Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

C S A S | *S C C S*

Canadian Science Advisory Secretariat | **Secrétariat canadien de consultation scientifique**

Proceedings Series 2002/025 | **Série des compte rendus 2002/025**

Proceedings of the PSARC Salmon Subcommittee Meeting October 23, 2002

R. Tanasichuk
Salmon Subcommittee Chair

Fisheries and Oceans Canada
Pacific Scientific Advice Review Committee
Pacific Biological Station
Nanaimo, British Columbia V9T 6N7

November 2002

ISSN 1701-1280
www.dfo-mpo.gc.ca/csas/
Canada

Proceedings of the
PSARC Salmon Subcommittee Meeting
October 23, 2002

R. Tanasichuk
Salmon Subcommittee Chair

Fisheries and Oceans Canada
Pacific Scientific Advice Review Committee
Pacific Biological Station
Nanaimo, British Columbia V9T 6N7

November 2002

PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE (PSARC)
SALMON SUBCOMMITTEE MEETING

SUMMARY

The PSARC Salmon Subcommittee met October 23, 2002 at the Pacific Biological Station, Nanaimo, B.C. The Subcommittee reviewed two Working Papers.

Working Paper S2002-11: Status of Cultus Lake sockeye salmon (*Oncorhynchus nerka*).

Historic data were examined to reveal trends in abundance of Cultus Lake sockeye and simulations were performed to estimate the probability of extirpation under various scenarios. The Subcommittee accepted the paper. Declines to date exceed the threshold for designation to the International Union for the Conservation of Nature (IUCN) Endangered category; if prespawning mortality continues to be high and exploitation continues to be moderate, projected declines exceed the threshold for the IUCN Critically Endangered category.

The Subcommittee recommended the development of a Risk Assessment framework for recovery planning. The Recovery Plan should include an evaluation scheme to prioritise restoration and biological monitoring activities. A strategy should be developed for creating the inter-sectoral working group.

Working Paper S2002-12: Pre-season run size forecasts for Fraser River sockeye and pink salmon in 2003.

The Subcommittee accepted the forecasts for Fraser River sockeye and pink salmon. The forecast of sockeye at the 50% level for all stocks combined is 5.5 million fish (89,000 Early Stuart, 412,000 Early Summer, 3.4 million Summer and 1.6 million Late run). The Summer Run forecast accounts for 61% of the total forecast with Quesnel and Chilko stocks in nearly equal proportion at 1.1 and 1.3 million sockeye respectively. The remainder is almost entirely Late run sockeye with the Late Shuswap forecast of 1 million sockeye accounting for 60% of the Late run component. Forecasts for Cultus Lake sockeye are especially low. The Fraser pink salmon forecast at the 50% level is 17 million fish.

The Subcommittee noted that forecasts for Late run sockeye are well below targets and there is uncertainty about whether prespawning mortality will continue. It recommended caution to limit exploitation on Early Stuart and Late run stocks in general. Extreme caution is advised for Cultus Lake sockeye.

SOMMAIRE

Le sous-comité du saumon du CEESP s’est réuni le 23 octobre 2002 à la Station biologique du Pacifique, située à Nanaimo, en Colombie-Britannique, pour passer en revue deux documents de travail.

Document de travail S2002-11 : Status of Cultus Lake sockeye salmon (*Oncorhynchus nerka*)

On a effectué un examen de données historiques pour établir les tendances de l'abondance du saumon rouge dans le lac Cultus et des simulations pour estimer la probabilité de la disparition de l'espèce de cet endroit d'après divers scénarios. Le sous-comité a donné son aval au document. Les déclins de l'abondance observés jusqu'à maintenant dépassent le seuil établi aux fins d'inscription à la catégorie des espèces en danger de l'Union mondiale pour la nature (UICN); si le niveau de mortalité pré-fraie continue à être élevé et l'exploitation, modérée, les déclins prédits dépassent le seuil pour l'inscription à la catégorie des espèces en danger critique d'extinction de l'UICN.

Le sous-comité a recommandé que soit élaboré un cadre d'évaluation des risques pour la planification du rétablissement du saumon rouge du lac Cultus. Le plan de rétablissement devrait inclure un plan d'évaluation en vue de prioriser les activités de rétablissement et de surveillance biologique. Une stratégie pour la mise sur pied du groupe de travail intersectoriel requis devrait aussi être élaborée.

Document de travail S2002-12 : Pre-season run size forecasts for Fraser River sockeye and pink salmon in 2003

Le sous-comité a accepté les prévisions pour le saumon rouge et le saumon rose du Fraser. La prévision pour le saumon rouge au niveau de 50 % pour tous les stocks combinés se chiffre à 5,5 millions d'unités (remonte hâtive de 89 000 dans la Stuart, remonte hâtive d'été de 412 000, remonte d'été de 3,4 millions et remonte tardive de 1,6 million). La prévision de la remonte d'été représente 61 % de la prévision de la remonte totale, les stocks de la Quesnel et de la Chilko y contribuant en proportion presque égale à 1,1 et 1,3 million d'unités, respectivement. Le reste est constitué presque complètement de saumons de remonte tardive, la prévision pour la Shuswap de 1,0 million d'unités représentant 60 % de la composante tardive. Les prévisions pour le saumon rouge du lac Cultus sont particulièrement basses, tandis que celles pour le saumon rose du Fraser au niveau de 50 % chiffrent la remonte à 17 millions d'unités.

Le sous-comité a constaté que les prévisions pour le saumon rouge de remonte tardive sont grandement inférieures aux cibles et que l'on ne sait pas si la mortalité pré-fraie perdurera. Il a donc recommandé qu'on fasse preuve de prudence et qu'on limite l'exploitation des stocks de remonte hâtive dans la Stuart et de remonte tardive en général et, dans le cas du saumon rouge du lac Cultus, de très grande prudence.

INTRODUCTION

The PSARC Salmon Subcommittee met on October 23, 2002, at the Pacific Biological Station in Nanaimo, British Columbia. External participants from the Pacific Fisheries Resource Conservation Council, the Fraser River Panel, Sports Fishing Advisory Board and the Fraser River Aboriginal Fisheries Secretariat attended the meeting. Observers included members of the public and representatives of the Area G Troll Association and the Fishing Vessel Owners Association. The Subcommittee Chair, R. Tanasichuk, opened the meeting by welcoming the participants. During the introductory remarks the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda.

The Subcommittee reviewed two Working Papers. Summaries of each paper are in Appendix 1. The meeting agenda appears as Appendix 2. A list of meeting participants, observers and reviewers is included as Appendix 3.

DETAILED COMMENTS FROM THE REVIEW

S2002-11: Status of Cultus Lake sockeye salmon (*Oncorhynchus nerka*).

N. Schubert, A. Cass, T. Cone, B. Fanos, M. Foy, J. Gable, J Grout, J. Hume, M. Johnson, M. Morton, K. Shortreed, M. Staley **Accepted with revisions**

Rapporteur: Chuck Parken

Data and Methods

The Subcommittee acknowledged that the data quality for Cultus sockeye is considered to be the highest for any sockeye population in the Region. The data include escapement, catch, size and age composition, fecundity as well as fry and smolt estimates. Additional information included historic data on the limnological characteristics of the lake as well as recent results on Fraser River sockeye genetic structure. The Subcommittee did note that Cultus sockeye are lake-spawners and post-spawned carcasses are not reliably sampled to estimate the sex and age composition of effective spawners in many years. For this reason the Subcommittee accepted the use of adult spawners rather than using effective female spawner that otherwise would better represent the reproductive potential of Cultus sockeye.

Two methods were used to assess the status of the stock: 1) the IUCN criteria that categorizes the status of the stock based on the recent trend in escapement, and 2) a Monte Carlo simulation model to evaluate the potential effects of high prespawning mortality (PSM) and various levels of exploitation on future production. The Monte Carlo simulations were based on a Bayesian stock-recruitment analysis to quantify uncertainties in population dynamics and simulate the probability of future population sizes. Scenarios tested considered a range of PSM of 70-90% and exploitation rates

of 0 through 30%. The large PSM in recent years was modeled in the simulations by initializing the model with an estimate of adult spawners based on spawner-to-smolt survival for one year of high PSM (1999). The Subcommittee noted that because the probability of quasi-extirpation was based on the probability of the spawning escapement declining to <50 effective adult spawners in any consecutive four year period it may be optimistic given the potential for depensatory mortality at low spawner abundance as noted by one Reviewer. The Subcommittee requested that a table of quasi-extirpation probabilities be constructed to show potential future implications over a wider range of exploitation and PSM scenarios. This table should also include probabilities for at least one additional quasi-extirpation threshold level (eg. 100 spawners).

Results

The Subcommittee concurred with the authors and reviewers concern for the very poor status of Cultus Lake. Although lake capacity estimates are poorly determined, as noted by the authors, current escapements are far less than even the lowest estimates inferred in the Working Paper. Escapements have undergone a persistent long-term decline particularly evident in the two off-cycle lines (Fig. 1). The off-cycle abundance has remained very low (<2,000 spawners) since the early 1970's. The most recent escapements on all cycles have been among the lowest ever recorded for Cultus Lake sockeye. The effective spawning population has declined to less than 4% of the long term average on each of the four cycles. Since the late 1960's the sub-dominant cycle adult escapements have declined steadily as well. The decline in the dominant cycle began in the last two cycle years (Fig. 1). Average returns were the highest in the 1950's, lower and stable in the 1960's, and have declined progressively beginning in the 1980's and averaged 1,300 in 2000 and 2001 (Fig. 2). The Subcommittee agreed that declining trends are consistent with the high exploitation rates well above levels appropriate for Cultus sockeye during 1952-95, and the recent high levels of PSM. Exploitation rates of Cultus Lake sockeye averaged 68% and ranged between 10.4% (1999) and 94.5% (1997) (Fig. 2). They have declined recently because fisheries have been adjusted in response to early migration of Late run sockeye. Evidence presented by the authors suggested that Cultus sockeye are less productive than other Fraser sockeye stocks and were less able to withstand the historically high exploitation rates compared to other stocks.

The high levels of PSM were associated with a change in migration timing. Since 1996, the start and peak of migration were as much as two months earlier than the 1941-95 mean. Available data suggested that PSM increased from 9% in 1945-95 to 52% in 1996-98. Prespawning mortality in 1999 and 2000, estimated indirectly by comparing the adult-to-smolt ratios in those years to the long-term average, was 93%. One Reviewer suggested that focusing the analysis on PSM resulting from *Parvicapsula* could divert attention from evaluating other contributing effects, such as water quality and habitat degradation.

The Working Paper provided evidence of poor freshwater survival based on juvenile abundance indices. Fry abundance estimates have been made sporadically but smolt estimates have been available in 46 of the last 78 years. Fry estimates were considerably lower for the 1999 and 2000 broods. Fry estimates for the 2000 brood were the lowest on record. Smolt abundance in 2001 and 2002 are some of the lowest on record (Table 1). It appears that freshwater survival has declined but no inferences can be made about recent trends in marine survival.

Lake phytoplankton species composition determined from 2001 sampling are comparable to that described in the 1930's. The seasonal average photosynthetic rate is the highest of any sockeye nursery lake in the Fraser system. Zooplankton species compositions described in 2001 are comparable to those reported for the 1930's, 1960's and 1970's. Zooplankton abundance or biomass appears unchanged. The Subcommittee was concerned, as were the authors, that changes in the habitat of the lake have occurred and could contribute to the low freshwater survival estimates. Human activities have modified the lake's littoral zone, tributary streams and water quality. There has been an invasion of Eurasian watermilfoil that may overtake spawning areas because of the low spawning activity.

Cultus Lake sockeye are genetically distinct from all other populations in the Fraser drainage, include the Chilliwack Lake population, which is also in the Chilliwack River drainage system. The Authors informed the Subcommittee that additional genetic information, further supporting the distinctiveness of Cultus Lake sockeye, will be included in the revision.

Cultus Lake sockeye escapements have declined by 51% over the last three generations. This results in a rate of decline of 6.5% annually across all cycles (Fig. 3). The reduction exceeds the IUCN criteria for *Endangered* (>50% decline, where causes may not be reversible or may not have ceased). It is a continuation of a longer term trend than began in the late 1960's and does not consider the incremental impact of the current high levels of prespawning mortality. There was some discussion about whether using IUCN criteria was appropriate in the context of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The Subcommittee felt that the IUCN criteria is a global standard and is therefore a useful benchmark to interpret trends. The Subcommittee further noted, however, that IUCN is also used by COSEWIC and therefore PSARC should be careful in the interpretation of results based solely on IUCN criteria Model simulations suggest that the prognosis of the stock is critical. If high PSM continues in the absence of fishing mortality, the probability of extirpation is estimated conservatively at one in 3; this is at a quasi-extirpation threshold of 50 effective spawners. If high PSM continues and exploitation is moderate, then the rate of decline over three generations is >80% and the probability of extirpation exceeds 50%, conditions defined as *Critically Endangered* by IUCN criteria. The model may underestimate the probability of extirpation for two reasons. First, the dominant 1999 cycle escapement reduces the probability that escapements will be below 50 fish for four consecutive years. Second, other factors such as depensatory mortality and

Eurasian watermilfoil expansion may affect adversely Cultus Lake sockeye production. One Reviewer suggested that depensatory mortality should be considering explicitly. An Author responded that, because uncertainty in the stock-recruit data is exceptionally high, depensatory mortality would be difficult to detect. Increasing the quasi-extirpation threshold to 100 spawners, as advised by the Subcommittee, was considered appropriate considering reproductive potential and survival at low spawner abundance (i.e. depensatory mortality) may decrease. The probability of quasi-extirpation at 50 and 100 spawner thresholds for expanded ranges of PSM at 40-90% and exploitation rates of 0-50% are presented in Table 2. At projections of 3 and 5 generations from the present, the probability of quasi-extirpation at a 100 fish threshold is about double over moderate ranges of PSM and exploitation rates compared to a 50 fish threshold.

Recommendations

The Subcommittee supported the Authors' recommendation that an inter-sectoral working group be formed to develop a risk assessment framework that explicitly evaluates the risks of different fisheries and recovery options in terms of their cultural, ecological, economic and social values. Considering the poor prognosis for Cultus Lake sockeye, the Department should to support short term mitigative efforts while developing the recovery plan. Finally, a number of activities (eg. enumerations, spawner surveys, lake and groundwater quality assessments) should be continued or started to adequately assess and document the status of Cultus Lake sockeye over the recovery period.

The Subcommittee discussed the need to prioritize assessment needs in the Region given competing assessment issues and shrinking budgets. The Subcommittee is concerned that budget restraints have created an urgency in identifying assessment priorities so that Managers are aware of impeding shortfalls in data collection activities that erode the ability to deliver quality assessments in the future.

Subcommittee Conclusions

The Subcommittee was highly complimentary of the paper and thanked the authors for all their efforts. The status of Cultus Lake sockeye was well-addressed and the fundamental assessment was sound. The paper was accepted with minor revisions.

The Subcommittee discussed potential future refinements to the simulation modeling such as a life-cycle model to help learn about mortality at different life history stages. The Subcommittee agreed that alternative approaches could be considered as part of future risk assessments.

Subcommittee Recommendations

The Subcommittee recommended the development of a Risk Assessment that explicitly evaluates the implications of different fisheries and recovery options in

terms of their cultural, ecological, economic and social values. There should be an evaluation scheme to prioritise Recovery Plan activities. A monitoring plan should be in place to continue collecting biological information. A strategy should be developed for creating an inter-sectoral working group.

S2002-12: Pre-season run size forecasts for Fraser River sockeye and pink salmon in 2003
A. Cass **Accepted with revisions**

Rapporteur: Rick McNicol

Data, forecasting models and forecast performance:

The Subcommittee acknowledged that the data sources and methods have been reviewed repeatedly by PSARC. In keeping with past practice, given that data and methods remain unchanged, the forecast Working Paper was not formally reviewed. Sockeye forecasts were made for each of 18 sockeye stocks and four run timing groups. Pink salmon forecasts were made for all Fraser River spawning populations combined.

The Subcommittee accepted the forecasts as presented in Table 3. The Subcommittee noted that although forecasts are presented as probability distributions, they are based on models that, with the exception of juvenile-based forecasts, assume average survival conditions. The Author noted that improvements to pre-season abundance forecasts are unlikely without a better understanding of environmental factors affecting survival. Oceanographic and meteorological conditions in the northeast Pacific and coastal British Columbia in 2000 and 2001 reflect moderate La Nina conditions. These years are the main ocean entry years for age-5 and age-4 sockeye returning in 2003. Ocean survival conditions were favourable for some sockeye stocks and pink returns respectively in 2002 and 2001. Correlations of survival and specific oceanographic variables, however, have not been demonstrated.

Given the high uncertainty in forecast performance the Subcommittee discussed the potential for alternative forecast methods that acknowledge stepped changes in survival due to climate regime shifts. The Author pointed out that retrospectively the performance of a stepwise average approach could be evaluated but that the starting dates of future regime shifts and their duration are uncertain. Given forecast uncertainty, the Subcommittee wondered whether forecasts based on simple averages are sufficient. The Author noted, however, that averages will under-forecast or over-forecast in situations where persistent trends occur. Based on comparison of different methods, simple averages of returns have not performed as well as those based on return-escapement or return-juvenile regression methods.

One participant asked whether forecasts based on cycle-line data have been assessed. The Author stated that the time series of data for cycle lines is short but in

the future as more years of data are collected an evaluation of performance of forecasts for cycle lines is appropriate.

The Subcommittee noted the association with recent El Niño events of the 1990s with low sockeye survival. The Subcommittee wondered whether there is a general correlation with the time series of El Niño events over the time series for which sockeye data are available. The Author stated that there is no strong El Niño influence on survival.

Stock status

For Early Stuart sockeye, the 2003 cycle line is the first off-cycle following the dominant (2001) and subdominant (2002) line returns. Spawning escapement in brood year 1999 was impacted by high Fraser River discharges during in-river migration; in-season estimates at Mission were 80% greater than the sum of spawning escapement and catch. Escapement estimates were low (Fig. 4) and females accounted for 39% of the spawners. Female pre-spawning mortality was estimated to be 15%.

Early summer run sockeye consist of several small stocks (Fennell, Bowron, Raft, Gates, Nadina, Pitt, Seymour and Scotch). In-season estimates at Mission in 1999 were 54% greater than the sum of spawning escapement and catch. Prespawning mortality was low (~ 5%).

There are four Summer run stocks (Chilko, Quesnel, Late Stuart and Stellako). Chilko escapement in 1999 was the fourth highest on record (Fig. 5). Escapement of Quesnel sockeye on the 2003 cycle-line has increased steadily from 2000 in 1983 to 214,000 in 1995. Escapement decline to 187,000 in 1999. Late Stuart escapement on the 2003 cycle-line has also increased, from less than 10,000 before 1970 to an average of 60,000 in the 1990s. Escapement in brood year 1999 was 62,000, the second highest on record for the cycle. The 2003 forecast for Stellako of 595,000 at the 50% level is near the annual and cycle-mean return (Table 3).

Spawning escapement for Late run sockeye (Late Shushwap, Cultus, Weaver, Birkenhead) appears to have declined recently (eg. Fig. 6). Spawning escapement to the Late Shushwap on the 2003 subdominant line has declined from 1.3 million in 1991 to 287,000 in 1999. The decline has been attributed to high in-river mortality as indicated by the difference in the Mission in-river estimate and the sum of escapement and catch. This in-river mortality has been implicated as the cause of decline in other Late run stocks. An in-lake pre-spawning mortality of 90% for Cultus Lake sockeye was estimated based on an assumed egg-to-smolt relationship.

Fraser pink escapement in 2001 (20 million) was almost double the estimated escapement in any year since quantitative assessment began (1961, Fig. 7). Fry-to-adult survival rates suggest that the large returns in 2001 were a consequence of good ocean survival. The estimated 681 million pink fry from the large 2001

escapement is near the record high of 697 million resulting from an escapement of 13 million in 1991. This produced a return of 17 million in 1993.

Subcommittee Conclusions

The Subcommittee accepted the paper with minor revisions and accepted the forecasts. The Subcommittee asked the Author to investigate two variations in recruitment forecasting methodology. The first is to use an assumed prespawning mortality of 90% for recent (post-1995) escapement for Cultus Lake sockeye. Second, the Author was asked to investigate the utility of using smolt abundance estimates and marine survival rate data as another approach to forecast Cultus Lake sockeye returns.

The Subcommittee expressed grave concerns about future levels of funding for salmon assessment. This was precipitated by the concern that high Fraser pink returns would result in assessment funding moving away from these stocks. The Subcommittee was under the impression that funding for assessment would be inadequate if DFO was the only funder. Managers may have to consider adjusting fishing plans to incorporate the increased risk associated with the declining quality of assessment data.

The Subcommittee noted the conservation concerns for Early Stuart and Late run sockeye. Early Stuart sockeye have suffered from persistent adverse environmental conditions during the Fraser River spawning migration. Late run stocks have undergone very high levels of pre-spawning mortality as a result of the early entry phenomenon since the mid 1990s. Prognosis for Late run sockeye is poor and highly uncertain given that future pre-spawning mortality rates cannot be predicted. Based on the escapement trends presented in the Working Paper, conservation concerns for the Early Summer and Summer runs are not apparent.

The Subcommittee discussed the ramification of funding cuts and the ability to produce forecasts and quality assessments in general. For example, pink escapement enumeration in 2003 may be not be funded. Given the very high pink forecast in 2003, the ability to evaluate status of Fraser River pinks in the future is questionable. One strategy for flagging assessment issues is for Science and Resource Managers to develop a long-term assessment plan. The PSARC Chair pointed out that discussions with Managers indicate a desire to develop a strategic plan that links fishing plans to assessment advice.

Subcommittee Recommendations

The Subcommittee accepted the forecasts and recommended caution to limit exploitation on Early Stuart and Late run stocks in general. Extreme caution is advised for Cultus Lake sockeye.

APPENDIX 1: Working Paper Summaries

S2002-11: Status of Cultus Lake sockeye salmon (*Oncorhynchus nerka*)

N. Schubert, A. Cass, T. Cone, B. Fanos, M. Foy, J. Gable, J Grout, J. Hume, M. Johnson, M. Morton, K. Shortreed, M. Staley.

This report documents an assessment of the status of Cultus Lake sockeye salmon (*Oncorhynchus nerka).* Sockeye escapements have declined precipitously on all cycles in recent years, a decline that is coincident with an earlier timing of migration into the river that is part of the broader phenomenon affecting all late run Fraser River sockeye populations. In association with early migration, there also has been a decline in spawning success that has resulted in the failure to observe a single successful spawner in some years. These observations led to the Pacific Scientific Advice Review Committee's request for a status report on this stock.

The Cultus sockeye population is among the most intensively studied salmon stocks in British Columbia. Studies of spawner abundance, lake characteristics and juvenile production began with the work of the Pacific Biological Station in the 1920's and have continued until the present with the work of the International Pacific Salmon Fisheries Commission and the Department of Fisheries and Oceans. This report summarizes or provides detailed data regarding: watershed geomorphology; lake limnology and fish ecology; sockeye life history; enhancement history; predator and exotic species control; spawner counts since 1925; sockeye fry assessments (lake hydroacoustic and trawl survey); smolt counts since 1926; fishery management processes and objectives; fishery catches and total returns since 1952; and marine distribution and migratory timing. These data are used to evaluate trends in escapements, juvenile abundance, catch and total return, and to calculate freshwater and total survival indexes and exploitation rates. Based on the available data and the analytic results, the authors provide an evaluation of the stock's productive capacity and current status, and use a simulation model based on Bayesian stock-recruitment analyses to evaluate future stock trajectories under different scenarios of prespawn mortality and exploitation.

Cultus is a potentially large stock (current escapements are a small fraction of the level that would utilize a substantial part of the stock's productive capability) that is less productive than the sockeye stocks with which it comigrates. The escapement of Cultus sockeye adults declined by 51% over the last three generations, a continuation of a trend that began following the construction of the Weaver Creek spawning channel in the late 1960's. The rate of decline is consistent with an *Endangered* classification as defined by the IUCN. There are two causal factors: exploitation rates that have exceeded the optimum rate associated with maximum sustainable yield in most years between 1952 and 1995; and extremely high prespawn moralities that have occurred since the onset of the early migration in 1995. The result is a current effective spawner population that is less than 4% of the long term average on each of the four cycles. Our model simulations suggest that if

the current conditions of high prespawn mortality continue, even in the absence of any fishing mortality, the prognosis for the stock is critical: the probability of extirpation is conservatively estimated at one in three. If exploitation continues at moderate levels, the modeled rate of decline over three generations is >80% and the probability of extirpation is >50%, conditions consistent with a *Critically Endangered* classification as defined by the IUCN.

The authors recommend the development of a risk assessment framework that evaluates risks of different fisheries and recovery options in terms of their cultural, ecological, economic and social values. While the framework is being developed, current mitigation efforts should continue and fisheries should be managed under a precautionary approach that recognizes the uncertainty associated with the early migration phenomena, and its potential severity, by minimizing exploitation rates to reduce the near term probability of extirpation and slow the rate of decline in spawner abundance. The authors also recommend the development of a comprehensive recovery plan that integrates options to improve freshwater survival with harvest controls and other measures, as well as the Department's support for the ongoing and new studies required to provide information important to our understanding of stock status and to the development of the risk assessment framework and recovery plan.

S2002-11: Pre-season run size forecasts for Fraser River sockeye and pink salmon in 2003

A. Cass

Sockeye production from the 2003 cycle line has been dominated by returns to Chilko Lake and Lower Adams River (Shuswap Lake). Average sockeye returns for all stocks on the cycle were 6.3 million sockeye/yr compared to an all-year average of 10.3 million fish/yr (1980-2000). At nearly equal proportions, Chilko and Late Shuswap sockeye together accounted for 61% of the total sockeye returns on the cycle since 1980. Forecasts are made for each of 18 individual sockeye stocks and four run timing groups (Table 4). Together the 18 sockeye stocks accounted for 96% of the estimated escapement to the Fraser River in brood year 1999. Escapement estimates for the remaining 4% are extrapolate based on mean recruits-per-spawner for combined stocks with escapement and recruitment data to forecast total returns for all spawning populations.

Fraser pink salmon forecasts for all spawning populations combined are also provided. Pink returns in brood year 2001 were near record levels at 21 million fish. Average pink returns in odd-numbered year was 14 million (1981-2001). Pink escapement in 2001 was well beyond recent historical levels.

Forecasts of returns are made using a variety of explanatory variables. For most stocks, forecasts are based on regression models that use spawning escapement to predict returning age-4 and age-5 sockeye in 2003. Additional explanatory variables

are available for some stocks and include smolt and fry data. Model performance was evaluated in a retrospective analysis by comparing forecasts to estimated (observed) run sizes for years that estimates are available. The root-mean-square error criteria was used to select the best model from several candidate models.

Forecasts are provided at various probability levels of achieving specified run sizes by stock and run-timing group. The forecast of sockeye at the 50% level for all stocks combined is 5.5 million fish (89,000 Early Stuart, 412,000 Early Summer, 3.4 million Summer and 1.6 million Late run). The Summer Run forecast accounts for 61% of the total forecast with Quesnel and Chilko stocks in nearly equal proportion at 1.1 and 1.3 million sockeye respectively. The remainder is almost entirely Late run sockeye with the Late Shuswap forecast of 1 million sockeye accounting for 60% of the Late run component. The Fraser pink salmon forecast at the 50% level is 17 million fish.

Forecasts are associated with high uncertainty. Although forecasts are presented as probability distributions, they are based on models that for most stocks assume average survival conditions. Improvements to pre-season abundance forecasts are unlikely without a better understanding of environmental factors affecting survival. Reliability of forecasts ultimately depend on understanding processes that affect survival in both freshwater and the marine environment. Migratory conditions in the Fraser River in 1999 were poor for many sockeye stocks as a result of high river discharge. The effect of stress on survival of the progeny from sockeye that spawned in 1999 is not known. Indicators of sockeye freshwater survival throughout the watershed for the brood were variable. Low egg-to-fry survival was evident for Early Stuart sockeye at one of three sites sampled as well as for Nadina sockeye. Lower than average freshwater survival to the smolt stage is evident in the two sockeye populations where smolts are enumerated (Chilko and Cultus). Cultus sockeye have experienced long-term declines exasperated by the recent high pre-spawning mortality of Late-timed runs generally.

Oceanographic and meteorological conditions in the northeast Pacific and coastal British Columbia in 2000 and 2001 reflect moderate La Niña conditions. These years are the main ocean entry years for age-5 and age-4 sockeye returning in 2003. Ocean survival conditions were favourable for some sockeye stocks and pink returns respectively in 2002 and 2001. Correlations of survival and specific oceanographic variables, however, have not been demonstrated.

APPENDIX 2: Revised PSARC Salmon Subcommittee Meeting Agenda OCTOBER 23, 2002

PSARC Salmon Subcommittee Meeting
October 23, 2002
Seminar Room, PBS, Nanaimo

Wednesday October 23, 9:00

9:00 – 9:30 Introduction and procedures
9:30 – 10:30 Cultus Lake Sockeye stock assessment (Schubert et al.)
10:30 – 10:45 Break
10:45 – 12:00 Cultus Lake Sockeye stock assessment (Schubert et al.)
12:00 – 13:00 Lunch
13:00 – 14:30 Fraser River Sockeye forecasts (Cass)
14:30 – 15:00 Break
15:00 – 16:00 Fraser River Sockeye forecasts (Cass)

APPENDIX 3: List of Attendees

Subcommittee Chair: Ron Tanasichuk
PSARC Chair: Al Cass

DFO Participants	**Wed**	
* denotes Subcommittee Members		
Anderson, Don*	x	
Bradford, Mike*	x	
Brahniuk, Randy	x	
Brown, Gayle	x	
Cass, Al*	x	
Cook, Roberta*	x	
Ennevor, Bridget	x	
Fanos, Brad	x	
Grout, Jeff	x	
Hargreaves, Brent*	x	
Holmes, John	x	
Holtby, Blair*	x	
Hyatt, Kim*	x	
Ionson, Bert*	x	
Luedke, Wilf*	x	
McNicol, Rick	x	
Meerberg, Dave*	x	
Parken, Chuck*	x	
Saunders, Mark	x	
Schubert, Neil	x	
Simpson, Kent	x	
Tanasichuk, Ron*	x	
Thomas, Greg	x	
Tompkins, Arlene	x	
Wood, Chris*	x	
External Participants:		**Affiliation**
Atkinson, Mary-Sue	x	PFRCC
Chatwin, Murray	x	Ocean Fisheries Ltd, PFRCC, and Fraser Panel
Otway, Bill	x	Sport Fishing Advisory Board
Riddell, Brian	x	PFRCC
Rombough, Les	x	Fraser River Panel
Wilson, Ken	x	Fraser River Aboriginal

		Fisheries Secretariat
Woody, Jim	x	Consultant
Observers:		**Affiliation**
Blackbourn, Dave	x	Consultant
Scarfo, Kathy	x	Area G. Troll Association

Reviewers for the PSARC papers presented at this meeting are listed below, in alphabetical order. Their assistance is invaluable in making the PSARC process work.

Brown, G.	Fisheries and Oceans Canada
Woody, J.	Consultant

Tables and Figures

Table 1. Annual Cultus sockeye smolt production by age class and annual smolt migration timing at the Sweltzer Creek enumeration fence, 1926 to 2002. ("-" indicates no project that year; "na" indicates data are unavailable)

	Estimated smolts at age			Sweltzer Creek fence dates			Fork length(mm) sample				
Year	Age-1	Age-2	Total	Fence installed[a]	50% adult migration	Fence removed[b]	N	mean	max	min	CI 95%
1926	1,398,000	na	1,398,000	-	-	-	-	-	-	-	-
1927	183,400	66,500	249,900	-	-	-	-	92 [c]	-	-	-
1928	336,200	1,700	337,900	19-Mar	26-Apr	11-Jun	-	81 [c]	-	-	-
1929	2,426,200	8,300	2,434,500	-	-	-	-	-	-	-	-
1930	38,600	66,600	105,200	-	-	-	-	-	-	-	-
1931	349,000	5,200	354,200	-	-	-	-	-	-	-	-
1932	788,400	200	788,600	-	-	-	-	-	-	-	-
1933	1,571,000	0	1,571,000	-	-	-	-	-	-	-	-
1934	121,200	63,300	184,500	-	-	-	-	-	-	-	-
1935	242,500	14,200	256,700	-	-	-	-	-	-	-	-
1936	501,600	1,400	503,000	-	-	-	-	-	-	-	-
1937	3,101,000	23,000	3,124,000	27-Mar	25-Apr	18-Jun	-	-	-	-	-
1938	1,627,000	20,000	1,647,000	16-Mar	25-Apr	26-Jun	-	-	-	-	-
1939	196,255	20,415	216,803	14-Mar	24-Apr	25-Jun	-	-	-	-	-
1940	1,374,800	138	1,376,736	28-Feb	10-Apr	10-Jun	-	-	-	-	-
1941	3,955,502	953	3,965,434	3-Jan	20-Apr	30-Jun	-	-	-	-	-
1942	1,752,551	20,705	1,777,964	25-Mar	27-Apr	21-Jun	-	-	-	-	-
1943	702,980	12,879	715,859	25-Mar	22-Apr	2-Jun	-	-	-	-	-
1944	2,009,186	2,730	2,015,179	16-Mar	22-Apr	16-Jun	-	-	-	-	-
1945	390,064	9,698	400,421	3-Mar	17-Apr	23-Apr	-	-	-	-	-
1946	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-	-	-	-
1953	392,801	<1%	392,801	6-Apr	19-Apr	14-May	-	-	-	-	-
1954	626,478	<1%	626,478	7-Apr	4-May	26-May	-	-	-	-	-
1955	-	-	-	-	-	-	-	-	-	-	-
1956	1,903,296	4,759	1,908,055	5-Apr	29-Apr	28-May	-	-	-	-	-
1957	2,688,063	23,589	2,711,652	5-Apr	26-Apr	22-May	-	-	-	-	-
1958	976,120	64,512	1,040,632	24-Mar	11-Apr	15-May	-	-	-	-	-
1959	319,495	184	319,679	27-Mar	2-May	5-Jun	-	-	-	-	-
1960	1,427,228	1,480	1,432,008	25-Mar	28-Apr	27-May	-	-	-	-	-
1961	1,327,842	2,215	1,330,057	1-Apr	28-Apr	2-Jun	-	-	-	-	-
1962	1,025,404	4,438	1,029,842	2-Apr	29-Apr	16-May	-	-	-	-	-
1963	1,200,498	24,859	1,225,357	28-Mar	27-Apr	20-May	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-
1967	131,106	4,682	135,788	3-Apr	21-Apr	8-May	-	-	-	-	-
1968	2,101,506	822	2,102,328	29-Mar	21-Apr	14-May	-	-	-	-	-
1969	2,441,694	17,446	2,459,140	17-Apr	8-May	28-May	-	-	-	-	-
1970	1,005,291	17,582	1,022,873	2-Apr	26-Apr	17-May	-	-	-	-	-
1971	186,787	7,652	194,439	2-Apr	2-May	16-May	-	-	-	-	-
1972	na	na	808,014	7-Apr	26-Apr	18-May	-	-	-	-	-
1973	1,086,016	17,335	1,103,351	7-Apr	28-Apr	14-May	-	-	-	-	-
1974	167,111	6,505	175,788	7-Apr	24-Apr	10-May	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-
1976	na	na	996,263	23-Mar	20-Apr	8-May	-	-	-	-	-
1977	na	na	1,231,526	7-Apr	22-Apr	13-May	-	-	-	-	-
1978	na	na	169,679	22-Mar	24-Apr	11-May	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-

Table 1 cont.

Year	Estimated smolts at age			Sweltzer Creek fence dates			Fork length(mm) sample				
	Age-1	Age-2	Total	Fence installed[a]	50% adult migration	Fence removed[b]	N	mean	max	min	CI 95%
1981	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-
1990	65,184	459	65,643	12-Apr	10-May	31-May	196	85 [d]	102	70	1.0
1991	52,865	372	53,237	12-Apr	15-May	14-Jun	1,421	99 [d]	129	51	0.5
1992	178,357	2,716	181,073	8-Apr	30-Apr	5-Jun	402	106 [d]	152	78	1.1
1993	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-
2001	62,564	70	62,634	4-Apr	9-May	28-May	894	109 [d]	126	88	0.4
2002[e]	na	na	5,681	5-Apr	15-May	5-Jun	na	na	na	na	na
Averages											
1998 Cycle	1,180,064	1,772	1,131,741	25-Mar	23-Apr	29-May	na	na	na	na	na
1999 Cycle	1,767,522	10,261	1,732,210	23-Mar	26-Apr	25-May	na	na	na	na	na
2000 Cycle	800,267	29,345	711,483	30-Mar	28-Apr	27-May	na	na	na	na	na
2001 Cycle	356,489	15,694	372,196	29-Mar	29-Apr	30-May	na	na	na	na	na
All years	1,034,906	14,200	1,004,498	27-Mar	26-Apr	27-May	na	na	na	na	na

[a.] Fence installation date is based on historical timing information and the first observation of migrating sockeye smolts.

[b.] Fence removal date is based on historical timing information and the last observations of migrating sockeye smolts.

[c.] Length data sample for one-year-old migrants only.

[d.] Length data sample includes one and two-year-old migrants.

[e.] Aging data not available as of July 15.

Table 2. Mean probabililty of quasi-extirpation for Cultus Lake sockeye by exploitation rate and pre-spawning mortality after 3, 5 and 25 generations. Quasi-extirpation is defined as the probability that spawner abundance is less than 50 and 100 spawners in 4 successive years based on forward simulation in a Population Viability Analysis.

		<50 spawners in successive four years			<100 spawners in successive four years		
		Generations from present			Generations from present		
Prespawning mortality	Exploitation Rate	3	5	25	3	5	25
0.4	0	0.00	0.00	0.00	0.00	0.00	0.00
	0.1	0.00	0.00	0.00	0.00	0.00	0.00
	0.2	0.00	0.00	0.00	0.00	0.00	0.00
	0.3	0.00	0.00	0.00	0.00	0.00	0.01
	0.4	0.00	0.00	0.01	0.00	0.01	0.03
	0.5	0.00	0.00	0.05	0.01	0.02	0.10
0.5	0	0.00	0.00	0.00	0.00	0.00	0.00
	0.1	0.00	0.00	0.00	0.00	0.00	0.01
	0.2	0.00	0.00	0.01	0.00	0.00	0.02
	0.3	0.00	0.00	0.02	0.00	0.01	0.04
	0.4	0.00	0.00	0.05	0.01	0.02	0.11
	0.5	0.00	0.01	0.16	0.02	0.05	0.26
0.6	0	0.00	0.00	0.00	0.00	0.00	0.02
	0.1	0.00	0.00	0.01	0.00	0.01	0.03
	0.2	0.00	0.00	0.03	0.01	0.01	0.07
	0.3	0.00	0.01	0.08	0.01	0.03	0.16
	0.4	0.00	0.02	0.19	0.02	0.05	0.30
	0.5	0.01	0.04	0.38	0.04	0.10	0.50
0.7	0	0.00	0.00	0.05	0.01	0.02	0.11
	0.1	0.00	0.01	0.10	0.01	0.03	0.19
	0.2	0.00	0.02	0.19	0.02	0.05	0.30
	0.3	0.01	0.03	0.33	0.03	0.09	0.45
	0.4	0.02	0.06	0.50	0.06	0.14	0.61
	0.5	0.04	0.12	0.66	0.10	0.23	0.74
0.8	0	0.01	0.04	0.38	0.04	0.10	0.50
	0.1	0.02	0.06	0.50	0.06	0.14	0.61
	0.2	0.03	0.10	0.61	0.08	0.19	0.70
	0.3	0.04	0.15	0.71	0.12	0.26	0.78
	0.4	0.07	0.22	0.78	0.17	0.35	0.83
	0.5	0.12	0.31	0.84	0.24	0.44	0.87
0.9	0	0.12	0.31	0.84	0.24	0.44	0.87
	0.1	0.15	0.36	0.86	0.28	0.49	0.89
	0.2	0.19	0.42	0.88	0.32	0.54	0.90
	0.3	0.24	0.48	0.89	0.37	0.59	0.92
	0.4	0.30	0.54	0.91	0.43	0.64	0.93
	0.5	0.36	0.60	0.92	0.49	0.68	0.94

Table 3. Pre-season sockeye and pink salmon forecasts for 2003 by stock/timing group and probability level.

Sockeye				**Probability of Achieving Specified Run Sizes** [a]				
stock/timing	**forecast**	**mean run size** [c]						
group	**model** [b]	**all cycles**	**2003 cycle**	**0.25**	**0.5**	**0.75**	**0.8**	**0.9**
Early Stuart	Power	**383,000**	**216,000**	**139,000**	**89,000**	**57,000**	**51,000**	**38,000**
Early Summer		**489,000**	**440,000**	**748,000**	**412,000**	**225,000**	**196,000**	**133,000**
Fennell	Power	27,000	31,000	87,000	46,000	25,000	21,000	14,000
Bowron	Power	23,000	29,000	52,000	31,000	18,000	16,000	11,000
Raft	Power	21,000	13,000	46,000	27,000	16,000	14,000	10,000
Gates	R/S	65,000	25,000	42,000	25,000	16,000	14,000	10,000
Nadina	Fry	78,000	107,000	66,000	37,000	21,000	18,000	13,000
Pitt	Power	46,000	29,000	138,000	82,000	49,000	43,000	30,000
Seymour	Power	168,000	190,000	113,000	61,000	32,000	28,000	18,000
Scotch	R/S	61,000	16,000	37,000	16,000	6,000	5,000	3,000
Misc [d]	R/S	-	-	167,000	87,000	42,000	37,000	24,000
Summer		**6,017,000**	**2,801,000**	**5,775,000**	**3,360,000**	**1,988,000**	**1,749,000**	**1,246,000**
Chilko	Smolt/esc [e]	1,982,000	1,896,000	2,063,000	1,323,000	849,000	760,000	566,000
Quesnel	Power	2,547,000	241,000	2,188,000	1,168,000	624,000	534,000	352,000
Stellako	Ricker	546,000	542,000	897,000	595,000	395,000	357,000	272,000
Late Stuart	Power	942,000	122,000	627,000	274,000	120,000	98,000	56,000
Late		**3,369,000**	**2,803,000**	**3,082,000**	**1,641,000**	**871,000**	**746,000**	**491,000**
Birkenhead	Power	536,000	528,000	575,000	322,000	180,000	156,000	106,000
Late Shuswap	Ricker	2,286,000	1,909,000	1,863,000	991,000	527,000	451,000	297,000
Cultus	Power	28,000	68,000	18,000	9,000	5,000	4,000	3,000
Portage	R/S	68,000	47,000	90,000	41,000	19,000	15,000	9,000
Weaver	R/S	451,000	251,000	370,000	191,000	98,000	83,000	53,000
Misc Shuswap [f]	R/S	-	-	100,000	52,000	25,000	22,000	14,000
Misc. non-Shuswap [f]	R/S	-	-	66,000	35,000	17,000	15,000	9,000
TOTAL		**10,258,000**	**6,260,000**	**9,744,000**	**5,502,000**	**3,141,000**	**2,742,000**	**1,908,000**
Pink	Fry+salinity [g]	**-**	**14,303,000**	**25,504,000**	**17,273,000**	**11,698,000**	**10,605,000**	**8,144,000**

[a] probability that the actual run size will exceed the specified projection
[b] see text for model descriptions
[c] 1980-2000 mean
[d] unforecasted miscellaneous Early Summer stocks
[e] based on multiple regression using smolts and escapement as the independent variables
[f] unforecasted miscellaneous Late stocks
[g] based multiple regression using fry and salinity (July - September) (see text)

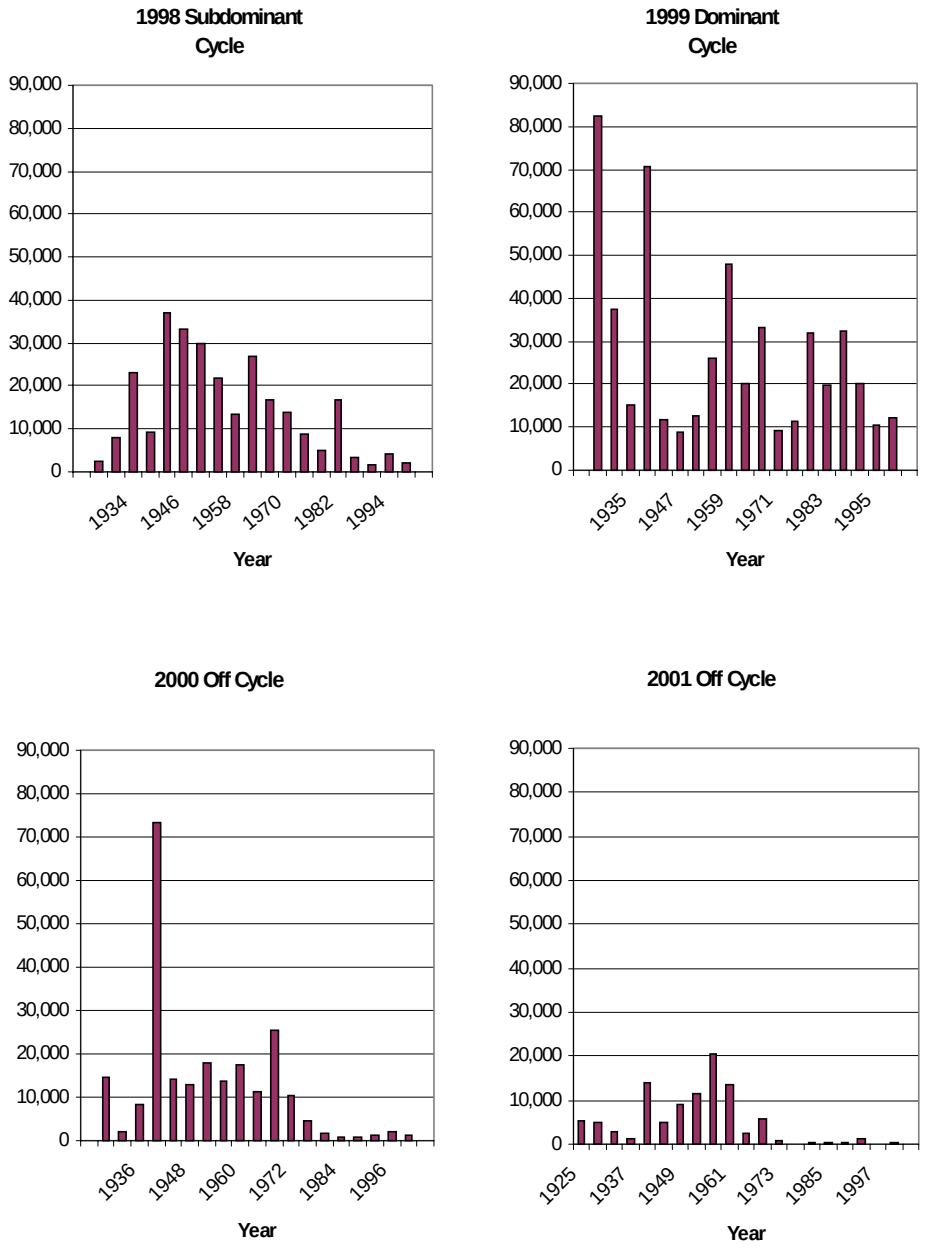

Fig. 1. Annual escapement of Cultus sockeye adults for the 1998, 1999, 2000 and 2001 cycles. Escapement is measured at Sweltzer Creek and is not adjusted for prespawning mortality.

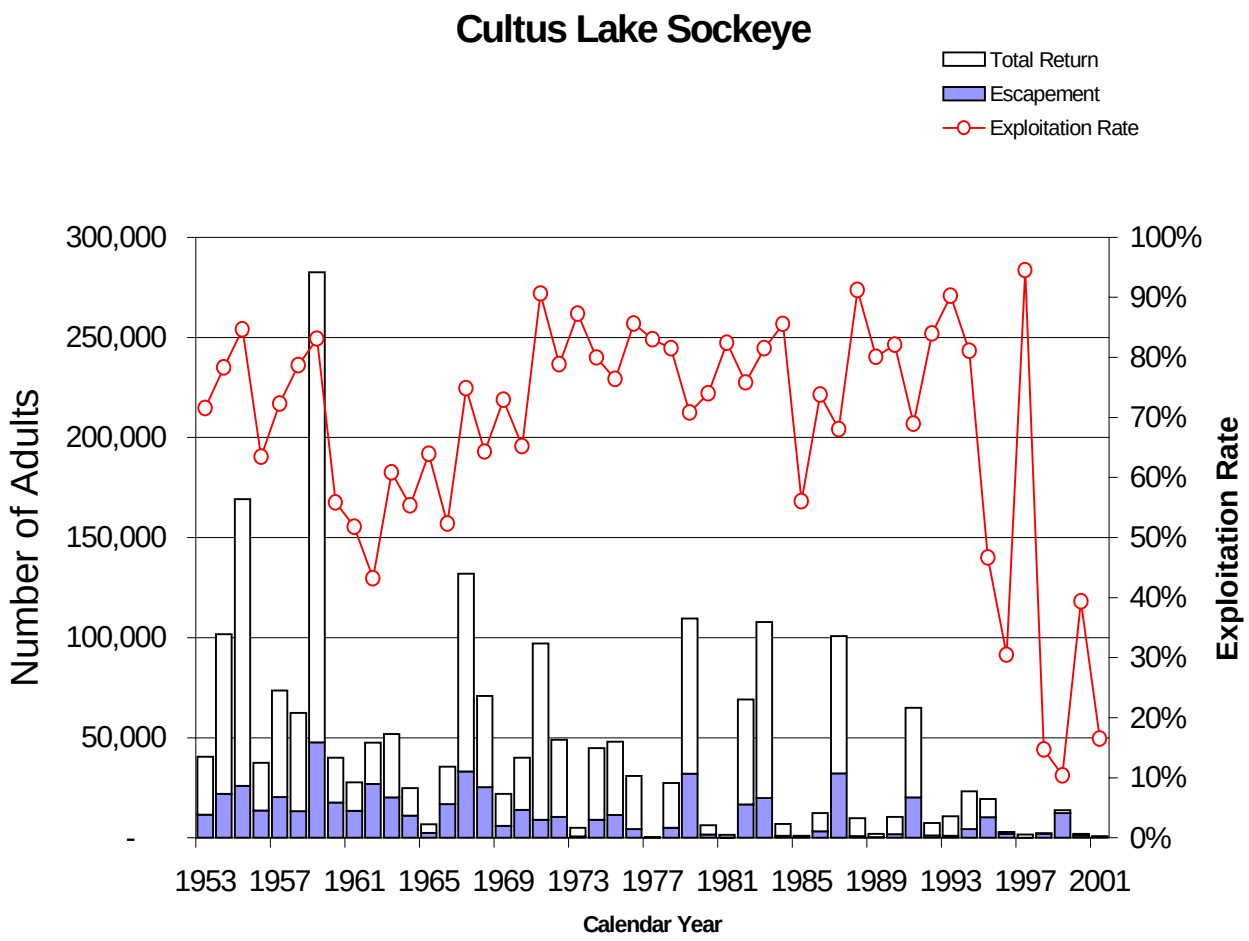

Fig. 2. Total return, catch, escapement and exploitation rate for Cultus sockeye salmon, 1952 to 2001. Escapement is measured at Sweltzer Creek and is not adjusted for prespawning mortality.

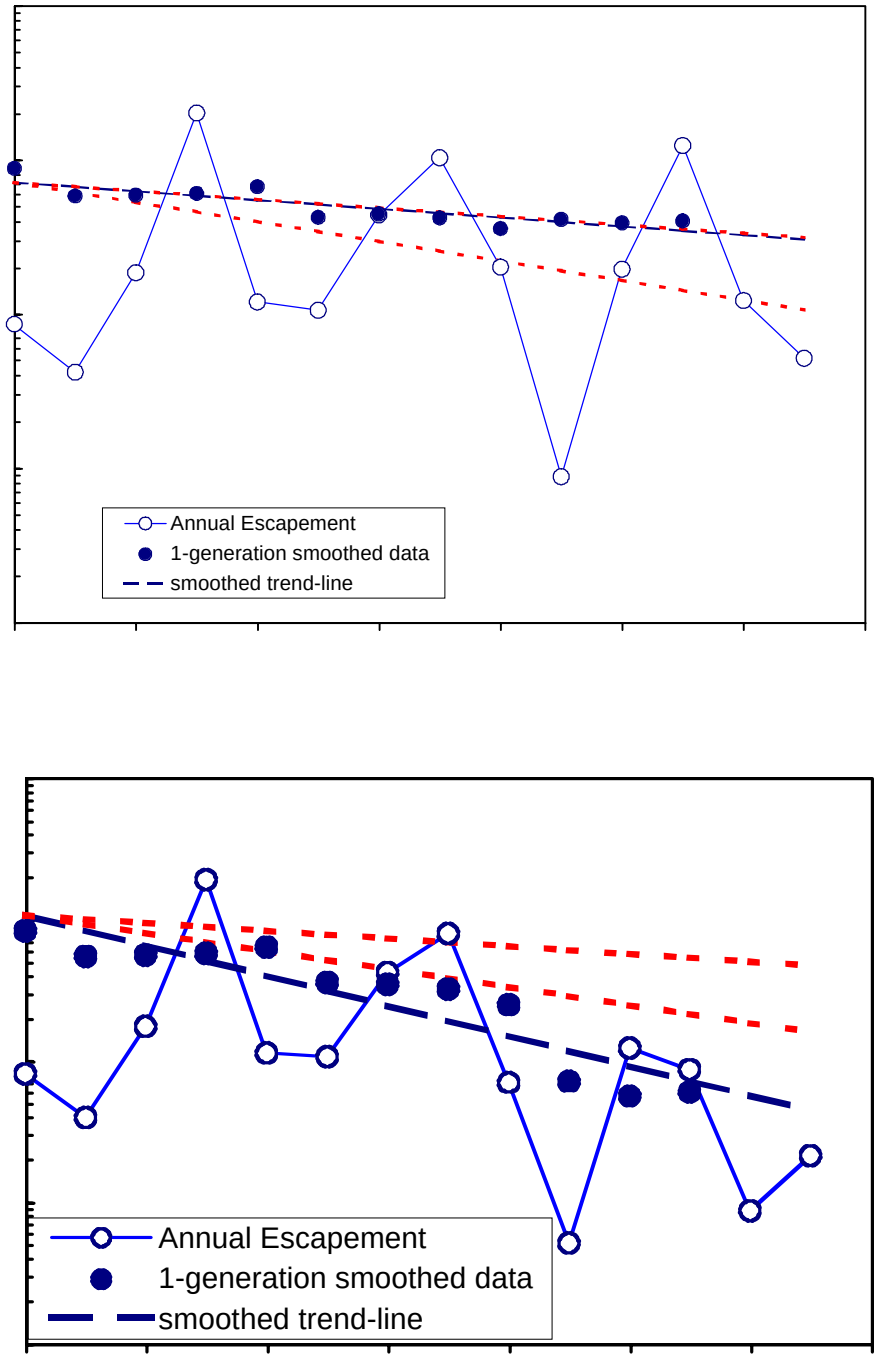

Fig. 3. Annual and one-generation smoothed adult escapement and effective spawner estimates in relation to 50% and 80% decline thresholds that coincide with the IUCN categories of *endangered* and *critically endangered*, respectively. Numbers of adults are plotted on a log scale.

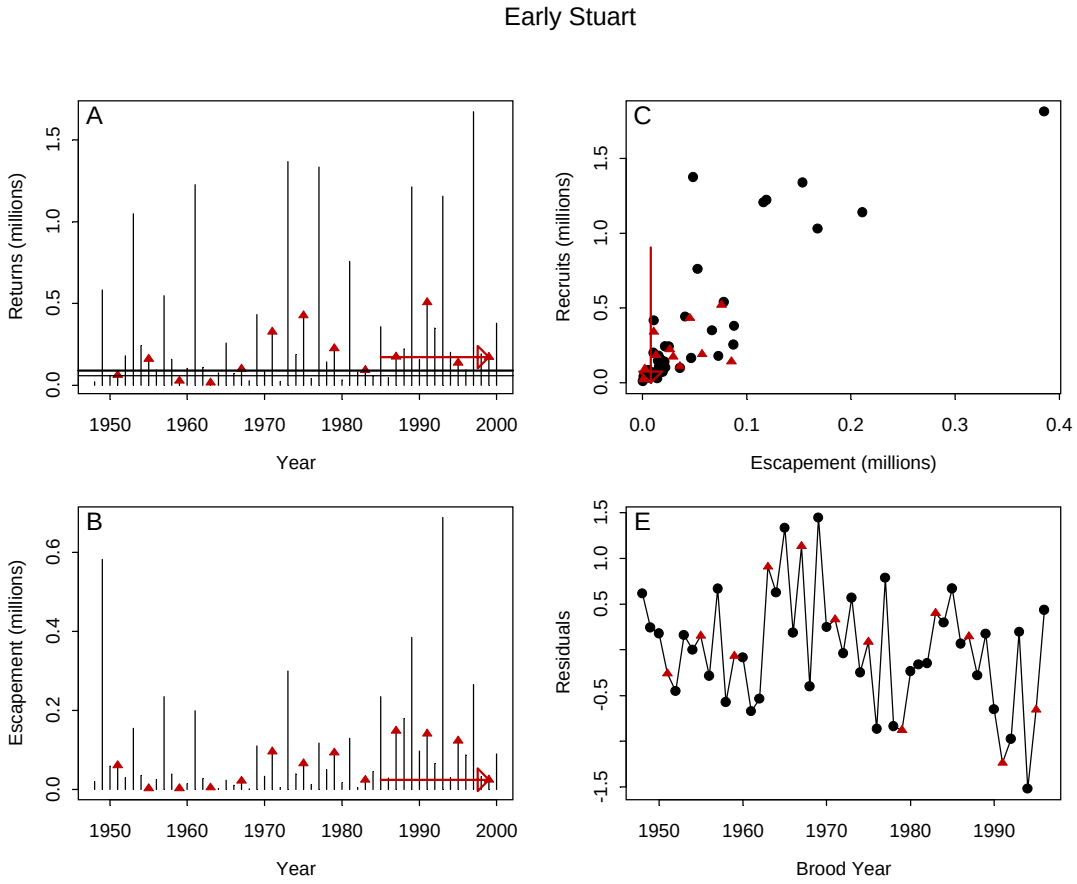

Figure 4. A) Trend in Early Stuart sockeye adult returns. Horizontal lines show the 2003 forecast at the 50% (upper) and 75% (lower) probability level. B) Trends in adult spawners, C) recruit-effective female escapement relationship and D) residual trend ($\log_e$ scale) from the fit of the power model to the relationship in C. Arrows depict 1999 data. Triangles (red) depict the 2003 cycle line data points.

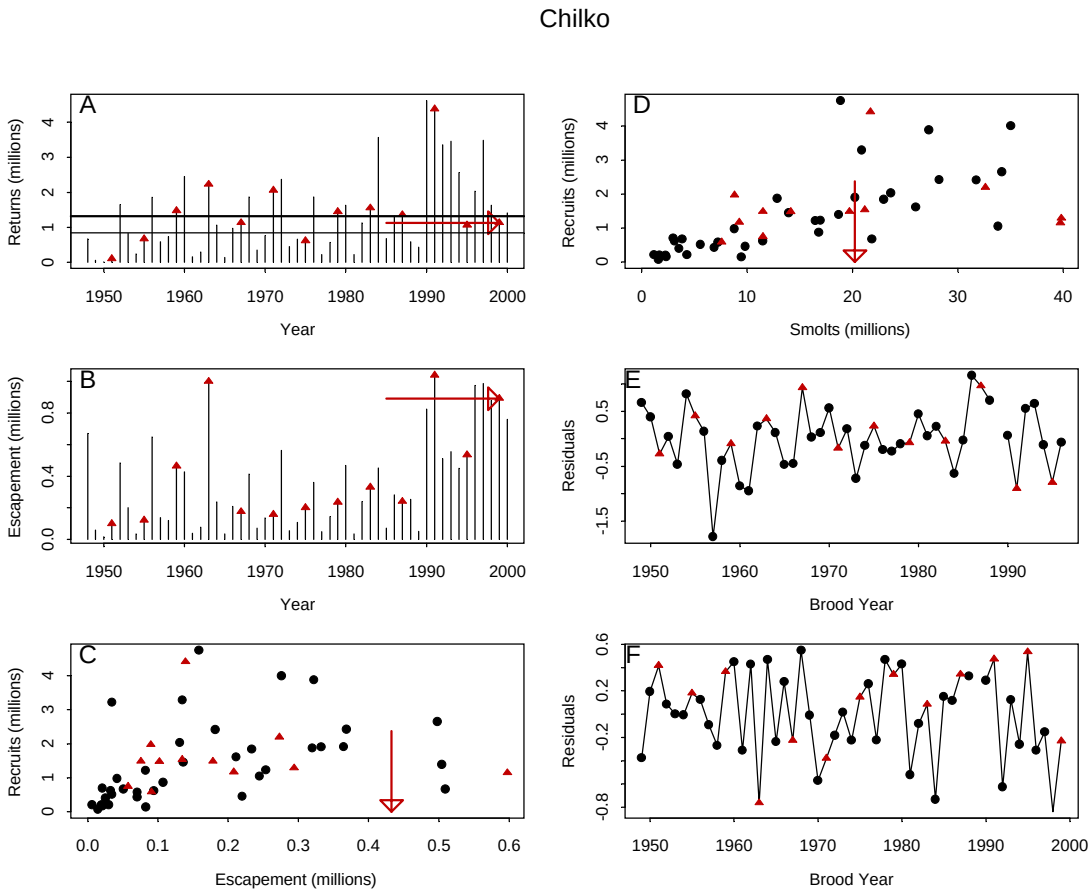

Figure 5. A) Trend in Chilko sockeye adult returns. Horizontal lines show the 2003 forecast at the 50% (upper) and 75% (lower) probability level. B) Trends in adult spawners, C) recruitment-effective female escapement relationship, D) recruitment - smolt relationship and E) residual trend ($\log_e$ scale) from the fit of power model to the relationship in D. Arrows depict 1999 data. Triangles (red) depict the 2003 cycle line data points.

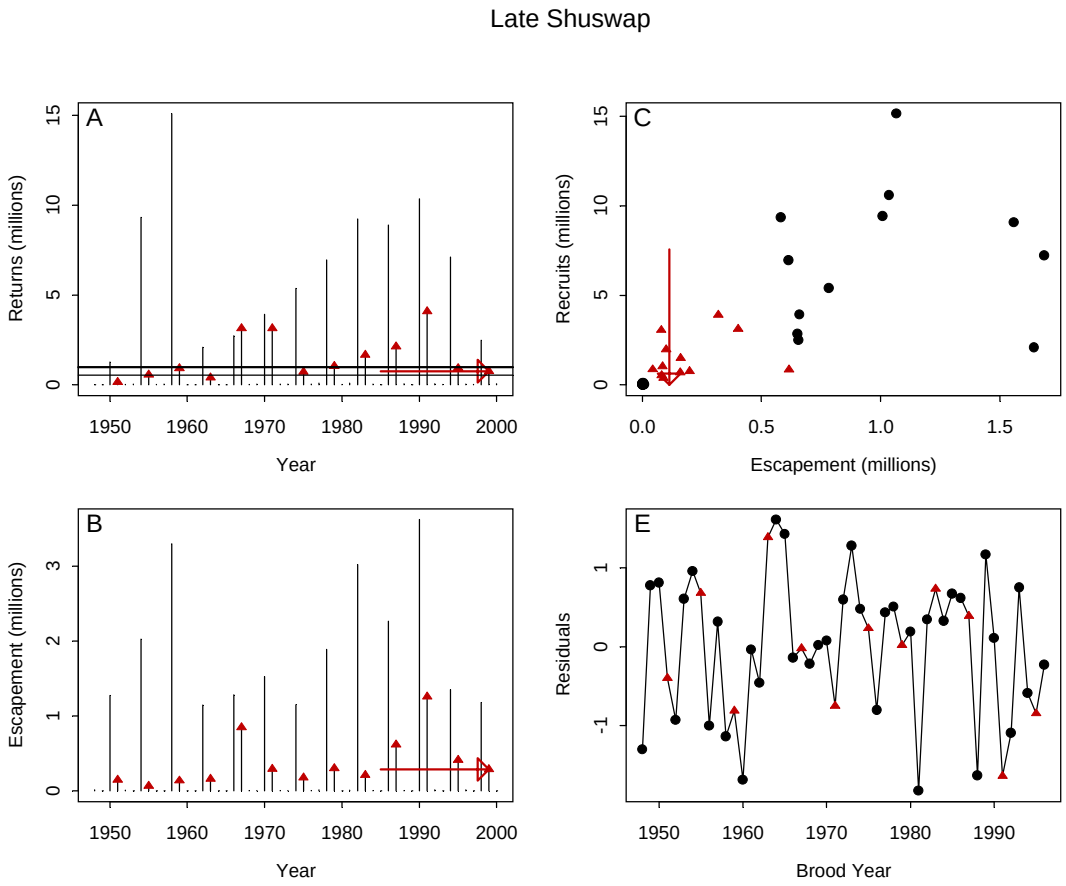

Figure 7. A) Trend in Late Shuswap sockeye adult returns. Horizontal lines show the 2003 forecast at the 50% (upper) and 75% (lower) probability level. B) Trends in adult spawners, C) recruit-effective female escapement relationship and D) residual trend ($\log_e$ scale) from the fit of the power model to the relationship in C. Arrows depict 1999 data. Triangles (red) depict the 2003 cycle line data points.

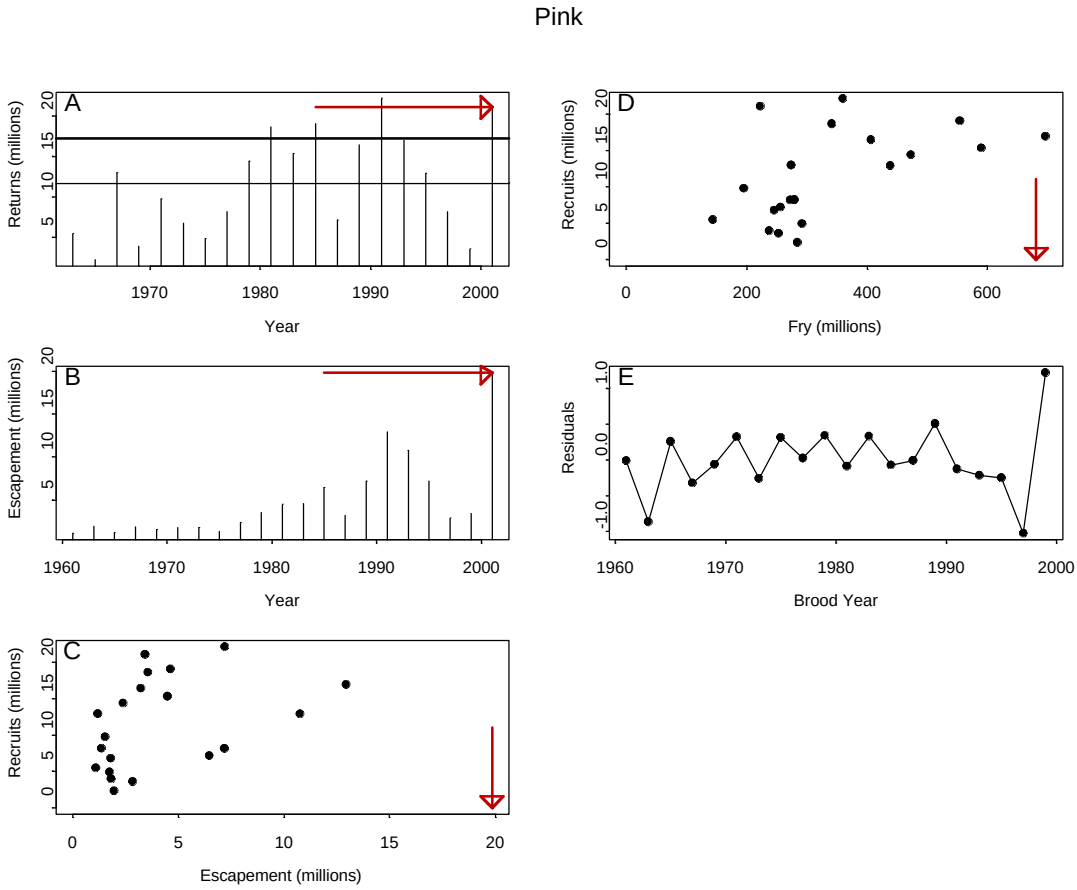

Fig. 7. A) Trend in Fraser pink salmon returns. Horizontal lines show the 2003 forecast at the 50% (upper) and 75% (lower) probability level. B) Trends in adult spawners, C) recruit-effective female escapement relationship and D) residual trend ($\log_e$ scale) from the fit of the power model that includes salinity as a variable to explain environmental variation. Arrows depict 2001 data.