PACIFIC SALMON COMMISSION
JOINT CHINOOK TECHNICAL
COMMITTEE REPORT

ESTIMATION AND APPLICATION OF INCIDENTAL FISHING MORTALITY IN CHINOOK SALMON MANAGEMENT UNDER THE 1999 AGREEMENT TO THE PACIFIC SALMON TREATY

REPORT TCCHINOOK (04)-1

April 8, 2004

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LIST OF ACRONYMS WITH DEFINITIONS

AABM	Aggregate Abundance Based Management
ADF&G	Alaska Department of Fish & Game
AEQ	Adult Equivalent
AI	Abundance Index
AWG	Analytical Working Group of the CTC
BC	British Columbia
CBC	Central British Columbia Fishing area – Kitimat to Cape Caution
CDFO	Canadian Department of Fisheries & Oceans
CLB	Calibration
CNR	Chinook Nonretention
CR	Columbia River
CRITFC	Columbia River Intertribal Fish Commission
CTC	Chinook Technical Committee
CWT	Coded Wire Tag
ER	Exploitation Rate
ESA	U.S. Endangered Species Act
EV	Environmental Variant
FI	Fishery Exploitation Rate Index
FP	Fishery Policy
FRAM	Fisheries Resource Assessment Model
GS	Strait of Georgia
IDFG	Idaho Department of Fish & Game
IDL	Interdam Loss
ISBM	Individual Stock Based Management
MRP	Mark-Recovery Program
MSY	Maximum Sustainable Yield for a stock, in adult equivalents
NA	Not Available
NBC	Northern British Columbia – Dixon Entrance to Kitimat including Queen Charlotte Islands
NCBC	North Central British Columbia - Dixon Entrance to Cape Caution
NM	Natural Mortality Rates
NMFS	National Marine Fisheries Service
NOC	Oregon Coastal North Migrating Stocks
NWIFC	Northwest Indian Fisheries Commission
ODFW	Oregon Department of Fish & Wildlife
OR	Oregon
PFMC	Pacific Fisheries Management Council
PS	Puget Sound
PSC	Pacific Salmon Commission
PSMFC	Pacific States Marine Fisheries Commission
PST	Pacific Salmon Treaty
QIN	Quinault Indian Nation
RT	A method used to estimate the number of CNR mortalities in the Chinook model
SEAK	Southeast Alaska – Cape Suckling to Dixon Entrance
SPFI	Stratified Proportional Fishery Index
SSRAA	Southern Southeast Regional Aquaculture Association
TBR	Transboundary Rivers
U.S.	United States
USFWS	U.S. Fish & Wildlife Service
WA	Washington
WA/OR	Ocean areas off Washington and Oregon North of Cape Falcon
WCVI	West Coast Vancouver Island - excluding Area 20
WDFW	Washington Department of Fisheries and Wildlife

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1. INTRODUCTION

In Annex IV, Chapter 3, Paragraph 3 of the 1999 Agreement (Agreement) to the Pacific Salmon Treaty, the Parties agreed to adopt a management framework for Chinook salmon based on total fishing mortality. The Parties recognized that significant uncertainty exists in predicting and estimating incidental mortality, and gave specific direction to the Chinook Technical Committee (CTC) to improve the technical basis for estimating incidental mortality as a prerequisite for full implementation of total mortality management. In the Appendix to Annex IV, Chapter 3, (1), the Agreement states:

"Improved estimates of incidental fishing mortality are to be developed based upon direct fishery observations. The CTC will collate and document existing information on the coastwide encounter rates for all sources of incidental mortality on Chinook coastwide. The CTC will report on the extent of incidental mortality and on deficiencies in the information coverage, and will recommend a work plan to address data deficiencies, including observer programs or other direct sampling procedures, that will enable implementation of a total fishing mortality regime for fisheries in 2002. The Parties will implement the work plan in a timely and comprehensive manner to ensure adoption of a total fishing mortality regime in 2002."

This report is an initial overview of the estimation and application of incidental mortality in Chinook salmon management in fisheries in the geographic areas covered in the Pacific Salmon Treaty. The information provides insight into the degree to which total mortality management is imbedded in the current management framework, how existing information is collected and used, and the status of coastwide programs to estimate encounter rates and associated mortality. This information is used to identify deficiencies in both data collection and analytical application, and to develop a work plan to address these deficiencies.

2. ESTIMATION AND USE OF INCIDENTAL MORTALITY IN THE CTC MODEL

2.1. Estimation Of Incidental Mortality In The CTC Model

The Agreement stipulated an abundance-based, coastwide Chinook management regime that was divided into two types of fisheries: aggregate abundance-based management regimes (AABM) and individual stock-based management regimes (ISBM). The CTC provides an assessment of these management regimes and, for AABM fisheries, an estimate of abundance to set annual allowable catch, through its annual exploitation rate analysis and CTC model calibration procedures (e.g., CTC 2002). Stock-specific brood year exploitation rates for Chinook indicator stocks are computed using a cohort analysis procedure. This procedure produces a variety of stock-specific statistics, including total exploitation rates, age-fishery specific exploitation rates, and maturation rates, which are combined with data on catches, escapements, Chinook non-retention (CNR) mortality, sublegal mortality from hook and line gear (shaker mortality), and enhancement to complete the annual calibration of the CTC model.

Estimates of incidental mortality are essential to the exploitation rate analysis and the CTC model calibration because cohort reconstruction and computation of brood year exploitation rates require estimates of total mortality. The categories of incidental mortality that are currently

defined in the CTC model and the cohort analysis are: 1) drop-off, 2) shakers, and 3) CNR (legal and sublegal). The computations for each of these types of incidental mortalities are described below.

2.1.1. Drop-off Mortality

Drop-off mortality are fish that escape or drop-off prior to being brought to the boat, but die as a result of the encounter with the fishing gear. The CTC (1997) recommended regional-specific and average drop-off mortality rates for commercial troll, recreational, and gillnet fisheries (drop-off mortality is considered to be zero for seine fisheries). Drop-off mortalities are estimated using these rates as a percentage of the total nominal encounters (landed catch plus estimated released encounters) for troll and recreational fisheries in the CTC model. These estimates for both legal and sublegal fish are now included as part of the shaker mortality estimates for troll and recreation retention periods (Appendix 1). Drop-off mortalities are also computed for legal or sublegal incidental mortalities during CNR fisheries. Currently, no drop-off mortality rate is applied for gillnet landings in the CTC model, because seine and gillnet fisheries are not currently separated in the model.

2.1.2. Shaker Mortality Estimates

Shakers are Chinook salmon that are encountered by fishing gear, brought to the boat, and released during a Chinook retention fishery because they are either below or above a legal size limit. A proportion of these fish will die and become shaker mortalities. Currently, only sublegal size shakers are included in the shaker estimation procedure. The general algorithm used to compute sublegal shakers is as follows:

1. Identify the stocks that contribute to the catch at any age in a given fishery (i.e., those with cohort sizes >0).
2. Calculate the encounter ratio for the fishery, i.e., number of fish not vulnerable to the gear over the number of fish vulnerable to the gear (e.g., an encounter ratio of 6/4 would be interpreted as for every four fish that are landed, there are six that are not vulnerable to the gear and subject to being a shaker).
3. Compute the total number of sublegal shakers using the landed catch, the encounter ratio, and the sublegal release mortality rate (which includes the associated drop-off rate).
4. Assume that all age classes of identified stocks contribute to the pool of sublegal size fish.
5. Distribute shaker mortalities across stocks and ages 2-5 in proportion to estimated contributions to the total non-vulnerable population.

Details of the calculations are shown in Appendix 1. At this time, CTC model-generated estimates of shaker mortality also include an adjustment for legal drop-off mortality. The algorithm automatically generates the encounter ratio. In contrast to CNR encounters, there is no mechanism in the current version of the CTC model or the exploitation rate analysis for utilizing observed encounters of sublegal size fish.

2.1.3. CNR Mortality Estimates

During CNR fisheries, the retention of Chinook salmon is legally prohibited. However, incidental catch and associated mortalities of Chinook occur during fisheries directed at other species of salmon. CNR mortalities are sublegal and legal size Chinook that are encountered by fishing gear, brought to the boat, and die after release. The computation of these mortalities depends on estimates of Chinook encounters during CNR periods and the application of associated gear-and size-specific release mortality rates (CTC 1997). When actual observations of sublegal and legal size releases are available, these can be used as direct inputs to the CM for calculating encounters during CNR periods. In the past, actual observations have generally not been available from most fisheries. The CM offers a number of methods that do not require direct observations for calculating encounters during CNR periods. Regardless of which method is used, the CM converts estimated encounters into mortalities and then allocates those mortalities among selected stocks and age classes. A list of all methods currently used for computing CNR encounters for individual fisheries in either the CM or the exploitation rate analysis ('ERA') and the observational data they require are listed below.

1. CNR Effort Ratio Method. Data required are a measure of effort during legal retention periods and a measure of effort during CNR periods in a fishery. The effort unit is typically boat days or angler trips.
2. CNR Season Length Ratio Method. Data required are the number of days the fishery was open for Chinook retention and the number of days that non-retention restrictions were in effect.
3. CNR Reported Legal Releases Ratio Method. Data required are the observed catch during retention periods and observed legal size releases during CNR in a fishery.
4. CNR Reported Encounters Method. Data required are the observed legal size releases and observed sublegal size releases during CNR and the legal catch during retention.
5. Catchability Coefficient (or instantaneous equation) Method. Data required are a measure of effort during CNR, the CNR season length and an estimate of re-availability time, i.e., the amount of time assumed necessary before a released fish will again be available to gear.
6. CNR Harvest Ratio (or RT) Method. No observational data are employed.

The method of choice for computing CNR incidental mortalities depends on the data available in any given year when CNR restrictions have been in effect in a fishery. The first three methods are all variants of a single method designed to compute a 'CNR encounter rate.' This is essentially a ratio representing encounters in the CNR period relative to the retention period. These three methods are those most frequently used, primarily because they utilize actual (though indirect) data and the data are easily obtained. The fourth method provides the most direct, and presumably the most accurate, method for estimating CNR incidental mortalities. Since the required observational data are obtained at higher cost and effort, it has been used less often than the first three. The fifth and sixth methods are used only in limited situations. The fifth, currently only available in the ERA analysis, is used when a CNR fishery is prosecuted in a year when no retention was permitted. The final method, though available in the ERA, has been used only in the CM to project CNR mortalities in future years.

For all methods, encounters and mortalities of legal and sublegal size Chinook are computed separately. Legal CNR mortalities are obtained by applying the encounter rate computed for legal size fish to the legal catch whereas sublegal CNR mortalities are obtained by applying the encounter rate computed for sublegal size fish to the pool of sublegal size shakers estimated from the legal retention fishery. The legal and sublegal CNR mortalities are also allocated to the CTC model stocks based on different assumptions. For legal size mortalities, the CM assumes that the stock composition is identical to that of the landed catch. For the sublegal size mortalities, the CM assumes a stock and age composition identical to that determined for the pool of shakers estimated from the legal retention periods. The main difference in the two methods for allocating the mortalities is that if a stock contributes to the legal catch at any age, all ages are assumed to contribute to the shakers and therefore, the sublegal CNR encounters as well.

The computation of both the legal and sublegal CNR encounter rates includes a drop-off rate (assumed equal for both sizes) that is added to the size-specific release mortality rate. Since the sublegal CNR mortalities are based on the computed shakers, which also include a drop-off component, the drop-off component is excluded from the shakers for the calculation of the sublegal CNR mortalities. The computation of the CNR encounter rates for each of the legal and sublegal fish also includes a size-specific selectivity factor. This factor represents the relative change in Chinook encounter rates resulting from gear restrictions or fishing methods when fisheries are directed at other species. The CNR restrictions are believed to reduce the number of encounters of legal size fish and the magnitude of change is expected to vary according to the restrictions employed in each fishery (see Appendix 2 for the selectivity factors currently used in the CM).

The general algorithm for computing CNR mortalities regardless of the method used to compute encounters is as follows:

1. Compute CNR ratios, i.e., encounter rates using the appropriate method.
2. Compute CNR mortalities without considering the probability of multiple encounters (which includes a drop-off component).
3. Allocate the CNR mortalities across stocks according to the stock and age composition of the legal catch for legal size mortalities and the stock composition of the shakers for the sublegal mortalities.

How each of the methods for computing encounters rates is used in the calculation of CNR mortalities is briefly described in the following sections. Details on the actual calculations resulting in stock, age, fishery and year specific mortalities are provided in Appendix 3.

2.1.3.1. CNR Effort Ratio, Season Length Ratio, and Reported Legal Releases Ratio Methods

These methods are used for years when a fishery included CNR periods but there are no observed encounter data. In each, the CNR encounter rate is a function of the size-specific gear selectivity factor, the size-specific release mortality rate plus the drop-off mortality rate, and the ratio of a measure of the CNR season (effort, duration or observed legal releases) to the same measure of the retention season. The encounter rate for legal or sublegal size fish is then multiplied by the landed catch or the estimated shakers from the retention season, respectively, to obtain the CNR mortalities.

2.1.3.2. CNR Reported Encounters Method

This method is used for years when observed encounters of sublegal and legal size Chinook from non-retention periods in a fishery are available to use as direct inputs to the CTC model. External encounter estimates are based on fishery-specific direct observational studies (e.g., observers on fishing boats, logbooks, dockside interviews, or postseason surveys). The observed encounters will not be stock specific.

The calculation of the encounter rate for legal size fish is straightforward and is simply a function of the legal size release rate plus the drop-off mortality rate and the ratio of the observed legal size encounters over the landed catch. The calculation of the encounter rate for the sublegal size fish is less immediately obvious but reduces to a function of the inverse of the shaker encounter rate from the retention period and the ratio of the sublegal size encounters over the landed catch. As with the previously described methods, the legal and sublegal CNR mortalities are obtained by multiplying the respective encounter rate by either the landed catch for the legal mortalities or the shakers estimated from the retention periods (excluding the drop-off component in the shakers). It is important to note that the observed encounters are input parameters to the CTC model calibration process; the numbers generated by the CM will not be identical to these input parameters. They should, however, be closer to the actual encounters than if the encounter data had not been used as inputs.

2.1.3.3. Catchability Coefficient (or Instantaneous Equation) Method

CNR restrictions have mostly been used only during a portion of a season once allowable limits on landed catch have been reached. In recent years, however, Chinook retention has been entirely prohibited in some fisheries due to severe conservation concerns for some stocks. This situation occurred in all Canadian troll fisheries in 1996 and in the Canadian Juan de Fuca Strait and Johnstone Strait net fisheries in 1995-98.

The methods previously described calculate CNR mortalities based on landed catch or the shakers estimated to have been associated with the landed catch. Total non-retention means that there is no landed catch (and consequently, no estimated shakers) for the calculation of CNR mortalities. Thus, a different method for computing CNR mortalities is required. The Catchability Coefficient Method utilizes instantaneous catch equations, and was first implemented for the ERA in 1997.

The general algorithm for computing legal size CNR mortalities under total non-retention is:

1. Estimate the average fishery and age-specific catchability coefficients (q) from historical estimates of exploitation rates of landed catch using the standard instantaneous catch equation. The drop-off mortality rate is currently included in the calculation of q.
2. Compute an annual landing rate for a hypothetical legal fishery.
3. Convert the annual landing rate to an instantaneous rate.
4. Divide the instantaneous landing rate for the hypothetical legal fishery by the ratio of the CNR season length in days over the estimated re-availability time in days. The result is the landing rate in the fishery under the CNR restrictions. The inclusion of the

reavailability time is an adjustment for the possibility of multiple recaptures of released fish.

5. The encounter rate of legal size fish during CNR is then obtained by converting the outcome in the above calculation step to its' instantaneous form.
6. The encounter rate is then multiplied by the release mortality rate for legal size fish and converted back to the discrete annual form to obtain the total incidental mortality rate.
7. Finally, estimate the legal CNR mortality by multiplying the total incidental mortality rate by the age-specific cohort size.

The sublegal CNR mortalities are calculated in a similar way except that in the current version of the cohort analysis code, the total incidental mortality rate does not include the adjustment for the release mortality rate of sublegal size fish. This may be an error in the code because it appears as if the total incidental mortality rate is an overestimate. Further review by the CTC will determine whether an adjustment for the sublegal release mortality rate should be applied.

2.1.3.4. CNR Harvest Ratio (or RT) Method

This method is used when forecasting incidental mortalities for future years, i.e., years without observed fishing seasons. Non-retention mortalities are estimated through a CTC model-generated 'RT' factor. RT is an abbreviation for 'ratio' since the RT factor represents the ratio between the landed catch and the catch that would have resulted under base period exploitation/harvest rates. In this case, the years prior to the implementation of ceiling fisheries (1979-1984) are used as the base period. RT values for fisheries in the base period are equal to 1, meaning that 100% of effort was spent in directed Chinook fisheries. RT values will be less than 1 in years when fisheries included CNR periods.

For the sublegal fish, the estimated CNR encounter rate is based on the fishery gear selectivity of sub-legal fish and the ratio of the estimated catch under base period exploitation rates to the estimated catch under current exploitation rates. The CNR encounter rate is multiplied by the estimated sublegal shakers in the retention fishing periods. These encounters are multiplied by the appropriate release mortality rate plus the drop-off rate to estimate the nominal number of sublegal fish killed. The CNR encounter rates for legal-size fish are similarly estimated. The CNR legal encounter rate is multiplied by the catch in the retention fishing periods, and the estimated encounters are multiplied by the appropriate hook and release mortality rate plus the drop-off rate to estimate the nominal number of legal fish killed.

2.2. *Application Of Incidental Mortality In The Management Regimes*

2.2.1. AABM Fisheries

AABM fisheries are currently managed for landed catch numbers (ceilings) that are set according to abundance index (AI) values computed by the CTC model, as per Table 1 of the Agreement. The AI for an AABM fishery is computed as the model-generated catch in a projected year, given the model cohort sizes for that year under base period exploitation rates and user specified size limits, divided by the average model catch in the base period under the same size limits. The formula for computation is shown in Appendix 4. Because estimates of total

mortality are necessary for estimating cohort sizes, incidental mortality estimates are an essential component in the computation of the AI and the catch limits for these fisheries.

2.2.2. ISBM Fisheries

The 1999 agreement states, "The non-ceiling index defined in TCCHINOOK (96)-1 … will be used to measure performance of ISBM fisheries." The non-ceiling index (hereinafter referred to as the ISBM index) is a stock specific total mortality index across all fisheries in a particular country. The Agreement further indicates that the general obligation is a reduction in "the total adult equivalent mortality rate, relative to the 1979-82 base period." So, both by definition of the index itself, and by specification in the agreement, the ISBM index is a total mortality index. Details of the calculations are shown in Appendix 5.

Direct application of the CTC model alone or CWT data alone is not possible in the computation of the ISBM indices for all stocks for several reasons. In some cases, computation of the stock specific ISBM index requires defining fisheries at a finer resolution than either the CTC model or exploitation rate analysis currently provide. In many cases, there are terminal area fisheries on wild ISBM stocks which cannot be accurately modeled or estimated directly since CWT based exploitation rate estimates (used in both CTC model and CWT derived estimates) are not applicable to the wild stock. Methods used to supplement the information generated by the CWT exploitation rate analysis and the CTC model are listed in Appendix 5.

3. ESTIMATES BY PSC FISHERY

3.1. *Coastwide Chinook Fisheries*

The current version of the CTC model contains 25 fisheries coastwide (Table 1). Catch estimates for 19 of these fisheries are essential data inputs for the exploitation rate analysis and the CTC model calibration. In 2001, catches in these fisheries ranged from 47 in the Juan de Fuca Net fishery to over 100,000 landed Chinook in the SEAK Troll fishery (Table 1). For six CTC model fisheries, catch numbers were generated as part of the model calibration. Model landed catch in these fisheries in 2001 ranged from 0 in the WCVI net fisheries to over 100,000 in the Terminal Net and Terminal Sport Fisheries (Table 1). These latter categories are amalgamations of a number of terminal fisheries that have been combined in the CTC model due to memory constraints in the old CTC model software. These catches are adjusted with actual catch data in the Fishery Performance input file during the calibration process. The CTC model catches are reported here to reflect the relative estimates of incidental mortality generated by the model for the CTC model PSC fisheries.

The total catch for CTC model fisheries in calibration 0206 in nominal fish was 1,040,800 fish in 2001 (Table 1), similar to the total reported catch for PSC fisheries of 979,900 fish (CTC 2002). The estimated incidental mortality for the CTC model fisheries was 226,000 nominal fish, or 18% of the landed catch. The estimates of incidental mortality for the 25 CTC model fisheries ranged from 4 in the Juan de Fuca Net fishery to almost 60,000 in the SEAK Troll fishery. CTC model estimates of incidental mortality in nominal numbers of fish were significantly ($P < 0.05$) related to the size of the landed catch; the correlation coefficient r was 0.45 for all 25 fisheries,

and was 0.61 for the 19 fisheries for which actual catch was a direct input into the CTC model. However, there was considerable variability among fisheries in the amount of incidental mortality in relation to the landed catch. The average ratio of incidental mortality to catch for the CTC model fisheries was 0.37, and ranged from 0.01 (Fraser Net) to >1.0 (SEAK Net, CBC Troll).

In 2001, estimates of incidental mortality in Table 1 were generated by the CTC model as outlined in Section 2 above. Agency programs were in place in 2001 to provide external estimates of incidental mortality for 7 of the 25 fisheries (Table 1). In 2004, existing and proposed sampling programs are projected to provide complete external estimates for 11 of the 25 fisheries.

External estimates of encounters and incidental mortality available for fisheries in 2001 are compared to CTC model-generated estimates in Tables 2 and 3. For four Chinook non-retention (CNR) fisheries, external estimates were used as inputs to the exploitation rate analysis: SEAK troll, SEAK Net, NBC troll, and NBC Net (Table 2). When external estimates were used as input, the CTC model generally provided good (close to external) estimates of incidental mortality for these fisheries. Model estimates of encounters using external estimates were generally consistent with the external input, ranging from 84% to 111% of the external estimates for both legal and sublegal fish (Table 2). Model estimates for mortality were also similar to external estimates for the SEAK and NBC troll fisheries, ranging from 84% to 107% of the external estimates. Model estimates of mortality for the net fisheries were biased high relative to the external estimates, ranging from 105% to 197%. This bias results from the use of a generic net estimate (gill net and seine) of 90% release mortality in the CTC model, rather than the somewhat lower rates accepted by the CTC (CTC 1997) for seine fisheries. Both the model and external estimates for these net fisheries are based only on seine catches, and do not account for drop-off mortality associated with gillnet fisheries.

If external estimates are not used as input to the CTC model, and instead effort data are used to estimate incidental encounters and mortality, the CTC model estimates become much more divergent from the external estimates. Calibration 0206 was rerun to generate estimates of encounters and mortality for these fisheries using effort data and internal CTC model algorithms. Model estimates for troll mortality using this method were biased high. For legal fish, model mortality estimates in the troll CNR fisheries were 149%-239% of the external estimates. For sublegal fish, model estimates were 6 to 25 times higher than the external estimates. Conversely, model estimates for net fisheries were biased low. For legal fish, model mortality estimates in the net CNR fisheries in Table 2 were 1%-10% of the external estimates. For sublegal fish, model mortality estimates in the net CNR fisheries were 0%-12% of the external estimates (Table 2).

In Table 3, CTC model estimates of mortality in retention fisheries are compared with available external estimates for three troll fisheries and four sport fisheries. Model estimates of sublegal mortality in these fisheries were higher than external estimates for 6 of the 7 fisheries. The exception was the Georgia Strait Troll fishery, where estimated encounters were very low and the model estimate for sublegal mortality was 78% of the external estimates. In the other 6 fisheries, model estimates for sublegal mortality were 1.3 – 9.8 times higher than the external estimates.

For legal fish, CTC model estimates in troll fisheries in Table 3 are the calculated drop-off rates. External estimates are similar for these fisheries, because drop-off is the major mortality component. For the sport fisheries, model estimates of incidental mortality were consistently lower for legal fish, ranging from 24% to 44% of the external estimates. Model estimates for legal fish in these fisheries are again limited to drop-off mortality as a percentage of the landed catch; the model does not estimate legal fish that are caught and released. However, the external estimates of encounters clearly show that large numbers of legal fish are released by recreational fishermen fishing non-consumptively or sorting for size (Table 3). External estimates include both drop-off mortality and catch and release mortality of these legal encounters, and thus are higher than the model-generated estimates.

In many cases, the CTC model fisheries are aggregations of fisheries by gear type within a region. The capability of incorporating new fisheries into a revised version of the CTC model provides the potential for better resolution in estimating incidental mortality. The following sections list the PSC fisheries in the CTC model by region, identify the component fisheries of each PSC fishery, and provide an overview of the current capability of management agencies to estimate incidental encounters and mortality of Chinook salmon. The overviews describe the programs in place to estimate encounters, and identify the mortality rate applied for encounters in specific fisheries to estimate incidental mortality.

Table 1. Total catch, associated incidental mortality (IM) estimates from the CTC model in nominal numbers of fish (using the estimation methodology in place in 2001), and potential for external estimates of mortality in the 2004 season for each of the 25 PSC Chinook fisheries in the CTC model. For 19 of the fisheries, catch numbers are the number of "treaty" fish input as catch in the 0206 model calibration. For the other 6 fisheries (*in italics*), the catch and IM estimates were both generated by the model calibration. "External" represents estimates of incidental encounters from direct sampling or sampling-derived relationships for the specific fishery. "Mixed" represents estimates by a mixture of external and CTC model techniques; the percentage shown is the proportion of landed catch for which there are direct estimates. Model estimates of incidental mortality are in "nominal" fish, scaled by the relationship between actual and model projected catches.

PSC Fishery	2001 Catch	2001 Total Model IM	2001 Estimation Methodology	Anticipated 2004 External Estimates
SEAK Troll[1]	128,916	59,791	Mixed (70%)	Yes
SEAK Sport	46,991	17,719	External	Yes
SEAK Net[1]	13,476	18,377	Mixed[2]	Partial
NBC Troll[1]	13,100[3]	3,911	Mixed (60%)	Yes
NBC Net[1]	11,899	15,246	Mixed	Partial
CBC Troll	543	714	Model	Yes
CBC Net	4,589	486	Model	Partial
NCBC Sport	45,211	7,146	Mixed (80%)	Partial
John St Net	303	18	Model	Partial
WCVI Troll	77,491	10,732	External	Yes
WCVI O. Sport	40,179	7,699	External	Yes
WCVI Net	0	1,272	External	Yes
Geo St Troll	248	81	External	Yes
Geo St Sport	31,259	20,929	External	Yes
Fraser Net	32,761	411	Model	Partial
J de F Net	47	4	External	Yes
Puget N Net	900	566	Model	No
Puget N Sport	6,000	2,944	Model	Partial
Puget S Net	96,682	5,348	Model	No
Puget S Sport	24,000	12,121	Model	No
Wash Coast Net	20,000	3,151	Model	No
Wash Coast Sport	25,400	4,458	Model	Yes
Wash/OR Troll	55,980	17,267	Model	Partial
Terminal Net	120,206	6,174	Model	Partial
Terminal Sport	126,730	9,429	Model	Partial

[1]External estimates of CNR mortality used as input to the CTC model calibration.
[2]Estimates available for component seine fisheries but not in component gillnet fisheries.
[3]Fishery constrained to unusually low level in 2001; catch was 96,475 in 2002.

Table 2. Encounter rates and mortality in 2001 in four PSC Chinook non-retention (CNR) fisheries, as estimated by (1) external observations and sampling; (2) by the CTC model, using external estimates as input; and (3) by the CTC model, using the CNR effort approach. Encounters and mortality are in nominal numbers of fish.

PSC Fishery	External Estimates[1]		Model With External Input		Model Internal Algorithms	
	Encounters	Mortality	Encounters	Mortality	Encounters	Mortality
Sublegals						
SEAK Troll	45,072	11,854	37,916	9,972	294,683	75,144
SEAK Net	10,773	8,549	11,997	10,797	119	107
NBC Troll	356	97	322	88	9,654	2,462
NBC Net	5,096	4,372	5,099	4,589	195	176
J de Fuca Net	33	26	--	--	4	4
Legals						
SEAK Troll	59,535	13,038	60,142	13,171	91,843	19,379
SEAK Net	3,245	1,655	3,627	3,265	184	166
NBC Troll	744	170	798	182	1,925	406
NBC Net	10,966	6,479	10,973	9,876	1,641	1,477
J de Fuca Net	1,030	562	--	--	0	0

[1] Numbers input to CTC model as external estimates, except for Juan de Fuca net.

Table 3. Comparison of CTC model-generated estimates of Chinook encounter rates and associated mortality with available estimates in retention fisheries in 2001.

PSC Fishery	Model Encounters	External Encounters		Model Mortality		External Mortality[1]	
	Sublegals only	Legals	Sublegals	Legals[2]	Sublegals	Legals	Sublegals
SEAK Troll[3]	81,680	0	44,167	760	17,888	763	10,026
SEAK Sport	97,927	36,390	59,145	2,149	15,570	5,786	9,404
NCBC Sport	36,229	30,522	3,900	1,386	5,760	4,578	585
WCVI Troll	34,617	0	20,507	1,318	9,416	1,253	4,122
WCVI Sport[4]	24,537	20,177	6,371	2,988	4,711	6,646	1,233
Geo St Troll	282	0	421	4	77	9	99
Geo St Sport	48,011	7,561	57,073	2,157	18,772	8,965	14,268

[1]Includes drop-off mortality assuming drop-off rates listed in CTC (1997).
[2]Drop-off mortality of legal fish, included in CTC model output as a component of "shaker" mortality.
[3]Summer fishery only. Model estimates for the entire 2001 SEAK troll fishery were scaled by 0.62, the proportion of the catch in the summer fishery.
[4]WCVI Outside Sport, the sport component of the WCVI AABM fishery.

3.2. *Southeast Alaska*

An overview of sampling programs by component fisheries for the SEAK Chinook fisheries is shown in Table 4, with descriptive narratives given below.

3.2.1. SEAK Troll

Logbook/observer programs to estimate incidental encounter/mortality in the SEAK troll fisheries currently (and historically) estimate encounters only in the summer season from July 1 – September 30. Since 1998, observer and logbook programs have been in place; estimates are calculated using the methods in Bloomquist and Carlile (2001); observers and logbook programs were also implemented from 1985-1989. The program has been expanded into the winter and spring fisheries beginning in the 2004 accounting period, which started in October 2003. The estimates of the number of sublegal Chinook encountered in the troll retention fisheries are made using estimates of the catch of sublegal Chinook per boat day of effort in the retention and non-retention fishery as recorded by the observer and logbook programs. A ratio of the number of sublegal Chinook in the non-retention fishery to that in the retention fishery is calculated. This ratio is used to multiply the estimate of the number of sublegals per boat day previously estimated. This is then expanded using the number of boat days of effort in the retention fishery.

Mortality rates of 25.5% for sublegal size and 21.1% for legal size Chinook, and a drop-off rate of 0.8%, are applied to estimate mortality from the estimates of sublegal encounters and catch, as recommended by the CTC (1997).

3.2.2. SEAK Sport

An overview of sampling programs by component fisheries for the SEAK sport fishery is shown in Table 4. Data are available from three data sources to compile Chinook encounter estimates for Southeast Alaska. Comprehensive coverage is provided by estimates derived from a State-wide harvest survey (SWHS) which is sent to a random sample of sport anglers annually. The SWHS has compiled estimates of harvested Chinook salmon by size class since 1977 as well as released Chinook salmon by size class since 1990. Estimates from the SWHS are not available until six to nine months after the season is completed. Creel survey data from interviews of anglers returning to boat launches and harbors are also available from a number of fisheries. These surveys estimate the numbers of Chinook salmon harvested and released by size class. Creel census data have been available since 1983 although there are some gaps in coverage. A third data source is a mandatory logbook program for marine charter vessels, which was first implemented in 1998. Although the data are derived from only one segment of the fishery, they provide an additional crosscheck with the first two data sources.

Table 4. Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries in Southeast Alaska.

PSC Fishery	Component Fisheries	Catch Estimates	Legal Estimates (CNR/Catch & Release)	Sublegal Estimates	Drop-off Rate Applied	Legal Size (Total Length)	Mort Rate Est. Source
SEAK Troll	Summer Troll	Fish Tickets	Logbook/Obs Verified	Logbook/Obs Verified	CTC (1997)	28 inches	CTC (1997)
	Winter Troll	Fish Tickets	No CNR	Logbook in 2003	CTC (1997)	28 inches	CTC (1997)
	Spring Troll	Fish Tickets	No CNR	Logbook in 2004	CTC (1997)	28 inches	CTC (1997)
SEAK Sport	Spring/Summer Marine Sport	SWHS[1]/Creel Census/Charter Logbooks	SWHS[1]/Creel Census/Charter Logbooks	SWHS/Creel Census/Charter Logbooks	CTC (1997)	28 inches	CTC (1997)
	Winter Marine Sport	SWHS[1]	SWHS[1]	SWHS[1]	CTC (1997)	28 inches	CTC (1997)
	Yakutat Freshwater Sport	NA	SWHS[1]	SWHS[1]	CTC (1997)	NA	CTC (1997)
SEAK Net	Purse Seine CR > 28"	Fish Tickets	NA	Ratio of Encounters to Landed Catch Verified[2]	NA	28 inches	CTC (1997)
	Seine CNR >28"	NA	Ratio of Encounters to Landed Catch Verified[2]	Ratio of Encounters to Landed Catch Verified[2]	NA	<=21 inches	CTC (1997)
	Seine CR[3] > 21"<28"	Fish Tickets (partial count)	Ratio of Encounters to Landed Catch Verified[2]	Ratio of Encounters to Landed Catch Verified[2]	NA	>21"<28"	CTC (1997)
	Seine CR[4] <=21"	Fish Tickets (partial count)	NA	NA	NA	<=21 inches	NA
	Drift Gillnet	Fish Tickets	NA	NA	No	No Size Limit	NA
	Yakutat Setnet	Fish Tickets	No Estimate[5]	NA	No	No Size Limit	NA
Other SEAK	Subsistence[6]	Permit	No Estimate	No Estimate	No	NA	NA

[1]SWHS = statewide harvest survey.
[2]An observer program for the SEAK net fisheries will be implemented in 2004.
[3]Chinook greater than 21" or less than 28" are legal to retain for personal use but not to sell at all times in the seine fishery. Normally, only a portion is accounted for on fish tickets.
[4]Chinook less than or equal to 21" are legal at all times in the seine fishery and are normally included as a portion of the pink salmon catch on fish tickets.
[5]CNR may be implemented when the Situk escapement is less than 730 fish.
[6]No directed subsistence fishery for Chinook in SEAK. Minimal incidental harvest not included in SEAK catch.

Because Alaska hatchery terminal fisheries are directed at hatchery returns which do not include stocks of treaty concerns, catches encounters that occur in these fisheries are not included in the treaty catch. Alaska hatchery terminal fisheries include the Blind Slough shoreline fishery, the Wrangell Narrows boat fishery near Petersburg, and shoreline fisheries at the head of Auke Bay and at Gastineau (Macaulay) Hatchery near Juneau. Although substantial boat fisheries also occur in marine terminal hatchery areas near Juneau and Ketchikan, these data are not excluded from the treaty catch because total catches and harvests in these areas include fish from stocks of treaty concern which currently cannot be separated from hatchery terminal harvests in the SWHS or creel surveys. Data were compiled for eight primary SWHS areas in Southeast Alaska, although the Glacier Bay and Yakutat areas were lumped for some analyses. Freshwater fishing for Chinook salmon is prohibited in Southeast Alaska except in the Yakutat area and in hatchery terminal areas.

A mortality rate of 12.3% and a drop-off rate of 3.6%, as recommended by the CTC (1997), are applied to estimate mortality from the estimates of sublegal encounters and catch.

3.2.3. SEAK Net

An overview of sampling programs by component fisheries for the SEAK net fishery is shown in Table 4. A regression of landed catch on the encounter estimates was developed from an observer program that was in place from 1985 through 1987 (Van Alen 1986,1987; Rowse 1990). Incidental CNR encounters in the purse seine fishery of both large (>28 inch) and small (<28 inch) Chinook, and retention period encounters for Chinook > 21 inches are currently estimated using this regression. External estimates of seine incidental mortality use the size-specific rates recommended in CTC (1997). However, in the CTC model, a generic rate of 90% mortality is used for both seine and gillnet encounters because the gear types are not separated in the model.

Incidental mortality estimates are not made for the SEAK gillnet fishery. There is presently no directed harvest of Chinook in the drift gillnet fishery, but incidental catches of Chinook salmon can be landed with no size restrictions. The Chinook management plan calls for CNR fishing to be imposed if gillnet landings exceed the annual gillnet allocation, but these annual limits have not been exceeded. Thus, there have not been any Chinook non-retention periods or reported CNR in the drift gill-net fishery. To maintain landed catch within the annual limits, area restrictions are used on an annual basis and nighttime closures of gillnet fishing may be imposed to reduce incidental catch of Chinook. No external estimate has been made for drop-off mortality. The CTC model also does not currently incorporate any estimate of drop-off mortality for gillnet catch.

3.3. Northern And Central British Columbia

An overview of sampling programs by component fisheries for North and Central British Columbia Chinook fisheries is shown in Table 5, with descriptive narratives provided below. Information has been presented by CTC model fishery and further broken down into component fisheries.

3.3.1. North Coast British Columbia Sport

Recreational fishing occurs throughout the North Coast. The four component fisheries are separated geographically into the Queen Charlotte Islands (QCI), the Chatham Sound area around Prince Rupert (Areas 3 to 5), the waters approaching Kitimat (Area 6) and the waters South of Kitimat to Cape Caution (Areas 7 to 10).

The sport fishery is open all year. The recreational size limit in the North Coast is 45 cm fork length.

Recreational catch data are available from creel surveys and voluntary logbooks offered to lodges and charter operators. Creel surveys were conducted in QCI and in Areas 3 to 5 from mid-May to mid-September. This timing covers most of the recreational Chinook catch. Chinook encounter data in the form of Chinook released are available for creel surveys. The release data are not size specific. The 2001 domestic management plan used 15% release mortality rate in all areas based on data from Cox-Rogers et al. (1999) with no adjustment for drop-off mortality.

Creel surveys were not conducted in Area 6 or Areas 7 to 10 prior to 1999. In 2000, a recreational creel survey was initiated in Area 9, and is conducted annually to monitor Chinook catch in that area. Voluntary logbook data from lodges suggest that most legal-size Chinook are retained. However, data on releases of both legal and sublegal size fish have only recently been recorded in logbooks. The component of the total recreational catch accounted for in logbooks is unknown, but is believed to represent the majority of catch by lodge fishers in these areas.

3.3.2. Northern British Columbia Troll

Troll catch data are derived from fish slips, hail data, and test fishery reports. Observers and hail data are used to assess Chinook encounters for portions of the retention and non-retention fisheries. The magnitude of the troll fishery was greatly reduced in 2001 due to domestic conservation concerns for Chinook stocks from the west coast of Vancouver Island, and coho stocks in the upper Skeena River and interior Fraser River drainages. The size limit in the northern troll fishery is 67 cm fork length.

3.3.3. Northern British Columbia Net

The Northern British Columbia net fishery is composed of three fisheries separated by gear type. The components are seine, gillnet and test fisheries. There are no size limits in the net fisheries.

3.3.3.1. Seine Fisheries

Since 1999, all seine fisheries operating in the NCBC have been required to release all Chinook and to brail catches to minimize handling effects. Seine catch data are obtained from fish slips and hail data. Hail data are provided by charter patrols at sea. Chinook encounter rates were estimated from direct observation and hail data in 2001. Fishing effort data are collected from overflights, charter patrols and observers.

Table 5. Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries in North and Central British Columbia.

PSC Fishery	Component Fisheries	Catch Estimates	CNR Estimates	Retention Fishery Sublegal Estimate	Drop-off Rate Applied	Legal Size	Mort Rate Est. Source
CBC Net	Summer Gillnet	Hails, Fish slips	NA	NA	No	No	CTC(1997)
	Fall Gillnet	Hails, Fish slips	NA	NA	No	No	CTC(1997)
	Purse Seine	Hails, Fish slips	Partial - Total CNR	No	NA	No	NA
Johnstone Strait Net	Summer Seine	Hails	No estimate	No	NA	No	NA
	Summer Gillnet [1]	Hails	No estimate	NA	No	No	NA
NBC Troll	Area 1-5 troll	Hails, Fish slips, test fisheries, observers	Yes – Observer/Hail	Partial	Yes	67 cm	DFO (2002)
CBC Troll	Area 6-12&30 troll	Hails, Fish slips	NA in 2001 (yes 2002)	No	Yes	67 cm	NA
NCBC Sport	Area 1 & 2 sport	Creel, logbook	Yes – Creel	No	Yes	45cm	DFO (2002)
	Area 3-5 sport	Creel	Yes - Creel	No	Yes	45 cm	DFO (2002)
	Area 6 sport	Partial logbook	No	No	Yes	45 cm	
	Area 7-10	Logbook	No	No	Yes	45 cm	
NBC Net	Seine	Hails, Fish slips, observers	Yes – observers	Yes	NA	No	CTC(1997)
	Gillnet	Hails, Fish slips	Hail	Hail	No	No	None
	Tyee Test gillnet	Test catch fully sampled	NA	NA	No	No	None

[1] Gillnets voluntarily released Chinook where possible

External estimates of seine mortality in 2001 were calculated using the mortality rates recommended in CTC (1997). However, observed short-term mortality rates of Chinook salmon released from seines in 2001 (I. Winther, CDFO, personal communication) were less than the rates in CTC (1997).

3.3.3.2. Gillnet Fisheries

Commercial gillnet catches are estimated from fish sales slip and hail data. A small number of Chinook are released from gillnets voluntarily. These data are captured in hail data only. There are no estimates of post-release mortality or drop-off mortality.

3.3.3.3. Tyee Test Net Fishery

The Tyee test fishery is a structured fishery operated with a multi-panel gillnet. All Chinook caught are extensively sampled. None are released. Drop-off rate is unknown.

3.3.4. Central British Columbia Troll

There were no directed-harvest troll fisheries for Chinook salmon in 2001. Chinook retention was permitted during the Johnstone Strait sockeye fishery.

3.3.5. Central British Columbia Net

The Central Coast net fisheries are focused in Areas 7 and 8, and target primarily local pink and chum stocks. For these fisheries, Chinook retention was permitted during the gillnet fishery; however, few Chinook were caught. The seine fisheries were non-retention for Chinook and releases were recorded and reported in hails as well as logbooks. Separate estimates of legal and sublegal releases for Chinook are not available. There is one terminal gillnet fishery directed at Chinook that targets the Atnarko River stock. This fishery accounts for most Central Coast net landings of Chinook. There was no size limit in this fishery and no releases were recorded. Catch numbers for this fishery are reported via hails and recorded in logbooks annually. Mortality rates associated with these releases are calculated using the rates in CTC (1997).

3.4. *Southern British Columbia Fisheries*

3.4.1. West Coast Vancouver Island and Strait of Georgia

An overview of sampling programs by component fisheries for West Coast Vancouver Island and Strait of Georgia Chinook fisheries is shown in Table 6, with descriptive narratives given below.

Table 6. Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries in Southern British Columbia.

PSC Fishery	Component Fisheries	Catch Estimates	CNR Estimates	Retention Fishery Sublegal Estimate	Drop-off Rate Applied	Legal Size (FL)	Mort Rate Est. Source
WCVI Troll	Spring Troll	Logbooks/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	Yes	55cm	CTC(1997)
	Summer Troll	Logbooks/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	Yes	55cm	CTC(1997)
	Fall Troll	Logbooks/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	Yes	55cm	CTC(1997)
	Winter Troll	Logbooks/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	Yes	55cm	CTC(1997)
WCVI Sport	Spring/Summer Sport	Creel Survey/ Logbook	Creel Survey/ Logbook	Creel Survey/ Logbook	Yes	45cm	DFO(2002)[1]
	Fall/Winter Sport	No estimate	No estimate	No estimate	Yes	NA	NA
WCVI Net	Summer Net	Logbook/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	No	55cm	CTC(1997)
	Fall Net	Logbook/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	No	55cm	CTC(1997)
GST-Troll	Summer Troll (Test Fishery)	Phone-in/ logbooks	No CNR	Phone-in/ logbooks	Yes	NA	CTC(1997)
GST Sport	Spring/Summer Sport	Creel Survey	Creel Survey	Creel Survey	Yes	45/62cm	DFO(2002)[1]
	Fall Sport (GST)	Creel (Partial)	Creel (Partial)	Creel (Partial)	Yes	62 cm	DFO(2002)[1]
	Winter Sport (J de F)	Creel Survey	Creel Survey	Creel Survey	Yes	62cm	DFO(2002)[1]
GST Net	Summer Net	Logbooks/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	No	55cm	CTC(1997)
	Fall Net	Logbooks/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	No	55cm	CTC(1997)

[1] Working document report. Assessment of 2001 Performance Measures for Post-Release Mortality Rates for Coho and Chinook, and Recommendations to the Development of the Integrated Fisheries Management Plan for the 2002 Fisheries. (DFO Internal Document)

3.4.1.1. WCVI Troll

Logbook and observer programs estimate incidental encounters and incidental mortalities of sub-legal Chinook in the WCVI troll fisheries. The estimates of the number of sub-legal Chinook encountered in the troll retention fisheries are made using estimates of the releases of Chinook per vessel in retention fisheries as recorded by observers and logbook programs. A ratio of the number of sub-legal Chinook/legal Chinook per boat day in the retention fishery is then calculated, and this ratio is then expanded using the number of boat days of effort in the retention fishery. Observer and logbook programs have been in place since 1998.

The mortality rates of 18.5% for legal size Chinook and 22.0% for sub-legal size Chinook are used, as recommend by the CTC for barbless hooks (CTC 1997). Drop-off mortality rates of 1.7% for legal and sub-legal Chinook are used, as recommended by the CTC (CTC 1997).

3.4.1.2. WCVI Sport

Estimates of encounters for both sub-legal (<45 cm total length) and legal (≥45 cm total length) Chinook salmon in WCVI mixed stock fisheries are generated directly from creel survey data. Many of these monitoring locations are located where fisheries also target terminal ISBM stocks, and Chinook encounters in the sport fishery are adjusted to calculate the encounters of stocks that are AABM concerns. WCVI Chinook terminal fisheries are separated into ISBM and AABM encounter estimates and include: Robertson Creek Chinook stocks and Conuma River Chinook stocks.

Mortality rates of 10.0% and a drop-off mortality rate of 15.0% are used, as recommended by DFO (DFO 2001).

3.4.1.3. WCVI Net

Logbook and observer programs are used in conjunction to estimate incidental encounters and mortality of legal and sub-legal Chinook in the WCVI net fisheries. These monitoring programs provide estimates of Chinook releases, and associated mortalities are subsequently calculated. WCVI net fisheries take place Barkley Sound (seines and gillnets), Nootka Sound (gillnets), and Nitinat (seines and gillnets). Most net fisheries in the WCVI area take place in areas and during times where there is virtually no impact on AABM Chinook stocks, and most net fisheries have mandatory non-retention for Chinook. Incidental encounters in the WCVI net fisheries of both large (>55 cm) and small (<55 cm) Chinook are currently estimated through catch estimates from the logbook program.

Mortality rates used are 60.0% for gillnet fisheries for Barkley Sound sockeye, Nootka Sound chum, and Nitinat chum; and 15.0% for the seine fishery for Barkley Sound sockeye, as recommended by DFO (DFO 2001).

3.4.2.1. Georgia Strait Sport (including Juan de Fuca)

Data from the annual May-September Georgia Strait (GST) creel survey program, and the year round Juan de Fuca (JDF) creel survey program, are used to compile Chinook encounter estimates for GST sport. Interview data are taken from fishing parties returning to boat launches and harbors in designated locations. Creel census data have been available since 1980. Supplemental data are also available from logbooks issued to sport lodges which estimate the number of Chinook salmon by size class harvested as well as released.

Estimates of encounters for both sub-legal (<62 cm. total length) and legal (≥62 cm total length) Chinook salmon in GST mixed stock ISBM fisheries are generated directly from creel survey data. Estimates of encounters of both sub-legal (<45 cm total length) and legal (≥45 cm total length) Chinook salmon in Juan de Fuca sport ISBM fisheries are also generated directly from creel survey data.

Sport mortality rates of 10.0% and a drop-off mortality rate of 15.0% are used, as recommended by DFO (DFO 2001).

3.4.2.2. Georgia Strait Net (including Juan de Fuca)

Logbook and observer programs are used in conjunction to estimate incidental en-counters and mortality of legal and sub-legal Chinook in the GST net fisheries. These monitoring programs provide estimates of Chinook releases, and associated mortalities are subsequently calculated. GST net fisheries take place in statistical areas 14, 18, 19 and 20 targeting sockeye and chum runs. Most net fisheries in the GST area take place in areas and during times where there virtually no impact on AABM Chinook stocks, and all net fisheries have mandatory non-retention for Chinook. Incidental encounters in the GST net fisheries of both large (>55 cm) and small (<55 cm) Chinook are currently estimated through catch estimates from the logbook program.

Seine mortality rates of 15.0% are used for sockeye and chum seine fisheries in statistical areas 14, 18, 19, and a mortality rate of 25% is used for sockeye seine fisheries in statistical area 20 as recommended by DFO (DFO 2001). A drop-off mortality rate of 8.0% is used for gillnet fisheries in statistical area 20 as recommended by the CTC (CTC 1997).

3.5. *Fraser River Fisheries*

An overview of sampling programs for Fraser River Chinook fisheries is shown in Table 7, with descriptive narratives below.

3.5.1.1. First Nation Fisheries

These fisheries are included in the Terminal Fraser net fishery in the CTC model. Sublegal and legal incidental mortality are estimated to be 90%, and drop-off mortality is assumed to be 0%. The CTC (1997) recommended a gillnet drop-off mortality rate of 8% for the Fraser River; no drop-off mortality is currently applied to net fisheries in the CTC model. The First Nation fisheries have two components: lower Fraser and upper Fraser.

Table 7. Overview of the component fisheries and sampling programs for catch and incidental mortality in the PSC Chinook fisheries for the Fraser River.

PSC Fishery	Component Fishery	Catch Estimates	CNR Estimates[1]	Retention Fishery Sublegal Estimates[2]	Drop-off (Y/N)	Mort. Rate Est. Source
Fraser River	First Nation Lower Fraser	Hails, Interviews, Observers	NA	NA	N	CTC(1997)
	First Nation Upper Fraser	Interviews, Catch Reports	NA	NA	N	CTC(1997)
	Recreational	Creel	None	NA	N	CTC(1997)
	Gillnet Test Fishery	Observers	NA	NA	N	CTC(1997)
	Commercial Gillnet	Interviews, Hails	NA	NA	N	CTC(1997)

[1] Chinook retention is permitted in all First Nation and gillnet fisheries; CNR estimates not developed for CNR recreational fisheries.
[2] No sub-legal size categories for Fraser River fisheries.

The lower Fraser River First Nation fishery is terminal and runs from March to November with specific time- and area-closures. Gillnets are used in the Fraser River, and beach seines and gaffs are used in the Harrison River. Catch estimates refer to landed catch, and are not separated by legal or sublegal size since all Chinook are mature fish. Few Chinook are released voluntarily. Drop-off mortality and the numbers released are not directly estimated; however, seal predation occurs in this fishery and contributes to drop-off mortality. There do not appear to be any studies or direct estimates of drop-off mortality rates or release mortality rates for this fishery. Catch estimates for the Fraser Mouth to Mission area may have negative bias because effort was estimated from roving surveys instead of a more instantaneous count method. Comparison of roving surveys and dockside interviews indicates that not all fishers are observed. Aerial surveys may provide a less biased estimate of effort. Furthermore, catch rate estimates from the roving surveys that are based on incomplete fishing trip interviews may contribute to negative bias in catch estimates. The effort units used are days and not hours in this fishery, thus incomplete trip interviews exclude any catch in subsequent sets/drifts. Dockside interviews may help describe the daily effort profile and bias may be reduced if effort units are changed to hours. Additionally, catch rate estimates from hails may have negative bias because of under-reporting to Fishery Officers. Landing site interviews may help assess bias of the hail catch rate estimates.

The upper Fraser River First Nation fishery is terminal and generally occurs from April through October. Gillnets and dipnets are the main fishing gear used in the Fraser River mainstem, and several gear types are used on the tributary systems (mainly rod and reel, dipnet, and gaff). Catch estimates refer to landed catch, and are not separated by legal or sublegal size since all Chinook are mature fish. Few Chinook are released voluntarily. Encounter rates are not estimated because drop-off mortality and the numbers released are not estimated. There do not appear to be any studies or direct estimates of drop-off mortality rates or release mortality rates

for this fishery. Seal predation does not occur in this fishery. For tributary systems, individual fishers and First Nation Band administration are contracted to monitor catch rates, effort, and catch. The current monitoring level is minimal on many tributary systems and significant areas of the mainstem; it may be helpful to verify estimates derived from the current method. At locations where CWT fish may be encountered the CWT recoveries are extremely low (<5 per year) and unlikely to be sampled sufficiently to develop adequate catch:sample ratios, with the exception of a few systems (e.g., Siska, Nicola, lower Shuswap). CWT recoveries in most of these fisheries may need to be estimated by methods other than direct sampling.

3.5.1.2. Recreational Fisheries

The lower Fraser River recreational fishery is terminal and generally occurs from May though October, with area- and time-specific fishery closures each year. These fisheries are included in the Terminal Sport fishery in the CTC model. Chinook non-retention regulations occur at some spawning tributaries, but they are not monitored for encounters. Incidental mortalities rates currently used are from CTC (1997). Fisheries occur on the Fraser River mainstem and tributaries. The tributary fisheries are managed to limit harvest rates at less than 5% within a general framework (Schubert 1995). Most recreational fisheries that encounter Chinook indicator stocks are monitored with a creel survey and sampled for CWT recoveries. These include the largest and most effective recreational fisheries. Less effective fisheries with low, stable effort and harvest are monitored at least once every five years where possible. New fisheries are monitored with a creel survey until angler effort and catch rates stabilize.

Creel surveys estimate the number of adult Chinook kept, adult Chinook released, jack Chinook kept, and jack Chinook released. These estimates are not separated by legal or sublegal since all Chinook are mature. There do not appear to be any studies or direct estimates of drop-off mortality rates in freshwater fisheries. CDFO (Richard Bailey, unpublished data) estimated release mortality rates for anglers float-fishing on the Nicola River (instantaneous mortality 0.8%; long-term mortality ~3%), and for Middle and Lower Shuswap rivers (long-term release mortality rates ~5%). Data quality is considered good, and several programs have been conducted since the 1980's. Sampling biases have not been investigated for the creel surveys, but are perceived to be minor. Data quality could be improved by increasing the sample size of angler interviews and effort surveys. Increased sampling by creel survey monitors could improve the accuracy of catch rate estimates, increase CWT recoveries, and improve the catch:sample ratio. Increased aerial surveys would improve precision and accuracy of effort and catch estimates.

3.5.1.3. Gillnet Test Fisheries

Four gillnet test fisheries occurred in the lower Fraser River in 2003. The CDFO Albion Chinook/chum test fishery occurs from April through October, and the PSC Whonnock and Cottonwood sockeye test fisheries occur from June through September. Other experimental test fisheries have occurred in some years (PSC Area E sockeye assessment test fishery, tangle-net test fishery). These fisheries are included in the Terminal Fraser Net fishery in the CTC model. CDFO applies an incidental mortality rate of 90% for both sublegal and legal encounters, and drop-off mortality of 0%. The CTC (1997) has recommended a gillnet drop-off mortality rate of 8% for the Fraser River. At Albion, all Chinook are recorded by technicians; none are released

voluntarily. At Whonnock, Cottonwood and experimental test fisheries technicians record separate tallies of the numbers of adult and jack Chinook kept and released. Estimates are not separated by legal or sublegal since all Chinook are mature. Seal predation occurs in these test fisheries, though records have been kept inconsistently at Albion. These seal predation rates are unlikely to be applicable to other Fraser River gillnet fisheries because the seals regularly follow the test fishery boat, and appear habituated to the test fishery. Regular reporting of seal encounters is recommended, however, once Chinook are not the dominant species in the catch, estimating seal encounters and assigning the encounters to individual species becomes highly subjective.

3.5.1.4. Commercial Gillnet Fisheries

Commercial gillnet fisheries are directed at sockeye from July though September and at chum in October and November and occur from the Fraser River mouth (parts of area 29-9 and 29-10) upstream to Mission Bridge (area 29-16). The sockeye fishery uses ~5 1/4 inch mesh and the chum fishery uses ~6 3/4 mesh. There are no Chinook non-retention regulations for this fishery. Essentially all Chinook caught during the sockeye fishery are retained; however some are released during the chum fishery. These fisheries are included in the Terminal Fraser Net fishery in the CTC model. A sublegal and legal incidental mortality rate of 90% and drop-off mortality of 0% are used by CDFO. The CTC recommended a gillnet drop-off mortality rate of 8% for the Fraser River (CTC 1997).

The rates of Chinook retained and released are generally estimated through phone reports (CDFO Fishery Operating System), and hail surveys are used on occasion. Effort is estimated from aerial surveys for the sockeye fishery and from boat surveys by Fishery Officers for the chum fishery. Some estimates of seal encounters have been made during sockeye selective fishery experiments. Data quality is perceived to be good.

3.6. *Puget Sound, Washington/Oregon Coast*

An overview of sampling programs by component fisheries for Puget Sound and the Washington and Oregon Coast Chinook fisheries is shown in Table 8, with descriptive narratives given below.

3.6.1. Ocean Troll Fisheries

Incidental mortalities in troll fisheries are related to the duration of retention and non-retention periods, size limit regulations, and gear types. Size limits have been used extensively for these fisheries and have changed only a few times since 1979. Recreational and troll fisheries have been allowed to retain fish larger than 24 inches since the mid- 1980's. Troll fishing techniques differ, depending on whether the target species is Chinook or coho. When coho are targeted, encounters with Chinook have been reduced, but not eliminated, by species-specific gear, location, and fishing technique. Other management measures to reduce incidental Chinook catch, such as landing limits, ratio fisheries, or Chinook non-retention fisheries are seldom utilized. 'Sorting,' the release of legal fish in order to retain a larger fish later, is a source of mortality associated with hook and line gear not currently accounted for in model-generated estimates

Utilizing funding from the USCTC, the Makah Tribe has monitored Chinook encounter rates in tribal troll fisheries since 1998, and, in conjunction with WDFW, for the entire Washington troll fishery since 2003. These data have been incorporated into pre-season fisheries modeling.

All ocean troll fisheries have a barbless hook requirement and the CTC hooking mortality rate of 22.0% for sub-legal sized Chinook is used in all PFMC regulation assessments. The CTC rate of 18.5% would be used for any regulations requiring release of legal sized Chinook. The PFMC uses a drop-off mortality rate of 5% applied to all landed Chinook. The CTC (1997) recommended a drop-off rate of 1.7%.

3.6.2. Ocean Recreational Fisheries

Estimates of sublegal encounters of Chinook are generated from dockside interviews. Beginning in 1999, anglers were surveyed for both Chinook and coho sublegal encounters separately, but historically only total number of encounters (all salmon combined) were surveyed. Beginning in 1998, extra sampling effort was expended for the ocean recreational fisheries to monitor the impacts from mark-selective regulations on coho salmon. This effort included on-the-water observations of encounters and ride-along observations on charter boats. Although this effort was directed at the evaluation of coho regulations, information on Chinook encounters was also collected.

The hooking mortality rate used for sublegal sized Chinook in ocean recreational fisheries is 14.0% with a drop-off rate of 5% added for all landed fish. This compares with the CTC values of 12.3% sublegal hooking mortality rate and 6.9% average drop-off rate.

3.6.3. Puget Sound North Recreational Fisheries

Estimates of sublegal Chinook encounters come primarily from dockside interviews during the fall through spring period. Chinook encounters during the summer period are estimated from on-the-water observations for the coho mark-selective fishery. Chinook non-retention regulations were in effect for the summer period and estimates of encounters were made. However, the nature of this fishery is different than a normal Chinook directed fishery and these estimates are not applicable for periods of Chinook retention.

The hooking mortality rates used for Puget Sound recreational fisheries are 20% for sublegal sized fish and 10% for legal sized fish. A 5% drop-off rate is applied to all landed fish. The CTC rates are 12.3% hooking mortality and 14.5% drop-off.

3.6.4. Puget Sound South Recreational Fisheries

All estimates of sublegal Chinook encounters come from dockside interviews. Estimation of total fishing effort and impacts is difficult because of the large number of launch sites in these areas. The fall through spring period is a fishery that is directed at immature Chinook. This is potentially a large source of sublegal encounters.

The hooking mortality rates used for Puget Sound recreational fisheries are 20% for sublegal sized fish and 10% for legal sized fish. A 5% drop-off rate is applied to all landed fish. The CTC rates are 12.3% hooking mortality and 14.5% drop-off.

3.6.5. Gillnet Fisheries

Gillnet fisheries in Washington do not have a non-retention regulation because release mortality is assumed to be 100%. Incidental mortalities related to this gear-type are due to net drop-off and marine mammal interactions. No direct estimates are made for either of these sources of mortality. In 1996, the minimum gill net mesh size for chum fisheries was increased to 6-1/4 from 5-3/4 inch mesh, in order to reduce the incidental catch of immature Chinook.

The net drop-off rate for gillnet fisheries is assumed to be 3%. This rate was derived from negotiations in the "North of Falcon" (NOF) process between the State of Washington and the Treaty Tribes of Washington. The CTC rate for Puget Sound gillnet fisheries is 8% and Washington coastal terminal areas is 2%.

3.6.6. Purse Seine Fisheries

Most of the purse seine fisheries have a Chinook non-retention regulation, and the only seine fishery directed at Chinook occurs in Bellingham /Samish Bay. Estimates of Chinook encounters in purse seine fisheries primarily come from the "hail" system. In 1998 and 1999, on-board observations were made in north Puget Sound and Hood Canal. This information was used to validate data from the "hail" system.

Since 1973, non-tribal fishery regulations have required that purse seines incorporate a strip of larger mesh at the top of the bunt to allow immature Chinook to escape. In 1997, all purse seine fisheries required release of all Chinook. In 1998, shoreline closures in Rosario Strait (Area 7) were adopted, designed to reduce impacts on Chinook salmon while still providing opportunities during sockeye and pink-directed fisheries. In 1999, purse seines were required to use brailers or hand dip nets to remove salmon from seine nets during sockeye and pink directed fisheries in Areas 7 and 7A to reduce by-catch mortality (R. Bernard, WDFW, pers comm. October 19, 2000).

The release mortality rates for purse seine fisheries with the brailing or hand dip requirements are assumed to be 45% for sublegal and 33% for legal sized Chinook. The CTC release mortality rates for small, medium, and large Chinook in purse seine fisheries are 85.8%, 73.5%, and 51.0%, respectively.

3.7. Columbia River

There are three main fishery seasons in the Columbia River: spring, summer and fall. The spring fishery runs from March through May, the summer fishery runs from mid-June through mid-August, and the fall fishery begins at the end of August and runs through mid-October. Prior to 2000, there was limited opportunity on the spring and summer fisheries. A directed summer fishery took place in 2002 and 2003 after 35 years of being closed. Estimates of incidental mortality vary depending on the time and area of the fishery.

Table 8. Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries for Puget Sound and the Washington/Oregon coast.

PSC Fishery	Component Fishery	Catch Estimates	CNR Estimates	Retention Fishery Sublegal Estimates	Drop-off Rate Applied	Mort. Rate Source
Puget Sound North Net	Areas 4B-6C, Gillnet	Fish Tickets	NA	NA-no size limit	Yes	FRAM[1]
	Areas 7-7A, Gillnet	Fish Tickets	NA	NA-no size limit	Yes	FRAM[1]
	Areas 7-7A, Purse Seine	Fish Tickets	Hail or FRAM[1]	Hail or FRAM[1]	No	FRAM[1]
Puget Sound North Sport	Areas 5-6 Summer (JDF[2])	Dockside Survey	On-water observations	On-water observations	Yes	STT(2000)
	Areas 5-6 Winter (JDF[2])	Mail-In Survey	No estimate	Dockside Survey	Yes	STT(2000)
	Area 7 (SJI[3])	Mail-In Survey	No estimate	Dockside Survey	Yes	STT(2000)
Puget Sound South Net	Areas 8-13, 7A-7E, Gillnet	Fish Tickets	NA	NA-no size limit	Yes	FRAM[1]
	Areas 8-13, 7B-7E, Purse Seine	Fish Tickets	On-water interview or No estimate	On-water interview or No estimate	No	FRAM[1]
Puget Sound South Sport	Areas 8-13	Mail-In Survey	Dockside Interview	Dockside Interview	Yes	STT(2000)
Puget Treaty Troll	Areas 4b-5, 6, 6C,7, 7A	Fish Tickets	NA	FRAM[1]	Yes	FRAM[1]
Puget FW Sport		Mail-In Survey	Not estimated	Not Estimated	Yes	FRAM[1]
Puget FW Net		Fish Tickets	NA	NA	Yes	FRAM[1]
Washington Coast Net	Grays Harbor, Willapa Bay Gillnet	Fish Tickets	NA	NA-no size limit	Yes	FRAM[1]
	Freshwater Treaty Gillnet	Fish Tickets	NA	NA-no size limit	Yes	FRAM[1]
Washington Coast Sport	Areas 1-4 Ocean Sport	In-Season Estimates, Mail-In Survey	On water observations, Dockside Interviews	On water observations, Dockside Interviews	Yes	STT(2000)
Washington/ Oregon Troll	Areas 1-4, (WA) Non-Treaty Troll	In-Season Estimates, Fish Tickets	Dockside Interviews or Logbooks	Dockside Interviews or Logbooks	Yes	STT(2000)
	Areas 2-4, (WA) Treaty Troll	Fish Tickets	On-Water Observations and Logbooks	On-Water Observations and Logbooks	Yes	STT(2000)
	Areas 1-5 (OR) Ocean Troll	Fish Tickets	NA	No estimate	No	STT(2000)
Oregon Coast Sport	NOC,MOC Stocks	Angler Harvest Cards	NA	NA	No	None

[1]FRAM = Fishery Regulation Assessment Model
[2]JDF = Juan de Fuca
[3]SJI = San Juan Islands

3.7.1. Columbia River Sport Fisheries

An overview of sampling programs for Chinook salmon incidental mortality in sport fisheries in the Columbia River basin is shown in Table 9. In 1986-1987, the Technical Advisory Committee (TAC, US v OR Technical Advisory Committee Minutes, 1987) reviewed literature on incidental mortality rates in sport fisheries, and agreed to assume a rate of 10%, which is used to estimate incidental mortality in the Buoy 10 sport fishery at the mouth of the Columbia River. From 1998 to 2002, Lindsay et al. (2004) studied catch and release mortality in the sport fishery on Willamette River spring Chinook. Hooking mortality varied from 0% to 81.6% depending on the anatomical location of the hook, with the lowest rate associated with being hooked in the eye, and the highest rate associated with being hooked in the gills. The majority of the hooked fish (81.5%) were hooked in the jaw, which had a 2.3% mortality.

3.7.2. Columbia River Net Fisheries

An overview of sampling programs for Chinook salmon incidental mortality in net fisheries in the Columbia River basin is shown in Table 9. Direct estimates of incidental mortality for Columbia River net fisheries are not available. Traditionally, there have not been legal size limits or Chinook non-retention in the net fisheries, so, there are no mortalities associated with intentional release of fish. There is probably some small percentage of gillnet drop-off fish that are caught but escape prior to landing, but it is difficult to design a study to estimate the mortality resulting from having “almost” been caught. Unaccounted mortalities also occur due to predation of fish that were caught, prior to retrieval from the net. There is no adjustment made for these drop-out mortalities.

In 2001 and 2002, tangle net gear was tested on the lower Columbia River to selectively harvest adult spring Chinook salmon (Vander Haegen 2002), and release mortality rates were estimated. Control fish that had not been captured in tangle nets were tagged and released from an adult trap in Bonneville Dam, just upstream of the fishing area. Survival rates, relative to the trapped fish, were estimated for tangle nets and the traditional 8-inch gillnet. In 2001, immediate survival from capture to release for adult spring Chinook salmon captured in the 8-in gill net was 99%, compared to 96% from the 3.5-in tangle net, and 97% from the 4.5-in tangle net. In 2002, immediate survival was 99%. Total survival of adults released from the tangle nets was 84%, with 95% confidence intervals of 82%-86%, in 2001; and 68%, with 95% confidence intervals of 65%-70%, in 2002. In the 2001 study, spring Chinook adults and jacks released from the 8-inch gill net were recovered at about 50% of the rate of the controls. A large proportion of the fish were gilled. Fifty percent long-term mortality is the best estimate of mortality to apply to Chinook captured in large mesh and released. In another brief test, spring Chinook were fished with a 5-inch gill net in tandem with an 8-inch gill net on the lower Columbia River. Immediate mortality associated with the 5-inch gill net was 10%, compared to 0% in the 8-inch gill net. In 2003, the Technical Advisory Committee (TAC, US v OR Technical Advisory Committee Minutes, 2003) recommended a mortality rate of 25% for the 4.25-inch mesh for the 2003 fishery.

Table 9. Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries for the Columbia River.

PSC Fishery	Component Fisheries	Catch Estimates	CNR Estimates	Retention Sublegal Estimates	Drop-off Rate Applied	Mort Rate Est. Source
Columbia River Net	Spring Zone 1-5 Gillnet	Fish tickets	NA	NA- No Size Limit	No	
	Spring Zone 1-5 Tangle Net	Fish tickets	NA	Yes (25%)	No	Technical Advisory Committee. US v OR TAC Minutes (2003).
	Spring Zone 6 Net	Fish tickets and Surveys	NA	NA- No Size Limit	No	
	SpringTreaty Ceremonial & Subsistence	Surveys	NA	NA- No Size Limit	No	
	Fall Zone 1-5 Gillnet	Fish tickets	NA	NA- No Size Limit	No	
	Fall Zone 6 Net	Fish tickets and Surveys	NA	NA- No Size Limit	No	
	Fall Treaty Ceremonial & Subsistence	Surveys	NA	NA- No Size Limit	No	
	Other gillnet (sockeye & shad gillnet) in Zone 1-5.	Fish tickets and surveys	Yes (35%)	NA- No Size Limit	No	Technical Advisory Committee. US v OR TAC Minutes (1987).
Columbia River Sport	Buoy 10 (fall) Legal (>24 inches)	Dockside sampling (creel surveys)	Yes - barbed (16%) or barbless (14%) hooks	Yes - barbed(16%) or barbless (14%) hooks	Yes (5%)	PFMC Salmon Technical Team (2000).
	Buoy 10 (fall) Sub-Legal (<24 inches)	Ratio of Encounters to Landed Catch (Angler Interviews)	Yes –(14-16%)	Yes – (14-16%)	Yes (5%)	PFMC Salmon Technical Team (2000).
	Spring Zone 1-5	Punch card	NA	Yes – 10%	No	Technical Advisory Committee. US v OR TAC Minutes (1987). Lindsay et. al (2004)
	Summer Zone 1-5	Punch card	NA	Yes- 10%	No	Technical Advisory Committee. US v OR TAC Minutes (2003). Lindsay et. al. (2004).
	Fall Zone 1-5	Punch card	NA	Yes – 10%	No	Technical Advisory Committee. US v OR TAC Minutes (1987)
	Mainstem above Bonneville (spring)	Punch card	NA	Yes – 10%	No	Technical Advisory Committee. US v OR TAC Minutes (2003). Lindsay et. al (2004)
	Mainstem above Bonneville (summer)	Punch card	NA	Yes – 10%	No	Technical Advisory Committee. US v OR TAC Minutes (2003). Lindsay et. al (2004)
	Mainstem above Bonneville (fall)	Punch card	NA	Yes – 10%	No	Technical Advisory Committee. US v OR TAC Minutes (1987).
	Spring Tributary	Punch card Creel	NA	Yes – 10%	No	Technical Advisory Committee. US v OR TAC Minutes (2003). Lindsay et. al (2004)
	Fall tributary	Punch card Creel	NA	Yes – 10%	No	Technical Advisory Committee. US v OR TAC Minutes (1987).
	Summer Tributary	Punch card Creel	NA	Yes – 10%	No	Technical Advisory Committee. US v OR TAC Minutes (1987).

4. ESTIMATES OF MORTALITY RATES BY GEAR TYPE

The release of salmon from various types of fishing gear results in some degree of impact on the fish, ranging from minor handling stress to serious injuries resulting from hooking, entanglement in nets, or loss of scales. Associated with catch and subsequent release are varying proportions of released fish that succumb to the impacts. Researchers have studied mortality rates associated with catch and release, and those related to escaping from various gear types, and have categorized the mortality into two broad categories; catch and release, and drop-off. Catch and release mortality is the mortality associated with capture and handling using a particular type of fishing gear or method,. This mortality includes both the immediate and short term mortality (within 24 hours of encounter), and delayed mortality (up to a week after release). Drop-off mortality is an estimate of mortality for fish that were not landed, but either died as a result of the encounter after they escaped from the gear, or were removed from the gear by predators, and died as a consequence.

Numerous studies have compiled information on incidental mortality rates for Pacific salmon. As the trend toward selective harvest has increased, researchers have attempted to tune fishing gear and methods to minimize incidental mortality to non-target stocks or species while maintaining acceptable harvest rates on target stocks or species. For Chinook salmon, studies on fishing related incidental mortality rates prior to and including 1997 were summarized by the CTC (1997). Since 1997, additional studies have been undertaken in an attempt to further define rates of mortality associated with specific gear types and fisheries. This section is intended to summarize studies of relevance to Chinook salmon. Incidental mortality rates are reviewed below, by gear type.

4.1. *Hook And Release Mortalities*

Encounters with hook and line gear have similar consequences, whether the gear is commercial troll or recreational angling gear. Fish are captured using one or more hooks that embed in the vicinity of the mouth, and retrieved to the shore or vessel for subsequent retention or release. Mortality results from injuries conferred by the hook(s) either penetrating vital organs or causing bleeding. Mortality also results from stress associated with handling, and internal or external injuries resulting from capture and subsequent release.

4.1.1. Commercial Troll

Commercial trollers release Chinook salmon either as undersized fish during targeted fisheries for Chinook, or during fisheries targeting other species when Chinook non-retention (CNR) regulations are in effect. The CTC (1997) reviewed release and drop-off mortality rates for troll-caught Chinook salmon. The CTC recommended mortality rates adjusted by hook type (barbed or not) and fish size. Across all fisheries, the CTC (1997) recommended hook and release mortality rates of 21.1% for barbed hooks and legal size fish; 25.5% for barbed hooks and sublegal sized fish; 18.5% for legal sized fish, captured and released using barbless hooks and 22.0% for sublegal sized fish captured on barbless hooks. The CTC also recommended additional fishery specific and average drop-off induced mortality rates. These rates varied from 0.8% for SEAK troll using barbed hooks to 2.5% in Oregon troll using barbless hooks. For all other fisheries, the CTC recommended use of an average value of 1.7% (Table 10). The SST

(2000) recommended a 5% drop-off mortality for fish encountered in ocean salmon hook-and-line fisheries to account for drop-off, predation loss, and noncompliance.

Natural Resources Consultants (1998) also reviewed and studied hook and release mortality rates for Chinook salmon captured using commercial troll gear. No additional information was provided on drop-off mortality. The NRC studies determined a release mortality rate of 20.9% using barbless hooks, similar to the rates proposed by the CTC.

Table 10. Summary of hook and release and drop-off mortality rate estimates for Chinook salmon released from commercial troll fisheries, by study, including and since CTC (1997).

Study	Specific Fishery	Mortality type	Hook Type / Fish Size category			
			Barbed legal	Barbed sub-legal	Barbless legal	Barbless sub-legal
CTC (1997)	No	Hook and release	21.1%	25.5%	18.5%	22.0%
	SEAK Troll	Drop-off	0.8%		2.5%	
	Oregon Troll	Drop-off				
	Average	Drop-off	1.7%			
NRC (1998)	No	Hook and release	No data		20.9%	

4.1.2. Recreational Fisheries

Similar to commercial troll fisheries, recreational fishers release Chinook salmon that have been captured using hook and line. Recreational hook and line fisheries may occur in a wide array of locations, from offshore ocean locations to extreme terminal areas adjacent to spawning grounds. Recreational fisheries often involve the use of natural baits fished actively or passively, and the combinations of factors that influence release mortality are almost infinite.

The CTC (1997) detailed estimates of release mortality of Chinook for recreational fisheries (Table 11). For fish >=33 cm, captured using barbed or barbless hooks, a rate of 12.3% was recommended, whereas for fish < 33 cm, a rate of 32.2% was proposed for saltwater fisheries. Fishery specific and average rates of drop-off mortality were also provided by the CTC. These rates ranged from 2.7% to 14.5%. Release mortality rates estimated by recent studies were very similar (Table 10). NRC (1998) reported average mortality rates of 10.2% using trolling or mooching, as did Cox-Rogers (CDFO personal communication) in the Northern B.C. coast recreational fishery. CDFO (2002) proposed a general rate of 15% for most recreational Chinook salmon releases. Recent investigations have also studied the impact of marine mammal predation on drop-off rates in recreational fisheries. For the Gulf of Georgia recreational fishery, CDFO (2002) reported marine mammal induced drop-off mortality of 15%. The SST (2000)

recommends a 5% drop-off mortality for fish encountered in ocean salmon hook-and-line fisheries to account for drop-off, predation loss, and noncompliance.

Once fully acclimated to freshwater, Chinook are less susceptible to hook and release mortality than while they are undergoing the shift in osmoregulation required for return to freshwater, or during their marine residence. In near terminal and terminal freshwater fisheries, CDFO, unpublished, and Cox-Rogers (CDFO, personal communication) have studied freshwater recreational fisheries-related catch and release mortality on Chinook salmon. There are two general sources of mortality from hook and release in freshwater; one is linked to blood loss, and the inability of the fish to regenerate blood to replace losses, while the other factor is related to the ability to rid the body of the by-products of anaerobic metabolism after capture and release. The latter factor becomes significant as the ambient water temperature exceeds 20C, and the fish is unable to extract sufficient O_2 from the water to rid the body of the lactic acid accumulated during its struggle for freedom.

Table 11. Summary of hook and release and drop-off mortality rate estimates for Chinook salmon released from recreational fisheries, by study, since TCCHINOOK (97)-1 (CTC 1997).

Study	Specific Fishery	Mortality type	Hook Type / Fish Size category			
			Barbed >=33cm	**Barbless >=33cm**	**Barbed <33cm**	**Barbless <33cm**
CTC (1997)	No	Hook and release	12.3%		32.2%	
	SEAK sport Puget Sound Oregon Average	Drop-off Drop-off Drop-off Drop-off	3.6% 14.5% 2.7% 6.9%			
NRC (1998)	Troll / mooch	Hook and release	10.2% barbless single or tandem			
CDFO (2002)	All	Hook and release	15 % Barbless legal			
	South Coast B.C.	Marine Mammal drop-off	15%			
Cox-Rogers (1999 and Pers. Comm)	Area 3	Hook and release	10.2%, trolled or mooched herring			
	Interior Skeena Bar	Hook and release	5%			
CDFO (unpubl)	Extreme terminal (FW) Nicola River	Hook and release	Barbless, all sizes, <4%, using natural bait, but hooks no larger than size 1			

On the Nicola River, B.C., immediate and delayed hooking mortalities never exceeded 3% in six years of study with a total of more than 3000 released fish for fish caught float-fishing using salmon roe as bait, and restricting hook sizes to size 1 or smaller to reduce the likelihood of deadly bleeding (CDFO, unpublished). Angling activities were also halted if water temperatures exceeded 20C. Cox-Rogers (CDFO, personal communication) reported a similar value of 5% for the Skeena River bar fishery in the vicinity of Terrace. Bendock and Alexandersdottir (1993) reported mortality rates ranging from 4.1% to 10.6% (mean 7.6%) in the Kenai River recreational fishery in Alaska. Wound location and bleeding were reported as the factors leading to mortality.

In estuarine areas, catch and release may have much more significant impacts. During the time that return migrating salmon undergo the shift in osmoregulatory function as the fish moves from marine to freshwater, the fish experiences significant stress. Adding additional stress through catch and release at this time may result in significant mortality. While there is little data available on catch and release of Chinook in estuaries, data for other Pacific salmon indicate significantly increased vulnerability to catch and release. Vincent-Lang et al. (1993) noted catch and release mortalities of 69% for coho caught in the estuary of the Little Susitna River, Alaska, but only 12% for those caught in freshwater in the river itself. Similarly, WDFW, when collecting Chinook salmon and chum salmon in estuarine area adjacent to river mouths, noted that mortality was substantially higher for both species for fish captured in the estuary relative to fish captured in freshwater (PSC 1995).

4.2. *Net Fisheries*

Encounters with net gears have different consequences than hook and line gears, and the impacts differ between seines and gill or tangle nets. Fish captured in nets are less likely to suffer externally visible bleeding; however, scale loss from mechanical abrasion, internal injuries from tangling in net web, and capture and handling stresses all may contribute to the release mortality. Predators also remove fish from nets, especially gill or tangle nets, although the rate of removal may be very difficult to quantify.

4.2.1. Seine Fisheries

Injury to fish during capture in seine gear occurs due to several factors. Upon closing the seine, fish attempt to “sound” or find the deepest portion of the net. As the net is retrieved, the fish scrape against the web. In severe cases, total scale loss may ensue. As the net is further retrieved, fish may be transferred to the deck of the vessel either by lifting the entire remaining portion of the net onto the vessel deck, or by “brailing” where some portion of the captured fish are dipped out of the net and transferred to the fishing vessel. Alternately, the net may be gathered and retrieved in board either using the power drum or power block. Power drums are illegal in Alaska, and brailing is mandatory in many fisheries in B.C. Internal injuries often occur, especially when larger catches are lifted on deck, and small fish are often squashed during this procedure.

The CTC (1997) reviewed incidental mortality associated with seine fisheries (Table 12). They determined size specific differences for immediate mortality, and recommended rates of 62.8% for small Chinook, 50.5% for medium Chinook and 28% for large Chinook. The CTC also

reviewed delayed mortality and revised previous estimates of delayed mortality due to seining down to 23% as an average value. The CTC also noted that extremely low values of delayed mortality could be achieved in situations where fish were within 45 to 60 d of spawning.

Table 12. Summary of non-retention mortality rate estimates for Chinook salmon released from seine fisheries, by study, since TCCHINOOK (97)-1 (CTC 1997).

Study	Specific Fishery	Mortality Type	Fish Size category		
			Small Chinook < 53 cm	**Medium Chinook 53-71cm**	**Large Chinook >71 cm**
CTC 1997	No	Immediate	62.8%	50.5%	28.0%
		Delayed	23.0%	23.0%	23.0%
		Total	85.8%	73.5%	51.0%
		Total	72.0% (all sizes comb.)		
	Terminal (<60d to spawning)	Delayed (immediate as above)	1.1%	1.1%	1.1%
		Total	63.9%	51.6%	29.1%
Winther (in prep)	Area 3-4 (brailed)	24 hr	71.6%	48.3%	21.0%

Recently, CDFO has conducted a number of fishery specific studies to investigate ways to reduce incidental mortality on non-target species during fisheries directed at sockeye and pink salmon. Winther (in prep) reported similar results to those reported by the CTC (1997), for immediate mortality (Table 12). Winther also noted that extra large Chinook (>100 cm FL) suffered additional mortality when brailed, due to internal injuries related to bending during transfer from the seine to the vessel deck.

4.2.2. Gill Nets

The CTC has previously noted that releases of Chinook from gill nets while targeting other species are unlikely to be implemented due to the high incidental mortality rates. In 1997, the CTC recommended maintaining a generic estimate of 90% release mortality for Chinook released from gill nets. Since that time, a number of studies have explored the use of live recovery boxes, alternative nets (tangle nets), and short soak time to reduce mortality of salmon released from gill nets. Live recovery boxes have been shown to improve physiological status and short-term viability of coho salmon caught by gill nets (Farrel et al. 2001).

In 2001 and 2002, tangle net gear was tested on the lower Columbia River to selectively harvest adult spring Chinook salmon (Vander Haegen et al. 2002a). The gear was fished in conjunction with live recovery boxes and short soak times. Immediate mortality was measured, and longer-term in-river mortality was estimated by comparing tag recovery rates to control fish tagged in the adult trap in Bonneville Dam, just upstream of the fishing area. Immediate mortality was low (1-3%) for both gear types. Recovery rates of fish marked from tangle nets were twice that of

fish from gill nets, total mortality for fish captured with tangle nets ranged from 16% to 32%. Based on these studies, the Technical Advisory Committee for the Columbia River in 2003 recommended a mortality rate of 25% for non-retention mortality of fish captured in tangle nets, used in conjunction with recovery boxes and short soak times. The studies also indicate a total mortality of around 50% for traditional gill nets when fished with short soak times and recovery boxes, considerably lower than the generic CTC (1997) assumption of 90%.

In another study comparing tangle nets and gill nets in Willapa Bay, Vander Haegen et al. (2002b) found that tangle nets had lower immediate mortality for adult fall Chinook (4% versus 13%), but found no difference in post-release recovery rates between the two gear types. Because no control group was feasible in the Willapa Bay study, total mortality was not estimated. However, the difference in immediate mortality rates for both gear types between the two study areas indicate that fishery-specific differences are important, and should be considered before adjusting mortality assumptions for gill nets.

These studies suggest reductions in the release mortality of Chinook salmon caught by gillnets are possible with gear modification, in conjunction with short soak time and changes in handling prior to release, e.g., gentle removal and use of recovery boxes. Soak time may be particularly important for reducing mortality; for coho salmon, Buchanen et al. (2002) estimated that mortality increases from 10% with 40 minute soak times to 60% with 140 minute soak times.

Drop-off mortality in gill net fisheries can be high, particularly if predators remove fish from the nets (Geiger 1985). Drop-off rates also increase with soak times, and with sea conditions (French and Dunn 1973). The CTC (1997) recommended region-specific drop-off rates (Table 13). However, the CTC model does not now calculate drop-off mortality for gillnet encounters because seine and gillnet fisheries are currently combined in the CTC model.

Table 13. Regional-specific rates for drop-off mortality in gillnet fisheries. Rates shown are additional mortality due to drop-off as a percentage of Chinook encountered in gillnet fisheries, from CTC (1997).

Region	Drop-off Mortality Rate
SEAK	2%
Fraser River	8%
Puget Sound	8%
Washington Coast	2%
Columbia River	3%

5. DISCUSSION

In the 1999 Agreement, the Parties agreed to implement an abundance-based coastwide Chinook management regime. Fishery regimes were classified as aggregate abundance-based management fisheries (AABM) or individual stock-based management regimes (ISBM). The parties also agreed to adopt a management framework for Chinook salmon based on total fishing mortality, and instructed the CTC to recommend a work plan to ensure adoption of a total fishing mortality regime.

Total fishing mortality is already a fundamental component of the abundance-based management regime implemented under the 1999 Agreement. Cohort reconstruction and computation of brood year exploitation rates require estimates of total mortality. These procedures underlie the estimation of fishery indices for setting AABM catch targets, and for evaluating ISBM fisheries in relation to escapement goals and general obligations to reduce harvest rates relative to the base period.

Estimates of incidental mortality are essential to the exploitation rate analysis and the CTC model calibration. These estimates are often based on limited empirical information, or are generated by CTC model algorithms based on unvalidated assumptions. The CTC has reviewed existing procedures and programs for estimating incidental and total mortality in this report. The CTC has identified and prioritized deficiencies in the estimation of fishery-specific encounter rates and associated mortality. The CTC has also identified CTC model changes necessary to improve model-derived estimates and reporting of total mortality.

5.1. *Data Gaps*

5.1.1. Encounter Rates

The comparisons of CTC model-derived estimates of incidental mortality with external estimates for CNR fisheries (Table 2) convincingly demonstrate that incorporating external estimates into the model calibration process improves the validity of the model estimates. External estimates of incidental mortality in retention fisheries were also often very different from model-generated estimates, indicating that developing the capability to use appropriate external data as model input for these fisheries would also improve the model estimates of total mortality. These results support the directive in the 1999 Agreement that "improved estimates of incidental mortality are to be developed based upon direct fishery observations" (Appendix to Annex 4, Chapter 3, page 48). In 2001, only 7 of the 25 CTC model fisheries had external estimates of incidental mortality. In 2004, this is projected to improve to 11 fisheries, with partial coverage for 10 other fisheries (Table 1). The CTC urges agencies to increase coverage of these PSC fisheries for incidental mortality estimation. In particular, the CTC encourages agencies to examine PSC fisheries with partial coverage to determine if appropriate expansions can be developed for estimating incidental mortality for the entire PSC fishery, so that the estimates can be used as external inputs to the CTC model.

Of the PSC fisheries for which there are not total direct estimates of incidental mortality, those fisheries that have relatively high levels of nominal mortality should be given priority for developing estimates of encounter rates from direct sampling or sampling-derived relationships

for the entire fishery. The highest priorities are the four fisheries that have only model-derived or partial estimates of nominal incidental mortality in excess of 10,000 fish. These fisheries are: SEAK Net, NBC Net, Puget Sound Net, and Washington/Oregon Troll (Table 1).

The CTC recognizes that direct estimation of incidental mortality is expensive and can be difficult, especially in fisheries that have large numbers of participants and are widely dispersed spatially and temporally. Development of fishery-specific indirect methods, such as relationships between encounters and landed catch or effort, may be necessary in some fisheries. Logbook and mail-in surveys can be cost-effective means of obtaining information on incidental mortality, relative to direct monitoring. However, validation of such methods is necessary on at least an intermittent basis. The CTC also has general concern and interest in information quality for estimates of incidental mortality that are reported by the CTC and that are or would be used as external inputs to the CTC model. At this time, the CTC relies on the agencies to provide information and data with reasonable scientific validity. To address this concern, the Bilateral Data Standards sub-committee of the CTC has been assigned to develop data standards for reporting incidental encounters and mortality of Chinook salmon.

Substantial increases in catch-and-release encounters of some CTC stocks are expected in selective fisheries. These fisheries are designed to reduce landed catch mortality on wild stocks while allowing harvest of abundant hatchery stocks. Currently, considerable effort is being directed at designing sampling programs for selective fisheries so that they will be adequately sampled for release encounter rates. These sampling programs are essential to provide information needed to adequately account for total mortality in PSC Chinook salmon fisheries.

5.1.2. Mortality Rates

The CTC has previously reviewed literature on mortality rates associated with release or drop-off of incidentally encountered Chinook salmon, and recommended both fishery-specific and gear-specific mortality rates (CTC 1997). These rates have been incorporated into the CTC model as appropriate. Subsequent to CTC (1997), several studies reported gear- or area-specific mortality rates that differ from the rates now assumed by the CTC. These studies are cited in Section 4 of this report. Also, the re-coded version of the CTC model will permit greater resolution in terms of number of fisheries, and thus allow the possibility of more specificity in the application of incidental mortality rates in the CTC model. The CTC is amenable to the adoption of fishery-specific mortality or drop-off rates in addition to or instead of the rates currently used as per CTC (1997). To adopt such mortality rates, the CTC would require the proposing agency to provide a report documenting the scientific basis of the rate estimates, for review and approval by the bilateral CTC.

The CTC encourages research into incidental mortality rates to refine existing rates or to develop more fishery-specific rates. In particular, the CTC identifies research on generic gillnet drop-off rates, and drop-off rates in fisheries with high marine mammal interactions (e.g., Georgia Strait Sport) as high priority issues.

5.2. *CTC Model Changes*

While the CTC model and exploitation analyses explicitly account for total mortality, the CTC has identified areas where estimation and reporting of incidental mortality can be improved. As noted earlier, comparison of CTC model estimates of incidental mortality with external estimates for both CNR and retention fisheries (Tables 2, 3) demonstrate that incorporating external estimates into the CTC model calibration process improves the validity of the CTC model estimates of incidental mortality. At this time, only external estimates of CNR incidental mortality can be incorporated into the CTC model. A high priority for CTC model improvement should be to modify the model to use external estimates of incidental mortality for retention fisheries.

Incidental mortality estimates may be improved by separating current CTC model fisheries into component fisheries. The CTC model has historically been constrained to 25 fisheries because of memory limitations of the Quick Basic programming language. The model has now been recoded into Visual Basic, which does not have the same limitations. This will allow resolution of fisheries into groupings that are more tractable for estimation of incidental mortality. Three specific types of PSC fisheries have high priority for separation into component fisheries. First, PSC fisheries that aggregate component fisheries with different gear types that have inherently different encounter and mortality rates need to be separated. Examples are the combination of seine and gill net fisheries in a number of the net fisheries. Second, PSC fisheries that include both AABM and ISBM fisheries need to be separated into these components. Examples are the NBC Sport and WCVI Sport fisheries. Third, the terminal fisheries that aggregate fisheries over a broad geographic range need to be separated into more specific areas. These are the Terminal Net and Terminal Sport fisheries.

Certain types of incidental mortality are not currently accounted for in the CTC model. These include mortality of fish above the legal minimum size in sport fisheries with sorting or slot limits, and fish landed in 'voluntary CNR' fisheries that have recently been implemented in some Canadian net fisheries. In these voluntary CNR fisheries, which may extend all season (e.g., Juan de Fuca net), dead or moribund Chinook can be retained but others are released on a voluntary basis. The implementation of certain measures such as short soak times in gillnet fisheries, a requirement for brailing in seine fisheries and voluntary use of mandatory onboard flow-through revival tanks have substantially improved the likelihood of survival of Chinook caught in such fisheries. Retained catch has been small relative to the number of mixed-size releases. For the CTC model to correctly model incidental mortality from sorting in sport fisheries and from voluntary-CNR fisheries will require both landed catch data as well as the CNR encounter information. Because not all fisheries will have such external estimates in the near future, the CTC also needs to investigate and develop computational algorithms for estimating these mortality sources for inclusion in the CTC model.

Comparisons between external estimates of incidental mortality and estimates generated by model algorithms indicate systematic bias in the CTC model estimates of encounters when the external estimates of encounters are not used as input to the model. Relative to actual observations, encounter rates and mortality of sublegal fish tend to be overestimated in troll and sport fisheries by the CTC model. In contrast, encounters and mortality in net fisheries tend to be underestimated by the CTC model. Again, the best solution to this issue is to develop and use external estimates for these mortality sources. But for estimation of incidental mortality in

fisheries that will not have external estimates, the CTC needs to evaluate and revise current model algorithms to reduce the observed biases.

5.3. *Reporting Of Total Mortality*

The CTC annual reports currently provide inadequate accounting or reporting of incidental and total mortality. The annual catch and escapement reports (e.g., CTC 2003) provide information on landed catch only, but the CTC exploitation rate analysis and CTC model calibration explicitly account for and use estimates of total mortality. However, in the most recent report (CTC 2002), only observed catch data were tabulated, and the estimation of non-catch mortality was reported only in the context of brood year total exploitation rates. Future reports need to be modified to adequately report the extent of non-catch mortality and total mortality in PSC fisheries. External estimates of incidental mortality, where available, should be included in the catch and escapement report. Reporting should include the estimates by size category (legal/sublegal) in nominal fish, and should be tabulated to facilitate comparison with CTC model estimates. The annual exploitation rate and CTC model calibration report should include the model estimates, in nominal fish, of landed catch, sublegal and legal non-catch mortality, and total mortality for each PSC fishery. The technique for generating CTC model estimates of non-catch mortality (estimated from input of external estimates versus internal model estimates) should be identified, and the estimates compared to external estimates from the catch and escapement report where possible.

5.4. *Workplan Schedule*

Part of the assignment to the CTC on incidental mortality was to recommend a workplan to address data deficiencies that will enable implementation of a total mortality regime. In Sections 5.2 and 5.3, the CTC has identified high priority data deficiencies that need to be addressed by the Parties' management agencies. The CTC also has identified the following list and time schedule for data and CTC model deficiencies that the CTC can directly address.

-Incorporate improved reporting of total and incidental mortality (in nominal fish) in the annual catch and escapement report. April 2004.

-Include CTC model-generated estimates of incidental mortality by size class (legal/sublegal) for each PSC fishery in the annual exploitation rate analysis and model calibration report. June 2004.

- Modify the CTC model to use available external estimates of encounters for retention fisheries. September 2004.

-Modify the CTC model to separate out component net fisheries (seine, gillnet). September 2005.

-Modify the CTC model to separate ISBM and AABM components in current model fisheries such as NBC sport, WCVI sport. September 2004.

-Modify the mortality rate matrix in the CTC model to account for fishery-specific differences on a case-by-case basis, as new rate estimates proposed by agencies are approved by the CTC for application in the model. Include the mortality rate matrix in the annual Model Calibration and Exploitation Rate Analysis Report starting June 2004.

-Develop bilateral data standards for estimates of incidental encounter sampling programs: concurrent with bilateral standards report.

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APPENDICES

Appendix 1. Equations used in calculating Shaker and Drop-off Mortality in the CTC Chinook Model.

(1) Identify the stocks that contribute to the catch in the fishery at any age

(2) For those stocks only,

(a) Compute the total non-vulnerable population and vulnerable population

$$TotPNV_f = \sum_s \sum_a Cohort_{s,a} * PNV_{f,a} \quad (1)$$

$$TotPVu\ln_f = \sum_s \sum_a Cohort_{s,a} * (1 - PNV_{f,a}) \quad (2)$$

Where Cohort is the Terminal Run Size for the stock if the fishery is a terminal fishery for that stock or the Pre-Fishery Cohort size otherwise.

(b) Compute the encounter rate (used by another subroutine to estimate the total shaker mortality):

$$EncRt_f = \frac{TotPNV_f}{TotPVu\ln_f} \quad (3)$$

(c) Compute the proportion of the shakers that should be allocated to each stock and age

$$FracNV_{f,s,a} = \frac{Cohort_{f,s,a} * PNV_{f,a}}{TotPNV_f} \quad (4)$$

The summation of the $FractNV_{s,a}$ across all stocks and ages for the fishery must equal 1.0.

Total shakers in the fishery is the product of the total catch times the encounter ratio times the shaker mortality rate.

$$TotShak_f = ShakMortRate_f \cdot EncRt_f \cdot \sum_s \sum_a legalCatch_{s,a,f} \quad (5)$$

$$ShakMortRte_f = SublegalReleaseMortRate_f + DropOffRate_f \quad (6)$$

Note. If you supplied new sublegal legal release mortality rates as well as a new drop-off rate to take effect after a specified year via the .im file, then eq 6 will be overwritten with the new rates.

(3) Total shakers are distributed by stock and age to get sublegal shakers.

$$SublegalShak_{f,s,a} = TotShak_{f} \cdot FracNV_{f,s,a} \quad (7)$$

LegalDrop-offs are added to the sublegal shakers to get total shakers:

$$ShakCat_{f,s,a} = SublegalShak_{f,s,a} + LegalDropOffs_{f,s,a} \quad (8)$$

where

$$LegalDropOffs_{f,s,a} = LegalCatch_{f,s,a} \cdot DropOffRate_{f} \quad (9)$$

Appendix 2. Selectivity Factors

Gear selectivity factors used to adjust legal and sublegal size encounters in the calculation of incidental mortalities in CNR fisheries in the Chinook Model. These values are included as input to the Chinook Model is the CNR file. Of the 25 Model fisheries, 17 have had CNR restrictions in effect in at least one annual period. The same values are used in the Exploitation Rate Analysis and are supplied to the Cohort Analysis in the PSL file.

Fishery Number	Fishery Name	Legal Selectivity Factor	Sublegal Selectivity Factor
1	Alaska Troll	0.34	1.00
2	Northern B.C. Troll	0.20	1.00
3	Central B.C. Troll	0.20	1.00
4	WCVI Troll	0.34	1.00
6	Strait of Georgia Troll	0.34	1.00
7	Alaska Net	0.34	1.00
8	Northern B.C. Net	1.00	1.00
9	Central B.C. Net	1.00	1.00
10	WCVI Net	1.00	1.00
11	Juan de Fuca Net	1.00	1.00
16	Johnstone Strait Net	1.00	1.00
17	Fraser Net	1.00	1.00
19	North/Central B.C. Sport	0.34	1.00
20	WCVI Sport	0.34	1.00
22	North Puget Sound Sport	0.34	1.00
23	South Puget Sound Sport	0.34	1.00
24	Strait of Georgia Sport	0.34	1.00

Appendix 3. Chinook Non-retention (CNR) Mortality Estimation in the CTC Chinook Model.

2.1. Estimation of CNR Encounters

2.1.1. CNR Harvest Ratio Method

$$CNRSublegalRatio_f = CNRSublegalSel_f \cdot \frac{1 - RT_f}{RT_f} \quad (1)$$

$$CNRLegalRatio_f = CNRLegalSel_f \cdot LegalCNRMortRate_f \cdot \frac{1 - RT_f}{RT_f} \quad (2)$$

where

$$LegalCNRMortRate_f = LegalShakerMortRate_f + DropOffRate_f \quad (3)$$

2.1.2. CNR Season Length Method

$$CNRSublegalRatio_f = CNRSublegalSel_f \cdot \frac{CNRSeasonLength_f}{LegalSeasonLength_f} \quad (4)$$

$$CNRLegalRatio_f = CNRLegalSel_f \cdot LegalShakerMortRate_f \cdot \frac{CNRSeasonLength_f}{LegalSeasonLength_f} \quad (5)$$

2.1.3. CNR Reported Encounter Method

$$CNRSublegalRatio_f = \frac{1}{EncRt_f} \cdot \frac{RptSublegalEncounters_f}{RptLegalCatch_f} \quad (6)$$

$$CNRLegalRatio_f = CNRMortRate_f \cdot \frac{RptLegalEncounters_f}{RptLegalCatch_f} \quad (7)$$

2.2. Estimation of CNR Mortality

$$SublegalCNRMorts_{f,s,a} = CNRSublegalRatio_f \cdot SublegalShak_{f,s,a} \quad (8)$$

$$LegalCNRMorts_{f,s,a} = CNRLegalRatio_f \cdot LegalCatch_{f,s,a} \quad (9)$$

Appendix 4. Computation of the Abundance Index for AABM Fisheries

$$AI_{f,y} = \frac{\sum_{s}\sum_{a}\left[C_{s,a,by} * SR_{a} * ER_{f,s,a} * \left(1 - PNV_{f,a}\right)\right]}{\sum_{1979}^{1982}\left\{\sum_{s}\sum_{a}\left[C_{s,a,by} * SR_{a} * ER_{f,s,a} * \left(1 - PNV_{f,a}\right)\right]\right\} \Big/ 4}$$

Where:
AI = Abundance Index
C = Cohort Size
SR = Survival Rate
ER = Base Period Exploitation Rate
PNV = Proportion Non-Vulnerable
f = fishery
s = stock
a = age
y = calendar year
by = y-a

Appendix 5. Computation of ISBM Indices

The 1999 agreement states that "the non-ceiling index defined in TCCHINOOK (96)-1 … will be used to measure performance of ISBM fisheries." The non-ceiling index (hereinafter referred to as the ISBM index) is a total mortality index defined for a stock/country combination:

$$ISBMIdx_{CY} = \frac{\sum_{f \in \{F\}} \sum_{a=Minage}^{Maxage} \left(TotMorts_{CY,f,a} * AEQ_{BY,a,f} \right)}{\sum_{f \in \{F\}} \sum_{a=Minage}^{Maxage} \left(BPISBMER_{f,a} * Cohort_{BY,a,f} \right)}$$

$$BPISBMER_{f,a} = \frac{\sum_{BPER=79}^{82} \frac{\left(TotMorts_{BPER,f,a} * AEQ_{BPER-a,a,f} \right)}{Cohort_{BPER-a,a}}}{4}$$

where:

ISBMIdx = passthrough index = ISBM index
CY = calendar year
f = ISBM fishery within a country
a = age
BY = *CY* - a
F = the set of passthrough fisheries within a country
Minage = 2 for ocean type stocks, 3 for stream type stocks
Maxage =5 for ocean type stocks, 6 for stream type stocks
Cohort = cohort size at age in year y after natural mortality. For terminal fisheries, cohort size is ocean escapement plus ocean net catch age 4+.
AEQ = adult equiv factor by age and year. If a fishery is terminal for a stock, AEQ =1 for all ages and years for that stock/fishery combination.
TotMorts = total mortalities = LC + Shakers +CNRLegal Mortalities + CNR Sublegal Mortalities.
BPER = base period exploitation rate

Direct application of the CTC model alone or CWT data alone is not possible in the computation of the ISBM indices for all stocks for several reasons. In some cases, computation of the stock specific ISBM index requires defining fisheries at a finer resolution than either the CTC model or exploitation rate analysis currently provide. In many cases, there are terminal area fisheries on wild ISBM stocks which cannot be accurately modeled or estimated directly since CWT based exploitation rate estimates (used in both model and CWT derived estimates) are not applicable to the wild stock.

In those instances the following methods are used. Not all methods are used in all situations. Choice of method depends on data availability and may vary by stock, year, and method of analysis.

1. To generate preseason model based ISBM indices, two pre-season models, the Fisheries Resource Assessment Model (FRAM) and/or the Columbia River Harvest Model, are used to predict stock-specific landed catch impacts in inside fisheries (Puget Sound net and sport, and the Columbia River net and sport fisheries respectively). These estimated impacts are used to compute the Chinook model fishing policy (FP) factors for the corresponding PSC model fisheries. PSC model estimates of total fishing mortality are then used to compute the index.

2. In some cases, for model generated preseason estimates of the ISBM index, no preseason prediction of harvest rates in ISBM fisheries or no prediction of wild stock abundance is available. In those cases, a repeat of the previous years harvest rates or abundances (cohort sizes) was assumed. In the case of Oregon coastal stocks, a repeat of harvest rates from 2 years previous is required. These estimated impacts are used to compute the Chinook model fishing policy (FP) factors for the corresponding PSC model fisheries. PSC model estimates of total fishing mortality are then used to compute the index.

3. In many instances, historic external estimates of impacts in terminal ISBM fisheries are used to generate FP estimates (for model generated estimates) or to modify estimated CWT recoveries (for CWT-based estimates) for many stocks. This is necessary because terminal impacts on many CWT indicator stocks are not representative of the fishery impacts on the stock of interest. Additionally, for CWT based estimates, terminal impacts are often based on landed, or observed catches only. In those instances, the ratio of observed CWT recoveries to estimated CWT incidental mortalities estimated in the same or a nearby fishery with regulations consistent with the wild stock fishery is used to estimate total mortalities of the wild stock in the fishery. These mortalities are then substituted for the observed CWT mortalities in the ISBM computations as needed.

4. For the CWT-based estimates, some CWT stocks used to represent wild stocks in the ISBM index did not have 1979 – 1982 base period recoveries. For these stocks, base period exploitation rates for the model stock associated with the wild stock were used, if available.