Appendix F
Pacific Salmon Commission Chinook Model Overview

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F.1 Brief History of Model Development

During the negotiations in the early 1980s, that led to the Pacific Salmon Treaty and the formulation of the Pacific Salmon Commission (PSC), efforts to reach agreement on chinook management focused on strategies that would rebuild depressed natural stocks within an agreed-upon time. At the technical level, several micro-computer models were developed to provide a method of consistently and objectively analyzing alternative options under consideration during the negotiations.

The models were initially designed to evaluate alternative fishery management regimes with respect to their implications for successfully rebuilding depressed stocks of chinook by 1998. Since that time, uses of the models have been expanded to provide stock expectations and appropriate fishery responses for use in assessing rebuilding progress, estimating of overall chinook abundance, and a variety of statistics on fishing impacts on stocks of concern to the PSC.

More detailed stratification of fisheries and stocks was required as different policy and technical questions were raised. The final model used for the Pacific Salmon Treaty negotiations in 1984 incorporated four stocks and nine fisheries. The model was modified in 1987 to enable it to simulate up to 25 fisheries and 26 stocks. Four more stocks were added in the mid-1990s, making the current total 30 modeled stocks. Efforts are underway now to increase both the number of stocks and the fisheries modeled.

In 2002, the model was recoded in Visual Basic 6.0. This recoding overcame the RAM limitations inherent in earlier versions of the model. This new version is now capable of modeling many more stocks and fisheries than the older version, and has the capability of simulating multiple time periods throughout a year. Limits on the scale or resolution of the model are now primarily driven by data availability and precision, rather than by limits to the model coding. Model uses have changed considerably over time. The model is now used primarily to predict the abundance of chinook available to each of the aggregate abundance based management (AABM) fisheries specified in the 1999 revisions to the Pacific Salmon Treaty (Alaska all-gear, Northern British Columbia troll and Queen Charlotte Island sport, and West Coast Vancouver Island troll and outside sport). The model is also used to predict stock-specific impacts resulting from prosecution of Individual Stock Based Management (ISBM) fisheries, also as specified in the 1999 revisions to the treaty. Other uses of the model include estimating exploitation rate indices for use in evaluating ESA compliance for certain stocks listed under the ESA, and estimating Alaska and Canadian fishery impacts for use as model inputs for other models used in domestic fishery management.

F.2 General Description of Chinook Model Flow and Structure

The model estimates chinook abundances by fishery, fishing mortalities, and escapements resulting from the implementation of various management strategies, including catch ceilings, quotas, harvest rate adjustments, chinook non-retention fisheries, size limit changes, and enhancement activities.

The model is currently deterministic. There is no attempt to incorporate stochastic elements into any of the parameters used in the model.

The model is written in the Visual Basic 6.0 language.

The model consists of three major sections: 1) an input section, 2) a computational section, and 3) a report generation section.

The input section reads data from files and accepts keyboard instructions to set up the model.

The computation section calculates catches, escapements, and recruitment under the specified management regimes, as defined in the input files. Computations are currently performed on an annual basis. The sequence of computations in the annual cycle reverses the procedures employed in the cohort analysis used to generate the stock-specific input data. The cycle consists of the following steps:

1) Population Aging

At the first of the year, all fish are aged by one year.

2) Natural Mortality

Natural (non-catch) mortality is assessed at the beginning of each year prior to fishing. It is assumed that no natural mortality occurs during the fishing season.

3) Ocean Fisheries

Ocean catch mortality by stock, age class, and fishery is computed next. Following all calculations of catch, the cohort sizes are decreased by the amount of catch in each age class.

4) Maturation

Next, the size of the mature run is calculated by multiplying the number of fish remaining in each stock cohort after the ocean fisheries by the appropriate age-specific maturation rate for each stock.

5) Terminal Fisheries

Terminal catch is calculated by multiplying the mature run size by the appropriate age-specific terminal harvest rate. Once a stock is rebuilt, fish in excess of the optimum escapement level may either be added to the terminal catch or to spawning escapement, depending upon a user-specified policy for managing spawning escapements (see paragraph 6 below).

6) Spawning Escapement

Escapements are computed by subtraction. Until escapement of age 3 + fish reaches the optimum specified by the input data, spawning escapement is simply computed as the difference between the mature run size (age 3 +) and the terminal catch. Thereafter, spawning escapements and terminal harvests for that stock can be modeled in one of two ways: (1) spawning escapement can be set at the escapement goal, and remaining fish can be added to the terminal catch; or (2) spawning escapements can allowed to increase indefinitely, and terminal catches can be computed by applying age-specific harvest rates to terminal run sizes.

7) Production of Age 1 Fish

A Ricker-type stock-recruitment function with parameters specific to individual stocks is used to predict resulting adult equivalent production from escapement of age 3 + fish. A truncated Ricker-type function is used in the model for stocks without PSC/CTC approved escapement goals. As spawning escapements increase, production rises up to the maximum level defined by the Ricker parameters; production does not decrease at escapements above the level associated with maximum production. For stocks with approved goals, an unmodified version of the Ricker curve is used (production can decrease at high spawning escapements). Adult equivalent production is converted to the actual number of age 1 recruits by using the following procedure: (1) estimate the probability that a chinook will survive to spawn at any age in the absence of fishing mortality by accumulating the survival rates by age multiplied by the maturation rate by age; (2) divide the adult equivalent production by this probability.

The current report generation section permits the user to select from a set of pre-formatted reports and/or to produce ASCII output files for post-processing.

F.3 Major Assumptions in the Chinook Model

The following are some of the most important assumptions that underlie the model. The list is not exhaustive, but it includes all of the most critical assumptions.

1) The only changes to harvest rates are those that result from the management actions being modeled.

2) Stock distributions and fishing patterns are identical from year to year.

3) The proportion of unrepresented stocks remains constant from year to year.

4) CWT tag release groups (generally hatchery stocks) used in the model are representative of the exploitation patterns on the natural stocks of concern.

5) Management actions on indicator stocks will also reflect changes in harvest management actions on the natural stocks of concern.

6) Stock productivities and optimum escapements do not change over the model simulation period (currently 1979 to 2005).

7) All age 4 (and older) fish taken by net fisheries are mature.

Stocks and Fisheries in the current version of the Model

Stock #	Stock	Fishery #	Fishery
1	Alaska South SE	1	Alaska T
2	North/Centr	2	North T
3	Fraser Early	3	Centr T
4	Fraser Late	4	WCVI T
5	WCVI Hatchery	5	WA/OR T
6	WCVI Natural	6	Geo St T
7	Georgia St. Upper	7	Alaska N
8	Georgia St. Lwr Nat	8	North N
9	Georgia St. Lwr Hat	9	Centr N
10	Nooksack Fall	10	WCVI N
11	Pgt Sd Fing	11	J De F N
12	Pgt Sd NatF	12	PgtNth N
13	Pgt Sd Year	13	PgtSth N
14	Nooksack Spring	14	Wash Cst N
15	Skagit Wild	15	Col R N
16	Stillaguamish Wild	16	John St N
17	Snohomish Wild	17	Fraser N
18	WA Coastal Hat	18	Alaska S
19	UpRiver Brights	19	Nor/Cen S
20	Spring Creek Hat	20	WCVI S
21	Lwr Bonneville Hat	21	Wash Ocn S
22	Fall Cowlitz Hat	22	PgtNth S
23	Lewis R Wild	23	PgtSth S
24	Willamette R	24	Geo St S
25	Spr Cowlitz Hat	25	Col R S
26	Col R Summer		
27	Oregon Coast		
28	WA Coastal Wild		
29	Lyons Ferry		
30	Mid Col R Brights		

T=Troll; Net=Net; S=Sport