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JOINT CHINOOK TECHNICAL
COMMITTEE REPORT

COMMITTEE RESPONSE TO QUESTIONS FROM THE PSC COMMISSIONERS REGARDING THE U.S. AND CANADIAN PROPOSALS FOR ABUNDANCE-BASED REGIMES FOR CHINOOK FISHERIES
REPORT TCCHINOOK (98)-1

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1.0 Introduction

In February of 1998, the United States (U.S.) and Canada exchanged proposals for abundance-based management regimes for chinook salmon. While many aspects of the proposals are similar, conceptual and technical differences exist. To identify and determine the significance of those differences, the Commissioners asked a bilateral workgroup to develop a list of expository questions. A subgroup of the Chinook Technical Committee (CTC) was subsequently requested by the Commissioners to address these questions. This report was prepared by the Chinook Technical Committee (CTC) in response to that request.

Briefly, both the U.S. and Canadian proposals include: 1) an abundance-based management approach for chinook salmon that includes limits for mixed-stock ocean fisheries and constraints for remaining fisheries; 2) provisions for adjusting allowable harvests in response to stock status; 3) a list of technical assignments; 4) approaches to reduce incidental mortalities; and 5) provisions for terminal exclusions, hatchery add-ons, and overage /underage policies.

This report discusses significant differences between the Canadian and U.S. proposals, including:

1) provisions for individual stock-based management (pass-through);
2) harvest regimes based on catch indices versus total mortality indices;
3) aggregation of fisheries;
4) harvest rate reductions;
5) methods for computing the allowable harvest.

There are differences between the proposals that the report does not address. For example, whereas both proposals include adjustments in allowable harvests in response to stock status, the mechanism triggering the response differs. Also, the entire U.S. proposal takes effect immediately and the Canadian proposal is to be implemented in stages. These and other differences may be more appropriate for discussion within the PSC.

The commissioners also requested a retrospective comparison of the U.S. and Canadian proposals, with predictions of the catches, exploitation rates, and escapements that would have occurred if the proposed regimes would have been in effect from 1985 through 1996. The CTC has not yet completed that assignment, but will provide a complete report prior to the end of 1998.

2.0 Types of Management Regimes

The U.S. and Canadian proposals each describe two broad classes of fishery regimes, aggregate abundance-based management and individual stock-based management. The first class, applicable to many fisheries previously managed with catch ceilings, is variously referred to as "a long-term abundance-based framework" (U.S. proposal) or "ocean-limit fisheries" (Canadian proposal). The second type, unnamed in the U.S. proposal and termed pass-through in the Canadian proposal, is applicable to many fisheries previously subject to the pass-through provision.

To simplify presentation of our analyses, we provide below a definition for each class that encompasses both the U.S. and Canadian proposals, while recognizing that important variations exist within each class. The implications of many of these variations are discussed in later sections of this report.

Aggregate Abundance-Based Management (AABM). AABM is management to constrain catch or total mortality to a numerical limit computed from either a preseason forecast or an inseason estimate of abundance and a desired harvest rate index measured as a proportion of the 1979 through 1982 base period value. Indices proposed by both the U.S. and Canada are substantially less than 1.0, indicating a reduction in harvest rates relative to the base period. Deviations from the target, which may be determined from postseason estimates of catch or total mortality and abundance, are addressed in the subsequent fishing year through an overage/underage policy[1,2,3].

Although the U.S. and both Canadian AABM regimes are consistent with this definition, they differ in at least five ways:

1) the CTC abundance index is computed for a fishery within a nation (U.S.) versus fishery aggregates that span both nations (Canada);
2) inseason estimates of abundance may be incorporated in management (U.S.) versus excluded from consideration (Canada);
3) the fishery impact limit is expressed in terms of catch (U.S.) versus catch plus a preseason or inseason estimate of incidental mortality (Canada);

[1] The U.S. and Canadian proposals for AABM regimes both provide additional harvest opportunities under some circumstances:

a) additional harvest may be provided in terminal fisheries in which naturally spawning chinook abundance is predicted to exceed escapement requirements (terminal exclusion);
b) additional harvest may be provided based on a demonstration of the contribution of each regions' new enhancement activities.

[2] The U.S. and Canadian proposals both indicate that the previous overage/underage procedures will be applied to AABM fisheries, but do not provide a detailed explanation of how they would be incorporated in the AABM fishing regimes.

[3] The U.S. and Canadian proposals also contain provisions for adjusting AABM regimes to provide additional protection for depressed stocks. The Canadian proposal also contains provisions to increase exploitation rates. The CTC did not evaluate these provisions.

4) the harvest rate index is fishery and abundance specific (U.S.) versus fixed at a 50% reduction[4];
5) the fishery impact limit in the U.S. proposal is computed from a prediction of abundance (preseason from the PSC model or inseason from catch and effort data), the target harvest rate index, and the historic relationship between abundance, catch, and postseason estimates of harvest rate indices. The Canadian proposal computes a fishery impact limit from a preseason prediction of abundance from the PSC model, the target harvest rate index, and the proportion of the actual catch accounted for by the PSC chinook model after a model calibration.

Individual Stock-Based Management (ISBM). ISBM is proposed to apply to all fisheries without AABM. Consequently, ISBM fisheries can have a wide variety of characteristics, but one key characteristic is that management is based upon the requirements of individual stocks. ISBM can be defined as a management regime in which a limitation is placed on the exploitation rate[5] or mortality[6,7] of a naturally spawning chinook stock in all non-AABM fisheries. For example, a mortality limit could be a fixed cap (e.g., 1000 fish) or, in some terminal areas, computed each year by subtracting the escapement objective from the run size. In the U.S. and Canada proposals, no preseason or inseason analysis is required to assure the PSC that proposed fishing regimes will comply with the ISBM requirements, nor are any overage/underage provisions included.

In summary, three primary differences between AABM and ISBM regimes are:

1) the allowable impact is computed based on the aggregate abundance of stocks (AABM) versus the status of individual stocks (ISBM). In an AABM regime, the aggregate abundance of stocks in the fishery and the target harvest rate index (which is not stock specific) are used to compute an allowable catch for the fishery. Conversely, in an ISBM regime, the allowable exploitation rate may be stock specific, and the total catch will vary depending on that rate and the aggregate abundance of stocks in the fishery;
2) preseason and/or inseason analysis is required to establish impact limits under annex provisions (AABM) or not required preseason but would be evaluated postseason (ISBM);

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[4] The Canadian proposal suggests that the target harvest rate indices will be revised by 2000 in response to new estimates of escapement goals, sustainable exploitation rates, and stock aggregate-specific management needs.

[5] The exploitation rates may be expressed relative to a cohort and/or to the maturing component of a cohort.

[6] The U.S. proposal requires that the fisheries "shall be managed so as not to contribute significantly over time to a decline below the MSY or other agreed biologically-based escapement objectives such that production from the stocks would be likely, through this agreement, to lead to additional constraints on the ocean or terminal fisheries covered by this agreement." The proposal does not provide an explicit definition of the key phrase of "contribute significantly"; presumably it could be expressed in terms of an allowable exploitation rate or an allowable number.

[7] The Canadian proposal states that "the pass-through index in CTC Report TCCHINOOK (96)-1 will be used to measure compliance with obligations for pass-through stocks and the fisheries these are exploited by." This index is exploitation rate based but would be applied only to depressed stocks. Stocks that are not depressed would presumably be managed in a manner consistent with the general obligations of the Pacific Salmon Treaty.

3) deviations from allowable impacts are addressed via an overage/underage policy (AABM) or not addressed (ISBM).

3.0 Comparison of ISBM Provisions

The U.S. and Canadian proposals provide vague and/or incomplete descriptions of the management provisions for the ISBM fisheries. The U.S. proposal states:

> "Fisheries south of the Washington-Canada border and other fisheries affecting the stocks subject to this agreement (but not otherwise specifically governed by this agreement) shall be managed in a complementary and coordinated manner with the fisheries governed in paragraphs 1 through 4 above. In general, the intent is to manage these fisheries so as to achieve the objective of MSY or other agreed biologically-based escapement objectives. More specifically, they shall be managed so as to not to contribute significantly over time to a decline below the MSY or other agreed biologically-based escapement objectives such that production from the stocks would be likely, through this agreement, to lead to additional constraints on the ocean or terminal fisheries covered by this agreement."

The concluding sentence is the most specific. However, in the absence of a quantitative definition for the key phrase, "contribute significantly over time to a decline" below the agreed escapement goal, the CTC would not be able to provide an evaluation of fishery compliance with the provision.

The Canadian proposal is more specific, stating:

> "In the two year implementation period, pass-through will be evaluated on a national basis using a target TFM reduction of [25%] of the base period (1979-1982) exploitation rate for depressed natural stocks. The pass-through index in CTC Report TCCHINOOK (96)-1 will be used to measure compliance with obligations for pass-through stocks and the fisheries these are exploited by."

This proposal defines a statistic to assess compliance, but does not define a "depressed stock" or identify the stocks to which the proposal applies. Is it all escapement indicator stocks currently identified by the CTC or a subset? The stocks covered by the provision could have a significant affect on the management actions that would be required.

Uncertainty exists in both the U.S. and Canadian proposals regarding the allowable exploitation rates on naturally spawning chinook stocks in ISBM fisheries. As previously discussed, the U.S. proposal leaves some key phrases undefined. The Canadian proposal suggests a 25% reduction from the 1979-1982 base period, but more restrictive management actions have occurred since 1985 in some Canadian fisheries. Consequently, Canadian members of the CTC believed that the 25% percent reduction in the Canadian proposal should be viewed as a "worst case" (least restrictive), and that management would often continue to be more restrictive.

Given the uncertainties in implementing either the U.S. or Canadian proposal, the CTC chose to complete a retrospective assessment of the ISBM regimes using a range of reductions (20%-40%) from the 1979-1982 base period (see response to question 3.3).

1) How do the fisheries covered by the ISBM provision differ between the U.S. and Canadian proposals?

The Canadian proposal suggests ISBM regimes for a number of fisheries that the U.S. proposal suggests for inclusion in AABM regimes (Central British Columbia (CBC) all gear, Georgia Strait (GS) sport and troll, and West Coast Vancouver Island (WCVI) sport) (Table 3-1). In addition, Canada proposes one fishery (North of Leadbetter Point, or NLP, troll) for AABM management that the U.S. includes in ISBM management. The Canadian proposal also provides the potential for the WCVI and NLP troll fishery to be managed under ISBM and AABM regime at different times of the year[8].

The U.S. proposal suggests managing the WCVI sport fishery, formerly a pass-through fishery, as an AABM fishery in conjunction with the WCVI troll fishery (Table 3-1).

Table 3-1. Summary of differences in the fisheries covered by the ISBM provision in the U.S. and Canadian proposals.

Fishery	U.S. Proposal	Canadian Proposal
CBC Troll, Net, and Sport	Included in NCBC AABM	ISBM
GS Sport and Troll	AABM	ISBM
WCVI Sport	Included in WCVI AABM	ISBM
NLP Troll	ISBM	AABM, potential for ISBM
WCVI Troll	AABM	AABM, potential for ISBM

2) What are the management consequences of ISBM versus AABM fisheries?

a) Since an ISBM regime is applied to all non-AABM fisheries within a nation, flexibility is provided in allocating impacts among those fisheries. Under the Canadian proposal, each Party would be free to annually reallocate impacts on a depressed stock among ISBM fisheries.

b) The total catch in both AABM and ISBM regimes will vary with the abundance of chinook available to the fishery, but:

   i) for an AABM regime, the magnitude of the catch is driven by the abundance of the major stocks contributing to the fishery. An AABM fishery will generally not be responsive to fluctuations in the abundance of stocks that contribute on average only a small portion of the total abundance of chinook available to the fishery[9];

[8] Consistent with the instruction accompanying the questions, the CTC did not evaluate any mixed AABM/ISBM regimes for a single fishery.

[9] Both the U.S. and Canadian proposals contain provisions for adjusting AABM regimes to provide additional protection for depressed stocks.

ii) the catch in an ISBM regime is potentially more responsive to fluctuations in the abundance of individual stocks than an AABM regime for at least two reasons. First, the allowable impacts may be specified on a stock-specific basis in an ISBM regime. Since each stock may have different management requirements, and the most constraining requirement could vary between years, substantial interannual variability can be anticipated. Second, the allowable impact in one fishery may be dependent upon the anticipated fishing regime in other ISBM fisheries. For example, if the impacts on chinook associated with the ISBM fishery result from incidental harvest during fisheries directed at other species, the fishery effort directed at harvesting that species and the abundance of chinook may determine the chinook catch. Potentially then, another ISBM fishery within that nation and year may have to compensate for the anticipated incidental impacts in other ISBM fisheries.

c) The proportion of a stock taken by a fishery will depend upon the characteristics of either the ISBM or AABM regime. AABM regimes may be designed to take a fixed proportion of a stock-cohort regardless of the CTC abundance index for the fishery (e.g., Canadian proposal) or a proportion that varies depending on the abundance index (e.g., U.S. proposal). For ISBM fisheries, the proportion of a stock taken by a fishery may depend upon run timing, abundance, management objectives (e.g., fisheries may be directed at species other than chinook; escapement objectives for the naturally spawning stocks occurring in that fishery).

d) Both parties have proposed adapting the overage/underage provisions previously used for ceiling fisheries for use in the AABM fisheries. These provisions may not be applicable to ISBM fisheries, and neither Party has proposed such a provision.

e) In comparison to AABM fisheries, the management requirements for pass-through fisheries have previously not been addressed as thoroughly in PSC preseason planning, nor are they in the proposals for ISBM fisheries provided by either Party. If more fisheries come under ISBM management, and the ambiguities remain in the requirements for ISBM fisheries, there would be less certainty in pre-season planning.

3) What are the relative effects of the U.S. and Canadian ISBM provisions on the escapement of wild stocks with escapements below goal?

As discussed in the introduction to this section, the ISBM provisions in both the U.S. and Canadian proposals are not sufficiently precise to allow the CTC to technically compare the effect each proposal would have upon the escapements of naturally spawning chinook However, we have provided a retrospective analysis of the sensitivity of escapement to a range of potential ISBM provisions.

The PSC chinook model was used to simulate the effect reductions in harvest rate indices of 20%, 30%, and 40% would have had on escapements in the years 1985 through 1996. The reductions were applied to two sets of fisheries. In the first set, the reductions were applied to the ISBM fisheries proposed by the U.S.; in the second, the reductions were applied to the ISBM fisheries proposed by Canada. Catches in AABM fisheries were set at observed levels for all analyses.

Results from a retrospective application of the alternative ISBM provisions are presented in Table 3-2. The table shows the average (1985-1996) percent difference in model stock escapements for PSC chinook model simulations with actual fisheries versus the escapements resulting from model simulations of six alternative ISBM provisions. The six model stocks included in the table reflect a variety of migration patterns and geographic locations. Note that the comparisons are made assuming that AABM fisheries are held at actual observed catches and are not adjusted in response to changes in escapements or production and that changes in escapements reflect cumulative effects resulting from production increases.

Table 3-2. Average annual percent change in spawning abundance resulting from three reductions in harvest rate indices (20%, 30%, and 40%) and two sets of fisheries (U.S. and Canadian proposals for ISBM fisheries). Note that all AABM fisheries were simulated at observed catch levels.

	U.S. Proposed ISBM Fisheries			Canada Proposed ISBM Fisheries		
Stock	**20%**	**30%**	**40%**	**20%**	**30%**	**40%**
Upper Strait of Georgia	- 3%	+ 2%	+ 6%	- 16%	- 6%	+ 3%
Lower Strait of Georgia	0%	+ 9%	+ 18%	+ 1%	+ 25%	+ 51%
Fraser Late	+ 13%	+ 26%	+ 40%	+ 5%	+ 29%	+ 55%
Skagit	+ 8%	+ 15%	+ 23%	+ 5%	+ 15%	+ 26%
Stillaguamish	+ 3%	+ 14%	+ 27%	+ 10%	+ 26%	+ 43%
Snohomish	+ 44%	+ 71%	+ 99%	+ 40%	+ 72%	+103%
Columbia R. Summer	+ 2%	+ 4%	+ 6%	- 7%	- 2%	+ 3%

4) What are the technical characteristics of fisheries for which AABM or ISBM fishery regimes are appropriate?

Three primary differences between AABM and ISBM regimes were identified in Section 2.0:

a) the allowable impact is computed based on the aggregate abundance of stocks (AABM) versus the status of individual stocks (ISBM), although both Parties suggested that AABM regimes may include adjustments to target harvest rate indices that depend upon the status of naturally spawning chinook stocks;
b) preseason and/or inseason analysis is required to establish impact limits under annex provisions (AABM) or not required preseason but would be evaluated postseason (ISBM);
c) deviations from allowable impacts are addressed via an overage/underage policy (AABM) or not addressed (ISBM).

These differences suggest the following general technical characteristics for an AABM and an ISBM fishery as they are presently defined in the proposals:

> AABM. An AABM fishery will typically exploit a large number of stocks. The exploitation rate may be relatively low since most mixed stock fisheries harvest one or more depressed stocks, and the status of individual stocks will be monitored to determine if additional management actions are needed. The management intent of the fishery will be to harvest a specified number of chinook (chinook will not be harvested on an incidental basis to other species) based on preseason or inseason estimates of abundance. Performance of the fishery can be assessed postseason with an estimate of a harvest rate index computed from recoveries of CWTs, and consistency of management with annex provisions would be addressed by an overage/underage policy.
>
> ISBM. In the absence of either postseason accountability or a requirement for preseason assessment or inseason evaluation of ISBM impacts, management targets should be risk averse with relatively low exploitation rates. If these conditions are not met, unanticipated impacts from management imprecision or lack of controls on chinook impacts may result in a failure to meet escapement objectives. The fishery may be managed to achieve a target harvest of chinook salmon, or the chinook salmon may be harvested incidentally to other species. The effect of ISBM fisheries on naturally spawning chinook stocks can be assessed postseason from recoveries of CWTs.

These characteristics may not include all fisheries either as currently managed or as proposed by the Parties; rather, they identify the appropriate characteristics of an ISBM or AABM fishery as those regimes are presently defined in the proposals.

Technical Conclusions.

In the absence of substantial interpretation by the CTC, it would not be possible for the CTC to conduct a postseason evaluation of the consistency of management regimes with the U.S. or Canadian provisions for ISBM fisheries. The U.S. proposal provides no measurable statistic against which to assess compliance. Although the Canadian proposal identifies a measurable statistic (a 25% reduction from the 1979-1982 base), it does not identify to which stocks the ISBM provision applies, or a process to identify those stocks.

The lack of a requirement for a preseason assessment of compliance with ISBM provisions and a postseason overage policy (or some other type of postseason accountability), are both significant shortcomings of the U.S. and Canadian proposals. In their absence, risk exists that expectations for the management of ISBM fisheries will not be realized, particularly if fisheries previously managed with a ceiling now fall under ISBM control.

An improved ISBM regime that includes a measurable statistic, a target value for the statistic for each stock, a preseason assessment procedure, and an overage or other postseason accountability policy could provide an appropriate management regime. We recommend adding these enhancements before implementation of an ISBM regime.

4.0 Harvest Regime Based on a Catch Index versus a Total Mortality Index

The U.S. and Canadian proposals concerning AABM regimes both link modeled abundance to fishery-specific harvest rate indices to establish an allowable mortality of chinook salmon as a management objective. The U.S. proposes that allowable mortality be expressed as landed catch, while Canada proposes that allowable mortality should be expressed as total mortality, that is landed catch plus incidental mortalities among chinook salmon caught and released[10].

1) What are the consequences of catch versus total mortality-based fishing regimes?

Either type of management regime can include provisions aimed at achieving chinook stock conservation and production objectives. For example, the U.S. proposal relies upon catch indices, but when the regime is simulated to evaluate exploitation rates and escapements, the predicted stock impacts include incidental mortality.

For a catch-based regime, no direct limit is placed on incidental mortalities; changes in regulations (such as size limits) can substantially affect the magnitude of incidental mortalities incurred to take a given level of catch. For a total mortality-based regime, the allowable catch is derived by subtracting estimates of incidental mortalities from total fishery impacts.

In annual implementation, catch-based regimes have the following advantages:

- computation of allowable harvest does not require estimation (with associated uncertainty) of the relationship of landed catch to the total mortality
- does not require explaining, predicting, accounting for, or adjusting for incidental mortality inseason.

Total mortality-based regimes have the following advantages:

- provide direct incentives to reduce incidental mortality;
- explicitly acknowledge regulation changes that affect mortality (e.g., minimum size limits);
- explicitly acknowledge the total mortality incurred during fishing.

2) What are the additional data needs associated with a total mortality-based fishing regime?

In addition to the data requirements of a catch-based regime, a total mortality-based management regime would require predictions of the incidental mortality in each AABM fishery. If historical relations (either PSC chinook model or empirical) between abundance, catch, and/or a measure of fishing effort were used to predict incidental mortality preseason, the anticipated incidental mortality could then be subtracted from the total mortality limit to provide a catch target to

[10] Attachment 1 of the Canadian proposal provided an example in which the allowable impact was computed based on landed catch and chinook nonretention mortality. Although the mortality of sublegal chinook was not included in the example, the CTC assumed that the total mortality referenced in the Canadian proposal does includes all of these sources of fishery related mortality.

manage the fishery. Alternatively, inseason sampling programs could be developed and used to monitor incidental mortality, and the allowable catch adjusted inseason.

3) What has been the historical relation between catch and total mortality indices?

The magnitude of the catch and total mortality indices will be similar in the absence of fishery changes (since the 1979-1982 base period) that have a differential impact on the reported catch or incidental mortality. Changes in the indices are summarized in Table 4-1.

Table 4-1. Comparison of reported catch and total mortality fishery indices.

Fishery	1985-1996 Average Percent Change Relative to 1979-1982 Base		Correlation of Indices 1985-1996	Source of Difference
	Reported Catch	Total Mortality		
SEAK Troll	-41%	-30%	0.88	Changes in CNR
NCBC Troll	-37%	-35%	0.99	Changes in CNR, size limits
WCVI Troll	-30%	-26%	0.99	Changes in CNR, size limits
GS Sport/Troll	-23%	-14%	0.94	Changes in CNR, size limits
US South Ocean Columbia R. Stocks	-42%	-42%	0.99	
US South Ocean Puget Sound Stocks	+146%	+145%	0.99	

4) What would be the annual steps in implementing a total mortality-based fishing regime?

Incidental mortality could be computed from historical relations between abundance, catch, and/or a measure of fishing effort (either PSC chinook model or empirical). The following steps would occur each year (steps a, b, and f are also required for a catch-based regime):

a) complete a preseason calibration of the PSC chinook model;
b) use the model to predict the total mortality for each of the AABM fisheries under base period conditions;
c) compute the total allowable mortality for the fishery aggregates by multiplying the total mortality under base period conditions by the target harvest rate index for the fishery;
d) predict the landed catch and incidental mortalities in the fishery necessary to achieve the total mortality target identified in c). If inseason estimates of incidental mortality are available, compute landed catch by subtracting incidental mortality estimates from total mortality targets;

e) if inseason estimates of abundance are available, recompute the total mortality target by multiplying the preseason prediction for the total mortality target by the ratio of the inseason estimate of abundance to the preseason prediction of abundance;
f) overage/underage policies, which could require consideration of total mortality, would require further development and inclusion in the annual process.

Additional complexity is added if the total mortality target is computed for a fishery aggregate. The total mortality under base period conditions must be added together for all fisheries included in the aggregate, multiplied by the target harvest rate index, and the allowable impacts allocated back to each individual fishery.

5) Based on hindcasting, how well can we model the elements necessary to implement a total mortality-based fishing regime?

The CTC added this question to provide the Commissioners with an understanding of our technical capabilities for predicting incidental mortality. Our analysis is based on hindcasting with the PSC chinook model the years 1985 through 1996. For each year, two model runs were completed. The first run was similar to a preseason prediction run, in that it relied on preseason predictions of stock abundance and standard model algorithms for computing incidental mortality. However, the actual fishery catch was used in order to examine the additional error produced by predicting total mortality. The second run used postseason data, including stock abundance and chinook non-retention data. The chinook non-retention data typically consisted of the ratio of boat days in the retention period to the non-retention period, or predictions of encounters from historical data.

A summary of the mean absolute percent error (MAPE) of the predictions of total adult equivalent mortalities obtained from hincasting is presented in Table 4-2. The table also provides the MAPE for each mortality component, and the percent of the total adult equivalent mortality that each component comprises is included in parentheses.

Careful interpretation of the results from the analysis is required:

a) any error in our ability to predict the appropriate catch level from a preseason prediction of abundance would accrue in addition to the error reported in the "Total Mortality" column. Since the actual catch was used in each run, the deviations in the landed catch column reflect only changes in the age structure of the catch (the adult equivalent value will differ depending upon the age structure), not failures to exactly achieve the catch target. For this reason, the MAPE for total adult equivalent mortality should be considered a minimal estimate of the likely error; and

b) the analysis does not address the accuracy of the postseason prediction of total mortality obtained from the PSC chinook model. That would require an independent estimate of total mortality from field sampling programs. Data for one component (encounters during chinook nonretention periods) are available for the SEAK troll fishery from 1985-1989. The average absolute percent error of the PSC chinook model prediction for sublegal and legal encounters during the chinook nonretention period, as compared with postseason estimates from an observer program, are provided in Table 4-3.

Table 4-2. Mean absolute percent error (MAPE) of preseason versus postseason predictions from the PSC chinook model of total adult equivalent mortality by component from 1985 through 1996. Percentages in parentheses reflect the portion of adult equivalent mortality occurring in each of its component parts: landed catch and incidental mortality by category. Analysis for Canadian fisheries excludes the 1996 fishing year due to the restrictive regulations for chinook retention.

Fishery	MAPE for Total Mortality	MAPE by Mortality Component (percent of total mortality)			
		Landed Catch	Sublegal	CNR Legal	CNR Sublegal
SEAK Troll	5%	1% (70%)	14% (13%)	59% (9%)	55% (7%)
NCBC Troll	12%	1% (80%)	12% (16%)	265% (1%)	314% (3%)
NBC Troll	3%	1% (80%)	12% (16%)	87% (1%)	83% (3%)
CBC Troll	62%	2% (80%)	17% (16%)	1861% (1%)	2399% (3%)
WCVI Troll	4%	2% (80%)	16% (18%)	265% (0%)	240% (1%)
GS Sport and Troll	24%	5% (79%)	104% (20%)	2025% (0%)	3611% (1%)
WA/OR Troll	2%	4% (82%)	14% (18%)	NA (0%)	NA (0%)

Table 4-3. Mean percent error (MPE) and mean absolute percent error (MAPE) of preseason predictions (Model) versus postseason estimates (from observer program) of legal and sublegal encounters during CNR periods in the SEAK troll fishery, 1985 through 1989.

Year	CNR Legal Encounters			CNR Sublegal Encounters		
	Observer	Model	% Error	Observer	Model	% Error
1985	118,191	26,449	- 78%	131,011	94,808	- 28%
1986	78,763	75,990	- 4%	104,820	184,580	+ 76%
1987	191,956	77,079	- 60%	171,156	254,315	+ 49%
1988	60,930	90,049	+ 48%	91,200	291,694	+220%
1989	150,600	55,872	- 63%	162,900	203,279	+ 25%
Mean Percent Error (MPE)			- 31%			+ 68%
Mean Absolute Percent Error (MAPE)			50%			79%

6) How could a regime based on catch indices be designed to constrain total fishing mortality and provide incentives to reduce incidental fishing mortality?

The correlation analysis provided in Table 4-1 indicates that a consistent relationship exists between harvest rate indices based on catch and total mortality in fisheries that are managed each year in a manner similar to the 1979-1982 base period. However, for fisheries with changes in size limits, or that had periods of chinook nonretention, the correlation between the catch and total mortality indices is not as high. This indicates that deviations do occur, and that risk exists that a regime based on catch indices could be implemented in a manner inconsistent with expectations (e.g., increases in minimum size limits or chinook nonretention mortality greater than anticipated). This may result in higher total exploitation rates and lower escapements than anticipated when the regime was established.

Total fishing mortality can be constrained when the management objective is expressed as a catch index by:

a) completely specifying the management regime (e.g., minimum size limit of *x*, ratio of encounters in chinook retention to CNR periods not to exceed *y*); and/or;

b) specifying that the total mortality index cannot differ from the management objective (target catch index) by more than a predetermined amount (e.g., the WCVI total mortality index cannot exceed the catch index by more than *z* percentage points); and

c) incorporating in an overage/underage policy a provision to address deviations in a) and b).

Due to differences in age structure between catch and incidental mortality, adjustments listed in **(b)** and **(c)** should be expressed in adult equivalents.

A variation on **(b)** can also be used to provide direct incentives to reduce incidental mortalities. Assume that a target harvest rate index (based on catch) of 0.55 was established, and that minimum size limits and CNR were anticipated to result in a total mortality harvest rate index of 0.65. If through modification of open periods, size limits, or other means, the total mortality rate index was reduced to 0.57, some or all of the savings in incidental mortality could be transferred to an increase in the target harvest rate index for catch if deemed appropriate by the Commissioners.

Technical Conclusions.

Incidental fishing mortality can comprise a significant component of the total fishing mortality. For example, the CTC exploitation rate analysis predicted that incidental mortality comprised an average of 37% of the fishing mortality in ocean fisheries for the most recent brood year for which complete CWT data are available (CTC 1996). The significance has been recognized by the PSC, which previously agreed to report to the governments (by January 15, 1994) on a program to "monitor and reduce incidental mortalities on a coast-wide basis." Similar statements are included in both the U.S. and Canadian proposals.

Significant uncertainty exists in both preseason and postseason predictions of incidental mortality. Preseason, we must predict: 1) the proportion of encounters during the chinook retention period that will be less than the minimum size limit; 2) drop-off, drop-out and other sources of incidental mortality in net fisheries; and 3) the number of encounters during any chinook nonretention period. The latter may be very uncertain, since it will depend upon the abundance and fishing regime for species other than chinook. For the postseason prediction, we may know the fishing effort during the nonretention period, but estimates of encounters from observer programs or other direct sampling procedures have been infrequent. As a result, even on a postseason basis, encounters must typically be predicted from historical relationships. Given the potential significance of incidental mortality and the uncertainty of many of our current predictions, it is imperative that management develop improved estimates of incidental fishing mortality based upon direct fishery observations. These postseason estimates would provide a means to: 1) evaluate total fishing mortality on stocks; 2) test assumptions used in our predictions; and 3) improve preseason predictions.

Although significant uncertainty exists in predictions of incidental mortality, the predictions are used in both the Canadian and U.S. proposals. Incidental mortality is explicitly considered in the Canadian proposal since it must be subtracted from the total mortality limit to obtain the allowable catch. In the U.S. proposal, the incidental mortality predictions were implicitly included when the proposed regime was assessed relative to management objectives. Risk exists that the regime could be implemented in a manner inconsistent with these predictions, which could result in higher exploitation rates and lower escapements than were anticipated when the regime was initially considered.

For these reasons, the CTC recommends that a new annex for chinook salmon directly address and assess total fishing mortality. At least two alternatives exist: 1) a total mortality-based fishing regime such as proposed by Canada (see footnote 10) that is applied to both AABM and ISBM fisheries; or 2) any of the enhancements to a catch-based regime developed by the CTC in response to question 4.6. The Canadian proposal provides a direct approach, but the need for a preseason prediction of incidental mortality could significantly complicate preseason planning and inseason management. The enhancements to a catch-based regime developed by the CTC would necessitate some additional complexity in the chinook annex and postseason assessments, but minimize the complexities and uncertainties of preseason planning.

5.0 Aggregation of Fisheries

While the U.S. and Canadian proposals each suggest implementing abundance-based management, different fishery aggregates are proposed in two instances for computing the abundance index (Table 5-1).

Table 5-1. Summary of difference in aggregation for AABM fisheries under the U.S. and Canadian proposals.

U.S. Proposal	Canadian Proposal
• SEAK troll fishery provides abundance index for SEAK troll, net, and sport fisheries. • NCBC troll fishery provides abundance index for NCBC troll, net, and sport fisheries	• Combined SEAK troll and NBC troll fisheries provides abundance index for SEAK troll, net and sport fisheries and NBC troll, sport, and net fisheries. • CBC is managed under ISBM
• WCVI troll fishery provides abundance index for WCVI troll and sport fisheries. • NLP troll fisheries managed under regulations of the PFMC.	• Combined WCVI troll and North Leadbetter Point (NLP) troll fisheries provides abundance index for the WCVI troll and NLP troll fisheries
• GS sport and troll fisheries provide abundance index for GS sport and troll fisheries.	• GS sport and troll is managed under ISBM

1) What are the advantages and disadvantages of aggregating fisheries over areas and/or gear types when computing abundance indices?

Advantages of aggregating fisheries:

- base period data are of poor quality for some gear types within a region. For example, the abundance index for the SEAK troll is used as a surrogate for the SEAK sport fishery since limited CWT recoveries were obtained from the SEAK sport fishery during the base period. Other examples include the NCBC sport fishery and the WCVI sport fishery;

- if stock distribution patterns vary within the region covered by aggregated fisheries, the total allowable impact may be more accurately determined and uncertainty, with respect to stock-specific impacts, may be reduced; and

- if inseason predictions of abundance are available for all fisheries comprising an aggregate, the use of an aggregate abundance index may reduce the risk of incorrectly interpreting shifts in distribution as differences in abundance from preseason expectations. A management process would be required to coordinate inseason assessments and interpret results.

Disadvantages of aggregating fisheries:

- the allowable mortality must be apportioned to each of the component fisheries;
- different stocks may be present in different proportions within fishery components of the aggregate, and these stocks may have differing management requirements;
- differences in stock composition may result in dissimilar abundance indices, and the resulting disaggregated impacts may not be appropriate for either fishery.

2) What are the technical characteristics of fisheries that suggest candidates are suitable for aggregation for the purpose of computing abundance indices?

Fisheries most suitable for aggregation have similar composition by stock and age. The lower the exploitation rates in a fishery, the less important differences in stock composition will become.

Information by age is not reflected in responses to questions 5.3 and 5.4. However, age information is inherent in model estimates of abundance and stock composition since the model calculations are all based on age and fishery-specific exploitation rates for model stocks during the base period.

3) How do the abundance indices compare for the fisheries aggregated in the Canadian proposal?

Graphs of the abundance indices for the fisheries are shown in Appendix 1 and comparative statistics for the fisheries are provided below.

SEAK Troll and NBC Troll
1985-1996 Average Abundance Index
SEAK Troll 1.62
NBC Troll 1.45
1985-1996 Correlation Coefficient 0.89

WCVI Troll and NLP Troll[11]
1985-1996 Average Abundance Index
WCVI Troll 0.74
NLP Troll 0.51
1985-1996 Correlation Coefficient 0.92

[11] The PSC chinook model does not differentiate the NLP troll fishery from other U.S. south troll fisheries. Abundance indices and the correlation coefficients are for all U.S. south troll fisheries impacting stocks included in the PSC chinook model.

The relatively high correlation coefficients indicate that the abundance indices of these fisheries covary, yet SEAK averaged 12% higher than NBC, and WCVI 45% higher than NLP. Covariance of trends may indicate similarity of stock composition in the fisheries, but differences in the index values occur because the abundance of all stocks did not vary consistently, and because the PSC chinook model stocks were not evenly distributed (as measured with exploitation rates) among the fisheries during the 1979-1982 base period.

4) How comparable are the stock compositions for the fisheries aggregated in the Canadian and U.S. proposals?

The PSC chinook model was used to predict stock composition in the years 1985 through 1996. The stock composition estimates rely upon the base period distribution of each model stock, the geographic distribution of effort in the fishery during the base period, and the relative abundance of each stock in subsequent years. Average estimated stock compositions (or stocks included in the PSC chinook model) for the landed catch in troll and net fisheries over the 1985-1996 period are summarized in tables 5-2 and 5-3.

A subjective evaluation based on absolute differences of 5 percentage points or more in stock contributions for troll fisheries indicates that:

> SEAK and NBC Troll. The stock composition of these fisheries is similar, with only 2 of the 30 model stocks (Alaska South SE, Oregon Coastal Far North Migrating) having a 5 percentage point or more difference in contributions;
>
> NBC and CBC Troll. The stock composition of these fisheries is less similar than the SEAK and NBC fisheries, with 7 of the 30 model stocks (North/Central B.C., Fraser Late, WCVI Hatchery, OR Lower River Tule, Willamette Spring, Columbia Upriver Bright, and Oregon Far North Migrating) having a 5 percentage point or more difference in contributions;
>
> WCVI and NLP Troll. The stock composition of these fisheries is less similar than the SEAK and NBC fisheries, with 4 of the 30 model stocks (WCVI Hatchery, Bonneville Pool Hatchery, OR Lower River Tule, and Columbia Upriver Bright) having a 5 percentage point or more difference in contributions.

The PSC chinook model has only a single net fishery for each region (e.g., SEAK net, NBC net, and CBC net). Typically, the catch in these fisheries is comprised of both catches from mixed stock fishing areas and from more terminal areas with net fisheries directed at specific stocks. Combination of these fisheries within a region may have obscured differences in stock composition. However, even at a regional level, significant differences exist between the model predictions of the average stock composition of catches for the troll and net fisheries:

> SEAK Troll and SEAK Net. Four of the 30 model stocks (WCVI Hatchery, Washington Coastal Fall Wild, Columbia Upriver Bright, and Oregon Far North Migrating) had a 5 percentage point or more difference in contributions.

Table 5-2. Estimated average stock composition of landed catch for the years 1985-1996 in the SEAK, NBC, and CBC troll and net fisheries. Stocks are sorted from largest to smallest contributor in the SEAK troll fishery.

	SEAK		NBC		CBC	
Stock	Troll	Net	Troll	Net	Troll	Net
Columbia Upriver Bright	16.8%	4.0%	12.6	14.1%	8.2%	15.0
WCVI Hatchery	16.5%	21.7%	11.6	12.1%	17.1%	6.1
North/Central B.C.	15.9%	18.0%	12.6	37.9%	7.1%	16.0
OR Cst. Far North Migrating	12.2%	2.7%	19.1	3.1%	1.6%	1.6
WCVI Natural	8.6%	11.5%	6.0	6.3%	8.8%	3.1
Fraser Early	5.7%	6.2%	6.9	6.8%	3.3%	3.3
Alaska South SE	5.3%	6.6%	0.3	0.3%	0.0%	0.0
WA Coastal Fall Wild	3.7%	9.0%	7.0	2.0%	3.8%	1.2
WA Coastal Fall Hatchery	3.0%	7.3%	5.8	1.6%	3.2%	1.0
Upper Georgia Str. Wild	2.9%	6.5%	3.4	6.6%	4.9%	12.7
Mid-Columbia Bright	2.9%	0.6%	2.2	2.5%	1.4%	2.6
Willamette Spring	2.3%	1.3%	6.5	1.5%	0.3%	0.7
Columbia River Summer	1.6%	0.0%	1.2	0.0%	2.2%	2.3
WA Lower River Wild	1.0%	0.9%	0.6	0.3%	0.7%	0.5
WA Lower River Tule	0.3%	0.0%	0.3	0.5%	0.0%	0.2
Lower Georgia Str. Wild	0.2%	1.8%	0.8	0.9%	3.0%	8.4
Fraser Late	0.2%	0.0%	0.7	0.3%	20.7%	9.4
Lower Georgia Str. Hatchery	0.2%	1.7%	0.8	0.7%	2.4%	5.7
PS Fall Fingerling Hatchery	0.1%	0.0%	0.2	0.4%	1.2%	1.0
WA Lower River Spring	0.1%	0.0%	0.3	0.1%	0.2%	0.2
Skagit Summer/Fall Wild	0.1%	0.1%	0.4	0.3%	1.0%	2.0
PS Fall Fingerling Wild	0.1%	0.0%	0.1	0.2%	0.7%	0.5
Snake River Fall Wild	0.1%	0.0%	0.1	0.0%	0.1%	0.0
Nooksack Fall	0.0%	0.1%	0.2	0.6%	1.8%	2.5
Snohomish Summer/Fall Wild	0.0%	0.0%	0.2	0.2%	0.6%	1.2
Stillaguamish Summer/Fall Wild	0.0%	0.1%	0.0	0.3%	0.1%	0.1
PS Fall Yearling Hatchery	0.0%	0.0%	0.1	0.2%	0.4%	1.3
Nooksack Spring	0.0%	0.0%	0.0	0.0%	0.0%	0.0
Bonneville Pool Hatchery	0.0%	0.0%	0.0	0.0%	0.2%	0.2
OR Lower River Tule	0.0%	0.0%	0.0	0.0%	5.0%	1.0

Table 5-1. Estimated average stock composition of landed catch for the years 1985-1996 in the WCVI and NLP troll fisheries. Stocks are sorted from largest to smallest contributor in the WCVI troll fishery.

Stock	WCVI Troll	NLP Troll
Oregon Lower River Tule	18.3%	38.0%
Fraser Late	17.4%	19.8%%
Columbia Upriver Bright	9.4%	3.0%
WCVI Hatchery	8.7%	0.0%
PS Fall Fingerling Hatchery	7.2%	3.5%
Nooksack Fall	5.6%	2.6%
WCVI Wild	4.4%	0.0%
PS Fall Fingerling Wild	4.0%	1.9%
Bonneville Pool Hatchery	4.0%	15.3%
Oregon Coast Fall Far North Migrating	3.9%	1.3%
Washington Coastal Fall Wild	2.2%	1.3%
Willamette Spring	1.9%	1.7%
Washington Coastal Fall Hatchery	1.8%	1.2%
Washington Lower River Tule	1.7%	4.0%
Mid-Columbia Bright	1.7%	0.5%
Columbia Upriver Summer	1.5%	0.3%
Fraser Early	1.1%	0.0%
PS Fall Yearling Hatchery	1.0%	0.2%
Lower Columbia River Wild	0.9%	1.3%
Skagit Summer/Fall Wild	0.8%	0.0%
Washington Lower River Spring	0.7%	3.7%
Snohomish Summer/Fall Wild	0.5%	0.0%
Lower Georgia Strait Wild	0.4%	0.0%
North/Central B.C.	0.4%	0.0%
Lower Georgia Strait Hatchery	0.3%	0.0%
Snake River Fall Wild	0.2%	0.4%
Upper Georgia Strait Wild	0.1%	0.0%
Stillaguamish Summer/Fall Wild	0.1%	0.0%
Nooksack Spring	0.0%	0.0%
Alaska South SE	0.0%	0.1%

NBC Troll and NBC Net. Four of the 30 model stocks (North/Central B.C., Washington Coastal Fall Wild, Willamette Spring, and Oregon Far North Migrating) had a 5 percentage point or more difference in contributions. The North/Central BC stock comprised 37.9% of the NBC net catch, but only 7.1% of the NBC troll catch.

CBC Troll and CBC Net. Seven of the 30 model stocks (North/Central B.C., WCVI Hatchery, WCVI Natural, Upper Georgia Strait Wild, Lower Georgia Strait Wild, Fraser Late, and Columbia Upriver Bright) had a 5 percentage point or more difference in contributions.

Given the differences observed between net and troll fisheries, it may also be useful to compare the stock composition of sport and troll fisheries within a region. The CTC did not conduct this analysis because of the limited number of CWT recoveries in the sport fisheries during the base period of the PSC chinook model. Time limitations precluded the CTC from an analyzing more recent CWT recovery data.

Technical Conclusions.

The chinook annex to the PST implemented in 1985 aggregated many fisheries based on a limited understanding of stock composition and geographic proximity. The technical capabilities of the CTC have improved since that time, and the U.S. and Canada have proposed management regimes tied to the abundance of chinook salmon. Replacing fixed catch ceilings with abundance-based management has important implications when considering alternative methods for aggregating fisheries. Computing an abundance index for an aggregate of fisheries within a region may improve our management capabilities if the fisheries have similar stock composition. The improved management could result from more reliable predictions of stock composition obtained by pooling CWT recoveries within a region and/or improved accuracy of abundance predictions in instances in which stock distribution varies annually between fisheries within a region.

Conversely, management capabilities can be degraded if we aggregate fisheries that do not have similar stock compositions. Stocks with different management needs may be present in the fisheries, and computation of an aggregate abundance index may result in disaggregated impacts that are not appropriate for either fishery.

The CTC review indicates that refinement of the time/area/gear aggregates could improve both the U.S. and Canadian proposals:

1) aggregation of the WCVI and NLP troll fisheries is not warranted given the differences between the stock composition of the catch in each fishery. These differences, and the geographic distribution of effort in the fishery during the chinook model base period, resulted in an average (1985-1996) abundance index for the WCVI troll fishery that was 45% higher than the index for the NLP troll fishery;

2) aggregation of the NBC and CBC troll fisheries is not warranted given the differences between the stock composition of the catch in each fishery. For example, the PSC

chinook model predicts that the Fraser Late stock comprised an average (1985-1996) of more than 20% of the catch in the CBC troll fishery, but less than 1% of the catch in the NBC troll fishery;

3) the technical merits of computing an aggregate abundance index for the SEAK and NBC troll fisheries is uncertain. The stock composition of the catch in the two fisheries was the most similar of the pairs examined, yet the average (1985-1996) abundance index for the SEAK troll fishery was 12% higher than the index for the NBC troll fishery. Additional analysis by the CTC would be required to determine the source of this difference, and if aggregation is appropriate;

4) using the abundance index in a troll fishery to establish an aggregate impact limit for net and troll fisheries within a region (e.g., NBC troll and NBC net, or SEAK troll and SEAK net) is not warranted given the differences between the stock composition of the catch of each gear type;

5) the CTC has not completed sufficient analysis to determine if using the abundance index from a troll fishery to establish an aggregate impact limit for sport and troll fisheries within a region (e.g., NBC troll and NBC sport, or SEAK troll and SEAK sport) is warranted.

Aggregation at a finer area, gear, and/or time level may be beneficial, but the CTC has not attempted to redefine the aggregates in the proposals.

6.0 Harvest Rate Reductions

The U.S. and Canadian proposals differ in the target harvest rate indices for the AABM fisheries. The target harvest rate indices are fishery and abundance specific in the U.S. proposal, while Canada proposes a fixed 50% reduction across all AABM fisheries.

1) What were the relative harvest rates in the Canadian and U.S. fisheries during the years 1979 through 1982?

Our ability to address this question is limited for several reasons. First, computation of a harvest rate requires an estimate of the number of fish available for harvest in a fishery, a difficult task for ocean fisheries. Second, the highly migratory nature of chinook salmon means that most stocks are exploited by many fisheries in Canada and the U.S. Since each stock has a different migration pattern, the relative harvest rates in each nation's fisheries will be stock dependent.

For these reasons, we have provided estimates of the proportion of the exploitation rate (expressed in total adult equivalents) that occurred in U.S. and Canada in the years 1979 through 1982 for each of the naturally spawning chinook stocks included in the PSC chinook model (Table 6-1).

Table 6-1. The average proportion of the total adult equivalent exploitation rates that occurred in U.S. and Canadian fisheries in the years 1979 through 1982 for each of the naturally spawning chinook stocks included in the PSC chinook model.

Model Stock	Proportion of Total Adult Equivalent Exploitation Rate	
	U.S. Fisheries	Canadian Fisheries
Alaska South S.E.	96%	4%
North/Central B.C.	49%	51%
Fraser Early	21%	79%
Fraser Late	12%	88%
WCVI Natural	39%	61%
Upper Georgia Strait	29%	71%
Lower Georgia Strait	2%	98%
Puget Sound Natural	61%	39%
Nooksack Spring	7%	93%
Skagit Summer/Fall	32%	68%
Stillaguamish Summer/Fall	37%	63%
Snohomish Summer/Fall	50%	50%
Columbia Upriver Bright	57%	43%
Lewis River Wild	67%	33%
Columbia Upriver Summer	38%	62%
OR Coastal North Migrating	50%	50%
WA Coastal Wild	58%	42%
Snake River Fall	47%	53%

2) What are the historical estimates of exploitation rates on the escapement indicator stocks?

Estimates of historical exploitation rates obtained from the PSC chinook model are provided in Appendix 2.

3) Provide by September 15, 1998, a list of stocks for which agreed MSY or other biologically based escapement goals have been developed.

Each of the 46 chinook indicator stocks that the CTC uses in the annual assessment of coastwide chinook escapements was reviewed to determine if the associated escapement goal (if defined) was an agreed upon MSY based or other biologically-based goal. The CTC concluded that the following stocks have agreed MSY or other biologically-based escapement goals:

a) Situk River
b) Alsek River
c) King Salmon River
d) Andrew Creek
e) Unuk River
f) Chickamin River
g) Keta River
h) Blossom River

Many of the remaining chinook escapement indicator stocks have established goals, but no other stock with an established goal had sufficiently current and/or adequate scientific analysis to provide a basis for a CTC review. To remedy this data limitation, the CTC has initiated the collection and analysis of datasets for the remainder of the stocks (see question 4). Upon completion of the analysis, the CTC will be able to identify any additional chinook indicator stocks for which the current goals are also agreed upon MSY or other biologically-based escapement goals.

Information on the basis of each current goal was compiled by the Escapement Goal Review Workgroup and will be released as a technical note. Although it was decided that the review process may lead to suggested improvements in the stock-recruitment relationship for any stock, the list provides a focus to review stocks without agreed biologically-based goals.

4) Develop by December 15, 1998 appropriate MSY or other biologically-based escapement goals and sustainable exploitation rates for wild stocks.

The CTC has initiated the collection of datasets and conducted a workshop in late-October to obtain expert advice in methods for estimating stock-recruit parameters. Given the CTC workload and difficulties encountered in completing this task, it is likely that by December 15 data will be compiled and preliminary analysis completed (estimates of stock recruit parameters, MSY escapement levels, and MSY exploitation rates for use in CTC analyses) for the following stocks only (in addition to those noted under question 6.3): Taku, Stikine, WCVI, Cowichan, Upper Fraser, Harrison, Skagit Summer/Fall, Skagit Spring, Stillaguamish Summer/Fall, Snohomish Summer/Fall, Green Summer/Fall, Queets Fall, Hoh Fall, Quillayute Fall, Grays Harbor Fall, Lewis, Columbia Upriver Bright, Columbia River Summer, Columbia Upriver Spring, Deschutes Fall, Nehalem, Siletz, and Siuslaw.

5) Provide a definition of MSY or other biologically-based exploitation rates; describe the scientific characteristics of MSY or other biologically-based exploitation rates; and identify the data required to develop MSY or other biologically-based exploitation rates.

Definition of MSY or biologically-based exploitation rates. Maximum sustainable yield (MSY) is a deceptively simple concept that has been institutionalized in a variety of forms over the years, including provisions of the Pacific Salmon Treaty that require the prevention of overfishing (defined as "fishing patterns which result in escapements significantly less than that required to produce maximum sustained yield").

For purposes of chinook management, the CTC considers MSY as the largest number of adult equivalent (AEQ)[12] fish that can be taken on average over time from a reproductively isolated population (a stock) under environmental conditions that vary randomly about an average value. The MSY exploitation rate is defined as the proportion of production that can be harvested when escapements are maintained at MSY levels. Because MSY and MSY exploitation rates are typically based on historical data, the values assume that the characteristics of the population, environment, and habitat were stable across the historical record and remain relatively unchanged into the future.

Scientific characteristics of MSY or biologically-based exploitation rates. Many stock-production relationships include a range of escapements in which more than one adult equivalent fish is produced per spawner, resulting in a surplus of production that can be harvested on a sustained basis (Figure 1). Without exploitation, competition for food and space would offset reproduction such that progeny (production) would be abundant enough to just replace their parents (spawners) in the next generation (point B in Figure 1). In an exploited stock, spawning abundance is reduced, limits on production decline, and progeny are more abundant than their parents. This surplus production (production minus spawning abundance) can theoretically be removed as catch on a sustained basis, and spawning abundance held constant across the years (sustainable yield). The sustainable exploitation rate is the sustainable yield divided by the number of fish produced when number of spawners are maintained.

Every level of spawner abundance below the replacement level theoretically has an associated sustainable yield (Figure 1) and sustainable exploitation rate (Figure 2). At low spawner abundance, there is little competition for space and resources, and sustainable yields grow with increasing spawner abundance up to a maximum limit (point A on Figure 1). At higher spawning abundance, competition intensifies, and sustainable yields decrease with further increases in abundance. The spawning abundance at which sustainable yields cease to rise and begin to fall defines one type of biologically based escapement goal, the escapement that would produce the maximum sustainable yield (MSY), and the associated exploitation rate the MSY exploitation rate.

[12] Because chinook salmon are exploited at several ages and often at several stages of maturity, a common currency, termed adult equivalents, is used to quantify production. An adult equivalent factor is computed from natural mortality and maturation rates, and is the probability that a fish of a given age would reach freshwater in the absence of fisheries.

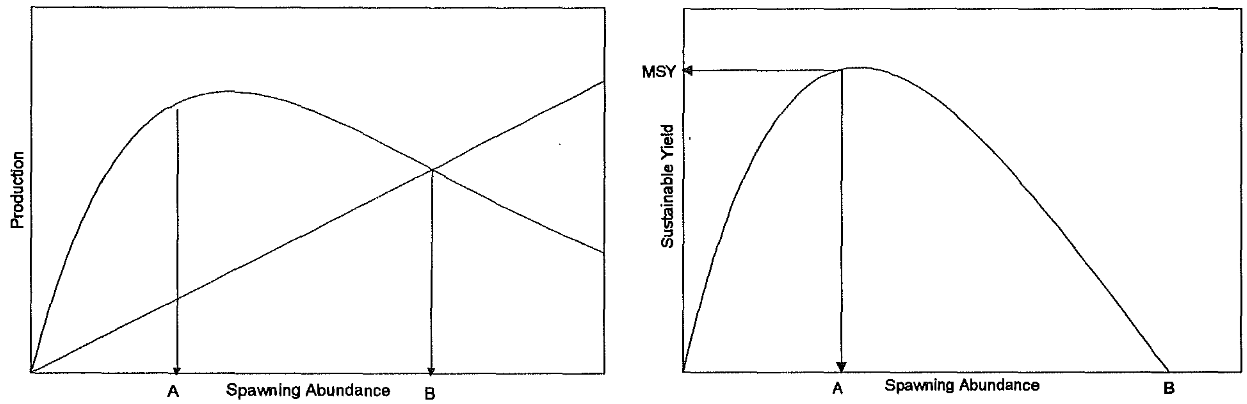


Figure 1. An example of the relationship between spawning abundance, production and sustainable yields. "A" represents the level of spawning abundance associated with maximum sustainable yields (MSY). "B" represents the equilibrium population level when there is no exploitation and the population has had time to build to that level.

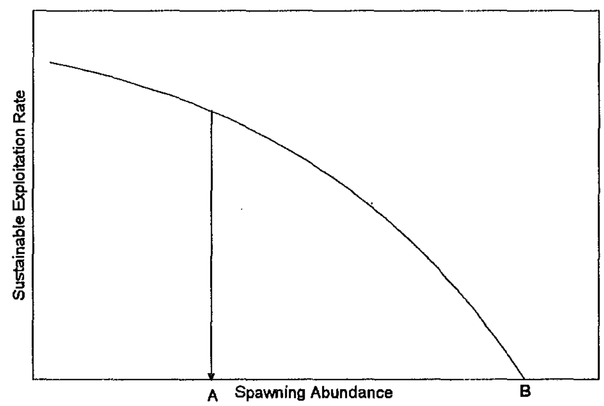


Figure 2. An example of how sustainable exploitation rate varies with spawning abundance. In this Ricker model example, sustainable exploitation rate increases as population size decreases. In reality, the upper limit of sustainable exploitation rate depends on the productivity of the stock at small population sizes, and per capita production may actually decrease due to factors such as difficulty in finding mates.

In application, there is a high degree of uncertainty in estimates of MSY, MSY exploitation rates, and the production predicted from a given number of spawners. Floods, predation, ocean upwelling, extreme temperatures, and other factors, often unknown, influence the survival of chinook salmon regardless of their abundance. Survival rates of eggs and juveniles in rivers vary from year to year, as do survival rates of smolts and immature fish at sea. A single level of spawning abundance does not always produce the same level of production, but rather, a range of production. The consequence is that over a limited range of spawners, similar production may result in any year. The uncertainty means that the expected production could be fairly consistent for a range of spawner abundances near the point estimate for the MSY spawner abundance level.

Additional uncertainty in the stock-productivity relation may result from trends in marine survival rates, characteristics of spawning populations resulting from selective fishing pressure, and reductions in the quality and quantity of freshwater habitat.

Data required to develop MSY or biologically-based exploitation rates. Sustainable yields and their associated exploitation rates, including those associated with MSY, can theoretically be determined for any level of spawning abundance if stock-specific data are available on spawning abundance and subsequent production. Annual statistics describing spawning abundance could be: 1) the number of spawners (after allowance for pre-spawning mortality); 2) the number of female spawners; or 3) the number of eggs produced. Because chinook salmon spawned in one year return over several years, natural production from each past brood year escapement is a sum of the resulting: 1) abundance of spawners by age; 2) AEQ catch by age; and 3) AEQ incidental fishing mortality by age. If the number of spawners is not an exact count, estimates of the variability of the spawner abundance will also be required. Estimates of the MSY spawner abundance and exploitation rates are likely to be uncertain in the absence of a substantial range of spawner abundance, over many years, in the historical dataset.

Technical Conclusions.

The CTC has been requested to provide estimates of MSY or other biologically based escapement goals and sustainable exploitation rates for wild stocks. Statistics on past escapement and subsequent recruitment, and/or habitat assessments, will be linked through mathematical models to produce a stock-production relationship. Once a valid production relationship has been estimated, biologically-based escapement goals and biologically-based exploitation rates can be determined from the relationship and used to manage fisheries to achieve objectives involving sustainable yields, such as MSY.

The biologically-based goals and exploitation rates, together with the retrospective analysis of the U.S. and Canadian proposals, could provide one technical means to assess the merits of each proposal. To complete the retrospective analysis, the CTC will require complete specification of the ISBM regimes and sharing of total mortality impacts in aggregated AABM regimes. One of the most important technical characteristics of the proposals is whether the cumulative impacts of the AABM and ISBM fisheries will result in stock production levels consistent with management objectives for spawning escapements and sustainable yields. Cumulative impacts of AABM and ISBM fisheries on exploitation rates, catches, and escapements will be assessed in the forthcoming retrospective analysis of the U.S. and Canadian proposals.

Both the U.S. and Canadian proposals for AABM fisheries refer to taking additional management actions in response to stock status and conservation needs. The adequacy of these stock sensitive provisions is another technical characteristic of AABM fisheries that may be beneficial, but the CTC has not yet attempted an assessment of their effectiveness.

7.0 Computation of Allowable Harvest

1) ***The U. S. and Canadian proposals use different methods to compute the allowable catch (or total mortality) from the projected abundance. What are the technical advantages and disadvantages of each method?***

As discussed previously in this report, the U.S. and Canadian proposals for AABM fisheries differ in several ways, including reliance upon total mortality or catch indices and cross fishery aggregation or disaggregation of abundance indices. However, even if these issues were resolved, a fundamental difference would exist between the proposals in the method used to compute an allowable fishery impact from the predicted abundance. We discuss this difference for the simplest case, assuming that allowable impacts are based upon a target harvest rate index for catch applied to the abundance index for a single fishery.

In both the U. S. and Canadian proposals, the basic concept behind abundance-based chinook management is that catch (C), harvest rate (HR), and abundance (A) are proportionally related so that:

$$C = (HR)(A)$$

For most fisheries, the CTC has estimates of only indices of harvest rates[13] (the harvest rate index HRI) and abundance (the abundance index AI), and a proportionality factor (q) relating the indices to the actual catch in the fishery must be added to the basic catch equation:

$$C = (q)(HRI)(AI)$$

To compute the allowable catch, the proportionality factor, a target harvest rate index, and the predicted abundance index can be simply multiplied together.

The U.S. and Canadian proposals differ in the method used to compute the proportionality factor. The U.S. method estimates the proportionality factor from the historical relationship (1979-1995) between postseason estimates of harvest rate indices derived from recoveries of CWT, the reported catch, and the abundance index from the PSC chinook model. The Canadian method relies upon the relation between the observed and PSC chinook model predictions of catch in the period from 1979-1984.

The effect the use of either method would have upon the computation of the allowable catch was evaluated in several hypothetical examples that relied upon abundance estimates from 1985 through 1996. Each example assumed a fixed target harvest rate index of 0.60 (was not varied with abundance) and harvest regimes based on landed catch (incidental fishing mortality was not considered). For the SEAK, NCBC, and GS fisheries, use of the U.S. method resulted in a lower allowable catch than the Canadian method (Table 6-1). Catches resulting from the U.S. method

[13] The CTC has not been able to examine the potential impacts that selective fisheries for adipose clipped fish may have on our ability to estimate harvest rate indices on wild stocks.

averaged 87% of the catches resulting from the application of the Canadian method in the SEAK and NCBC troll fisheries, and 77% in the GS sport and troll fishery. Catches were similar using both methods in the WCVI troll fishery.

Table 7-1. The average ratio (1985 through 1996) between the landed catch computed from method 1 (U.S.) and method 2 (Canada) for several fisheries. All examples assumed a harvest rate reduction of 40% from the 1979-1982 base period.

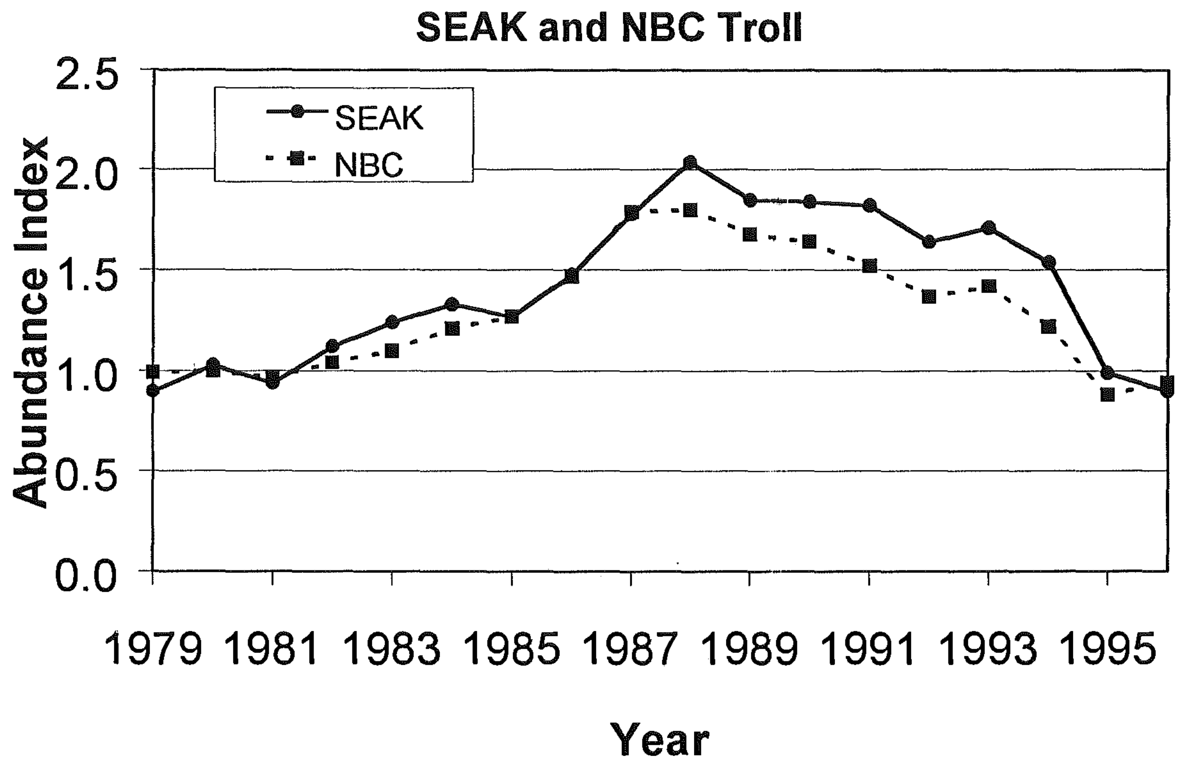
Fishery	(Method 1 Catch)/(Method 2 Catch)
SEAK Troll	0.87
NCBC Troll	0.87
WCVI Troll	1.06
GS Sport and Troll	0.77

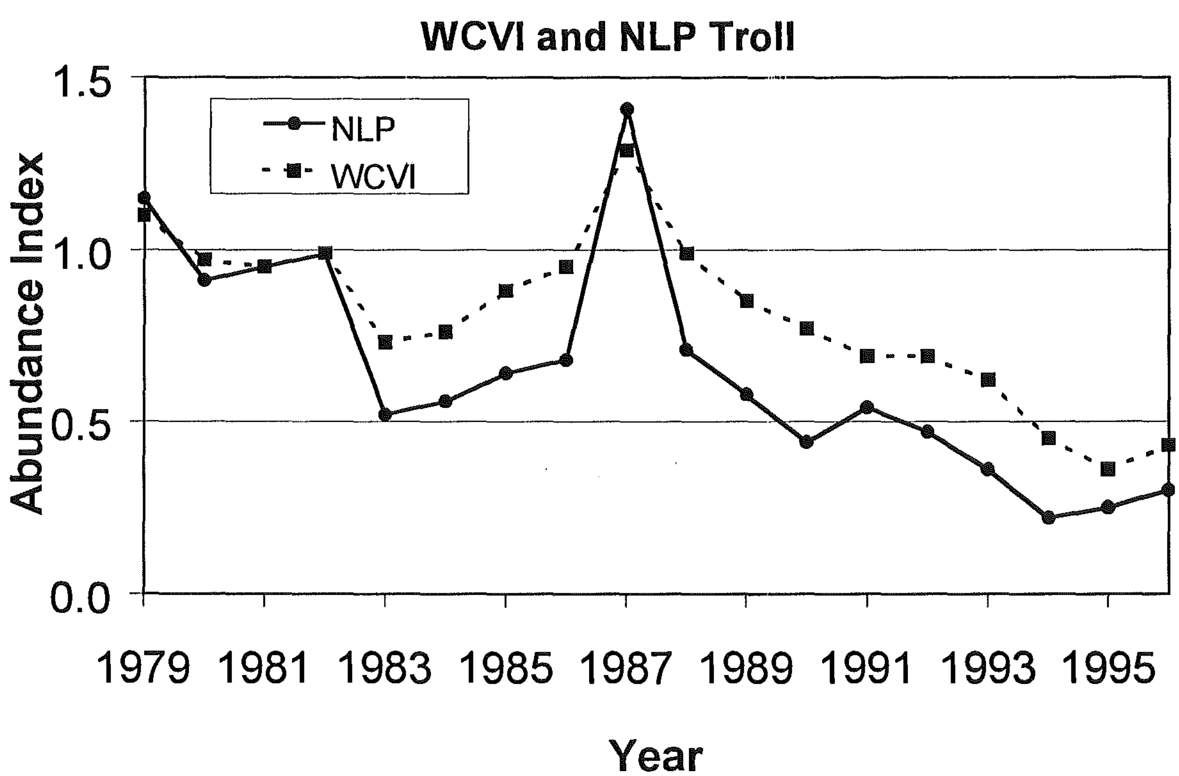
Technical Conclusions.

The U.S. method has several potential advantages. In fisheries with adequate estimates of the harvest rate index (SEAK troll, NBC troll, and WCVI troll), this method provides a means to use CWTs from outside the base period of the PSC chinook model. The additional data can be used to assess the consistency of the relationship between catch, the abundance index, and the harvest rate index. If significant changes in the time and areas of catch in the fishery have occurred, and these have resulted in a temporal trend in the proportionality factor, the use of CWT data from outside the base period of the PSC chinook model may improve our ability to predict the catch level needed to achieve a given harvest rate index.

The Canadian method may be useful in fisheries in which adequate estimates of the harvest rate index are not available (CBC troll, GS sport). The cessation of tagging or sampling, low levels of catch, or limited numbers of CWT recoveries from indicator stocks, may make it less reliable to estimate a harvest rate index outside of the base period of the PSC chinook model. In this case, direct computation of the allowable harvest from the PSC chinook model may provide the best means to establish harvest levels.

Appendix 1. Comparison of abundance indices for AABM fisheries aggregated in the Canadian proposal.





Appendix 2. PSC chinook model predictions of AEQ total mortality brood year exploitation rates for naturally spawning chinook stocks.

Brood Year	Alaska South SE	North/Central B.C.	Fraser Early	Fraser Late	WCVI Natural	Upper Georgia Strait	Lower Georgia Strait	PS Fall Fingerling	Nooksack Spring	Skagit Summer/Fall	Stillaguamish Summer/Fall	Snohomish Summer/Fall	WA Coastal Fall	Columbia Upriver Bright	WA Lower River Wild	Columbia River Summer	Snake River Fall	OR Cst. Far North Migrating
1977	0.50	0.49	0.62	0.83	0.60	0.82	0.90	0.77	0.85	0.64	0.68	0.79	0.68	0.61	0.53	0.58	0.59	0.48
1978	0.61	0.47	0.58	0.82	0.67	0.79	0.90	0.82	0.85	0.65	0.69	0.77	0.71	0.53	0.56	0.55	0.54	0.57
1979	0.43	0.45	0.42	0.81	0.68	0.76	0.89	0.85	0.90	0.61	0.68	0.78	0.67	0.44	0.58	0.55	0.54	0.66
1980	0.45	0.43	0.48	0.77	0.63	0.72	0.86	0.84	0.70	0.52	0.64	0.75	0.60	0.57	0.65	0.49	0.57	0.60
1981	0.38	0.39	0.57	0.72	0.56	0.70	0.85	0.80	0.60	0.51	0.61	0.70	0.61	0.62	0.66	0.42	0.58	0.58
1982	0.40	0.35	0.44	0.70	0.47	0.68	0.79	0.78	0.57	0.47	0.56	0.65	0.59	0.64	0.60	0.41	0.61	0.57
1983	0.36	0.33	0.35	0.71	0.50	0.64	0.77	0.77	0.58	0.49	0.54	0.62	0.64	0.63	0.60	0.42	0.62	0.47
1984	0.38	0.33	0.32	0.74	0.42	0.65	0.75	0.79	0.54	0.47	0.53	0.63	0.62	0.64	0.67	0.41	0.65	0.51
1985	0.39	0.36	0.47	0.67	0.48	0.66	0.77	0.77	0.48	0.48	0.52	0.67	0.69	0.65	0.70	0.37	0.64	0.56
1986	0.45	0.42	0.40	0.63	0.51	0.68	0.71	0.77	0.50	0.41	0.51	0.66	0.68	0.64	0.69	0.44	0.64	0.58
1987	0.41	0.42	0.37	0.68	0.52	0.67	0.72	0.74	0.50	0.44	0.54	0.64	0.68	0.58	0.76	0.39	0.59	0.53
1988	0.39	0.41	0.31	0.66	0.59	0.70	0.73	0.74	0.50	0.41	0.52	0.59	0.67	0.51	0.81	0.38	0.53	0.53
1989	0.39	0.41	0.44	0.65	0.62	0.67	0.74	0.74	0.51	0.39	0.53	0.54	0.68	0.49	0.81	0.42	0.52	0.56
1990	0.47	0.41	0.40	0.64	0.55	0.62	0.73	0.72	0.46	0.39	0.51	0.54	0.66	0.48	0.87	0.38	0.45	0.53
1991	0.45	0.43	0.24	0.60	0.45	0.57	0.70	0.65	0.46	0.36	0.51	0.55	0.61	0.45	0.70	0.33	0.37	0.51
1992	0.50	0.43	0.23	0.45	0.37	0.56	0.71	0.59	0.35	0.29	0.51	0.55	0.54	0.43	0.61	0.24	0.36	0.45