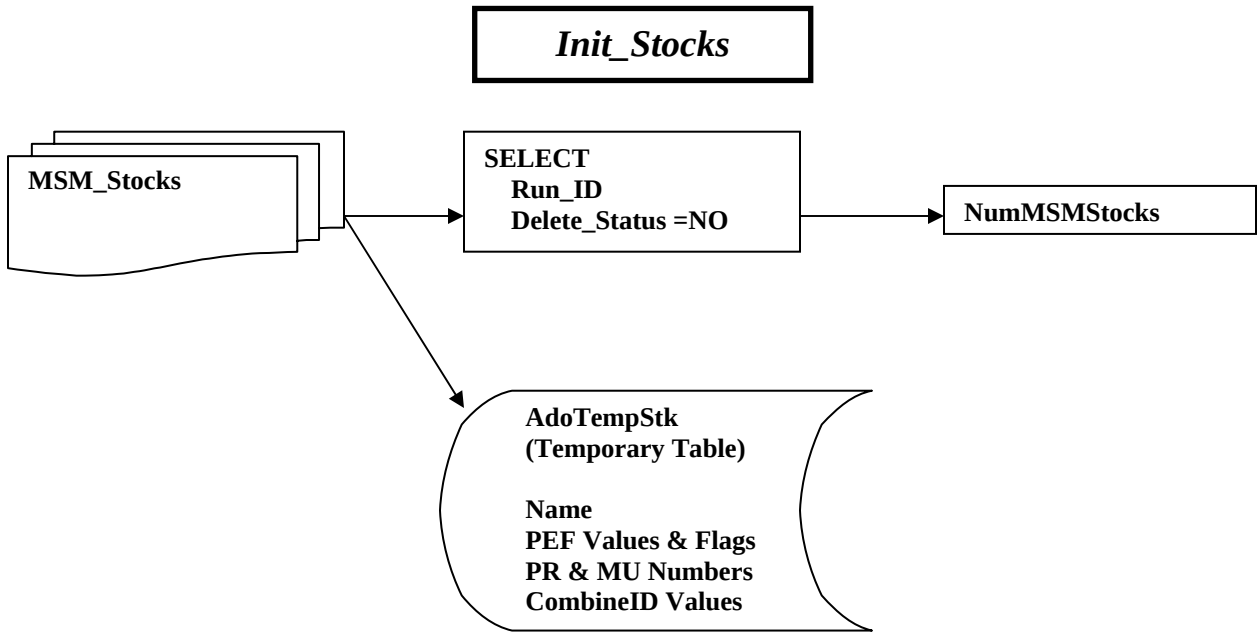

Figure 4. Flowchart of subroutine "Init_Stocks" in MSM-VB program.

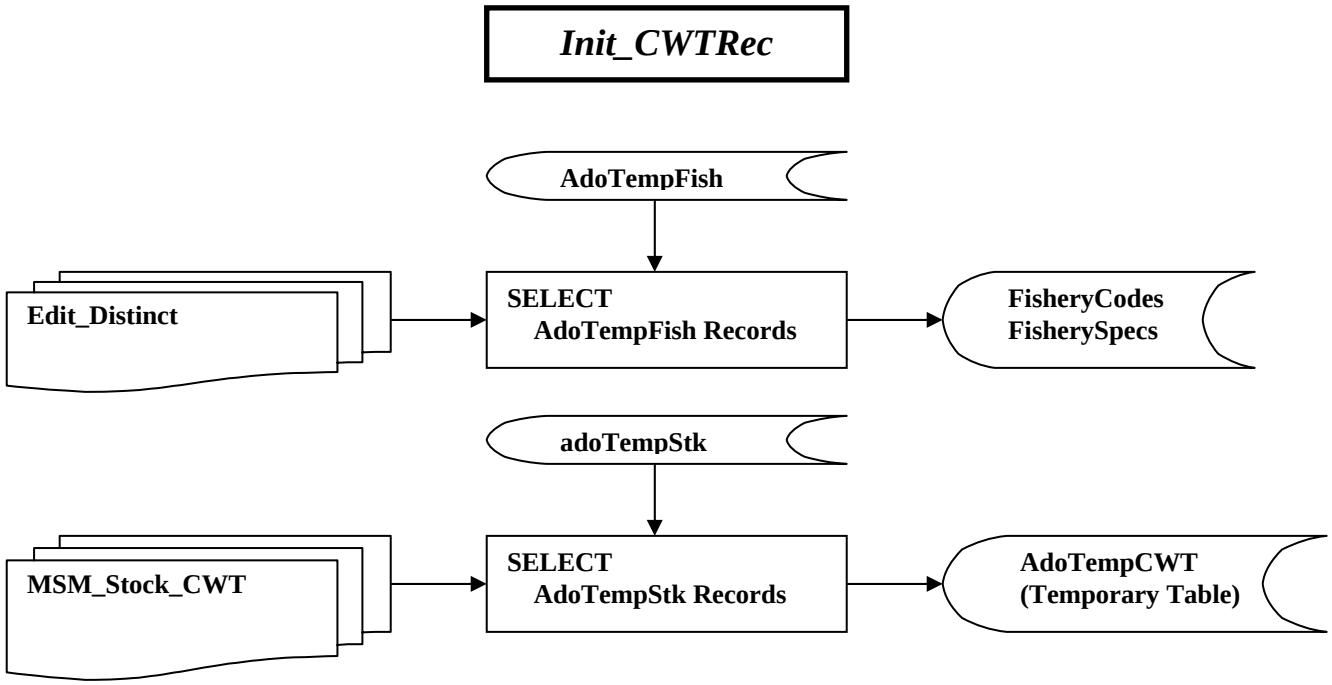

Figure 5. Flowchart of subroutine “Init_CWTRec” in MSM-VB program.

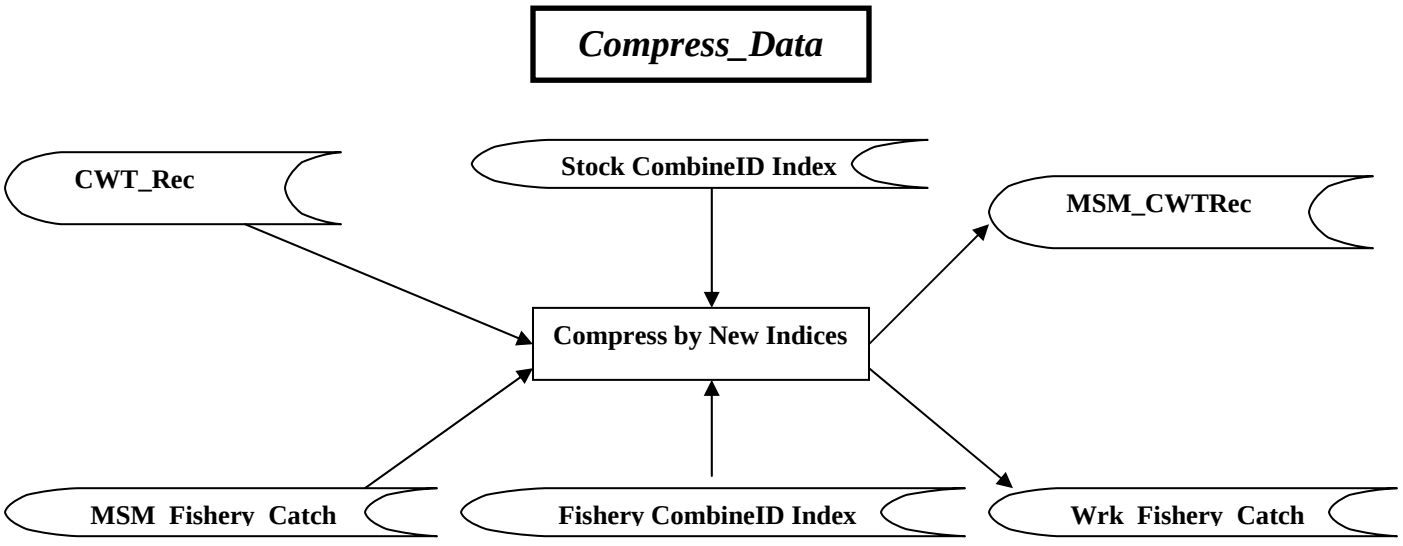

Figure 6. Flowchart of subroutine “Compress_Data” in MSM-VB program.

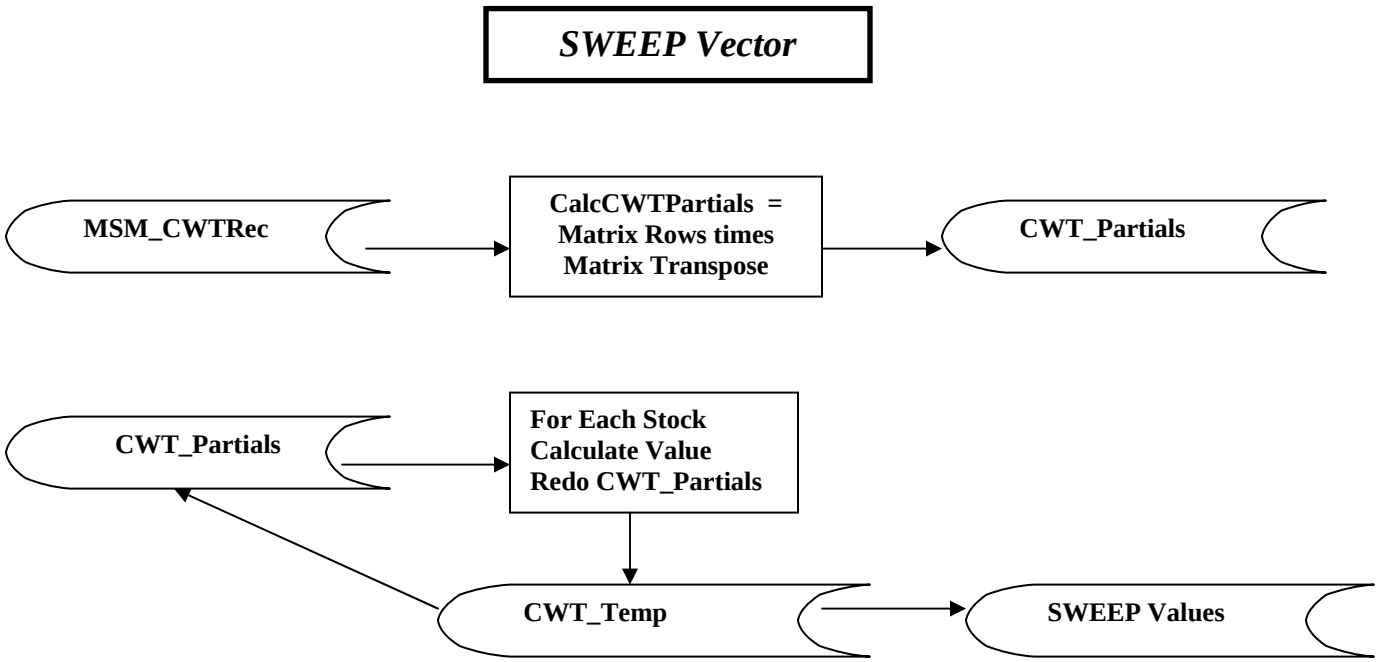

Figure 7. Flowchart of subroutine "SweepVector" in MSM-VB program.

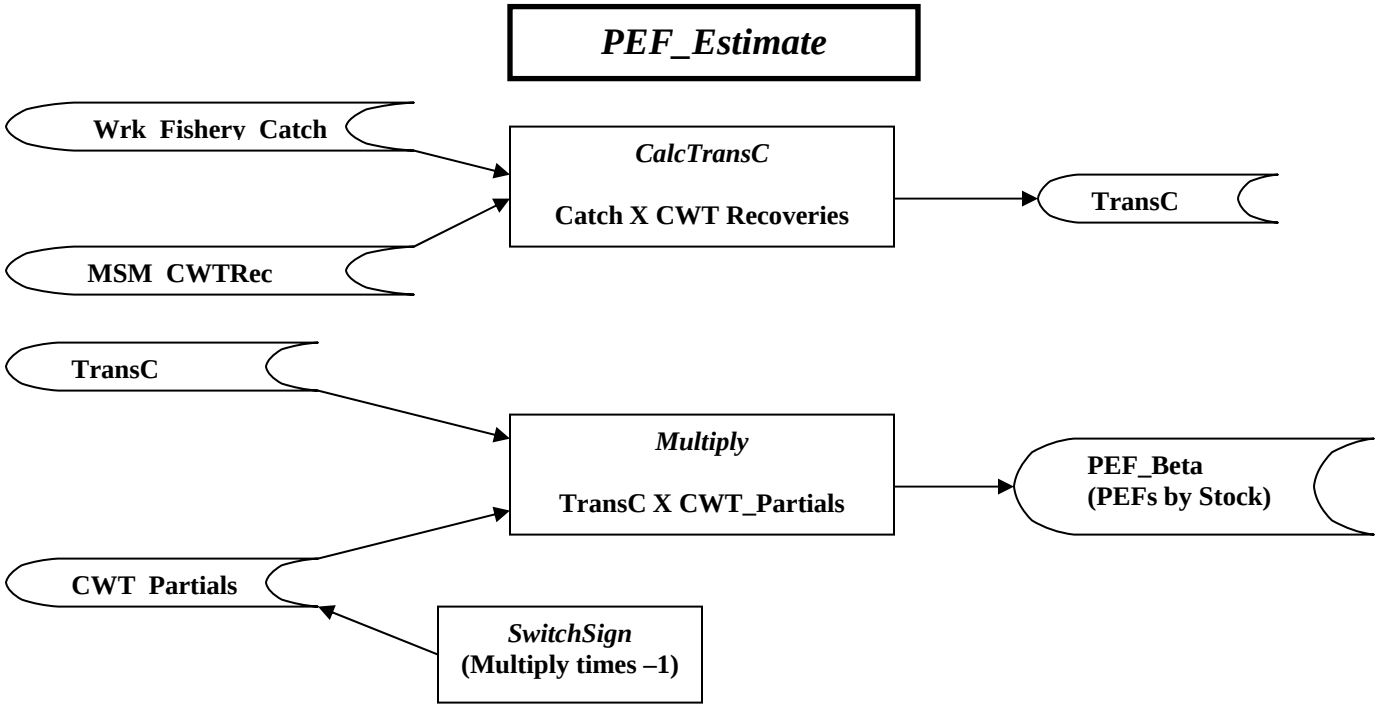

Figure 8. Flowchart of subroutine "PEF_Estimate" in MSM-VB program.

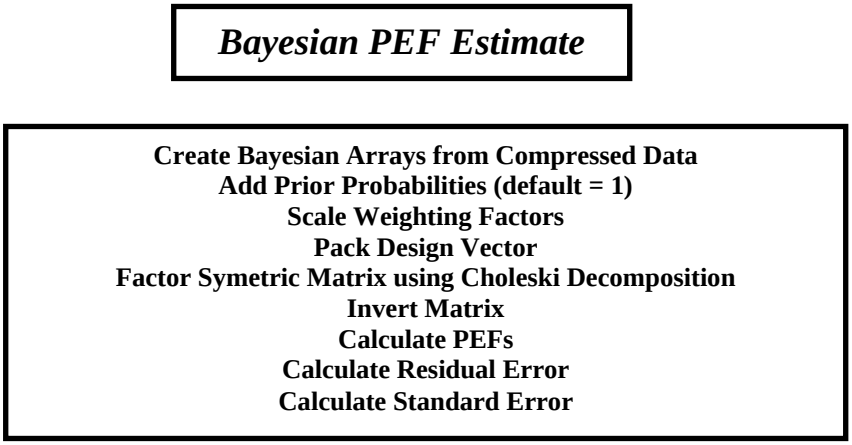

Figure 9. Steps performed by the subroutine “Bayesian_PEF_Estimate” in MSM-VB program.

Tables

Table 1. Description of tables in MSM-VB MS-Access database file.

Table Name	Description
Run_Data	Recordset attributes; including Recordset index number, catch year, and run description
CohoCWTyyyy	CWT recovery data by catch year – yyyy is catch year
CS_yyyy	CWT catch/sample data by catch year – yyyy is catch year
All_Releases	All CWT release data available from RMIS
Edit_Distinct	Specifications of PSC Recovery_Location_Code for each fishery
MSM_Fisheries	Indexed fishery list and fishery status (Flag) by Recordset Number
MSM_Stock	Indexed stock list and stock status (Flag) by Recordset Number
MSM_Stock_CWT	CWT release codes associated with MSM_Stocks
MSM_TermRun	Terminal run catch and estimated CWT recoveries
MSM_CWT_Reject	CWT recoveries not used (record does not meet Recovery_Location_Code specifications in Edit_Distinct table)
CA_Data	Catch Area data used in RRTERM and FRAM
PR_Data	Production Region data used in RRTERM and FRAM
MU_Data	Management Unit data used in RRTERM and FRAM

Table 2. Variables included in MSM-VB MS-Access database tables (table names).

CWT Recovery tables (CohoCWTyyyy and MSM_CWT_Reject)	**Catch/Sample** tables (CS_yyyy)
record_code	record_code
format_version	format_version
submission_date	submission_date
reporting_agency	reporting_agency
sampling_agency	sampling_agency
recovery_id	catch_sample_id
species	species
run_year	catch_year
recovery_date	period_type
recovery_date_type	period
period_type	first_period
period	last_period
fishery	fishery
gear	adclip_selective_fishery
adclip_selective_fishery	estimation_level
estimation_level	catch_location_code
recovery_location_code	detection_method
sampling_site	sample_type
recorded_mark	sampled_maturity
sex	sampled_run
weight	sampled_length_range
weight_code	sampled_sex
weight_type	sampled_mark
length	number_caught
length_code	escapement_estimation_method
length_type	number_sampled
detection_method	number_estimated
tag_status	number_recovered_decoded
tag_code	number_recovered_no_cwts
tag_type	number_recovered_lost_cwts
sequential_number	number_recovered_unreadable
sequential_column_number	number_recovered_unresolved
sequential_row_number	number_recovered_not_processed
catch_sample_id	number_recovered_pseudotags
sample_type	mr_1st_partition_size
sampled_maturity	mr_1st_sample_size
sampled_run	mr_1st_sample_known_ad_status
sampled_length_range	mr_1st_sample_obs_adclips
sampled_sex	mr_2nd_partition_size
sampled_mark	mr_2nd_sample_size
estimated_number	mr_2nd_sample_known_ad_status
recovery_location_name	mr_2nd_sample_obs_adclips
record_origin	mark_rate
	awareness_factor
	sport_mark_incidence_sampl_size
	sport_mark_inc_sampl_obs_adclips

Table 2. Variables included in MSM-VB MS-Access database tables (continued).

CWT Release table
(All_Releases)

record_code
format_version
submission_date
reporting_agency
release_agency
coordinator
tag_code_or_release_id
release_location_state
release_location_psc_region
release_location_psc_basin
release_location_name
tag_type
first_sequential_number
related_group_type
related_group_id
species
run
brood_year
first_release_date
last_release_date
release_location_code
hatchery_location_code
stock_location_code
release_stage
rearing_type
study_type
release_strategy
avg_weight
avg_length
study_integrity
cwt_1st_mark
cwt_1st_mark_count
cwt_2nd_mark
cwt_2nd_mark_count
non_cwt_1st_mark
non_cwt_1st_mark_count
non_cwt_2nd_mark
non_cwt_2nd_mark_count
counting_method
tag_loss_rate
tag_loss_days
tag_loss_sample_size
tag_reused
comments
hatchery_location_name
stock_location_name
record_origin

PSC Fishery Specification table
(Edit_Distinct)

Gear
Fishery_Short_Name
Fishery_Number
Num_Chars
PSC_Code

MSM_Fisheries table

Run_ID
CA_Number
CA_Short_Name
Delete_Status
CombineID
Weight_Factor

MSM_Stock table

Run_ID
PR_Number
PR_MU_Number
MSM_Short_Name
MSM_Long_Name
PSC_State
Combine_StockID
Delete_Status
MSM_User_PEF
MSM_User_PEF_Flag

MSM_Stock_CWT table

Run_ID
PR_Number
PR_MU_Number
CWT_Code

CA_Data table

PR_Short_Name
CA_Number
FRAM_Flag

Table 2. Variables included in MSM-VB MS-Access database tables (continued).

MSM_TermRun table
Run_ID
Terminal_Name
PR_Number
PR_MU_Number
MSM_Short_Name
MSM_Long_Name
Terminal_RunSize
Terminal_SampleRate
Terminal_CWT_Recs
Weight_Factor
Terminal_Description

MU_Data table
PR_Short_Name
MU_Short_Name
FRAM_MU_Number
PR_Number
PR_MU_Number
MU_Long_Name
IOFlag
PSC_State
Type_Calc
State
CA_Long_Name
CWT_Flag
Cat_Flag
CA_Short_Name
FRAM_CA_Number

PR_Data table
PR_Short_Name
PR_Number
PR_Long_Name
PSC_State

Table 3. Stocks included in the Coho FRAM.

Production Region	Unmarked Stock #	Abbreviated Name	Coho Stock Name
NOOKSM	1	nkskrw	Nooksack River Wild
NOOKSM	3	kendlh	Kendall Creek Hatchery
NOOKSM	5	skokmh	Skookum Creek Hatchery
NOOKSM	7	lumpdh	Lummi Ponds Hatchery
NOOKSM	9	bhambh	Bellingham Bay Net Pens
NOOKSM	11	samshw	Samish River Wild
NOOKSM	13	ar77aw	Area 7/7A Independent Wild
NOOKSM	15	whatch	Whatcom Creek Hatchery
SKAGIT	17	skagtw	Skagit River Wild
SKAGIT	19	skagth	Skagit River Hatchery
SKAGIT	21	skgbkh	Baker (Skagit) Hatchery
SKAGIT	23	skgbkw	Baker (Skagit) Wild
SKAGIT	25	swinch	Swinomish Channel Hatchery
SKAGIT	27	oakhbh	Oak Harbor Net Pens
STILSN	29	stillw	Stillaguamish River Wild
STILSN	31	stillh	Stillaguamish River Hatchery
STILSN	33	tuliph	Tulalip Hatchery
STILSN	35	snohow	Snohomish River Wild
STILSN	37	snohoh	Snohomish River Hatchery
STILSN	39	ar8anh	Area 8A Net Pens
HOODCL	41	ptgamh	Port Gamble Net Pens
HOODCL	43	ptgamw	Port Gamble Bay Wild
HOODCL	45	ar12bw	Area 12/12B Wild
HOODCL	47	qlcnbh	Quilcene Hatchery
HOODCL	49	qlcenh	Quilcene Bay Net Pens
HOODCL	51	ar12aw	Area 12A Wild
HOODCL	53	hoodsh	Hoodsport Hatchery
HOODCL	55	ar12dw	Area 12C/12D Wild
HOODCL	57	gadamh	George Adams Hatchery
HOODCL	59	skokrw	Skokomish River Wild
SPGSND	61	ar13bw	Area 13B Misc. Wild
SPGSND	63	deschw	Deschutes R. (WA) Wild
SPGSND	65	ssdnph	South Puget Sound Net Pens
SPGSND	67	nisqlh	Nisqually River Hatchery
SPGSND	69	nisqlw	Nisqually River Wild
SPGSND	71	foxish	Fox Island Net Pens
SPGSND	73	mintch	Minter Creek Hatchery
SPGSND	75	ar13mw	Area 13 Miscellaneous Wild
SPGSND	77	chambh	Chambers Creek Hatchery

Table 3. Stocks included in the Coho FRAM (continued).

Production Region	Unmarked Stock #	Abbreviated Name	Coho Stock Name
SPGSND	79	ar13mh	Area 13 Misc. Hatchery
SPGSND	81	ar13aw	Area 13A Miscellaneous Wild
SPGSND	83	puyalh	Puyallup River Hatchery
SPGSND	85	puyalw	Puyallup River Wild
SPGSND	87	are11h	Area 11 Hatchery
SPGSND	89	ar11mw	Area 11 Miscellaneous Wild
SPGSND	91	ar10eh	Area 10E Hatchery
SPGSND	93	ar10ew	Area 10E Miscellaneous Wild
SPGSND	95	greenh	Green River Hatchery
SPGSND	97	greenw	Green River Wild
SPGSND	99	lakwah	Lake Washington Hatchery
SPGSND	101	lakwaw	Lake Washington Wild
SPGSND	103	are10h	Area 10 H inc. Ebay,SeaAq NP
SPGSND	105	ar10mw	Area 10 Miscellaneous Wild
SJDFCA	107	dungew	Dungeness River Wild
SJDFCA	109	dungeh	Dungeness Hatchery
SJDFCA	111	elwhaw	Elwha River Wild
SJDFCA	113	elwhah	Elwha Hatchery
SJDFCA	115	ejdfmw	East JDF Miscellaneous Wild
SJDFCA	117	wjdfmw	West JDF Miscellaneous Wild
SJDFCA	119	ptangh	Port Angeles Net Pens
SJDFCA	121	area9w	Area 9 Miscellaneous Wild
MAKAHC	123	makahw	Makah Coastal Wild
MAKAHC	125	makahh	Makah Coastal Hatchery
QUILUT	127	quilsw	Quillayute R Summer Natural
QUILUT	129	quilsh	Quillayute R Summer Hatchery
QUILUT	131	quilfw	Quillayute River Fall Natural
QUILUT	133	quilfh	Quillayute River Fall Hatchery
HOHRIV	135	hohrvw	Hoh River Wild
HOHRIV	137	hohrvh	Hoh River Hatchery
QUEETS	139	quetfw	Queets River Fall Natural
QUEETS	141	quetfh	Queets River Fall Hatchery
QUEETS	143	quetph	Queets R Supplemental Hat.
QUINLT	145	quinfw	Quinault River Fall Natural
QUINLT	147	quinfh	Quinault River Fall Hatchery
GRAYHB	149	chehlw	Chehalis River Wild
GRAYHB	151	chehlh	Chehalis River (Bingham) Hat.
GRAYHB	153	humptw	Humptulips River Wild
GRAYHB	155	humpth	Humptulips River Hatchery

Table 3. Stocks included in the Coho FRAM (continued).

Production Region	Unmarked Stock #	Abbreviated Name	Coho Stock Name
GRAYHB	157	gryhmw	Grays Harbor Misc. Wild
GRAYHB	159	gryhbh	Grays Harbor Net Pens
WILLAPA	161	willaw	Willapa Bay Natural
WILLAPA	163	willah	Willapa Bay Hatchery
COLRIV	165	colreh	Columbia River Early Hatchery
COLRIV	167	youngh	Youngs Bay Hatchery
COLRIV	169	sandew	Sandy Early Wild
COLRIV	171	clakew	Clakamas Early Wild
COLRIV	173	claklw	Clakamas Late Wild
COLRIV	175	colrlh	Columbia River Late Hatchery
OREGON	177	orenoh	Oregon North Coastal Hat.
OREGON	179	orenow	Oregon North Coastal Wild
OREGON	181	orenmh	Oregon No. Mid Coastal Hat.
OREGON	183	orenmw	Oregon No. Mid Coastal Wild
OREGON	185	oresmh	Oregon So. Mid Coastal Hat.
OREGON	187	oresmw	Oregon So. Mid Coastal Wild
OREGON	189	oranah	Oregon Anadromous Hatchery
OREGON	191	oraqah	Oregon Aqua-Foods Hatchery
ORECAL	193	oresoh	Oregon South Coastal Hat.
ORECAL	195	oresow	Oregon South Coastal Wild
ORECAL	197	calnoh	California North Coastal Hatch
ORECAL	199	calnow	California North Coastal Wild
ORECAL	201	calcnh	California Central Coastal Hat.
ORECAL	203	calcnw	California Central Coastal Wild
GSMLND	205	gsmndh	Georgia Strait Mainland Hat.
GSMLND	207	gsmndw	Georgia Strait Mainland Wild
GSVNCI	209	gsvcih	Georgia Strait Vanc. Is. Hat.
GSVNCI	211	gsvciw	Georgia Strait Vanc. Is. Wild
JNSTRT	213	jnstrh	Johnstone Strait Hatchery
JNSTRT	215	jnstrw	Johnstone Strait Wild
SWVNCI	217	swvcih	SW Vancouver Island Hat.
SWVNCI	219	swvciw	SW Vancouver Island Wild
NWVNCI	221	nwvcih	NW Vancouver Island Hatchery
NWVNCI	223	nwvciw	NW Vancouver Island Wild
FRSLOW	225	frslwh	Lower Fraser River Hatchery
FRSLOW	227	frslww	Lower Fraser River Wild
FRSUPP	229	frsuph	Upper Fraser River Hatchery
FRSUPP	231	frsupw	Upper Fraser River Wild

Table 3. Stocks included in the Coho FRAM (continued).

Production Region	Unmarked Stock #	Abbreviated Name	Coho Stock Name
BCCNTL	233	bccnhw	BC Central Coast Hat./Wild
BCNCST	235	bcnchw	BC North Coast Hatchery/Wild
TRANAC	237	tranhw	Trans Boundary Hatchery/Wild
NIASKA	239	niakhw	Alaska No. Inside Hat./Wild
NOASKA	241	noakhw	Alaska No. Outside Hat./Wild
SIASKA	243	siakhw	Alaska So. Inside Hat./Wild
SOASKA	245	soakhw	Alaska So. Outside Hat./Wild

Table 4. Fisheries included in the Coho FRAM.

Fishery Abbrev.	Fish Num.	Fishery Long Name	Fishery Abbrev.	Fish Num.	Fishery Long Name
No Cal Trm	1	North California Coast Terminal Catch	Area3TrlNT	38	Area 3 Troll Nontreaty (LaPush)
Cn Cal Trm	2	Central California Coast Term Catch	Area3TrlTR	39	Area 3 Troll Treaty (LaPush)
Ft Brg Spt	3	Fort Bragg Sport	Area 3 Spt	40	Area 3 Sport (LaPush)
Ft Brg Trl	4	Fort Bragg Troll	Area 4 Spt	41	Area 4 Sport (Neah Bay)
Ca KMZ Spt	5	KMZ Sport (Klamath Management Zone)	A4/4BTrlNT	42	Area 4/4B (Neah Bay PFMC Regs) Troll NotTreaty
Ca KMZ Trl	6	KMZ Troll (Klamath Management Zone)	A4/4BTrlTR	43	Area 4/4B (Neah Bay PFMC Regs) Troll Treaty
So Cal Spt	7	Southern California Sport	A 5-6C Trl	44	Area 5, 6, 6C Troll (Strait of Juan de Fuca)
So Cal Trl	8	Southern California Troll	Willpa Spt	45	Willapa Bay (Area 2.1) Sport
So Ore Trm	9	South Oregon Coast Terminal Catch	Wlp Tb Spt	46	Willapa Tributary Sport
Or Prv Trm	10	Oregon Private Hatchery Terminal Catch	WlpaBT Net	47	Willapa Bay & FW Trib Net
SMi Or Trm	11	South-Mid Oregon Coast Terminal Catch	GryHbr Spt	48	Grays Harbor (Area 2.2) Sport
NMi Or Trm	12	North-Mid Oregon Coast Terminal Catch	SGryHb Spt	49	South Grays Harbor Sport (Westport Boat Basin)
No Ore Trm	13	North Oregon Coast Terminal Catch	GryHbr Net	50	Grays Harbor Estuary Net
Or Cst Trm	14	Mid-North Oregon Coast Terminal Catch	Hump R Spt	51	Humptulips River Sport
Brkngs Spt	15	Brookings Sport	LwCheh Net	52	Lower Chehalis River Net
Brkngs Trl	16	Brookings Troll	Hump R C&S	53	Humptulips River Ceremonial & Subsistence
Newprt Spt	17	Newport Sport	Chehal Spt	54	Chehalis River Sport
Newprt Trl	18	Newport Troll	Hump R Net	55	Humptulips River Net
Coos B Spt	19	Coos Bay Sport	UpCheh Net	56	Upper Chehalis River Net
Coos B Trl	20	Coos Bay Troll	Chehal C&S	57	Chehalis River Ceremonial & Subsistence
Tillmk Spt	21	Tillamook Sport	Wynoch Spt	58	Wynochee River Sport
Tillmk Trl	22	Tillamook Troll	Hoquam Spt	59	Hoquiam River Sport
Buoy10 Spt	23	Buoy 10 Sport (Columbia River Estuary)	Wishkh Spt	60	Wishkah River Sport
L ColR Spt	24	Lower Columbia River Mainstem Sport	Satsop Spt	61	Satsop River Sport
L ColR Net	25	Lower Columbia River Net (Excl Youngs Bay)	Quin R Spt	62	Quinault River Sport
Yngs B Net	26	Youngs Bay Net	Quin R Net	63	Quinault River Net
LCROrT Spt	27	Below Bonneville Ore. Tributary Sport	Quin R C&S	64	Quinault River Ceremonial & Subsistence
Clackm Spt	28	Clackamas River Sport	Queets Spt	65	Queets River Sport
SandyR Spt	29	Sandy River Sport	Clrwtr Spt	66	Clearwater River Sport
LCRWaT Spt	30	Below Bonneville Washington Tributary Sport	Salm R Spt	67	Salmon River (Queets) Sport
UpColR Spt	31	Above Bonneville Sport	Queets Net	68	Queets River Net
UpColR Net	32	Above Bonneville Net	Queets C&S	69	Queets River Ceremonial & Subsistence
A1-Ast Spt	33	Area 1 (Illwaco) & Astoria Sport	Quilly Spt	70	Quillayute River Sport
A1-Ast Trl	34	Area 1 (Illwaco) & Astoria Troll	Quilly Net	71	Quillayute River Net
Area2TrlNT	35	Area 2 Troll Nontreaty (Westport)	Quilly C&S	72	Quillayute River Ceremonial & Subsistence
Area2TrlTR	36	Area 2 Troll Treaty (Westport)	Hoh R Spt	73	Hoh River Sport
Area 2 Spt	37	Area 2 Sport (Westport)	Hoh R Net	74	Hoh River Net

Table 4. Fisheries included in the Coho FRAM (continued).

Fishery Abbrev.	Fish Num.	Fishery Long Name	Fishery Abbrev.	Fish Num.	Fishery Long Name
Hoh R C&S	75	Hoh River Ceremonial & Subsistence	Ar8A NetNT	109	Area 8A Stillaguamish/Snohomish Net Nontreaty
Mak FW Spt	76	Makah Tributary Sport	Ar8A NetTR	110	Area 8A Stillaguamish/Snohomish Net Treaty
Mak FW Net	77	Makah Freshwater Net	Ar8D NetNT	111	Area 8D Tulalip Bay Net Nontreaty
Makah C&S	78	Makah Ceremonial & Subsistence	Ar8D NetTR	112	Area 8D Tulalip Bay Net Treaty
A 4-4A Net	79	Area 4, 4A Net (Neah Bay)	Stil R Net	113	Stillaguamish River Net
A4B6CNetNT	80	Area 4B, 5, 6C Net Nontreaty (Strait of JDF)	Snoh R Net	114	Snohomish River Net
A4B6CNetTR	81	Area 4B, 5, 6C Net Treaty (Strait of JDF)	Ar 8-2 Spt	115	Area 8.2 Marine Sport
Ar6D NetNT	82	Area 6D Dungeness Bay/River Net Nontreaty	Stil R Spt	116	Stillaguamish River Sport
Ar6D NetTR	83	Area 6D Dungeness Bay/River Net Treaty	Snoh R Spt	117	Snohomish River Sport
Elwha Net	84	Elwha River Net	Ar 10 Spt	118	Area 10 Marine Sport (Seattle)
WJDF T Net	85	West JDF Straits Tributary Net	Ar10 NetNT	119	Area 10 Net Nontreaty (Seattle)
EJDF T Net	86	East JDF Straits Tributary Net	Ar10 NetTR	120	Area 10 Net Treaty (Seattle)
A6-7ANetNT	87	Area 7, 7A Net Nontreaty (San Juan Islands)	Ar10ANetNT	121	Area 10A Net Nontreaty (Elliott Bay)
A6-7ANetTR	88	Area 7, 7A Net Treaty (San Juan Islands)	Ar10ANetTR	122	Area 10A Net Treaty (Elliott Bay)
EJDF FWSpt	89	East JDF Straits Tributary Sport	Ar10ENetNT	123	Area 10E Net Nontreaty (East Kitsap)
WJDF FWSpt	90	West JDF Straits Tributary Sport	Ar10EnetTR	124	Area 10E Net Treaty (East Kitsap)
Area 5 Spt	91	Area 5 Marine Sport (Sekiu)	10F-G Net	125	Area 10F-G Ship Canal/Lake Washington Net Treaty
Area 6 Spt	92	Area 6 Marine Sport (Port Angeles)	Duwm R Net	126	Green/Duwamish River Net
Area 7 Spt	93	Area 7 Marine Sport (San Juan Islands)	Duwm R Spt	127	Green/Duwamish River Sport
Dung R Spt	94	Dungeness River Sport	L WaSm Spt	128	Lake Washington-Lake Sammamish Tributary Sport
ElwhaR Spt	95	Elwha River Sport	Ar 11 Spt	129	Area 11 Marine Sport (Tacoma)
A7BCDNetNT	96	Area 7B-7C-7D Net Nontreaty (Bellingham Bay)	Ar11 NetNT	130	Area 11 Net Nontreaty (Tacoma)
A7BCDNetTR	97	Area 7B-7C-7D Net Treaty (Bellingham Bay)	Ar11 NetTR	131	Area 11 Net Treaty (Tacoma)
Nook R Net	98	Nooksack River Net	Ar11ANetNT	132	Area 11A Net Nontreaty (Commencement Bay)
Nook R Spt	99	Nooksack River Sport	Ar11ANetTR	133	Area 11A Net Treaty (Commencement Bay)
Samh R Spt	100	Samish River Sport	Puyl R Net	134	Puyallup River Net
Ar 8 NetNT	101	Area 8 Skagit Marine Net Nontreaty	Puyl R Spt	135	Puyallup River Sport
Ar 8 NetTR	102	Area 8 Skagit Marine Net Treaty	Ar 13 Spt	136	Area 13 Marine Sport (South Puget Sound)
Skag R Net	103	Skagit River Net	Ar13 NetNT	137	Area 13 Net Nontreaty (South Puget Sound)
SkgR TsNet	104	Skagit River Test Net	Ar13 NetTR	138	Area 13 Net Treaty (South Puget Sound)
SwinCh Net	105	Swinomish Channel Net	Ar13CNetNT	139	Area 13C Net Nontreaty (Chambers Bay)
Ar 8-1 Spt	106	Area 8.1 Marine Sport	Ar13CNetTR	140	Area 13C Net Treaty (Chambers Bay)
Area 9 Spt	107	Area 9 Marine Sport (Admiralty Inlet)	Ar13ANetNT	141	Area 13A Net Nontreaty (Carr Inlet)
Skag R Spt	108	Skagit River Sport	Ar13ANetTR	142	Area 13A Net Treaty (Carr Inlet)

Table 4. Fisheries included in the Coho FRAM (continued).

Fishery Abbrev.	Fish Num.	Fishery Long Name	Fishery Abbrev.	Fish Num.	Fishery Long Name
Ar13DNetNT	143	Area 13D Net Nontreaty (South Puget Sound)	No BC Trl	175	Northern British Columbia Troll
Ar13DNetTR	144	Area 13D Net Treaty (South Puget Sound)	NoC BC Trl	176	North Central British Columbia Troll
A13FKNetNT	145	Area 13F-13K Net Nontreaty (South PS Inlets)	SoC BC Trl	177	South Central British Columbia Troll
A13FKNetTR	146	Area 13F-13K Net Treaty (South PS Inlets)	NW VI Trl	178	NW Vancouver Island Troll
Nisq R Net	147	Nisqually River Net	SW VI Trl	179	SW Vancouver Island Troll
McAlls Net	148	McAllister Creek Net	GeoStr Trl	180	Georgia Straits Troll
13D-K TSpt	149	13D-13K Tributary Sport (South PS Inlets)	BC JDF Trl	181	British Columbia Juan de Fuca Troll
Nisq R Spt	150	Nisqually River Sport	No BC Net	182	Northern British Columbia Net
Desc R Spt	151	Deschutes River Sport (Olympia)	Cen BC Net	183	Central British Columbia Net
Ar 12 Spt	152	Area 12 Marine Sport (Hood Canal)	NW VI Net	184	NW Vancouver Island Net
1212BNetNT	153	Area 12-12B Net Nontreaty (Upper Hood Canal)	SW VI Net	185	SW Vancouver Island Net
1212BNetTR	154	Area 12-12B Net Treaty (Upper Hood Canal)	Johnst Net	186	Johnstone Straits Net
Ar9A NetNT	155	Area 9A Net Nontreaty (Port Gamble)	GeoStr Net	187	Georgia Straits Net
Ar9A NetTR	156	Area 9-9A Net Treaty (Port Gamble/On Reservation)	Fraser Net	188	Fraser River Gill Net
Ar12ANetNT	157	12A Net Nontreaty (Quilcene Bay)	BC JDF Net	189	British Columbia Juan de Fuca Net
Ar12ANetTR	158	12A Net Treaty (Quilcene Bay)	No BC Spt	190	Northern British Columbia Sport
A12CDNetNT	159	12C-12D Net Nontreaty (Lower Hood Canal)	Cen BC Spt	191	Central British Columbia Sport
A12CDNetTR	160	12C-12D Net Treaty (Lower Hood Canal)	BC JDF Spt	192	British Columbia Juan de Fuca Sport
Skok R Net	161	Skokomish River Net	WC VI Spt	193	West Coast Vancouver Island Sport
Quilcn Net	162	Quilcene River Net	NGaStr Spt	194	North Georgia Straits Sport
1212B TSpt	163	12-12B Tributary FW Sport	SGaStr Spt	195	South Georgia Straits Sport
Quilcn Spt	164	12A Tributary FW Sport (Quilcene River)	Albern Spt	196	Alberni Canal Sport
12C-D TSpt	165	12C-12D Tributary FW Sport	BCCNTL TTR	197	BCCNTL Terminal Run (Catch + Escapement)
Skok R Spt	166	Skokomish River Sport	BCNCST TTR	198	BCNCST Terminal Run (Catch + Escapement)
GSMLND Trm	167	Georgia Strait Mainland Terminal Catch	QUEENC TTR	199	QUEENC Terminal Run (Catch + Escapement)
GSVNCI Trm	168	Georgia Strait Vancouver Island Terminal Catch	NASSRV TTR	200	NASSRV Terminal Run (Catch + Escapement)
JNSTRT Trm	169	Johnstone Strait Terminal Catch	SKEENA TTR	201	SKEENA Terminal Run (Catch + Escapement)
SWVNCI Trm	170	SW Vancouver Island Terminal Catch	SW AK Trl	202	Southwest Alaska Troll
NWVNCI Trm	171	NW Vancouver Island Terminal Catch	SE AK Trl	203	Southeast Alaska Troll
FRSLOW Trm	172	Lower Fraser River Terminal Catch	NW AK Trl	204	Northwest Alaska Troll
FRSUPP Trm	173	Upper Fraser River Terminal Catch	NE AK Trl	205	Northeast Alaska Troll
THOMPR Trm	174	Thompson River Terminal Catch	Alaska Net	206	Alaska Net (Areas 182:183:185:192)

Table 5. Coded-wire-tag groups chosen to represent Mixed-Stock-Model (MSM) stocks for catch years 1992-1997.

MSM Stock		Catch Year					
Production Region	Mgt Unit	1992	1993	1994	1995	1996	1997
BRITISH COLUMBIA CENTRAL COAST		020161	021127	020922	021254	180147	181119
		020162	021128	020923	021255	180412	181120
		020233	021357	020924	021256	180713	181121
		020746	021358	180141	021258	181242	
		020747	021359	180142	021259	181315	
		021015	021415	180143	021260	181326	
		021016	180125	180533	021340	181550	
		021017	180207	180534	021341	181857	
		026151	180208	180838	021355		
		026152	180240	180919	181221		
		026153	180241	180920			
				181005			
BRITISH COLUMBIA NORTH COAST (BCNCST)		020824	020508	020925	021241	080163	080905
		020825	020545	020926	021242	081613	181116
		020843	020546	020927	021243	082915	181117
		020844	020911	020935	021247	180701	181118
		020845	020912	020936	021248	180702	
		020846	020913	020937	021249	180703	
		025041	020914	021228	021336	180704	
		026028	020915	021229	021337	180705	
		026204	020916	021230	082912	180706	
		026205	021036	021231	082913	180707	
		026206	021037	021232	082916	180708	
		026306	021308	021233	180847	180709	
		080801	021309	021234	180922	180710	
		080805	021416	080125	180933	180711	
		080909	021417	080129		180712	
			025656	080151		180714	
			080126	080152		180715	
			080128	080153		180716	
			080802	080802		181218	
			080803	180145		181250	
			180925	180146		181842	
			180926	180537		181843	
			180927	180801		181856	
			180928	180832		182051	

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
				180929			
				180930			
COLUMBIA RIVER (COLRIV)		052532	052749	071428	053305	053626	053248
		052533	074045	071516	070256	070137	070925
		074222	074046	071521	070257	070138	070958
		074517	074047	071522	070337	070356	070959
		074518	074520	071523	070338	070554	071147
		075426	074644	071524	070339	070555	071148
		075427	074645	071530	070340	070556	071149
		075533	075616	071534	070341	071544	075334
		075534	075617	074832	070342	071545	075415
		075535	075620		070362	075262	075901
		075536	075621		075130	075329	635433
		075538	075622		076145	075445	635448
		075549	075624		634805	075446	635450
		075551	075625		634860	635361	635739
		631155	075721		634862	635363	635763
		633722	075748		635063	635444	635917
		633723	634003		635104	635462	635951
		633944	634005		635301		
		635531	634006				
		635631	634248				
		635632	634342				
	Clakamas Early Wild	075552	052620	052745	053260	053624	053827
		075553		052746	053261		
					053262		
					053263		
	Col Rvr Late Hatchery/ Wild	631359	075747	071533	074936	635342	075414
		631462	633963	634440	635101	635356	635730
		633338	634001	634641	635236	635359	635731
		633339	634002	634727	635348	635360	635732
		633922	634007		635349	635463	635740
		633923	634253			635725	635741
		633924	634254			635955	635742
		633945	634343				635802
		635532	634344				635912
		635635					
	Sandy Early W	075542	075720	071531	070239	070551	070837

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		075543	075724	071532	074929	070552	070838
		075544		075951	074930		070839
		075545		076016	074933		070840
		075546		076017	074934		071134
		075547		076018	075126		071135
				076019	075127		
	Youngs Bay Hatchery	075554	075455	075952	070124		070961
		075555	075712	076014	070135		071222
		075558		076015	070136		071223
		075559		076111	076142		071242
				076128			
				076129			
				076130			
GEORGIA STRAIT MAINLAND		020617	021046	021046	180757	180720	181134
		021018	021124	021311	180758	181107	181302
		021027	021125	021351	180759	181108	181303
		021028	021126	021353	180760	181638	181806
		021111	021219	021354	180944	181743	182101
		021116	021224	025213	180945	181744	182102
		021117	180101	025214	181601	181745	182103
		026162	180102	180128	181602	181806	182104
		026207	180103	180129	181603	181958	182107
		026208	180104	180130	181604	181959	182108
		026228	180109	180131	181605	181960	
		026229	180110	180604	181606	181961	
		026230	180111	180739	181607	182101	
		026233	180112	180740	181608	182102	
		026360	180237	180741	181609	182103	
		026361	180238	180742	181610	182104	
		026362					
		026363					
GEORGIA STRAIT VANCOUVER ISLAND (GSVNC)		020812	021008	020839	080145	080150	080813
		021019	021040	080141	080147	080707	080814
		021020	021151	080142	080148	080810	181940
		021021	021225	080143	080149	080811	181941
		021023	021226	080144	080154	080812	181942
		021024	021227	080145	080155	080813	181943
		021025	080123	080147	080156	181251	182012

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		021026	080134	080148	080157	181252	182013
		021040	080142	080149	080158	181253	182054
		021152	081007	080156	080160	181747	182109
		026154	081008	080159	080810	182004	182110
		026201	081009	081834	080812	182005	
		026202	081010	081835	180736	182006	
		026203	081011	081836	180737	182007	
		080804	081832	180127	180946	182008	
		081001	081833	180559	180947	182009	
		081002	081834	180560	180948	182010	
		081003	081836	180724	181618	182011	
		081004	180114	181003	181620		
		081005	180115	181004	181621		
		081006	180116		181624		
		081007	180117		181625		
		081008	180120		181626		
		081009	180121		181634		
		081010	180122		181746		
		081011	180123		182005		
		082715			182006		
		082717					
		180120					
		180121					
		180122					
		180123					
GRAYS HARBOR (GRAYHB)		633403	634258	634712	634753	635115	635430
		633917	634307	634718	634906	635116	635456
		633918	634308	634733	635060	635403	635746
		633919	634345	634734	635102	635404	635747
		633920	634346	634808	635103	635447	635803
		633921	634347	634809	635212	635503	635804
		633942	634348	634829	635215	635505	635853
		633943	634349	634838	635402	635636	635929
		633946	634350	634839	635411	635726	635933
		633947	634359		635412	635727	635945
		633961	634360			635743	635954
		634009	634453				636010
		634010	634454				

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		634033	634532				
		634157					
HOH		213516	212050	212304	212422	635337	635854
		631322	212248	212405			
		631325					
		631416					
HOOD CANAL (HOODCL)		052451	052613	052450	053418	053746	054058
		052452	052614	052910	053419	053747	054059
		052453	052615	052911	053420	053748	054060
		211823	211825	053140	212334	053749	054061
		633934	634018	634445	634963	212458	212460
		633935	634352	634828	635304	635455	634334
		633936	634415		635658	635744	635653
		633937	634439		635660		635818
		634310	634650				
JOHNSTONE STRAIT		020157	180105	180132	180243	180961	181304
		025758	180106	180133	181611	181762	181305
		026145	180107	180134	181612	181763	181306
		026146	180108	180135	181613		181307
		026147	180132	180545	181614		182115
			180133		181615		182116
			180134				182629
			180135				182630
			180206				182631
			180249				182632
							182633
							182634
							182635
							182636
LOWER FRASER RIVER (FRSLOW)		020158	020229	020134	180652	082909	023245
		020160	020551	020135	180653	181555	181308
		020218	020917	026352	180654	181760	181309
		020219	020919	026353	180655	181761	182112
		020220	020920	180136	180656	181801	182113
		020221	020921	180157	180657	181802	182114
		020228	021412	180158	180659	181844	182301
		020318	021413	180646	180660	181845	182302
		020544	021414	180647	180661	181846	182305

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		020849	180113	180648	180662	181847	182431
		020850	180118	180939	180663	181848	182601
		020851	180119	180940	181616	181849	182603
				180941	181617	181850	
				180942	181619	181851	
				180943	181627	181854	
					181628	181855	
					181635	181962	
					181636	181963	
					181637	182001	
						182002	
						182003	
MAKAH COASTAL		052352	052616	052912	053136	053424	054044
		052505	052618	052913	053421	053750	054045
		052506	052658	052914	053422	053751	054046
		052507	052660	053123	053423	053752	054047
							054057
NOOKSACK/ SAMISH		211859	212021	212227	212230	212456	212623
		211861	212024	212229	212243	212457	212627
		631159	634112	212310	212421	212539	635457
				634448	634754	212627	635648
				634710	634909	635260	635939
					635233	635346	635940
NORTHERN ALASKA INSIDE		042944	040704	040707	040714	040715	040717
		043106	042850	040708	043837	043555	043734
		043110	042851	043554	043841	043842	043735
		043544	043622	043649	043956	043843	043836
		043545	043624	043840	043957	043954	044015
		043550	043649	043909	043958	043960	044448
		043551	043650	043910	043959	044330	044449
		043610	043725	043911	044048	044360	044450
		043611	043730	044023	044122	044361	044515
		043612	043731	044024	044123	044362	044516
		043613	043732	044039	044124	044363	044517
		043614	043808	044040	044125	044403	044518
		043615	043831	044041	044130	044433	044529
		043621	043832	044042	044131	044434	044535
		043623	043833	044043	044132	044435	044660

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		043634	043834	044054	044246	044436	044661
		0401011505	043835	0401020503	044247	044443	500406
			043844	0401020901	044248	044447	500407
			043846		044249	044514	500408
			0401011505		044250		500409
			0401011512		044322		500410
			0401020503		044323		044534*1
NORTHERN ALASKA OUTSIDE (NOASKA)		043138	042852	0401010912	0401010912	0401021310	0401030209
		043354	043335	043654	044114	0401021313	0401030514
		043433	043636	043807	044115	044018	044347
		043434	043637	043915	044116	044327	044401
		043538	043638	043916	044117	044328	044402
			043656	043921	044119	044332	044404
			043722	043922	044217	044356	044520
			043723	043924	044306	044357	044612
			043760	044053		044510	
			043761	044055			
NORTHWEST VANCOUVER ISLAND		020227	020908		181208	181417	181515
		020534	020909				
		020535	020910				
		020536	180159				
		020610					
OREGON NORTH AND MID COAST	Oregon North Coast Hatchery	074819	074932	070316	070316	070853	071137
		075424	074935	074920	070317	075251	075339
		075425	075731	074923	070853	075252	075410
		075556	075750	074924	075137		
		075557	075751	074927	075138		
			075752		075139		
					075251		
					075252		
	Oregon North-Mid Coast Hatchery	074829	074413	071519	070258	075253	071224
		074830	074919	071520	070260	075254	075416
		074831	074921	075953	070262	075255	
		074902	074922	076008	070263	075257	
		074904	074941	076012	070312	075258	
		074907	074942		070363		
		074908	075817		076035		
		074911					

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		074913					
		074922					
	Oregon South-Mid Coast Hatchery	072338	074937	071422	070248	075249	075332
		074937	074938	071423	070319	075250	075411
		075238	075609	076005	070320	075260	075412
		075239	075610	076006	075261	075261	075736
		075240	075612	076007		075411	091811
		075241	075613			075412	091812
		075242	075614				
		075428					
		075431					
		075432					
		075610					
		075613					
		075614					
OREGON SOUTH/ CALIFORNIA COAST (ORECAL)	California North Coast Hatchery	065660	0601080106	062820	062819		
		066320	065657		065760		
		066323	066325				
	Oregon South Coast Hatchery	075531	075615	071526	070642	070641	071116
				071527	076354	070642	071221
				071528	076355	070643	
				075950	076356	070645	
					076357	070646	
					076358		
					076359		
					076360		
QUEETS	Queets River Fall Hatchery	211936	212056	B50814	212415	212543	212935
		212007	212057				
	Queets River Fall Natural	211943	212031	212336	212346	212433	212846
		211945	212032	212338	212352	212438	212901
		211946	212105	212341	212353	212443	212904
		211948	212109	212342	212354	212445	212906
		211951	212110	212343	212356	212446	212908
		211953	212112	212345	212357	212447	212909
		211954	212118	212347	212358	212448	212912
		211957	212123	212348	212360	212848	212915
		211958	212124		212361	212851	212916
		211960	212127		212362	212853	213005

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		211963	212129		212363	212854	213006
		212001	212130		212430	212857	213007
		212002	212133		212431	212863	213008
		212003	212134		212434	212902	213009
		212004	212136		212435	212903	213010
		212005	212139		212436	212905	213011
		212030			212440	212913	213012
		213541			212442		213014
							213015
	Queets River Suppl. Hatchery	633925	634524	633732	212417	212512	212523
			634525	634410	212418	212515	212932
					212419	212517	
					212420	212518	
						212520	
						212524	
QUILLAYUTE		211854	212050	212304	212422	635337	635854
		211855	212248	212405	635333		
			634230	634729			
QUINAULT		211857	052659	053128	053137	053615	053857
		211863	052661	053129	053138	053616	053858
			052714	053130	053139	053617	053859
			211939	212307		212545	053860
			212058				212937
SKAGIT		212008	212036	212151	212148	635130	635909
		212009	212038	212312	634910	635254	635910
		212033	212041	212313	635128	635345	635927
		212034	212063	212316	635401	635745	635946
		212035	212103	212318			
		212037	212140	212319			
		212039	212143	212320			
		212040	212145	634715			
		631355	634536	634717			
		634011		634820			
				634846			
SOUTH PUGET SOUND		211821	212025	053220	053536	053540	212459
		211822	212233	053221	053537	053541	212630
		631331	213708	053222	053538	053542	212924
		631332	634353	053223	053539	053543	634324

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		631356	634354	212223	212331	212424	634325
		631361	634356	212311	212332	212455	634326
		631442	634357	634322	212411	212540	634327
		633948	634358	634451	212427	212557	634328
		633949	634409	634540	634954	634333	635423
		633950	634457	634541	634957	635131	635426
		633952	634458	634801	634960	635258	635427
		633956	634460	634802	635105	635362	635657
		634518		634803	635109	635438	635736
		634519			635129	635439	635810
		634520			635303	635451	635915
						635452	635924
						635454	
SOUTHERN ALASKA INSIDE (SIASKA)		043361	043143	043729	042856	043724	043733
		043448	043145	043754	043743	043728	043809
		043451	043151	043758	043744	044156	044214
		043452	043630	043759	043961	044226	044215
		043453	043631	043850	044009	044256	044321
		043454	043659	043851	044010	044257	044458
		043455	043660	043852	044011	044258	044459
		043456	043661	043853	044014	044307	044460
		043457	043662	043854	044045	044308	044461
		043458	043703	043855	044136	044309	044462
		043459	043709	043856	044138	044310	044463
		043460	043710	043908	044139	044311	044501
		043461	043711	043931	044140	044312	044540
		043520	043712	043932	044141	044313	044541
		043521	043713	043935	044144	044405	044542
		043522	043714	043940	044145	044406	044545
		043523	043715	043941	044146	044408	044546
		043524	043716	043942	044147	044409	044547
		043525	043717	043943	044150	044410	044548
		043526	043718	043944	044151	044411	044549
		043527	043719	044012	044152	044412	044550
		043528	043814	044013	044153	044413	044551
		043529	043848	044016	044154	044414	044552
		043552	471650	044022	044155	044415	044553
		043602	471652	471655	044245	044422	044554

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		043603	0401011514	471656	044259	044423	044555
		043632	0401011515	471657	471659	044424	044556
		471607		0401011003	471662	044429	044557
		471611			471663	044444	044558
		471649			0401021212	044445	044559
						044446	044560
						471702	044609
						471703	471721
						471704	471722
						471706	471724
						471707	
						471710	
SOUTHERN ALASKA OUTSIDE		043425	043515	043755		044341	044613
		043444	043516	043806		044342	044614
		043503	043517	043860			
		043505	043752	043861			
		043506	043753	043862			
		043508		043901			
		043509					
		043510					
		043511					
		043512					
		043513					
		043514					
SOUTHWEST VANCOUVER ISLAND (SWVNCI)		020316	020222	021342	180949	181209	181210
		020317	020514	021343	180950	181210	
		020529	021030	021344	180951	181803	
		020530	021031	180605	181629	181804	
		020531	021032	180606	181630		
		020537	021360	180607	181631		
		020538	021361		181632		
		020539	021362				
		020540	021554				
		020541					
		020542					
		020816					
		082815					
		082821					

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
STILLAGUAMISH/ SNOHOMISH		211824	212023	212022	212333	212224	212633
		631362	634436	212301	634958	212534	212926
				634804		212536	212927
						635453	212928
							212929
							635735
							635811
STRAIT OF JUAN DE FUCA		211858	212047	212220	212406	212423	212454
		633340	634302	634821	212409	212458	212460
		634316		634822	212410	212510	212620
		634317					
TRANSBOUNDARY ALASKA CANADA		042849		043801	044209	044232	044233
				043802	044210		
UPPER FRASER RIVER (FRSUPP)		020651	020745	020510	020137	021103	181257
		020718	020761	020862	021338	025948	181262
		020719	020762	020931	021339	181249	181263
		020720	020852	020932	021447	181254	181301
		020721	020853	020933	025926	181255	181513
		020722	020854	020934	180649	181310	182243
		020723	020855	021047	180650	181559	182244
		020724	020856	180126	180952	181639	
		020725	020857	180205	180953	181757	
		020726	020858		181207	181758	
		020737	020859		181219	181852	
		025953	020860		181220		
		025954	021538				
		025955	021539				
		026218	180257				
		026219	180258				
		026220	180307				
		026221	180308				
		026222	180331				
		026223					
		026224					
		026225					
		026226					
		026227					
		026335					

MSM Stock Production Region	Mgt Unit	Catch Year					
		1992	1993	1994	1995	1996	1997
		026336					
		026337					
		026338					
WILLAPA BAY		633403	634355	634538	635108	635720	635857
		633961					
		634010					
		634033					

Table 6. Preliminary "User-Defined" PEF values for Washington State Production Regions for potential use in MSM PEF estimation process. These values were derived using release information and smolt trap information, when available.

Brood year >	1989	1990	1991	1992	1993	1994
Return year >	1992	1993	1994	1995	1996	1997
MSM Production Region						
NOOKSM						
Wild smolts	113,000	113,000	113,000	113,000	113,000	113,000
H smolts	4,221,656	5,202,979	4,846,242	5,284,854	4,802,550	3,744,483
Total smolts	4,334,656	5,315,979	4,959,242	5,397,854	4,915,550	3,857,483
Tagged H smolts	145,420	149,141	200,645	276,459	193,780	196,531
Tagged W smolts	n/a	n/a	n/a	n/a	n/a	n/a
Total tagged smolts	145,420	149,141	200,645	276,459	193,780	196,531
PEF	**29.81**	**35.64**	**24.72**	**19.52**	**25.37**	**19.63**
SKAGIT						
Wild smolts	652,000	1,073,000	623,000	1,129,000	727,000	1,125,000
H smolts	355,616	577,024	500,905	403,366	682,386	363,878
Total smolts	1,007,616	1,650,024	1,123,905	1,532,366	1,409,386	1,488,878
Tagged H smolts	96,451	129,971	125,587	44,613	126,198	347,307
Tagged W smolts	43,550	37,674	39,686	27,261	21,060	19,687
Total tagged smolts	140,001	167,645	165,273	71,874	147,258	366,994
PEF	**7.20**	**9.84**	**6.80**	**21.32**	**9.57**	**4.06**
STILSN						
Wild smolts	1,192,000	1,192,000	1,192,000	1,192,000	1,192,000	1,192,000
H smolts	1,278,447	1,310,771	1,271,672	1,256,500	1,368,012	1,307,813
Total smolts	2,470,447	2,502,771	2,463,672	2,448,500	2,560,012	2,499,813
Tagged H smolts	253,305	94,162	116,283	92,223	109,751	143,080
Tagged W smolts	n/a	n/a	n/a	n/a	n/a	n/a
Total tagged smolts	253,305	94,162	116,283	92,223	109,751	143,080
PEF	**9.75**	**26.58**	**21.19**	**26.55**	**23.33**	**17.47**
SPGSND						
Wild smolts w/out Deschutes	443,000	443,000	443,000	443,000	443,000	443,000
Deschutes	14,103	56,170	20,353	7,191	19,130	n/a
H smolts	9,132,989	10,369,813	8,124,913	7,709,098	7,663,714	9,415,423
Total smolts	9,590,092	10,868,983	8,588,266	8,159,289	8,125,844	9,858,423
Tagged H smolts	348,180	377,372	403,062	493,025	531,680	449,813
Tagged W smolts	1,996	7,154	10,908	1,354	3,571	5,817
Total tagged smolts	350,176	384,526	413,970	494,379	535,251	455,630
PEF	**27.39**	**28.27**	**20.75**	**16.50**	**15.18**	**21.64**
HOODCL						
Wild smolts	550,000	550,000	550,000	550,000	550,000	550,000
H smolts	1,587,365	1,704,802	1,543,980	1,509,655	1,516,464	1,298,758
Total smolts	2,137,365	2,254,802	2,093,980	2,059,655	2,066,464	1,848,758

Brood year >	1989	1990	1991	1992	1993	1994
Return year >	1992	1993	1994	1995	1996	1997
MSM Production Region						
Tagged H smolts	299,773	247,209	130,492	204,682	247,151	141,209
Tagged W smolts	21,149	16,979	10,908	16,274	15,146	21,834
Total tagged smolts	320,922	264,188	141,400	220,956	262,297	163,043
PEF	**6.66**	**8.53**	**14.81**	**9.32**	**7.88**	**11.34**
SJDFCA						
Wild smolts	300,000	300,000	300,000	300,000	300,000	300,000
H smolts	1,017,646	1,219,378	949,400	1,542,131	1,609,700	1,593,821
Total smolts	1,317,646	1,519,378	1,249,400	1,842,131	1,909,700	1,893,821
Tagged H smolts	108,955	97,791	107,025	149,488	145,368	144,895
Tagged W smolts	n/a	n/a	n/a	n/a	n/a	n/a
Total tagged smolts	108,955	97,791	107,025	149,488	145,368	144,895
PEF	**12.09**	**15.54**	**11.67**	**12.32**	**13.14**	**13.07**
MAKAHC						
Wild smolts	n/a	n/a	n/a	n/a	n/a	n/a
H smolts	366,500	351,028	335,210	359,880	341,489	1,047,163
Total smolts	366,500	351,028	335,210	359,880	341,489	1,047,163
Tagged H smolts	130,022	95,259	108,709	68,054	60,683	127,551
Tagged W smolts	n/a	n/a	n/a	n/a	n/a	n/a
Total tagged smolts	130,022	95,259	108,709	68,054	60,683	127,551
PEF	**2.82**	**3.68**	**3.08**	**5.29**	**5.63**	**8.21**
QUILUT/HOH						
Wild smolts	618,000	618,000	618,000	618,000	618,000	618,000
H smolts	1,276,311	855,133	586,376	594,211	822,900	793,400
Total smolts	1,894,311	1,473,133	1,204,376	1,212,211	1,440,900	1,411,400
Tagged H smolts	87,228	69,717	65,163	63,922	73,116	73,302
Tagged W smolts	9,838	9,411	16,611	22,751	0	0
Total tagged smolts	97,066	79,128	81,774	86,673	73,116	73,302
PEF	**19.52**	**18.62**	**14.73**	**13.99**	**19.71**	**19.25**
QUEETS						
Wild smolts	444,000	444,000	444,000	444,000	444,000	444,000
H smolts	628,293	1,009,418	650,108	753,374	1,057,131	999,033
Total smolts	1,072,293	1,453,418	1,094,108	1,197,374	1,501,131	1,443,033
Tagged H smolts	108,518	155,009	106,122	157,126	212,569	135,330
Tagged W smolts	32,163	41,156	20,202	31,319	31,738	23,460
Total tagged smolts	140,681	196,165	126,324	188,445	244,307	158,790
PEF	**7.62**	**7.41**	**8.66**	**6.35**	**6.14**	**9.09**
QUINLT						
Wild smolts	217,000	217,000	217,000	217,000	217,000	217,000
H smolts	592,758	741,785	713,553	659,322	731,806	270,774
Total smolts	809,758	958,785	930,553	876,322	948,806	487,774

Brood year >	1989	1990	1991	1992	1993	1994
Return year >	1992	1993	1994	1995	1996	1997
MSM Production Region						
Tagged H smolts	78,662	99,812	145,697	68,802	107,068	85,806
Tagged W smolts	n/a	n/a	n/a	n/a	n/a	n/a
Total tagged smolts	78,662	99,812	145,697	68,802	107,068	85,806
PEF	**10.29**	**9.61**	**6.39**	**12.74**	**8.86**	**5.68**
GRAYHB						
Wild smolts	1,702,000	1,702,000	1,702,000	1,702,000	1,702,000	1,702,000
H smolts	2,618,250	3,209,508	3,444,173	3,319,376	3,115,790	3,682,514
Total smolts	4,320,250	4,911,508	5,146,173	5,021,376	4,817,790	5,384,514
Tagged H smolts	466,538	495,724	261,238	250,741	285,816	299,169
Tagged W smolts	89,028	42,971	32,027	76,161	57,321	46,942
Total tagged smolts	555,566	538,695	293,265	326,902	343,137	346,111
PEF	**7.78**	**9.12**	**17.55**	**15.36**	**14.04**	**15.56**
WILLAP						
Wild smolts	425,000	425,000	425,000	425,000	425,000	425,000
H smolts	2,939,175	3,905,934	3,470,035	3,421,495	2,117,300	2,543,000
Total smolts	3,364,175	4,330,934	3,895,035	3,846,495	2,542,300	2,968,000
Tagged H smolts	n/a	50,374	26,502	23,781	74,758	76,069
Tagged W smolts	n/a	n/a	n/a	n/a	n/a	n/a
Total tagged smolts	0	50,374	26,502	23,781	74,758	76,069
PEF	**n/a**	**85.98**	**146.97**	**161.75**	**34.01**	**39.02**

Table 7. Estimated escapement, average marine exploitation rate and total CWT recovery data used to derive total marine catch and "User-Defined" Production Expansion Factors (PEF) for upper Fraser River coho (FRSUPP) Production Region.
Marine Catch = (Esc-(1-ER))-Esc). PEF = Marine Catch / MSM Tag Recoveries.
MSM Tag Recoveries include all recoveries made in MSM fisheries of FRSUPP tag groups listed in Table 5.

	Catch Year					
Estimate	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Total Escapement (Esc)	50,528	29,381	35,517	22,996	9,294	18,675
Average Marine Exploitation Rate (ER)	0.81	0.88	0.43	0.56	0.83	0.40
Marine Catch	222,077	206,635	27,160	29,458	47,022	12,704
MSM Tag Recoveries	7,870	4,279	2,585	1,248	496	455
PEF	28.22	48.29	10.51	23.60	94.86	27.95

Appendices

Appendix A. CWT recoveries by fishery and Production Region are updated frequently, stored in a file titled "92-97 cwt matrices.xls" and can be downloaded at:
http://www.fws.gov/filedownloads/ftp_westwafwo/FRAM

Appendix B. Catches by fishery and year are stored in a file titled "92-97 catch.xls" and can be downloaded at:
http://www.fws.gov/filedownloads/ftp_westwafwo/FRAM

Appendix C. RRTERM summary tables of the terminal runsize estimates are stored in a file titled "MSM_Appendix_C.Zip" and can be downloaded at:
http://www.fws.gov/filedownloads/ftp_westwafwo/FRAM

Appendix D. Financial Statement of Expenditures

Project: FRAM Coho Model Development & Support

Anticipated and Actual Project Expenditures

Categories	Anticipated	Actual
Salaries & Wages	$ 63,135	$ 77,726
Labor/Employer Costs	$ 13,039	$ 16,688
Site/Project Costs:		
Travel	$ 4,800	$ 738
Computer Lease	$ 2,400	$ 412
Overhead	$ 34,311	$ 34,310
subtotal	$117,685	$129,874
Subcontractors:		
USFWS	$ 33,728	$ 33,728
NWIFC	$ 85,710	$ 58,280
Totals	**$237,123**	**$221,882**