Review of North and Central Coast Salmon Indicator Streams and Estimating Escapement, Catch and Run Size for each Salmon Conservation Unit

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Fisheries and Oceans, Canada

18 April 2012

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EXECUTIVE SUMMARY

A large amount of time and resources are expended each year by DFO, PSC, First Nations, stewardship groups and NGOs to obtain the catch and escapement data needed to monitor trends for BC salmon stocks and Conservation Units (CUs). Some of these data are combined in regional or coast-wide models to derive estimates of run size and exploitation rates for specific salmon indicator stocks (e.g. Northern Boundary Sockeye model; PSC Chinook and NCCC Coho models). In most instances, the results from these substantial data collection and analysis efforts have not been fully applied to the challenge of tracking trends in catch and escapement by CU.

LGL Limited was contracted by the Pacific Salmon Foundation in October 2011 to work with DFO stock assessment biologists to update the core datasets, database systems and analysis tools needed to track stock status and trends for BC salmon stocks. This project builds on a previous work supported by the State of the Salmon Program (SOS) in 2008-09 to produce estimates of escapement, catch and run size for each BC Salmon CU (English et al. 2009).

The analytical procedures used to compute escapement, catch and run size estimates for each SA and CU range from the relatively simple summation of annual catch and escapement estimates to complex run reconstruction techniques. The foundation for the escapement estimates presented in this report is the nuSEDS database and list of indicator streams identified by NCCC biologist as the most reliable set of escapement data available for each CU. All of our analyses are linked directly to a downloaded copy of the nuSEDS database so these analyses can be readily updated as new information is loaded into the database. The critical step in the escapement estimation process was identifying the streams with the most reliable escapement records. The DFO regional biologists identified 781 stream-species combinations where escapement survey data was of sufficient quality and quantity to be used as an indicator of annual escapement trends for a specific CU (Table 7). The majority of these indicator streams (81%) were assigned survey quality ratings of fair (2) or good (3). The streams with the highest quality survey data (ratings of 4 and 5) accounted for 6% of the indicator streams and 13% of the indicator streams were assigned a poor quality rating. This report provides details on the methods used to convert the escapement estimates for indicator stream into total escapement estimates for each Statistical Area and CU as well as a description of the sources of the exploitation rate estimates need to compute annual harvest and total run size estimates for each salmon CU. The last section of the report provides several recommendations regarding improvements to DFO databases and further analyses that should be conducted to assess the sensitivity of CU specific exploitations rates to different assumptions regarding run timing through coastal fisheries.

INTRODUCTION

LGL Limited was contracted by the Pacific Salmon Foundation in October 2011 to work with DFO stock assessment biologists to update the core datasets, database systems and analysis tools needed to track stock status and trends for BC salmon stocks. This project builds on a previous work supported by the State of the Salmon Program (SOS) in 2008-09 to produce estimates of escapement, catch and run size for each BC Salmon Conservation Unit (English et al. 2009). The SOS-supported project built on the 2004-06 efforts by DFO, INAC and LGL to estimate escapement, catch and harvest rates for each salmon species by statistical area (English et al. 2004a; 2006a;b). In this project, our efforts were limited to salmon stocks that spawn in streams flowing into BC's North Coast and Central Coast (NCCC) regions (Statistical Areas 1-10). The primary purpose for this project was to compile and/or produce the best available estimates for escapement, catch, run size and age composition for each NCCC Statistical Area (SA) and Conservation Unit (CU) to facilitate further analysis by DFO and PSF scientists to define the lower and upper benchmarks for each CU.

This project was initiated in mid-October 2011 with a target completion date of 30 November 2011. Given the large amount of data compilation and analyses that had to be completed in a very limited amount of time, little time was allocated to the preparation of this report.

METHODS

General Analytical Approach

The analytical procedures used to compute escapement, catch and run size (ECR) estimates for each SA and CU range from the relatively simple summation of annual catch and escapement estimates to complex run reconstruction techniques. A summary of the major components of the data compilation and analytical sequence is provided below:

a. Identify the streams with reliable and consistent time-series of escapement data for a specific species and run timing group (indicator streams);
b. Record information about the escapement survey methods and relative quality of the escapement estimates for each indicator stream using a 5 point scale along with other meta data related to these escapement estimates;
c. Obtain the latest version of the nuSEDS database to extract the escapement data for each indicator stream and all the non-indicator streams that have been monitored;
d. Link the nuSEDS database, Blair Holtby's October 2011 version of his "CU decoder ring" database and our new set of indicator streams using the unique nuSEDS POPID code which is common to each of these separate databases;
e. Evaluate alternate methods used to account for missing escapement estimates in the available time series for a specific SA or CU;
f. Obtain the best estimates of catch by species, week, gear type and SA;
g. Obtain the most recent version of the available run reconstruction analyses for intensively monitored and assessed stocks (e.g. Nass and Skeena Sockeye and Chinook stocks);
h. Estimate Canadian and total exploitation rates for Pink and Chum salmon returning to Area 3, 4 and 5 using harvest rate-effort relationships and/or adjustments to Sockeye harvest rates to account for species-stock specific run-timing differences;

i. Obtain total fishing mortality or exploitation rate (ER) estimates for each Chinook and Coho indicator stocks and link these estimates to the appropriate SA and CU for each species;
j. Upload all of the above information into an MS Access database; and
k. Run the analyses using procedures similar to those described in North and Central Coast Core Stock Assessment Report (English et al. 2006a) and Appendix A of this report to produce annual estimates of total escapement, Canadian harvest, total harvest, run size and exploitation rates for each SA and CU;

The foundation for the escapement estimates presented in this report is the nuSEDS database and list of indicator streams identified by NCCC biologist as the most reliable set of escapement data available for each CU. All of our analyses are linked directly to a downloaded copy of the nuSEDS database so these analyses can be readily updated as new information is loaded into the database. Two different approaches have been used to covert escapement estimates for a specific CU into a time series of comparable estimates. One approach uses the estimates for the most reliably monitored streams (indicator streams) to determine the trends in the escapement data, corrects for missing estimates for these indicator streams using an algorithm similar to that described in (Little and Rubin 1987) and expands the total for indicator streams to the represent all streams in a specific SA or CU (English et al. 2006; Appendix A). The other approach proposed in Holtby (2011) uses criteria related to the number of annual estimates in a specified period to determine the escapement data that should be used to determine trends and employs a relatively complex algorithm (Brown 1974) to fill in the missing values for each stream based on the available data for the other streams in a SA or CU. Prior to selecting the best approach for this project, we compared the methods used to correct for missing estimates and determined that the results were essentially identical when the same set of streams were selected. Therefore, we employed the approach initially described by Little and Rubin (1987) because it was easier to implement and more readily understood of the two methods.

The critical step in the escapement estimation process was identifying the streams with the most reliable escapement records. We used the set of indicator streams previously identified by NCCC biologist (English et al. 2004a; 2006; 2009) as the starting point for this project. The most recent set of nuSEDS data for all NCCC streams was linked to our initial set of indicator streams and we worked with DFO biologist to review the escapement time series for every NCCC stream for each CU. Together, we determine which indicator streams should be removed and which of the other streams that should be added to the indicator stream list. The quality of the escapement data for each indicator stream was assessed on a 5 point scale (see below).

The following sections summarize the reviews and analyses conducted between 17 October 2011 and 30 November 2011, organized by species.

Sockeye Salmon

The list of NCCC Sockeye indicator streams was sent to Dave Peacock on 27 October 2011 and returned on 3 November 2011 with 27 new indicator streams identified and 5 previous indicator streams removed. Of the new streams added to the indicator list, 16 were associated with CUs that did not have indicator streams identified for previous analyses. All of the streams removed from the indicator list had very few escapement estimates in the last 10 years.

Exploitation rate estimates for the Nass and Skeena Sockeye stock aggregates are estimated annually using the Northern Boundary Sockeye Run Reconstruction (NBSRR) Model (English et al. 2004b; 2005; Alexander et al. 2010). For this project, we used available data on the migration timing by CU to derive preliminary estimates of the marine ERs for each CU or group of CUs with the same migration timing. The average CU timing relative to the mean run timing for the Nass Sockeye aggregate was estimated using DNA stock composition data reported in Hall et al. (2010). The average CU timing relative to the mean run timing for the Skeena Sockeye aggregate was derived from Cox-Rogers et al. (2004). The timing distribution for each CU was defined by a normal curve with its peak defined by the relative timing (offset) parameter and duration determined by the standard deviation (SD) parameter (e.g. a duration of 6 weeks = 42d = a SD of 10.5d). A summary of these timing offsets and run duration parameters for Nass and Skeena Sockeye CUs is provided in Appendix B along with some examples of the shape of the aggregate run based on these parameters. The methods and assumptions use to derive Canadian and Total ERs for stocks returning to each SA are summarized in Table 1. In the absence of any direct ER estimates for Area 1, 2E and 2W the assumption of a constant 20% ER was used. The ERs for Area 5 Sockeye stocks were assumed to be equal to the ER estimates for Lakelse Sockeye which have similar run timing to those of Area 5 Sockeye stocks. ERs for Area 6-10 Sockeye stocks were derived by combining the escapement and catch estimates for each SA, as described below for Pink and Chum salmon returns to these areas.

The Canadian and Alaska ERs were combined with the escapement estimates for Sockeye salmon to produce the estimates of Canadian catch, Alaska catch and total run size for each SA or CU. The relationship between the Sockeye salmon CUs and the ER estimates for Sockeye returning to each SA is provided in Table 2.

Pink Salmon

The list of NCCC Pink indicator streams was sent to Dave Peacock on 31 October 2011 and returned on 2 November 2011 with 8 new indicator streams identified and 27 previous indicator streams removed. Most of the new streams added had good survey coverage over the past 30 years and appeared to have been overlooked in previous reviews. All of the streams removed from the indicator list had very few escapement estimates in the last 10 years.

A summary of the methods used to estimate the Canadian and Alaska ERs for NCCC Pink salmon stocks is provided in Table 1. Canadian HRs for Area 1, 2E, 2W, and 6-10 were derived by combining the escapement and catch estimates for each SA using methods similar to those described in English et al. (2004a). The biggest changes in the recent Pink salmon assessment were associated with the estimation of Canadian exploitation rates (ERs) for Pink salmon stocks returning to SA 3, 4, and 5. Previously, the annual harvest rates (HRs) were the same for each of these Areas and estimated by summing the annual Area 3-5 catch and dividing by the total abundance estimate for all these SAs combined (sum of escapement and catch). In this project, we used HRs from the 1982-95 run reconstruction analyses conducted for northern boundary Pink salmon (Gazey and English 2000) to derive the relationship between annual HRs and fishing effort for Inside Area 3 Pink salmon stocks in Area 3 fisheries and Skeena Pink salmon in Area 4 and Outside Area 3 fisheries. The effort-HR relationships for the 1982-95 period were combined with annual fishing effort for 1996-2010 to produce annual estimates of HRs for the post-1995 period.

Catch, effort and CPUE estimates for the Area 3 and 4 seine and gillnet fisheries were used to derive a time series of annual effort estimates that account for variability in weekly fishing effort for both seine and gillnet gear during the period when Pink salmon were harvested in these fisheries. This process included the following steps for Inside Area 3 Pink salmon stocks:

1) Use weekly Pink CPUE to determine the period when Pink salmon were most abundant in Area 3;
2) using Pink catch and effort estimates for the above period, compute estimates of annual CPUE for gillnet gear for comparison with annual CPUE estimates for seine gear;
3) Compute the annual ratio of gillnet CPUE to seine CPUE (mean 0.052, 95% bounds ±0.01), and use these annual ratios to convert gillnet effort into seine effort; and
4) Adjust annual effort estimates based on weekly timing, such that fishing effort during the peak migration period for Pink salmon would receive higher weighting than fishing effort during other periods. The weekly weights were derived from relative weekly CPUE for gillnet and seine gear.

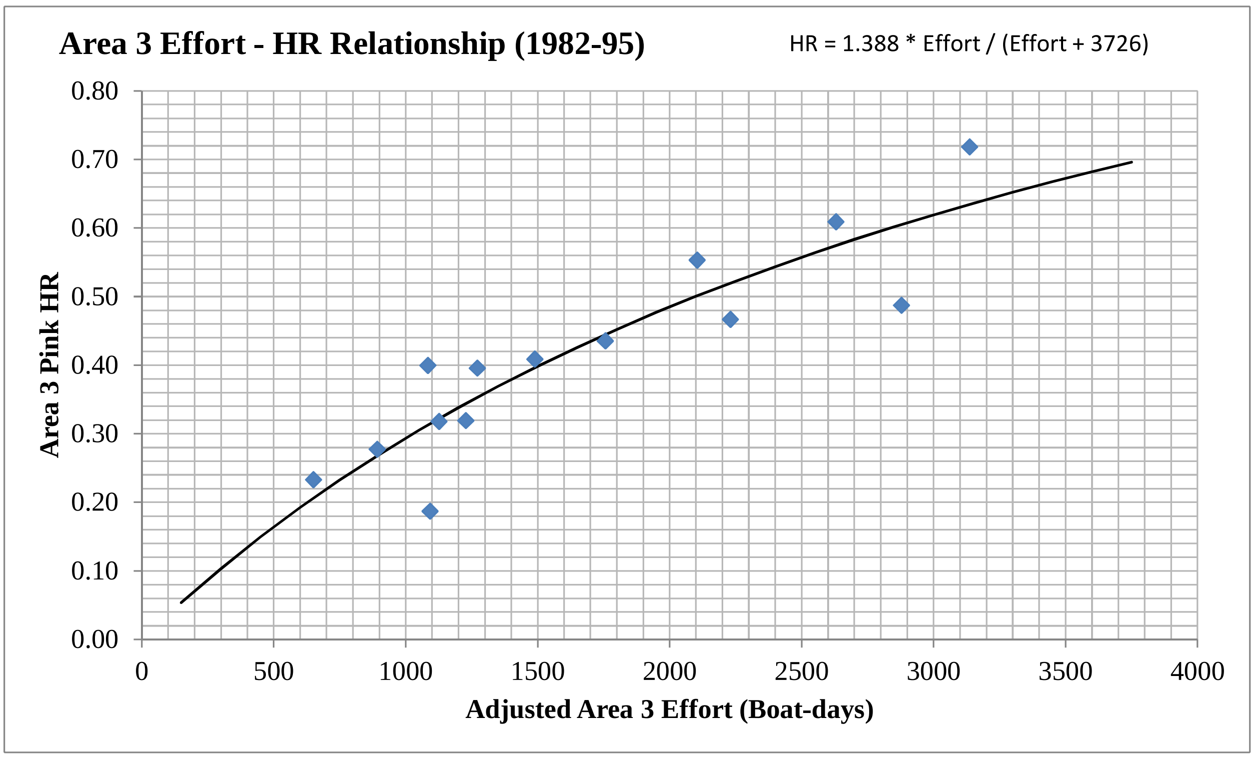

Figure 1. Relationship between the annual Area 3 fishing effort and the annual harvest rates estimated for Inside Area 3 stocks in Area 3 fisheries from 1982-95.

The annual HRs for Inside Area 3 Pink salmon in Area 3 fisheries derived from the EHR relationship (Figure 1) were expanded to represent all Canadian fisheries by dividing these HRs by the average portion that Area 3 HRs were of the total Canadian HRs during the 1982-1995 period (90%). Similarly, for Skeena Pink salmon, the annual HRs for Skeena Pink salmon in

Area 3xy and Area 4 fisheries derived from the EHR relationship (Figure 2) were expanded to represent all Canadian fisheries by dividing these HRs by the average portion that Area 3xy and Area 4 HRs were of the total Canadian HRs during the 1982-1995 period (83%).

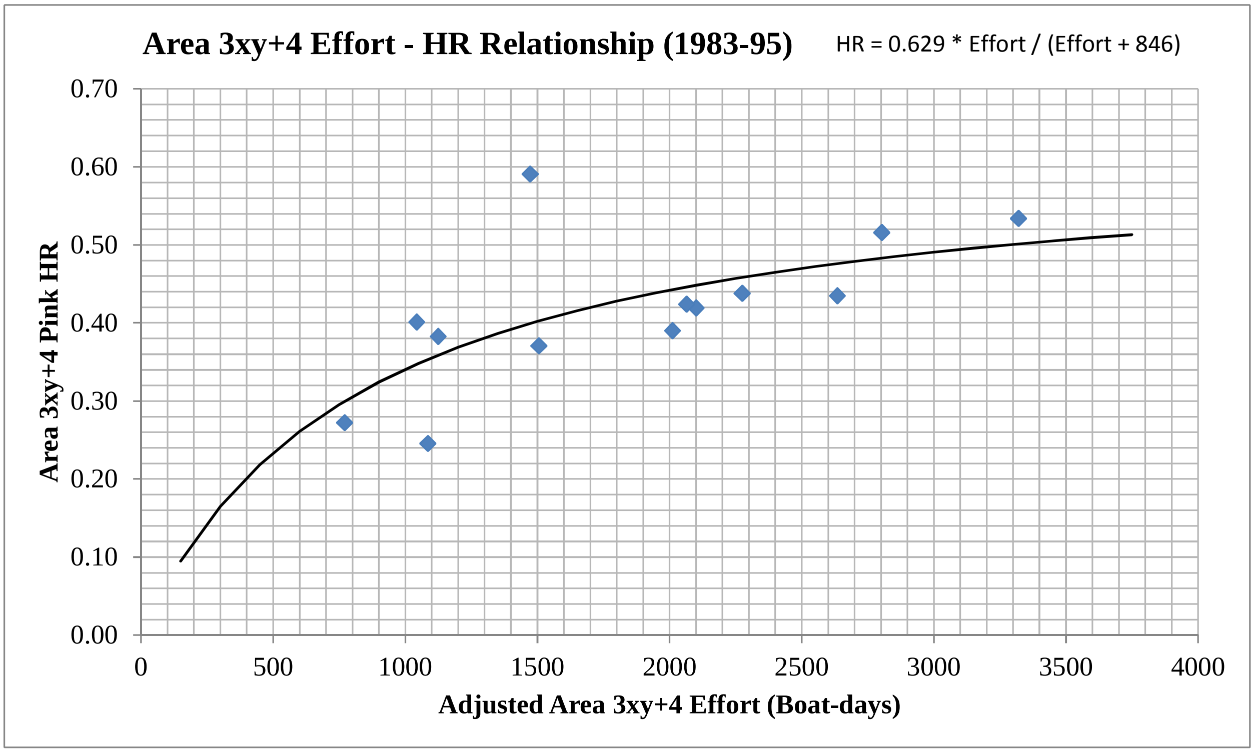

Figure 2. Relationship between the annual Area 3xy+4 fishing effort and the annual harvest rates estimated for Skeena Pink salmon stocks in Area 3xy+4 fisheries from 1983-95.

For Area 5 Pink salmon, we adjusted the annual effort estimates using an estimate of the timing for Area 5 Pink salmon through Area 3xy+4 fisheries (one week later than Skeena Pink salmon timing). EHR model for Area 3xy+4 fisheries (Figure 2) was used to convert these adjusted effort estimates into annual HRs which were further adjusted using the assumption that only 50% of Area 5 Pink salmon would migrate through the Area 3xy+4 fisheries. As for Skeena Pink salmon, these annual HRs for Area 5 Pink salmon in Area 3xy+4 fisheries were expanded to represent all Canadian fisheries by dividing these HRs by the average portion that Area 3xy and Area 4 HRs were of the total Canadian HRs for Skeena Pink salmon during the 1982-1995 period (83%).

A similar Effort-Exploitation Rate (EER) approach was used for Alaskan purse seine fisheries in District 101, 102 and 104 to convert annual fishing effort into ER estimates for Inside Area 3 and Skeena Pink salmon stocks harvested in Alaskan fisheries (Table 1). The Alaskan ERs for Area 5 Pink salmon were assumed to be equal to those estimated for Skeena Pink salmon. The Alaskan ERs for Area 1, 2E, 2W and Central Coast (Area 6-10) Pink salmon stocks were assumed to be zero (Dave Peacock, pers. comm.).

The resulting Canadian HR_i and Alaskan ER_i for stock “i” were combined in the following equation to compute the total ER_i for Canadian fisheries:

$$\text{Total Canadian } ER_i = \text{Canadian } HR_i * (1 - \text{Alaska } ER_i)$$

The Canadian and Alaska ERs were combined with the escapement estimates for Pink salmon to produce the estimates of Canadian catch, Alaska catch and total run size for each SA or CU. The relationship between the Pink salmon CUs and the ER estimates for Pink salmon returning to each SA is provided in Table 3.

Chum Salmon

The list of NCCC Chum indicator streams was sent to Dave Peacock on 26 October 2011 and returned on 2 November 2011 with 54 new indicator streams identified and 26 previous indicator streams removed. Of the new streams added to the indicator list, 30% were added because of improved survey coverage over the past 10 years and 70% were surveyed in most years since 1980 but were overlooked in previous reviews. All of the streams removed from the indicator list had very few escapement estimates in the last 10 years.

A summary of the methods used to estimate the Canadian and Alaska ERs for NCCC Chum salmon stocks is provided in Table 1. Canadian HRs for Area 1, 2E, 2W, and 6-10 were derived by combining the escapement and catch estimates for each SA using methods similar to those described in English et al. (2004a). As for pink salmon, the methods used to estimate the Canadian HRs for Chum salmon stocks returning to Areas 3, 4 and 5 was substantially different from previous analyses. Previously, the annual harvest rates (HRs) were the same for each of these Areas and estimated by summing the annual Area 3-6 Chum catches and dividing by the total Chum abundance estimates (escapement plus catch) for all these areas combined. For this project, we used weekly estimates of the HRs for Nass and Skeena Sockeye in Area 3-5 fisheries, combined with Chum run timing and adjustments for gillnet and seine Chum non-retention periods to compute HRs for Area 3 and 4 Chum stocks. Descriptions of the Area 3, 4 and 5 Chum Models and related analyses are provided below.

Assessments of the harvests of Area 3 and 4 Chum stocks in the Area 3-5 seine and gillnet fisheries were complicated by the mixture of Chum stocks in these fisheries, lack of any direct measures of Chum harvest rates and the recent implementation of Chum non-retention regulation in specific weeks for some fisheries. Since most of the Canadian harvest of Area 3 and 4 Chum stocks was believed to occur as bycatch in the Area 3-5 Sockeye fisheries, we used weekly estimates of the catch and HRs for Nass and Skeena Sockeye (English et al. 2005; Alexander et al. 2010) to estimate HRs for Chum stocks. The Area 3 Chum Model included the capability to apply adjustments for Chum non-retention by week and gear type for each of the Area 3 (3A, 3B, 3C, 3D, 3E) and Area 4 (4W, 4X) fisheries where Nass Sockeye are harvested. These weekly adjusted HRs were weighted by the portion of the Area 3 Chum migrating through these fisheries each week to compute the annual HRs for Area 3 Chum. The migration timing for Area 3 Chum was derived from the 1994-2009 daily Nass fishwheel Chum catch data adjusted for weekly variability in fishwheel catch efficiencies and annual variability in the duration of fishwheel operations (Will Duguid, LGL Limited, pers. comm.). The Area 4 Chum Model was similar to the Area 3 Model but included all the Canadian fisheries that harvested significant numbers of

Skeena Sockeye (Sub-area 3A, 3B, 3C, 4W, 4X, 4Y, 4Z, and Area 5). The Area 4 Chum run timing was derived from that used in the Skeena Model (Dave Peacock, pers. comm.). The Area 5 Chum Model used all the same Skeena Sockeye harvest rates and fisheries included in the Area 4 Chum Model along with an assumption that the run timing for Area 5 Chum stocks is one week later than that for Area 4 Chum stocks.

The HRs for Area 3 Chum salmon in Canadian fisheries outside Area 3 and 4 was set to be equal to the HRs for Nass Sockeye salmon in those fisheries. The HRs for Area 4 and 5 Chum salmon in Canadian fisheries outside Area 3, 4 and 5 were set equal to the HRs for Skeena Sockeye salmon in those fisheries.

The Alaska ERs for Area 3 and 4 Chum salmon stocks were assumed to be equal to the Alaska ERs for Nass and Skeena Sockeye, respectively, as derived from the Northern Boundary Sockeye run reconstruction analyses (English et al. 2004b; 2005; Alexander et al. 2010). The Alaska ERs for Area 5 Chum salmon stocks were assumed to be equal to the Alaska ER estimates for Skeena Sockeye. The Alaska ERs for Area 1, 2E, 2W and Central Coast (Area 6-10) Chum stocks were assumed to be zero (Dave Peacock, pers. comm.).

As described for Pink salmon, the resulting Canadian HR_i and Alaskan ER_i for stock "i" were combined in the following equation to compute the total ER_i for Canadian fisheries:

$$\text{Total Canadian } ER_i = \text{Canadian } HR_i * (1 - \text{Alaska } ER_i)$$

The Canadian and Alaska ERs were combined with the escapement estimates for Chum salmon to produce the estimates of Canadian catch, Alaska catch and total run size for each SA or CU. The relationship between the Chum CUs and the ER estimates for Chum returning to each SA is provided in Table 4.

Coho Salmon

The list of NCCC Coho indicator streams was sent to Dave Peacock on 26 October 2011 and returned on 2 November 2011 with 35 new indicator streams identified and 9 of the previous indicator streams were removed. The new streams were added because of better survey coverage in recent years after a period of poor coverage in the 1990s. The opposite was true for all the indicator streams removed.

ER estimates for NCCC Coho stocks were derived from a combination of CWT data for Coho indicator stocks and the NCCC Coho Model (Dave Peacock, pers. comm.). Coho CWT indicator stocks for Area 2E and 2W were Zolzap (1993-99) and Deena (1997-98, 2000-01, 2003-08); Zolzap and Lachmach (1992-99) for Area 3 (Nass); Toboggan (1980-2010) and Babine for Area 4 (Skeena); West Arm (2003-07) and Kitimat for Area 6; Snootli and Johnston for Area 8, 9 and 10. The Canadian ER estimates for Area 1, 2E and 2W Coho stocks were set to be equal to those for Nass Coho for all years where Deena River estimates could not be derived (1980-96, 99, 02 and 07). The Nass and Skeena estimates were used for Area 3 and 4, respectively. Skeena estimates for 1980-2002 were combined with the West Arm estimates for 2003-2008 and NCCC Coho Model estimates to produce the Canadian ER time series for Area 6-10 stocks. The estimates of Alaskan ERs for Area 2E and 2W Coho were derived from the NCCC Coho Model and analyses for Nass and Skeena provided Alaskan ERs for Area 3 and 4, respectively. The Alaska ERs for Area 6, 8 and 10 were 60%, 40% and 20%, respectively, of the annual Alaska ERs for Skeena Coho. The relationship between the Coho CUs and the ER estimates for Coho returning to each SA is provided in Table 5.

Chinook Salmon

The NCCC Chinook indicator streams were reviewed with David Peacock and Ivan Winther on 16-18 November 2011 in Prince Rupert. The results of the 1980-2007 analyses for Area 3 (Nass), Area 4 (Skeena), Areas 6, 8, 9 and 10 were also reviewed. North and Central Coast Chinook run reconstruction analyses were conducted using MS Excel workbooks where the spreadsheets results for each SA were linked to a table that summarized the results in the standard output format used for all other species. These spreadsheet analysis results were uploaded into our MS Access database to facilitate further analyses of each Chinook CU. The relationship between the Chinook CUs and the ER estimates for Chinook returning to each SA is provided in Table 6.

The Area 3 analyses are updated annually by the Nisga'a Joint Technical Committee (NJTC) as required for implementation of the Nisga'a Treaty (Richard Alexander, LGL, pers. comm.). The revised version of the NJTC Nass Chinook tables have been reduced to the 1992-2010 period because of the high degree of uncertainty associated with the escapement and catch estimates prior to the implementation of the Nisga'a Fisheries Program in 1992. The data sources and methods used to produce the estimates for Nass Chinook are identified in the footnotes for the Nass Chinook summary table (Appendix Table C1) and further documentation can be found in NJTC reports.

The estimates for Skeena Chinook built on the work completed in June 2008 as part of the Skeena Independent Science Review Panel process (Walters et al. 2008). The Skeena Chinook time series started in 1984 with the initiation of a rigorous mark-recapture program for estimating the escapement for Kitsumkalum Chinook. These estimates were combined with those from the Babine fences, and visual surveys of the Bear, Kispiox, and Morice rivers to produce an annual index of the escapement. This index was expanded to represent the entire Skeena using decadal averages of the portion that these indicator streams represented of the total for all Skeena Chinook spawning areas. Estimates of harvest for marine fisheries were derived by expanding CWT return data for Kitsumkalum Chinook. Estimates for Skeena River Chinook fisheries were derived from First Nation and recreational catch monitoring programs (Appendix Table C2).

Escapement estimates for the non-enhanced Chinook streams in Area 6 were based on recorded escapements for three indicator streams (Wahoo, Brim and Khutze) which represent 25% of the average total escapement to the non-enhanced Chinook streams in Area 6. Harvest estimates for Area 6 Chinook were derived using the Canadian marine and total marine ERs for Skeena Chinook (Appendix Table C3).

Escapement estimates for Area 8 Chinook were produced by summing the available estimates for the Bella Coola and Dean rivers, and filling a few missing values for the Dean River. The previous harvest estimates for Area 8 Chinook were completely replaced using the results from a recent Cohort analyses based on the 1990-2010 CWT data for Atnarko River Chinook (Vélez-Espino et. al 2011). Harvest estimates for 1985-89 were derived using the average total ER for the 1990-94 period (43%) and the average distribution of the harvest between Canadian and Alaskan fisheries (Appendix Table C4).

Escapement and harvest estimates for Area 9 Summer, Area 9 Fall (Wannock) and Area 10 Chinook stocks were derived using assumptions similar to those used in past analyses (English et al. 2006). These data and assumptions are provided in (Appendix Tables C5, C6, and C7).

Age Composition Data

Estimates of the average annual age composition for each salmon species returning to each SA and CU were derived from the Pacific Region Salmon Age Dataset (Brian Spilsted, pers. comm.). Additional data on the annual age composition of Sockeye returns to the Nass and Skeena watershed were provided by Richard Alexander and Steve Cox-Rogers, respectively.

RESULTS

The DFO regional biologists identified 781 stream-species combinations where escapement survey data was of sufficient quality and quantity to be used as an indicator of annual escapement trends for a specific CU (Table 7). The majority of these indicator streams (81%) were assigned survey quality ratings of fair (2) or good (3). The streams with the highest quality survey data (ratings of 4 and 5) accounted for 6% of the indicator streams and 13% of the indicator streams were assigned a poor quality rating of 1 according to the BC16 escapement database (Brian Spilsted, pers. comm.). The number of indicator streams rated poor was higher than previous analyses because of the desire to produce escapement, catch and run size estimates for as many CUs as possible. Most of the Pink and Chum streams with poor ratings could have been removed from the indicator stock list without affecting the estimates because they were associated with CUs that had many other streams with higher survey quality ratings. For Sockeye, Coho and Chinook, there were several CUs for which all the indicator streams were assigned a poor rating for survey quality. For these CUs, escapement trends should be interpreted with caution since the available estimates are only slightly better than no data at all. Tables 2-6 provide the total number of streams, number of indicator streams and survey quality ratings for each CU with at least one indicator stream.

Tables 8-12 provide the annual Canadian and total ERs for each species and SA derived using the various analyses described above. Blanks in these tables indicate years when estimates of total run size could not be derived for a specific SA because escapement or ERs could not be estimated for that year. The time series for Area 3 and 4 Sockeye (Table 8) included those years (1982-2008) with completed run reconstructions using the NBSRR model. Pink salmon estimates for Area 1 and 2W were not available for odd numbered years (Table 9) because no indicator streams were identified for the odd-year returns of Pink salmon in these SAs. The time series for Area 3-5 Pink salmon estimates started in 1982 because the time series of weekly fishing effort data by sub-SA started in 1982 and the effort-harvest rate relationships for Area 3 and 4 Pink salmon stocks was derived from the 1982-95 Pink run reconstruction results (Gazey and English 2000). The time series for Area 3-5 Chum salmon estimates started in 1982 because annual Chum ERs were derived from the 1982-2008 time series of weekly Sockeye harvest rates generated by the NBSRR Model. The Area 3-5 Chum ERs for 2009 and 2010 were the averages of the ERs estimated for the 2005-08 period (Table 10). Coho salmon ERs were estimated for each year in the 1980-2010 period, therefore, the blanks in Table 11 are due to the lack of escapement estimates for indicator streams in those years. The start of the time series of estimates for Area 3, 4 and 8 Chinook salmon (Table 11) was determined by the first year when escapement estimates improved substantially for Nass, Kitsumkalum and Bella Coola (Atnarko) Chinook, respectively.

The results from the escapement and harvest rate analyses described above were organized into a series of workbooks that facilitated the preparation of two primary types of figures showing: 1) escapement, catch and harvest rate trends (Figures 3-7, upper graph); and 2) the relative data quality and completeness of the escapement monitoring efforts for the selected SA or CU (Figures 3-7, lower graph).

The relative survey rating scale presented in (Figures 3-7, lower graph) was comprised of three sub-ratings, which included: a) survey quality; b) survey execution and c) survey coverage for the indicator streams within each SA or CU. A five point scale was used for each of these three sub-ratings, where 1= a poor score and 5= an excellent score.

The ratings for survey quality were:

1) **Poor quality** - An estimate of poor reliability due to few surveys, counting deficiencies, etc.
2) **Fair quality** - An estimate of moderate reliability based on two or more visual inspections (i.e., low quality AUC estimate);
3) **Good quality** - An estimate of good reliability based on three or more visual inspections (i.e., medium quality AUC estimate);
4) **Very Good quality** - An estimate of high reliability based on MR data, almost complete fence counts, or high quality AUC estimates;
5) **Excellent quality** - An estimate of very high reliability from an unbreached fence count.

The ratings for the degree to which the surveys of indicator streams were conducted (survey execution) were calculated based on the expansion factor used to account for indicator streams not surveyed in a given year. The portion that the surveyed streams represent of the average escapement to all indicator stream was converted in to a rating of 1-5 as follows:

1) **Poor execution –** 1-20% of the average escapement for indicator streams;
2) **Fair execution –** 20-40% of the average escapement for indicator streams;
3) **Good execution –** 40-60% of the average escapement for indicator streams;
4) **Very Good execution –** 60-80% of the average escapement for indicator streams; and
5) **Excellent execution –** 80-100% of the average escapement for indicator streams.

The indicator streams represent a portion of the total escapement to all streams within a SA or CU (index portion). This portion provided another indication of survey coverage for a specific SA or CU. For example: if the indicator streams represented less than 10% of the average annual escapement to streams in a SA or CU over a 10 year period, a rating of 1 was assigned for that 10 year period. The proportions were converted in to a rating of 1-5 as follows:

1) **Poor –** <20% of the average total escapement for surveyed streams;
2) **Fair** – 20-30% of the average total escapement for surveyed streams;
3) **Good** – 30-40% of the average total escapement for surveyed streams;
4) **Very Good** – 40-50% of the average total escapement for surveyed streams; and
5) **Excellent** – >50% of the average total escapement for surveyed streams.

The three sub-ratings are summed together to provide an overall rating of survey quality. A combined rating above 13 would be indicative of reliable escapement estimates. A score of 13 could occur when the average quality rating was at least good, 80-100% of the escapement to indicator streams was monitored, and the index streams represented more than 50% of the total escapement for a species to all streams within a SA or CU. The survey execution and index portion components of the overall survey rating can vary by year or decade. The survey quality component was usually constant over all years unless there was a change in the survey method for one or more of the indicator streams for a specific SA/CU/Species combination.

The escapement, catch and run size estimates for each species (Chinook, Coho, Sockeye, Pink odd, Pink even, and Chum) were organized into a single file to facilitate the preparation of summary tables and figures for any selected SA or CU. Figures 3-7 are samples of the stock abundance, harvest and exploitation rate trends for selected CUs for each species within each region. These particular figures were selected to provide examples of the variability in survey quality, survey execution, abundance and exploitation rates observed among the species and CUs. While the quality and quantity of data used to generate these plots was often substantially different between CUs, these types of figures provide a quick means for examining trends in abundance, catch and exploitation over the past 30 years.

Nass Chinook provide a graphic example of the result of substantial improvement to escapement estimation procedures (Figure 3). Previous summaries for Nass Chinook have included run size estimates back to 1980; however, the level of uncertainty in the pre-1992 estimates was so large that regional managers and stock assessment biologist agreed that the Nass Chinook time series should start in 1992. Prior to 1992, escapement estimates for Nass Chinook were derived from visual surveys of variable numbers of spawning areas. From 1992 to present, these estimates were derived from intensive mark-recapture programs (thus, the high survey quality rating for this period). Nass Chinook provides an example of relatively stable abundance (total run size usually in the 30,000-60,000 range) and total ERs averaging 52% since 1992. The difference between the total ERs and Canadian ERs indicates that a small portion of this stock (averaging <3%) was harvested in US fisheries. Area 4 Coho (Figure 4) provide an example of a stock with lower quality survey ratings, generally good coverage and much higher variability in annual abundance than Nass Chinook. The substantial reduction in the Canadian ERs from 1996 to 1998 reflects the fishery closure resulting from the 1997 “Coho crisis”. The portion of the run harvested in Alaskan fisheries has remained fairly stable over the years and, with the decline in Canadian harvests, Alaskan fisheries have accounted for the majority of the catch of Skeena Coho since 1997. Area 10 (Smith Inlet) Sockeye provide an example of a stock in which abundance levels declined dramatically over a short period and have not recovered despite the complete closure of the fishery (Figure 5). Escapement estimates for this stock have been derived from a counting fence since 1982 and thus the survey quality is consistently high. All harvests of this stock occurred in Canadian waters (i.e. Canadian ER = Total ER). Chum salmon escapement estimates for the Hecate Strait Lowland CU (Figure 6) were derived from visual surveys of up to 41 indicator streams. The average survey quality rating is only fair (rating=2), but the frequency of surveys and coverage has been sufficient to produce an annual survey rating consistently above 10 on the 15 point scale (Figure 6, lower graph). The last North-Central Coast example is for Hecate Strait Fjords even-year Pink salmon returns (Figure 7). This figure shows the very large returns Pink salmon for this CU in 1986 and 1988 (15-22 M) and the substantial decline to less than 1 M in 2008 and 2010. As a result of the even-odd cycles for Pink salmon, there are fewer years on these graphs than those for other species, but there are two Pink salmon graphs (one for even-years and one for odd-years) for most SAs. In some SAs, consistently small returns or poor survey coverage limit the Pink salmon graphs to one of the two cycles (e.g., North and West Haida Gwaii CUs).

DISCUSSION

A large amount of time and resources are expended each year by DFO, PSC, First Nations, stewardship groups and NGOs to obtain the catch and escapement data needed to monitor trends for BC salmon stocks and CUs. Some of these data are combined in regional or coast-wide models to derive estimates of run size and exploitation rates for specific salmon indicator stocks (e.g., Northern Boundary Sockeye model; PSC Chinook and NCCC Coho models). In most instances, the results from these substantial data collection and analysis efforts have not been fully applied to the challenge of tracking trends in catch and escapement by CU.

In this project, we have worked with region fisheries biologists to identify or compute the most reliable time series of escapement and exploitation rate estimates and to link these time series to the correct CUs for each species. While there have been substantial improvements to the DFO catch and escapement databases over the past 3 years, there are still several important issues that need to be addressed. The nuSEDS database is supposed to contain the most reliable escapement estimate for each monitored salmon spawning area. However, some of the escapement time series that are the foundation for the regional analysis models are not included in the nuSEDS database. For example: the nuSEDS database does not include the escapement estimates that are routinely used to assess the status and trends for several major stocks, including: Nass River Sockeye, Chinook, Coho, and Babine Sockeye. Similarly, a single source for the complete set of catch and fishing effort data for BC salmon fisheries does not exist. Alternative estimates of commercial catches for the same fishery can be found in the sale slip and FOS databases, and these estimates can be substantially different. Recreational catch estimates have been systematically organized for some fisheries and completely lacking for others. Harvests estimates are available for most First Nation fisheries, but most of these estimates are not contained in any database.

Reliable estimates of the annual age composition for return salmon is available for only a few NCCC stocks (e.g. Nass and Babine Sockeye). Age composition data for Babine Sockeye was used to derive two estimates of recruits per spawner (R/S): 1) using the annual age composition data and 2) using the average age composition data for returns over the time series. This analysis for Babine Sockeye revealed substantial difference between the best estimates of R/S based on annual age composition and those derived using the average age composition estimate (Figure 8).

The following section outlines a set of recommendations resulting from lessons learned during the course of this project and the previous DFO-Ecotrust project (English et al. 2009). It is hoped that the information and experience gained through this project will be used to address these major data management challenges. Streamlining the data compilation and analysis required to derive annual estimates of catch and escapement for each BC salmon CU is essential so that this important information is made more available to decision makers both inside and outside the management agencies in the near future.

RECOMMENDATIONS

1. The procedures for uploading escapement estimates into the nuSEDS database and completing the review of these data need to be streamlined. Data coordinators need to be identified for each region and assigned the responsibility of ensuring that escapement data are complete and uploaded into the nuSEDS database in a timely manner.

2. The most reliable annual escapement estimates for every indicator stream must be added to the nuSEDS database. This is important for ensuring consistency between the various analyses conducted using salmon escapement data (e.g. Babine fence counts, Nass River escapement estimates derived using mark-recapture techniques).

3. Procedures and responsibilities for updating databases must be clearly defined. One individual within each region should be responsible for ensuring that catch and exploitation rate data are uploaded into the appropriate DFO database.

4. One individual within each region (not necessarily the same individual as in Recommendation 3) should be responsible for updating the escapement, catch, and run size analyses described in this report.

5. A new database should be established to house all exploitation rate estimates needed to compute the harvest and run size estimates for each SA and CU.

6. DFO's catch databases for commercial, recreational and First Nation fisheries harvest statistics need to be upgraded to industry standards and more accessible to DFO staff (i.e. single source, consistent format, accessible through the web via high speed servers).

7. Further analyses should be conducted to assess the sensitivity of sub-stocks exploitation rates to the assumptions regarding run timing parameters for Nass and Skeena Sockeye sub-stocks and CUs.

8. Estimates of recruits/spawner (R/S) derived using average age composition can be substantially different from those derived using annual age composition estimates; therefore, stock recruitment analysis based on average age composition data should be used with caution for species with multiple ages of returns (i.e. Chinook, Sockeye, Chum and Coho.

ACKNOWLEDGEMENTS

This project would not have been possible without the previous data compilation and analyses efforts of Blair Holtby, Dave Peacock, Steve Cox-Rogers, Brian Spilsted, Ivan Winther, Peter Hall, and Bruce Baxter with Fisheries and Oceans, Canada. We thank each of these individuals for their assistance and we are especially grateful to Blair Holtby who prepared the critical databases needed to link all BC salmon streams to a Conservation Unit. We thank Bill Gazey for his timely work related to the Northern Boundary sockeye run reconstruction model which was important for the estimation of exploitation rates for Nass and Skeena sockeye CUs. We also thank Richard Alexander and Will Duguid with LGL Limited for their assistance with data compilation and analyses related to Area 3 salmon stocks and Anita Blakley with LGL Limited for her assistance with the preparation of this report.

Funding for this project was provided by the Pacific Salmon Foundation. We would also like to acknowledge previous support received from the Pacific Salmon Foundation, Fisheries and Oceans Canada, Ecotrust, State of the Salmon Program and LGL Limited for work related to North Coast and Central Coast salmon databases and analytical methods which provided the foundation for this project.

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TABLES

Table 1. Summary of the sources for Canadian and Alaskan exploitation rates used for Sockeye, Pink and Chum salmon stock originating from each NCCC Statistical Area.

	Canadian Exploitation Rates (CDN ERs)					Alaska Exploitation Rates (AK ERs)				
	Area 1, 2E,2W	Area 3	Area 4	Area 5	Area 6-10	Area 1,2E,2W	Area 3	Area 4	Area 5	Area 6-10
Sockeye Salmon										
1982-2008	20%	NBSRR Model	NBSRR Model	NBSRR Lakelse	TCC&E	Zero	NBSRR Model	NBSRR Model	NBSRR Lakelse	Zero
Pink Salmon										
1982-95	TCC&E	A3I Pink-RR	Skeena Pink-RR	50%*Skeena	TCC&E	Zero	A3I Pink-RR	Skeena Pink-RR	A4 ER	Zero
1996-2010	TCC&E	A3-EHR Model	A3+4 EHR Model	50%*Skeena	TCC&E	Zero	AK EER Model	AK EER Model	A4 ER	Zero
Chum Salmon										
1982-2008	TCC&E	A3 Chum Model	A4 Chum Model	A5 Chum Model	TCC&E	Zero	Nass SX ER	Skeena SX ER	A4 ER	Zero

All Species	
TCC&E=	CDN ERs derived from Total Canadian Catch (TCC) and escapement (E) estimates for that statistical area, where ER= TCC/(TCC+E)
x%*A3 ER =	AK ERs estimated by applying a fixed % to the Alaskan exploitation rate for Area 3 (Nass) stocks of that species.
x%*A4 ER =	AK ERs estimated by applying a fixed % to the Alaskan exploitation rate for Area 4 (Skeena) stocks of that species.
A4 ER =	AK ERs were set equal to the Alaskan exploitation rate for Area 4 (Skeena) stocks of that species.
Sockeye	
NBSRR =	Northern Boundary sockeye run reconstruction model provided the 1982-2008 time series of CDN and AK ERs for Area 3 (Nass) and Area 4 (Skeena) sockeye stocks (English et al. 2004b; 2005, Alexander et al. 2010).
NBSRR Lakelse =	Northern Boundary sockeye run reconstruction model provided the 1982-2008 time series of CDN and AK ERs for Lakelse sockeye which are similar to Area 5 sockeye in their early run timing.
Pink Salmon	
A3I Pink RR =	CDN ERs derived from Area 3 Inside (A3I) pink salmon run reconstruction estimates (Gazey and English 2000)
Skeena Pink RR =	CDN ERs derived from Skeena pink salmon run reconstruction estimates (Gazey and English 2000)
A3-EHR Model =	CDN ERs derived from Effort-Harvest Rate (EHR) relationship for Area 3 Inside pink salmon harvested in Area 3 fisheries using harvest rates from 1982-95 Skeena pink salmon run reconstruction estimates (Gazey and English 2000)
A3+4 EHR Model =	CDN ERs derived from Effort-Harvest Rate (EHR) relationship for Skeena pink salmon harvested in Area 3x,y and Area 4 fisheries using harvest rates from 1982-95 Skeena pink salmon run reconstruction estimates (Gazey and English 2000)
AK EER Model =	AK ERs derived from Effort-Harvest Rate (EHR) relationship for Area 3 Inside and Skeena pink salmon harvested in Alaskan fisheries using harvest rates from 1982-95 Skeena pink salmon run reconstruction estimates (Gazey and English 2000)
Chum Salmon	
A3 Chum Model =	CDN ERs derived using weekly harvest rates from the 1982-08 run reconstruction analyses for Nass sockeye and estimates of chum migration timing for Area 3 stocks, with adjustment for periods of non-retention in Area 3 gillnet and seine fisheries.
A4 Chum Model =	CDN ERs derived using weekly harvest rates from the 1982-08 run reconstruction analyses for Skeena sockeye and estimates of chum migration timing for Area 4 stocks, with adjustment for periods of non-retention in Area 3 gillnet and seine fisheries.
A5 Chum Model =	CDN ERs derived using weekly harvest rates from the 1982-08 run reconstruction analyses for Skeena sockeye and estimates of chum migration timing for Area 5 stocks, with adjustment for periods of non-retention in Area 3 gillnet and seine fisheries.
% of Nass SX ER =	AK ERs derived from annual exploitation rates from the 1982-08 run reconstruction analyses for Nass sockeye (English et al. 2005, Alexander et al. 2010).
% of Skeena SX ER =	AK ERs derived from annual exploitation rates from the 1982-08 run reconstruction analyses for Skeena sockeye (English et al. 2005, Alexander et al. 2010).

Table 2. Sockeye salmon Conservation Units and associated Statistical Areas and source for exploitation rate estimates.

		Exploitation Rate Indicator		Total	Indicator	Survey Quality Ratings				
CU Code	Conservation Unit	Stock/Area Name	Stat. Area #	Streams	Streams	1	2	3	4	5
SX_L-15-01	Long	Area 10	10	3	2				2	
SX_L-15-02	Owikeno	Area 9	09	11	8		5	3		
SX_L-17-02	Awun	Area 1	01	1	1		1			
SX_L-17-05	Marian	Area 1	01	1	1		1			
SX_L-17-06	Mathers	Area 2E	02E	1	1		1			
SX_L-17-07	Mercer	Area 2W	02W	1	1			1		
SX_L-17-08	Skidegate	Area 2E	02E	1	1				1	
SX_L-17-09	Yakoun	Area 1	01	1	1			1		
SX_L-18-01	Backland	Area 6	06	1	1		1			
SX_L-18-02	Canoona	Area 6	06	1	1		1			
SX_L-18-04	Evelyn	Area 6	06	1	1			1		
SX_L-18-05	Kainet Creek	Area 7	07	1	1	1				
SX_L-18-08	Kitlope	Area 6	06	1	1		1			
SX_L-19-02	Bloomfield	Area 6	06	1	1		1			
SX_L-19-11	Curtis Inlet	Lakelse	05	1	1	1				
SX_L-19-14	Devon	Lakelse	05	1	1	1				
SX_L-19-20	Freeda	Lakelse	05	1	1	1				
SX_L-19-21	Hartley Bay	Area 6	06	1	1		1			
SX_L-19-24	Kadjusdis River	Area 7	07	1	1		1			
SX_L-19-26	Keecha	Lakelse	05	1	1	1				
SX_L-19-33	Koeye	Area 8	08	1	1	1				
SX_L-19-34	Kooryet	Lakelse	05	1	1		1			
SX_L-19-36	Kwakwa Creek	Area 6	06	1	1		1			
SX_L-19-39	Lowe/Simpson/Weir	Lakelse	05	1	1	1				
SX_L-19-40	Mary Cove Creek	Area 7	07	1	1	1				
SX_L-19-43	Mikado	Lakelse	05	1	1		1			
SX_L-19-45	Namu	Area 8	08	1	1		1			
SX_L-19-46	Port John	Area 8	08	1	1	1				
SX_L-19-49	Prudhomme	Lakelse	04	2	2		2			
SX_L-19-50	Roderick	Area 7	07	1	1	1				
SX_L-19-54	Shawatlan	Lakelse	04	1	1			1		
SX_L-19-60	Tankeeah River	Area 7	07	1	1			1		
SX_L-19-62	Tsimtack/Moore/Roger	Lakelse	05	1	1	1				
SX_L-19-70	Yeo	Area 7	07	1	1	1				
SX_L-20-01	Alastair	Alastair	04	3	2		2			
SX_L-20-05	Johnston	Johnston	04	2	1	1				
SX_L-20-06	Kitsumkalum	Kalum	04	7	2		1	1		
SX_L-20-07	Lakelse	Lakelse	04	9	3	1	1	1		
SX_L-20-08	Mcdonell	Zymoetz	04	1	1			1		
SX_L-21-02	Babine	Area 4	04	33	9		2	7		
SX_L-21-05	Kitwancool	Kitwanga	04	1	1					1
SX_L-21-07	Morice	Morice+	04	4	1		1			
SX_L-21-09	Stephens	Swan+	04	2	1		1			
SX_L-21-10	Swan	Swan+	04	6	3		1	2		
SX_L-21-11	Tahlo/Morrison	Babine WM	04	2	1		1			
SX_L-22-01	Asitika	Bear+	04	1	1		1			
SX_L-22-02	Azuklotz	Bear+	04	1	1		1			
SX_L-22-03	Bear	Bear+	04	3	2	1	1			
SX_L-22-04	Damshilgwit	Slamgeesh	04	1	1			1		
SX_L-22-08	Motase	Motase	04	1	1		1			
SX_L-24-02	Damdochax	Damdochax	03	1	1	1				
SX_L-24-03	Fred Wright	Kwinagees	03	1	1		1			
SX_L-24-05	Meziadin	Hanna-Tin, MezBeach	03	1	1					1
SX_R16	Northern Coastal Fjords	Area 6,7,8	6,7,8	73	4	1	1			
SX_R19	Skeena River-high interior	Swan+	04	1	1			1		
SX_R20	Lower Nass-Portland	Gingit+	03	15	1			1		
SX_R21	Upper Nass River	BrownBear	03	3	1			1		
Total		57		219	84	17	36	24	3	2

Table 3. Pink salmon Conservation Units and associated Statistical Areas and source for exploitation rate estimates.

		Exploitation Rate Indicator		Total	Indicator	Survey Quality Ratings				
CU Code	Pink Conservation Units (odd years)	Stock/Area Name	Stat. Area #	Streams	Streams	1	2	3	4	5
Pko-8	8_Homathko-Klinaklini-Smith-Rivers	Area 8-10	8,9,10	46	10	6	2	2		
Pko-9	9_East Haida Gwaii	Area 2E	2E	44	6		1	3	2	
Pko-11	11_West Haida Gwaii	Area 2W	2W	32						
Pko-12	12_Hecate Strait-Lowlands	Area 5-10 Average	5,6,7,8,9,10	169	35	2	22	11		
Pko-13	13_Hecate Strait-Fjords	Area 6-8 Averag	6,7,8	100	52	2	29	20	1	
Pko-14	14_Nass-Skeena Estuary	Area 3	3	32	13	1	5	7		
Pko-15	15_Lower Skeena	Area 4	4	48	5	2	3			
Pko-16	16_Middle & Upper Skeena	Area 4	4	53	3		1	1	1	
Pko-17	17_Nass-Portland-Observatory	Area 3	3	58	16	1	7	7	1	
Total		9		140	140	14	70	51	5	0

		Exploitation Rate Indicator		Total	Indicator	Survey Quality Ratings				
CU Code	Pink Conservation Units (even years)	Stock/Area Name	Stat. Area #	Streams	Streams	1	2	3	4	5
Pke-5	5_Hecate Lowlands	Area 5-10 Average	5,6,7,8,9,10	185	39	4	24	11		
Pke-6	6_Hecate Strait-Fjords	Area 6-10 Average	6,7,8,9,10	146	70	9	35	25	1	
Pke-7	7_Nass-Skeena Estuary	Area 3	3	160	37	4	18	14	1	
Pke-8	8_Middle-Upper Skeena	Area 4	4	56	3		1	1	1	
Pke-9	9_North Haida Gwaii	Area 1 (Masset)	1	17	7			4	3	
Pke-10	10_East Haida Gwaii	Area 2E	2E	110	23		3	13	7	
Pke-11	11_West Haida Gwaii	Area 2W	2W	70	12		4	6	2	
Total		7		744	191	17	85	74	15	0

Table 4. Chum salmon Conservation Units and associated Statistical Areas and source for exploitation rate estimates.

		Exploitation Rate Indicator		Total	Indicator	Survey Quality Ratings				
CU Code	Chum Conservation Units	Stock/Area Name	Stat. Area #	Streams	Streams	1	2	3	4	5
CM-12	12_Smith Inlet	Area 9-10 Average	9,10	11	5		3	2		
CM-13	13_Rivers Inlet	Area 9	9	15	5	2	1	2		
CM-15	15_Spiller-Fitz-Hugh-Burke	Area 7-9 Average	7,8,9	69	28	4	17	6	1	
CM-16	16_Bella Colla-Dean Rivers	Area 8	8	22	7	1	2	4		
CM-17	17_Bella Coola River-Late	Area 8	8	9	7		1	5	1	
CM-18	18_Hecate Lowlands	Area 3-7 Average	3,4,5,6,7	142	41	7	30	4		
CM-19	19_Mussel-Kynock	Area 6-7 Average	6,7	14	12	3	7	2		
CM-20	20_Douglas-Gardner	Area 6	6	62	27		20	7		
CM-21	21_East Haida Gwaii	Area 2E	2E	95	32		10	14	8	
CM-22	22_Skidegate	Area 2E	2E	40	13			11	2	
CM-23	23_West Haida Gwaii	Area 2W	2W	61	31	5	16	10		
CM-24	24_North Haida Gwaii	Area 1	1	11	3		3			
CM-25	25_North Haida Gwaii-Stanley	Area 1	1	1	1			1		
CM-27	27_Lower Skeena	Area 4	4	32	6	3	2	1		
CM-28	28_Middle Skeena	Area 4	4	16	2	1	1			
CM-30	30_Portland Inlet	Area 3	3	19	5	1	2	2		
CM-31	31_Lower Nass	Area 3	3	13	1	1				
CM-32	32_Portland Canal-Observatory	Area 3	3	15	6	1	2	2	1	
Total		18		647	232	29	117	73	13	0

Table 5. Coho salmon Conservation Units and associated Statistical Areas and source for exploitation rate estimates.

		Exploitation Rate Indicator		Total	Indicator	Survey Quality Ratings				
CU Code	Coho Conservation Units	Stock/Area Name	Stat. Area #	Streams	Streams	1	2	3	4	5
CO-20	Smith Inlet	Area 9-10	10	12	2		1		1	
CO-21	Rivers Inlet	Area 9-10	9	24	2	2				
CO-22	Bella Coola - Dean Rivers	Area 8	8	30	11	4	6	1		
CO-23	Haida Gwaii|Hecate Strait - Q.C. Sound	Area 2E	2E	109	5			3	2	
CO-24	Haida Gwaii|Outer Graham Island	Area 2W	2W	62	3	1	2			
CO-25	Haida Gwaii-Graham Island Lowlands	Area 2WE		28	1			1		
CO-26	Mussel-Kynoch	Area 6-8	7	14	2	2				
CO-27	Hecate Strait Mainland	Area 4-9	5	176	10	1	7	2		
CO-28	Brim-Wahoo	Area 6	6	2	2		2			
CO-29	Douglas Channel-Kitimat Arm	Area 6	6	33	2	2				
CO-30	Northern Coastal Streams	Area 6-8		58	17	1	12	4		
CO-31	Skeena Estuary	Area 3	3	23	3		2	1		
CO-32	Lower Skeena	Area 4	4	84	11	1	6	4		
CO-33	Middle Skeena	Area 4	4	74	15		5	8	1	1
CO-34	Upper Skeena	Area 4	4	17	4	1	2		1	
CO-35	Lower Nass	Area 3	3	22	4		2	1	1	
CO-36	Upper Nass	Area 3	3	13	2			2		
CO-37	Portland Sound-Observatory Inlet-Portlaı	Area 3	3	26	2	1	1			
Total		18		807	98	16	48	27	6	1

Table 6. Chinook salmon Conservation Units and associated Statistical Areas and source for exploitation rate estimates.

		Exploitation Rate Indicator		Total	Indicator	Survey Quality Ratings				
CU Code	Chinook Conservation Units	Stock/Area Name	Stat. Area #	Streams	Streams	1	2	3	4	5
36	Docee	Area 10	10	1	1	1				
37	Rivers Inlet	A9 Summer	9	14	6	2	4			
38	Wannock	A9 Wannock	9	1	1	1				
39	Bella Coola-Bentinck	Area 8	8	5	1				1	
40	Dean River	Area 8	8	1	1		1			
41	NCC-late timing	Area 6	6	16	1	1				
42	NCC-early timing	Area 6	6	39	3	3				
46	Ecstall	Skeena	4	4	1		1			
47	Gitnadoix	Skeena	4							
48	Lower Skeena	Skeena	4	14	4	1	3			
49	Kalum-Early	10% of Skeena	4	2	1		1			
50	Kalum-Late	Skeena	4	7	1				1	
52	Middle Skeena	Skeena	4							
53	Middle Skeena-large lakes	Skeena	4	12	5	1	2	1	1	
54	Middle Skeena mainstem tributaries	Skeena	4	24	3		2	1		
55	Upper Bulkley River	10% of Skeena	4	4	1			1		
57	Portland Sound-Observatory Inlet-Lower Nass	Nass	3	14	3		1	2		
58	Upper Nass	Nass	3	17	3		1	2		
Total		18		175	36	10	16	7	3	0

Table 7. Summary of the number of CUs, total number of streams, number of indicators by survey quality code by species for all NCCC Statistical Areas.

	Number	Total	Indicator	Survey Quality Ratings				
Species	of CUs	Streams	Streams	1	2	3	4	5
Sockeye salmon	57	219	84	17	36	24	3	2
Pink salmon (odd years)	9	582	140	14	70	51	5	0
Pink salmon (even years)	7	744	191	17	85	74	15	0
Chum salmon	18	647	232	29	117	73	13	0
Coho salmon	18	807	98	16	48	27	6	1
Chinook salmon	18	175	36	10	16	7	3	0
Total	127	3174	781	103	372	256	45	3
Percentage				13.2%	47.6%	32.8%	5.8%	0.4%

Table 8. Canadian and total exploitation rates for Sockeye salmon stocks summarized by NCCC Statistical Area, 1980-2010.

	Canadian Exploitation Rates										
Year	**01**	**02E**	**02W**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**
1980	20%	20%	20%				53%	83%	67%	0%	2%
1981	20%	20%	20%				72%	90%	58%	6%	42%
1982	20%	20%	20%	45%	60%	19%	43%	89%	35%	2%	58%
1983	20%	20%	20%	39%	35%	3%	50%	60%	62%	3%	40%
1984	20%	20%	20%	37%	44%	9%	12%	62%	23%	8%	20%
1985	20%	20%	20%	30%	48%	30%	38%	39%	50%	12%	60%
1986	20%	20%	20%	25%	41%	15%	36%	67%	66%	20%	66%
1987	20%	20%	20%	36%	36%	7%	36%	68%	70%	29%	49%
1988	20%	20%	20%	26%	50%	35%	54%	8%	63%	31%	60%
1989	20%	20%		40%	40%	20%	5%	26%	42%	11%	32%
1990	20%	20%		24%	44%	23%	54%	62%	69%	24%	30%
1991	20%	20%		44%	47%	24%	20%	62%	41%	23%	69%
1992	20%	20%		46%	48%	39%	21%	43%	48%	38%	77%
1993	20%	20%	20%	49%	51%	35%	7%	42%	57%	13%	56%
1994	20%	20%	20%	33%	38%	24%	19%	50%	76%	19%	56%
1995	20%	20%	20%	50%	56%	32%	13%	32%	30%	16%	32%
1996	20%	20%		45%	64%	38%	15%	3%	16%	0%	14%
1997	20%	20%		33%	51%	47%	10%	7%	35%	0%	2%
1998	20%	20%	20%	25%	24%	12%	26%	1%	20%	0%	0%
1999	20%	20%	20%	52%	15%	7%	11%	55%	7%	0%	0%
2000	20%	20%	20%	54%	64%	37%	25%	0%	5%	0%	0%
2001	20%	20%	20%	36%	54%	17%	28%	3%	3%	0%	0%
2002	20%	20%	20%	62%	50%	20%	22%	1%	4%	0%	0%
2003	20%	20%	20%	65%	28%	11%	41%	2%	22%	0%	0%
2004	20%	20%	20%	48%	27%	10%	7%	11%	6%	0%	0%
2005	20%	20%	20%	45%	13%	1%	42%	5%	17%	0%	0%
2006	20%	20%	20%	50%	49%	26%	1%	4%	5%	0%	0%
2007	20%	20%	20%	31%	28%	7%	19%	0%	8%	0%	0%
2008	20%	20%	20%	30%	54%	2%	0%	0%	2%	0%	0%
2009	20%	20%					0%	0%	5%	0%	0%
2010	20%	20%	20%				3%	0%	1%	0%	0%

	Total Exploitation Rates										
Year	**01**	**02E**	**02W**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**
1980	20%	20%	20%				53%	83%	67%	0%	2%
1981	20%	20%	20%				72%	90%	58%	6%	42%
1982	20%	20%	20%	62%	67%	21%	43%	89%	35%	2%	58%
1983	20%	20%	20%	66%	50%	5%	50%	60%	62%	3%	40%
1984	20%	20%	20%	63%	53%	12%	12%	62%	23%	8%	20%
1985	20%	20%	20%	52%	57%	32%	38%	39%	50%	12%	60%
1986	20%	20%	20%	68%	56%	19%	36%	67%	66%	20%	66%
1987	20%	20%	20%	63%	40%	9%	36%	68%	70%	29%	49%
1988	20%	20%	20%	61%	62%	38%	54%	8%	63%	31%	60%
1989	20%	20%		78%	54%	24%	5%	26%	42%	11%	32%
1990	20%	20%		61%	61%	26%	54%	62%	69%	24%	30%
1991	20%	20%		68%	63%	25%	20%	62%	41%	23%	69%
1992	20%	20%		66%	65%	40%	21%	43%	48%	38%	77%
1993	20%	20%	20%	75%	63%	36%	7%	42%	57%	13%	56%
1994	20%	20%	20%	63%	58%	25%	19%	50%	76%	19%	56%
1995	20%	20%	20%	77%	66%	33%	13%	32%	30%	16%	32%
1996	20%	20%		79%	72%	41%	15%	3%	16%	0%	14%
1997	20%	20%		75%	68%	49%	10%	7%	35%	0%	2%
1998	20%	20%	20%	63%	42%	14%	26%	1%	20%	0%	0%
1999	20%	20%	20%	75%	22%	10%	11%	55%	7%	0%	0%
2000	20%	20%	20%	67%	69%	37%	25%	0%	5%	0%	0%
2001	20%	20%	20%	71%	65%	18%	28%	3%	3%	0%	0%
2002	20%	20%	20%	71%	53%	22%	22%	1%	4%	0%	0%
2003	20%	20%	20%	78%	35%	14%	41%	2%	22%	0%	0%
2004	20%	20%	20%	78%	38%	11%	7%	11%	6%	0%	0%
2005	20%	20%	20%	66%	30%	6%	42%	5%	17%	0%	0%
2006	20%	20%	20%	68%	56%	26%	1%	4%	5%	0%	0%
2007	20%	20%	20%	73%	46%	10%	19%	0%	8%	0%	0%
2008	20%	20%	20%	43%	56%	3%	0%	0%	2%	0%	0%
2009	20%	20%					0%	0%	5%	0%	0%
2010	20%	20%	20%				3%	0%	1%	0%	0%

Table 9. Canadian and total exploitation rates for Pink salmon stocks summarized by NCCC Statistical Area, 1980-2010.

	Canadian Exploitation Rates										
Year	01	02E	02W	03	04	05	06	07	08	09	10
1980	20%	0%	23%				70%	61%	30%	8%	43%
1981		1%					67%	68%	56%	32%	34%
1982	3%	0%	8%	31%	22%	20%	48%	44%	10%	1%	23%
1983		0%		48%	33%	19%	81%	16%	23%	9%	20%
1984	27%	13%	52%	39%	42%	19%	35%	35%	9%	32%	46%
1985		12%		36%	40%	19%	46%	64%	19%	18%	32%
1986	41%	24%	19%	34%	38%	17%	66%	72%	36%	28%	49%
1987		0%		47%	46%	22%	48%	63%	37%	30%	44%
1988	18%	13%	20%	42%	51%	16%	76%	51%	68%	33%	69%
1989		3%		31%	25%	13%	5%	7%	14%	6%	21%
1990	39%	20%	49%	25%	35%	12%	62%	41%	48%	30%	72%
1991		0%		54%	41%	18%	38%	30%	3%	18%	32%
1992	23%	2%	42%	30%	53%	18%	41%	14%	30%	43%	96%
1993		0%		42%	43%	18%	2%	4%	11%	11%	45%
1994	7%	10%	21%	17%	35%	13%	24%	3%	46%	14%	78%
1995		0%		42%	49%	23%	3%	13%	17%	12%	4%
1996	10%	2%	0%	33%	46%	20%	24%	5%	11%	0%	7%
1997		2%		23%	35%	13%	21%	8%	14%	0%	68%
1998	6%	15%	56%	14%	8%	3%	38%	3%	31%	0%	0%
1999		0%		50%	41%	19%	2%	15%	7%	0%	
2000	0%	3%	51%	20%	46%	18%	35%	1%	3%	0%	0%
2001		0%		14%	35%	14%	38%	23%	18%	0%	
2002	0%	3%	5%	17%	36%	15%	34%	14%	25%	0%	0%
2003		0%		12%	28%	11%	59%	5%	24%	0%	0%
2004	0%	0%	29%	24%	36%	14%	5%	23%	22%	0%	
2005		0%		19%	27%	11%	60%	8%	23%	0%	0%
2006	0%	0%	29%	9%	40%	16%	2%	6%	13%	0%	0%
2007		0%		23%	35%	14%	40%	1%	16%	0%	0%
2008	0%	0%	0%	3%	28%	10%	0%	0%	1%	0%	0%
2009		0%		6%	14%	5%	0%	0%	4%	0%	0%
2010	8%	12%	0%	1%	2%	1%	6%	0%	0%	0%	

	Total Exploitation Rates										
Year	01	02E	02W	03	04	05	06	07	08	09	10
1980	20%	0%	23%				70%	61%	30%	8%	43%
1981		1%					67%	68%	56%	32%	34%
1982	3%	0%	8%	44%	32%	30%	48%	44%	10%	1%	23%
1983		0%		70%	60%	45%	81%	16%	23%	9%	20%
1984	27%	13%	52%	55%	62%	39%	35%	35%	9%	32%	46%
1985		12%		51%	55%	35%	46%	64%	19%	18%	32%
1986	41%	24%	19%	56%	58%	38%	66%	72%	36%	28%	49%
1987		0%		55%	54%	30%	48%	63%	37%	30%	44%
1988	18%	13%	20%	53%	64%	29%	76%	51%	68%	33%	69%
1989		3%		58%	49%	37%	5%	7%	14%	6%	21%
1990	39%	20%	49%	44%	51%	28%	62%	41%	48%	30%	72%
1991		0%		81%	72%	48%	38%	30%	3%	18%	32%
1992	23%	2%	42%	47%	70%	34%	41%	14%	30%	43%	96%
1993		0%		69%	63%	38%	2%	4%	11%	11%	45%
1994	7%	10%	21%	34%	57%	35%	24%	3%	46%	14%	78%
1995		0%		60%	65%	39%	3%	13%	17%	12%	4%
1996	10%	2%	0%	51%	64%	38%	24%	5%	11%	0%	7%
1997		2%		35%	48%	25%	21%	8%	14%	0%	68%
1998	6%	15%	56%	29%	22%	17%	38%	3%	31%	0%	0%
1999		0%		63%	54%	33%	2%	15%	7%	0%	
2000	0%	3%	51%	30%	56%	28%	35%	1%	3%	0%	0%
2001		0%		31%	52%	31%	38%	23%	18%	0%	
2002	0%	3%	5%	28%	46%	25%	34%	14%	25%	0%	0%
2003		0%		24%	40%	23%	59%	5%	24%	0%	0%
2004	0%	0%	29%	35%	47%	25%	5%	23%	22%	0%	
2005		0%		30%	39%	22%	60%	8%	23%	0%	0%
2006	0%	0%	29%	13%	44%	20%	2%	6%	13%	0%	0%
2007		0%		35%	46%	25%	40%	1%	16%	0%	0%
2008	0%	0%	0%	10%	36%	17%	0%	0%	1%	0%	0%
2009		0%		17%	26%	17%	0%	0%	4%	0%	0%
2010	8%	12%	0%	10%	11%	9%	6%	0%	0%	0%	

Table 10. Canadian and total exploitation rates for Chum salmon stocks summarized by NCCC Statistical Area, 1980-2010.

	Canadian Exploitation Rates										
Year	01	02E	02W	03	04	05	06	07	08	09	10
1980	35%	34%	30%				56%	75%	65%	14%	18%
1981	30%	12%	9%				42%	49%	72%	20%	9%
1982	10%	9%	31%	30%	24%	16%	40%	47%	52%	4%	15%
1983	5%	0%	12%	33%	28%	23%	52%	12%	58%	6%	7%
1984	7%	35%	52%	39%	25%	20%	15%	52%	27%	22%	18%
1985	36%	57%	40%	26%	32%	23%	32%	50%	61%	21%	36%
1986	45%	36%	19%	22%	31%	26%	32%	59%	78%	35%	24%
1987	8%	29%	22%	30%	34%	26%	40%	55%	71%	20%	22%
1988	15%	50%	8%	16%	37%	27%	53%	50%	72%	29%	14%
1989	16%	23%	35%	23%	24%	18%	4%	28%	55%	59%	22%
1990	54%	39%	39%	21%	31%	24%	31%	48%	60%	67%	8%
1991	61%	44%	31%	33%	32%	22%	26%	34%	64%	37%	30%
1992	49%	37%	19%	39%	40%	31%	29%	37%	47%	55%	49%
1993	24%	32%	31%	44%	32%	25%	8%	36%	47%	39%	34%
1994	22%	31%	19%	22%	22%	15%	24%	49%	57%	33%	45%
1995	44%	9%	16%	31%	31%	22%	8%	35%	68%	26%	11%
1996	9%	26%	2%	27%	27%	18%	16%	14%	44%	0%	4%
1997	49%	17%	7%	16%	19%	14%	10%	14%	44%	0%	13%
1998	3%	21%	11%	10%	2%	1%	37%	16%	56%	0%	0%
1999	2%	21%	14%	36%	2%	2%	19%	20%	38%	0%	0%
2000	1%	22%	20%	22%	17%	11%	18%	10%	11%	0%	0%
2001	0%	0%	0%	8%	16%	9%	34%	26%	42%	0%	0%
2002	0%	4%	1%	16%	16%	10%	37%	33%	42%	0%	0%
2003	0%	3%	0%	13%	11%	8%	54%	30%	42%	0%	0%
2004	0%	0%	6%	10%	13%	10%	44%	41%	56%	0%	0%
2005	0%	0%	7%	5%	0%	0%	71%	16%	43%	0%	0%
2006	1%	0%	17%	15%	24%	17%	20%	7%	46%	0%	0%
2007	0%	0%	0%	4%	9%	5%	20%	4%	43%	0%	0%
2008	0%	0%	0%	7%	17%	10%	2%	0%	3%	0%	0%
2009	48%	2%	0%	8%	12%	8%	0%	1%	10%	0%	0%
2010	0%	4%	0%	8%	12%	8%	4%	3%	4%	0%	0%

	Total Exploitation Rates										
Year	01	02E	02W	03	04	05	06	07	08	09	10
1980	35%	34%	30%				56%	75%	65%	14%	18%
1981	30%	12%	9%				42%	49%	72%	20%	9%
1982	10%	9%	31%	47%	31%	23%	40%	47%	52%	4%	15%
1983	5%	0%	12%	61%	44%	39%	52%	12%	58%	6%	7%
1984	7%	35%	52%	65%	34%	29%	15%	52%	27%	22%	18%
1985	36%	57%	40%	48%	41%	32%	32%	50%	61%	21%	36%
1986	45%	36%	19%	64%	46%	41%	32%	59%	78%	35%	24%
1987	8%	29%	22%	57%	38%	30%	40%	55%	71%	20%	22%
1988	15%	50%	8%	52%	49%	40%	53%	50%	72%	29%	14%
1989	16%	23%	35%	61%	38%	32%	4%	28%	55%	59%	22%
1990	54%	39%	39%	59%	48%	41%	31%	48%	60%	67%	8%
1991	61%	44%	31%	57%	48%	39%	26%	34%	64%	37%	30%
1992	49%	37%	19%	59%	57%	47%	29%	37%	47%	55%	49%
1993	24%	32%	31%	70%	44%	37%	8%	36%	47%	39%	34%
1994	22%	31%	19%	52%	42%	35%	24%	49%	57%	33%	45%
1995	44%	9%	16%	57%	41%	32%	8%	35%	68%	26%	11%
1996	9%	26%	2%	61%	35%	25%	16%	14%	44%	0%	4%
1997	49%	17%	7%	58%	36%	31%	10%	14%	44%	0%	13%
1998	3%	21%	11%	47%	20%	19%	37%	16%	56%	0%	0%
1999	2%	21%	14%	60%	9%	9%	19%	20%	38%	0%	0%
2000	1%	22%	20%	36%	23%	16%	18%	10%	11%	0%	0%
2001	0%	0%	0%	43%	26%	20%	34%	26%	42%	0%	0%
2002	0%	4%	1%	25%	19%	13%	37%	33%	42%	0%	0%
2003	0%	3%	0%	26%	18%	14%	54%	30%	42%	0%	0%
2004	0%	0%	6%	40%	25%	21%	44%	41%	56%	0%	0%
2005	0%	0%	7%	27%	17%	17%	71%	16%	43%	0%	0%
2006	1%	0%	17%	33%	30%	24%	20%	7%	46%	0%	0%
2007	0%	0%	0%	46%	27%	23%	20%	4%	43%	0%	0%
2008	0%	0%	0%	19%	19%	12%	2%	0%	3%	0%	0%
2009	48%	2%	0%	31%	23%	19%	0%	1%	10%	0%	0%
2010	0%	4%	0%	31%	23%	19%	4%	3%	4%	0%	0%

Table 11. Canadian and total exploitation rates for Coho salmon stocks summarized by NCCC Statistical Area, 1980-2010.

	Canadian Exploitation Rates										
Year	**01**	**02E**	**02W**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**
1980		18%	18%	18%	40%	27%	27%	26%	27%	26%	
1981		18%	18%	18%	42%	28%	28%	27%	28%	28%	
1982		18%	18%	18%	45%		30%	29%	30%	29%	
1983		18%	18%	18%	43%	29%	29%	28%	29%	28%	
1984		18%	18%	18%	42%	28%	28%	27%	28%	27%	
1985		17%	17%	17%	42%	28%	28%	27%	28%	27%	
1986		17%	17%	17%	42%	28%	28%	27%	28%	27%	
1987		17%	17%	17%	40%		27%	26%	27%	26%	
1988		17%	17%	17%	40%		27%	26%	27%	26%	
1989		17%	17%	17%	40%		27%	26%	27%	27%	
1990		17%	17%	17%	45%	30%	31%	30%	30%	30%	
1991		17%	17%	17%	33%		22%	21%	22%		
1992		18%	18%	18%	29%	19%	19%	19%	19%		
1993		16%	16%	16%	29%	19%	19%	19%	19%		
1994		19%	19%	19%	30%		20%	19%	20%		
1995		14%	14%	14%	19%		13%	13%	13%		
1996		22%	22%	22%	47%		32%	30%	31%		
1997		19%	13%	9%	13%		18%	22%	23%		
1998		0%	2%	1%	2%	5%	3%	5%	5%	5%	5%
1999		2%	1%	2%	2%	4%	3%	4%	4%		4%
2000		0%	1%	12%	5%	4%	2%	3%	4%		4%
2001		1%	1%	12%	4%	6%	4%	5%	6%		6%
2002		6%	3%	6%	9%	7%	5%	6%	7%	6%	6%
2003		5%	3%	12%	9%	8%	6%	7%	8%		8%
2004		20%		17%	18%	13%	8%	12%	13%	13%	13%
2005		44%	3%	10%	6%	9%	12%	8%	9%	8%	8%
2006		17%		10%	6%	8%	7%	7%	8%		7%
2007		10%		10%	15%	7%	10%	6%	7%	6%	6%
2008		2%	5%	7%	7%	7%	7%	6%	7%	6%	6%
2009		0%	6%	7%	0%	8%	15%	7%	8%	7%	7%
2010		0%		9%	0%	9%	9%	8%	9%	8%	8%

	Total Exploitation Rates										
Year	**01**	**02E**	**02W**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**
1980		24%	24%	66%	65%	37%	52%	41%	42%	31%	
1981		24%	24%	66%	65%	37%	51%	41%	42%	32%	
1982		24%	24%	66%	65%		50%	41%	42%	33%	
1983		24%	24%	66%	65%	37%	51%	41%	42%	33%	
1984		24%	24%	66%	65%	37%	51%	41%	42%	32%	
1985		23%	23%	66%	65%	37%	51%	41%	42%	32%	
1986		23%	23%	66%	65%	37%	51%	41%	42%	32%	
1987		23%	23%	66%	65%		52%	41%	42%	31%	
1988		23%	23%	66%	65%		52%	41%	42%	31%	
1989		23%	23%	66%	62%		49%	39%	40%	31%	
1990		23%	23%	66%	70%	40%	55%	44%	45%	35%	
1991		23%	23%	66%	62%		52%	39%	40%		
1992		24%	24%	66%	65%	34%	56%	41%	41%		
1993		22%	22%	63%	57%	30%	47%	35%	36%		
1994		25%	25%	72%	65%		56%	41%	41%		
1995		20%	20%	68%	38%		32%	24%	24%		
1996		28%	28%	61%	74%		58%	47%	48%		
1997		24%	18%	54%	50%		55%	45%	45%		
1998		6%	8%	47%	19%	12%	21%	15%	16%	9%	9%
1999		8%	7%	50%	22%	12%	22%	15%	16%		8%
2000		5%	6%	52%	18%	9%	14%	11%	11%		6%
2001		6%	7%	52%	28%	16%	27%	19%	20%		10%
2002		9%	6%	22%	23%	12%	19%	14%	15%	9%	9%
2003		8%	7%	44%	27%	16%	24%	18%	19%		11%
2004		26%		53%	40%	22%	29%	26%	26%	17%	17%
2005		49%	8%	46%	27%	17%	33%	21%	22%	13%	13%
2006		21%		47%	23%	14%	24%	17%	18%		11%
2007		15%		46%	43%	18%	37%	22%	23%	12%	12%
2008		6%	9%	44%	34%	18%	35%	22%	23%	12%	12%
2009		5%	10%	45%	0%	8%	15%	7%	8%	7%	7%
2010		4%		46%	0%	9%	9%	8%	9%	8%	8%

Table 12. Canadian and total exploitation rates for Chinook salmon stocks summarized by NCCC Statistical Area, 1980-2010.

	Canadian Exploitation Rates											
Year	**01**	**02E**	**02W**	**03**	**04**	**05**	**06**	**07**	**08**	**9S**	**9W**	**10**
1980							19%			28%	59%	17%
1981							19%			31%	34%	17%
1982							19%			22%	69%	20%
1983							19%			17%	44%	23%
1984					29%		20%			22%	66%	16%
1985					27%		19%		32%	23%	38%	56%
1986					36%		19%		32%	33%	39%	38%
1987					28%		19%		32%	21%	37%	21%
1988					36%		29%		32%	22%	33%	17%
1989					28%		18%		32%	24%	34%	26%
1990					32%		15%		28%	20%	35%	18%
1991					41%		33%		33%	38%	50%	21%
1992				49%	30%		21%		38%	19%	26%	33%
1993				42%	38%		32%		30%	22%	25%	14%
1994				41%	37%		31%		30%	22%	32%	14%
1995				58%	49%		44%		35%	27%	26%	13%
1996				44%	24%		21%		31%	10%	26%	6%
1997				44%	21%		14%		34%	9%	28%	9%
1998				45%	16%		4%		41%	8%	31%	6%
1999				55%	26%		11%		26%	8%	75%	6%
2000				40%	23%		14%		29%	7%	26%	6%
2001				31%	25%		20%		37%	7%	37%	6%
2002				43%	24%		18%		47%	7%	36%	6%
2003				34%	20%		12%		59%	8%	56%	6%
2004				45%	22%		11%		51%	8%	34%	1%
2005				41%	20%		10%		51%	9%	28%	1%
2006				32%	23%		14%		32%	8%	32%	1%
2007				33%	18%		12%		47%	9%	20%	1%
2008				27%	41%		31%		30%	7%	13%	
2009				24%	23%		15%		58%	8%	17%	
2010				24%	23%		16%		45%	18%	24%	

	Total Exploitation Rates											
Year	**01**	**02E**	**02W**	**03**	**04**	**05**	**06**	**07**	**08**	**9S**	**9W**	**10**
1980							38%			28%	59%	17%
1981							38%			31%	34%	17%
1982							38%			22%	69%	20%
1983							38%			17%	44%	23%
1984					55%		45%			22%	66%	16%
1985					55%		47%		43%	23%	38%	56%
1986					45%		28%		43%	33%	39%	38%
1987					42%		33%		43%	21%	37%	21%
1988					64%		57%		43%	22%	33%	17%
1989					48%		38%		43%	24%	34%	26%
1990					45%		28%		51%	20%	35%	18%
1991					63%		56%		41%	38%	50%	21%
1992				51%	46%		37%		46%	19%	26%	33%
1993				44%	53%		46%		42%	22%	25%	14%
1994				43%	49%		43%		38%	22%	32%	14%
1995				61%	65%		60%		40%	27%	26%	13%
1996				46%	41%		38%		34%	10%	26%	6%
1997				46%	42%		34%		40%	9%	28%	9%
1998				47%	29%		16%		48%	8%	31%	6%
1999				58%	47%		33%		34%	8%	75%	6%
2000				42%	42%		32%		35%	7%	26%	6%
2001				33%	46%		41%		45%	7%	37%	6%
2002				45%	45%		39%		53%	7%	36%	6%
2003				36%	37%		29%		63%	8%	56%	6%
2004				47%	38%		28%		60%	8%	34%	1%
2005				42%	39%		29%		63%	9%	28%	1%
2006				36%	42%		33%		41%	8%	32%	1%
2007				34%	35%		28%		59%	9%	20%	1%
2008				28%	51%		41%		38%	7%	13%	
2009				27%	40%		32%		64%	8%	17%	
2010				27%	40%		32%		54%	18%	24%	

FIGURES

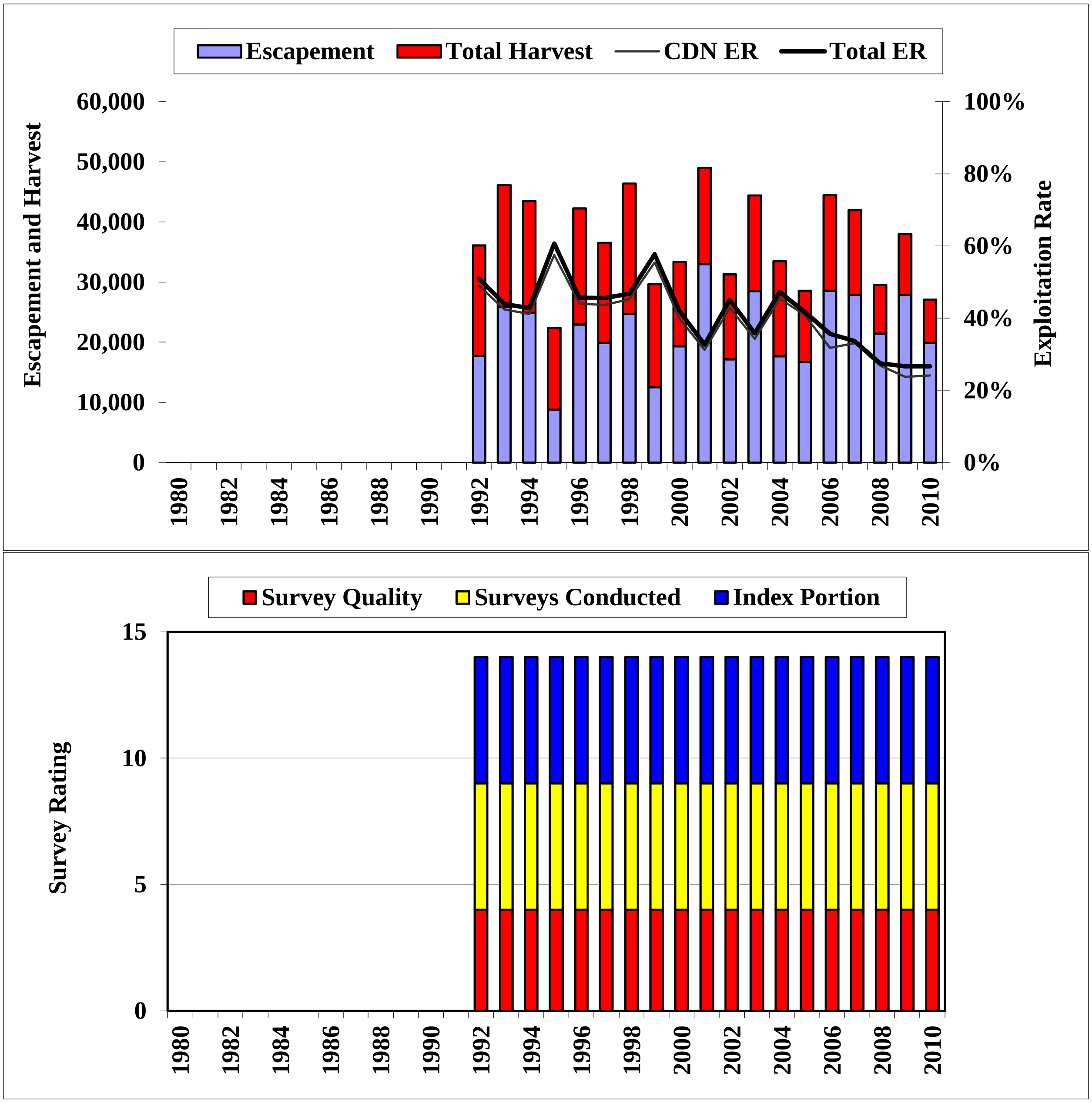


Figure 3. Escapement, harvests and exploitation rate trends for Area 3 (Nass) Chinook.

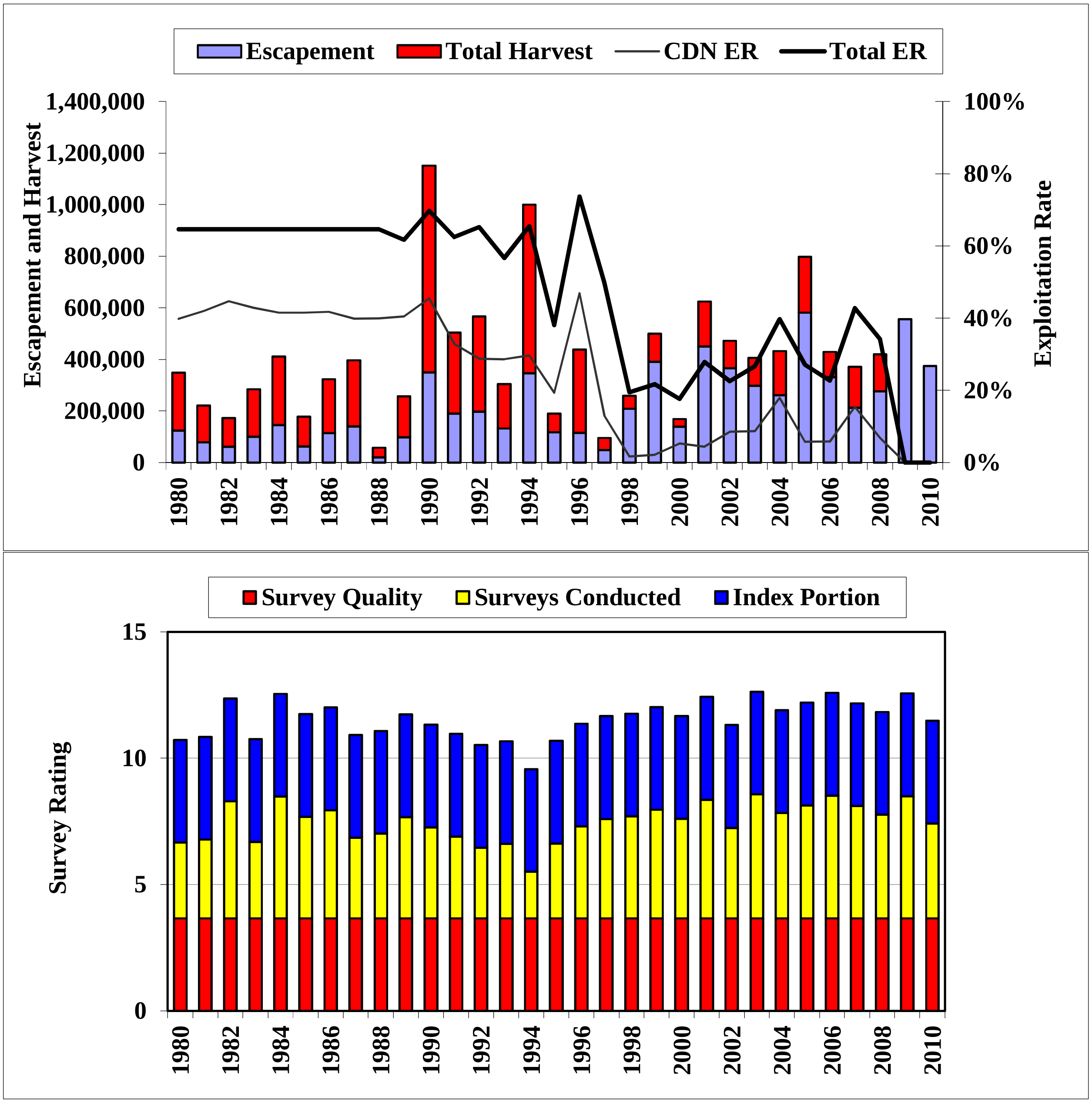
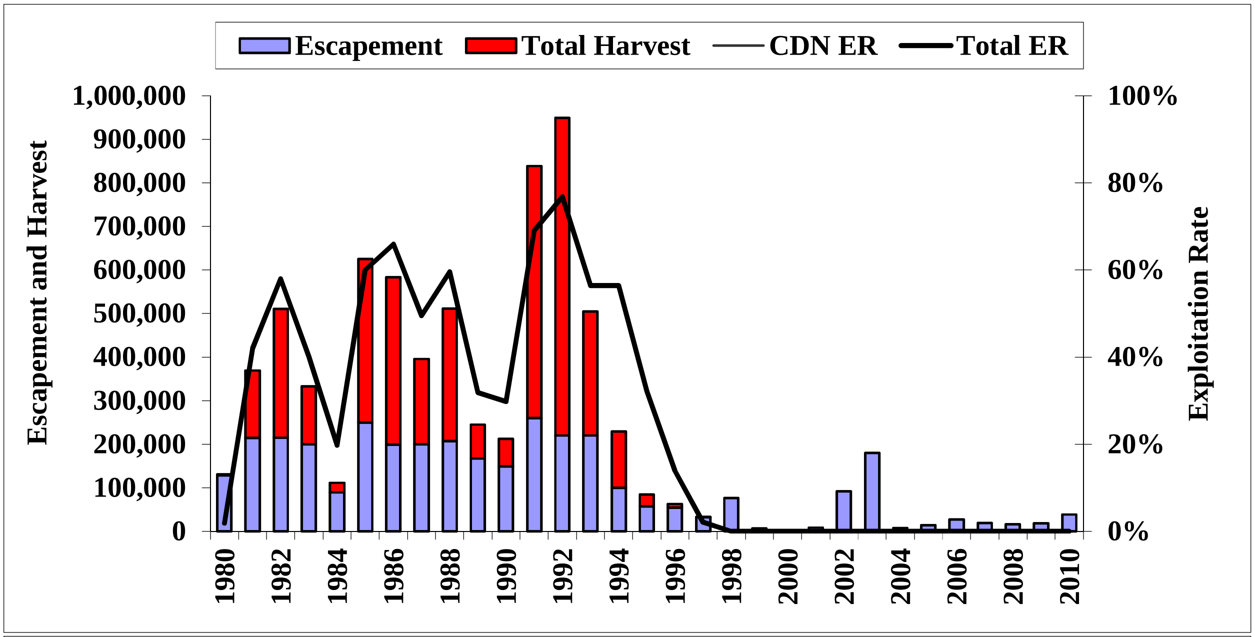


Figure 4. Escapement, harvests and exploitation rate trends for Area 4 (Skeena) Coho.



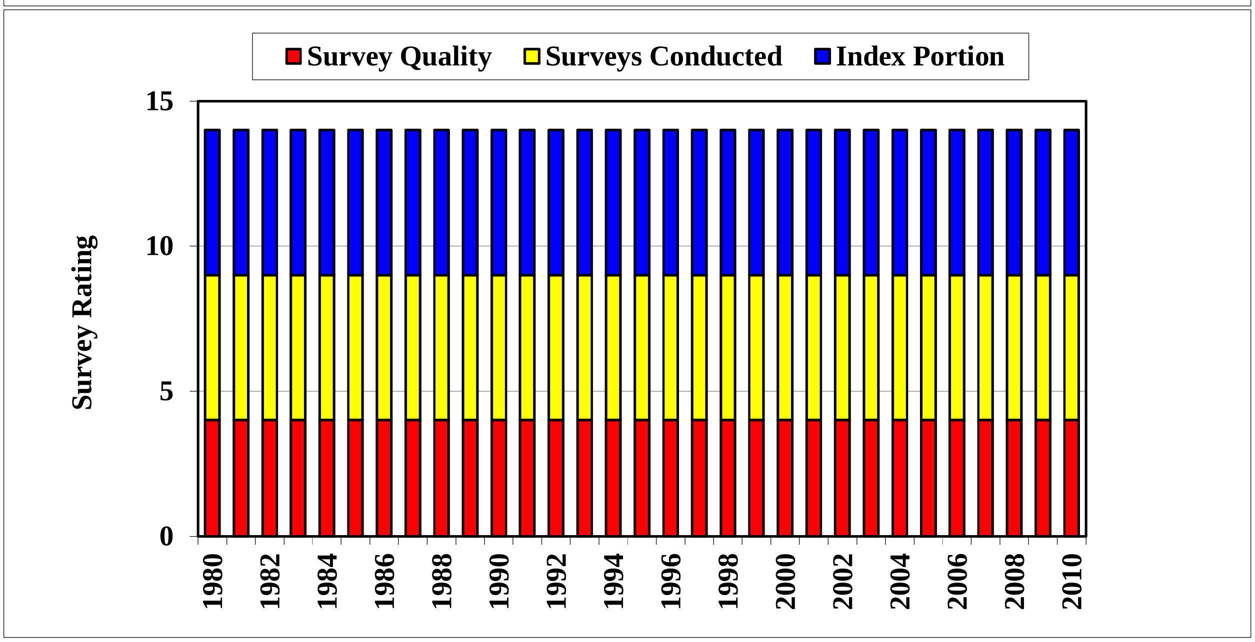
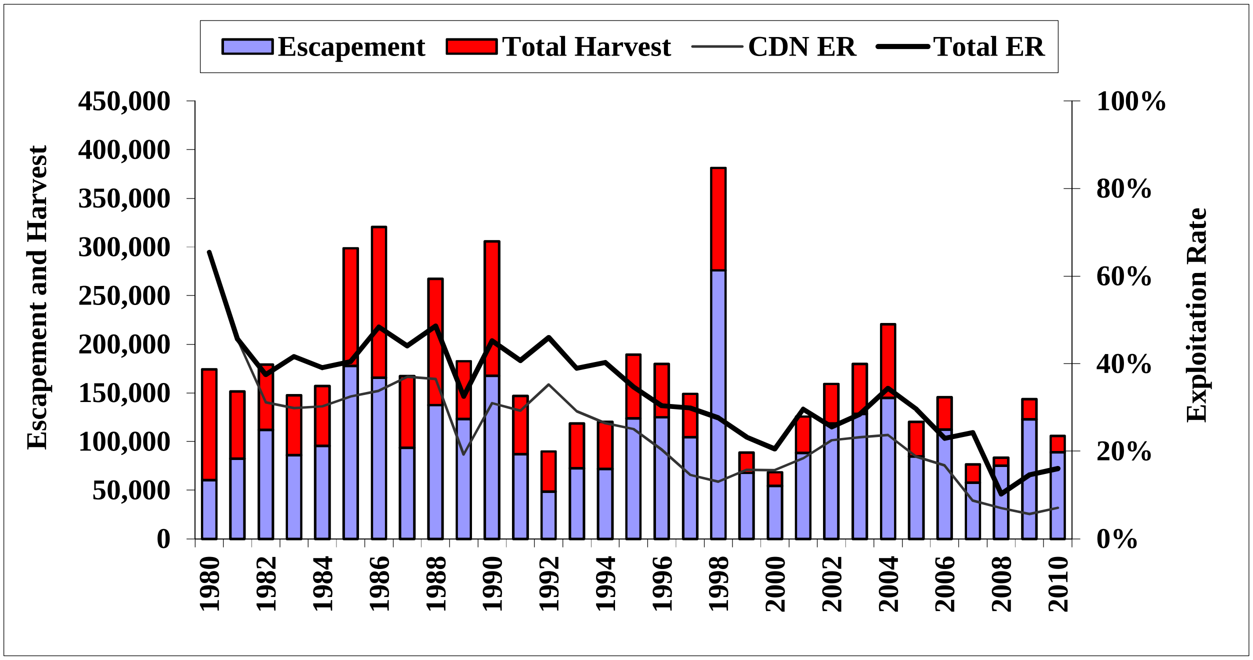


Figure 5. Escapement, harvests and exploitation rate trends for Long Lake Sockeye CU (Area 10 Smith Inlet Sockeye).



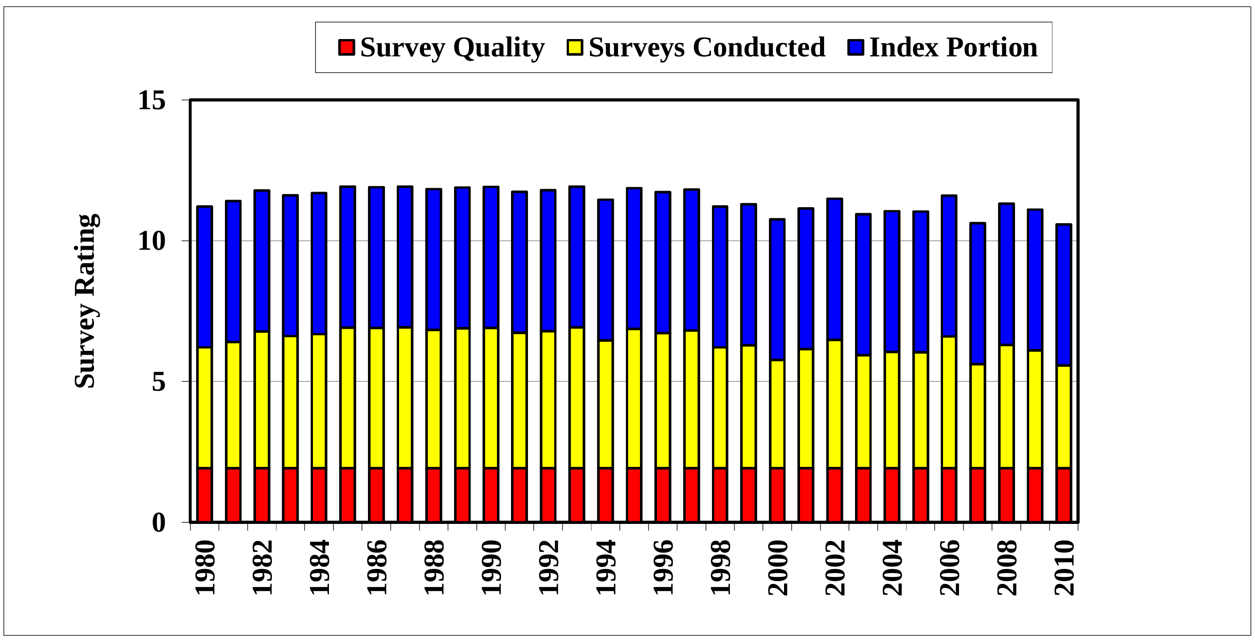
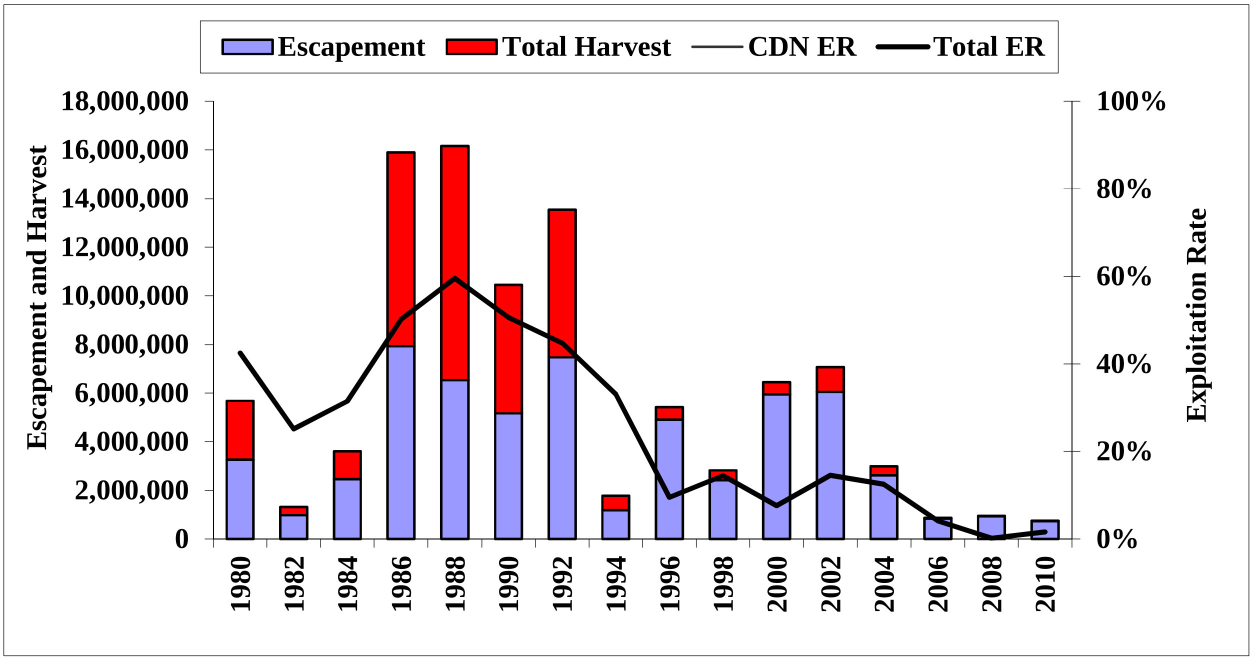


Figure 6. Escapement, harvests and exploitation rate trends for the Hecate Lowlands Chum salmon CU.



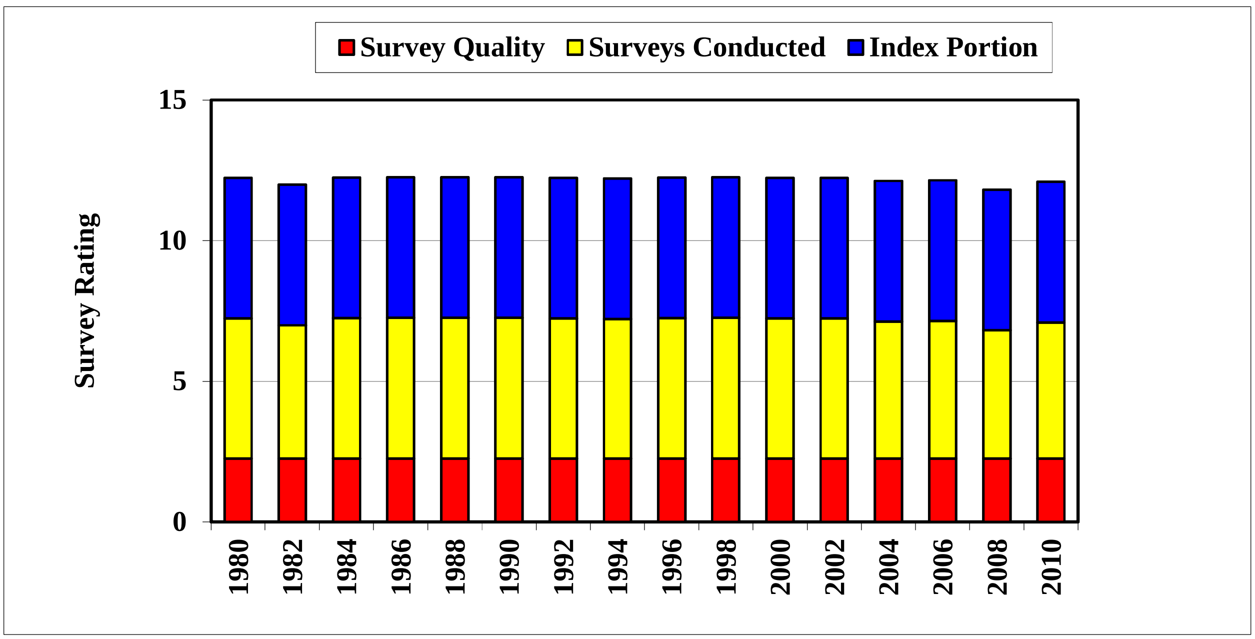


Figure 7. Escapement, harvests and exploitation rate trends for Hecate Strait Fjords even year Pink salmon CU.

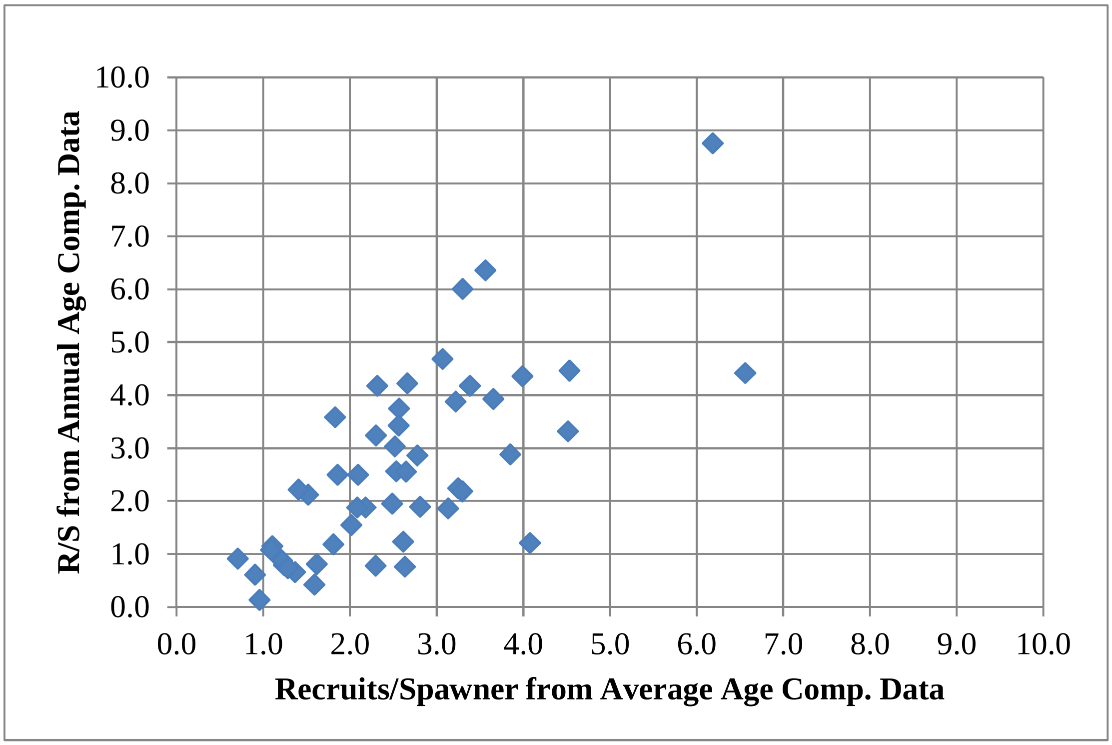


Figure 8. Comparison of estimates of recruits per spawner for Babine Sockeye using average and annual age composition estimates.

APPENDICES

APPENDIX A

Methods used to estimate total escapement, the total return to Canada and total run size for North and Central coast salmon stocks.

The assessment of long-term trends in abundance is critical for determining stock status, setting annual fisheries management goals and defining harvest sharing agreements for First Nations, sport and commercial fisheries. The first task in any stock assessment is to define the stocks to be assessed. For salmon populations, the resolution of stock units range from specific run-timing groups for a specific spawning area to numerous spawning streams within a geographic region. While sound biological and genetic rationale are available to define some of these stock groups, the practical constraints on our ability to assess long-trend trends in abundance for specific salmon stocks is largely determined by the quantity and quality of the available catch and escapement data. For all salmon stocks, the minimum requirement for stock specific assessments is information on the number of adults returning to the spawning area (i.e. spawning escapement). Escapement data are available for a large number of streams but not all streams and all species within each statistical area. Since both escapement and catch data are routinely organized by statistical area, we used the North Coast and Central Coast (NCCC) statistical areas (Areas 1-10) as the basic units for our initial assessment. Within these statistical areas there are a number of instances where the assessment is limited to a specific stock or stock group because of data quality or limitations (e.g. Skeena Sockeye, Nass Sockeye, Nass Coho, Bella Coola Chinook). The goal for these analyses was to provide systematic estimates of the total escapement, total return to Canadian waters, total run size and exploitation rates for each salmon species by statistical area. The exploitations rates for each statistical area could then be applied to escapement estimates for each Conservation Unit (CU) to produce estimates of total run size for each CU.

The major sources of data and estimates used in these analyses were:

- Annual escapement data for all monitored streams within a statistical area;
- Weekly catch data for Sockeye, Pink and Chum by gear type for each statistical area;
- Annual exploitation rate estimates for Chinook and Coho from CWT data and the NCCC Coho Model; and
- Annual estimates of the catch and escapement for Nass and Skeena Sockeye aggregates and CUs from the Northern Boundary run reconstruction (NBSRR) Model.

The procedures used for each combination of species and statistical area were determined by the quantity and quality of the available data. The most common approach used to estimate total escapement was the indicator stream method, where a series of expansions were used to convert the observed escapement for frequently monitored streams into a series of annual escapement estimates for a statistical area. The procedures and equations used to estimate the total annual escapement are described below.

Symbols and notation

a = statistical area
i = indicator stream or river (sum = I)
j = non-indicator stream or river (sum = J)
s = species
d = decade (1=1980-89, 2=1990-99)
y = year in a decade with escapement survey data (max. 10)
Y_{siad} = total years of escapement survey data, by stratum
w = weighting factor
C = catch
$\bar{E}_{siad}$ = observed indicator stream escapement, averaged over years with survey data, by stratum
$\bar{E}_{sjad}$ = observed non-indicator stream escapement, averaged over years with survey data, by stratum
E_{siady} = observed escapement to an indicator stream, by stratum
E'_{sady} = adjusted observed escapement to all indicator streams, by stratum
$\hat{E}_{sady}$ = total estimated escapement by stratum
P = portion of total mean escapements of all streams accounted for by stream r
F'_{sady} = correction factor for missing indicator stream survey data, by stratum
F''_{sady} = correction factor non-indicator stream contributions, by stratum
F'''_{sa} = correction factor for observer efficiency, by species and area
ER_{Total} = total exploitation rate (i.e. total harvest) for a specific year, species and statistical area
ER_{CDN} = Canadian exploitation rate for a specific year, species and statistical area
$TRTC$ = total return to Canada for a specific year, species and statistical area

Description of estimators

The observed escapement of a species to an indicator stream, average over years with survey data in a decade and stratum is

$$\overline{E}_{siad} = \frac{\sum_{y=1}^{Y_{srd}} E_{siady}}{Y_{siad}}$$

The indicator stream escapement contribution to that of all indicator streams in a stratum is

$$P_{siad} = \frac{\overline{E}_{siad}}{\sum_{i=1}^{I} \overline{E}_{siad}}$$

An expansion factor is used to weight the contributions of indicator streams with missing survey data, and give an adjusted observed escapement to all indicator streams in a stratum

$$F'_{sady} = \frac{1}{\sum_{i=1}^{I}\left(P_{siad} \cdot w_{siady}\right)} \qquad \begin{cases} w_{siady} = 0 \text{ if } E_{siady} = 0 \\ w_{siady} = 1 \text{ if } E_{siady} > 0 \end{cases}$$

$$E'_{sady} = F'_{sady} \sum_{i=1}^{I} E_{siady}$$

The overall observed escapement to all streams in an area is obtained by accounting for the contribution of non-indicator streams to the total average escapement for all streams in that statistical area for the user defined decade or period with the best survey coverage for that statistical area (Appendix Table A1).

$$F''_{sady} = \frac{\sum_{i=1}^{I} \overline{E}_{siady} + \sum_{j=1}^{J} \overline{E}_{sjady}}{\sum_{i=1}^{I} \overline{E}_{siady}}$$

$$E_{sady} = E'_{sady} \cdot F''_{sady}$$

The same approach was used to account for the contribution of non-indicator streams within a CU. The decade or period with best survey coverage has to be defined for each CU (Appendix Table A2) since the historical pattern of stream survey effort and number of indicator streams associated with each CU could be substantially different from the totals for the associated statistical area. Summaries of the resulting F''_{sady} values for each species by year and statistical area are provided in Appendix Tables (A3).

Finally, the total estimated escapement to a statistical area is obtained by accounting for observer efficiency, as determined by the regional DFO staff familiar with the escapement monitoring techniques used in each statistical area (Table A4). In the current analyses, the correction factors are considered to be constant over all years for each species, but vary both between species and in some instances between survey areas

$$\hat{E}_{sady} = E_{sady} \cdot F'''_{sa}$$

The stock-specific exploitation rates were derived from indicator stocks for Chinook and Coho salmon or by combining catch and escapement data for individual or groups of statistical areas for Sockeye, Pink, and Chum salmon. A summary of the methods and sources used to compute these exploitation rates are described in the report for all species with additional information provided in Appendix B for Sockeye and Appendix C for Chinook.

The Total Run (TR) in a given year for each species and statistical area was estimated by combining the estimated total escapement (TE) with an estimate of the annual exploitation rate for all fisheries (ER_{Total}) in the following equation:

$$TR = TE / (1-ER_{Total})$$

The Total Return to Canada (TRTC) in a given year for each species and statistical area was estimated by combining the estimated total escapement (TE) with an estimate of the annual exploitation rate for Canadian fisheries (ER_{CDN}) in the following equation:

$$TRTC = TE + TR * ER_{CDN}$$

For a few area-species combinations, the desired estimates were derived from formal run reconstruction or Cohort analyses (e.g. Nass and Skeena Sockeye, Atnarko Chinook).

Appendix Table A1. Summary of the number of stream, number of indicator streams and portion of the total escapement represented by indicator stream by decade for each North Coast and Central Coast Statistical Area. Shaded cells indicate the specific periods used when decadal averages are not appropriate.

Area	Species	TotalNoStreams	Streams1980s	Streams1990s	Streams2000s	Indicators	Indicators1980s	Indicators1990s	Indicators2000s	Ind1980s	Ind1990s	Ind2000s	AvgPeriod	
01	CM	12	10	7	11	4	4	4	4	0.961	0.990	0.955	0	
02E	CM	123	114	111	84	40	39	39	40	0.764	0.823	0.884	1	
02W	CM	71	55	67	56	36	35	36	36	0.743	0.888	0.882	0	
03	CM	51	40	31	28	13	12	12	13	0.838	0.945	0.971	1	
04	CM	51	41	40	11	8	7	8	7	0.752	0.565	0.946	4	
05	CM	40	34	30	23	9	9	9	9	0.470	0.704	0.779	4	
06	CM	136	129	103	84	52	51	52	52	0.723	0.437	0.328	1	*
07	CM	79	66	64	56	37	32	32	37	0.878	0.947	0.954	4	
08	CM	57	38	38	44	24	14	14	24	0.891	0.907	0.706	0	
09	CM	22	21	19	16	7	7	7	7	0.417	0.623	0.959	0	
10	CM	5	4	4	5	3	3	3	3	0.915	0.935	0.962	0	
01	CN	2	2	1	1									
02E	CN	5		5	2									
03	CN	24	20	22	10	8	8	8	7	0.513	0.428	0.689	4	
04	CN	75	58	55	38	15	13	15	15	0.804	0.861	0.861	4	
05	CN	3	2	2	1	1	1	1	1	0.987	0.840	1.000	5	
06	CN	35	29	20	10									
07	CN	2	2											
08	CN	9	9	7	3	2	2	2	2	0.975	0.970	0.999	4	
09	CN	12	11	10	9	7	7	7	7	0.955	0.995	0.996	1	
10	CN	2	2	2	1	1	1	1	1	0.960	0.957	1.000	4	
01	CO	16	15	13	11									
02E	CO	123	116	106	58	6	6	6	6	0.421	0.492	0.666	4	
02W	CO	52	43	45	31	3	3	3	3	0.097	0.047	0.044	4	
03	CO	60	58	26	20	8	8	6	8	0.248	0.392	0.572	1	
04	CO	172	122	121	95	32	24	28	32	0.288	0.482	0.561	4	
05	CO	53	50	41	6	3	2	3	3	0.057	0.103	0.471	4	
06	CO	139	133	88	38	22	21	22	22	0.316	0.196	0.698	1	
07	CO	57	50	45	22	5	5	5	5	0.298	0.560	0.554	4	
08	CO	51	23	16	34	14	5	5	14	0.637	0.927	0.891	3	
09	CO	23	23	17	6	2	2	2	2	0.129	0.741	0.695	1	
10	CO	7	5	6	2	1		1	1		0.929	0.911	5	
01	PKe	16	15	15	14	7	7	7	7	0.969	0.980	0.964	0	
02E	PKe	93	76	85	58	23	23	23	23	0.899	0.947	0.960	4	
02W	PKe	61	50	53	38	12	12	12	12	0.900	0.857	0.763	4	
03	PKe	73	64	54	45	22	20	22	22	0.767	0.845	0.915	4	
04	PKe	104	94	92	36	14	14	14	14	0.628	0.699	0.917	4	
05	PKe	51	49	49	36	15	15	15	15	0.643	0.699	0.727	4	
06	PKe	133	125	110	91	50	50	50	50	0.864	0.715	0.694	4	
07	PKe	63	56	53	48	21	21	21	21	0.837	0.882	0.825	4	
08	PKe	48	37	34	40	14	14	14	14	0.791	0.815	0.947	0	
09	PKe	25	23	22	18	12	12	12	12	0.777	0.899	0.991	0	
10	PKe	6	5	4	3	1	1	1	1	0.950	0.968	0.979	4	
01	PKo	13	13	13	13									
02E	PKo	44	42	44	38	6	6	6	6	0.345	0.473	0.448	0	
02W	PKo	31	30	31	24	2	2	2	2	0.318	0.276	0.308	4	
03	PKo	67	59	52	44	20	20	20	20	0.777	0.811	0.908	4	
04	PKo	117	103	91	42	13	13	13	13	0.602	0.668	0.877	4	
05	PKo	51	49	48	37	12	12	12	12	0.581	0.603	0.618	4	
06	PKo	127	121	106	92	48	48	48	48	0.852	0.696	0.683	4	
07	PKo	66	59	51	51	21	21	21	21	0.840	0.884	0.824	0	

Appendix Table A1 (cont'd). Summary of the number of stream, number of indicator streams and portion of the total escapement represented by indicator stream by decade for each North Coast and Central Coast Statistical Area. Shaded cells indicate the specific periods used when decadal averages are not appropriate.

Area	Species	TotalNoStreams	Streams1980s	Streams1990s	Streams2000s	Indicators	Indicators1980s	Indicators1990s	Indicators2000s	Ind1980s	Ind1990s	Ind2000s	AvgPeriod
08	PKo	51	37	33	45	13	13	13	13	0.786	0.813	0.937	0
09	PKo	23	22	20	18	6	6	6	6	0.327	0.686	0.864	0
10	PKo	6	6	4	3	1	1	1	1	0.945	0.968	0.979	4
01	SX	6	6	5	4	3	3	3	3	0.876	0.973	0.919	4
02E	SX	14	12	6	5	2	2	2	2	0.989	0.999	0.999	1
02W	SX	24	7	20	5	1	1	1	1	0.812	0.841	0.663	4
03	SX	20	19	9	6	5	5	4	5	0.870	0.907	1.000	1
04	SX	91	69	69	54	35	31	29	35	0.197	0.193	0.265	4
05	SX	27	18	27	11	8	8	8	8	0.714	0.833	0.712	4
06	SX	83	57	54	32	9	9	9	9	0.663	0.822	0.733	4
07	SX	36	32	22	17	7	7	7	7	0.760	0.929	0.962	1
08	SX	21	15	20	13	4	4	4	4	0.695	0.724	0.686	4
09	SX	19	19	13	9	8	8	8	8	0.460	0.397	0.992	4
10	SX	7	4	5	2	2	2	2	2	1.000	0.999	1.000	4

* Note: Kitimat Hatchery chum major recent producer and not an indicator stock

Appendix Table A2. Summary of the number of stream, number of indicator streams and portion of the total escapement represented by indicator stream by decade for each North Coast and Central Coast Conservation Unit. Shaded cells indicate the specific periods used when decadal averages are not appropriate.

Species	CU Code	CU_name	TotalNoStreams	Streams1980s	Streams1990s	Streams2000s	Indicators	Indicators1980s	Indicators1990s	Indicators2000s	Ind1980s	Ind1990s	Ind2000s	AvgPeriod
CM	CM_12	Smith Inlet	10	8	9	9	5	5	5	5	0.923	0.932	0.954	0
CM	CM_13	Rivers Inlet	15	15	12	11	5	5	5	5	0.407	0.899	0.968	0
CM	CM_14	Wannock	1	1	1									
CM	CM_15	Spiller-Fitz Hugh-Burke	68	55	49	50	28	23	23	28	0.830	0.924	0.864	0
CM	CM_16	Bella Coola-Dean Rivers	22	15	16	16	7	3	3	7	0.860	0.913	0.825	0
CM	CM_17	Bella Coola River-Late	9	1	2	9	7	1	1	7	1.000	0.909	0.618	3
CM	CM_18	Hecate Lowlands	134	124	111	70	41	41	41	41	0.652	0.794	0.845	1
CM	CM_19	Mussel-Kynoch	14	13	13	13	12	12	12	12	1.000	1.000	1.000	0
CM	CM_20	Douglas-Gardner	61	58	43	45	27	26	27	27	0.701	0.365	0.251	1
CM	CM_21	East HG	93	89	84	57	32	32	32	32	0.711	0.804	0.887	4
CM	CM_22	Skidegate	40	32	35	39	13	12	12	13	0.864	0.858	0.866	0
CM	CM_23	West Haida Gwaii	61	48	59	44	31	30	31	31	0.726	0.890	0.889	0
CM	CM_24	North Haida Gwaii	11	9	6	10	3	3	3	3	0.960	0.990	0.953	0
CM	CM_25	North Haida Gwaii-Stanley Creek	1	1	1	1	1	1	1	1	1.000	1.000	1.000	0
CM	CM_26	Skeena Estuary	17	8	11	9	1			1			0.181	3
CM	CM_27	Lower Skeena	29	25	24	9	6	5	6	6	0.756	0.599	0.942	4
CM	CM_28	Middle Skeena	14	12	10	1	2	2	2	1	0.736	0.480	1.000	4
CM	CM_30	Portland Inlet	19	10	10	17	5	5	5	5	0.988	0.923	0.939	0
CM	CM_31	Lower Nass	13	13	8	1	1	1	1	1	0.006	0.034	1.000	4
CM	CM_32	Portland Canal-Observatory	15	15	10	7	6	6	6	6	0.954	0.970	0.995	1
CN	CN_36	Docee	1	1	1	1	1	1	1	1	1.000	1.000	1.000	0
CN	CN_37	Rivers Inlet	12	11	10	8	6	6	6	6	0.781	0.937	0.987	1
CN	CN_38	Wannock	1	1	1	1	1	1	1	1	1.000	1.000	1.000	0
CN	CN_39	Bella Coola-Bentinck	4	4	4	1	1	1	1	1	0.988	0.977	1.000	4
CN	CN_40	Dean River	1	1	1	1	1	1	1	1	1.000	1.000	1.000	0
CN	CN_41	North & Central Coast-late timing	9	6	6	2	1	1	1	1	0.065	0.224	0.966	4
CN	CN_42	North & Central Coast-early timing	35	31	18	10								
CN	CN_43	Haida Gwaii-North	2	2	1	1								
CN	CN_44	Haida Gwaii-East	4		4	1								
CN	CN_45	Skeena Estuary	4	4	1	1								
CN	CN_46	Ecstall	4	4	2	2	1	1	1	1	0.149	0.179	0.259	1
CN	CN_48	Lower Skeena	14	14	11	10	5	5	5	5	0.231	0.233	0.531	0
CN	CN_49	Kalum-early timing	2	2	2	2	1	1	1	1	0.807	0.839	0.903	0
CN	CN_50	Kalum-late timing	3	3	3	1	1	1	1	1	0.950	0.926	1.000	4
CN	CN_51	Lakelse	3	3	2									
CN	CN_53	Middle Skeena-large lakes	10	7	9	7	2	2	2	2	0.927	0.924	0.768	0
CN	CN_54	Middle Skeena-mainstem tributaries	23	15	17	8	3	2	3	3	0.622	0.860	0.935	4
CN	CN_55	Upper Bulkley River	3	3	3	1	1	1	1	1	0.835	0.893	1.000	4
CN	CN_56	Upper Skeena	4	2	2	2								
CN	CN_57	Portland Sound-Observatory Inlet-Lower Na	10	7	10	5	5	5	5	4	0.759	0.771	0.965	4
CN	CN_58	Upper Nass	14	13	12	5	3	3	3	3	0.443	0.338	0.613	4
CN	CN_80	Zymoetz	5	1	3	4	1		1	1		0.210	0.333	0
CO	CO_20	Smith Inlet	6	5	5	2	1		1	1		0.931	0.911	0
CO	CO_21	Rivers Inlet	22	22	16	6	2	2	2	2	0.134	0.742	0.695	1
CO	CO_22	Bella Coola-Dean Rivers	30	7	4	25	11	2	2	11	0.817	0.941	0.914	3
CO	CO_23	Haida Gwaii-East	106	101	92	50	5	5	5	5	0.322	0.427	0.516	4
CO	CO_24	Haida Gwaii-West	56	46	48	32	3	3	3	3	0.095	0.047	0.044	4
CO	CO_25	Haida Gwaii-Graham Island Lowlands	28	27	23	17	1	1	1	1	0.151	0.096	0.317	4
CO	CO_26	Mussel-Kynoch	12	12	11	9	2	2	2	2	0.671	0.666	0.655	4
CO	CO_27	Hecate Strait Mainland	167	155	119	33	10	9	10	10	0.228	0.266	0.563	1
CO	CO_28	Brim-Wahoo	2	2	2	2	2	2	2	2	1.000	1.000	1.000	0
CO	CO_29	Douglas Channel-Kitimat Arm	33	32	9	5	2	2	2	2	0.030	0.011	0.194	1

Appendix Table A2 (cont'd). Summary of the number of stream, number of indicator streams and portion of the total escapement represented by indicator stream by decade for each North Coast and Central Coast Conservation Unit. Shaded cells indicate the specific periods used when decadal averages are not appropriate.

Species	CU Code	CU_name	TotalNoStreams	Streams1980s	Streams1990s	Streams2000s	Indicators	Indicators1980s	Indicators1990s	Indicators2000s	Ind1980s	Ind1990s	Ind2000s	AvgPeriod
CO	CO_30	Northern Coastal Streams	56	47	45	26	17	16	17	17	0.401	0.679	0.788	4
CO	CO_31	Skeena Estuary	21	21	12	4	3	3	3	3	0.342	0.618	0.971	1
CO	CO_32	Lower Skeena	82	55	71	45	11	10	11	11	0.287	0.387	0.380	4
CO	CO_33	Middle Skeena	61	49	36	36	14	11	12	14	0.289	0.597	0.621	1
CO	CO_34	Upper Skeena	14	3	4	10	4		2	4		0.878	0.885	3
CO	CO_35	Lower Nass	22	22	12	6	4	4	3	4	0.164	0.245	0.684	1
CO	CO_36	Upper Nass	13	13	5	3	2	2	1	2	0.310	0.605	0.823	1
CO	CO_37	Portland Sound-Observatory Inlet-Portland (	21	19	9	11	2	2	2	2	0.284	0.410	0.426	1
Pke	PKe_5	Hecate Lowlands	172	158	147	103	39	39	39	39	0.751	0.721	0.817	4
Pke	PKe_6	Hecate Strait-Fjords	142	126	114	124	70	70	70	70	0.819	0.814	0.832	0
Pke	PKe_7	Nass-Skeena Estuary	141	127	112	79	37	35	37	37	0.724	0.727	0.884	4
Pke	PKe_8	Middle-Upper Skeena	45	38	42	12	3	3	3	3	0.511	0.703	0.959	4
Pke	PKe_9	North Haida Gwaii	16	15	15	14	7	7	7	7	0.969	0.980	0.964	0
Pke	PKe_10	East Haida Gwaii	91	74	83	57	23	23	23	23	0.899	0.947	0.960	4
Pke	PKe_11	West Haida Gwaii	63	52	55	39	12	12	12	12	0.900	0.856	0.763	4
Pke	PKe_12	Upper Nass	5	4	3	1								
Pko	PKo_8	Homathko-Klinaklini-Smith-Rivers-Bella Co	46	35	28	37	10	10	10	10	0.933	0.970	0.953	0
Pko	PKo_9	East Haida Gwaii	43	41	43	37	6	6	6	6	0.345	0.473	0.448	4
Pko	PKo_10	North Haida Gwaii	13	13	13	13								
Pko	PKo_11	West Haida Gwaii	32	31	32	25	2	2	2	2	0.318	0.275	0.308	4
Pko	PKo_12	Hecate Strait-Lowlands	167	158	138	104	35	35	35	35	0.608	0.621	0.697	1
Pko	PKo_13	Hecate Strait-Fjords	100	92	85	95	52	52	52	52	0.670	0.578	0.711	0
Pko	PKo_14	Nass-Skeena Estuary	32	30	31	23	13	13	13	13	0.583	0.445	0.647	4
Pko	PKo_15	Lower Skeena	48	45	34	15	5	5	5	5	0.685	0.680	0.890	4
Pko	PKo_16	Middle & Upper Skeena	52	43	42	16	3	3	3	3	0.507	0.703	0.957	4
Pko	PKo_17	Nass-Portland-Observatory	57	51	44	38	16	16	16	16	0.772	0.815	0.906	4
Pko	PKo_18	Upper Nass	5	4	3	1								
SX	SX_L-15-01	Long	3	2	2	2	2	2	2	2	1.000	1.000	1.000	5
SX	SX_L-15-02	Owikeno	11	11	11	9	8	8	8	8	0.589	0.533	0.992	5
SX	SX_L-15-03	Owikeno-Late timing												
SX	SX_L-15-04	Wannock[Owikeno]	1	1	1									
SX	SX_L-16-01	South Atnarko Lakes												
SX	SX_L-17-01	Ain/Skundale/Ian	1	1	1	1								
SX	SX_L-17-02	Awun	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-17-03	Fairfax	1	1	1	1								
SX	SX_L-17-04	Jalun	1	1	1									
SX	SX_L-17-05	Marian/Eden	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-17-06	Mathers	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-17-07	Mercer	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-17-08	Skidegate	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-17-09	Yakoun	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-17-10	Marie												
SX	SX_L-17-11	(N)Mayer												
SX	SX_L-17-12	(N)Gudal												
SX	SX_L-18-01	Backland	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-18-02	Canoona	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-18-03	Dome	1		1									
SX	SX_L-18-04	Evelyn	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-18-05	Kainet Creek	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-18-06	Kimsquit	1	1	1	1								
SX	SX_L-18-07	Kitkiata	1	1	1	1								
SX	SX_L-18-08	Kitlope	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5

Appendix Table A2 (cont'd). Summary of the number of stream, number of indicator streams and portion of the total escapement represented by indicator stream by decade for each North Coast and Central Coast Conservation Unit. Shaded cells indicate the specific periods used when decadal averages are not appropriate.

Species	CU Code	CU_name	TotalNoStreams	Streams1980s	Streams1990s	Streams2000s	Indicators	Indicators1980s	Indicators1990s	Indicators2000s	Ind1980s	Ind1990s	Ind2000s	AvgPeriod
SX	SX_L-18-09	Pine River	1	1		1								
SX	SX_L-18-11	Whalen	1		1									
SX	SX_L-19-01	Banks	1	1	1	1								
SX	SX_L-19-02	Bloomfield	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-03	Bolton Creek	1		1									
SX	SX_L-19-04	Bonilla	1	1	1	1								
SX	SX_L-19-05	Borrowman Creek	1	1	1									
SX	SX_L-19-06	Busey Creek												
SX	SX_L-19-07	Cartwright Creek	1	1										
SX	SX_L-19-08	Chic Chic	1		1									
SX	SX_L-19-09	Tuwartz	1	1										
SX	SX_L-19-10	Fannie Cove	2	1	1	2								
SX	SX_L-19-11	Curtis Inlet	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-12	Dallain Creek												
SX	SX_L-19-13	Deer	1	1	1									
SX	SX_L-19-14	Devon	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-15	Douglas Creek	1	1	1									
SX	SX_L-19-16	Elizabeth												
SX	SX_L-19-17	Elsie/Hoy	1	1	1									
SX	SX_L-19-18	End Hill Creek	1	1	1									
SX	SX_L-19-19	Evinrude Inlet	1	1	1									
SX	SX_L-19-20	Freeda/Brodie	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-21	Hartley Bay	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-22	Hevenor Inlet	1	1	1									
SX	SX_L-19-23	Higgins Lagoon	1	1										
SX	SX_L-19-24	Kadjusdis River	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-25	Kdelmashan Creek	1	1										
SX	SX_L-19-26	Keecha	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-27	Kent Inlet Lagoon Creek	1	1		1								
SX	SX_L-19-28	Kenzuwash Creeks	1		1									
SX	SX_L-19-29	Keswar Creek	1	1	1									
SX	SX_L-19-30	Kildidt Creek	1	1										
SX	SX_L-19-31	Kildidt Lagoon Creek	1	1										
SX	SX_L-19-32	Kisameet	1	1	1	1								
SX	SX_L-19-33	Koeye	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-34	Kooryet	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-35	Kunsoot River	1	1	1									
SX	SX_L-19-36	Kwakwa Creek	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-37	Lewis Creek	1		1									
SX	SX_L-19-38	Limestone Creek	1	1	1									
SX	SX_L-19-39	Lowe/Simpson/Weare	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-40	Mary Cove Creek	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-41	Mcdonald Creek	1	1										
SX	SX_L-19-42	Mcloughlin	1	1	1									
SX	SX_L-19-43	Mikado	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-44	Monckton Inlet Creek	1	1	1									
SX	SX_L-19-45	Namu	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-46	Port John	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-47	Powles Creek	1	1	1									
SX	SX_L-19-48	Price Creek	1	1	1	1								
SX	SX_L-19-49	Prudhomme	2	2	2	2	2	2	2	2	1.000	1.000	1.000	5
SX	SX_L-19-50	Roderick	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-51	Ryan Creek	1	1	1									

Appendix Table A2 (cont'd). Summary of the number of stream, number of indicator streams and portion of the total escapement represented by indicator stream by decade for each North Coast and Central Coast Conservation Unit. Shaded cells indicate the specific periods used when decadal averages are not appropriate.

Species	CU Code	CU_name	TotalNoStreams	Streams1980s	Streams1990s	Streams2000s	Indicators	Indicators1980s	Indicators1990s	Indicators2000s	Ind1980s	Ind1990s	Ind2000s	AvgPeriod
SX	SX_L-19-52	Salter												
SX	SX_L-19-53	Scoular/Kilpatrick	1	1	1									
SX	SX_L-19-54	Shawatlan	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-55	Sheneeza Inlet	1	1	1									
SX	SX_L-19-56	Ship Point Creek	1	1										
SX	SX_L-19-57	Spencer Creek	1		1	1								
SX	SX_L-19-58	Stannard Creek	1	1	1									
SX	SX_L-19-59	Talamoosa Creek	1	1	1									
SX	SX_L-19-60	Tankeeah River	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-61	Treneman Creek	1	1										
SX	SX_L-19-62	Tsimtack Lakes	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-63	Tuno Creek East	1	1	1									
SX	SX_L-19-64	Tuno Creek West	1	1										
SX	SX_L-19-65	Tyler Creek	1	1	1									
SX	SX_L-19-66	Wale Creek	1	1										
SX	SX_L-19-67	Watt Bay												
SX	SX_L-19-68	West Creek	1	1										
SX	SX_L-19-69	Yaaklele Lagoon												
SX	SX_L-19-70	Yeo	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-19-71	Sockeye Creek												
SX	SX_L-19-72	(N)Sylvia Creek												
SX	SX_L-19-73	(N)South Bonnila												
SX	SX_L-20-01	Alastair	2	2	2	2	2	2	2	2	1.000	1.000	1.000	5
SX	SX_L-20-02	Aldrich												
SX	SX_L-20-03	Dennis												
SX	SX_L-20-04	Ecstall/Lower	1	1	1	1								
SX	SX_L-20-05	Johnston	2	2	2	1	1	1	1	1	0.993	0.979	1.000	5
SX	SX_L-20-06	Kitsumkalum	6	6	3	2	2	2	1	2	0.266	0.887	1.000	5
SX	SX_L-20-07	Lakelse	9	7	6	5	3	3	3	3	0.922	0.948	0.986	5
SX	SX_L-20-08	Mcdonell	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-21-01	Atna												
SX	SX_L-21-02	Babine	30	23	28	21	9	9	9	9	0.171	0.160	0.225	5
SX	SX_L-21-03	Bulkley												
SX	SX_L-21-05	Kitwancool	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-21-06	Maxan												
SX	SX_L-21-07	Morice	3	2	1	2	1	1	1	1	0.936	1.000	0.942	5
SX	SX_L-21-08	Nilkitkwa	1	1	1									
SX	SX_L-21-09	Stephens	2	2	2	1	1	1	1	1	0.894	0.962	1.000	5
SX	SX_L-21-10	Swan	6	1	3	5	3	1	1	3	1.000	0.391	0.834	5
SX	SX_L-21-11	Tahlo/Morrison	2	2	2	1	1	1	1	1	0.986	0.983	1.000	5
SX	SX_L-21-12	Footsore/Hodder												
SX	SX_L-21-13	(N)Onerka												
SX	SX_L-22-01	Asitika	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-22-02	Azuklotz	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-22-03	Bear	3	2	2	2	2	2	1	2	1.000	0.567	1.000	5
SX	SX_L-22-04	Damshilgwit	1			1	1			1			1.000	5
SX	SX_L-22-05	Johanson	1	1	1									
SX	SX_L-22-06	Kluatantan												
SX	SX_L-22-07	Kluayaz												
SX	SX_L-22-08	Motase	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-22-09	Sicintine												
SX	SX_L-22-10	Slamgeesh	2	1		1								
SX	SX_L-22-11	Spawning												

Appendix Table A2 (cont'd). Summary of the number of stream, number of indicator streams and portion of the total escapement represented by indicator stream by decade for each North Coast and Central Coast Conservation Unit. Shaded cells indicate the specific periods used when decadal averages are not appropriate.

Species	CU Code	CU_name	TotalNoStreams	Streams1980s	Streams1990s	Streams2000s	Indicators	Indicators1980s	Indicators1990s	Indicators2000s	Ind1980s	Ind1990s	Ind2000s	AvgPeriod
SX	SX_L-22-12	Sustut	1	1	1									
SX	SX_L-23-01	Clements	1	1										
SX	SX_L-23-02	Split Mountain/Leverson	1	1										
SX	SX_L-24-01	Bowser	1	1	1									
SX	SX_L-24-02	Damdochax/Wiminasik	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-24-03	Fred Wright	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-24-04	Kwinageese												
SX	SX_L-24-05	Meziadin	1	1	1	1	1	1	1	1	1.000	1.000	1.000	5
SX	SX_L-24-06	Oweegee	1	1										
SX	SX_R12	Rivers-Smith Inlets	8	7	2									
SX	SX_R13	East Haida Gwaii	12	10	4	3								
SX	SX_R14	West Haida Gwaii	22	5	18	3								
SX	SX_R15	North Haida Gwaii	1	1										
SX	SX_R16	Northern Coastal Fjords	70	42	52	34	4	4	4	4	0.867	0.915	0.685	5
SX	SX_R17	Northern Coastal Streams	27	17	15	4								
SX	SX_R18	Skeena River	10	7	6									
SX	SX_R19	Skeena River-high interior	1			1	1			1			1.000	5
SX	SX_R20	Lower Nass-Portland	10	10	3	2	1	1	1	1	0.826	0.902	0.996	5
SX	SX_R21	Upper Nass River	3	2	2	1	1	1		1	0.766		1.000	5
SX	SX_R22	Northern Transboundary Fjords	13	12	12	9								
SX	SX_R23	Chilkat River												
SX	SX_R24	Alsek River	3	2	2	2								

Appendix Table A3. Summary of Expansion Factor II values used to expand indicator stream escapement represent all streams within a Statistical Area by decade.

	Statistical Areas/Stock Group												
Decades	**01**	**02E**	**02W**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**9S**	**9W**	**10**
Sockeye													
1980	1.13	1.01	1.23	1.00	1.00	1.31	1.48	1.32	1.42	2.27			1.00
1990	1.13	1.01	1.23	1.00	1.00	1.31	1.48	1.32	1.42	2.27			1.00
2000	1.13	1.01	1.23	1.00	1.00	1.31	1.48	1.32	1.42	2.27			1.00
2010	1.13	1.01	1.23			1.31	1.48	1.32	1.42	2.27			1.00
Even-Year Pink													
1980	1.03	1.08	1.16	1.29	1.56	1.52	1.26	1.17	1.26	1.29			1.04
1990	1.02	1.08	1.16	1.29	1.56	1.52	1.26	1.17	1.23	1.11			1.04
2000	1.05	1.08	1.16	1.29	1.56	1.52	1.26	1.17	1.06	1.01			1.04
2010	1.05	1.08	1.16	1.29	1.56	1.52	1.26	1.17	1.06	1.01			
Odd-Year Pink													
1980		2.90		1.32	1.63	1.72	1.28	1.19	1.27	3.05			1.04
1990		2.12		1.32	1.63	1.72	1.28	1.13	1.23	1.46			1.04
2000		2.23		1.32	1.63	1.72	1.28	1.21	1.07	1.16			1.04
2010													
Chum													
1980	1.04	1.31	1.35	1.19	1.49	2.03	1.38	1.10	1.12	2.40			1.09
1990	1.01	1.31	1.13	1.19	1.49	2.03	1.38	1.10	1.10	1.61			1.07
2000	1.05	1.31	1.13	1.19	1.49	2.03	1.38	1.10	1.44	1.05			1.03
2010	1.05	1.31	1.13	1.19	1.49	2.03	1.38	1.10	1.44	1.05			1.03
Coho													
1980		2.27	20.71	4.03	2.46	14.00	3.16	2.41	1.12	7.78			
1990		2.27	20.71	4.03	2.46	14.00	3.16	2.41	1.12	7.78			1.15
2000		2.27	20.71	4.03	2.46	14.00	3.16	2.41	1.12	7.78			1.15
2010		2.27		4.03	2.46	14.00	3.16	2.41	1.12	7.78			1.15
Chinook													
1980					1.25		4.01		1.02		1.44	1.00	1.00
1990					1.30		4.01		1.03		1.44	1.00	1.00
2000					1.34		4.01		1.03		1.44	1.00	1.00
2010					1.34		4.01		1.03		1.44	1.00	

Appendix Table A4. Summary of observer efficiency expansion factors, by species and statistical area.

Stat. Area	**Sockeye**	**Pink**	**Chum**	**Chinook**	**Coho**
1	3.0	1.5	1.5	1.5	5.0
2E	3.0	1.5	1.5	na	5.0
2W	3.0	1.5	1.5	na	5.0
3	NB Model	1.5	1.5	NJTC	NJTC
4	NB Model	1.5	1.5	1.22	5.0
5	3.0	1.5	1.5	na	5.0
6	3.0	1.5	1.5	2.0	5.0
7	3.0	1.5	1.5	na	5.0
8	2.0	1.5	1.5	1.35	5.0
9	2.0	1.5	1.5	1.94	5.0
10	1.0	1.5	1.5	1.5	5.0

NB Model = Northern Boundary Run Reconstruction Model (English et al. 2004b).
NJTC = Nisga'a Joint Technical Committee analyses 1992-2010.

APPENDIX B

Northern Boundary Sockeye run reconstruction model run timing parameters for Nass and Skeena Sockeye Conservation Units.

This appendix provides a brief description of the run timing parameters and modifications made to the Northern Boundary Sockeye Run Reconstruction (NBSRR) model to derive exploitation rate (ER) estimates for each Sockeye run timing group and CU within the Nass and Skeena watersheds.

The available data and methods needed to derive ERs for Nass and Skeena Sockeye CUs were examined by Steve Cox-Rogers, Karl English, Bill Gazey and Richard Alexander on 5 October 2011 during a one day workshop. In the absence of detailed historic stock composition data for each fishery that harvests Nass and Skeena Sockeye, we used existing information on run timing and geographic distribution of CUs within the Nass and Skeena watersheds to define the stock groups to be included in the model. While we could have defined separate sub-stocks for each CU, there was little point in deriving separate ER estimates for CUs that had similar timing and were exposed to all the same fisheries. For two of the major CUs (Meziadin and Babine), there was sufficient differences in run timing within these CUs to warrant the disaggregation of these CUs. These initial discussions resulted in the definition of 10 sub-stocks for Nass Sockeye (Table B1) and 20 sub-stocks for Skeena Sockeye (Table B2).

Test fisheries on the lower portions of the Nass and Skeena watersheds have documented substantially year to year variability in the run timing for the total Sockeye returns to these watersheds. Daily escapement estimates for Nass and Skeena Sockeye from test fishery data have been used in the NBSRR model to derive estimates of harvest and ER for major northern boundary Sockeye stocks from 1982-08. In order to retain information on the annual variability in run timing for the aggregate Nass and Skeena stocks, the timing for each sub-stock was defined using a number of days “offset” relative to the 50% point for the aggregate stocks. For example: an offset of -14 days for Gingit Sockeye indicates a run timing two weeks earlier than that for the aggregate for all Nass Sockeye stocks and an offset of 14 days for Damdochax and Kwinageese Sockeye indicates that these stocks are typically two weeks later than the Nass aggregate (Table B1). The average CU timing offset from the mean run timing for the Nass Sockeye aggregate was estimated using DNA stock composition data reported in Hall et al. (2010). The average CU timing offset from the mean run timing for the Skeena Sockeye aggregate was derived from Cox-Rogers et al. (2004). The timing distribution for each CU is defined by a normal curve with its peak defined by the offset parameter and duration determined by the standard deviation (SD) parameter (e.g. a duration of 6 weeks = 42d = a SD of 10.5d). The duration of runs for Nass Sockeye varied between 42 and 70 days for the different sub-stocks based on fairly consistent run timing patterns from recent DNA data. The timing and duration for the largest components of the Skeena Sockeye run (Babine-Pinkut, Babine-Fulton and Babine Wild Mid-timing) was set equal to that for the Skeena aggregate (Table B2). The duration for all other Skeena sub-stocks was set to 42 days as done in previous analyses (Cox-Rogers et al. 2004; Gazey 2008). For both Nass and Skeena, did not vary the run timing offset or duration parameters between the years. However, DNA data does suggest that there can been substantial difference in the relative timing and run duration for major stock components of Nass Sockeye. Appendix Figure B1 provides an example of the shape of the 2005 aggregate run based on the average timing and duration parameters for Nass Sockeye and Appendix Figure B2 shows the 2005 using parameters derived from the 2005 DNA data. Appendix Figures B3 and B4 provide examples of the run timing distributions for 2005 and 2007 Skeena Sockeye escapement derived using the sub-stock parameters and aggregate run timing for these years. Our initial evaluations indicate that sub-stock ER estimates can be very sensitive to these run timing and duration parameters and further evaluations are warranted to be confident that the parameters used accurately reflect our best understanding of the run timing patterns for these sub-stocks and CUs. Appendix Tables B3 and B4 provide the preliminary estimates of the total marine exploitation rates for each Nass and Skeena sockeye CU. The marine exploitation rates for the Nass and Skeena aggregate stocks in Tables B3 and B4 are different from the total exploitation rates in Table 8 because the Table 8 values include harvest in freshwater fisheries.

Appendix Table B1. Relative abundance, run timing and duration parameters for ten Nass Sockeye sub-stocks.

Sub-stock Number	Sub-Stock Name	Timing Offset	Timing SD	Average % of Escapement
1	Damdochax	14	14	1.5%
2	Kwinagees	14	10.5	3.4%
3	Oweegee	14	14	0.1%
4	Bowser	14	14	8.3%
5	Hanna-Tin	-7	17.5	56.9%
6	MezBeach	21	14	25.4%
7	BrownBear	21	17.5	2.1%
8	Cranberry	21	17.5	0.7%
9	Gingit+	-14	10.5	1.2%
10	Zolzap	0	17.5	0.3%

Appendix Table B2. Relative abundance, run timing and duration parameters for twenty Skeena Sockeye sub-stocks.

Sub-stock Number	Sub-Stock Name	Timing Offset	Timing SD	Average % of Escapement
1	Kluatan+	-10.5	10.5	0.1%
2	Motase	-3.5	10.5	0.1%
3	Sustut+	-10.5	10.5	0.4%
4	Bear+	3.5	10.5	0.4%
5	Slamgeesh	-3.5	10.5	0.1%
6	Sicintine	-3.5	10.5	0.1%
7	Babine-WE	-10	10.5	4.0%
8	Babine-WM	0	0	2.0%
9	Babine-WL	10	10.5	17.0%
10	Babine-P	0	0	21.0%
11	Babine-F	0	0	43.0%
12	Swan+	-10.5	10.5	2.2%
13	Bulkley+	-17.5	10.5	1.0%
14	Morice+	-17.5	10.5	1.5%
15	Kitwanga	3.5	10.5	0.2%
16	Zymoetz	3.5	10.5	0.7%
17	Kalum	3.5	10.5	0.8%
18	Lakelse	-24.5	10.5	0.9%
19	Alastair	-24.5	10.5	1.5%
20	Johnston	-24.5	10.5	1.0%

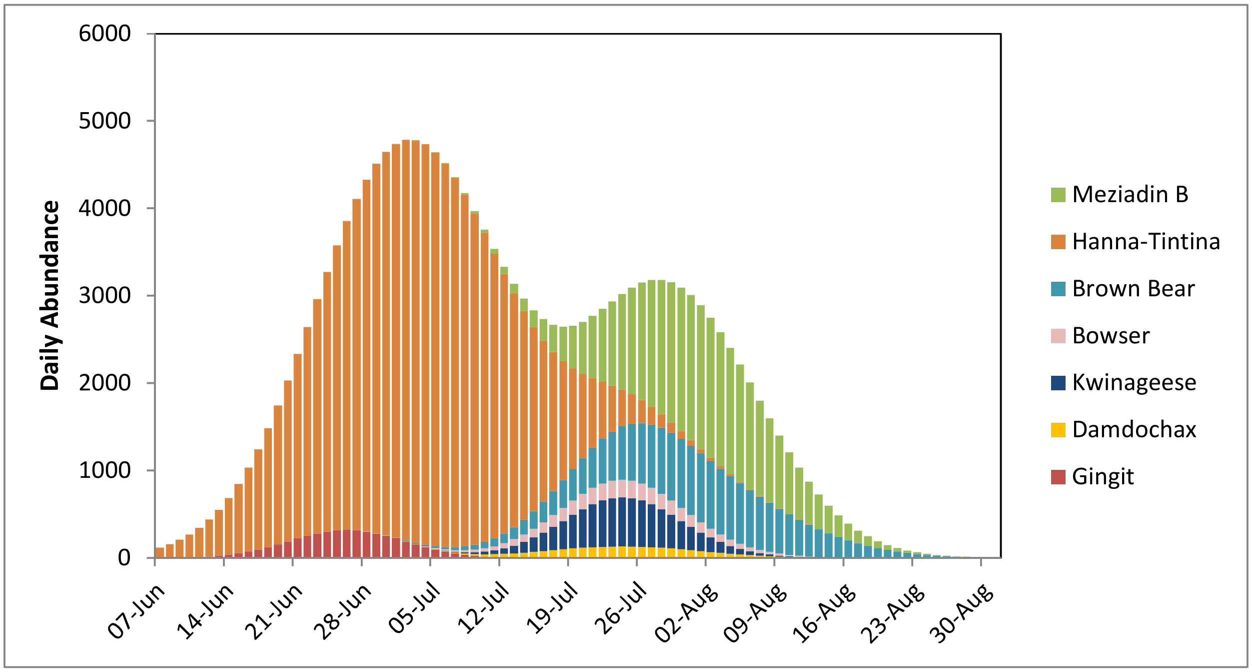
Appendix Table B3. Preliminary estimates of total marine exploitation rates (%) for Nass Sockeye CUs, 1982-08.

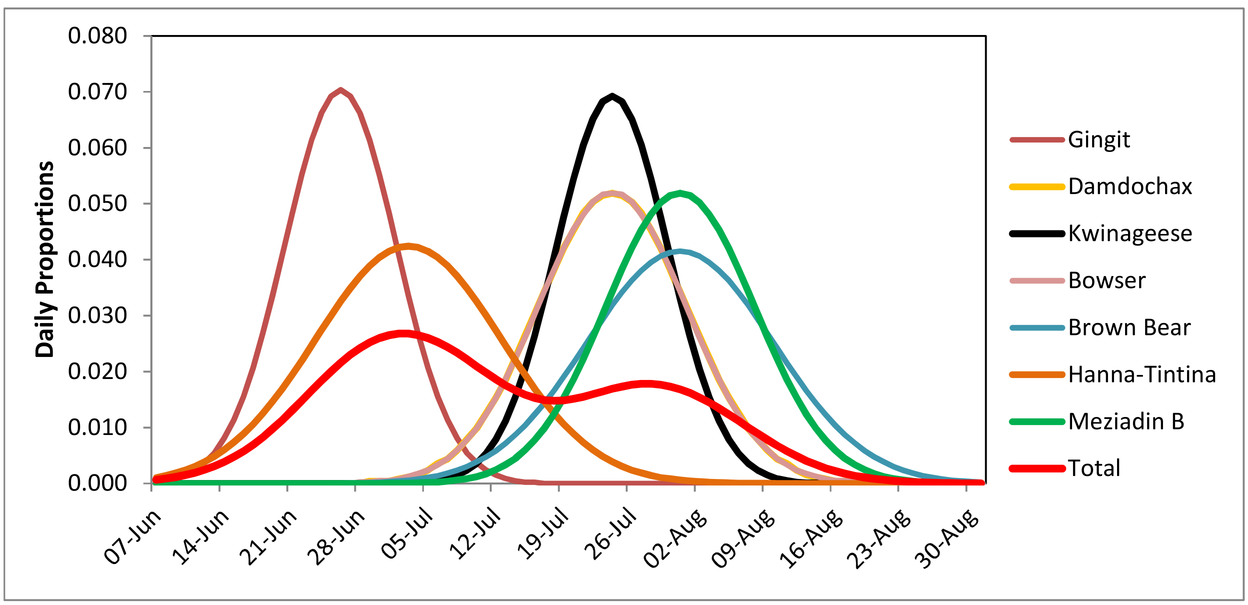
	Damdochax	Kwinagees	Oweegee	Bowser	Hanna-Tin	MezBeach	BrownBear	Cranberry	Gingit+	Zolzap	Nass Agg.
1982	64	65	64	64	55	66	65	65	52	58	60
1983	73	74	73	73	42	80	79	79	16	54	62
1984	65	64	65	65	38	74	73	73	26	47	55
1985	56	57	56	56	33	65	64	64	22	40	47
1986	69	69	69	69	40	78	77	77	21	50	61
1987	66	67	66	66	37	75	71	71	18	46	55
1988	62	64	62	62	42	68	66	66	29	48	53
1989	79	80	79	79	52	85	83	83	37	61	73
1990	65	67	65	65	41	72	69	69	27	48	55
1991	71	71	71	71	45	78	75	75	27	54	60
1992	72	71	72	72	51	78	76	76	37	58	63
1993	80	82	80	80	66	82	81	81	57	71	73
1994	65	65	65	65	55	65	64	64	50	59	59
1995	83	85	83	83	65	83	80	80	52	73	74
1996	82	81	82	82	68	85	84	84	58	74	76
1997	76	79	76	76	67	74	72	72	61	71	71
1998	59	53	59	59	52	67	68	68	55	54	57
1999	73	72	73	73	67	76	75	75	65	68	70
2000	60	61	60	60	48	59	56	56	40	52	52
2001	59	59	59	59	53	65	64	64	55	54	57
2002	62	63	62	62	61	59	59	59	57	62	61
2003	60	55	60	60	68	58	61	61	74	68	65
2004	62	58	62	62	63	65	66	66	65	63	63
2005	43	43	43	43	50	41	41	41	56	49	48
2006	51	51	51	51	58	48	49	49	62	57	55
2007	67	60	67	67	55	77	79	79	55	58	63
2008	35	36	35	35	24	39	39	39	19	28	28
Average	65	65	65	65	52	69	68	68	44	56	60

Appendix Table B4. Preliminary estimates of total marine exploitation rates (%) for Skeena Sockeye CUs, 1982-08.

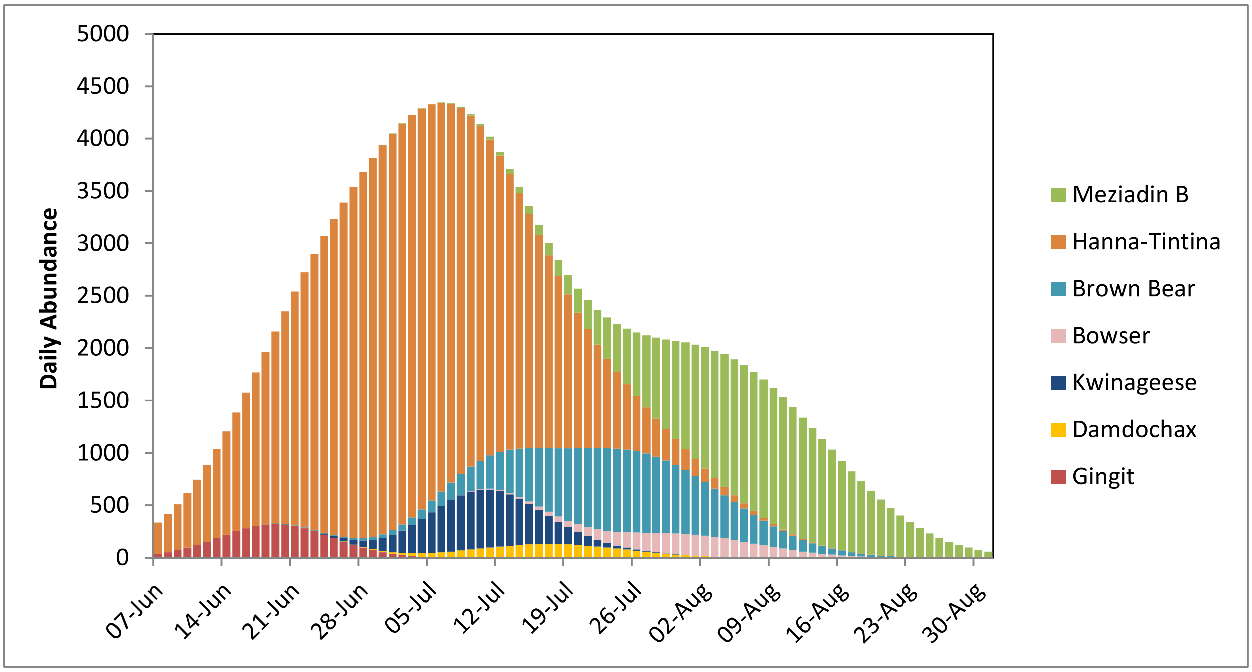
	Kluatan+	Motase	Sustut+	Bear+	Slamgeesh	Sicintine	Babine-WE	Babine-WM	Babine-WL	Babine-P	Babine-F	Swan+	Bulkley+	Morice+	Kitwanga	Zymoetz	Kalum	Lakelse	Alastair	Johnston	Skeena Agg.
1982	57	69	57	74	69	69	58	58	75	58	58	57	39	39	74	74	74	21	21	21	62
1983	24	36	24	46	36	36	25	43	55	43	43	24	13	13	46	46	46	5	5	5	43
1984	37	50	37	58	50	50	38	42	61	42	42	37	23	23	58	58	58	12	12	12	46
1985	52	58	52	62	58	58	52	51	63	51	51	52	43	43	62	62	62	32	32	32	54
1986	42	50	42	55	50	50	43	46	59	46	46	42	31	31	55	55	55	19	19	19	48
1987	25	34	25	43	34	34	26	31	51	31	31	25	16	16	43	43	43	9	9	9	34
1988	62	68	62	69	68	68	63	56	69	56	56	62	52	52	69	69	69	38	38	38	59
1989	43	48	43	52	48	48	44	47	57	47	47	43	35	35	52	52	52	24	24	24	48
1990	46	55	46	62	55	55	47	53	67	53	53	46	36	36	62	62	62	26	26	26	55
1991	50	60	50	68	60	60	51	57	72	57	57	50	38	38	68	68	68	25	25	25	59
1992	54	61	54	70	61	61	55	58	76	58	58	54	48	48	70	70	70	40	40	40	62
1993	57	61	57	63	61	61	57	54	64	54	54	57	48	48	63	63	63	36	36	36	56
1994	44	51	44	57	51	51	45	48	64	48	48	44	36	36	57	57	57	25	25	25	51
1995	58	65	58	68	65	65	59	58	69	58	58	58	47	47	68	68	68	33	33	33	60
1996	66	70	66	71	70	70	66	63	71	63	63	66	56	56	71	71	71	41	41	41	65
1997	66	69	66	69	69	69	66	62	66	62	62	66	59	59	69	69	69	49	49	49	63
1998	27	27	27	27	27	27	27	29	32	29	29	27	22	22	27	27	27	14	14	14	29
1999	6	5	6	7	5	5	5	9	13	9	9	6	7	7	7	7	7	10	10	10	10
2000	55	58	55	56	58	58	56	47	54	47	47	55	48	48	56	56	56	37	37	37	49
2001	43	50	43	55	50	50	43	46	57	46	46	43	31	31	55	55	55	18	18	18	48
2002	46	52	46	53	52	52	46	39	51	39	39	46	35	35	53	53	53	22	22	22	42
2003	30	33	30	33	33	33	30	29	34	29	29	30	22	22	33	33	33	14	14	14	29
2004	23	28	23	35	28	28	23	28	43	28	28	23	17	17	35	35	35	11	11	11	30
2005	12	16	12	21	16	16	13	18	24	18	18	12	9	9	21	21	21	6	6	6	18
2006	45	49	45	49	49	49	46	34	45	34	34	45	38	38	49	49	49	26	26	26	37
2007	26	34	26	41	34	34	26	38	50	38	38	26	17	17	41	41	41	10	10	10	40
2008	18	31	18	43	31	31	19	31	51	31	31	18	8	8	43	43	43	3	3	3	35
Average	41	48	41	52	48	48	42	44	55	44	44	41	32	32	52	52	52	23	23	23	46

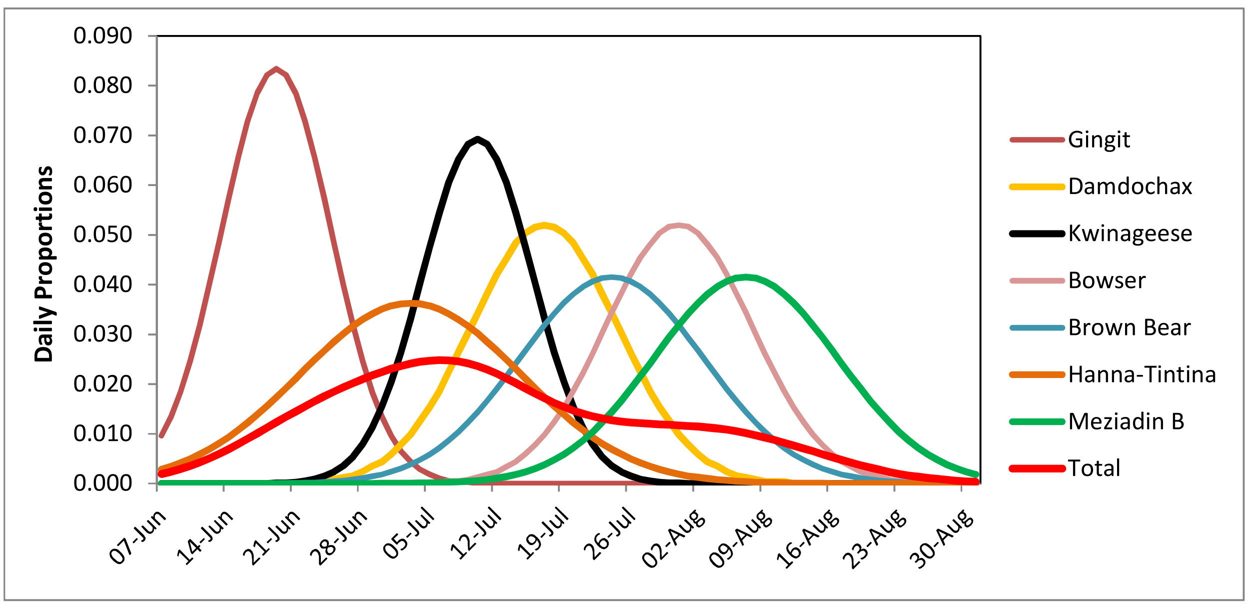
Appendix Figure B1. Run timing distributions for Nass Sockeye sub-stocks using average timing parameters for the 2005 Sockeye return.



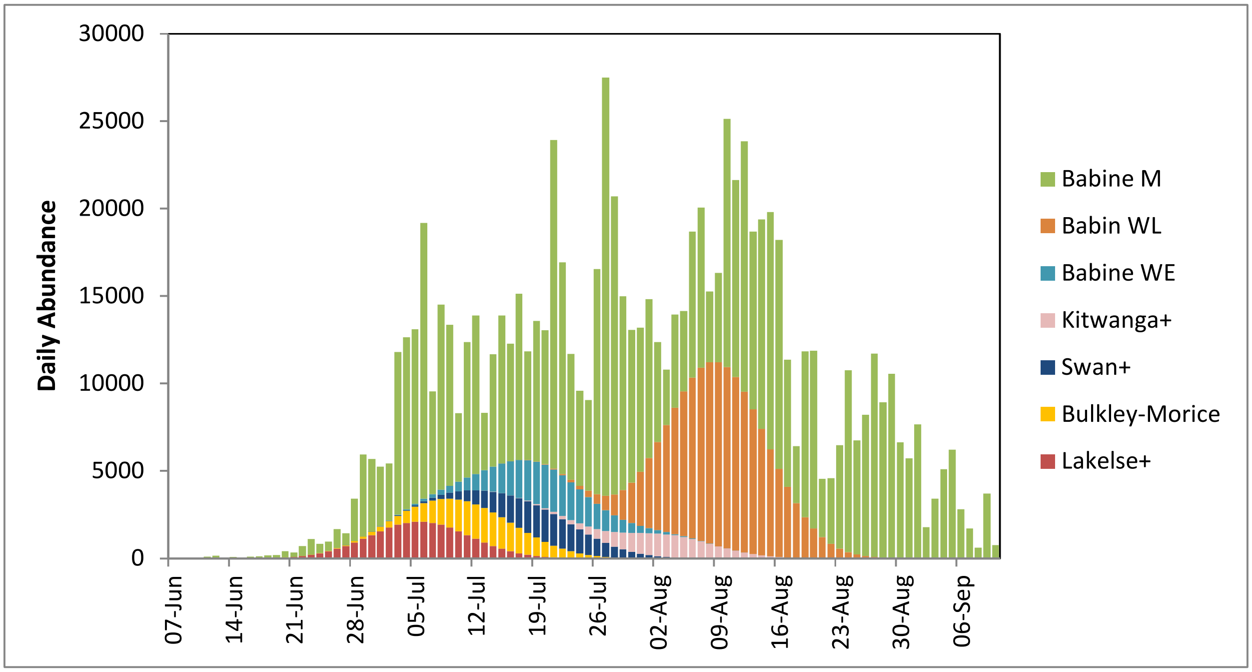


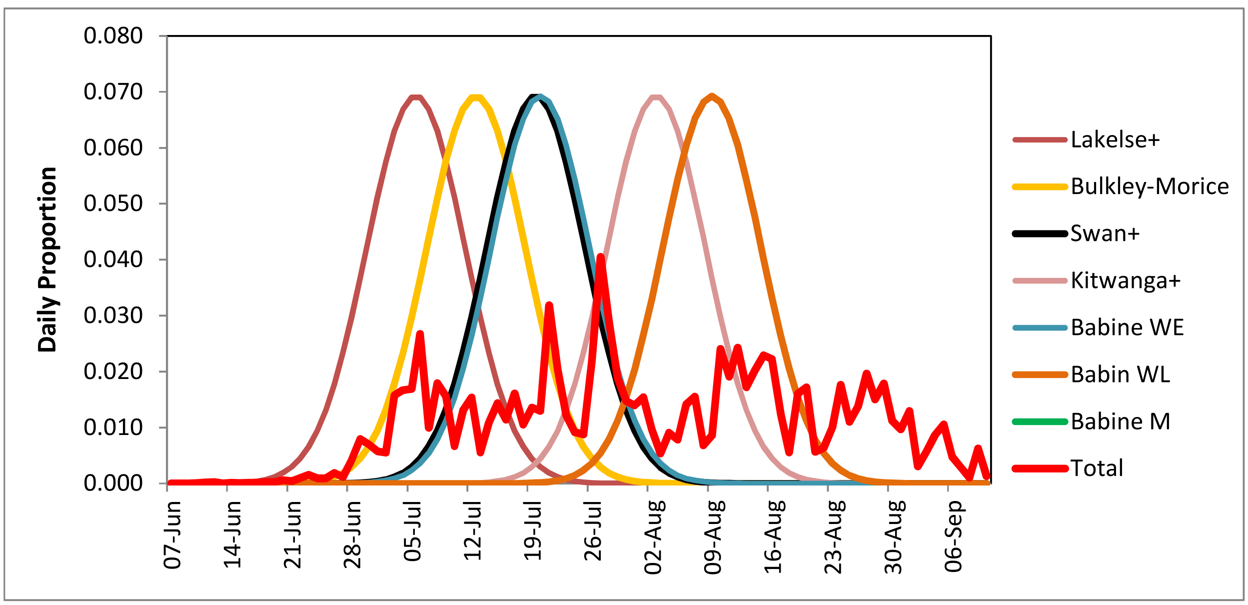
Appendix Figure B2. Run timing distributions for Nass Sockeye sub-stocks using run timing parameters derived from 2005 DNA data for the 2005 Sockeye return.



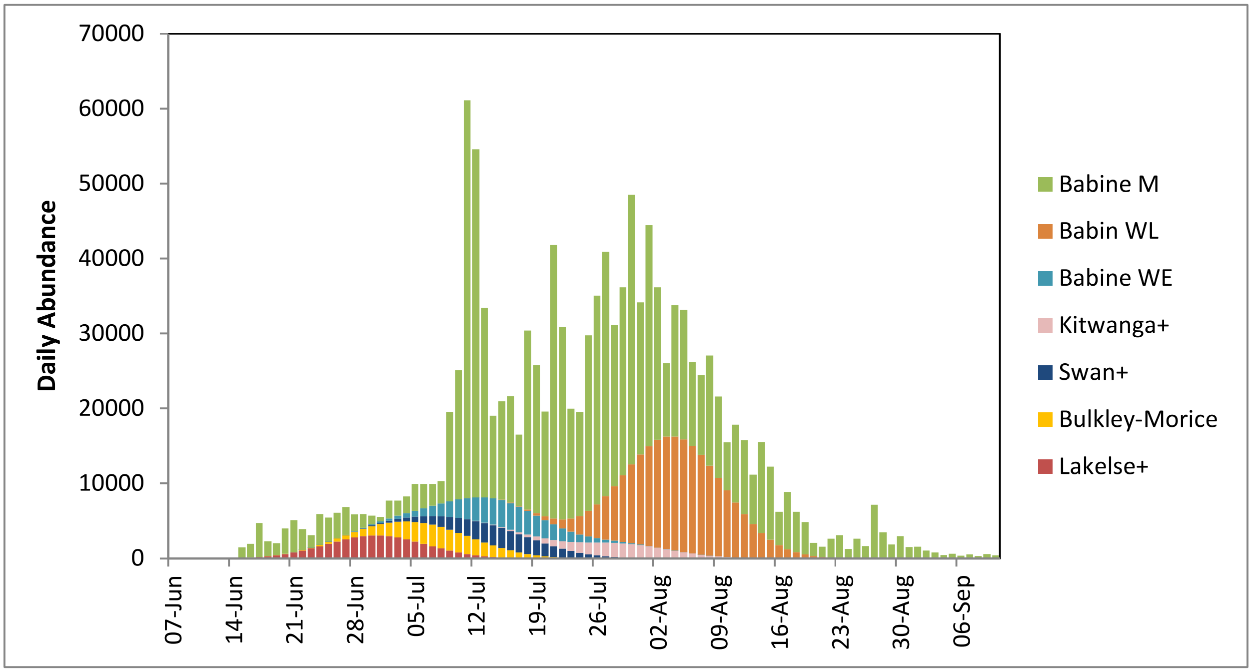


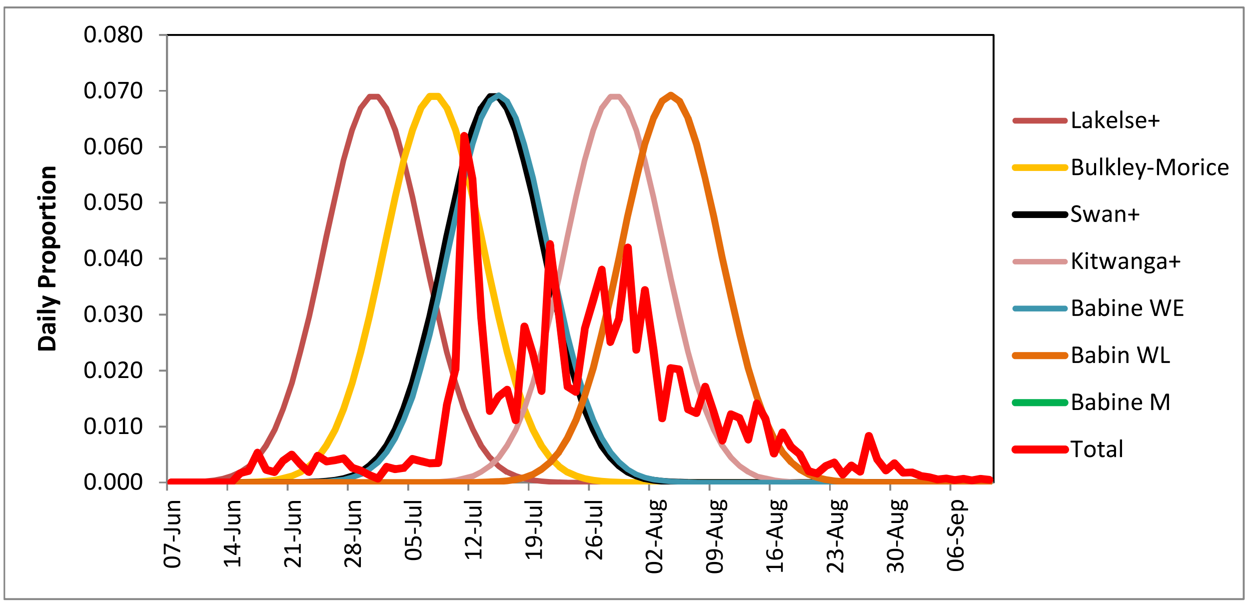
Appendix Figure B3. Run timing distributions for Skeena Sockeye sub-stocks using average timing parameters for the 2005 Sockeye return.





Appendix Figure B4. Run timing distributions for Skeena Sockeye sub-stocks using average timing parameters for the 2007 Sockeye return.





APPENDIX C

Annual escapement and run size estimates for North and Central coast Chinook salmon

Appendix Table C1. Annual estimates of escapement catch and total stock size estimates for adult Chinook salmon returning to the Nass River, 1992 to 2010.

	Upper & Middle Nass River						Lower Nass R. & Coastal Nass Area				Total Nass Area										
		In-river Catch						In-river Catch				In-river Catch				Marine Catch[h]					
Year	Net Esc.[a]	Git.[b]	Sport[c]	Nisga'a[d]	Total	Run size to GW[e]	Net Esc.[f]	Sport[c]	Nisga'a[d]	Total	Net Esc.[g]	Git.[b]	Sport[c]	Nisga'a[d]	Total	Comm.	Sport	Total	Total Return to Canada[i]	Alaskan catch[j]	Total Run[k]
1992	16,808	612	1,339	1,308	3,259	20,067	908	0	5,751	5,751	17,716	612	1,339	7,059	9,010	5,465	3,207	8,672	35,397	700	36,097
1993	24,814	600	983	1,526	3,109	27,923	1,039	0	4,060	4,060	25,853	600	983	5,586	7,169	7,809	4,583	12,393	45,414	700	46,114
1994	21,169	120	893	2,098	3,111	24,280	3,703	0	4,115	4,115	24,872	120	893	6,213	7,226	6,731	3,951	10,682	42,780	700	43,480
1995	7,844	72	695	1,812	2,579	10,423	973	0	4,904	4,904	8,817	72	695	6,716	7,483	3,409	2,001	5,409	21,709	700	22,409
1996	21,842	49	477	1,834	2,360	24,202	1,108	0	5,866	5,866	22,950	49	477	7,700	8,226	6,538	3,837	10,376	41,551	700	42,251
1997	18,702	41	203	1,877	2,121	20,823	1,191	0	4,828	4,828	19,893	41	203	6,705	6,949	5,664	3,324	8,989	35,831	700	36,531
1998	23,213	345	196	1,595	2,136	25,349	1,462	0	7,470	7,470	24,675	345	196	9,065	9,606	7,191	4,221	11,412	45,693	700	46,393
1999	11,544	193	82	1,608	1,883	13,427	982	0	7,309	7,309	12,526	193	82	8,917	9,192	4,562	2,677	7,239	28,957	700	29,657
2000	18,047	49	1,023	2,498	3,570	21,617	1,302	59	6,828	6,887	19,348	49	1,082	9,326	10,457	1,826	986	2,812	32,617	700	33,317
2001	28,329	195	722	5,457	6,374	34,703	4,623	0	6,307	6,307	32,952	195	722	11,764	12,681	928	1,705	2,633	48,266	700	48,966
2002	13,352	151	703	1,875	2,729	16,081	3,810	0	3,556	3,556	17,162	151	703	5,431	6,285	5,980	1,116	7,096	30,543	700	31,243
2003	25,848	181	1,030	2,403	3,614	29,462	2,629	50	4,306	4,356	28,478	181	1,080	6,709	7,970	6,076	1,167	7,243	43,691	700	44,391
2004	15,185	230	643	1,926	2,799	17,984	2,486	170	3,622	3,792	17,670	230	813	5,548	6,591	6,689	1,925	8,614	32,876	598	33,474
2005	13,706	179	760	2,262	3,201	16,907	2,957	50	3,753	3,803	16,663	179	810	6,015	7,004	3,115	1,542	4,657	28,324	251	28,575
2006	23,594	456	760	3,525	4,741	28,335	4,983	150	3,725	3,875	28,577	456	910	7,250	8,616	4,513	983	5,496	42,689	1750	44,439
2007	22,136	24	810	4,020	4,854	26,990	5,705	481	2,694	3,175	27,842	24	1,291	6,714	8,029	4,031	1,810	5,841	41,712	274	41,986
2008	19,630	174	810	1,079	2,063	21,693	1,760	547	3,323	3,870	21,390	174	1,357	4,402	5,933	385	1,620	2,005	29,328	190	29,518
2009	26,226	148	810	2,785	3,743	29,969	1,604	190	2,650	2,840	27,830	148	1,000	5,435	6,583	1,123	1,316	2,439	36,852	1111	37,963
2010	18,381	88	628	1,703	2,419	20,800	1,480	32	2,795	2,827	19,861	88	660	4,498	5,246	822	464	1,286	26,393	696	27,089
Mean:																					
92-09	19,555	212	719	2,305	3,236	22,791	2,401	94	4,726	4,820	21,956	212	813	7,031	8,056	4,558	2,332	6,889	36,902	699	37,600
00-09	20,605	179	807	2,783	3,769	24,374	3,186	170	4,076	4,246	23,791	179	977	6,859	8,015	3,467	1,417	4,884	36,690	697	37,387
Min	7,844	24	82	1,079	1,883	10,423	908	0	2,650	2,827	8,817	24	82	4,402	5,246	385	464	1,286	21,709	190	22,409
Max	28,329	612	1,339	5,457	6,374	34,703	5,705	547	7,470	7,470	32,952	612	1,357	11,764	12,681	7,809	4,583	12,393	48,266	1,750	48,966

[a] Net escapement estimates are from radio telemetry (1992-1993; Koski et al. 1996ab) and mark recapture (1994-current) fishwheel programs (see annual reports cited in text) conducted by Nisga'a Fisheries.

[b] Chinook salmon catches in the Gitanyow fishery are from radio telemetry estimates for 1992-1993, and for other years from DFO (Jim Steward, Prince Rupert, BC, pers. comm.) and GFA (Greg Rush, Kitwanga, BC).

[c] In-river sport catch estimates of Nass Chinook salmon from 1992-2004 are from Baxter (2005), and 2005-10 are from Nisga'a Fisheries (2006-2011).

[d] Nisga'a catch estimates of Nass River Chinook salmon from 1992 to 2005 are from Stephens and Humble (2006), and 2006-10 are from Nisga'a Fisheries (2007-2011).

[e] Run size estimates of Nass River Chinook salmon to Gitwinksihlkw are derived by summing the Upper and Middle net escapement and in-river catch.

[f] Net escapement estimates of Chinook salmon for the Lower Nass and Coastal areas are calculated in two steps. The first step sums observed escapements from DFO aerial surveys of Ishkeenickh, Iknouk, Kincolith, Kwinamass, and Kitsault systems; and correcting for missing data based on proportions among systems for 1977-current year. The second step expands the summed escapement in step 1 to account for true escapement; 150% for 1992-2000 and 2001-current by observed proportion of mark-recapture (Kwinamass) and/or weir (Kincolith) estimates to visual surveys conducted on Kwinamass and Kincolith rivers, respectively.

[g] The total net escapement estimate of adult Nass Chinook salmon to the Nass River are derived by summing the Upper and Middle net escapement to the Lower and Coastal net escapement estimate.

[h] Estimates are provided by the Nisga'a-Canada-BC Joint technical committee.

[i] Total Return to Canada estimates for Nass River Chinook salmon are derived by summing the total estimates of net escapement, in-river catch and marine catch.

[j] Alaskan catch data were updated by DFO (Ivan Winther, Prince Rupert, BC) in May 2011 based on recent results from extensive genetic analyses.

[k] Total run size estimates for Nass River Chinook salmon are derived by summing the Total Return to Canada and Alaskan catch.

Appendix Table C2. Annual escapement estimates for Chinook indicator streams and total stock size estimates for Skeena River Chinook, 1984-2007.

Year	Babine River	Bear River	Kispiox River	Morice River	Kitsumkalum River	Johnston Creek	Index Streams Totals Obs.	Index Streams Totals Adj.	Stat. Area 4 Obs.	Stat. Area 4 Est.[1]	First Nation Harvest[2]	Commercial Catch[3]	Sport Catch[3]	Return to Canada	Alaska Catch	Total Run
	fence count															
1984	1,400	12,000	1,100	4,500	11,825	100	30,925	30,925	38,707	46,935	9,585	20,604	0	77,124	26,330	103,454
1985	658	21,500	2,300	11,300	8,308	600	44,666	44,666	55,906	67,789	12,390	28,536	0	108,715	42,734	151,449
1986	252	17,000	4,000	15,000	10,151	600	47,003	47,003	58,831	71,336	21,344	24,990	0	117,670	11,229	128,899
1987	711	7,200	4,000	10,000	24,508	200	46,619	46,619	58,351	70,753	11,770	19,245	3,396	105,164	17,207	122,372
1988	1,057	14,000	5,000	12,000	22,755	800	55,612	55,612	69,607	84,402	17,035	58,467	9,100	169,004	67,795	236,799
1989	1,983	12,500	3,500	10,200	19,900	250	48,333	48,333	60,496	73,355	14,814	20,940	4,478	113,586	28,315	141,901
1990	1,604	10,000	4,500	12,000	20,000	300	48,404	48,404	62,775	76,715	23,752	18,560	2,598	121,625	18,684	140,308
1991	1,043	5,500	3,500	25,500	9,200	150	44,893	44,893	58,221	71,150	15,375	51,536	12,692	150,752	44,036	194,789
1992	1,685	10,500	14,000	16,000	14,000		56,185	56,349	73,078	89,306	15,526	25,952	8,549	139,333	26,105	165,438
1993	1,290	23,000	3,400	18,000	15,000	50	60,740	60,740	78,773	96,266	13,062	55,713	8,527	173,568	29,183	202,751
1994	395		4,500		14,000	50	18,945	49,446	64,126	78,366	9,811	35,489	11,733	135,399	19,266	154,665
1995	493	9,500	2,300	10,500	6,312		29,105	29,190	37,856	46,262	6,544	52,724	4,135	109,665	20,805	130,471
1996	1,893	19,000	4,300	30,000	11,849		67,042	67,238	87,200	106,563	6,091	34,678	2,890	150,223	31,247	181,469
1997	1,128	9,500	3,700	18,000	5,342		37,670	37,780	48,996	59,877	7,730	7,970	5,926	81,503	20,947	102,449
1998	2,753	8,500	5,500	14,000	9,521		40,274	40,391	52,383	64,016	11,577	1,140	2,118	78,850	11,321	90,171
1999	579	6,000	6,000	17,000	10,000		39,579	39,694	51,479	62,911	17,316	936	12,374	93,537	26,204	119,741
2000	2,927	10,000		17,000	14,533	200	44,660	51,200	68,491	84,250	13,452	9,134	10,633	117,469	27,265	144,734
2001	3,531	12,000	8,000	18,000	24,076	150	65,757	65,757	87,963	108,202	10,354	29,492	11,133	159,181	41,601	200,782
2002	2,332	2,500	3,514	7,500	23,849		39,695	39,863	53,324	65,593	6,290	7,853	14,089	93,825	24,944	118,769
2003	3,348	6,000	6,400	10,000	23,608		49,356	49,564	66,302	81,558	10,803	7,103	8,327	107,790	21,430	129,221
2004	1,667	3,000		4,800	25,767		35,234	40,590	54,297	66,790	11,428	2,158	10,004	90,379	17,948	108,327
2005	1,876	1,400		7,000	15,046		25,322	29,171	39,022	48,000	7,958	1,956	5,643	63,557	15,047	78,605
2006	3,538	1,700		13,000	12,368		30,606	35,258	47,165	58,017	8,396	7,672	6,713	80,797	18,508	99,305
2007	2,096	800		11,000	16,265		30,161	34,746	46,479	57,173	5,829	2,060	8,073	73,136	14,417	87,552
2008	2,363	7,818		6,000	10,374		26,555	30,591	40,922	50,338	10,318	14,880	16,674	92,209	10,659	102,868
2009	1,618	8,597		12,082	10,703		33,000	38,016	50,854	62,555	8,136	5,942	10,166	86,799	17,220	104,020
2010	3,161	6,646	3,357	11,897	13,712		38,773	38,937	52,086	64,070	8,061	6,086	10,413	88,630	17,637	106,267
1980s	1,010	14,033	3,317	10,500	16,241	425	45,526		0	69,095	14,490	28,797	2,829	115,211	32,268	147,479
1990s	1,286	11,278	5,170	17,889	11,522	138	47,283		0	75,143	12,678	28,470	7,154	123,446	24,780	148,225
2000s	2,587	5,496	5,318	10,753	17,300	175	41,629		0	67,868	9,184	8,576	10,170	95,798	20,607	116,404
1980s	2%	31%	7%	23%	36%	1%			80%		31%	62%	6%			
1990s	3%	24%	11%	38%	24%	0%			77%		26%	59%	15%			
2000s	6%	13%	13%	26%	42%	0%			75%		33%	31%	36%			

[1] Estimated total escapement = (104% of index stock escapement + 135% of other stock escapement)* 110% for missed stocks (mainstem spawners).

[2] FN chinook catch revised

[3] Canadian exploitation rates were obtained from the Annual Exploitation Rate Analysis and Model Calibration (TCChinook 03-1). Using %catch&esc not TFM.

Appendix Table C3. Annual escapement and total stock size estimates for Area 6 Chinook salmon, 1980-2010.

	Wahoo	Brim	Khutze	Index Stream Total		Total Area 6	Exp	CDN	Alaska	Total	Marine	Marine
Year	River	River	River	Obs.	Adj. [1]	Escapement [2]	Factor 2	Harvest	Harvest	Run	CDN ER	TOT ER
1980	50	150	60	260	260	1,044	4.0	324	323	1,691	0.19	0.38
1981	100	150	10	260	260	1,044	4.0	324	323	1,691	0.19	0.38
1982	150	200	35	385	385	1,545	4.0	480	478	2,504	0.19	0.38
1983	100	200	40	340	340	1,365	4.0	424	423	2,211	0.19	0.38
1984	50	200	38	288	288	1,156	4.0	421	539	2,116	0.20	0.45
1985	50	125	30	205	205	823	4.0	293	439	1,554	0.19	0.47
1986	50	200	40	290	290	1,164	4.0	314	141	1,619	0.19	0.28
1987	10	150	71	231	231	927	4.0	254	193	1,375	0.19	0.33
1988		50	20	70	156	627	4.0	418	419	1,464	0.29	0.57
1989		50	25	75	167	672	4.0	194	216	1,081	0.18	0.38
1990	200	20	60	280	280	1,124	4.0	237	209	1,570	0.15	0.28
1991	25	10	62	97	97	389	4.0	289	198	877	0.33	0.56
1992	100	20	30	150	150	602	4.0	198	150	950	0.21	0.37
1993	200	10	42	252	252	1,012	4.0	594	270	1,876	0.32	0.46
1994	110	25	20	155	155	622	4.0	333	136	1,091	0.31	0.43
1995	78	12	29	119	119	478	4.0	514	188	1,180	0.44	0.60
1996	100			100	181	727	4.0	243	202	1,172	0.21	0.38
1997	70	25	55	150	150	602	4.0	124	187	912	0.14	0.34
1998	180	12	38	230	230	923	4.0	40	138	1,101	0.04	0.16
1999	35	16	31	82	82	329	4.0	55	108	491	0.11	0.33
2000			25	25	167	672	4.0	136	187	995	0.14	0.32
2001	185	20	12	217	217	871	4.0	298	306	1,475	0.20	0.41
2002	185	20		205	241	967	4.0	295	336	1,598	0.18	0.39
2003	130	10	35	175	175	702	4.0	117	163	983	0.12	0.29
2004	80	30	17	127	127	510	4.0	79	117	706	0.11	0.28
2005	130	5	16	151	151	606	4.0	82	163	851	0.10	0.29
2006	200		19	219	312	1,253	4.0	271	349	1,874	0.14	0.33
2007	500			500	906	3,636	4.0	585	832	5,053	0.12	0.28
2008	110		35	145	207	830	4.0	432	146	1,407	0.31	0.41
2009	322			322	583	2,342	4.0	534	570	3,446	0.15	0.32
2010	60	10		70	82	330	4.0	76	81	487	0.16	0.32

[1] Filled in missing data for indicator streams using 1980-2010 average contribution.

[2] Expansion for other streams with no enhancement in Area 6 using 1980-2010 average contribution.

Appendix Table C4. Annual escapement and total stock size estimates for Area 8 Chinook salmon, 1985-2010.

	Bella Coola	Dean	Index Stream Total		Total Area 8	First Nation	Commercial	Sport	Return to	Alaska	Total
Year	River	River	Obs.	Adj. [1]	Escapement [2]	Harvest	Catch	Catch	Canada	Harvest	Run
1985	27,560	4,000	31,560	32,960	33,765	1,656	14,814	2,467	52,702	7,002	59,704
1986	21,300	3,300	24,600	25,755	26,009	1,984	10,979	1,829	40,800	5,190	45,990
1987	14,425	1,144	15,569	15,969	16,618	1,305	6,992	1,165	26,079	3,305	29,385
1988	15,000	1,300	16,300	16,755	17,398	791	7,671	1,278	27,138	3,626	30,764
1989	22,000	2,300	24,300	25,105	25,422	1,961	10,718	1,785	39,886	5,066	44,952
1990	17,000	2,000	19,000	19,700	20,282	1,689	9,465	557	31,993	9,465	41,458
1991	17,800	2,400	20,200	21,040	21,283	1,631	9,219	1,062	33,196	2,673	35,869
1992	27,000	3,000	30,000	31,050	31,442	2,779	16,363	3,072	53,656	4,970	58,626
1993	35,000	700	35,700	35,945	37,152	2,738	13,012	3,466	56,368	7,236	63,604
1994	26,800	1,300	28,100	28,555	29,514	1,275	11,125	1,701	43,615	3,632	47,247
1995	32,000	1,100	33,100	33,485	34,609	3,201	13,387	3,319	54,516	3,047	57,563
1996	25,000	2,000	27,000	27,700	28,630	3,015	7,688	2,483	41,816	1,241	43,057
1997	18,000	1,400	19,400	19,890	20,558	3,036	6,025	2,640	32,258	1,832	34,090
1998	22,000	3,000	25,000	26,050	26,925	4,827	11,853	4,293	47,898	3,546	51,444
1999	25,000	1,800	26,800	27,430	28,351	3,103	4,719	3,172	39,345	3,370	42,715
2000	25,000	1,200	26,200	26,620	27,514	3,335	6,066	2,974	39,890	2,583	42,473
2001	24,000	3,795	27,795	29,123	30,101	3,606	13,112	3,571	50,390	4,184	54,574
2002	13,950	3,700	17,650	18,945	19,581	2,832	13,606	3,161	39,180	2,159	41,339
2003	14,890	3,700	18,590	19,885	20,553	3,103	19,032	10,381	53,070	2,464	55,534
2004	17,600	3,500	21,100	22,325	23,074	3,838	18,513	6,922	52,347	5,151	57,498
2005	17,500	2,200	19,700	20,470	21,157	3,894	15,666	9,690	50,407	7,322	57,729
2006	26,000	3,700	29,700	30,995	32,036	3,878	8,617	5,120	49,651	4,866	54,517
2007	11,000	2,300	13,300	14,105	14,579	1,896	11,243	3,403	31,121	4,103	35,224
2008	9,000	1,100	10,100	10,485	10,837	2,821	2,284	189	16,131	1,236	17,367
2009	11,555	1,400	12,955	13,445	13,896	3,729	16,294	2,575	36,494	2,504	38,998
2010	11,364	1,600	12,964	13,524	13,978	3,626	7,233	2,953	27,790	2,899	30,688
Average (1990-1994)							11,837	1,972	43,766	5,595	
							61%	10%		29%	

Assumptions:

[1] Filled in missing data for Dean River in 1982 using the average of counts from 1977-1987.

Expansion factor for Dean River observer efficiency & small stream observer efficiency: 1.35

[2] Filled in missing data for small stream stocks from 1993-03 using the average ratio of BC/Dean counts to small stream counts from 1977-92: 1.034

Appendix Table C5. Annual escapement and total stock size estimates for Area 9 summer Chinook salmon, 1980-2010.

	Kilbella	Chuckwalla	Ashlum	Neechanz	Index Stream Totals		Stat. Area 9		First Nation	Commercial	Sport	Terminal	Return to
Year	River	River	Creek	River	Obs.	Adj.	Obs.	Est.[1]	Harvest[2]	Catch[3]	Catch[4]	Run	Canada
1980			25		25	651	939	1,409		269	93	1,771	1,967
1981	75	25	25		125	140	201	302		13	76	391	435
1982	400	550	50	75	1,075	1,075	1,551	2,327		290	85	2,702	3,002
1983	1,000	400	20	75	1,495	1,495	2,157	3,236		222	61	3,518	3,909
1984	175	400		75	650	676	975	1,463		158	77	1,698	1,887
1985	300	40	4	14	358	358	517	775		53	74	901	1,002
1986	150	25	60	26	261	261	377	565		53	144	761	846
1987	500	200	12	20	732	732	1,056	1,584		111	118	1,814	2,015
1988	200	175	10	20	405	405	584	877		47	86	1,010	1,122
1989	23	25	3	200	251	251	362	543		22	76	642	713
1990	80	40	15	400	535	535	772	1,158		74	76	1,308	1,453
1991	75	50	10		135	151	218	326		24	122	472	524
1992	400	150	10		560	625	902	1,353		43	109	1,505	1,673
1993	250	125	10	50	435	435	628	942		13	128	1,083	1,203
1994	200	100			300	350	505	758		10	105	872	969
1995	55	45			100	117	168	253		3	56	311	346
1996	300	200			500	583	842	1,263		0	71	1,334	1,404
1997	600	320	60		980	1,094	1,579	2,369		0	109	2,478	2,608
1998	1,000	780	10	22	1,812	1,812	2,615	3,922		0	131	4,053	4,267
1999	1,710	453	8	20	2,191	2,191	3,162	4,742		0	143	4,885	5,142
2000	1,232	898	230	149	2,509	2,509	3,620	5,431		0	130	5,561	5,853
2001	1,298	700	147	444	2,589	2,589	3,736	5,604		0	146	5,750	6,053
2002	1,600	600	250	330	2,780	2,780	4,012	6,017		0	129	6,146	6,470
2003	600	300	80		980	1,094	1,579	2,369		0	88	2,456	2,586
2004	550	400	100	140	1,190	1,190	1,717	2,576		0	87	2,662	2,803
2005	725	360	70	120	1,275	1,275	1,840	2,760		0	115	2,875	3,026
2006	610	320	65	115	1,110	1,110	1,602	2,403		0	84	2,487	2,618
2007	295	205	65	95	660	660	952	1,429		0	65	1,493	1,572
2008	350	180	70	100	700	700	1,010	1,515		0	27	1,543	1,624
2009	350	200	60	100	710	710	1,025	1,537		0	50	1,587	1,670
2010	150	75			225	262	379	568		0	93	661	696

Assumptions:

[1] The adjusted escapement estimates are 150% of the recorded escapement.

[2] First Nations catch in Area 9 was assumed to be Wannock chinook.

[3] Commercial catch was estimated using 50% of the commercial harvest rate for Wannock chinook.

[4] Sport catch was assumed to be 5% of the sport fishery catch estimate for Area 9.

Appendix Table C6. Annual escapement and total stock size estimates for Area 9 Wannock Chinook salmon, 1980-2010.

Year	Wannock River [1]	Adjusted Escapement [2]	First Nation Harvest[3]	Commercial Catch[4]	Sport Catch[5]	Terminal Run	Return to Canada[6]
1980	2,000	3,885	10	2,723	1,861	8,479	9,421
1981	3,000	5,827		653	1,474	7,954	8,837
1982	750	1,457		935	1,830	4,222	4,691
1983	1,750	3,399	50	705	1,349	5,503	6,115
1984	750	1,457	40	745	1,578	3,820	4,244
1985	3,000	5,827	37	1,078	1,494	8,436	9,373
1986	6,000	11,654	50	2,943	2,538	17,185	19,094
1987	4,500	8,740	28	1,637	2,112	12,517	13,908
1988	4,000	7,769	50	1,060	1,628	10,507	11,674
1989	3,000	5,827	0	626	1,471	7,924	8,805
1990	3,500	6,798	0	1,138	1,541	9,477	10,530
1991	2,000	3,885		954	2,222	7,061	7,846
1992	7,500	14,567	3	1,087	2,095	17,752	19,724
1993	8,000	15,538	1	497	2,522	18,558	20,620
1994	3,500	6,798		223	1,983	9,004	10,005
1995	3,000	5,827	0	180	1,035	7,042	7,825
1996	2,500	4,856		0	1,345	6,201	6,527
1997	4,000	7,769		1	2,548	10,318	10,861
1998	3,500	6,798	30	0	2,490	9,318	9,808
1999	500	971		0	2,773	3,744	3,941
2000	4,500	8,740		0	2,413	11,153	11,740
2001	3,000	5,827	1	0	2,956	8,784	9,246
2002	2,800	5,438	2	0	2,677	8,117	8,544
2003	1,000	1,942		0	2,237	4,179	4,399
2004	3,000	5,827	0	0	2,503	8,330	8,768
2005	4,500	8,740	67	0	2,697	11,504	12,109
2006	3,000	5,827	22	0	2,308	8,157	8,586
2007	4,500	8,740	12	0	1,641	10,393	10,940
2008	5,000	9,711	126	0	735	10,572	11,128
2009	3,800	7,381	63	0	1,003	8,447	8,892
2010	4,000	7,769	21	0	1,863	9,653	10,161

Assumptions:

[1] Mark recapture (MR) studies were conducted in 1991 (4,000 females), 1992 (15,000 fish), 1993 (17,400 fish) and 2000 (7433 fish; PST report). Carcass counts were expanded by the average ratio of MR estimates to carcass counts in 1992, 1993 and 2000.

[2] Expansion factor based on ratio of MR and carcass counts: 1.94

[3] First Nations catch in Area 9 was assumed to be Wannock chinook.

[4] Commercial catch was estimated using fixed %'s of the Area 9 commercial harvest (20% of troll, 50% of gillnet and 50% of seine)

[5] Sport catch estimated using DNA samples collected in sport fishery (81.4% of Area 9 + 12.2% of Area 7 & 8).

[6] Total return to Canada = terminal run / 90% (1977-1995) or terminal run / 95% (1996-2003)

Appendix Table C7. Annual escapement and total stock size estimates for Area 10 Chinook salmon, 1980-2010.

	Docee	Nekite	Index Stream Totals		Stat. Area 10		First Nation	Commercial	Sport	Terminal	Return to
Year	River	River	Obs.	Adj.	Obs.	Est.[1]	Harvest[2]	Catch[3]	Catch[4]	Run	Canada[5]
1980	1200		1,200	1,250	1,250	1,875	19	149		2,043	2,270
1981	1000	20	1,020	1,020	1,020	1,530	15	104		1,650	1,833
1982	1500		1,500	1,562	1,562	2,343	23	275		2,642	2,936
1983	1000	50	1,050	1,050	1,050	1,575	16	252		1,842	2,047
1984	750	20	770	770	770	1,155	12	72		1,238	1,376
1985	200	30	230	230	230	345	3	361		709	788
1986	500	32	532	532	532	798	8	360		1,166	1,295
1987	1000	50	1,050	1,050	1,050	1,575	16	205		1,796	1,995
1988	1000	50	1,050	1,050	1,050	1,575	16	107		1,698	1,886
1989	200	25	225	225	225	338	3	70		411	456
1990	500	10	510	510	510	765	8	66		839	932
1991	500		500	521	521	781	8	99		888	986
1992	500		500	521	521	781	8	256		1,045	1,161
1993	1000	50	1,050	1,050	1,050	1,575	16	67		1,658	1,842
1994	750	15	765	765	765	1,148	11	40		1,199	1,332
1995	400		400	417	417	625	6	12		643	715
1996	250		250	260	260	391	4	2		396	417
1997	100		100	104	104	156	2	5		163	171
1998	1100		1,100	1,146	1,146	1,718	17	0		1,736	1,827
1999	500		500	521	521	781	8	0		789	830
2000	500		500	521	521	781	8	0		789	830
2001	300		300	312	312	469	5	0		473	498
2002	300		300	312	312	469	5	0		473	498
2003	300		300	312	312	469	5	0		473	498
2004	480		480	500	500	750	7	0		757	757
2005	300		300	312	312	469	5	0		473	473
2006	700		700	729	729	1,094	11	0		1,104	1,104
2007	600		600	625	625	937	9	0		947	947
2008	A/P						0	0			
2009	A/P										
2010	A/P										

Assumptions:

[1] The adjusted escapement estimates are 150% of the recorded escapement.

[2] First Nations catch was estimated to be 1% of the adjusted escapement estimate.

[3] Commercial catch was estimated using fixed %'s of the Area 10 commercial harvest (20% of troll, 50% of gillnet)

[4] Sport catch was assumed to be zero in Area 10.

[5] Total return to Canada = terminal run / 90% (1977-1995) or terminal run / 95% (1996-2003).

APPENDIX D

Model Assumptions and Uncertainties

APPENDIX D
Model Assumptions and Uncertainties

Escapement Estimation

The assumptions associated with deriving escapement estimates for a specific CU are:

A. **Assumption 1 - Selection of indicator streams:** The escapement estimates for the selected set of indicator streams within a CU provide a reliable indication of the year to year variability and trends in escapement for that CU;
B. **Assumption 2 - Correction factors for missing estimates for indicator streams (Factor I):** The average of the available 1980-2010 escapement estimates for each indicator streams within a CU represent the relative contribution of each indicator stream to the total for all indicator streams in a CU;
C. **Assumption 3- Correction factors for converting the total estimate for indicator streams to a total for all streams in a CU (Factor II):** The average of the escapement estimates for the period when the largest number of streams were surveyed within a CU (e.g. 1980-1999 for many CUs) provide an adequate estimate of the contribution the indicator streams to the total escapement for a CU;
D. **Assumption 4 - Correction factor for observer efficiency (Factor III):** on average the recorded escapement estimates for streams within a CU tend to underestimate the total escapement.
    a. For a specific species and statistical area, this correction factor is the same across all years; therefore, this factor will not affect the trend in escapement estimates.
    b. The purpose of this factor is to increase the escapement estimates in order to obtain a more realistic estimate of total run size and exploitation rate (ER) for some species and areas.
    c. This factor does not affect our ER estimates for those statistical areas and CUs where ERs were derived from analyses of CWT data (all coho and some Chinook CUs), the NBSRR model or the Chum Models which use the NBSRR harvest rates (HRs) to derive ERs for Area 3-5.

E. For sockeye, pink and chum returns to Area 1, 2E, 2W and Areas 6-10 where run size is estimated by adding local area catch estimates to the escapement estimate (TCC&E), the above methods used to correct for escapement underestimation in the nuSEDS data will result in higher escapement estimates and thus lower ERs estimates.
F. There are a few instances where indicator streams and the above correction factors were not used because better escapement estimates have been derived from other sources. For Nass (Area 3) sockeye and chinook, the 1992-2010 escapement estimates were derived from mark-recapture studies which estimate the total number of fish migrating upstream of a canyon in the lower Nass River (see Nisga'a Fisheries Annual Reports and Appendix Table C1). For Skeena (Area 4) sockeye, the escapement time series was derived by combining sockeye counts from the Babine fence with escapement estimates for non-Babine stocks (see Alexander et al. 2010).

Total Canadian Catch and Escapement (TCC&E) Estimates

G. **Assumption 5 – Stock composition in fisheries:** The sockeye, pink or chum harvested in a specific statistical area are destined to spawn in streams within that statistical area.
H. **Assumption 6 – Catch estimates for Area 1, 2E, 2W and Area 6-10:** The catch estimates derived from DFO databases for commercial fisheries in these statistical areas represent the vast majority of the harvest of sockeye, pink and chum in these statistical areas.
I. **Assumption 7 – Alaska catch estimates:** Alaska fisheries do not harvest significant numbers of sockeye, pink and chum salmon originating from Area 1, 2E, 2W and Area 6-10.

Northern Boundary Sockeye Run Reconstruction Model

J. **Assumption 8 – Marine ERs for aggregate sockeye stocks 1982-08:** The combination of fishery specific stock composition estimates, migration route parameters and daily escapement estimates for Nass and Skeena sockeye used in the NBSRR model produce reliable estimates of the marine ERs for Canadian and Alaskan fisheries.
K. **Assumption 9 – Marine ERs for Nass and Skeena sockeye CUs:** the migration routes are that same for all Nass sockeye CUs and the available data on differences in migration timing for Nass sockeye CUs is sufficient to estimate marine ERs for Nass sockeye CUs.
L. **Assumption 10 – Marine ERs for Skeena sockeye CUs:** The migration routes are that same for all Skeena sockeye CUs and the available data on differences in migration timing for Skeena sockeye CUs is sufficient to estimate marine ERs for Skeena sockeye CUs.
M. **Assumption 11 – Area 5 sockeye ERs:** ERs for Area 5 sockeye stocks in Canadian and Alaskan fisheries are the same as those estimated for the Lakelse sockeye CU.
N. Note: the ER estimates provided in Appendix B are marine ERs for each CU and the aggregate Nass and Skeena stocks. The NBSRR reports provide estimates of the total ERs for the aggregate Nass and Skeena sockeye stocks include in-river harvest of these stocks but estimates of the total ERs for each CU require further analyses to assign in-river harvests to specific sockeye CUs.

Pink Salmon Run Reconstruction Model

O. **Assumption 12 – HRs for Area 3 Inside and Area 4 pink salmon stocks 1982-95:** The combination of daily catch estimates, migration route, run timing and annual escapement estimates for Northern Boundary pink salmon stocks in the Gazey and English (2000) run reconstruction model produced reliable estimates of the HRs for Area 3 Inside and Area 4 pink salmon stocks in Area 3 and Area 4 fisheries and ERs in Alaskan fisheries.
P. **Assumption 13 – Equal vulnerability:** The vulnerability of each pink salmon stock in each Northern Boundary fishery will be proportional to the abundance of that stock in that fishery during each fishing period.

Effort-Harvest Rate Analysis Models

Q. **Assumption 14 – Area 3 HRs for Area 3 Inside pink salmon:** The Effort-HR relationship derived for Area 3 Inside pink salmon stocks harvested in Area 3 fisheries for 1982-95 can be used to estimate annual HRs 1996-2010 from annual fishing effort estimates for 1996-2010.

R. **Assumption 15 –Area 3x, 3y and 4 HRs for Area 4 pink salmon:** The Effort-HR relationship derived for Area 4 pink salmon stocks in harvested Area 3x, 3y and 4 fisheries for 1982-95 can be used to estimate annual HRs 1996-2010 from annual fishing effort estimates for 1996-2010.

S. **Assumption 16 –Area 3x, 3y and 4 HRs for Area 5 pink salmon:** Only half (50%) of Area 5 pink salmon are vulnerable to fisheries in Area 3x, 3y and 4; and the run-timing of Area 5 pink salmon is one week later than that for Area 4 pink salmon. The Effort-HR relationship for Area 4 pink salmon stocks is appropriate for estimating HRs for Area 5 pink salmon stocks.

T. **Assumption 17 – Alaska ERs for Area 3 Inside and Area 4 pink salmon:** Effort-ER relationships for Area 3 Inside and Area 4 pink salmon stocks harvested in Alaska fisheries for 1982-95 can be used to estimate annual ERs 1996-2010 from annual fishing effort estimates for 1996-2010.

U. **Assumption 18 – Alaska ERs for Area 5 pink salmon:** ERs for Area 5 pink salmon in Alaskan fisheries is the same as that for Area 4 pink salmon.

V. **Assumption 19 – Canadian ERs for Area 3 Inside, Area 4 and Area 5 pink salmon:** The average portion that Area 3 and Area 4 HRs were of the total Canadian HRs during the 1982-95 period is appropriate for the 1996-2010 to expand the above HRs to total Canadian HRs that can be combined with Alaskan ERs to compute total Canadian ERs for Area 3 Inside, Area 4 and Area 5 pink salmon stocks.

Chum Models

W. **Assumption 20 – Canadian HRs for Area 3 chum stocks:** Area 3 chum migrating through fisheries in Area 3, 4 and 5 have the same weekly HR as those estimated for co-migrating Nass (Area 3) sockeye using the NBSRR model;

X. **Assumption 21 – Canadian HRs for Area 4 chum stocks:** Area 4 chum migrating through fisheries in Area 3, 4 and 5 have the same weekly HRs as those estimated for co-migrating Skeena (Area 4) sockeye using the NBSRR model;

Y. **Assumption 22 – Canadian HRs for Area 5 chum stocks:** Area 5 chum migrating through fisheries in Area 3, 4 and 5 have the same weekly HRs as those estimated for co-migrating Skeena (Area 4) sockeye using the NBSRR model.

Z. **Assumption 23 – Run timing for Area 3-5 chum salmon:** The 1994-2009 daily Nass fishwheel chum catch per effort provides a reasonable estimate of the run timing for Area 3 chum stocks; the Skeena test fishery provides a reasonable estimate of the run timing for Area 4 chum stocks; and the run timing for Area 5 chum was estimated to be one week later than that for Area 4 chum.

AA. **Assumption 24 – Non-retention fisheries:** The mortality rate for chum salmon released during non-retention fisheries was assumed to be 10% for purse seine fisheries and 60% for gillnet fisheries. Therefore, weekly HRs estimated for sockeye salmon were reduced by these factors during weeks when chum non-retention regulations were in effect.

BB. **Assumption 25 - Alaska ERs for Area 3 chum salmon**: Area 3 chum migrating through Alaskan fisheries have the same annual ER as those estimated for Nass (Area 3) sockeye using the NBSRR model.

CC. **Assumption 26 - Alaska ERs for Area 4-5 chum salmon:** Area 4 and 5 chum migrating through Alaskan fisheries have the same annual ER as those estimated for Skeena (Area 4) sockeye using the NBSRR model.

Coho Exploitation Rates

DD. Page 8 in the report describes the link between the various coho ER indicator stocks and the NCCC statistical areas. Table 5 defines the link between each CU and the coho ERs estimated for each statistical area or group of statistical areas.

EE. **Assumption 27 – Coho CWT data:** The available information on the number of CWT coho caught in fisheries and escaping to spawning areas is adequate to estimate ERs for these indicator stocks and these ERs are appropriate for other unmarked coho populations in the associated statistical area or CU.

FF. **Assumption 28 – NCCC Coho Model:** Dave Peacock will need to provide the assumptions associated with this model.

Chinook Exploitation Rates

GG. Table 6 in the report defines the link between each CU and the Chinook ERs estimated for each Chinook ER indicator stock. Appendix C provides the tables with the escapement and catch estimates and assumptions used to derive these ERs. The analysis years along with the primary source for data and assumptions are provided in the overarching assumptions for each Chinook ER indicator stock below.

HH. **Assumption 29 – Nass Chinook:** Estimates of escapement and catch for Nass River Chinook derived by the Nisga'a Joint Technical Committee for 1992-2010 are adequate to produce reliable annual ER estimates for Nass Chinook (see Appendix Table C1).

II. **Assumption 30 – Skeena Chinook:** Estimates of escapement and catch for Skeena River Chinook derived by DFO for 1984-2010 are adequate to produce reliable annual ER estimates for Skeena Chinook (see Appendix Table C2).

JJ. **Assumption 31 – Area 6 Chinook:** The marine ERs for Skeena Chinook are appropriate for Area 6 chinook streams where production has not be directly affected by the release of hatchery reared fish.

KK. **Assumption 32 – Area 8 Chinook:** The ERs for Area 8 chinook were derived from analysis of Atnarko River Chinook CWT data (see Appendix Table C4, Velez-Espino et al. 2011 for assumptions associated with these analyses).

LL. **Assumption 33 – Area 9 summer Chinook:** Estimates of escapement and catch for Area 9 summer run Chinook derived by DFO for 1985-2010 are adequate to produce reliable annual ER estimates for Area 9 summer run Chinook stocks (see Appendix Table C5).

MM. **Assumption 34 – Area 9 Wannock Chinook:** Estimates of escapement and catch for Wannock Chinook derived by DFO for 1980-2010 are adequate to produce reliable annual ER estimates for Wannock Chinook (see Appendix Table C6).

NN. **Assumption 35 – Area 10 Chinook:** Estimates of escapement and catch for Area 10 Chinook derived by DFO for 1980-2010 are adequate to produce reliable annual ER estimates for Area 10 Chinook stocks(see Appendix Table C7).

Responses to Written Questions Submitted to LGL on March 27, 2012 from the Marine Conservation Caucus

1. The foundation for the escapement estimates presented in English et al. (2011) is the nuSEDS database and a list of appropriate indicator streams.

a) What indicator streams are used for each species and CU (i.e., please provide the complete list of indicator streams used)?

Response: A list of the indicator streams will be provided in a separate file.

b) How were indicator streams selected (i.e., what guidelines were used: >5 enumeration records in a given decade?)?

Response: The initial set of indicator streams was developed from 2005-2009 through consultations with regional biologists and individuals that conduct the escapement monitoring programs. This initial list was modified in Nov. 2011 through review of the available nuSEDS escapement data for all streams associated with each CU. This review was conducted by DFO North Coast stock assessment personnel working with LGL analysts. DFO personnel identified streams to be added to, and subtracted from the initial set. Generally, streams with less than 5 escapement estimates in the most recent set of ten years did not qualify as indicator streams thus streams without estimates in the last 5-10 years were removed and those with at least 5 recent escapement estimates were considered and often added to the list. Those evaluating the indicator stream list were encouraged to remove streams where the quality of the escapement estimates is highly variable or unreliable.

c) What effect did the change in indicator stream selection have on CU escapement estimates (i.e., do the CU escapement estimates in this report differ from previous estimates, such as Cox-Rogers et al. 2004; English et al. 2004, 2006; Gazey 2009)?

Response: Cox-Rogers et al. 2004 reported the raw nuSEDS escapement estimates for the major non-Babine sockeye lakes, thus, these values were usually identical to the nuSEDS data we used to estimate returns by CU. However, Cox-Rogers et al. 2004 did not apply any of the correction factors described above to account for missing indicator stream values, spawning in non-indicator stream or observer efficiencies. For those CUs with only one monitored stream, our estimates were twice those reported in Cox-Rogers et al. 2004 due to the application of an observer efficiency expansion factor of 2.0 to account for underestimation bias. English et al. (2004; 2006) report the escapement estimates used in the NBSRR model. The non-Babine sockeye component of the total annual escapement estimate for Skeena sockeye was estimated by multiplying the reported nuSEDS estimates for non-Babine stocks by factors ranging from 3.0-6.76. These factors include variable annual adjustments for streams not surveyed and a fixed adjustment of 2.59 for observer efficiency. English et al. (2004, 2006) provided estimates for the aggregate Skeena sockeye escapement but CU specific estimates were not possible because the CUs had not been defined prior to 2006. Gazey 2009 adjusted the nuSEDS escapement estimates for non-Babine sockeye by a factor of

2.59, thus our escapement estimates for non-Babine sockeye stocks would be roughly 77% of those reported in Gazey (2009).

d) How were escapement count expansion factors estimated, were they applied to NuSEDS escapement estimates or before being entered in NuSEDS, and how large are the uncertainties in these estimates (i.e., have the expansion factors been ground-truthed)?

Response: The expansion factors used in our analyses were applied to the annual escapement estimates obtained from the nuSEDS database (see page 3 of the report). The methods used to derive the first two expansion factors are described in Appendix B. The third expansion factor was provided by DFO stock assessment biologist to account for common underestimation bias in the nuSEDS escapement estimates for North and Central Coast streams. For some CUs, expansion factor III was derived from comparisons of reported estimates with those derived from periodic more intensive escapement monitoring efforts (e.g. mark-recapture programs or counting weirs). The magnitude of the uncertainty in these estimates will be related to the size of the expansion factor and the number of years with missing escapement estimates for the indicator stream. Expansion Factor III was held constant for all years so uncertainty in this estimate would not affect escapement trends, but it would affect the estimated ERs for Area 1, 2 and 6-10 CUs for pink, chum and sockeye salmon. ERs estimated for Chinook and coho were derived from analyses of CWT and fishing effort data (NCCC Coho Model) and thus are independent from the escapement estimates for these species.

e) How were specific periods of escapement data for CUs chosen in place of decadal averages as shown in Appendix Table A2?

Response: The period chosen for estimating Expansion Factor II were those decades where the number of streams with non-zero escapement estimates was similar to that for the decade with the largest number of steams with non-zero escapement estimates (number of stream surveyed). Appendix Table A1 and A2 identify the periods chosen for estimating the average annual escapement for each stream within a statistical area and CU, respectively. For example: if the number of streams surveyed within a CU was similar for each decade, we used the decadal averages (e.g. Rivers and Smith Inlet chum). For CUs with substantially more streams surveyed in the 1980s than in the 1990s or 2000s, the averaging period was 1980-89 (e.g. Douglas-Gardner chum). There were a few instances when the 2000s had the most streams surveyed and decadal average for the 2000s was used for all other years (e.g. Bella Coola River-Late chum). There were many instances where the number of stream surveyed was similar in the 1980s and 1990s and substantially more than the number of streams surveyed in the 2000s, so the average annual escapements were derived for the 1980-99 period (e.g. Lower and Middle Skeena chum CUs).

f) How will the relative quality of the escapement estimates for each indicator stream (i.e., data uncertainty) be incorporated into the run-reconstruction estimates?

Response: Alternative escapement estimates could be derived by using only those indicator streams with higher quality ratings (e.g. ratings >2 or >3). This would reduce the number of indicator streams for some CUs and may eliminate our ability to estimate escapement for some CUs.

g) Considering that escapement and catch data are the only real numbers we have for some Skeena lake sockeye populations, why are data restricted to 1980-2010 and not inclusive of data as far back as 1950?

Response: The estimates of catch for Skeena sockeye are based on detailed run reconstruction analyses that has only been done from 1982-2008 (English et al. 2004b; 2005; Alexander et al. 2010).

2. Run-timing assumptions.

a) There appears to be an underlying assumption that the run timing of stocks in a given Skeena CU varies in unison with other CUs both in-season and inter-annually. This is unlikely to hold true for all lake sockeye CUs in all years. For example, Kitwanga appears to run outside the normal curve approximations in some years. How is the actual timing variation of stocks (CUs) like Kitwanga, and the uncertainties associated with assigning exploitation rates, accounted for?

Response: Annual variations in run timing for individual stocks is not accounted for in the current analysis. DNA data from Nass and Skeena test fisheries could be used to assess the sensitivity of the exploitation rate estimates to observed changes in run timing.

b) There is some evidence to suggest that run timing is affected by fishing pressure. Have harvest impacts on run timing been accounted for? If so, what is the degree of impact? Has there been a sensitivity analysis as to the impact should the mean of the un-enhanced CU's be shifted towards the mean of the aggregate abundance? Have the uncertainties discussed in Gazey (2009) been incorporated in the analysis?

Response: A recent analysis conducted by Steve Cox-Rogers reported in a 23 February 2012 memo, attempts to correct the Tyee Test Fishery run timing estimates for Skeena sockeye CUs using weekly harvest rates for the Area 3 and 4 marine fisheries. These analyses suggest that the corrected peak timing is one week later for 9 Skeena sockeye CUs, one week earlier for 6 CUs and unchanged for 6 CUs. Most of the uncertainties discussed/listed in Gazey (2009) are related to estimating the in-river harvest rates for Skeena sockeye sub-stocks. The NBSRR run reconstruction results for Skeena and Nass include in-river harvest in the calculation of marine ERs for each sub-stock but the additional in-river ERs for each sub-stock have not been calculated. There are plans to address the uncertainties identified by Gazey and others through the development of an in-river run reconstruction model similar to the ones developed for Fraser sockeye and Chinook.

c) Genetic data sample sizes for many of the small lake sockeye populations are poor. How is the uncertainty accounted for when constructing run-timing distributions and assigning exploitation rates for these CUs?

Response: Uncertainties in run-timing estimates has not accounted for in our analyses but could be assessed by conducting sensitivity analysis using alternative run-timing parameters.

d) Do any sockeye CUs lack DNA or biological characteristics data that affects specific run-timing and abundance data or outcomes? If so, how is this uncertainty accounted for?

Response: Steve Cox-Rogers has indicated that over 95% of the Skeena sockeye CUs are represented in the DNA baseline samples and biological sampling data.

e) How will run-reconstructions be performed for the numerous river-type sockeye populations (CUs) that remain without genetic baseline data?

Response: The model needs run-timing parameters to generate exploitation rates. However, if there are no escapement estimates, it is unlikely that defensible benchmarks can be defined for these river-type sockeye. The management approach for river-type sockeye assumes that their run-timing will be similar to lake-type sockeye destined for the same watershed. Genetic baseline data has been collected for two of the larger river-type sockeye CUs (Nangeese and Maxan).

f) Current stock status is estimated relative to the potential abundance of a CU. If the potential abundance of the CU is calculated, in part, through recent recruitment estimates, and recent recruitment timing, abundance, and distribution has been impacted by fishing pressure, won't estimates of the potential abundance of the CU be confounded? If so, how will this be accounted for?

Response: The abundance of each CU is calculated based on the information obtained from 1980-2010. Estimates of fishing pressure (ERs) have varied substantially over this period for most NCCC stocks where ERs can be estimated (e.g. 22-72% for Skeena sockeye, 0-72% for Central Coast pink and chum salmon, 22-72% for Nass coho; and 29-65% for Skeena Chinook). For those CUs, that have been consistently overharvested, recent returns are probably less than their productive capacity. For some species (e.g. lake-type sockeye) we can compare returns to the habitat capacity for sockeye rearing lakes to assess the degree to which a CUs is below its potential production level. For many stocks, the range in run sizes and ERs over the past 30 years has been sufficient to define the production capacity for the types of environmental conditions and marine survival rates that can be reasonably expected to occur over the next decade. While a clear set of management benchmarks must be established, it is fully expected that these benchmark will change if better information becomes available.

3. Given the paucity of age-class data for all species, how will you account for the bias in the resulting higher productivity estimates that are produced when an average age composition is used in place of year-specific age composition?

Response: Year specific age composition estimates would likely produce more variable estimates of recruitment. Initial analyse of Nass and Skeena stock recruitment data indicate that using average age composition estimates has less effect on the stock-recruitment parameters for Nass sockeye than Skeena sockeye. This may be partly due to the more complex age composition of Nass sockeye or the higher variability in returns observed for Skeena sockeye observed over the past 30 years. Further analysis using simulation models would be helpful to assess the direction and magnitude of any potential bias associated with using average age composition estimates.

4. Can the uncertainties outlined in the questions above be incorporated into the run-reconstruction analyses so as to derive confidence intervals (rather than point estimates) for Dr. Korman's subsequent benchmark work?

Response: This would require a substantial effort and increase the uncertainty associated with benchmarks that are based on the stock-recruitment analysis. The complexity and utility of addressing these uncertainties varies by species and the types of benchmarks established for each CU:

a. **Sockeye: Lower and upper benchmarks could be based on percentages of lake productive capacity and run reconstruction results could be used to assess stock status and exploitation rate trends for each assessable CU.**
b. **Pink and Chum: For CUs that have not been heavily exploited, the use of 25^{th} and 75^{th} percentiles of the escapement time series for indicator stocks could be a viable approach for setting lower and upper benchmarks. For more heavily exploited pink and chum stocks, the management goal should be to reduce ERs to a defined safe level.**
c. **Chinook and Coho: Habitat capacity models could be used to set lower and upper benchmarks for seeding freshwater habitat and marine survival should be monitored using indicator stocks to determine exploitation rate limits. Each of these alternative approaches to setting benchmarks should be informed by stock –recruitment analyses where the available data permits meaningful analyses.**

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