Nechako Fisheries Conservation Program
5 Year Plan: 2007-2012

January, 2007

Prepared by:

NFCP Technical Committee

Executive Summary

Nechako Fisheries Conservation Program planning occurs annually to provide operational guidance for monitoring projects. This 5 yr plan was developed by the NFCP Technical Committee to help direct program activities over the period 2007-2012. The plan is based on a systematic evaluation of the need for, and consequences of, alterations to the frequency and scheduling of monitoring activities. For the purposes of this planning document, it is assumed that core water management activities including the Annual Water Allocation (AWA) and Summer Temperature Management Program (STMP) will remain unchanged, consistent with 1987 Settlement Agreement requirements. Both adult and juvenile Chinook monitoring will be reduced and streamlined so as to improve overall program efficiency. Recommended modifications include reductions in helicopter overflight frequency during annual abundance surveys, adoption of the long term average residency time for scaling adult Chinook numbers, and reduced frequency of fry emergence and juvenile outmigration surveys. Adult carcass surveys will continue to provide biological supporting data for the Chinook population counts and to provide linkage to the historic data set. Program reviews by the Technical Committee are recommended for early October during each calendar year so as to inform annual planning and programming.

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Introduction

The Nechako Fisheries Conservation Program (NFCP) has a mandate to carry out monitoring, research and, if necessary, remedial measures to conserve Chinook salmon in the Nechako River. The program was designed to detect long-term changes in the Nechako River chinook salmon population in relation to changes in flow. The *1987 Settlement Agreement* which was prepared in anticipation of the Kemano Completion Project sets out a “Conservation Goal” to sustain a target population of between 1,700 to 4,000 Chinook spawners. Since 1988, the NFCP has measured Chinook spawning escapements to the Nechako to assess achievement of the Conservation Goal.

Juvenile Chinook monitoring has also been undertaken to assess in-river habitat quality and to potentially trigger remedial activities in the event of habitat degradation in relation to flow changes. The fry emergence project has shown that the quality of the incubation environment in the Upper Nechako River is stable. The juvenile out-migration project has shown that the numbers of juveniles produced in the Nechako River have generally been sufficient to return spawners within the values identified by the Conservation Goal.

The overall conclusions reported in the NFCP Technical Data Review are that “in-river conditions examined by the committee are sufficient to sustain a population of chinook salmon that fluctuates generally within the target population range” and “the intent and spirit of the Conservation Goal have been met”. In order to have a reasonable level of certainty that the in-river conditions remain stable, the Technical Committee is tasked with monitoring and evaluation of fish and fish habitat indices to identify possible long-term trends. However, in view of the observed stability in environmental conditions over the past 17 years (NFCP Technical Data Review, 2005), it is timely to re-evaluate program activities and determine how they might be streamlined and/or modified over the period 2007-2012. This is a logical evolution of the program from undertaking all projects in all years to an approach, based on experience, of undertaking the right projects in the right years. One of the main guiding principles for the planning exercise is the necessity to maintain data integrity as well as the ability to monitor trends over time. Planning also builds on the results of previous NFCP investigations; these results have been summarized in the Appendix.

It is assumed that the established core flow management and temperature monitoring components of the program will continue according to the terms of the *1987 Settlement Agreement*. The present evaluation was undertaken to determine whether changes can be made to juvenile and/or adult Chinook salmon monitoring activities so as to increase efficiency and reduce costs. Results presented in the document reflect a consensus-based plan to help guide program activities for the years 2007-2012. The 5-yr plan will also provide supporting rationale for future annual plans to be developed over this period.

Overview of NFCP Monitoring Programs

The main activities of the NFCP are fisheries, flow discharge and water temperature monitoring. Careful monitoring and critical evaluation provides the essential feedback to the NFCP whether the Conservation Goal and the other program objectives are being met.

NFCP activities presently include monitoring of:

- Skins Lake Spillway discharge of the Annual Water Allocation (AWA),
- effectiveness of summer discharges to moderate stream temperatures as part of the Summer Temperature Management Program (STMP),
- adult Chinook spawner abundance and biological sampling, and,
- Chinook incubation and rearing conditions.

Changes to the monitoring of Skins Lake Spillway discharges (AWA) or the effectiveness of summer discharges to moderate stream temperatures (STMP) are not contemplated. However, given the documented stability of the habitat performance indices over the past 17 years, the Technical Committee has undertaken a critical review of the methods used for estimating spawner abundance and other biological monitoring projects. The following sections document the Technical Committees' recommendations for these projects.

Nechako River Chinook have been monitored annually in relation to the Conservation Goal. Spawner enumeration has been carried out using Area-Under-the-Curve methodology since 1988; prior to then, spawner counts were obtained by DFO Fishery Officers using less rigorous methods. Results are shown in Figure 1.

To further evaluate fish habitat quality, NFCP has developed a set of relationships between spawner abundance and fry emergence as well as juvenile outmigration. A future reduction in incubation and juvenile habitat quality may be detectable as outliers or departures from the measured statistical relationships.

The Area under the Curve (AUC) method uses both periodic helicopter counts of spawner numbers during fall Chinook spawning and estimates of the time female spawners spend on the redd (residence time) in the calculation of the spawner population size. The following sections evaluate the sensitivity of the spawner estimate to different approaches to these aspects of the project.

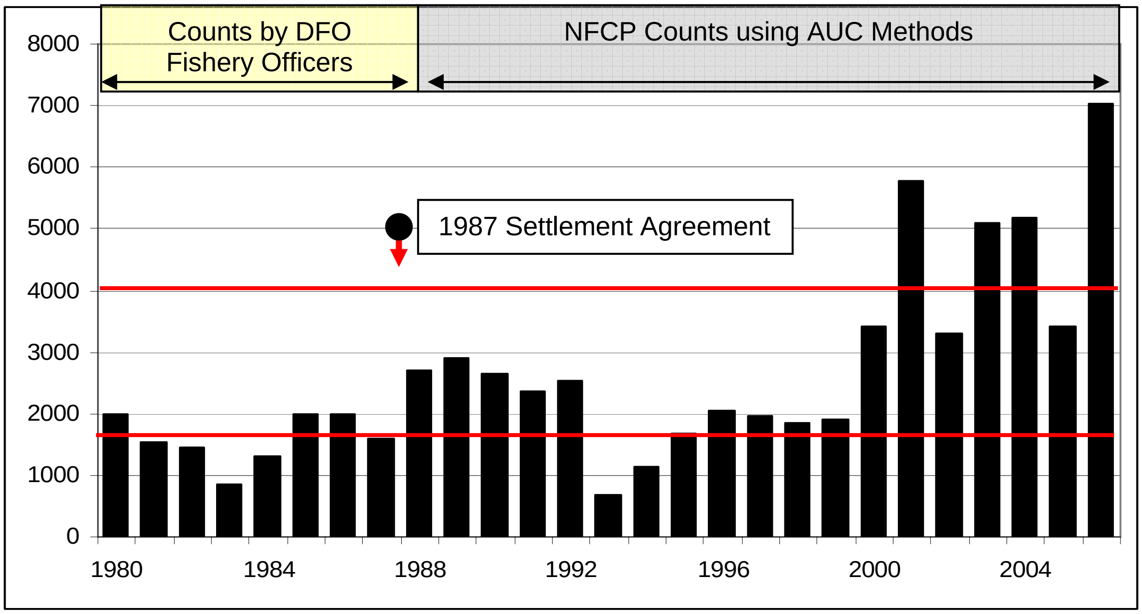

Figure 1. Number of adult Chinook in the Nechako River since 1980. Horizontal lines indicate target population level of 1700 – 4000 spawners. Annual spawner counts have remained above 3000 adults since the year 2000.

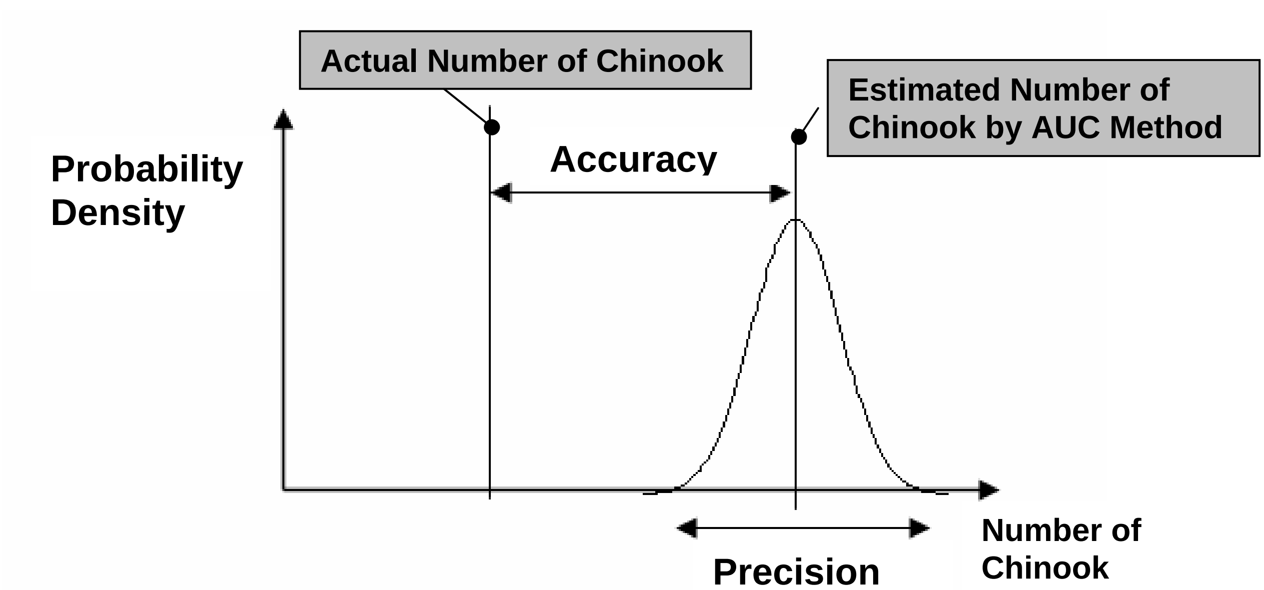

Figure 2. Graphic to illustrate the concepts of accuracy and precision, as they pertain to Chinook abundance estimation in the Nechako River.

Evaluation

Reductions in Overflight Frequency

There is no absolute ground truth of the number of spawning Chinook in the Nechako, such as a fence count. The accuracy of applicable survey methods, including the area-under-the-curve method, is only partially understood. In contrast, the precision of the estimates could be measured by means of repeated measurements (i.e. replicate helicopter surveys within single days), but these are largely impractical. In general, higher sampling frequencies result in more precise measurements. These relationships are illustrated in Figure 2.

DFO have analyzed the loss in spawner abundance measurement precision associated with reductions in the overflight frequency. The primary estimation method is area-under-the-curve which relies on sequential helicopter over-flights and estimates of mean female spawner residency time. The method integrates abundance over time and either uses a trapezoidal approach (i.e. “connect the dots”) or a maximum likelihood approach (MLA) to fit a normal curve to the data. Figure 3 shows the 1989 aerial overflight observations relative to the fitted normal curve; subsequent years are shown in Figure 4. The MLA has better statistical properties than the trapezoidal approach, thus providing a better estimate of the true Chinook population size. From 1988 to 2005 the NFCP used the trapezoidal method as the basis for the annual population estimate. In 2006, the NFCP adopted the MLA based on analyses conducted by DFO, which are reported below. Graphic representations shown in Figures 3 and 4 demonstrate the robustness of the MLA using historic data for Nechako Chinook. In addition, Table 2 indicates that the use of the MLA has limited the departure from escapement counts generated by the trapezoidal method and also provides adequate precision at lower flight frequencies.

DFO reviewed the sensitivity of the precision of the spawner estimate to the frequency of the spawner flights (N. Trouton, in prep) and concluded that the use of five weekly flights (occurring throughout the first 4 weeks in September and first week of October) achieved the best balance between survey frequency, accuracy of resultant escapement estimates, and ability to produce reliable inferences for stock status. This result is similar to the results of an analysis by Hill and Irvine (NFCP 10 Year Data Review Workshop). Table 1 compares the results with the entire data series (6-9 overflights/year) with the MLA using all data; this analysis shows that the reduced flight frequency had a mean percent error of 1.3% (95% CI is ±0.6%).

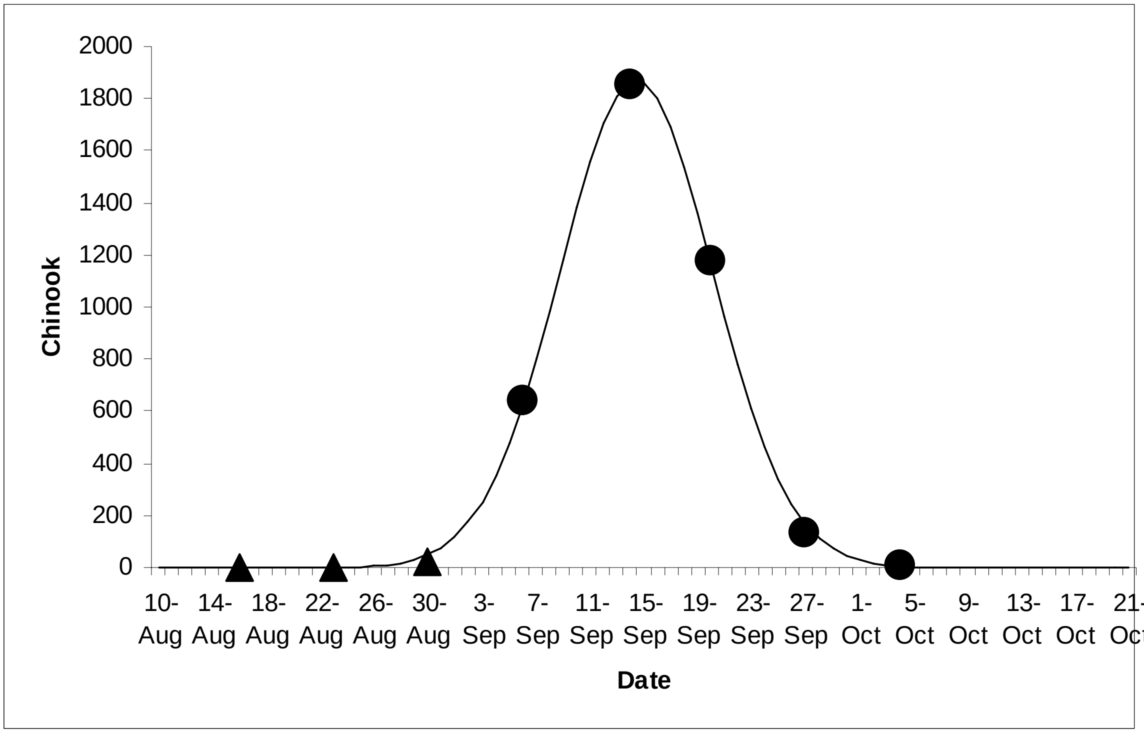

Figure 3. 1989 Maximum Likelihood Analysis graph for adult Chinook in the Nechako River. Round circles indicate the five observations that fall within a September/first week of October timing window; triangles are observations that fall outside the recommended sampling window.

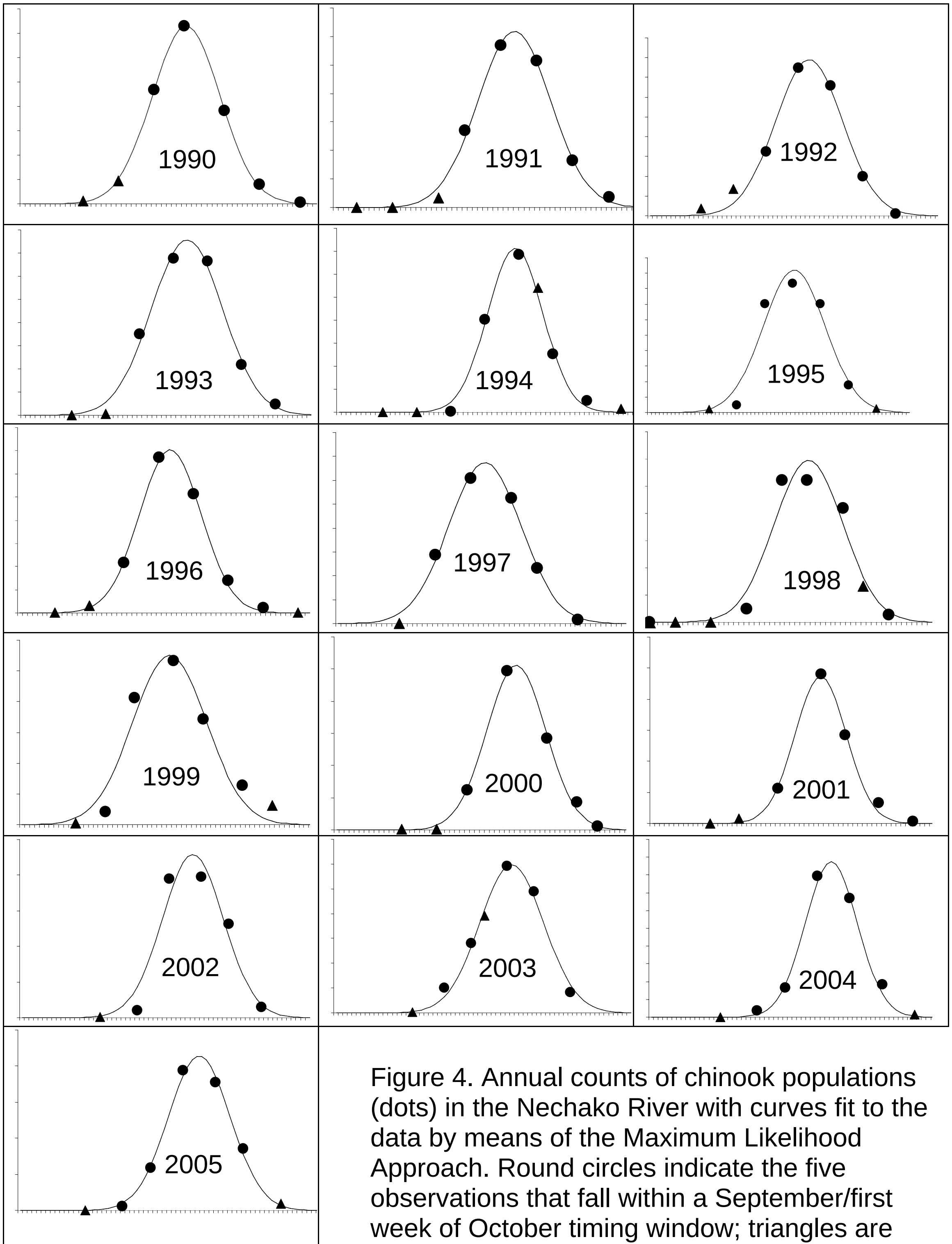

Figure 4. Annual counts of chinook populations (dots) in the Nechako River with curves fit to the data by means of the Maximum Likelihood Approach. Round circles indicate the five observations that fall within a September/first week of October timing window; triangles are observations that fall outside the recommended sampling window.

Table 1. DFO sensitivity analysis of Nechako flight frequency for estimating Chinook population. ML = maximum likelihood, AUC = area-under-the-curve.

Option	Description	Mean Absolute Percent Error	95% CI
1: ML AUC – 5	5 of the original weekly flights thru the first 4 weeks of Sept. and first week of Oct.	1.3%	±0.6%
2: ML AUC – 5	5 of the original weekly flights thru the last week in Aug. and the first 4 weeks of Sept.	2.8%	±2.5%
3: ML AUC – 4	4 of the original weekly flights thru the first 4 weeks of Sept.	3.9%	±3.5%
4: ML AUC – 4	1 flight from the last week in Aug. and the first 3 flights in Sept.	17.4%	±12.9%
5:Trapezoidal – AUC	All original flights	3.3%	±2.8%
6: Peak count	Original flight with highest count and 1.56 expansion factor (assumes 65% of population is observed)	14.2%	±4.8%
7: Peak count	Original flight with highest count and 1.68 expansion factor (assumes 61% of population is observed)	12.2%	±6.5%

These observations are consistent with a threshold mechanism between flight frequency and measurement precision of Chinook escapements. Additional flights above the threshold will not greatly improve precision. In contrast, a reduced number of flights below the threshold will lead to rapid degradation of the precision of escapement estimates.

Table 2 provides further information about the effects of methodology and flight frequency on measurement precision. Utilizing all of the available flight data, there is a mean 2.1 % difference in estimates between MLA and Trapezoidal methods, a mean 1.5 % difference between MLA with 5 flights and MLA with all flights, and a mean 3.4 % difference between MLA with 5 flights and Trapezoidal with all flights.

Table 2. Difference between Trapezoidal vs. MLA Methods for Estimating the Nechako Chinook Population.

	Trap All	MLA All			MLA 5 (Aug 31 to Oct 4)				
Year	Estimate	Estimate	# of fish different vs Trap All	% difference vs Trap All	Estimate	# of fish different vs ML All	% difference vs ML All	# of fish different vs Trap All	% difference vs Trap All
1989	2915	2928	13	0.4%	2935	7	0.2%	20	0.7%
1990	2645	2628	-17	-0.6%	2639	11	0.4%	-6	-0.2%
1991	2363	2371	8	0.3%	2427	56	2.4%	64	2.7%
1992	2525	2451	-74	-2.9%	2393	-58	-2.4%	-132	-5.2%
1993	673	685	12	1.8%	697	12	1.8%	24	3.6%
1994	1150	1138	-12	-1.0%	1103	-35	-3.1%	-47	-4.1%
1995	1686	1741	55	3.3%	1746	5	0.3%	60	3.6%
1996	2040	2005	-35	-1.7%	1998	-7	-0.3%	-42	-2.1%
1997	1954	2021	67	3.4%	2050	29	1.4%	96	4.9%
1998	1851	1919	68	3.7%	1993	74	3.9%	142	7.7%
1999	1915	1876	-39	-2.0%	1870	-6	-0.3%	-45	-2.3%
2000	3405	3459	54	1.6%	3467	8	0.2%	62	1.8%
2001	5785	5532	-253	-4.4%	5515	-17	-0.3%	-270	-4.7%
2002	3296	3397	101	3.1%	3403	6	0.2%	107	3.2%
2003	5108	5121	13	0.3%	5236	115	2.2%	128	2.5%
2004	5189	4978	-211	-4.1%	4718	-260	-5.2%	-471	-9.1%
2005	3427	3418	-9	-0.3%	3424	6	0.2%	-3	-0.1%
Absolute % Difference									
Maximum				4.4%			5.2%		9.1%
Mean				2.1%			1.5%		3.4%
Absolute Difference									
Maximum			253			260		471	
Mean			61			42		101	

Use of a Single Site for Residency Estimates

Parameters affecting the accuracy and precision of the Chinook spawner population estimate were evaluated by Triton (1997)[1]. There was no significant impact on population estimates when mean residency times were pooled for sampling sites (upper river vs. lower river) and spawning times (early spawners vs. late spawners). This implies that a single monitoring site located in the upper river will suffice for measurements of residency time. Figure 5 shows the impact of pooling the upper and lower river estimates of residency times on the spawner population estimate. During the simulation, the difference in the two calculation methods only varied between 0.4% and 7.7% with no consistent direction in difference. In a similar analysis, there were no differences in estimates using residence time values for early vs. late spawners.

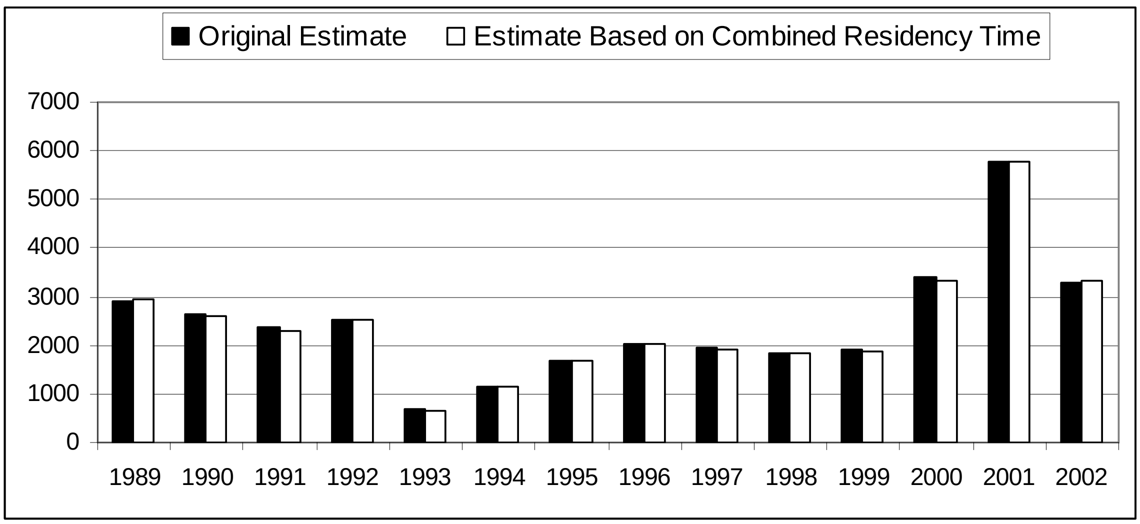

Figure 5. Source: NFCP TDR (2005) Figure 5.1-13.

[1] NFCP 10 Year Review: Background Report (1997)

Use of Mean Residency Time for Population Estimate

AUC estimates are sensitive to estimates of female residency time, necessitating the use of accurate estimates. In the Nechako, there is a good historical data set and the statistical properties of the residency time estimates are well understood. Mean female residency time on redds (Figure 6) has varied between 8.9 days in 1994 to 12.5 days in 2004.

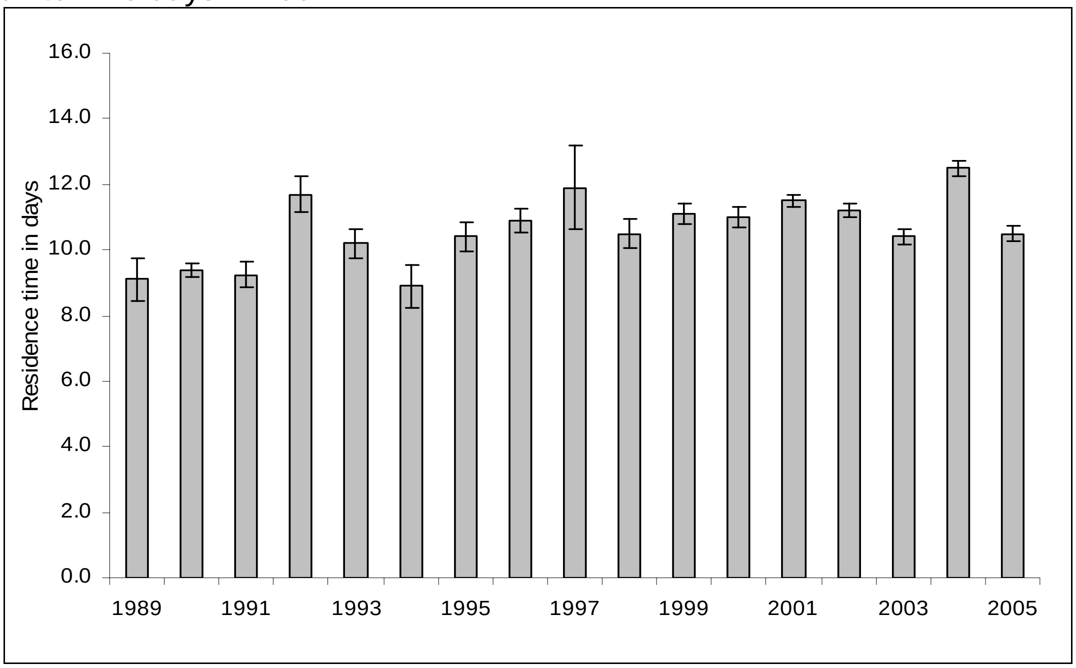

Figure 6. Mean residence times (± SE) of female Nechako River chinook salmon, 1989-2005.

Variations in the residency time affect the population estimate in a predictable fashion (Figure 7). Use of the minimum residency time inflates the estimate while use of the maximum residency time underestimates the population.

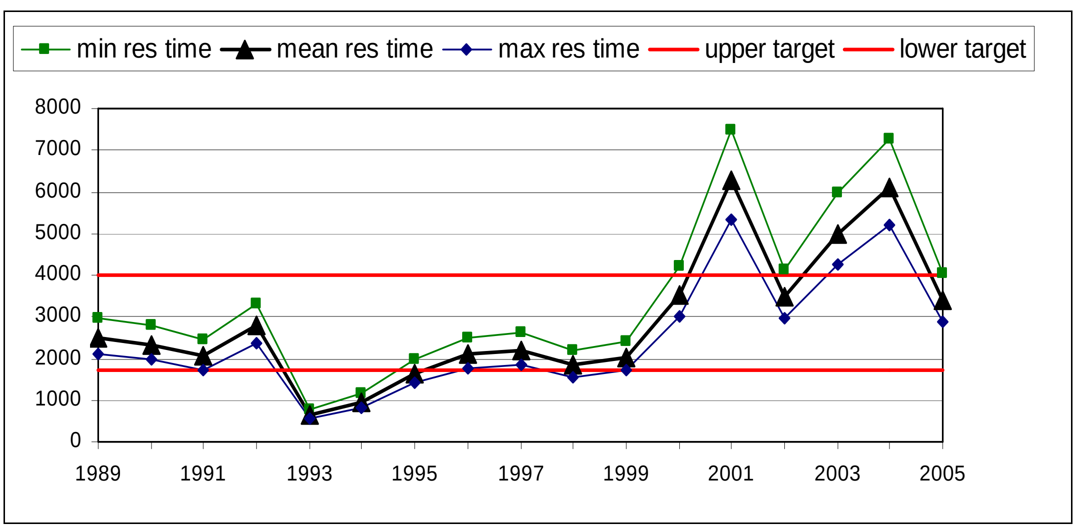

Figure 7. Effects of changing residency time estimate on population estimates.

Across the different years, the average residency time is 10.6 days. Population estimates based on the mean residency time are less precise than estimates derived using annual observations. However, Figure 8 shows that the use of mean residency time results generally in a relatively small loss of measurement precision. The magnitude of difference in the annual population estimate introduced by using the mean residency time varied between 0 to ±18 % between the period 1989 – 2005. Deviations greater than 10 % occurred in 7 out of 17 years. This reduction in measurement precision (from using the mean residency time) over the course of the program would not have altered any conclusions regarding the achievement of the Conservation Goal (Figure 8).

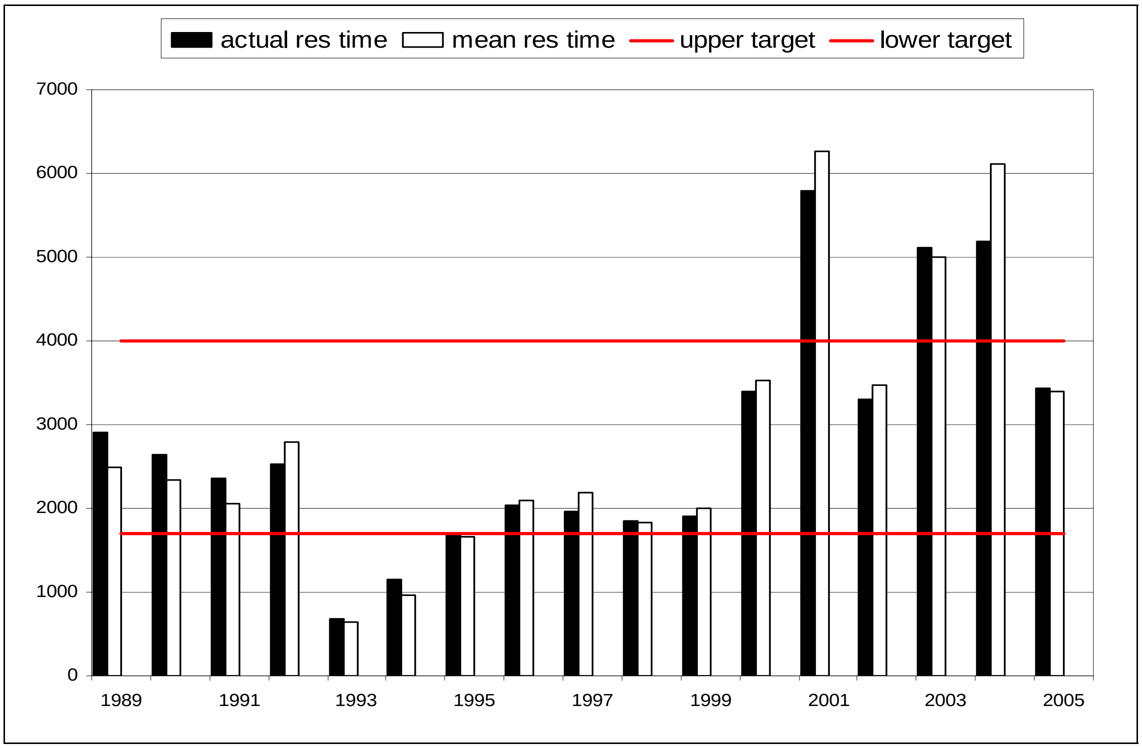

Figure 8. Comparison of historical Chinook abundance estimates using actual measured residency time with estimates based on mean residency time (10.6 days).

The Technical Committee has concluded, based on the results of this analysis, that use of the mean residence time (10.6 days) in future AUC calculations will provide a sufficiently precise estimate of the spawner population. However, if the population were to approach the minimum level (1700) included in the 1987 Settlement Agreement, the Technical Committee would re-evaluate the necessity to revert to annual estimates of the residence time.

Level of Effort During Carcass Surveys

Sampling of Chinook carcasses has been conducted annually by NFCP to collect biological data on age, size, life history, sex and egg retention. In particular, age data are used to interpret enumeration results as they indicate which brood years contributed to the spawning population. Length data are used as an indicator of changes in growth patterns as well as a comparison with other Chinook populations (DFO, unpubl. data)[2]. Sampling has been conducted across the entire spawning area and across the entire period of die-off to ensure that any potential differences in population by spawning location and timing can be identified.

The study area has previously been divided into three sub-areas: upper, middle and lower river. Analysis of length data has indicated that there is little difference between the fish biological characteristics in the three different areas. Samples were also separated into two run timing periods, early and late, in relation to the peak-of-spawn date. Analysis of length data indicates that there is little difference between fish that die-off early vs. fish that die-off late.

A series of statistical tests were used to determine if there were significant variations from "expected" frequencies of age-at-return for males and females in each year. The analyses identified differences in many of the comparisons, but in most cases those differences were attributed to relatively small sample sizes. When the data were pooled across all years, there were no significant differences in age-at-return between early vs. late males or early vs. late females.

It is recommended that the carcass recovery project continue to be structured such that representative sampling is conducted across the three river areas, and that a minimum sample size of 200 fish be maintained. It is further recommended that the project be structured such that representative sampling is conducted across both the earlier and later timing of die-off. This will provide the opportunity to detect departures from the established statistical relationships.

Alternate Methodologies

The NFCP Chinook enumeration program has provided estimates to compare the population size with the Conservation Goal. Since 1989, different assessment methodologies have been developed in BC and elsewhere, and it is worthwhile evaluating whether it may be advantageous to apply them in the Nechako. Potential methods for enumerating adult salmon include counting fences, remote

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[2] NFCP: Analysis of Nechako River chinook carcass data. Prepared by Byron Nutton. November 2006.

sensing including video and side-scan SONAR, and mark-recapture programs. An evaluation of the applicability of the different methods is provided below.

A project undertaken by A. Lill and W. Peterson in 1988 called the “Nechako Counting Fence Project” provides insight into the practicality of a Nechako River chinook counting fence. One of the major challenges in the Nechako is the need to operate a fence during periods of cooling water flows. Any fence structure would need to handle the high volume late-summer flows which co-incide with Chinook migration periods.

The Fort Fraser Highway Bridge was recommended as the preferred enumeration site. A fence site below Vanderhoof was not considered practical due to the presence of co-migrating sockeye salmon en route to the Nautley River. One of the main drawbacks of any barrier counting fence (physical or otherwise) is the potential impact of the fence itself on adult behavior and distribution. For example, at DFO’s Bowron River fence, the percentage of Chinook which spawned above the fence site went from 80% to 20% prior to, and following, fence installation. A fixed permanent barrier fence in the Nechako was deemed impractical because even a small dam or weir would contribute to an already serious flooding situation at the desired enumeration locations. An electric fence was also rejected due to concerns over modified fish behavior and the effectiveness of the barrier.

Lill and Peterson considered the use of video cameras underneath the highway bridge at Fort Fraser, but these techniques were never tested or pursued. White panels would be secured to the river bed making salmon visible as they crossed the panel grid. Side scan SONAR has been utilized to count Chinook salmon in the Kenai River in Alaska, so the method is potentially applicable in the Nechako. However, one of the major challenges is distinguishing the signal (adult Chinook) from the noise (resident fish species). There has been much interest in the application of DIDSON imaging SONAR technology for counting salmon, but due to the short range of the system (10-20 m) it would be necessary to place a temporary weir structure in the river to force the fish to swim through the narrow sonic field. While there is no doubt that a counting fence could be made to work given adequate effort, the logistical challenges and high expense undermine the applicability of this approach in the Nechako River.

Mark-recapture is a standard enumeration technique and was carried out for many years in the Stuart River as part of the NFCP program. For monitoring the Chinook abundance in the Nechako, it is unlikely whether an acceptable level of precision could be achieved, and there would also be questions about accuracy if the assumptions inherent in the methods were violated.

Use of Stuart Chinook as a Reference Population

The Stuart River enumeration project was formerly carried out by the NFCP to identify escapement trends in a nearby unregulated system for comparison with Chinook escapements in the regulated Nechako. The intention was to use the Stuart escapement data to identify when extrinsic factors (i.e. outside of the Nechako watershed) might explain unexpected changes in abundance in Nechako Chinook. The project was implemented between 1988 to 2003.

During the Technical Data Review, DFO Science Branch and Stock Assessment personnel advised the Technical Committee that they believed the technique currently used to enumerate the Stuart escapement, both in theory and in practice, was highly variable and that its value in identifying future trends in the escapement would be very limited. In response the Technical Committee decided to discontinue the annual project.

Use of the Summer 5_2 Aggregate as an Index for Spawner Abundance

The NFCP Technical Committee routinely monitors Chinook returns to the Nechako River as part of activities under the 1987 Settlement Agreement. The performance goal is defined as a range of 1700-4000 animals with an average of 3100, based on "the average escapement to the river plus the average harvest during the period 1980-1986."

Apart from the measurement inaccuracies for the1980-1986 escapements, a more significant confoundment is the inability to ascertain the harvest component for the stock. It is widely recognized that the current ability to define harvest is beyond the ability of fisheries science. This being the case, the NFCP has explored alternate means to identify whether variations in year-to-year chinook returns to the Nechako are a result of independent variation in the productivity of this stock or whether these variations are synchronous in other stocks. The latter would reflect extrinsic events taking place outside of the Nechako River.

As concern regarding the utility of the Stuart River enumeration methodologies has been raised, the NFCP assessed whether there were alternate system(s) that could serve as a reference stream for the Nechako. This was done by first assessing trends from other stocks in geographical proximity (i.e. Stuart River) and comparing escapement per escapement[3] of non-Nechako vs. Nechako stocks and, second, by examining aggregates of DFO Chinook Technical Committee (CTC) index stocks.

Chinook escapement data from other Fraser stocks were compared to Nechako returns to assess whether there was another stock(s) that correlated with Nechako returns over the period of record. No individual stock correlated with

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[3] synonymous with recruits-per-spawner

Nechako returns over the periods 1980 to 2003 and 1988 to 2003 (after NFCP monitoring began). Comparisons were also undertaken by comparing CTC Spring and Summer index stocks (aggregates) with trends in Nechako chinook returns. Both Summer 5-2 Chinook (Chilko, Quesnel, Nechako[4], Stellako, Stuart, Clearwater, Mahood, Raft, Portage, N.Thompson, Seton and Portage stocks) and mid Fraser stocks (Maria Slough, Upper Pitt, Birkenhead, Bridge, Portage, Seton, Chilcotin, Chilko, Cottonwood, Horsefly, Quesnel and Westroad) were compared.

The results from the comparison of Escapement per Escapement (EPE) suggest that the Summer 5-2 and mid-Fraser stocks are strongly coherent. However neither the Stuart nor the aggregates (CTC Summer or mid Fraser) provide a suitable reference for the Nechako population (Figure 9). Aggregate data are collected annually by DFO stock assessment division and more refinement of the appropriate aggregate may help to define a suitable comparative index for Nechako escapements in future. For the present, it is prudent to assume that Nechako Chinook fluctuate independently of the other Fraser River stocks.

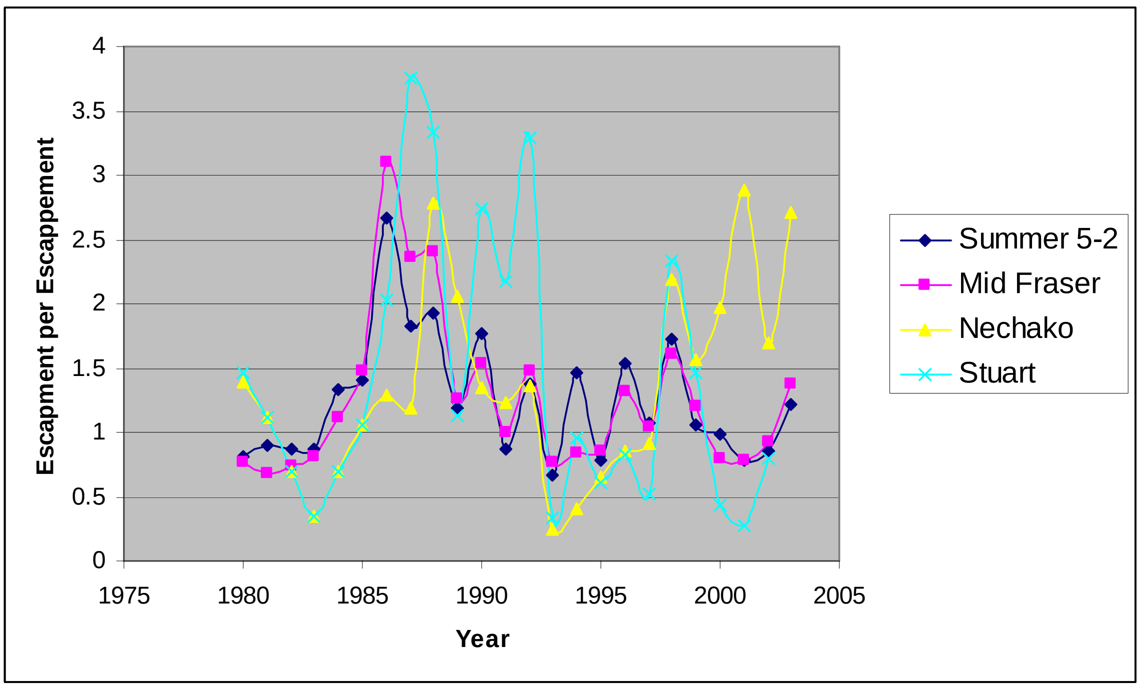

Figure 9. Nechako River vs. Fraser Summer 5-2, mid Fraser and Stuart escapement per escapement estimates.

[4] excluded from aggregate value

Fry Emergence and Juvenile Outmigration Surveys

Juvenile life history data indicate several strong correlations between number of spawners in the river and corresponding juvenile production indices. The indices developed by NFCP include:

- Fry emergence index
- In- river rearing index as expressed by catch-per-unit-effort of electrofishing
- Juvenile outmigration index

These relationships are presented in Figures 10-12.

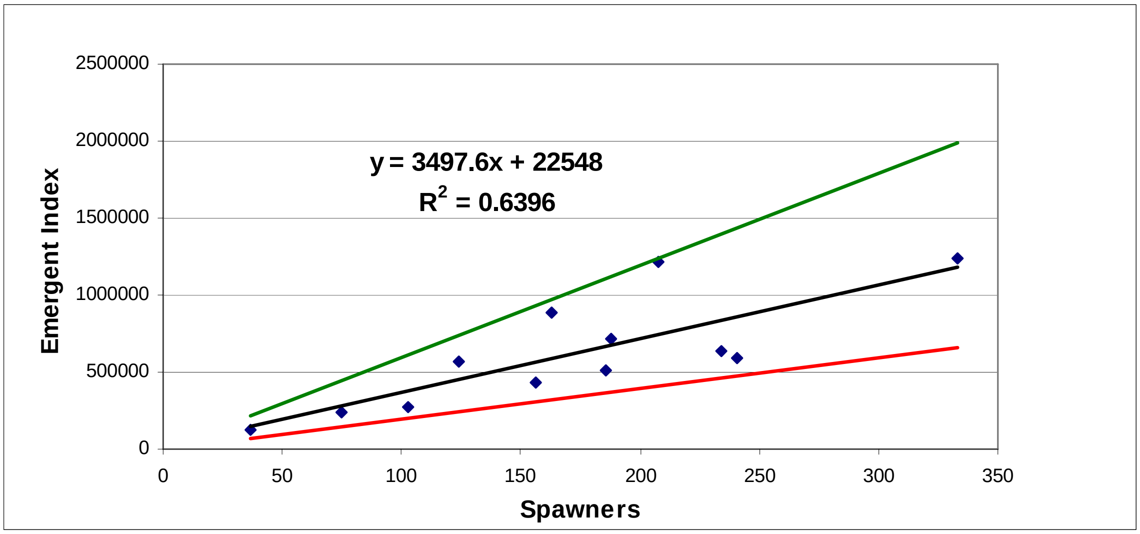

Figure 10. Index of emergence vs spawners 1990-2002. Upper and lower lines indicate the upper and lower data envelopes.

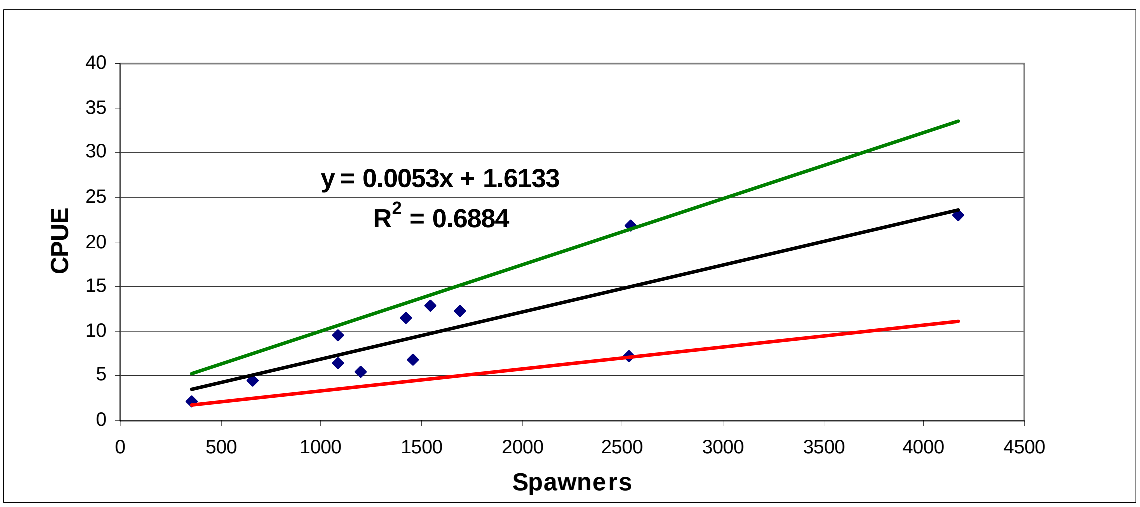

Figure 11. Juvenile Chinook catch-per-unit-effort vs spawners1992 to 2002. Upper and lower lines indicate the upper and lower data envelopes.

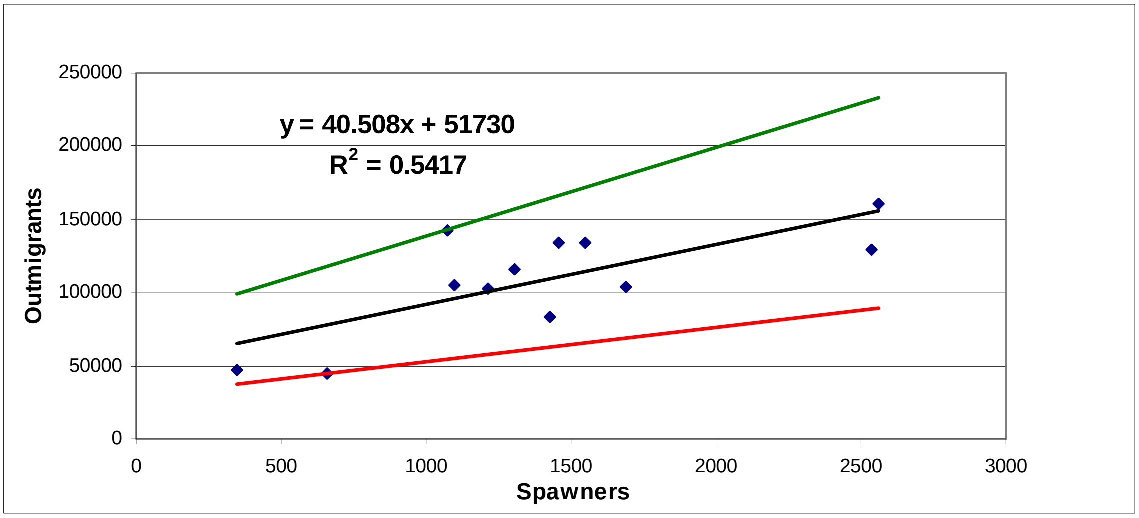

Figure 12. Outmigration vs spawners upstream of Diamond Island. Upper and lower lines indicate the upper and lower data envelopes.

The regressions indicate a stable riverine environment over the period of record. In addition the relationships provide the opportunity to identify the % departure for each of the project years. Based on the data on record and corresponding adult returns, the ranges in index values reflect conditions that are consistent with the achievement of the Conservation Goal. Based on this demonstrated stability these ranges can be used to establish a threshold envelope to assess future indexing results. Values below the lower envelopes would trigger additional actions. The magnitude of departure from the established “norm” would dictate the appropriate action.

Formerly, NFCP undertook fry and juvenile surveys on an annual basis. Based on the strength of the statistical relationships and the apparent stability of in-river habitat conditions, it is recommended that fry and juvenile surveys be carried out in future with a frequency of once every five years. It is further recommended that measurements of adult residence time be scheduled for the year prior to fry and juvenile surveys so as to optimize the accuracy of fry per spawner and juvenile outmigrants per spawner estimates.

Recommendations

The 5-year plan defines a set of projects that meet the requirements of the 1987 Settlement Agreement and also take into account the results of NFCP monitoring between 1989 – 2005. The water management functions of the NFCP are narrowly defined under the Settlement Agreement; it is assumed that the AWA and STMP components will remain unchanged in future

The evaluation of NFCP projects has identified a number of refinements for the Chinook monitoring component that can improve the overall cost-effectiveness and build on the knowledge that has been generated throughout the program. One major refinement is the use of the historic mean residency time, 10.6 days, during future AUC surveys.

In the event that Chinook population levels declined below the lower target value of 1700, the NFCP will consider reverting to annual measurements of residency time. If/when new residency time measurements are deemed necessary, then it is recommended that this be undertaken at a single site in the Upper Nechako. Additionally it is recommended that measurements of residency time be scheduled for the year prior to fry and juvenile surveys so as to optimize the accuracy of fry per spawner and juvenile outmigrants per spawner estimates.

It is recommended that the area-under-the-curve/helicopter survey program be continued between 2007-2012 to generate reliable adult Chinook population estimates. A flight frequency of 5 weekly overflights per year scheduled to start in the first week of September will provide a defensible population estimate.

Alternative enumeration methods do not provide a practical means to generate population estimates. In the event that alternate methods of enumerating adult Chinook become available, it will be necessary to maintain the AUC program for at least several years so as to calibrate any new approaches.

The NFCP previously measured Chinook abundance in the Stuart River to evaluate the utility of the Stuart as a reference site. As well, Chinook indices based on the aggregate escapement of other Fraser stocks have been evaluated for their use as a reference for Nechako Chinook. Neither approach appears to provide a suitable reference. However, NFCP recommends that Fraser River Chinook data continue to be evaluated in future in regards to their suitability for this purpose.

Relationships between fry emergence indices, rearing densities, outmigrant densities and adult spawners are well established from data collected over a 13 yr period. It is recommended that if/when future observations fall below the lower data envelopes for the established statistical relationships, that this serve as a trigger for the consideration of additional evaluation.

In summary, the NFCP recommends the following program for 2007-2012:

- Key water management activities including establishment of the Annual Water Allocation (AWA) and operation of the Summer Temperature Management Program (STMP) to continue annually unchanged, consistent with the 1987 Settlement Agreement.

- Annual adult Chinook surveys using the Area-Under-The-Curve method and the Maximum Likelihood Approach for population estimation;

- A total of 5 helicopter flights per year scheduled on a weekly basis between early September and the end of the 1st week of October;

- Use of the historical mean redd residency time of 10.6 days for calculating adult numbers

- Measurement of the mean redd residency time at the Upper River site in 2008 during the year prior to fry and juvenile surveys (2009);

- Annual Chinook carcass recovery program scheduled both during the early and late portion of the migration period and covering the lower, middle and upper sections of the enumeration area;

- Regular (annual) evaluation of the utility of using other Fraser Chinook stocks or other methods to establish a reference population unaffected by flow regulation;

- Fry emergence program scheduled in 2009 (frequency of once out of 5 yr) to confirm stability of in-river conditions; decisions regarding additional scheduling of the program based on current habitat conditions;

- Juvenile outmigration program scheduled in 2009 (frequency of once out of 5 yr) to confirm stability of in-river conditions; decisions regarding additional scheduling of the program based on current habitat conditions;

- Physical data collection to be initiated during the fall prior to, and continuing through, the duration of the fry program;

- Measurement of substrate quality and composition every 10 yr (to commence in 2010);

- Annual inspections of instream structures.

Table 3 shows the seasonal timetable of NFCP activities.

As part of ongoing NFCP activities for 2007-2012, it is recommended that there be an annual evaluation to provide a formalized process for reviewing monitoring results prior to the initiation of program activities during the following year. The annual meeting would be scheduled during early October of every calendar year, early enough so that mobilization of fry and juvenile sampling could take place in the event that spawning escapements fall below the Conservation Goal.

Risk Assessment

The Recommendations identify a number of changes to current NFCP Chinook monitoring that were arrived at based on a combined assessment of technical merit, cost-effectiveness and practicality. These changes represent a refinement to the current program and a significant reduction in effort however they do not represent a risk in terms of the NFCP's ability to meet it's mandate.

It is proposed that the NFCP continue to conduct annual projects on the Nechako River to assess Chinook spawner abundance and to conduct biological sampling of carcasses. The proposal includes refinements to the methods used to conduct these projects, but the technical aspects of the proposed changes have been thoroughly examined and data quality will be consistent with the historic dataset. These changes will not affect the NFCP's ability to assess the annual spawner abundance against the Conservation Goal.

The most significant proposed change is to move from annual assessments of fry emergence and juvenile outmigration on the Nechako River to periodic assessments, every 5 years. This change has been evaluated based on technical merit, and it has been identified that there is a very small risk that a potential change in the suitability of in-river habitat could occur, but not be detected for several years. Based on the information collected to date, it appears that the habitat is stable and it is unlikely that this will change except in the event of a dramatic physical perturbation in the river, or as a result of a very long-term, gradual trend. A dramatic physical perturbation would be observed and the NFCP would respond by re-initiating annual assessments, and a long-term trend would be detectable by the proposed period assessments.

Overall, the proposed changes the Chinook monitoring program introduce a very low level of risk to the NFCP's ability to detect and respond to environmental changes. The continuation of some annual projects assures that personnel are out on the river on a regular basis and that the NFCP remains a functional group, annually reviewing project results, discussing potential concerns, and responding to any unforeseen difficulties.

Table 3. Seasonal timing of NFCP projects and activities for 2007-2012.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Water Management				Apr 1: water year begins Apr 20 spring flows begin			STMP: July 10 to Aug 20		Sep 1 fall/ winter flows begin			
Adult Chinook									5 weekly helicopter flights in Sep and 1st week of Oct			
Fry Emergence (every 5 yr)			late March to mid-May									
Juvenile Outmigration (every 5 yr)				mid-April to mid-July							1 week	
Physical measurements (every 5 yr during juvenile programs	continuous data loggers											
Habitat complex inspections				opportunistically during juvenile surveys								
Gravel surveys		field surveys during low water periods?										

Budget Projections

Annual operational costs of different NFCP program elements are shown below. Totals are based on estimated personnel costs of $400/day (2006 dollars).

	Frequency	Days	Expenses	Total Cost
Remedial Measures - funded by Alcan 100%				
Summer Temperature Management	annual	109.5	$15,910	**$59,710**
Flow Control	annual	22.5	$3,410	**$12,410**
Instream Habitat Complex Inspection	annual	12	$4,821	**$9,621**
Chinook Monitoring – equally funded by DFO & Alcan				
Spawner Enumeration – 5 flights	annual	16	$25,400	**$31,800**
Carcass Recovery - Nechako	annual	20	$4,000	**$12,000**
Residence Time – upper site only	5 yrs	146	$30,000	**$88,400**
Juvenile Outmigration	5 yrs	541.5	$67,552	**$284,155**
Fry Emergence	5 yrs	222	$23,945	**$112,745**
Gravel Study	10 yrs		$100,000	**$100,000**

This 5-year plan includes a proposed schedule for conducting specific projects, however it also includes the principle that the NFCP will remain flexible and responsive to both the results of the scheduled projects and to observed or unexpected events in the watershed. Budget projections for any given year will be determined by the NFCP's response to these situations, but the costs of the anticipated monitoring program, as proposed in this plan have been projected below.

The total cost of the annual Remedial Measures projects, which are funded by Alcan, is $81,741. In addition to these costs, Alcan will be responsible for funding half of the total cost of monitoring in each year, as described below.

The total cost of the annual Chinook Monitoring projects is $43,800. Calendar years 2008 and 2009 will mark the first "five-year cycle" for conducting the Residence Time (2008) and Fry/Juvenile projects (2009) and the next scheduled Gravel study will occur in 2011. The total cost of monitoring in any given year will be determined by the projects which are conducted, but those costs will be equally shared by DFO and Alcan.

The total annual funding requirement from each agency in order to carry out the projects as proposed in this 5-year plan is summarized in the table below. Again, these costs are based on conducting the projects as proposed, but the projects conducted in any given year may vary from the proposed plan depending on observed or expected events in the watershed.

	Chinook Monitoring		Remedial Measures
Calendar Year	**DFO**	**Alcan**	**Alcan**
2007	$21,900	$21,900	$81,741
2008	$66,100	$66,100	$81,741
2009	$220,350	$220,350	$81,741
2010	$21,900	$21,900	$81,741
2011	$71,900	$71,900	$81,741
2012	$21,900	$21,900	$81,741

Appendix: Review of Previous NFCP Documents

Existing NFCP reports and planning papers are briefly reviewed below with a view towards informing the present planning exercise.

Document	Description	Findings	NFCP Monitoring Implications (5-year plan)
NFCP 10 Year Review: Background Report (1997)	Prepared to support NFCP refocusing in the context of KCP cancellation. Draft report was used by participants at the ESSA workshop (below).	Report presents most of the relevant monitoring data that was collected to 1997. Not much data interpretation is provided.	Report contains valuable appendices covering: 1) sources of AUC measurement bias and imprecision, 2) optimization of aerial over-flight frequency, 3) statistical properties of escapement estimates
NFCP: the last 10 years and the next 10 years (ESSA 1998)	Report from the ESSA workshop that was designed to: 1) review the NFCP 10-Year Review Background Report, 2) maximize what could be learned from the previous ten years of monitoring data, and 3) identify studies that would help guide the NFCP program over the next ten years.	Participants included numerous experts in applied fisheries monitoring areas. Impressive output from a 2-day workshop. Report takes a broad, somewhat academic view of the NFCP program and mandate.	Important implications include: *"AUC estimates are very sensitive to estimates of female residence time, which advises against eliminating this component of escapement monitoring."* *"There were no conclusive suggestions on the value of the early warning indicators, except the general opinion that the fry emergence index and juvenile density estimation from CPUE data were more useful than the juvenile out-migration index."* *"Some participants felt that while most juvenile monitoring projects were likely powerful enough to detect change after KCP, they are now likely only useful for detecting catastrophic natural events."*

Document	Description	Findings	NFCP Monitoring Implications (5-year plan)
Report of the NEEF Management Committee (2001)	The Nechako Environmental Enhancement Fund (NEEF) was established as part of the 1997 Alcan/BC Agreement. The Management Committee decided to use NEEF funds to construct a cold water release facility at Kenney Dam.	Report is essentially a pre-feasibility study for a KCWRF	Report recommends that the mandate of NFCP be expanded to include community input and to explore, jointly with NWC, ways to improve the management of the Nechako watershed. NFCP would also be tasked with proposing an optimal flow regime (taking into account recent work by the NWC). The interim flow regimes required to go from the current flows to the optimal flow regime would be established by the NFCP. $150k would be provided by the NEEF to NFCP for scientific support.
NFCP – Options for the Future (Draft 2005)	Paper prepared for the Steering Committee by the Technical Committee	Discusses 5 options for the future: 1. status quo; 2. sunset the NFCP; 3. sunset the NFCP and create a new agreement; 4. reduce the scope of the NFCP to a bare minimum; 5. set new objectives and renew the NFCP with modified mandate	Technical Committee agreed that the next step to pursue is option 5 involving the same three principle partners, a new name, and modified mandate that may include additional participants. For the short-term and the purpose of 5-year plan development, options 1 and 4 are the most relevant.
NFCP: "The Future" (ESSA 2005)	Summary of an ESSA visioning and scoping workshop designed to make explicit the goals, interests, and concerns of existing parties associated with future watershed management in the Nechako Basin.	Discusses the 5 alternative options above, and provides a preliminary road map for implementation. Decision-making is outside of the analytical frame of reference.	Report focuses on "Futures Planning" beyond a 5-year time horizon. As such, it doesn't have major implications for the present planning exercise.

Document	Description	Findings	NFCP Monitoring Implications (5-year plan)
NFCP: Technical Data Review (2005)	Report prepared to synthesize all of the work undertaken since NFCP inception in 1987.	Main findings include: 1) the STMP and AWA have been successful, 2) the spirit and intent of the Chinook Conservation Goal have been met, and 3) incubation and rearing habitat quality has been stable since 1987. Various measures were developed if the need arose to remediate the river due to post-KCP flow impacts.	Existing NFCP monitoring data provides an excellent long-term baseline for comparison with altered environmental conditions in future e.g. post-CWRF construction, habitat changes from salvage logging or climate change effects.
NFCP Schedule of activities for five year plan 2005-2010 (Draft 2005)	Draft plan developed by TC to incorporate reduced frequency in NFCP activities. Proposed plan to remain in effect until new management model or mandate established for NFCP.	Proposed activities: • STMP as previously • AWA as previously • In-stream habitat structures inspected annually, more thoroughly during fry and juvenile programs • Rigorous, annual spawner enumeration • Chinook carcass recovery to continue annually • Juvenile outmigration studies to be conducted following a suspected significant change in in-river rearing or incubation conditions or every 5 yr, whichever comes first • Fry emergence program to be conducted following a suspected significant change in in-river rearing or incubation conditions or every 5 yr, whichever comes first, and 2 yr apart from the juvenile outmigration study • Annual physical data collection • Measurement of substrate quality and composition to be conducted every 10 yr.	Need to evaluate the utility of the Fraser Summer Chinook complex as a reference for Nechako population.