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Research Document 2009/071 | **Document de recherche 2009/071**

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Using Qualitative Risk Evaluations to Prioritize Resource Assessment Activities for Fraser River Sockeye

Évaluations qualitatives du risque pour prioriser les activités d'évaluation des ressources visant le saumon rouge du Fraser

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ISSN 1499-3848 (Printed / Imprimé)

Canada

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Abstract

Management of Fraser River sockeye salmon is evolving towards an inclusive and transparent process. An important part of this evolution is to establish clear guidelines for developing assessment plans, interpreting the collected information, and sharing scientific advice. As a first step, this paper proposes a framework for risk-based rapid appraisals of Fraser River sockeye to identify major threats and information gaps.

We establish a comprehensive hierarchy of criteria and specify risk-based qualitative scales for evaluating performance relative to each of the criteria. Risk evaluations incorporate the two dimensions of severity (i.e. judging current status) and uncertainty (i.e. judging quality of information) to delineate five distinct risk categories:

- insufficient information
- status probably poor, but little information
- status poor, high confidence
- status probably good, high uncertainty
- status good, high confidence.

This research document illustrates the proposed framework, using rapid appraisals we completed for 36 conservation units based on data up to 2007. Preliminary risk evaluations proved useful for identifying information gaps, sorting sockeye stocks into risk categories, establishing risk profiles for each management grouping of Fraser sockeye, and comparing those risk profiles to past patterns of assessment coverage. For example, conservation units can be ranked based on a combination of status, vulnerability, and current human impacts. Stuart-EStu and Cultus-L emerge as the highest priority, because the risk-based evaluations indicate *very poor* status. Next in the priority list are CUs with *poor* status, and either high levels of harvest mortality (Trembleur/Takla-S) or high vulnerability (Kamloops-L).

Additional work will be necessary before the proposed framework can be fully implemented. Specifically, we recommend that DFO:

- Establish an expert panel to complete risk-based rapid appraisals
- Expand the inventory of risks and information gaps
- Complete formal assessments of priority CUs
- Build a system model for evaluating alternative harvest and assessment strategies
- Develop integrated assessment approaches

Résumé

La gestion du saumon rouge du Fraser évolue vers un processus inclusif et transparent. L'établissement de lignes directrices claires pour l'élaboration des plans d'évaluation, l'interprétation de l'information recueillie et le partage des avis scientifiques est l'une des composantes importantes de cette évolution. En guise de première étape, le présent document propose un cadre d'évaluation basé sur le risque, lequel cadre permettrait d'évaluer rapidement le saumon rouge du Fraser et d'identifier les principales menaces pesant sur l'espèce et les lacunes dans l'information.

Nous établissons une hiérarchie détaillée de critères, puis nous précisons des échelles qualitatives fondées sur le risque afin d'évaluer le rendement de chacun des critères. Les évaluations du risque englobent deux composantes, à savoir la gravité (appréciation de la situation actuelle) et l'incertitude (appréciation de la qualité de l'information), ce qui permet de définir cinq catégories de risque distinctes :

- information insuffisante
- situation probablement mauvaise, mais peu d'information
- situation mauvaise, degré de confiance élevé
- situation probablement bonne, degré d'incertitude élevé
- situation bonne, degré de confiance élevé

Le présent document de recherche expose le cadre proposé à l'aide d'évaluations rapides de 36 unités de conservation basé sur des données jusqu'à 2007. Les évaluations du risque préliminaires ont été utiles pour : déterminer les lacunes dans l'information, classer les stocks de saumons rouges de risques, établir les profils du risque pour chaque unité de gestion du saumon rouge et comparer ces profils du risque aux profils passés de couverture des évaluations. Ainsi, les unités de conservation peuvent être classées selon une combinaison de situations, de vulnérabilité et d'impacts anthropiques actuels. Les unités de conservation Stuart-EStu et Cultus-L arrivent au sommet de la liste des priorités en raison de leur mauvaise situation, d'après les évaluations fondées sur le risque. Les unités qui suivent sur la liste des priorités sont celles qui ont une mauvaise situation et, soit un taux de mortalité par la pêche élevé (Trembleur/Takla-S), soit une vulnérabilité élevée (Kamloops-L).

Des travaux supplémentaires sont nécessaires avant que le cadre proposé puisse être entièrement mis en œuvre. De manière plus précise, nous recommandons que le MPO :

- mette en place un comité d'experts pour effectuer les évaluations rapides fondées sur le risque
- améliore l'inventaire des risques et comble les lacunes dans l'information
- effectue les évaluations officielle des UC prioritaires
- construise un modèle de système afin d'évaluer d'autres stratégies de pêche et d'évaluation
- développe des approches d'évaluation intégrées

1 INTRODUCTION

1.1 A Framework for Prioritizing Resource Assessment Activities

Management of Fraser River sockeye is evolving towards a more inclusive and transparent process. An important part of this evolution is to establish clear guidelines for developing assessment plans, interpreting the collected information, and sharing scientific advice. As a first step towards the transparent design of annual assessment plans for Fraser River sockeye, this paper proposes system-wide qualitative risk evaluations to identify data gaps and major threats. Assessment activities can then be prioritized based on the balance between two considerations:

- The relative magnitude of different threats to sustainability, based on consistent qualitative evaluations of severity (i.e. current status) and uncertainty (i.e. quality of information).
- The feasibility of different assessment strategies within the opportunities and constraints of the management system (e.g. budgets, technological advancements, opportunities for collaboration).

Appendix 1 outlines a broader Resource Assessment Framework for using these risk evaluations to identify specific assessment priorities under different policy domains, and to prioritize project proposals. The proposed framework is structured around four building blocks:

- *Risk evaluations* with clearly documented guidelines to ensure consistent and transparent interpretation of raw data.
- *Assessment priorities* that identify which risks and information gaps require the most urgent attention.
- *Strategic assessment plans* that map out timelines for addressing the highest priority risks.
- *Standardized project comparisons* that allow funding agencies to select among proposals based on their contribution to the identified priorities and strategic plans.

Emerging policies and on-going initiatives establish the basic requirements for each of the building blocks. For example, the *Wild Salmon Policy* (WSP) identifies *Conservation Units* (CU) as the required level of detail for assessment, reporting, and planning. Appendix 2.1 summarizes the policy context for the assessment of Fraser River sockeye, highlighting the WSP, aboriginal rights, the *Pacific Salmon Treaty*, and on-going structural changes in Pacific fishing fleets (e.g. *Fisheries Reform*). Pestal *et al.*(2009) describe the coast-wide management approach for BC salmon fisheries, and cover each of these topics in more detail.

Based on this policy context, we propose five over-arching objectives for resource assessment:

1 - Determine the status of conservation units.

2 - Predict biological consequences of human activities.

3 - Proactively participate in the development and application of the resource management process.

4 - Improve understanding and explanation of the biological system through adaptive learning.

5 - Improve service delivery.

Appendix 2.2 describes a proposed set of assessment priorities that flow from these objectives.

1.2 The need for qualitative judgment

Recommendations for improved fisheries management typically call for clear management objectives and unambiguous performance benchmarks (Cochrane 2000, Stephenson and Lane 1995, O'Boyle 1993). However, an objective can appear to be highly specific while providing little practical guidance for management or transparency for public consultation. Qualitative judgments are usually necessary to bridge the gap from theory to implementation and from technical details to broader communication.

For example, a low benchmark for salmon populations could be defined as the *"spawning escapement required to produce a percentage of the maximum juvenile abundance (say 10-25%)"* (DFO 2005). This statement seems to capture an unambiguous objective which should allow us to transparently evaluate the performance of different salmon populations, and assess the relative risks posed by alternative management strategies. This is not the case. Several elements remain subject to differing interpretations:

- *Definitions:* There are no universally accepted definitions for quantities like spawning escapement or juvenile abundance, and each variation comes with its own set of implications. If spawning escapement is defined as "the number of adult salmon reaching the spawning grounds" then any mortality that occurs prior to spawning is effectively excluded from the evaluation. If escapement is defined in terms of *effective* spawners then these mortalities would be accounted for, but the additional estimation step increases the uncertainty of the evaluation.
- *Unique characteristics:* Each salmon population has its unique characteristics and faces a unique set of circumstances throughout the life cycle. Objectives, benchmarks, and performance measures should take these unique characteristics into account. For example, the lower benchmark for a population that has shown high productivity in past years could be reasonably set at the escapement that produces 10% of the maximum juvenile abundance. For a low-productivity population, 25% might be a more appropriate benchmark, because the implications of falling short are more severe.
- *Data quality and availability:* Many years of data are necessary to estimate the relationship between spawning escapement and juvenile abundance across a representative range of escapements and environmental conditions. For the majority of sockeye populations there is no consistent estimate of juvenile abundance. How should the benchmark be specified for data-deficient populations?
- *Assumptions:* Even where there is sufficient data to estimate the relationship between spawning escapement and juvenile abundance, alternative assumptions about the shape of the relationship will produce different values for the benchmark. For example, if a population shows regular cycles in abundance (and the cycles are assumed to be the result of biological mechanisms rather than past harvest patterns), then separate benchmarks may need to be identified for each step in the cycle, or the benchmark has to be redefined in terms of a generational average. For Fraser River pink salmon this could mean that we either specify separate benchmarks for even years and odd years, or define the benchmark in terms of the 2-year running average. For cyclic Fraser sockeye populations, we could identify 3 benchmarks (dominant year, sub-dominant year, off years), or define the benchmark in terms of the 4-year running average.

- *Risk tolerance:* Even if a single, specific benchmark value can be identified for most of the populations, performance evaluations are still subject to different interpretations of acceptable risk. How frequently does population have to fall below the benchmark to trigger an extensive recovery effort? More than once per decade? More than 2 years in a row?

Each of these elements requires careful judgment on a case-by-case basis, because numerical consistency is not the same as consistency with respect to the intent of the evaluation. This is especially pronounced for comparisons across cases with substantially different characteristics, such as species with fundamentally different life histories and ecological roles (Pestal 2008).

All of these challenges are magnified for composite indices commonly designed to capture more intricate evaluations, such as the Environmental Performance Index (Esty et al. 2006). A lot of expert knowledge is implicit in the definitions and weights used to construct this type of multi-variate summary indices.

Consistency and transparency will remain elusive as long as analysts are put into a position where they have to use personal judgment to reconcile simplistic definitions with complex biological realities, while keeping up the appearance of not doing so. The only way out of the dilemma is to acknowledge the need for personal judgments, develop qualitative guidelines to ensure they are reasonably consistent, and create incentives for extensive documentation.

1.3 Qualitative Risk Evaluations

1.3.1 Concepts

Qualitative, risk-based guidelines for evaluating threats and information gaps can be a highly effective tool for capturing expert judgment and establishing a consistent context for raw data. The resulting inventory of evaluations facilitates collaborative planning and lends itself to communication with a broader audience, which in turn enhances the transparency of the decision process.

Qualitative evaluations, regardless of the specific format and elicitation technique, have three basic elements:

- Consistent decomposition into manageable parts
- Qualitative scales for evaluating each part
- Consistent synthesis of qualitative evaluations

The first step is to decompose a complex problem into manageable pieces, encouraging consistent evaluation of a stable set of indicators. This decomposition becomes useful when it is applied consistently over time (e.g. from one year to the next) or across many cases (e.g. conservation units).

Typically, a hierarchical structure is developed to establish a link between general objectives and specific measurable indicators (Keeney and McDaniels 1999, Pestal 2004, Garcia and Cochrane 2005). This hierarchical structure helps to build agreement among the participating experts, because it de-emphasizes the ever-evolving technical details and focuses initial discussions on the broader decision context.

Choices made at this initial stage can have considerable implications for the planning priorities that will ultimately be identified. No hard and fast rules exist for setting up an evaluation hierarchy, but the following considerations offer some guidance:

- A larger set of simple indicators produces more consistent evaluations than a few complex indicators
- A deeper hierarchy, with more levels and fewer elements in each level, produces more consistent evaluations than a shallower hierarchy.
- Nesting similar indicators within a hierarchy minimizes problems with double counting and conceptual interdependence.
- Fewer indicators produce clearer recommendations.

These and other practical considerations are discussed by Borcherding and von Winterfeldt (1988), Keeney and McDaniels (1999), Hobbs and Meier (2000), Pestal (2004), Rice and Rochet (2005), and Keeney and Gregory (2005). Note that the terminology used by different authors is somewhat inconsistent (e.g. indicator vs. criterion vs. attribute vs. metric).

Qualitative scales establish the context for each indicator at the core of the hierarchical evaluation guidelines. This step converts raw data, such as 4-year average escapement, into a context-specific judgment, such as *"abundant"* or *"poor"*. Clearly specified scales, though arbitrary, ensure that each indicator is evaluated consistently across cases and by different respondents. In recent years, aspects of risk and uncertainty have been built into the evaluations, as described in the examples below. Pestal (2008) discusses probability concepts in the context of qualitative risk evaluations.

Consistent decomposition and qualitative evaluation scales are useful on their own, but the final step is to bring all the pieces back together into an overall evaluation. Many different approaches have been used for summarizing performance over a set of indicators. Rochet and Rice (2005) briefly discuss the range of alternatives, from simple graphical displays to sophisticated ordination methods. Pestal (2004) compares common multi-criteria decision support tools and reviews fisheries applications.

1.3.2 Practical Applications in Fisheries

Qualitative evaluations have been successfully used for decision-support analyses in fisheries management, but in each case the details were carefully adapted to the decisions to be made, the available information, and the intended end-users. This section briefly reviews four examples to illustrate the diversity of approaches and to establish the background for our choices described in the Methods section.

Pitcher and Preikshot (2001) developed a comprehensive sustainability checklist of several dozen indicators in five categories (ecological, economic, ethical, social, and technological).

- For each indicator they specified scoring criteria to assign up to 5 distinct values (e.g. Has average fish size landed changed in past 5 years; no (0); yes, a gradual change (1); yes, a rapid, large change (2))
- They summarize the sustainability of a fishery using multi-criteria ordination.

Pestal (2004) developed a hierarchy of multi-year objectives, annual objectives, and measurable attributes for each of the four categories of salmon allocation (i.e. conservation, FSC, recreational, commercial), for a total of 18 measurable attributes.

- For each attribute, indifference ranges and verbal assessments were elicited from the fisheries manager (e.g. Percent hatchery fish in chinook run: 0-10% = long-term target, 21-40% = acceptable in medium-term, 41-60% acceptable in short-term, 61%+=unacceptable).
- The relative importance of attributes was elicited using a graphical interface.

Fletcher (2005) describes the process used for developing a set of 3 component trees (retained species, non-retained species, indirect ecosystem impacts) for seven Western Australian fisheries. For each issue identified in the component trees, performance was evaluated in 4 steps:

- Assign one of six levels of consequence, ranging from negligible (0) to catastrophic (5) to assess fishery impacts, with context-specific definitions of each level (e.g. habitat: Minor = 1 = measurable but localized impact affects 1 to 5% of total habitat area)
- Assign one of six levels of probability, ranging from remote (1) to likely (6), with specific definitions of each. (e.g. possible = 4 = some evidence to suggest this is possible here)
- Define an overall risk score = consequence score * probability score
- Specify a range of reporting requirements and management actions triggered by the risk scores (e.g. full risk assessment report required if risk score > 7, significant additional management activity needed if risk score > 20).

Angelidis and Kamizoulis (2005) developed a similar set of scoring guidelines for each of several criteria (e.g. public health) and sub-criteria (e.g. priority pollutants, pathogenic microorganisms) to identify pollution-sensitive coastal areas.

- They used 3 possible scores, and context-specific definitions. (e.g. Priority Pollutants: 0 = minor industrial activities in drainage, 1 = existing or planned industrial activity conforming to national standards, 3 = existing or planned industrial activity not conforming to national standards)
- They summarize the sensitivity of a coastal area using a weighted additive score.

The qualitative evaluations in each of these examples summarize a large amount of expert judgment in the choice of indicators, definition of evaluation scales, and method of synthesis. They bring diverse indicators into a consistent frame of reference, and link each indicator to the overall management objectives.

1.4 Project Outline

The ultimate goal of this work is to establish a consistent, transparent framework that translates general policies and objectives into practical guidelines for prioritizing assessment projects. However, stock assessment information is used for a wide range of purposes within DFO, and by many other agencies and organizations as well. These different end-users generally bring their own assessment priorities, and sometimes even their own budgets, into a complex multi-agency planning and implementation process.

To support this planning process, we identify a comprehensive suite of criteria, grouped into clusters of closely related considerations, and specify risk-based qualitative scales for evaluating performance relative to each of the criteria. These consistent, system-wide evaluations serve as the basis for the integrated planning of assessment activities, yet are flexible enough to inform a wide range of operational decisions by different end-users.

This report illustrates the proposed approach for 3 biological considerations (status, vulnerability, direct human impacts) and outlines future work needed to capture additional elements, such as socio-economic considerations and information requirements at different stages in the annual planning cycle for sockeye management. This report covers the following:

- Consistent, practical guidelines that can be applied quickly for a system-wide screening to highlight information gaps and identify major threats to sustainability.
- Inventory of resource assessment activities.
- Initial evaluations of Fraser sockeye conservation units.
- Recommendations for future development and implementation of a Resource Assessment Framework for Fraser sockeye.

2 METHODS

2.1 Units of evaluation

We evaluate Fraser sockeye at the level of conservation units (CUs), which capture one or more populations that are closely connected and function independently of other populations. Given the inevitable ripple effect of Wild Salmon Policy (WSP) implementation, the most prudent approach is to develop the basic building blocks for a stock assessment framework at the CU level, and evaluate indicators at coarser or finer resolutions evaluations where appropriate or necessary.

Some of the indicators can only be evaluated for management units (MU). For example, we approximate harvest mortality for small CUs based on recent exploitation rates for co-migrating major stocks.

Information requirements for a management unit can be evaluated based on threats and information gaps identified for the component CUs. For example, in-season assessment requirements for the Early Summer aggregate will be strongly influenced by the status and vulnerability of the 13 CUs in that management unit.

Some of the indicators explicitly reflect the individual populations that make up a CU. For example, our evaluation criteria for CU vulnerability incorporate measures of diversity within a CU (e.g. life histories, genetic) and the distribution of abundance across component populations.

2.2 Data Sources

2.2.1 Conservation Units and Escapement Data

The most comprehensive source of information about Fraser sockeye populations is the Salmon Escapement Database System (nuSEDS) maintained by DFO, which contains an almost complete archive of escapement observations at a very detailed level (i.e. individual sampling sites).

nuSEDS data was used to identify the conservation units for Fraser sockeye. Conservation units capture one or more populations that are closely connected and function independently of other populations. For sockeye, this was defined based on a combination of life history (i.e. lake, ocean, or river type), rearing lake, and run timing.

A summary of 46 preliminary CUs and corresponding nuSEDS data was provided by Blair Holtby (DFO) in March 2007, and was used for draft versions of this report. The methodology for identifying CUs has since gone through a scientific peer review (Holtby and Ciruna 2007, DFO 2008), and the resulting list of CUs has been revised after scientific and public review (DFO 2009a). Carrie Holt (DFO) provided an updated list of CUs and corresponding escapement data up to the year 2007 in March 2009. In this latest version, 275 sampling sites of Fraser River sockeye are grouped into 36 conservation units (Table 1 to Table 4).

In this report, CUs are labelled based on the management group and rearing lake. For example, Takla/Trembleur-EStu is an early-migrating group of populations that rear in Takla and Trembleur lakes and are managed as part of the Early Stuart timing group. These have been identified as functionally distinct from a second group of populations that also rear in Takla and Trembleur lakes, but migrate as part of the Summer run. Holtby and Ciruna (2007) also identify several CUs of river-type sockeye, which are labelled based on CU name and type in this report (e.g. Widgeon-R).

Table 5 to Table 7 summarize current escapement surveys, and Figure 1 shows the availability of escapement estimates.

Table 8 lists the 36 conservation units for Fraser River sockeye with a summary of escapement data. Building on this rich dataset, many of the biological indicators are based on escapement information (e.g. trend in abundance, variability in abundance, number of populations in a conservation unit). Note that only non-zero escapement observations were used for the results presented in this report. nuSEDS records indicating “presence”, “not inspected”, or “no information” for a sampling site in a given year were excluded. Estimates of zero escapement for a CU (i.e. sum of site escapements = zero) were treated as missing observations.

Figure 2 shows the distribution of long-term average escapement across sites, CUs, and stocks.

Reviewers of this report continue to raise concerns regarding the definition of some CUs, as well as the corresponding escapement data. These on-going discussions affect up to half of the current list of CUs, which are marked by * throughout the results presented in this report. Escapement data for these CUs will be formally reviewed and consolidated as WSP implementation continues with the development and peer-review of formal status benchmarks (DFO 2005, Holt 2009).

Keri Benner (DFO) and Timber Whitehouse (DFO) provided the following commentary on 18 of the 36 CUs identified by DFO (2009a):

- *Chilko-ES*: This population on the south end of Chilko Lake has similar timing as the other three Chilko populations, which are combined in the Chilko-S. However, this population has a distinct life history, consisting solely of lake spawners with a unique early freshwater nursery. This population is assessed annually as part of Chilko surveys, and escapements were reported separately until 1989, but are now rolled up into the total Chilko estimate. DFO Stock Assessment could generate a separate estimate for recent years and develop a status evaluation based on available index data.
- *Chilliwack-ES:* The available escapement time series for Chilliwack Lake goes back to 1938, but most years before 1970 are zero entries, which are excluded for the results presented in this paper. The escapement time series for Dolly Varden Creek is shorter, with a first observation in 1988 and spotty coverage until 2000.
- *Francois-S*: These 3-4 sites constitute recent overflow from Stellako, and would be surveyed if warranted by observations. Historically there may have been a distinct population in Nithi River that would have met the lake- rearing criterion for CU definitions, but now this population is simply correlated with Stellako abundance (i.e. only see abundance here in large Stellako years).
- *Fraser-ES*: This is potentially an extirpated CU or relic population. More escapement data is available than the 7 non-zero observations currently in nuSEDS. The population was checked annually until 1991, with generally small abundances (<1,500) and several unrecorded 0 counts in the 1980s. Stellako populations (Fraser-S CU) are surveyed annually, and if fish were observed going into the Endako they would be surveyed. In some recent years the Endako has been checked, but the 0 observations were not recorded in nuSEDS.
- *Indian/Kruger-ES:* This is not a persistent population. Opportunistic surveys are conducted if warranted due to high abundance or difficult migratory conditions.
- *Kamloops-L*: This is the South Thompson river population. A complete time series of escapement since 1838 is available. This population is most abundant 2 of 4 years on

dominant and sub-dominant Adams River/Shuswap Lake cycles. It is likely not genetically distinct from the Adams River/Shuswap Lake populations, but uses a separate rearing lake.

- *Kawkawa-L*: This is not a persistent population, because fish going into Kawkawa are likely exhausted migrants from different populations. While this site consistently has spawners, the source populations probably change depending on migration conditions.
- *McKinley-S*: This population is probably not genetically distinct, but does use a separate rearing lake. The McKinley system is surveyed annually, providing fence counts of all fish into system. However, the resolution to break out Upper vs. Lower McKinley is only provided in some years when the survey crew has the opportunity to put in a second fence. Stock Assessment could develop a trend indicator for this population based on the historical fraction of Upper vs. Lower abundances.
- *Nadina-ES*: This site in Glacier Creek has no long-term persistence and is genetically identical to the Nadina River and channel populations, which are rolled up into to the Francois-ES CU. The Nadina system is surveyed annually, and the survey is expanded to cover Glacier Creek if fish are present. The survey frequency is the same as for Francois-ES, but only 2 non-zero records are currently included in nuSEDS.
- *Nahatlatch-ES:* The combined escapement time series for the lake and river goes back to 1938, but most of the nuSEDS entries before the late 1970s are either “0” or “no information”
- *Stuart - EStu*: This is not a persistent population. Surveys of these 2 sites are conducted if warranted based on observations in the rest of the Stuart system (e.g. high abundance, indications of stress or difficult migratory conditions).
- *Taseko-ES:* There are 43 non-zero escapement observations currently in nuSEDS, but more data is available going back to 1938 (i.e. 0 records, presence/absence).
- *River-type CUs (6)*: These are subject to on-going review of genetic composition in constituent spawning sites. For example, annual surveys are conducted on all persistent populations of the Middle Fraser–R CU (i.e. Quesnel and Nechako mainstems), supplemented by opportunistic surveys on all remaining (non-persistent) populations are conducted when warranted, typically in years with high abundance or high migratory stress. The source populations for these sites probably change depending on migration conditions in the Fraser.

The following 4 preliminary CUs (March 2007 version) were incorporated into other CUs (DFO 2009a). Keri Benner (DFO) and Timber Whitehouse (DFO) had previously provided the following commentary:

- *Mabel-ES:* This site would be surveyed if there were fish observed moving into it from other systems, but it hasn't been a distinct population in recent decades. It may have been a distinct population prior to the 1913 Hell's Gate slide.
- *Momich-ES*: The Upper Momich population is likely not genetically distinct from the lower Momich population, but uses a separate rearing lake. This population is covered by the annual Momich-Cayenne survey. If abundance in the lower system warrants it, then the survey is expanded to cover the Upper Momich. More data is available for this population than the 3 observations currently in nuSEDS, but many of these are 0 entries from years where the system would have been surveyed if fish were present. The Upper Momich population is now part of the Shuswap Complex – ES conservation unit.

- *Pitt-L*: This single observation of apparent lake spawners was simply a mismatched record from 1956. Pitt River is surveyed annually and occasional spawners at the mouth of river ("on the fan") are included in the Pitt River estimate.
- *Wasko-S*: Wasko Creek is surveyed annually, but is likely an overflow population during abundant Horsefly years. Horsefly spawners are rolled up into the Quesnel-S CU and mark-recapture tagging studies show mixing of Wasko and Horsefly spawners. Wasko Creek is now part of the Quesnel-S CU

Reviewers of this report also raised the following potential concerns regarding nuSEDS escapement data:

- Not all populations are consistently surveyed and some reviewers identified potential concerns regarding data continuity when individual populations are rolled up into a conservation unit without adjusting the total escapement for missing data. For example, a trend in CU abundance could be caused by a change in survey coverage of the component populations. However, this shouldn't significantly affect the conclusions of this preliminary evaluation of Fraser sockeye CUs (Timber Whitehouse, pers. Comm.).
- The nuSEDS output may not reflect the distinction between the wild and enhanced components of populations with spawning channels. This could strongly bias the risk evaluation of Anderson-ES, which roughly corresponds to the Gates Creek stock unit, and Harrison Upstream-L, which corresponds to Weaver Creek.

For this report, which focuses on demonstrating the concepts and illustrating the approach with extensive examples, it is sufficient to work with the most recent list of CUs (DFO 2009a) and corresponding nuSEDS data as provided by Carrie Holt (DFO) in March 2009. The on-going review of conservation units and corresponding escapement data does not affect the methods and recommendations presented in this report. The comments provided by Keri Benner (DFO) and Timber Whitehouse have been included in the interactive decision support tools.

Updated versions will be made available once CUs and associated data have been finalized.

2.2.2 Production and Exploitation Data

The *Production Database* maintained by the Pacific Salmon Commission (PSC) contains a record of escapement and recruitment estimates for stock groupings of Fraser sockeye. Many CUs match the popular notion of a sockeye stock (e.g. Chilko-S) and some of the commonly used stock groupings contain several CUs (e.g. Early Stuart has 2). However, not all of the CUs exactly match the stock groupings used in the production database. Table 1 matches CUs to stocks used for forecasting, based on data files provided by Ian Guthrie (PSC) and Sue Grant (DFO)

Rough qualitative evaluations of exploitation rates (e.g. 10-30% = Low) for each CU were based on estimates for corresponding stocks.

2.2.3 Capacity Data

Estimates of lake capacity for sockeye production are based on the photosynthetic rate (PR) model provided by Jeremy Hume (DFO) in March 2005. The PR model estimates the escapement that maximizes juvenile recruits based on the maximum smolt biomass that can be supported in the lake, as determined by surface area and daily photosynthetic rate, adjusted for non-sockeye fish biomass.

Estimates of lake capacity were adjusted using the following assumptions:

- In cases where a capacity estimate covers multiple CUs in a single lake, partition the estimate among CUs based on recent percent contribution to the lake. For example, Harrison Lake has the estimated capacity to support the smolts produced by about 793,000 spawners. Harrison D/S-L made up about 15% of recent escapement into Harrison Lake resulting in a capacity estimate of 120,000. Harrison-L U/S contributed 85% of recent escapements, resulting in a 673,000 capacity estimate for that CU.
- Use the natural, not fertilized, capacity estimate for Chilko Lake.
- Use the 2003 estimate of 2.2 Million for Quesnel, not the pre-1995 estimate of 1 Million.

2.2.4 Marine Survival Data

Annual estimates of smolt abundance since 1951 are based on photographic sampling at the outlet of Chilko Lake. Biological samples are collected for age and body size (length and weight) composition. Smolt abundance coupled with adult recruitment are the basis for estimating post-smolt (ocean) survival. Estimates of ocean survival from Chilko Lake are the only long-term estimates of ocean survival for Fraser sockeye. These data are instrumental for assessing the response of Fraser sockeye to ocean and climate effects on survival and productivity of Fraser sockeye.

2.2.5 Inventory of Current Assessment Activities

Summary descriptions of current escapement surveys were provided by Timber Whitehouse (DFO), Cindy Samaha (DFO) and Keri Benner (DFO), and are included in Table 5 to Table 8. Catch monitoring surveys have not been matched to conservation units, and are not formally dealt with in this version of the risk evaluations.

Jeremy Hume (DFO) contributed an inventory of rearing lake surveys. Following suggestions by David Patterson (DFO), this information was adjusted for lakes with multiple CUs. Lake productivity surveys apply equally to all CUs in a lake, but biosampling of juveniles and acoustic surveys in the Fall cover only abundant CUs (Table 8):

- If the average abundances of both CUs in a lake are roughly at the same order of magnitude, then the assessment likely included samples from both CUs. However, results can’t be assigned to a specific CU, which introduces an additional source of uncertainty. This includes Adams Lake (Early Summer and Late), Shuswap Lake (Early Summer and Late), and Trembleur Lake (Early Stuart and Summer).
- If one CU is much less abundant than the other, then the surveys likely don’t reflect it, and these are entered into the inventory as “no data available”. This group includes Stuart-EStu, Chilko-S, Fraser -EStu and Kamloops-ES.

Figure 3 shows lake assessments by CU.

2.3 Risk factors

2.3.1 Definition

The medical literature defines risk factors as attributes or traits associated with increased incidence of an illness. Risk factors can often be identified even if no direct causal mechanism has been established. For example, exposure to sunlight was identified as a risk factor for skin cancers before the physiological mechanisms were fully understood. The same approach can be used to tackle the many complex considerations that affect the health and sustainability of a conservation unit.

We define three categories of risk factors to identify information gaps and threats to sustainability:

Biological risk factors = characteristics of a CU that are associated with increased probability of not meeting biological objectives (e.g. vulnerability).

Social risk factors = characteristics of a CU that are associated with increased probability of not meeting social objectives (e.g. harvest stability).

Management risk factors = quality and timeliness of information required for managing towards biological and social objectives (e.g. quality of in-season abundance estimates).

2.3.2 Hierarchical Structure: From Risk Factors to Indicators

A basic building block for the resource assessment framework is consistent decomposition of the many complex considerations into manageable pieces for evaluation. Figure 4 illustrates the proposed hierarchical structure for grouping and evaluating the many different indicators that influence the overall evaluation of each CU:

- *Risk factors* capture groups of closely related criteria (e.g. vulnerability of a CU is risk factor, and productivity is one of seven general criteria to evaluate vulnerability).
- *Qualitative guidelines* describe how evaluations for a set of general criteria are combined into an overall evaluation for each risk factor. These guidelines should explicitly document the types of special cases encountered by the evaluators. For example, how should productivity be considered in combination with life history and habitat sensitivity to evaluate overall vulnerability of a CU? Should this evaluation be adjusted to account for the observed inverse relationship between productivity and abundance (i.e. typically observe high recruitment *per spawner* at lower abundance)? Qualitative guidelines, and thorough documentation by evaluators, establish as a robust and practical framework for dealing with the many possible cases, and the complex interactions between the different characteristics of salmon populations. Sections 2.4.3 to 2.4.7 document the proposed guidelines.
- For each of the general criteria, a *specific indicator* exactly defines the quantity being evaluated, with an emphasis on readily available data. For example, we define productivity as average recruits per spawner (R/S) over the last 3 generations.
- For each of the specific indicators, a set of *qualitative scales* ensures consistent evaluation across conservation units. We identified severity and uncertainty as the two most important aspects to be evaluated for each of the indicators (e.g. R/S between 1 and 2 = poor = severity score of 4). These scales should be very prescriptive to ensure consistency in this step, which

brings raw information into a common frame of reference. Case-by-case nuances should be considered, and documented, when individual indicator scores are rolled up into the broader evaluation for a risk factor.

Several considerations influence the choice of risk factors and criteria:

- Each risk factor should be clearly linked to one or more of the objectives identified in Appendix 2.2. For example, status evaluations are a core element of the *Wild Salmon Policy*.
- Each risk factor should point to a specific type of advice or information need. For example, conservation units that are identified as highly vulnerable require more frequent status assessments.
- The risk factors and criteria should clearly fall within the scope of resource assessment.
- To support system-wide comparisons, indicators should draw on information that is readily available for most of the conservation units. For example, we evaluated most of the biological indicators based on total escapement data. Theoretically, many of the same indicators should also be evaluated for total run size, recruitment, and effective female spawners (e.g. trend, recent relative to long term average).
- To establish information needs for the future, additional indicators need to consider *Wild Salmon Policy* objectives relating to salmon habitat and the broader ecosystem. For example, we include an indicator that compares current abundance to the system capacity indicated by Traditional Ecological Knowledge. This indicator has not been scored, but flags an important information gap.

2.3.3 Biological Risk Factors

We propose to group biological indicators into four categories as follows:

- *Status* captures current performance of the conservation unit
- *Vulnerability* identifies how susceptible a CU is to potential future threats
- *Level of direct human impact* summarizes different sources of mortality,
- *Environmental conditions* reflect long-term, large scale changes that affect Fraser sockeye throughout their life cycle

Following this interpretation, habitat-related criteria are incorporated into three different risk factors. Abundance relative to habitat capacity falls under status, sensitivity of critical habitat is included under vulnerability, and spawning and rearing habitat are evaluated based on capacity and quality under environmental conditions.

Similarly, criteria related to the distribution of escapement within a CU or over time are incorporated into two separate risk factors. The relative abundance of component populations in the most recent 4-years is included under status, but the variability in abundance between and within generations falls under vulnerability.

The distinction between status, vulnerability, and environmental conditions is not clear-cut. For example, poor migration conditions resulting in high en-route mortality are currently captured under environmental conditions, but they also increase the vulnerability of a CU, and some stakeholders might argue that they indicate poor status under a broad interpretation of the WSP. However, the main purpose here is to develop a practical, consistent tool for evaluating the differences between CUs, and prioritizing assessment activities based on these differences. For this purpose it is sufficient to develop some reasonably comprehensive hierarchy that puts the most important indicators into broader context and avoids double-counting.

Figure 5 lists the general criteria identified for each of the biological risk factors, and matches these criteria to the basic questions they address.

2.4 Qualitative Evaluation of Risk Factors

2.4.1 Qualitative Scales for Evaluating Severity and Uncertainty

Qualitative evaluations are a highly effective format for compiling expert judgment. They establish a consistent frame of reference for the raw data and encourage analysts to explicitly state their opinions based on available information. We propose qualitative evaluations for each indicator based on two important aspects of risk:

- For *severity*, evaluations reflect the immediacy and magnitude of actions required to address the issue. Severity is evaluated on a scale from 1 to 5 (i.e. negligible to major).
- For *uncertainty*, evaluations reflect the amount and quality of available data. Uncertainty is evaluated on scale from 1 to 4 (i.e. very low to high).
- If the available information is not sufficient for evaluating severity, the severity field is left blank and a score of 10 is assigned for uncertainty. This is intended to capture the precautionary approach entrenched in the *Wild Salmon Policy*, and works well to flag information gaps in the additive risk scores (see next section).

Figure 6 illustrates these general qualitative scales for evaluating severity and uncertainty. Appendix 3 lists proposed indicators and evaluation scales for the biological criteria identified previously.

Evaluating severity and *uncertainty* is subtly different from evaluating severity and *probability*. Classic risk analysis addresses two separate questions: How likely is it that an undesirable event occurs, and if it occurs, what are the implications? The answers to both questions are combined to estimate risk, which is defined as *expected loss*. This concept works well for decision settings with clearly discrete, catastrophic events. For example, engineers may compare alternative designs for a hydro-electric dam based on the estimated probability of a dam breach during an earthquake, and estimated losses associated with a complete breach at different sites. Both of these estimates are uncertain. Risk matrices have been developed as a qualitative approximation for situations in which severity or probability are difficult to pin down. For example, Fletcher (2005) evaluates frequency of occurrence and level of consequence, and multiplies the two qualitative scores to arrive at a risk score (i.e. expected loss).

This basic concept has to be adapted for the context of prioritizing assessment activities. The purpose of our evaluation is not to compare risks (i.e. expected losses) associated with alternative strategies, and considerations such as the *status* or *vulnerability* of a conservation unit are not discrete events. The question of interest here is not "*What are the losses associated with a poor status of this CU, and how likely will these losses occur?*", but rather "*What is the current status of this CU, and how much confidence do we have in our estimate of its status?*" That second question leads us to evaluate *severity* and *uncertainty*.

Pestal (2008) further discusses probably concepts in qualitative risk evaluations, and contrasts the assumptions implicit in four types of risk assessments: (1) quantitative estimates of probability,

(2) qualitative estimates of probability, (3) quantitative estimates of probability and severity (i.e. expected loss), and (4) qualitative estimates of probability and severity.

As part of the evaluation, the rationale for each score should be documented by the analysts, and include additional information, such as some judgment about short-term vs. long-term implications, and expected future trends in indicators. For example, some statement about expected changes in harvest pattern should be included with the risk score for current levels of harvest mortality.

Figure 7 shows how the biological indicators fit into a broader context, and illustrates one of the interactive decision support tools compiled for this project.

2.4.2 Additive Risk Scores

Evaluations of severity and uncertainty can be considered individually, or combined into an additive risk score. Figure 8 illustrates the three steps in the evaluation, from a general description of different possibilities (e.g. “Believe that performance is good, but have little information) to a numerical score.

The additive risk scores have several conceptual and methodological advantages:

- *Easier to interpret:* The additive risk scores produce distinct categories of combinations. For example, a total risk score of 8 or 9 indicates that both severity and uncertainty are high to very high.
- *Better reflect uncertainty:* High uncertainty means that severity could be better or worse than indicated by the spotty data. In our opinion that clearly increases the potential threat associated with a particular risk factor, and adding the scores ensures that higher uncertainty implies a higher threat level. Numerically, direct multiplication of the qualitative scores for severity and uncertainty produces misleading results, because a criterion with moderate performance (3) and moderate uncertainty (3) would receive a much higher combined risk score (9) than a criterion with very bad performance and very low uncertainty (5*1=5).
- *More robust:* Multiplying the scores for severity and uncertainty also makes the final risk score more sensitive to small changes in the qualitative evaluations. For example, a criterion with very poor performance (5) would yield a risk score of 5 with an uncertainty score of 1, and a risk score 10 with an uncertainty score of 2. Given that these evaluations are by necessity rough and subjective, the overall risk score should be more robust. The additive risk score for the same scenarios is either 6 or 7. A small change in one of the component scores results in a small change in the overall risk score.

Any summary of the scores for uncertainty and severity will result in some combinations that need to be explored further, but keeping in mind different end-users we seek to provide some reasonably intuitive summary scores as well as the detailed break-down.

2.4.3 Overall Evaluation for a Risk Factor

Many complex interactions determine an expert’s assessment of a vague notion such as status or vulnerability, but not all criteria have the same influence on the overall evaluation. Any indicator can be highly misleading in isolation, and any automated summary calculation can produce false positives or miss threats. Therefore, we chose the hierarchical structure illustrated in Figure 5.

We argue that some clear guidelines for each grouped set of criteria can encourage analysts to make explicit judgments. For some risk factors it may be appropriate to simply use an average of the scores for component criteria (i.e. equal weighting). However, for many of the risk factors one of the following approaches may be more appropriate:

- Anchor scoring on the most important criterion, and then adjust the score based on the remaining criteria.
- Consider the severity of cumulative risk (e.g. different sources of mortality).
- Consider distinct combinations (e.g. high productivity is not a positive sign if it is due to low abundance).

The first priority for this project was to build agreement around a suite of indicators and to complete a rough inventory of the qualitative evaluations based on readily available information wherever possible (Figure 5). Only then do the alternative weightings even become an issue. Proposed evaluation guidelines for three biological risk factors follow below.

2.4.4 Guidelines for Evaluating CU Status

Our evaluation of CU status combines 9 criteria: trend in abundance, cycle line abundance, abundance, distribution of abundance across populations in a CU, and recent abundance compared to five different reference values: long-term average abundance, largest observed abundance, current capacity, potential capacity, and abundance based on traditional ecological knowledge. Formal status benchmarks are being developed as part of the on-going *Wild Salmon Policy* implementation, and can be easily integrated into this evaluation hierarchy once the are available (DFO 2005, Holt 2009).

The following guidelines are intended to support consistent evaluations of status across conservation units:

- *Trend in abundance* is the most important criterion, but it needs to be evaluated in the context of the other criteria. Consequently, the overall evaluation is anchored on the score for *trend in abundance*, and adjusted upward or downward based on the scores for the other five criteria.
- If the CU is abundant (escapement > 100,000) or near the long-term average, then the overall evaluation of status is 1-2 grades better than the score for *trend in abundance*. In this case the decline may simply be the result of an unusual peak 2 to 3 generations ago.
- If abundance is very low (<1,000) or far below the long-term average, then the overall evaluation of status is 1-2 grades worse than the score for trend in abundance.
- If abundance is highly concentrated on one population within the CU, then consider deducting 1 grade.

Example 1: A CU is declining strongly (4), and is at a very low abundance (4) which is far below the long-term average (4).

⇨ Status = Very Poor (4)

Example 2: A CU is not declining (1), but is at a very low abundance (4) and that abundance is low compared to highest observed period (3)

⇨ Status = Moderate (3)

Example 3: A CU has declined severely over the last 3 generations (5), but is at a moderate abundance (3) near the long-term average (1), and not too far below the highest observed (3)

⇨ Status = Moderate (3)

2.4.5 Guidelines for Evaluating CU Vulnerability

Evaluation of CU vulnerability combines 7 criteria: Productivity, diversity – life history, diversity – genetic, sensitivity of critical habitat, overlap with CUs of high harvest potential, variability in abundance, and the strength of the cyclic pattern in abundance. The following guidelines are intended to support consistent evaluations of vulnerability across conservation units.

- A good starting point for evaluating vulnerability is productivity, because low productivity (e.g. less than 2 recruits per spawner) has a clear and intuitive effect on vulnerability. Consequently, the overall evaluation for vulnerability is anchored on the score for productivity.
- If all the other criteria have good scores, then consider adding 1 grade.
- If several of the other criteria have poor scores, then deduct 1 grade.
- If several of the other criteria have very poor scores, then deduct 2 grades

Example 4: A CU is highly productive (1), but has only a few component populations (4) and abundance is quite variable between generations (3), and highly cyclic (5).

⇨ Vulnerability = Low (2)

Example 5: A CU is moderately productive (3) and abundance shows little variability (2) or cyclicity (2), but the CU has only very few component populations (5)

⇨ Vulnerability = Moderate (3)

Example 6: Additional information can influence the evaluation of a particular CU. For example, a CU is highly productive (1) and shows little variability, but there are only a few populations in the CU (4). However, if the CU has a strong enhanced component (e.g. spawning channel), then the productivity estimate may be inflated.

⇨ Vulnerability = Moderate (3)

2.4.6 Guidelines for Evaluating Direct Human Impacts on a CU

Evaluation of direct human impact combines 4 distinct sources of mortality: targeted harvest, incidental harvest, harvest-induced, and non-harvest. The overall evaluation is therefore based on cumulative mortality. For example, scores of *low* (<5%) and *very low* (<1%) for each of the four criteria add up to a moderate (<20%) for the overall severity of direct human impacts.

2.4.7 Guidelines for Evaluating Environmental Conditions

Evaluation of environmental condition combines criteria for each life stage. The overall evaluation is therefore based on the limiting factor, which would receive the worst score.

3 RESULTS

Note the comments on CUs and escapement data in Section 2.2.1.

3.1 Preliminary Evaluations

As a starting point, we focused on completing a rough, system-wide evaluation of preliminary Fraser sockeye conservation units according to three biological risk factors. The information gaps and main sources of risk identified during this initial screening then provide the basis for a strategic evaluation of assessment priorities and build support for the work required to complete evaluations for the remaining criteria (i.e. social risk factors, management risk factors).

Implementation of the *Wild Salmon Policy* (WSP) continues, and the risk inventory described in this report can be easily updated as the 6 implementation strategies of the WSP take shape. There are 3 specific areas for cross-over between WSP implementation and future extensions of these qualitative risk evaluations:

- Under Strategy 1, DFO and others are finalizing the list of Fraser sockeye conservation units and starting scientific analyses to develop WSP benchmarks for each CU (DFO 2005, Holt 2009). Once these benchmarks are publicly available, they can be easily integrated into the risk inventory (e.g. as part of the status evaluation)
- Under Strategy 2, DFO and others are focusing on habitat assessments. Once finished, the concepts and criteria developed for WSP implementation can also be included in the assessment framework (e.g. as part of evaluating environmental conditions)
- Under Strategy 4, DFO and others are building integrated planning processes. This inventory of risks and information gaps is a valuable tool for multi-sector discussions.

Note that the preliminary evaluations presented here are based on data up to 2007. More formal and up-to-date status evaluations are currently underway.

3.2 Information Gaps and Data Legacy

Strategic planning of resource assessment activities requires that each project is clearly linked to one or more of the objectives in Appendix 2.2, and the risk-based evaluations serve as a reference for establishing that connection. For example, one element of Objective 4 is to build a data legacy of biological and social information for future researchers.

The proposed risk evaluations directly address current and future information needs through the uncertainty score. For example, if the frequency or quality of escapement surveys for a conservation unit is reduced, then the uncertainty score for status indicators increases over time as fewer recent observations are available. According to the scoring guidelines for status, the uncertainty score would increase over time, and flag the growing information gap. Even if the status remained stable, the additive risk score would increase over time if escapement coverage stops, or data quality declines (e.g. changed from mark-recapture to visual survey).

Figure 9 summarizes assessment coverage since 1975 for 2 early-migrating sockeye CUs rearing in the Stuart system. The display emphasizes the timeline of data collection and total number of observations, and overlays the 4yr running average escapement for context:

- Escapement estimates are available for all years. Lake surveys on Takla and Trembleur lakes were conducted in the late 1970s and early 1980s, just before a period with increasing abundance, and then again in the early 1990s in the middle of a sustained decline. These two sets of lake surveys establish baseline information for the lake and allow comparisons between time periods. Additional lake surveys over the years 2009 to 2011 would be required to roughly continue the past level of coverage, capture lake information during a period of declining abundance, and build a usable data legacy.

Table 9 sorts the 36 conservation units for Fraser sockeye based on survey coverage since 1975, and systematic gaps in the data legacy emerge:

- 4 conservation units have complete escapement data, but no recent assessment of rearing conditions (e.g. lake capacity, smolt size).
- 2 CUs have extensive escapement data, but no assessment of rearing conditions.
- 4 CUs have shorter escapement time series, but fairly complete escapement data from recent decades. 9 CUs have scarce escapement data[1].

Table 10 and Table 11 illustrate how information gaps are identified in the qualitative evaluation:

- If information was available to evaluate a criterion for most CUs, then those CUs with insufficient information received an uncertainty score of 10, which translates into the highest possible additive risk score (see Section 2.4.2).
- If the information to evaluate a criterion hasn't yet been assembled, the evaluations were left blank. For example, 3 of 9 status criteria have not yet been evaluated: distribution of abundance across populations in a CU, abundance relative to potential capacity, and abundance relative to capacity judged using traditional ecological knowledge. However, current status could still be evaluated based on the other 6 criteria.

Figure 10 and Figure 11 illustrate the approach for Chilko-S and Takla/Trembleur-EStu.

3.3 Risk Profiles by Management Group

3.3.1 Reading Risk Profiles

Table 10 contrasts overall risk scores for each CU with assessment coverage:

- Looking down a column, one can quickly identify CUs which are performing poorly for a particular risk factor, or lack the required information. For example, current status couldn't be evaluated for 11 (30%) of the CUs (i.e. uncertainty score is 10). Status was found to be poor or very poor for another 6 CUs (i.e severity score is 4 or 5). Overall, roughly a third of the current list of conservation units for Fraser sockeye are flagged as very poor or unknown status[1].
- Looking along a row, one can quickly identify where the problem areas are for a specific CU. For example, there isn't enough escapement data for McKinley-S[2] to assess status or vulnerability, but the level of direct human impacts was considered similar to Quesnel-S and scored as moderate.

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[1] Note the comments on CUs and escapement data in Section 2.2.1.

[2] Note the comments on McKinley-S in Section 2.2.1.

3.3.2 Early Stuart

The Early Stuart group has 2 conservation units:

- The status of both conservation units ranges from poor to very poor, and for one of them (Takla/Trembleur-EStu) there is little uncertainty in the status evaluation. Less information is available for Stuart – EStu[3], resulting in a higher uncertainty score.
- The status of the later migrating CUs rearing in these lakes (Stuart-S, Takla/Trembleur-S) ranges from moderate to poor, with low to moderate levels of uncertainty.
- Overall, these evaluations show that there is little doubt about the poor state of the sockeye populations in the Stuart system.

3.3.3 Early Summer

The Early Summer group has 13 conservation units:

- Current status could not be evaluated for 4 of them due to a lack of consistent escapement data, but the status for the 9 CUs that could be evaluated is moderate, with varying levels of uncertainty in the evaluation.
- Kamloops-ES, which roughly corresponds to the more familiar Raft and Fennell Creek stock units, illustrates the need for thorough case-by-case consideration of each criterion and conservation unit to arrive at an overall evaluation. In this case the trend indicator is highly sensitive to alternative trend measures due to a unique combination of cyclic pattern and decline off a peak in the 1990s (not shown, refer to interactive decision tool). For example, fitting a slope through the 4yr running average indicates a severe decline, but fitting a slope through log-transformed escapements estimates only a slight decline.

3.3.4 Summer

The Summer group has 7 conservation units:

- Current status could not be evaluated for 2 of them because quantitative escapement estimates are infrequently reported (McKinley-S, Francois-S)[4].
- The late components of the Stuart system show moderate to poor status (see above).
- Current status for the remaining three conservation units (Quesnel-S, Chilko-S, and Fraser-S) is good to very good. They are the 3 largest contributors to total escapement into the watershed and contribute a considerable portion of the total Fraser sockeye harvest (Figure 2). This is reflected in the risk scores for direct human impacts for the entire Summer group, which range from moderate to high, covering a range of estimated mortality rates from 30% to 70% (for exact definitions of these criteria refer to Appendix 3).

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[3] Note the comments on Stuart-EStu in Section 2.2.1.

[4] Note the comments on McKinley-S and Francois-S in Section 2.2.1.

3.3.5 Late

The Late group has 8 conservation units:

- For Kawkawa-L current status could not be evaluated, because escapement estimates are not available since 1991
- For Kamloops-L[5] current status could be evaluated according to the proposed criteria, but only with a high level of uncertainty due to missing data in recent years. Escapement observations are available for only 8 of the last 12 years, but even this spotty data indicates poor status.
- The current status for Late – Cultus is very poor, and with very low uncertainty in the evaluation.
- Current status for the remaining 5 CUs ranges from moderate to very good, with varying levels of uncertainty in the evaluation. For several CUs this positive evaluation is driven by recent increases in escapement, which in turn are a result of the drastically reduced exploitation rates implemented to protect Cultus Lake sockeye. *Note:* Some of the status indicators need to be cautiously interpreted in this case due to the high variability in recent escapement combined with a strong cyclic pattern (Check the interactive decision tools).

3.3.6 River-type

6 of the conservation units are river-type sockeye:

- Current status could not be evaluated for four of them due to a lack of non-zero quantitative escapement data.
- Current status for Lower Fraser-R seems good, with a moderate level of uncertainty in the evaluation.
- Current status for Widgeon-R seems poor, with a moderate level of uncertainty in the evaluation.

3.4 Sorting conservation units into 5 categories of status

Conservation units can be screened in accordance with different policy statements. For example, an important component of WSP implementation is to evaluate the status of all conservation units and identify priority CUs for closer attention.

Table 11 sorts CUs based on the total risk scores for status. Figure 12 plots the status evaluations according to severity and uncertainty. The CUs are separated into 5 categories, each with clearly distinct assessment priorities under the WSP:

Category 1: Not enough information to evaluate status based on the proposed indicators

The first priority for the 11 CUs in this category is to determine whether these groups of populations truly are distinct functional units of sockeye, and to develop a strategic plan for evaluating the status of those that really are CUs. All of these are under review as Fraser sockeye CUs are being finalized and associated benchmarks are being developed under the *Wild Salmon*

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[5] Note the comments on Kamloops-L in Section 2.2.1.

Policy. Keri Benner (DFO) and Timber Whitehouse (DFO) provided commentary on each of these, as summarized in Section 2.2.1.

Assessment priorities for CUs in this category are to compile additional information (e.g. local knowledge, other agencies), collect additional data (e.g. escapement surveys), and develop robust assessment and harvest strategies (e.g. cap on exploitation rate) that provide precautionary protection to CUs of unknown status.

Category 2: Status is probably very poor, but very little information is available

The first priority for the 2 CUs in this category is to reduce the uncertainty in status evaluations by compiling or collecting additional data. However, these CUs also have very low average abundances (Table 8), and regular escapement surveys may not be feasible. Alternative assessment approaches or local collaboration may be needed to assess the status of Stuart-EStu and Kamloops-L

Category 3: Status is poor, and enough information is available to evaluate status with high confidence.

2 CUs fall into this category: Cultus-L, Takla/Trembleur-S. Under the WSP, the highest priority for these CUs is to identify predominant pressures and support the development of recovery/response plans.

Assessment priorities for CUs in this category are to collect to collect data about environmental conditions and sources of mortality.

Category 4: Status is probably not too bad, but there is some risk associated with potential vulnerability due to uncertainty scores.

The highest priority for the 8 CUs in this category is to establish a monitoring protocol that can detect worsening status in a timely manner.

Category 5: Status is probably good, and enough information is available to evaluate status with high confidence.

The highest priority for the 7 CUs in this category is to collect timely estimates of in-season abundance to support fisheries planning.

3.5 Past assessment coverage vs. CU importance

The previous two sections highlight numerous information gaps and uncertainties. Not all of these can be addressed with limited budgets, and assessment projects need to be prioritized based on the relative importance of different conservation units or different kinds of information. For example, should we focus assessment on those CUs with the highest spawning or rearing capacity?

Conservation units can be prioritized based on their biological contribution to the Fraser system. We identified 4 alternative measures of biological importance, and illustrate the approach with 2 of them:

- Biodiversity, approximated as % of all Fraser sockeye spawning sites captured in a CU.
- Abundance/Marine nutrients, measured as recent % contribution to total escapement into the Fraser.
- Production, measured as recent % contribution to total returns.

- Potential production, measured as % share of spawning or rearing capacity.

Table 12 illustrates the effect of using these alternative measures of CU importance. Once again, clear assessment priorities emerge. Preliminary conservation units are sorted based on % of total spawning sites.

Escapement data is complete or nearly complete for those CUs that have consistently contributed the most to total escapements, which is consistent with a production-focused approach to prioritizing assessment activities (i.e. left-hand side of Figure 2). However, assessment priorities are realigning under the Wild Salmon Policy to focus on biological diversity and the current status of all CUs (i.e. right-hand side of Figure 2). Similarly, the Pacific Fisheries Reform initiative is bringing broader social considerations into the planning process, beyond the harvested amount (Appendix 2.1).

More work is needed to expand the inventory of risk evaluations and integrate additional measures of CU importance.

3.6 Prioritizing Assessment Activities

Previous sections illustrate several different approaches for identifying assessment priorities based on the inventory of qualitative risk evaluations. Real-world planning processes, however, are not as clearly bounded as the reasoning laid out in these earlier examples. Before arriving at a decision, participants would probably explore a broader range of criteria and consider alternative combinations of criteria, risk scores, and measures of CU importance.

A significant portion of this project focused on packaging the risk evaluations and other related information so they can effectively contribute to different decision processes. We developed a stand-alone application for accessing the compiled inventory of risk evaluations, information gaps, and current assessment activities. Users can explore the inventory by looking up a conservation unit, indicator, or social group. After exploring the inventory, users can select the criteria that are most relevant to a particular decision and prioritize conservation units based on their risk scores for those criteria. For example, Fraser sockeye CUs can be sorted to reflect the question: *"Which CUs are currently facing the most severe threats?"* The intent of the question is translated for the decision tool by selecting a combination of the overall evaluations for current status, vulnerability and level of human impacts, sorting CUs based on the severity score, setting current status twice as important as either vulnerability or direct human impacts, and assigning equal importance to all CUs.

- CUs with very poor status are identified as the highest priority (Stuart-EStu, Cultus-L).
- Next in the priority list are CUs with *poor* status, and either high levels of harvest mortality (Trembleur/Takla-S) or high vulnerability (Kamloops-L).

The prototype is built in Macromedia Flash, which can be easily integrated into a website or distributed as a self-contained package in a range of file formats (e.g. pdf, powerpoint slides). E-mail framework@solv.ca for access to the latest version of these decision support tools.

4 DISCUSSION

4.1 Qualitative Risk Evaluations

4.1.1 Interpretation

The qualitative risk evaluations proposed in this report serve as a standardized inventory of expert evaluations for a comprehensive set of biological indicators, based on readily available information. There are many different uses for the qualitative information compiled for all of the conservation units, *as long as the evaluations are reasonably consistent*. The intent is not to replace subsequent expert judgment, but to support complex planning decisions with consistent qualitative evaluations of readily available information. Just as the raw data, the qualitative evaluations have to be carefully interpreted in the context of the decision at hand. Once finalized and formally reviewed, these consistent, system-wide evaluations provide the basis for the integrated planning of assessment activities, but are flexible enough to inform a wide range of specific decisions.

How funding decisions incorporate these risk scores will differ from one situation to the next. Some end-users may want to look at total scores for high level risk factors, while others may choose to look at the subset of indicators that is most relevant to a specific budget decision. Similarly, decision makers may choose to consider the additive score, or look only at one or the other component. For example, some projects under the WSP may focus on information gaps in status. In contrast, a joint federal-provincial project for habitat improvement might screen CUs based on rough evaluations of *status* and *environmental conditions* to identify highest priority spawning streams or rearing lakes. Finally, the Fraser Panel may focus on those CUs that are important across sectors but perform poorly with respect to management risk factors such as the quality of in-season abundance data (not yet completed). These are the policy filters discussed in Appendix 1.

While the decision processes may function independently, and apply different priorities, it is absolutely crucial to have a *standardized inventory of CU evaluations* to improve the consistency and transparency of the resulting assessment choices. For criteria where expert judgment is the main source of information (e.g. habitat condition) it is crucial to record brief summaries of the reasoning provided by the assembled experts.

4.1.2 Advantages of Qualitative Evaluation

This report describes a hierarchical, qualitative approach to develop a system-wide inventory of risk evaluations for Fraser sockeye. Given the scope of the decision setting, this approach has several advantages over rigidly defined, quantitative evaluations. Figure 10 and Figure 11 show two examples to illustrate the advantages:

- *Overall evaluations for a risk factor, such as status, can be completed even if the necessary information has not been assembled for all of the component criteria.* Preliminary evaluations of status presented in this report are based on a CU's performance with respect to 6 of the 9 criteria. For example, Takla/Trembleur-EStu shows a severe decline in escapement, both in the generational average (4yr running geometric mean) and by cycle line. Recent escapements are low compared to the highest observed escapements (i.e. <25%) and compared to estimated rearing lake capacity. Overall, status is severe even though recent abundance is only moderately low (i.e. between 10,000 and 100,000 spawners) and not too far below the long-term average (i.e. between 25% and 50%). However, the long-term average is pulled down by the strong cyclic pattern. Figure 11 summarizes this evaluation.

- *Overall evaluations reflect the relative importance of the different indicators and the many potential interactions between them.* For example, Quesnel-S shows good to moderate performance for all but one of the criteria for which information has been compiled (not shown). The highly cyclic pattern indicates some potential vulnerability to extreme events, but overall vulnerability is very low due to high productivity and the large number (43!) of sampling sites within the CU (used to approximate the number of populations, and scored under Diversity – Life history). A highly cyclic pattern in escapement does not necessarily point to high vulnerability of a CU (e.g. Quesnel-S), but in combination with moderately low productivity it could be considered a threat (e.g. Takla/Trembleur-EStu).
- *Some criteria may influence the overall uncertainty score more than the overall severity score.* For example, we assume that mortality due to targeted harvest is much higher than the 3 other types of human-induced mortality combined. However, estimates of incidental, harvest-induced, and non-harvest mortality are much poorer and increase the uncertainty in our overall estimate of direct human impact.
- *Uncertainty scores capture the quality and consistency of available information.* For example, the uncertainty scores for status also reflect the quality and consistency of escapement data. The evaluation scales in Appendix 3 show that an uncertainty score of 4 indicates spotty data in recent years (e.g. Stuart-EStu); 3 means that the escapement record is fairly complete, but consists mostly of visual estimates (e.g. Takla/Trembleur-S); 2 indicates a fairly complete record with some calibration of visual estimates (e.g. Quesnel-S); 1 indicates the lowest level of uncertainty and is reserved for CUs with consistent record of census data such as well-designed mark-recapture programs (e.g. Chilko-S).
- *Evaluations can be based on groups of CUs, or draw on comparisons with other CUs*. For example, we assume that the level of direct human impact falls into the same rough range for all CUs in the Early Stuart management group.

4.2 Future Work

4.2.1 Scope

The risk inventory described in this report uses partial evaluations of conservation units (CU). The purpose of these examples is to illustrate the concepts and support discussions within DFO in preparation for future planning processes.

Most early reviewers found the concept of risk factors intuitive in this context, but several pointed out that not all of the relevant considerations lend themselves to this approach. There are many complex interactions and correlations among the different risk factors and they all operate at different spatial and temporal scales. It is particularly difficult to link social considerations to a specific conservation unit.

Conservation units can also be prioritized based on their relative importance to different social groups, or based on their role in the management process (e.g. indicator populations). Social and management information can be seamlessly integrated into the proposed framework of qualitative risk evaluations.

These additional considerations have not been fully incorporated at this point, but we developed some of the concepts through workshops and feedback from intended end-users.

4.2.2 Biological risk factors

This report includes preliminary evaluations for three biological risk factors: status, vulnerability, and direct human impact. Several conceptual questions still need to be addressed before the biological criteria and indicators for these three risk factors can be finalized.

- The approach to capturing cyclic stock dynamics needs to be reviewed. The current set of indicators tracks 4yr average escapement and cycle-specific escapement under status, as well as patterns within and between 4-year generational cycles as part of the vulnerability evaluation.
- Capacity estimates for each CU need to be developed to complete the evaluation of status. These include current capacity, potential capacity, and historical capacity based on traditional and local knowledge.
- Generally applicable, simple proxy indicators need to be developed for genetic diversity and sensitivity of critical habitat to complete the evaluation of vulnerability.

Information regarding environmental conditions, captured in the fourth biological risk factor, needs to be compiled and evaluated. Conceptually, this requires a multi-disciplinary team that reviews available information for each life stage and each CU to identify bottlenecks in survival.

In the long term, the inventory of biological risk evaluations should also incorporate physiological considerations such as fecundity or fish health, and eventually expand beyond sockeye to consider other species.

4.2.3 Social and Economic Considerations

Strategic and operational choices in the assessment of Fraser sockeye are shaped not only by biological risks and information gaps, but also by many considerations that relate to the social and economic objectives of fisheries management. Through discussions with intended end-users we identified two required elements for capturing social and economic considerations in the assessment framework:

- *Social and economic risk factors* to capture characteristics of a CU that tend to be associated with increased probability of not meeting social and economic objectives. The concept of risk factors is not as intuitive for social considerations, but it should still provide a workable approach for an initial screening of conservation units. Several reviewers of earlier draft materials provided substantial feedback regarding social and economic considerations.
- *Measures of CU importance* to reflect the vast diversity of interests reliant on Fraser sockeye. Concepts and templates were developed through a pilot project with the Secwepemc Fisheries Commission (SFC).

Further development is necessary for both of these elements (see recommendations in Section 5). The remainder of this section summarizes comments and suggestions compiled so far.

The scope of social considerations included in the resource assessment framework can be bounded by establishing a link back to the types of advice that resource assessment typically provides to the decision process. For example, estimating harvest efficiency, measured as catch-per-effort, clearly falls within the scope of resource assessment. Profitability of different fisheries, measured as return on investment, is also an important indicator, but that falls outside the scope of resource assessment, and therefore outside the scope of this framework.

Harvests of Fraser sockeye are highly variable and sharing patterns are evolving in response to new policy developments (e.g. WSP, PFR). In this setting it is important to establish evaluation guidelines that can be adapted to changing sharing arrangements (e.g. treaties), and to choose an appropriate time horizon for evaluating social risk considerations.

The *Wild Salmon Policy* clearly establishes CUs as the basic unit for evaluating biological threats and information gaps, even though some indicators may be assessed for components of a CU or for a group of CUs (Section 2.1). Appropriate units of evaluation for social and economic considerations are harder to identify, because of the diversity of interests and local differences. We propose the following approach:

- Identify geographic regions with relatively homogenous harvester dynamics for each sector (FSC: marine, lower Fraser, mid-Fraser, upper Fraser / Recreational: marine, bar, terminal / Commercial: licence areas)
- Evaluate social risk factors for each run timing group and for each of the geographic areas.
- Summarize evaluations across geographic areas to arrive at an overall evaluation for a run timing group.
- Evaluate each conservation unit relative to the management unit. Is it more or less severe than for the management unit?

We compiled the following suggestions during discussions with intended end-users:

- Social considerations become more CU-specific the further up-river a harvester group is located. Specifically, harvesters in marine areas and the lower river have potential access to all of the conservation units, and social objectives are based on aggregate harvest across all those CUs. Further up-river, social objectives become very specific to the few accessible conservation units. However, some stocks have unique importance to harvesters along the entire migration route (e.g. Early Stuart providing the first fish of the year for ceremonial purposes).
- Many of the social considerations are very specific to a particular location and fishing gear. For example, sharing arrangements are defined for the total Fraser TAC based on gear types, but actual harvests vary depending on location and diversion rate.
- The social benefits derived from a conservation unit go beyond the value of harvested fish, and non-harvest benefits need to be reflected on the overall evaluation (e.g. tourism benefits of dominant Adams River run, ecosystem benefits of periodic large escapements).
- Some social objectives may need to be considered at the population level rather than at the CU level (e.g. First Nations ceremonial needs and preferred fishing sites).
- The assessment program itself has social and economic benefits that need to be captured, ranging from local employment to building capacity and trust.
- The appropriate time frame for social and economic evaluation criteria can differ substantially within and between harvester groups and attitudes toward risk are subject to drastic changes as annual fisheries unfold.

As a starting point for the development of social and economic risk factors, we structured suggestions from intended end-users into 5 categories:

- *Current benefits – General:* This risk factor identifies whether a CU is contributing a lot to the total social benefits derived from Fraser sockeye. It is analogous to status in the biological risk factors. General criteria for evaluating this risk factor include total harvest, harvest efficiency, harvest variability, harvester participation in assessment, local employment in assessment, and distribution among harvester groups.
- *Current benefits – FSC:* This risk factor identifies whether a CU is contributing a lot to FSC fisheries. General criteria need to reflect whether terminal allocations are met, how much a CU contributes to total FSC harvest, and whether FSC needs are being met (e.g. ability to preserve fish, ability to catch fresh fish for ceremonial needs, and ability to use preferred fishing method).
- *Current benefits – Commercial:* This risk factor could be approximated based on the CU's largest percent contribution to commercial harvest in recent years.
- *Current benefits – Recreational:* This risk factor could be approximated based on the CU's largest percent contribution to recreational harvest and effort in recent years.
- *Potential benefits:* This risk factor captures how current benefits compare to potential future benefits. This is similar to the notion of vulnerability in the biological risk factors. General criteria should reflect whether harvests on a CU are constrained by the status of another CU, whether harvests are constrained by uncertain information (e.g. timing, harvest rates), and how current harvests compare relative to potential harvests.

Secwepemc Fisheries Commission (SFC) staff participated in a pilot project for capturing First Nation's stock assessment priorities. During a 1-day workshop we developed a draft template for scoring the relative importance of conservation units as well as the current performance of those CUs that are locally important. The template has been offered to other First Nations technical staff for review, and will be revised based on further feedback.

SFC staff identified several distinct considerations that shape the evaluation of local importance:

- Spawning or rearing within the traditional territory
- Current fisheries contribution
- Future potential contribution
- Historic fisheries contribution
- Cultural significance
- Diversity of harvest sites (i.e. a CU may only contribute a small amount, but at a unique location)
- Overall stability and predictability of FSC benefits (i.e. substitutes when other CUs at low abundance)

Our intent is to elicit this type of information from a cross-section of BC First Nations and explore geographic patterns in CU importance (e.g. within and between the 4 areas identified earlier). A similar approach may be feasible for other harvester groups, or other approximations of importance might have to be used for recreational fisheries and commercial fisheries.

4.2.4 Management Considerations

This third category of considerations captures the quality and importance of information used in the management process. Poor performance on these evaluation criteria points to potential constraints on our ability to meet biological and social objectives (e.g. quality of in-season abundance estimates).

The management process for Fraser sockeye follows a distinct annual cycle of pre-season planning, in-season management, and post-season review. Annual pre-season abundance, timing and Johnstone Strait diversion forecasts are used to consult on fishing plans and guide management decisions early in the fishing season. In-season assessment activities in support of management are based on data inputs from a variety of sources and levels of uncertainty. Final escapement estimates are based on a wide range of survey methods.

Most of the steps in this annual management process do not operate at the CU level, and further work is necessary to identify an appropriate scope for incorporating management considerations into the risk inventory. As a starting point, we propose evaluating the quality and importance of different management inputs for each CU. For example, in-season estimates of abundance are very important for fine-tuning fisheries on abundant CUs (e.g. Quesnel-S), which is linked to social and economic considerations, but stock identification may more important for CUs of concern (e.g. Cultus-L). As the inventory of qualitative risk evaluations expands, these types of trade-offs can be incorporated into interactive decision support tools.

5 RECOMMENDATIONS

5.1 Establish an expert panel to complete risk-based rapid appraisals

We propose a risk-based framework to prioritize resource assessment activities for Fraser River sockeye. This research document illustrates the proposed framework, using a rapid appraisal we completed for 36 conservation units based on information available at this time[6]. A more formal evaluation process will be necessary before DFO and other agencies can fully implement the proposed framework.

The most efficient approach for this formal evaluation is to establish a panel of 3-4 experts tasked with the following:

- Review the proposed method for qualitative risk evaluations
- Revise the risk factors, indicators, and qualitative scales where necessary
- Complete a rapid appraisal of each risk factor for each conservation unit

This formal evaluation can be completed quickly, and serves as the basis for a strategic assessment plan to address major threats and information gaps. This work needs to be closely synchronized with the on-going implementation of the *Wild Salmon Policy*, but should not be delayed pending completion of formal status assessments under the policy.

5.2 Expand the inventory of risks and information gaps

The examples in this report show that even a partial inventory of risks and information gaps can provide important insights for setting assessment priorities. However, more information has to be integrated before the proposed framework can reach its full potential. The usefulness of the inventory grows substantially with each additional piece of information that is matched to conservation units and evaluated in a consistent frame of reference. This is analogous to a Geographic Information System (GIS), which references each set of data to specific map locations. In both cases, most of the effort goes into establishing the fundamental structure and developing the information interfaces, but most of the benefits are derived as the information base grows.

More information needs to be compiled and matched to individual conservations units or social groups. For social and management criteria it may not be necessary to collect any new data, but to tap into information that already exists elsewhere in DFO or in partnering organizations.

Systematic information gaps in the current inventory include:

- Some aspects of current status and vulnerability (e.g. distribution of escapement across populations in a CU, genetic diversity, habitat sensitivity)
- Independent estimates of environmental conditions and capacity for each life stage
- CU-by-CU measure of importance to different social groups
- Template for capturing management considerations
- Importance of catch estimation

[6] Note the comments on CUs and corresponding escapement data in Section 2.2.1.

Over the long-term, the inventory should be expanded to cover broader issues:

- Aquatic invasive species (e.g. Bass in Quesnel and Shuswap systems, mackerel during El Nino years)
- Vulnerability to climate change (e.g. southern end of sockeye range, earliest and latest migrating populations are more vulnerable)
- Ecosystem services (e.g. benefits of periodic large escapements)

5.3 Complete formal assessments of priority CUs

Conservation units (CU) serve as the basic unit of evaluation for the risk evaluations in this report, but this does not imply that all CUs have to receive the same level of assessment. Qualitative risk evaluations identify information gaps and threats, and it then becomes a policy choice to prioritize the responses.

The first step is to identify groups of CUs facing similar threats or information gaps. Once threats and information gaps have been identified, they can be prioritized based on biological and social objectives reflected in the relevant policy documents. These priorities will differ among end-users. For example, assessment priorities under the WSP focus on conservation units and their status, while assessment priorities under the Pacific Salmon Treaty focus on fisheries management (Appendix 1).

As an illustration, we identify five categories of conservation units, each with a unique combination of severity and uncertainty in the status evaluation (Section 3.4). This type of summary brings unresolved policy questions to the forefront and encourages decision makers to develop an assessment plan. For example, how should we balance our assessment efforts between potential CUs for which very little data is currently available (e.g. Chilliwack-ES[7]) and CUs for which a good information base indicates high levels of risk (e.g. Cultus-L)?

As WSP implementation progresses, the 5 status categories developed here can be matched up against the 3 biological status zones defined in the policy (i.e. Red / Amber / Green). This is consistent with the notion that CU status under the WSP will be evaluated based on a combination of indicators, not based on a single benchmark (Holt 2009).

We also identify a preliminary list of priority CUs based on a combination of the overall evaluations for current status, vulnerability and level of human impacts, assuming that all CUs are considered equally important. Priorities can be determined based on severity or uncertainty.

"Which CUs are currently facing the most severe threats?"

- Stuart-EStu and Cultus-L are identified as the highest priority because their status was evaluated as *very poor*.
- Next in the priority list are CUs with *poor* status, and either high levels of harvest mortality (Trembleur/Takla-S) or high vulnerability (Kamloops-L[8]).

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[7] Note the comments on Chilliwack-ES in Section 2.2.1.

[8] Note the comments on Kamloops-L in Section 2.2.1.

"Which CUs are currently facing the highest levels of uncertainty?"

- CUs with insufficient information for all three risk factors are identified as the highest priority (4 of the 6 River-type CUs[9]).
- Next in the priority list are CUs for which current status or vulnerability can't be evaluated, but for which migration route and timing are roughly known, allowing for a crude evaluation of harvest mortality indicated by an uncertainty score of 4 (4 of the 13 Early Summer CUs: Indian/Kruger, Nadina, Chilko, Fraser[10]).

5.4 Build a system model for evaluating alternative harvest and assessment strategies

This document lays out a strategic approach for prioritizing assessment activities using risk-based qualitative evaluations of biological, social and management risk factors. Decision makers can then array the information depending on their perspective to help guide choices about where and how to invest funding for resource assessment (Appendix 1). During development of this framework it became apparent that an additional step is required towards a fully integrated framework for assessing alternative management and assessment strategies.

Using the terminology of the International Whaling Commission, we recommend that a modeling team begin developing a Management Strategy Evaluation (MSE). Resource management and assessment is characterized by multiple and conflicting objectives, multiple user groups and clients with divergent interests. Uncertainty in the biological and management systems can result in high levels of contention and poor management outcomes. This has been a significant challenge to resource management agencies worldwide. The intent of MSE is to explicitly deal with uncertainty, trade-offs between management and assessment objectives and the consequences of alternative strategies. In many respects, the MSE is the tool needed to integrate the potential assessment options in a consistent and integrated framework for evaluating alternatives for a system-wide approach to assessment.

Key steps in the approach involve 1) identifying specific performance measures from the broader objectives of assessment and management, 2) identifying and incorporating key uncertainties in the evaluation and communicating the results effectively to client groups and decision makers. A principal prerequisite for success is the development of a process to engage and accommodate effective client participation and buy-in.

The work is proposed to occur in two stages. A conceptual MSE developed in Stage 1 will serve as a base upon which a quantitative and practical MSE model will be developed in Stage 2. As part of Stage 1, SFU hosted a workshop involving key science and management experts from DFO, PSC, First Nations, and industry. The purpose of the workshop was to build consensus on the essential biological and management system components of the model, including:

- sockeye stock and migration dynamics;
- fishery dynamics;
- in-season assessment data and methods;
- management objectives;

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[9] Note the comments on River-type CUs in Section 2.2.1.

[10] Note the comments on these Early Summer CUs in Section 2.2.1.

- in-season management and allocation process; and
- quantitative indicators of management performance.

"It is expected that stakeholder participation in model development will improve the process in three important ways. First, it will provide a way for stakeholders to have direct input to the design of a model of the Fraser sockeye management system. Second, it will expose all stakeholders to potential conflicting objectives and interactions in a computer-based environment (i.e., as opposed to testing management actions in the real world). Finally, it will improve stakeholder understanding of the purpose, inputs, and results of management simulation exercises for Fraser sockeye fisheries." (Terms of Reference – MSE Workshop)

In Stage 2, the team will develop a quantitative management model of Fraser River sockeye fisheries to evaluate the feasibility and quantitative implications of selected management and assessment procedures. Feasibility and tradeoffs will be judged relative to indicators of management performance identified in the Stage 1 workshop.

We view the MSE project as a very high priority given the roll-out of initiatives related to the *Wild Salmon Policy* and *Pacific Fisheries Reform*, which have the potential to change fishing patterns. The First Nations Treaty process will also obligate DFO to assess the ability of alternative management and assessment strategies to deliver harvest to various user groups both on the Fraser and in marine areas and meet escapement objectives with known precision.

5.5 Develop integrated assessment approaches

Once qualitative evaluations have been compiled, the focus of this project shifts back to policy requirements, and the development of strategic plans for the highest priority threats and information gaps (see Appendix 1).

Key management risk factors are the timeliness and accuracy of run size estimates at specific points in the migratory corridor including marine approach areas and in the Fraser watershed including terminal spawning locations. Reliable run size estimates are required to estimate total mortality incurred due to human activities (i.e. fishing) and environmental impacts. Several factors affect the accuracy and precision in run size estimation by species, stock and CU, including assumptions about test fishery expansion factors, diversion estimations, Mission acoustic estimation, catch estimation and en-route mortality estimation.

Recent technological advances provide an opportunity to explore alternative assessment tactics for estimating run size and total mortality in time and space during the adult migratory phase. These new developments include acoustic estimation (DIDSON), DNA stock composition, radio telemetry, and genomic assessment of vulnerability to stress and mortality.

Throughout this project, respondents expressed broad interest in developing an integrated program for improving high priority assessment activities by taking advantage of these recent technological advances. The purpose is to develop a system-wide strategy to estimate run size and mortality with known precision. There are extensive radio telemetry results from a five-year study to quantified the fate of migrating sockeye in marine and freshwater tagging locations.

A feasibility study submitted to the SEF proposes using a fish-wheel sampling platform and second sampling site to estimate abundance. This study provides an opportunity to assess an integrated program that combines radio telemetry and standard mark-recapture theory. The plan would involve two-stage sampling to estimate the total run of untagged and tagged fish, using the established hydroacoustic estimates at Mission and the telemetry estimates from the second sampling site. A pilot project over the next few years will help verify Mission abundance estimates. In the longer term, the project could lead to near-real time estimates of abundance throughout the migratory corridor.

Acknowledgements

This work was funded by DFO and the Pacific Salmon Commission's Southern Endowment Fund.

Carrie Holt (DFO) provided nuSEDS escapement data by sampling site from 1938 to 2007.

Keri Benner (DFO) and Timber Whitehouse (DFO) provided clarifications around conservation units and escapement data, as documented in Section 2.2.1.

Secwepemc Fisheries Commission (SFC) staff participated in a pilot project for capturing First Nation's stock assessment priorities.

Participants at the following meetings commented on preliminary risk evaluations and prototypes for the interactive decision tools: Fraser River Panel Technical Committee (Vancouver, January. 8, 2007), Fraser River Aboriginal Fisheries Secretariat (Kamloops, February 8, 2007), Fraser River Watershed Joint Technical Committee (Kamloops, March 7, 2007), Southern Endowment Fund Committee (Nanaimo, April 17, 2007)

The following reviewers provided substantial comments on earlier drafts of this material: Keri Benner (DFO), Karl English (LGL Ltd.), Jim Gable (PSC), Jeff Grout (DFO), Jim Irvine (DFO), Mike Lapointe (PSC), Pat Mathew (SFC), Dave Patterson (DFO), Paul Ryall (DFO), Mike Staley (IAS Ltd.), Michelle Walsh (SFC), and Timber Whitehouse (DFO).

The final draft of this research document was discussed by the Salmon Subcommitte of the Pacific Scientific Advice Review Committee (PSARC) on May 21, 2008. Proceedings from the subcommittee meeting will be made available at http://www.pac.dfo-mpo.gc.ca/SCI/psarc/proceedings_e.htm.

Keri Benner (DFO), Sue Grant (DFO), and Ann-Marie Huang (DFO) provided comments on revised results in July 2009.

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Tables and Figures

Table 1: Overview of 36 conservation units for Fraser River sockeye salmon

Mgmt Group		CU label	CU type	# of Lakes	# of Sites	Escapement* Obs	Avg(all)	Latest	Freshwater Adaptive Zone	CU Rationale	Stock**
Early Stuart	*	Stuart-EStu	lake	1	2	13	59	2007	Middle Fraser	lake	Early Stuart
		Takla/Trembleur-EStu	lake	2	42	70	82,462	2007	Middle Fraser	lake complex	Early Stuart
Early Summe		Anderson-ES	lake	1	2	59	11,094	2007	Middle Fraser	lake	Gates
		Bowron-ES	lake	1	2-3	70	9,231	2007	Upper Fraser	lake	Bowron
	*	Chilko-ES	lake	1	1	19	38,104	1989	Middle Fraser	lake	Chilko
	*	Chilliwack-ES	lake	1	2	36	3,787	2007	Lower Fraser	lake	Early Summer Miscellaneous
		Francois-ES	lake	1	3-4	67	12,905	2007	Middle Fraser	lake	Nadina
	*	Fraser-ES	lake	1	2	43	583	2005	Middle Fraser	lake	Early Summer Miscellaneous
	*	Indian/Kruger-ES	lake	3	1	3	29	1986	Upper Fraser	lake	
		Kamloops-ES	lake	2	9	70	15,246	2007	North Thompson	lake	Raft, Fennel, ES Miscellaneous
	*	Nadina-ES	lake	1	1	2	2,516	2001	Middle Fraser	lake	Nadina
	*	Nahatlatch-ES	lake	1	2	33	4,540	2007	Fraser Canyon	lake	Early Summer Miscellaneous
		Pitt-ES	lake	1	2	69	28,648	2007	Lower Fraser	lake	Pitt
		Shuswap Complex-ES	lake	8	21-27	66	47,614	2007	South Thompson	lake complex	Scotch,Seymour, ES Misc.
	*	Taseko-ES	lake	1	1-2	43	3,286	2007	Middle Fraser	lake	Early Summer Miscellaneous
Summer		Chilko-S	lake	1	3	70	332,114	2007	Middle Fraser	lake	Chilko
	*	Francois-S	lake	1	3	9	273	2002	Middle Fraser	lake	Stellako
		Fraser-S	lake	1	1	70	96,733	2007	Middle Fraser	lake	Stellako
	*	Mckinley-S	lake	1	1	19	4,432	2007	Middle Fraser	lake	Quesnel
		Quesnel-S	lake	4	51-66	67	293,220	2007	Middle Fraser	lake	Quesnel
		Stuart-S	lake	1	5	64	79,565	2007	Middle Fraser	lake	Late Stuart
		Takla/Trembleur-S	lake	2	4-5	67	48,254	2007	Middle Fraser	lake complex	Late Stuart
Late		Cultus-L	lake	1	1	70	13,805	2007	Lower Fraser	lake	Cultus
		Harrison (D/S)-L	lake	1	6-8	68	3,276	2007	Lower Fraser	lake	Misc. non-Shuswap
		Harrison (U/S)-L	lake	1	4	70	37,636	2007	Lower Fraser	lake	Weaver
	*	Kamloops-L	lake	1	1	48	11,853	2006	South Thompson	lake	Misc. Shuswap
	*	Kawkawa-L	lake	1	1-2	8	503	1991	Fraser Canyon	lake	
		Lillooet-L	lake	1	8	70	90,409	2007	Lillooet	lake	Birkenhead
		Seton-L	lake	1	1	60	6,073	2007	Middle Fraser	lake	Portage
		Shuswap Complex-L	lake	1	44-58	70	645,208	2007	South Thompson	lake complex	Late Shuswap, Misc. Shuswap
River	*	Fraser Canyon	river	-	6	10	3,662	1991	Fraser Canyon	ecotypic	
	*	Lower Fraser	river	-	5	70	21,689	2007	Lower Fraser	genetics	Harrison
	*	Middle Fraser	river	-	8-10	36	1,185	2007	Middle Fraser	timing + gen.	Stellako, Quesnel
	*	Thompson	river	-	2	4	4,255	1991	N&S Thompson	ecotypic, gen.	similar to MFR, diff. timing
	*	Upper Fraser	river	-	1	1	2	1984	Upper Fraser	ecotypic, status uncertain	
	*	Widgeon	river	-	1	65	694	2007	Lower Fraser	genetics	Misc. non-Shuswap

Total Sites: 271-275

* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.
** Stocks currently used for forecasts and spawner-recruit models (e.g. DFO 2009b). Refer to Section 2.2.2 for comments.

Table 2: Sampling sites for Early Stuart and Early Summer conservation units

CU label	Sites	Stock**
* Stuart-EStu	Nahounli Creek, Sowchea Creek	Early Stuart
Takla/Trembleur-EStu	15 Mile Creek, 25 Mile Creek, Ankwill Creek, Bates Creek, Bivouac Creek, Blackwater Creek, Blanchette Creek, Casimir Creek, Consolidate Creek, Crow Creek, Driftwood River, Dust Creek, Fleming Creek, Forfar Creek, Forsythe Creek, French Creek, Frypan Creek, Gluske Creek, Hooker Creek, Hudson Bay Creek, Kastberg Creek, Kazchek Creek, Kotsine River, Leo Creek, Lion Creek, Maclaing Creek, Mcdougall Creek, Middle River-Rossette Bar, Narrows Creek, O'Ne-Ell Creek, Paula Creek, Point Creek, Porter Creek, Sakeniche River, Sandpoint Creek, Shale Creek, Sidney Creek, Sinta Creek, Takla Lake - Unnamed Creek (North of Blanchette), Tildesley Creek, Tliti Creek, Van Decar Creek	Early Stuart
Anderson-ES	Gates Channel, Gates Creek	Gates
Bowron-ES	Antler Creek, Bowron River, Huckey Creek	Bowron
* Chilko-ES	Chilko Lake-South End	Chilko
* Chilliwack-ES	Chilliwack Lake, Chilliwack River-Upper	Early Summer Miscellaneous
Francois-ES	Nadina River, Nadina River, Nithi River, Tagetochlain Creek	Nadina
* Fraser-ES	Endako River, Ormond Creek	Early Summer Miscellaneous
* Indian/Kruger-ES	Indianpoint Creek	
Kamloops-ES	Barriere River, Clearwater River, Fennell Creek/Saskum Creek, Finn Creek, Harper Creek, Lemieux Creek, Mann Creek, North Thompson River, Raft River	Raft, Fennel, ES Miscellaneous
* Nadina-ES	Glacier Creek	Nadina
* Nahatlatch-ES	Nahatlatch Lake, Nahatlatch River	Early Summer Miscellaneous
Pitt-ES	Pitt Lake, Pitt River-Upper	Pitt
Shuswap Complex-ES	Adams River, Adams River-Channel, Adams River-Upper, Anstey River, Burton Creek, Bush Creek, Cayenne Creek, Celista Creek, Crazy Creek, Eagle River, Hiuihill Creek, Hunakwa Creek, Loftus Creek, Mcnomee Creek, Momich River, Momich River-Upper, Nikwikwaia Creek, Onyx Creek, Perry River, Ross Creek, Salmon River, Scotch Creek, Seymour River, Shuswap River-Middle, Sinmax Creek, Yard Creek, Crazy Creek	Scotch,Seymour, ES Misc.
* Taseko-ES	Taseko Lake	Early Summer Miscellaneous

* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.
** Stocks currently used for forecasts and spawner-recruit models (e.g. DFO 2009b). Refer to Section 2.2.2 for comments.

Table 3: Sampling sites for <u>Summer</u> and <u>Late</u> conservation units

CU label	Sites	Stock**
Chilko-S	Chilko Channels, Chilko Lake-North End, Chilko River	Chilko
*Francois-S	Francois Lake, Sweetnam Creek, Uncha Creek	Stellako
Fraser-S	Stellako River	Stellako
*Mckinley-S	Mckinley Creek-Upper	Quesnel
Quesnel-S	Abbott Creek, Amos Creek, Bill Miner Creek, Blue Lead Cr. - Lake shore, Blue Lead Creek, Bouldery Cr. - Lake shore, Bouldery Creek, Buckingham Creek, Cameron Creek, Deception Point, Devoe Cr. - Lake shore, Elysia - Shore 1 km west, Franks Creek, Goose Creek, Goose Point, Grain Cr. - Lake Shore, Grain Creek, Hazeltine Creek, Horsefly Channel, Horsefly River, Horsefly River-Upper, Isaiah Creek, Junction Creek, Junction Shore, Killdog Creek, Little Horsefly River, Long Cr. - Lake Shore, Long Creek, Lynx Cr. - Lake Shore, Lynx Creek, Marten Creek, Mckinley Creek, Mitchell River, Moffat Creek, Niagara Creek, North Arm - Unnamed Cove, Penfold Creek, Quesnel Lake, Roaring R. - Lake shore, Roaring River, Service Creek, Spusks Creek, Sue Creek, Summit Creek, Taku Creek, Tasse Creek, Trickle Creek, Wasko Cr. - Lake shore, Wasko Creek-Lower, Watt Creek, Whiffle Creek	Quesnel
Stuart-S	Kuzkwa River, Pinchi Creek, Sowchea Creek, Stuart Lake, Tachie River	Late Stuart
Takla/Trembleur-S	Dust Creek, Kazchek Creek, Middle River-Rossette Bar, Sakeniche River, Takla Lake	Late Stuart
Cultus-L	Cultus Lake	Cultus
Harrison (D/S)-L	Big Silver Creek, Cogburn Creek, Douglas Creek, Sloquet Creek, Tipella Creek, Trout Lake Creek	Misc. non-Shuswap
Harrison (U/S)-L	East Creek, Steelhead Creek, Weaver Channel, Weaver Creek	Weaver
*Kamloops-L	South Thompson River	Misc. Shuswap
*Kawkawa-L	Sucker Creek	
Lillooet-L	Birkenhead River, Green River, John Sandy Creek, Lillooet River-Upper, Miller Creek, Poole Creek, Ryan River, Sampson Creek	Birkenhead
Seton-L	Portage Creek	Portage
Shuswap Complex-L	Adams L. east side shore, Adams L. north end shore, Adams L. south end shore, Adams Lake, Adams River, Adams River - Shore, Adams River-Channel, Adams River-Upper, Anstey River, Besette Creek, Bush Creek, Bush Creek - Lake shore, Canoe Creek, Cayenne Creek, Celista Creek, Crazy Creek, Cruikshank Point West, Devoe Creek, Eagle River, Four Mile Creak - Shore, Hiuihill Creek, Hlina Creek - Shore, Hunakwa Creek, Knight Creek - Shore, Lee Creek - Shore, Little River, Mara Lake, Mcnomee Creek, Momich River, Momich River - Lake Shore, Nikwikwaia Creek, Noisy Creek, Onyx Creek, Onyx Creek - Shore, Pass Creek - Lake Shore, Perry River, Queest Creek - Shore, Reinecker Creek - Shore, Rienecker Creek, Ross Creek, Ross Creek - Shore, Salmon River, Scotch Creek, Scotch Creek - Shore, Seymour River, Shuswap L. main arm north shore, Shuswap L. main arm south shore, Shuswap L. Salmon Arm north shore, Shuswap L. Salmon Arm south shore, Shuswap Lake, Shuswap River-Lower, Shuswap River-Middle, Sinmax Creek, Tappen Creek, Tsuius Creek, Vanishing Creek - Shore, Wap Creek, Yard Creek	Late Shuswap, Misc. Shuswap

* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.
** Stocks currently used for forecasts and spawner-recruit models (e.g. DFO 2009b). Refer to Section 2.2.2 for comments.

Table 4: Sampling sites for River-type conservation units

CU label	Sites	Stock**
*Fraser Canyon	American Creek, Coquihalla River, Emory Creek, Silverhope Creek, Spuzzum Creek, Yale Creek	
*Lower Fraser	Chehalis River, Chilliwack/Vedder River, Harrison River, Maria Slough, Wahleach Creek	Harrison
*Middle Fraser	Bridge River, Cariboo River, Cayoosh Creek, Churn Creek, Lyon Creek, Nechako River, Seton And Cayoosh Creeks, West Road River, Yalakom River, Quesnel River	Stellako, Quesnel
*Thompson	Deadman River, Thompson River	
*Upper Fraser	Swift Creek	
*Widgeon	Widgeon Creek	Misc. non-Shuswap

* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.
** Stocks currently used for forecasts and spawner-recruit models (e.g. DFO 2009b). Refer to Section 2.2.2 for comments.

Table 5: Current escapement surveys for Early Stuart and Early Summer conservation units

CU label	CU type	# of Sites	Esc Obs* #	Esc Obs* Latest	2004 - 2008 Survey Summary: Adult	2004 - 2008 Survey Summary: Juvenile	Project Names
* Stuart-EStu	lake	2	13	2007	Visual surveys of Sowchea Creek	None	Early Stuart adults, Early Stuart fry
Takla/Trembleur-EStu	lake	42	70	2007	Fence at Dust Creek, Visual calibration fences at Gluske, Forfar, and Kynock creeks, visual surveys of remaining tribs to Takla Lake, Trembleur Lake, and Middle River, biological/PSC sampling	Fry outmigration / freshwater survival estimates on Gluske and Forfar creeks, biosampling	Early Stuart adults, Early Stuart fry
Anderson-ES	lake	2	59	2007	Visual surveys of Gates Creek proper, annual adult carcass census in Gates, annual biological/PSCsampling	Annual fry enumeration of Gates	N/S Thompson adults, Gates census by OHEB
Bowron-ES	lake	2-3	70	2007	Visual surveys of the Bowron system, biological/PSC sampling	None	Bowron adults
* Chilko-ES	lake	1	19	1989	Annual Mark-Recapture on Chilko River/Lake stocks (but not broken out by timing group), biological/PSC sampling	Smolt outmigration / freshwater survival estimates, biological/PSC sampling	Chilko Lake/River adults, Chilko smolts
* Chilliwack-ES	lake	2	36	2007	Visual surveys of Chilliwack Lake, biological/PSC sampling	None	Lower Fraser adults
Francois-ES	lake	3-4	67	2007	Visual surveys of Nadina River, Fence enumeration, biological / PSC sampling	Annual fry enumeration of Nadina	Nadina adults, Nadina fence by OHEB
* Fraser-ES	lake	2	43	2005	Annual visual surveys of Ormond Creek, opportunistic surveys of Endako River on abundant Stellako years.	None	Stellako River adults
* Indian/Kruger-ES	lake	1	3	1986	Opportunistic surveys on years of high abundance and/or difficult migratory conditions	None	Not linked to a regular project
Kamloops-ES	lake	9	70	2007	Visual surveys of North Thompson River mainstem and tributaries; Visual survey of Fenneral Creek and Harper Creek, biological/PSC sampling	None	N/S Thompson adults
* Nadina-ES	lake	1	2	2001	Nadina visual survey expanded to cover Glacier Creek if fish are present	None	Nadina adults
* Nahatlatch-ES	lake	2	33	2007	Visual surveys of Nahatlatch River and lake, biological/PSC sampling	None	N/S Thompson adults
Pitt-ES	lake	2	69	2007	Annual MR on Upper Pitt River and tributaries, no persistent spawning SK in Pitt Lake; annual biological/PSC sampling	None	Upper Pitt adults
Shuswap Complex-ES	lake	21-27	66	2007	Annual enumeration fence at Scotch; MR on Seymour in dominant year, visual surveys in other 3 years; Visual surveys on remaining streams (e.g. Adams, Momich, Eagle); Biological/PSC sampling	None	N/S Thompson adults
* Taseko-ES	lake	1-2	43	2007	Visual surveys of Taseko Lake spawners, biological/PSC sampling	None	Chilko Lake / River adults

* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

Table 6: Current escapement surveys for Summer and Late conservation units

CU label	CU type	# of Sites	Esc Obs* #	Esc Obs* Latest	2004 - 2008 Survey Summary: Adult	2004 - 2008 Survey Summary: Juvenile	Project Names
Chilko-S	lake	3	70	2007	Annual Mark-Recapture on Chilko River/Lake stocks (but not broken out by timing group), biological/PSC sampling	Smolt outmigration / freshwater survival estimates, biological / PSC sampling	Chilko Lake/River adults, Chilko smolts
* Francois-S	lake	3	9	2002	Visual surveys of Francois Lake tribs	None	Stellako River adults
Fraser-S	lake	1	70	2007	Stellako River Fence, biological/PSC sampling	None	Stellako River adults
* Mckinley-S	lake	1	19	2007	Opportunistic Visual Surveys when McKinley Creek fence not operating (1 of 4 years); Included in McKinley Creek estimate under Quesnel-S CU other years	None	Horsefly River / Quesnel Lake adults
Quesnel-S	lake	51-66	67	2007	Mark-Recapture on Horsefly and Mitchell River (3 of 4 cycles), McKinley Creek Fence (3 of 4 cycles), visual surveys on remaining cycle and on other Quesnel lake stocks, biological / PSC sampling	None	Horsefly River / Quesnel Lake adults
Stuart-S	lake	5	64	2007	Mark-recapture on Tachie River and counting fence on Kuzkwa Creek (2 of 4 years), visual surveys in other years, and on remaining Tachie River / Stuart Lake tributaries, biological/PSC sampling	None	Late Stuart adults
Takla/Trembleur-S	lake	4-5	67	2007	Mark-Recapture on Middle River (05/06 cycle only, visual surveys on remaining cycles). visual surveys on Sakeniche River and Kazchek Creek, biological/PSC sampling	None	Late Stuart adults
Cultus-L	lake	1	70	2007	Annual Cultus Adult fence, mark status assessment (captive broodstock / supplementation program), biological/PSC sampling	Smolt outmigration / freshwater survival estimates, mark status assessment, biological / PSC sampling	Cultus adults, Cultus smolts
Harrison (D/S)-L	lake	6-8	68	2007	Visual surveys of Harrison Lake tributaries (Big Silver, Cogburn, Douglas creeks), biological/PSC sampling	None	Lower Fraser adults
Harrison (U/S)-L	lake	4	70	2007	Visual surveys of Weaver Creek, fence enumeration	None	Lower Fraser adults
* Kamloops-L	lake	1	48	2006	Visual surveys of the S. Thompson River mainstem	None	Late South Thompson adults
* Kawkawa-L	lake	1-2	8	1991	None	None	None
Lillooet-L	lake	8	70	2007	Annual Birkenhead River Fence; Visual surveys of Lillooet Lake/Upper Lillooet River tribs (Lil'wat FN), biological/PSC sampling	None	Birkenhead adults
Seton-L	lake	1	60	2007	Visual surveys of Portage Creek, biological/PSC sampling	None	Portage Creek adults
Shuswap Complex-L	lake	44-58	70	2007	Mark-Recapture on Adams River (2 of 4 years), Shuswap River (1 of 4) and Little River (1 of 4); Visual surveys on other years and all remaining tributaries	None	Late South Thompson adults

* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

Table 7: Current escapement surveys for <u>River-type</u> conservation units

CU label	CU type	# of Sites	Esc Obs* #	Esc Obs* Latest	2004 - 2008 Survey Summary: Adult	2004 - 2008 Survey Summary: Juvenile	Project Names
* Fraser Canyon	river	6	14	1994	Opportunisitic surveys when possible on years of difficult migratory conditions	None	Not linked to a regular project
* Lower Fraser	river	5	69	2006	Visual surveys of Harrison River, biological/PSC sampling	None	Lower Fraser adults
* Middle Fraser	river	9	60	2006	Annual surveys are conducted on Quesnel and Nechako mainstems; opportunistic surveys on all remaining streams on years of high abundance and/or difficult migratory conditions	None	Quesnel Adults (Quesnel River); Stellako Adults (Nechako River)
* Thompson	river	2	6	1994	Opportunistic surveys on years of high abundance and/or difficult migratory conditions	None	Not linked to a regular project
* Upper Fraser	river	1	5	1989	Opportunistic surveys on years of high abundance and/or difficult migratory conditions	None	Not linked to a regular project
* Widgeon	river	1	68	2006	Visual surveys of Widgeon Slough, biological/PSC sampling	None	Lower Fraser adults

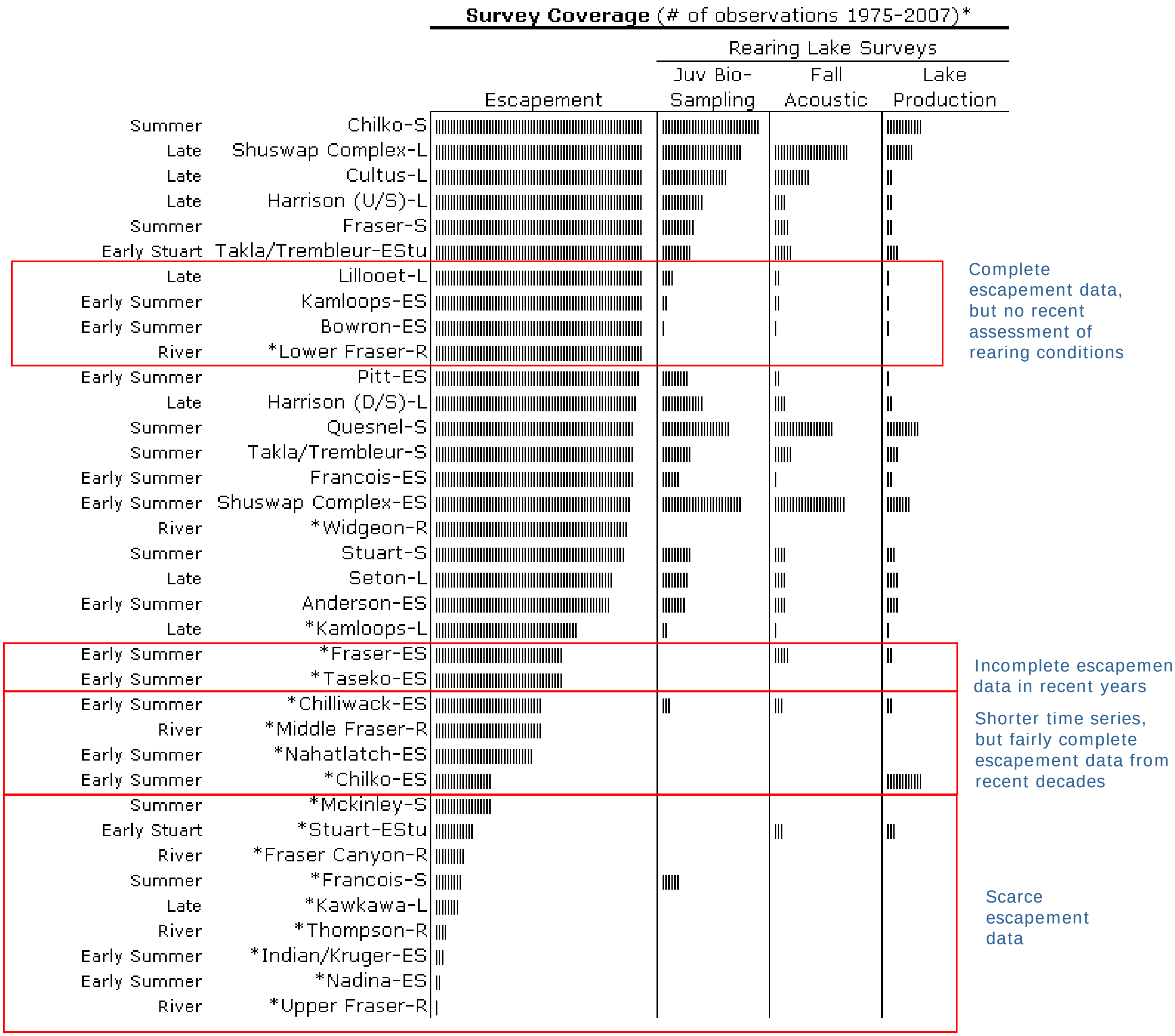
* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

Table 8: Escapement summary for 36 conservation units of Fraser sockeye

		CU Structure				Escapement*					Trend		
Mgmt Unit	Conservation Unit	Sites	Obs*	Variability score (5=high)	Cyclicity score (5=high)	Average (All)	Median (All)	Geomean (All)	Geomean (Last 4)	Latest Obs	Annual slope in gen. avg. over 12 yrs	Recent / Avg	Largest cycle decline (Recent/Earlier)
Early Stuart	* Stuart-EStu	2	13	3	5	59	25	24	14	2007	**-16.97%**	55%	
	Takla/Trembleur-EStu	42	70	2	4	82,462	32,656	30,014	20,439	2007	-7.26%	68%	**15%**
Early Summer	Anderson-ES	2	59	2	3	11,094	4,816	3,452	6,170	2007	-5.02%	179%	44%
	Bowron-ES	3	70	2	2	9,231	6,344	5,858	1,521	2007	-6.20%	**26%**	**23%**
	* Chilko-ES	1	19	2		38,104	15,000	15,183		1989			
	* Chilliwack-ES	2	36	3	5	3,787	1,085	897	4,160	2007	4.78%	464%	70%
	Francois-ES	4	67	2	2	12,905	4,017	3,827	4,544	2007	-2.59%	119%	**7%**
	* Fraser-ES	2	43	3		583	283	231	99	2005	11.04%	43%	
	* Indian/Kruger-ES	1	3			29	24	20		1986			
	Kamloops-ES	9	70	2	3	15,246	8,647	8,786	38,169	2007	4.37%	434%	79%
	* Nadina-ES	1	2			2,516	2,516	394		2001	**-19.88%**		
	* Nahatlatch-ES	2	33	2	2	4,540	2,755	3,165	1,983	2007	-5.86%	63%	32%
	Pitt-ES	2	69	2	2	28,648	19,043	21,617	49,783	2007	5.39%	230%	219%
	Shuswap Complex-ES	27	66	2	5	47,614	19,289	18,016	24,151	2007	-3.41%	134%	71%
	* Taseko-ES	1	43	2	4	3,286	1,470	1,321	537	2007	-1.32%	41%	**20%**
Summer	Chilko-S	3	70	2	2	332,114	240,999	196,062	291,006	2007	-5.29%	148%	37%
	* Francois-S	3	9			273	209	79		2002	-6.35%		
	Fraser-S	1	70	2	2	96,733	74,726	63,684	98,152	2007	-1.05%	154%	44%
	* Mckinley-S	1	19	3		4,432	1,166	828	617	2007	1.18%	75%	142%
	Quesnel-S	51	67	3	5	293,220	8,901	10,659	103,112	2007	-3.76%	967%	47%
	Stuart-S	5	64	3	4	79,565	9,186	9,776	39,376	2007	-3.21%	403%	**23%**
	Takla/Trembleur-S	5	67	2	5	48,254	7,621	7,149	8,947	2007	-4.82%	125%	**22%**
Late	Cultus-L	1	70	2	5	13,805	10,902	6,251	405	2007	-5.39%	**6%**	**10%**
	Harrison (D/S)-L	6	68	3	2	3,276	1,219	1,061	10,859	2007	8.01%	1023%	394%
	Harrison (U/S)-L	4	70	2	2	37,636	27,324	25,112	36,872	2007	-2.22%	147%	**16%**
	* Kamloops-L	1	48	4	5	11,853	351	578	356	2006	-0.37%	62%	**10%**
	* Kawkawa-L	1	8			503	187	146		1991			
	Lillooet-L	8	70	2	3	90,409	65,133	63,686	84,561	2007	-0.70%	133%	**6%**
	Seton-L	1	60	2	3	6,073	3,545	2,288	4,750	2007	-3.93%	208%	40%
	Shuswap Complex-L	58	70	2	5	645,208	87,834	86,353	76,615	2007	3.53%	89%	**13%**
River	* Fraser Canyon	6	10			3,662	133	158		1991			
	* Lower Fraser	5	70	3	3	21,689	8,899	8,051	64,913	2007	5.45%	806%	138%
	* Middle Fraser	10	36	3	4	1,185	420	307	1,832	2007	4.78%	597%	99%
	* Thompson	2	4			4,255	1,343	985		1991			
	* Upper Fraser	1	1			2	2	2		1984			
	* Widgeon	1	65	2	2	694	599	470	145	2007	4.09%	31%	41%

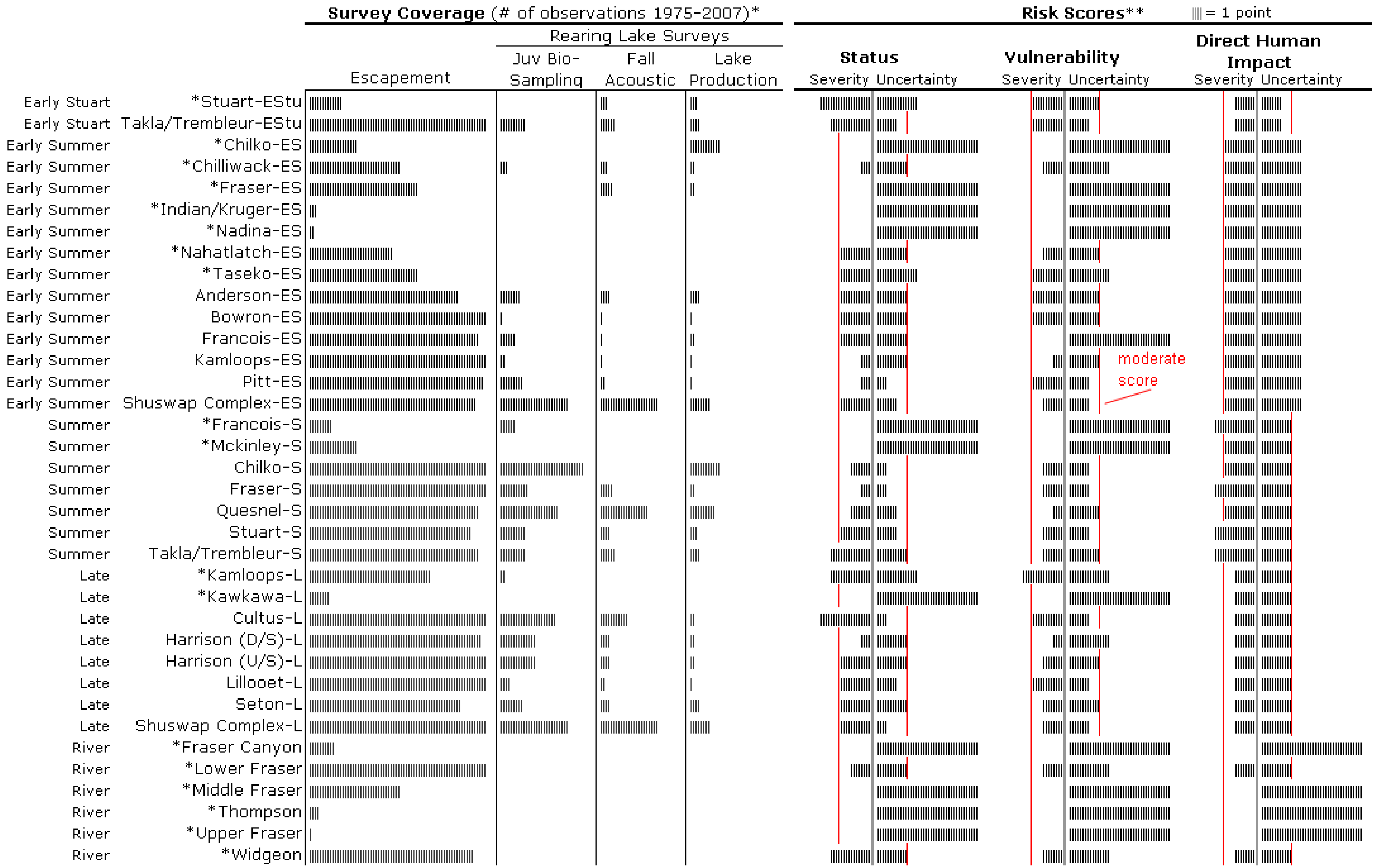
* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

Table 9: Fraser sockeye conservation units sorted by survey coverage



* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

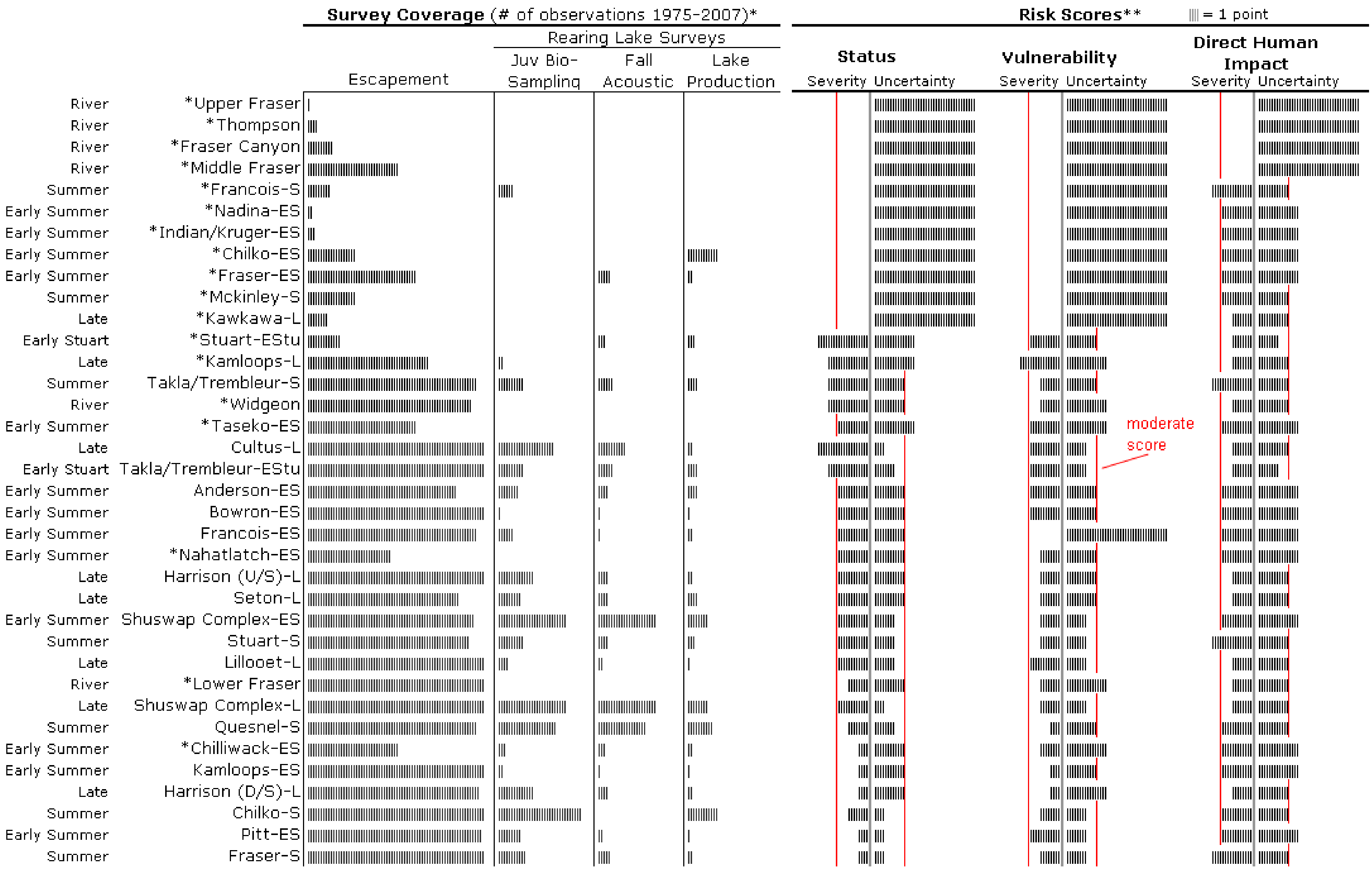
Table 10: Fraser sockeye assessment coverage and risk profiles sorted by management group



* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

**Severity scores range from 1 = Negligible to 5 = Severe; Uncertainty scores range from 1= Very Low to 4 = High and 10 = Insufficient Information

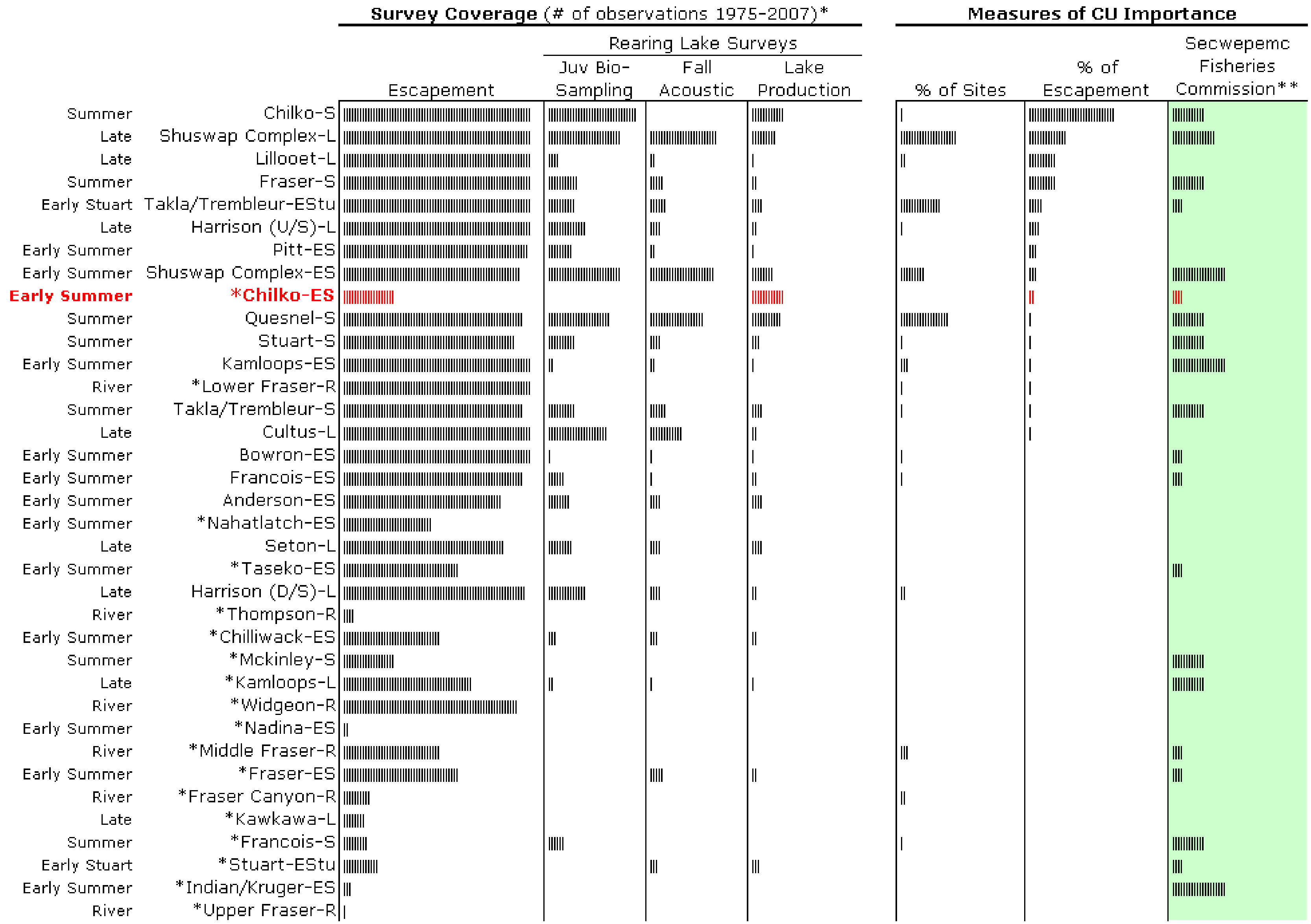
Table 11: Fraser sockeye conservation units sorted based on status (total risk score)



* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

**Severity scores range from 1 = Negligible to 5 = Severe; Uncertainty scores range from 1= Very Low to 4 = High and 10 = Insufficient Information

Table 12: Fraser sockeye conservation units sorted based on % of average escapement.



* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.
. ** Preliminary importance scores provided as an illustration by SFC staff during a pilot project. Subject to revision.

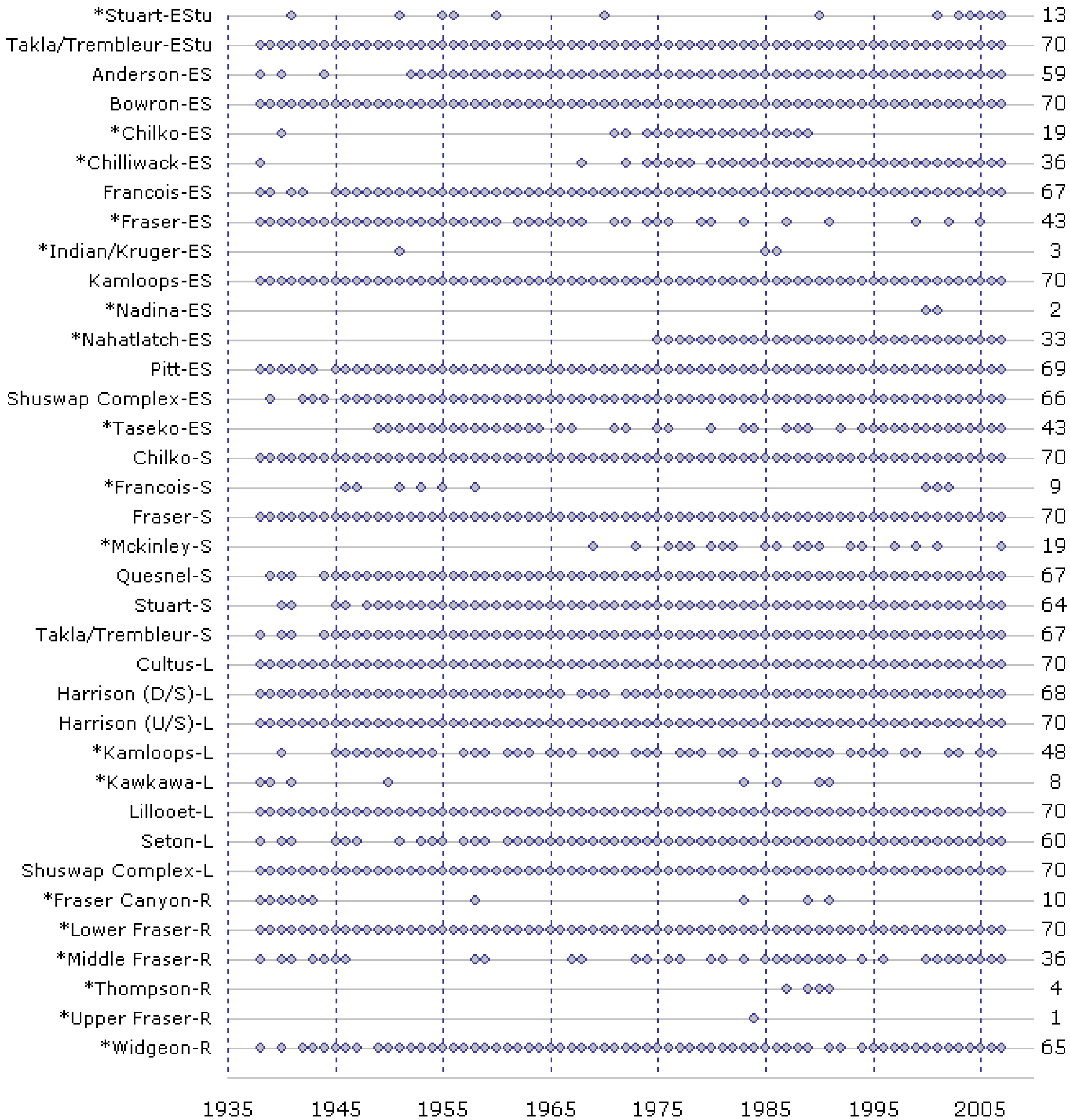


Figure 1: Availability of escapement estimates for Fraser sockeye CUs since 1938
This figure shows only non-zero escapement observation currently included in nuSEDS. Refer to Section 2.2.1 for general comments on the escapement data, and for specific comments on CUs marked by *.

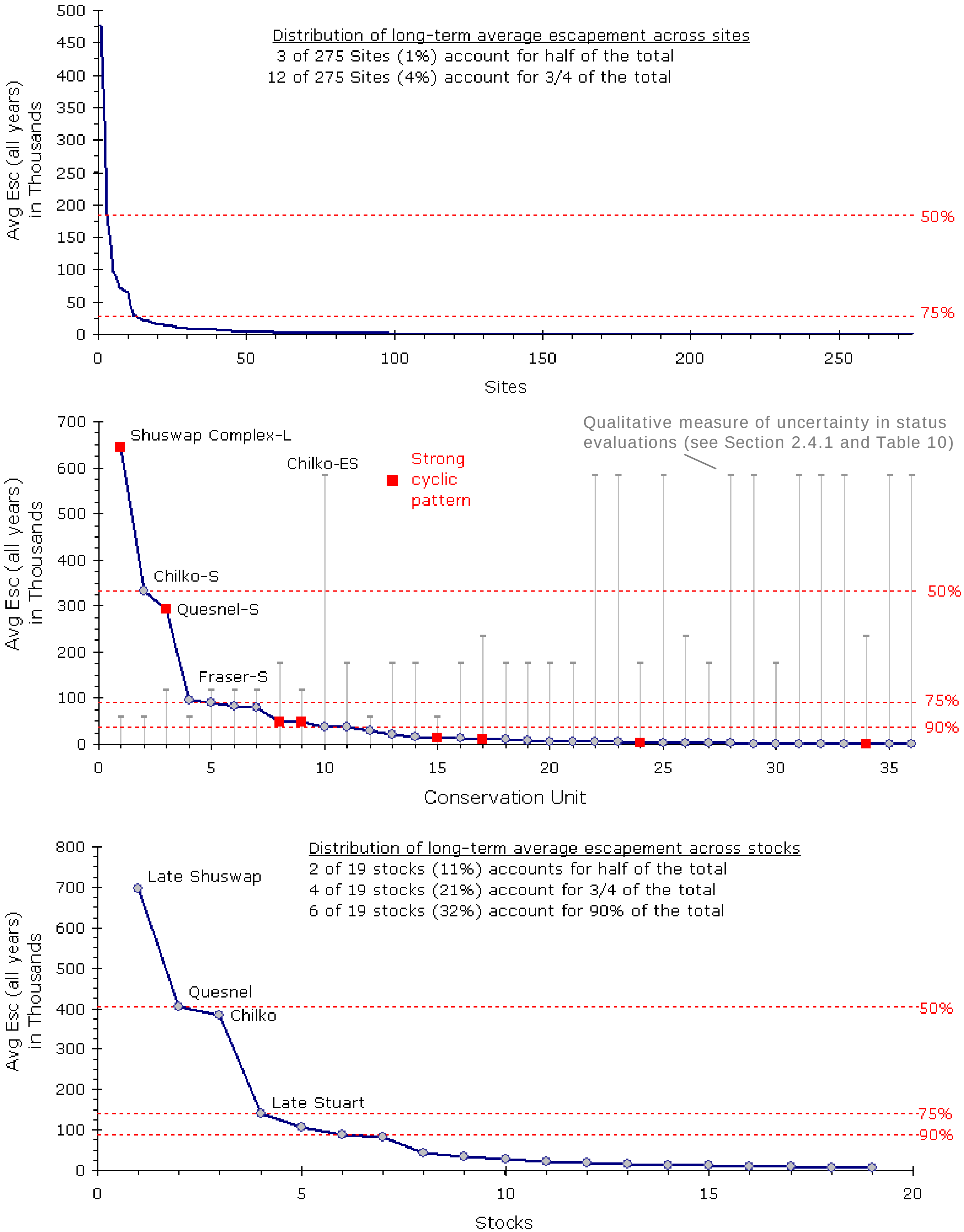


Figure 2: Distribution of escapement across 275 sites, 36 CUs, and 19 stocks.
Note the comments in Section 2.2.1 on 18 of the 36 CUs and corresponding escapement data, and the comments in Section 2.2.2 regarding the match between stocks and CUs.

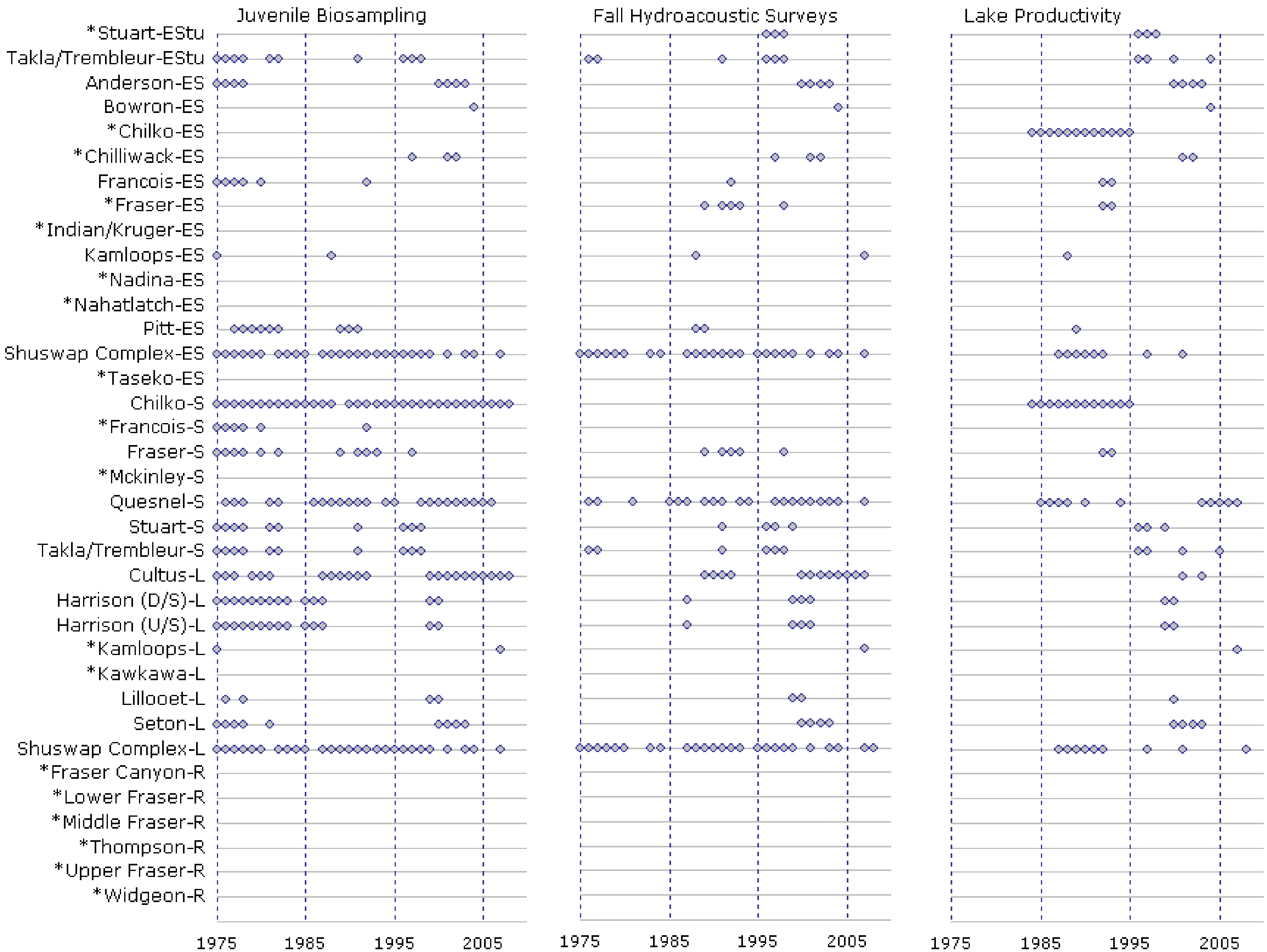


Figure 3: Availability of lake assessments for Fraser sockeye CUs since 1975

Refer to Section 2.2.1 for comments on CUs marked by *, and to Section 2.2.5 for comments on lake assessments.

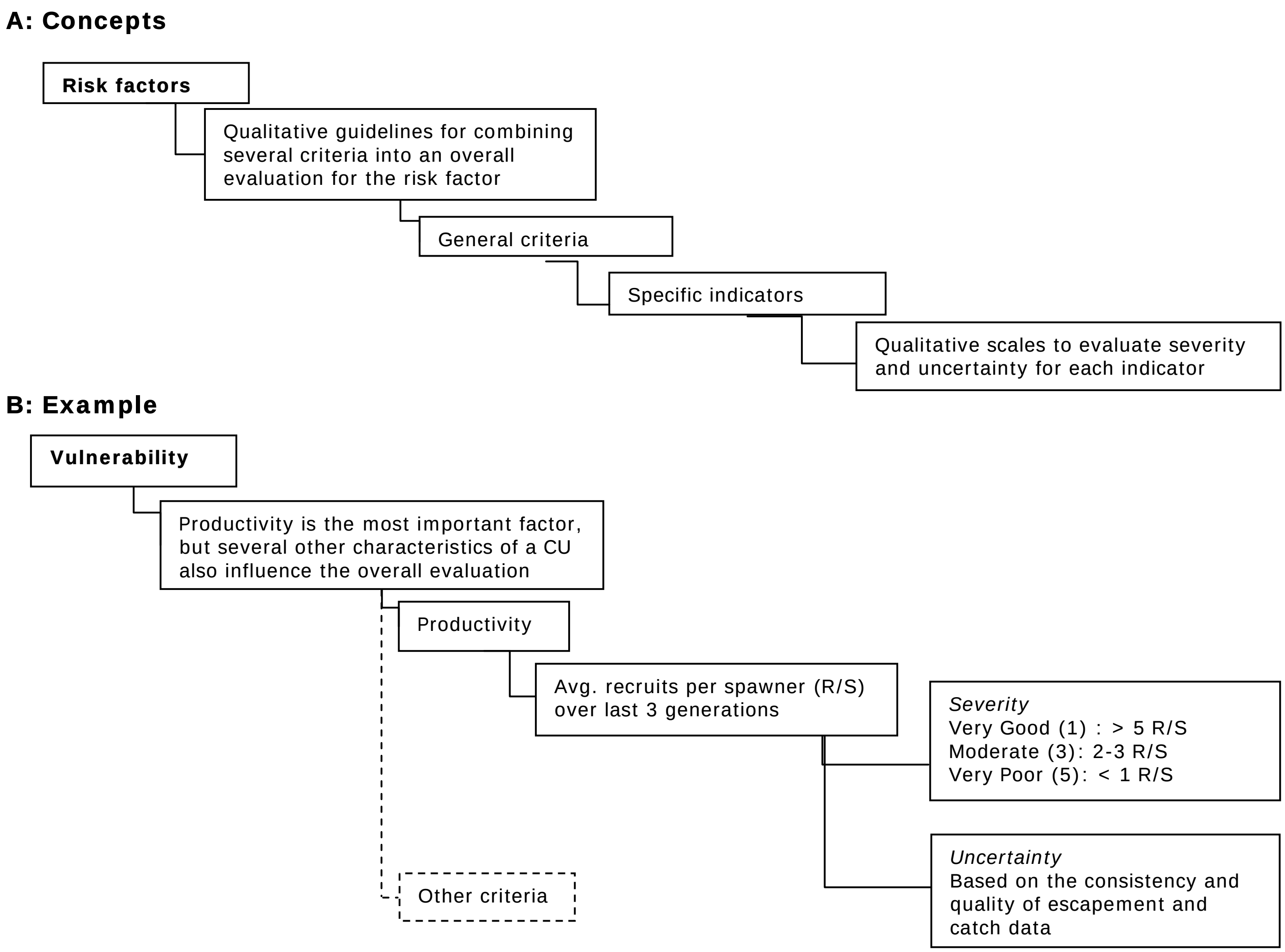


Figure 4: Hierarchical structure for evaluating risk factors

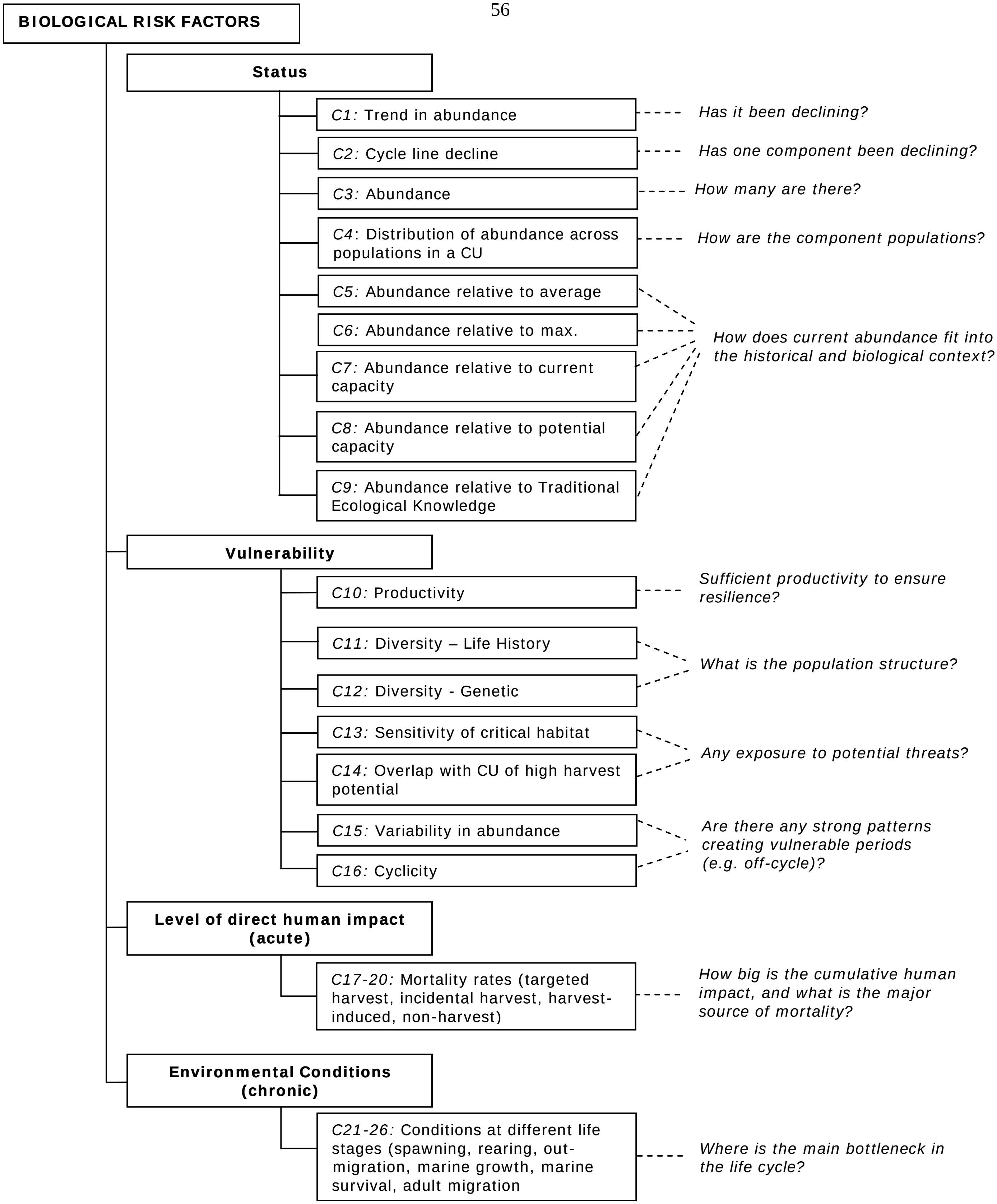


Figure 5: Criteria for evaluating biological risk factors

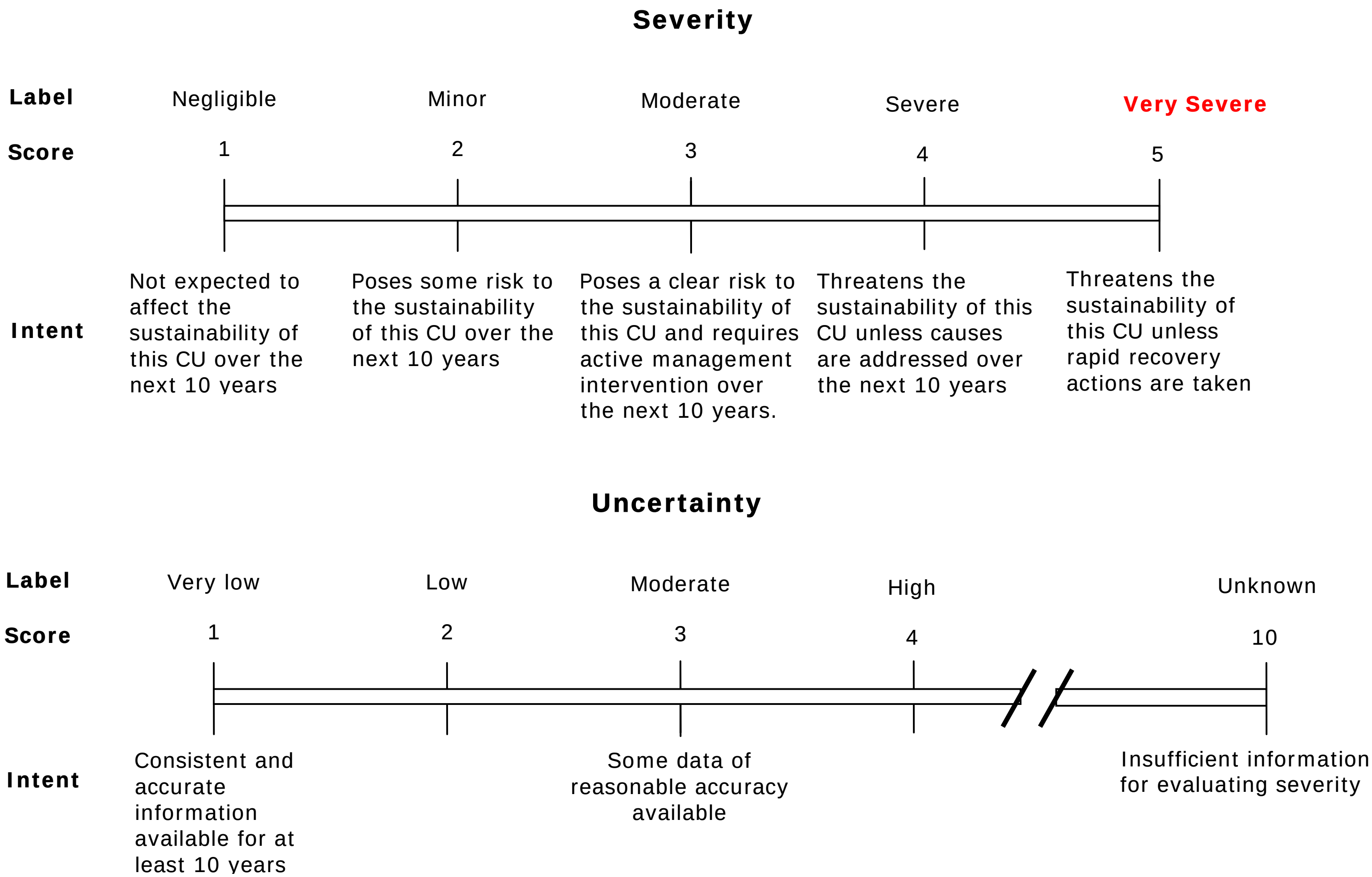


Figure 6: Intent of qualitative scales for evaluating risk factors

Note: These general scales are adapted to each indicator. Appendix 3 lists the proposed indicators and evaluation scales for each.

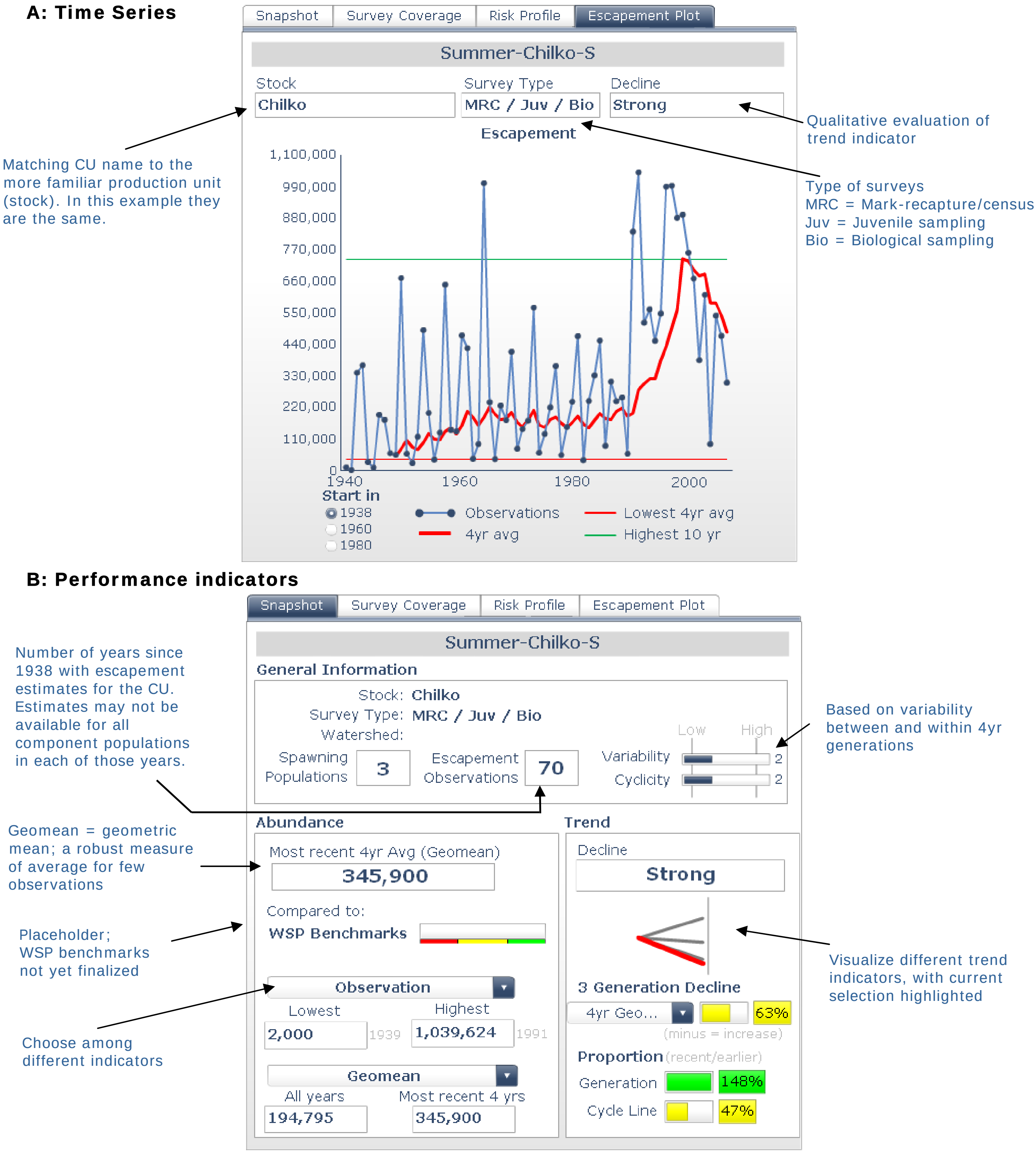


Figure 7: Status indicators in context, illustrated for Chilko-S sockeye (Screen capture)

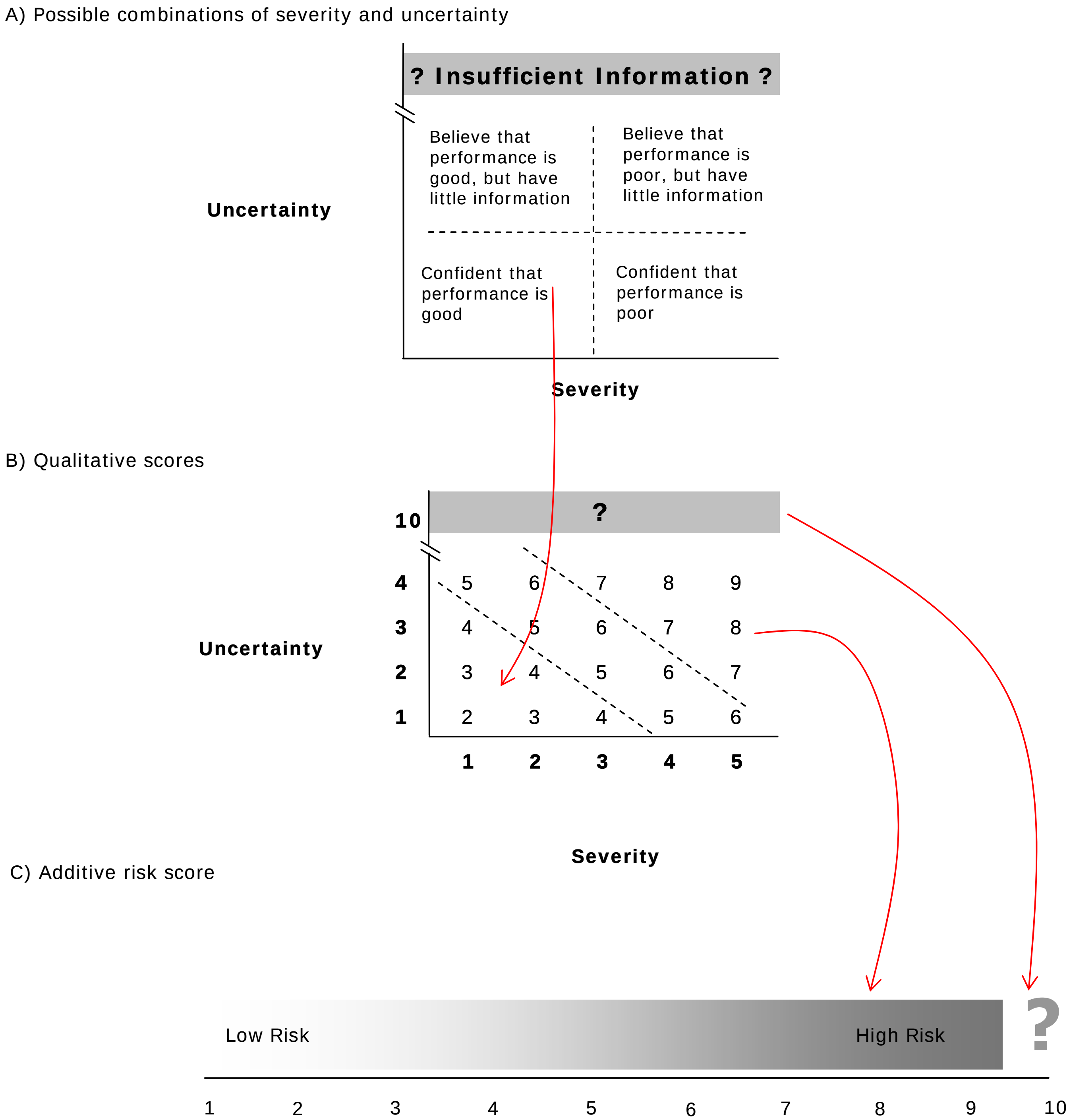
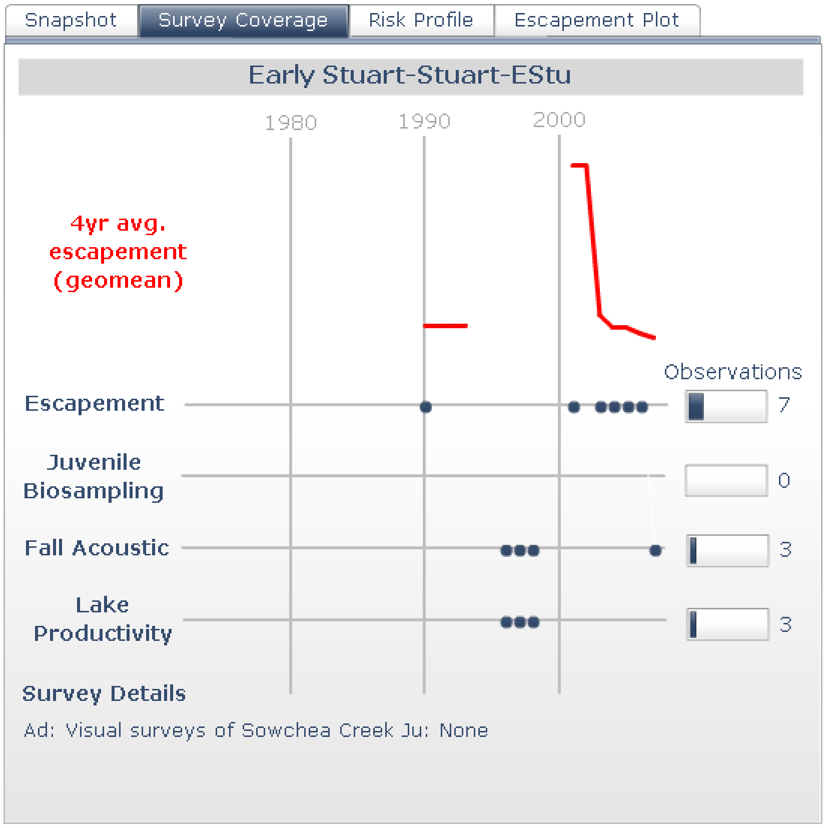


Figure 8: Combining evaluations of severity and uncertainty into an additive risk score



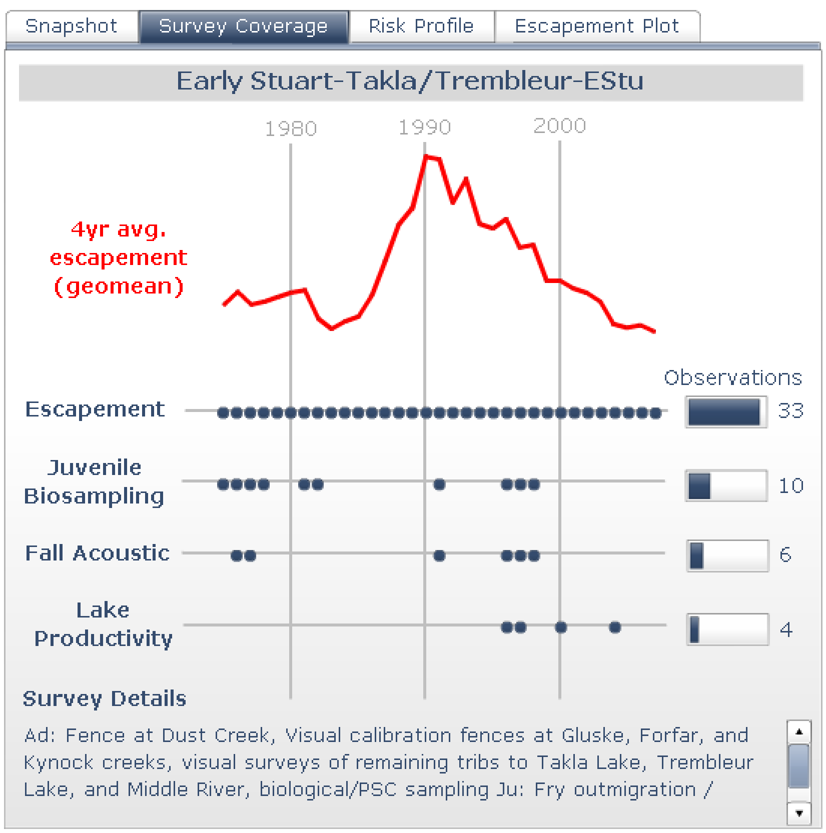
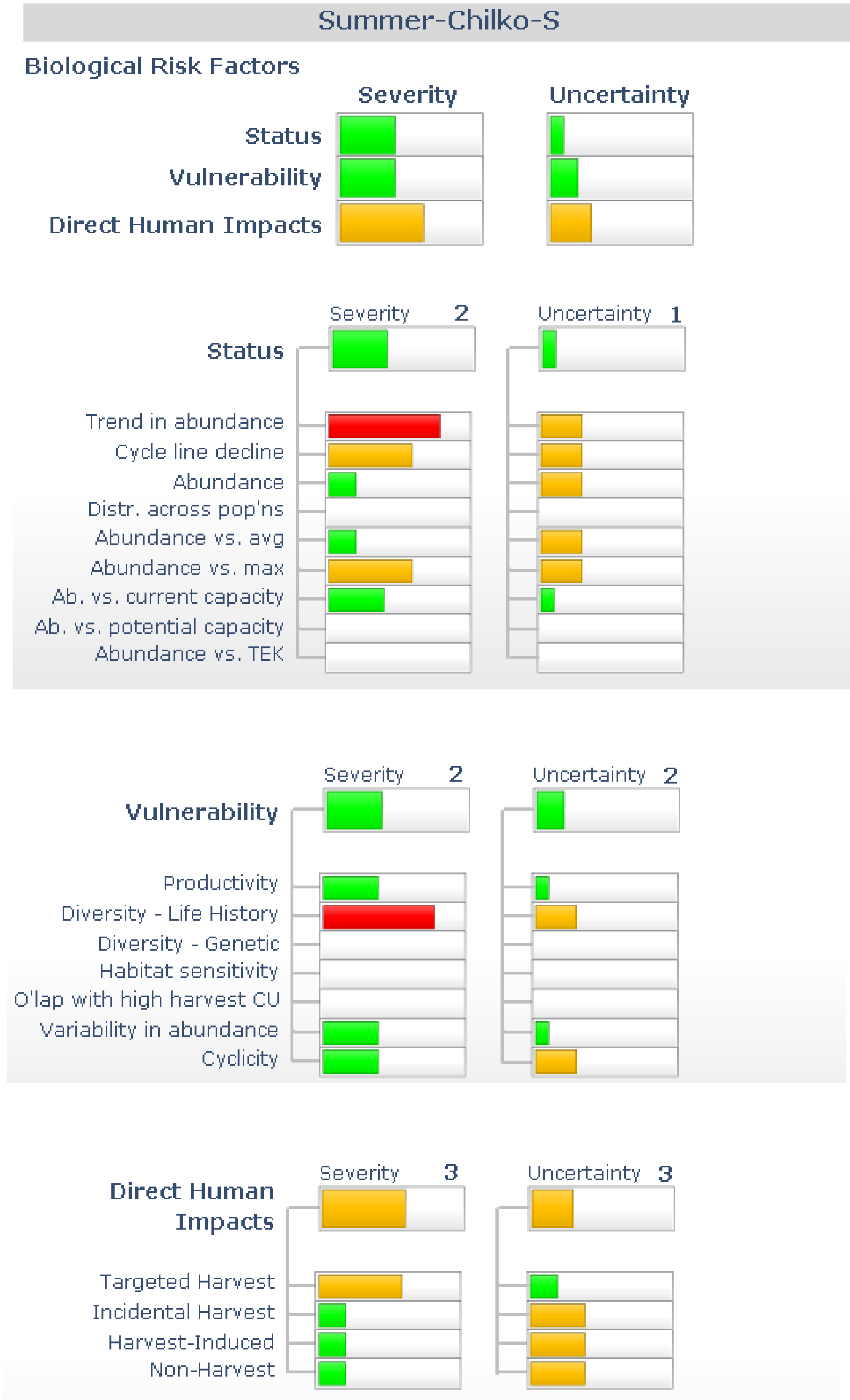


Figure 9: Survey coverage for two sockeye CUs rearing in the Stuart system
Escapement data are complete for Takla/Trembleur – Estu, but are only available recently for Stuart – EStu are only available from recent years. Note comments on Stuart-Estu in Sect. 2.2.1.

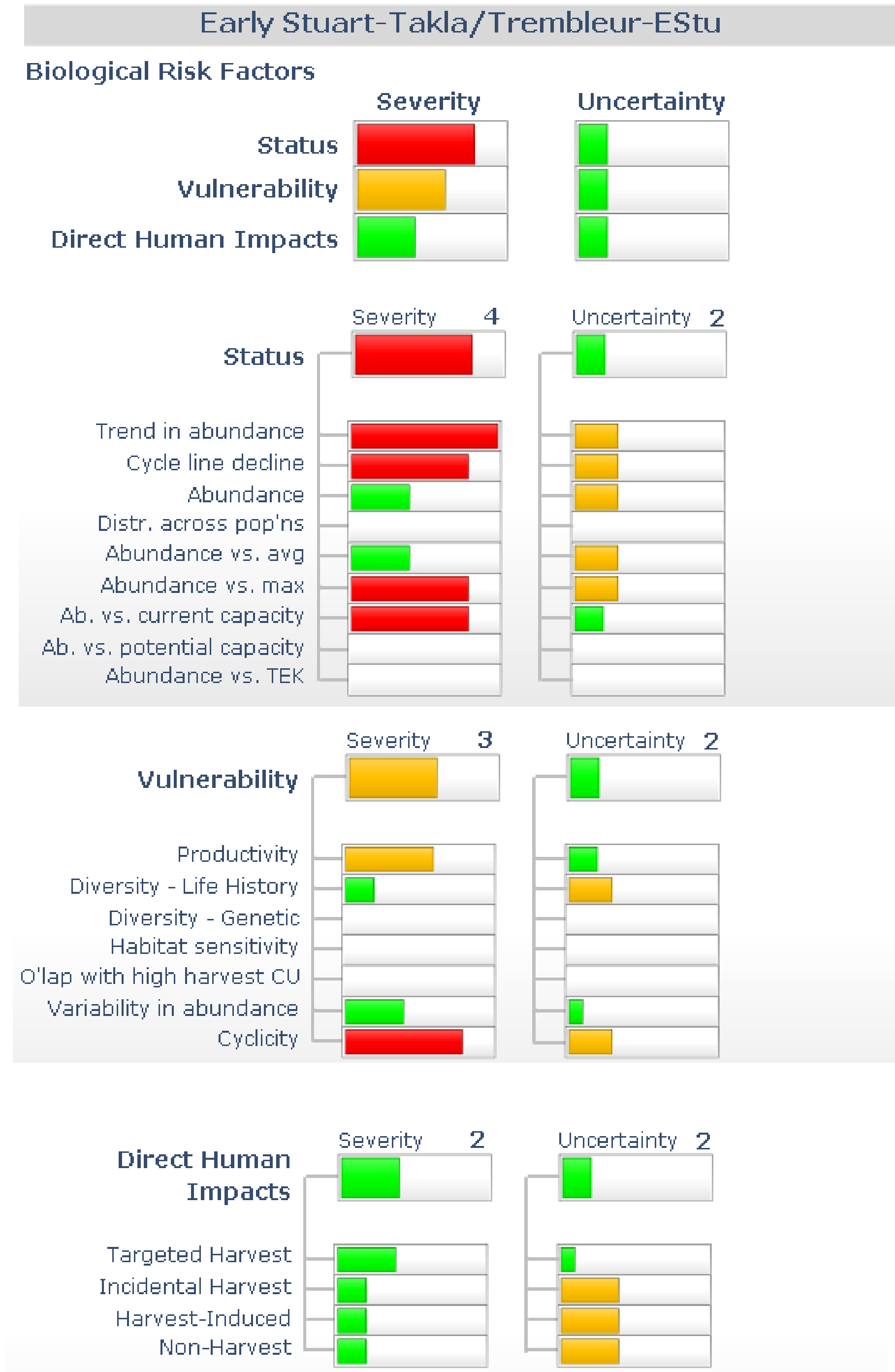


The overall evaluation of CU status is based on a combination of indicators. In this case, the trend indicators pick up a severe decline, but recent abundance is substantial in absolute numbers and falls above the long-term average, indicating a decline off a recent peak. This interpretation is supported by the time series plot (Figure 7), which shows that abundance has declined from a peak in the 1990s.

The overall evaluation of CU vulnerability anchors on long-term productivity. In this case, good estimates of escapement and recruitment are available (low uncertainty score). Production has exceeded 3 recruits per spawner over the last 3 generations, and there are no strong patterns that create vulnerable periods (e.g. strong cycles). The low number of distinct populations is a potential source of vulnerability.

The overall evaluation of direct human impacts considers the cumulative effect of different mortality sources. Targeted harvest is well estimated (low uncertainty score), with a recent average below 50%. Other mortality sources are not as well estimated (higher uncertainty score), but are probably much less than 10%.

Figure 10: Qualitative risk evaluations for Chilko-S sockeye (screen capture)



The overall evaluation of CU status is based on a combination of indicators. In this case, the trend indicators pick up a severe decline in average escapement and cycle line escapement. In combination with escapement far below the highest observed period, and far below capacity, the observed declines lead to an overall evaluation of *very poor* (i.e. severity score = 4)

The overall evaluation of CU vulnerability anchors on long-term productivity. In this case, good estimates of escapement and recruitment are available (low uncertainty score). Production has only been between 2 and 3 recruits per spawner over the last 3 generations, and the strong cyclic pattern creates vulnerable periods.

The overall evaluation of direct human impacts considers the cumulative effect of different mortality sources. Targeted harvest is well estimated (low uncertainty score), with a recent average below 30%. Other mortality sources are not as well estimated (higher uncertainty score), but are probably much less than 10%.

Figure 11: Qualitative risk evaluations for Takla/Trembleur-EStu sockeye (screen capture)

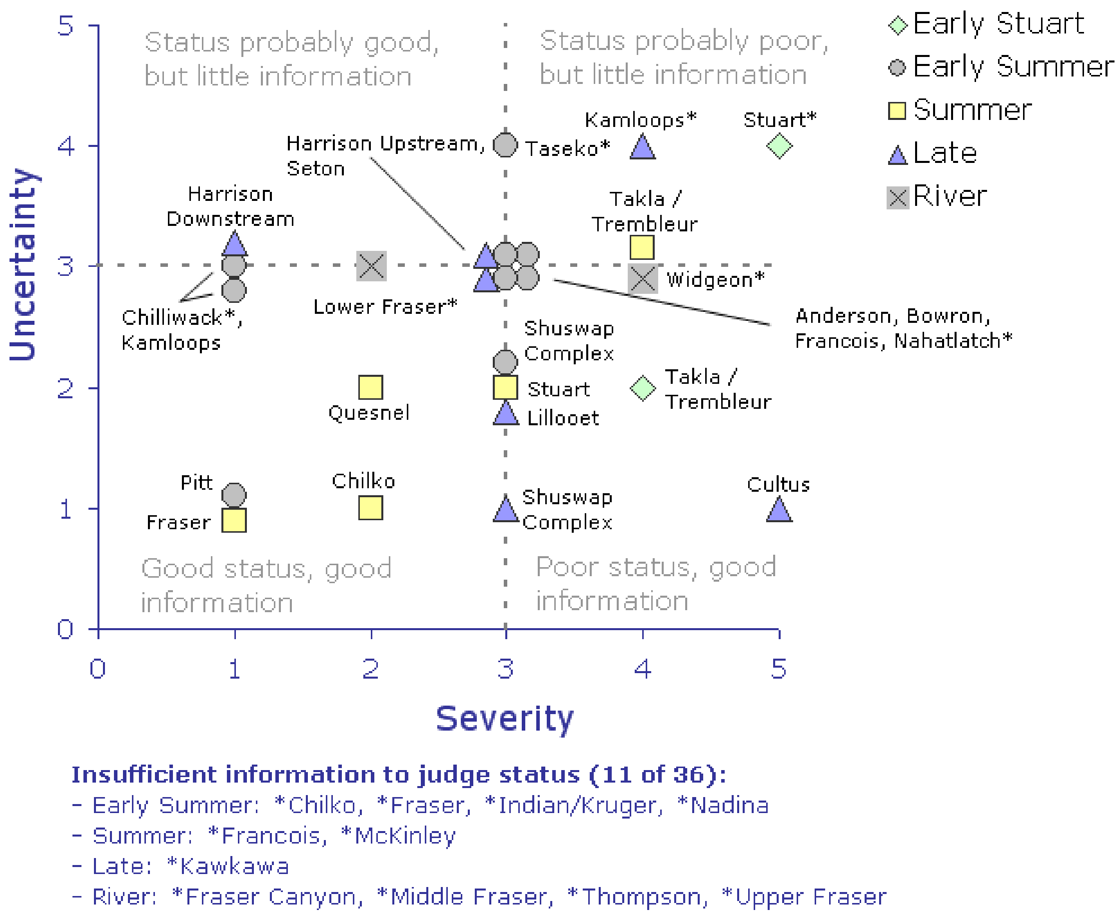
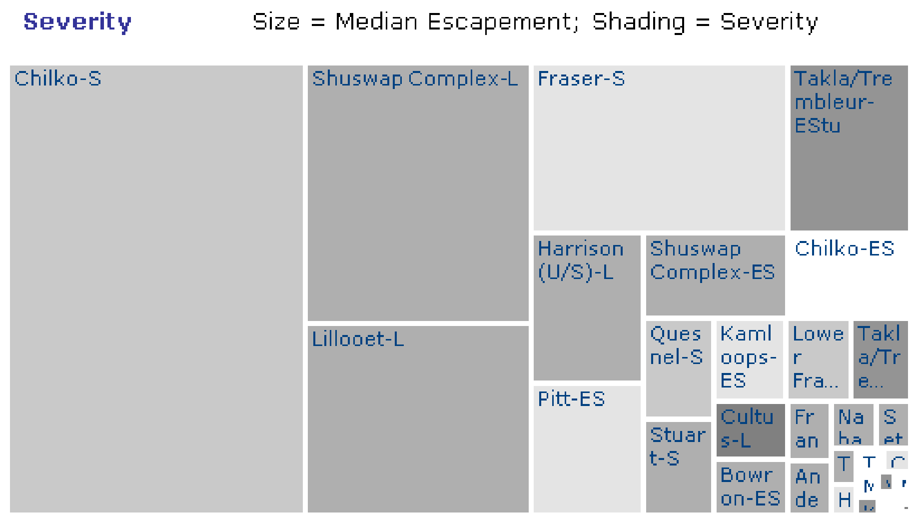


Figure 12: Status evaluations for 36 conservation units of Fraser sockeye
* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

	CU label	Median Esc	Status Sev.	Status Unc.
*	Stuart-EStu	24	5	4
	Takla/Trembleur-EStu	30,014	4	2
	Anderson-ES	3,452	3	3
	Bowron-ES	5,858	3	3
*	Chilko-ES	15,183		10
*	Chilliwack-ES	897	1	3
	Francois-ES	3,827	3	3
*	Fraser-ES	231		10
*	Indian/Kruger-ES	20		10
	Kamloops-ES	8,786	1	3
*	Nadina-ES	394		10
*	Nahatlatch-ES	3,165	3	3
	Pitt-ES	21,617	1	1
	Shuswap Complex-ES	18,016	3	2
*	Taseko-ES	1,321	3	4
	Chilko-S	196,062	2	1
*	Francois-S	79		10
	Fraser-S	63,684	1	1
*	Mckinley-S	828		10
	Quesnel-S	10,659	2	2
	Stuart-S	9,776	3	2
	Takla/Trembleur-S	7,149	4	3
	Cultus-L	6,251	5	1
	Harrison (D/S)-L	1,061	1	3
	Harrison (U/S)-L	25,112	3	3
*	Kamloops-L	578	4	4
*	Kawkawa-L	146		10
	Lillooet-L	63,686	3	2
	Seton-L	2,288	3	3
	Shuswap Complex-L	86,353	3	1
*	Fraser Canyon	158		10
*	Lower Fraser	8,051	2	3
*	Middle Fraser	307		10
*	Thompson	985		10
*	Upper Fraser	2		10
*	Widgeon	470	4	3



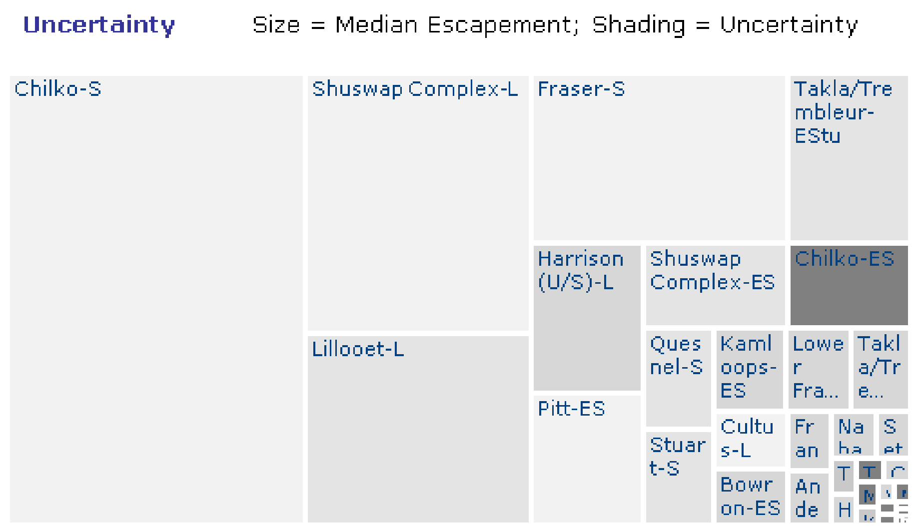


Figure 13: Treemap of status evaluations for 36 conservation units of Fraser sockeye

* Refer to Section 2.2.1 for comments on these CUs and corresponding escapement data.

Appendix 1: Building blocks for a resource assessment framework

This appendix briefly discusses the range of expectations we encountered during the scoping phase for this project and introduces proposed building blocks for an integrated assessment framework.

A1.1 Scope: What should a resource assessment framework include?

We encountered many different expectations for this project during the scoping phase, and these were again evident in the comments received during the first round of reviews.

Most fundamentally, expectations for the final product spanned the range from:

- A clear description of assessment activities (e.g. "Perform at least a visual escapement survey for each conservation unit at least 2 out of every 4 years"), to
- Tools for assessing operational trade-off questions (e.g. "What is the optimal split for distributing funds between in-season run-size estimation for abundant stocks and consistent escapement monitoring of less abundant stocks?").

Stock assessment information is used for a wide range of purposes within DFO, and by many other agencies and organizations as well. These different end-users generally bring their own assessment priorities, and sometimes even their own budgets, into a complex multi-agency planning process. It is not practical to force these different priorities into a single strategic assessment plan and assign a relative importance to priorities resulting from different policies (e.g. *Wild Salmon Policy* vs. *Pacific Fisheries Reform*). Rather, we envision a process where each particular planning exercise (e.g. different initiatives, budgets, or agencies) works through four steps:

Step 1: Apply the appropriate policy filters to a system-wide evaluation of risks and information gaps.

Step 2: Identify problem areas and set assessment priorities.

Step 3: Develop a strategic assessment plan for each problem area.

Step 4: Choose projects based on their contribution to the identified priorities and strategic plans.

A1.2 Four Building Blocks

To support this decision process, the assessment framework is structured around four building blocks:

- *Risk evaluations* with clearly documented guidelines to ensure consistent and transparent interpretation of raw data.
- *Assessment priorities* that identify which risks and information gaps require the most urgent attention.
- *Strategic assessment plans* that map out timelines for addressing the highest priority risks.
- *Standardized project comparisons* that allow funding agencies to select among proposals based on their contribution to the identified priorities and strategic plans.

During the first phase of the project we compiled system-wide risk evaluations for Fraser sockeye and identified a set of assessment priorities based on the risks and information gaps. DFO and the Pacific Salmon Commission reviewed these materials prior to the 2007/2008 planning cycle.

Risk evaluations

The assessment planning process faces growing public scrutiny as stakeholders take a more active role in fisheries management, and increasingly participate in assessment projects through data collection and funding. A transparent framework for prioritizing assessment projects therefore has to establish a clear link between emerging policy requirements and the complex technical details of evaluating biological and social indicators. The most important considerations then need to be summarized in a format that can be easily communicated.

Qualitative, risk-based guidelines for evaluating threats and information gaps can be a highly effective tool for capturing expert judgment and establishing a consistent context for raw data. The resulting inventory of evaluations lends itself to communication with a broader audience. Chapter 4 discusses each of these steps in more detail.

The first, and most fundamental, step is to develop an inventory of existing information and evaluate that information consistently. The emphasis here is to complete a rough but comprehensive evaluation of the whole system, rather than a detailed evaluation of some aspects for some parts. The rough evaluations highlight the major information gaps and most severe threats, and help prioritize additional work.

We identify a comprehensive suite of criteria, grouped into clusters of closely related considerations, and specify risk-based evaluation scales for each of the criteria. Qualitative evaluations provide a standardized inventory of expert judgments, and are not intended as an automated calculation that specifies an annual assessment plan. The intent is not to replace expert judgment, but to support decisions with consistent qualitative evaluations of readily available information. Just as the raw data, the qualitative evaluations will have to be carefully interpreted in the context of the decision at hand. Once completed, these consistent, system-wide evaluations then serve as the basis for the integrated planning of assessment activities, but are flexible enough to inform for a wide range of specific decisions.

Example A1.1: Evaluating status

The current status of a conservation unit can’t be evaluated based on any one indicator. Recent abundance needs to be judged in its historic and biological context (e.g. trends, long-term average, cyclic patterns, and capacity). The Wild Salmon Policy (WSP) includes examples of benchmarks that could be used to determine CU status, but definitions have not been finalized at this point. The indicators and evaluation scales developed for the risk inventory are consistent with the intent of the examples in the WSP and will be updated as the technical details of WSP implementation evolve.

Questions to be considered for this building block include:

- *What are the most appropriate units of evaluation?*
- *What are the most important criteria for evaluating conservation or management units?*
- *What is the current performance of each unit relative to each of those indicators?*
- *How good is our current information base for evaluating performance for each of these indicators?*
- *How do we combine different indicators into an overall evaluation?*

The main challenges for this first part of the project are:

- Finding a balance between ensuring consistent evaluations and leaving sufficient flexibility for dealing with the multitude of nuances that can't be formally captured.
- Building agreement among experts from a wide range of backgrounds on the scope and overall rationale of formalized risk evaluations.
- Translating complex expert judgment into a manageable set of indicators and guidelines for qualitative evaluation.
- Compiling readily available information to complete a first round of consistent evaluations for all Fraser sockeye.

Assessment priorities

The first step is to identify groups of conservation units facing similar threats or information gaps. Once threats and information gaps have been identified, they can be prioritized based on biological and social objectives reflected in the relevant policy documents. These priorities will differ among parts of DFO and other end-users. For example, assessment priorities under the WSP focus on conservation units and their status, while assessment priorities under the Pacific Salmon Treaty focus on fisheries management.

Questions to be considered for this building block include:

- *Which sources of risk have to be addressed first?*
- *Which conservation units require special attention?*
- *Given biological, social, and management considerations, which aspects of a conservation unit should assessment activities focus on?*
- *Given an overall budget, how should it be allocated throughout the Fraser system, and across different types of information?*
- *How much of the current budget should be allocated towards technological advances to improve delivery efficiencies in the future?*
- *What are the minimal assessment requirements for each conservation unit?*

Strategic assessment plans

Once assessment priorities have been identified, they can feed into the development of strategic assessment plans to address the most pressing threats or information gaps. We provide interactive decision tools and reference materials to support the process of developing strategic assessment plans.

Example A1.2: Information gaps under the WSP

Current information is insufficient for evaluating the status of several CUs. A strategic plan needs to be developed for first determining whether these really are distinct functional units of sockeye, and then completing some preliminary status evaluation for those that truly are CUs.

Standardized project comparisons

Project proposals can be compared based on their expected contribution to reducing uncertainty and the risk to conservation and sustainability. A project that addresses a common threat or information gap for a group of conservation units could be assigned a higher priority than another project that addresses some unique issue for one conservation unit.

Example A1.3: Southern Endowment Fund

A standardized list of questions could to be added to the evaluation of project proposals submitted to the Southern Endowment Fund. These questions could use the compiled risk inventory to quickly highlight which CUs directly and indirectly benefit from the proposed project, what their current status is, and how the project addresses broad-scale information gaps.

A1.3 The flow of information: From policies to strategic plans

All four building blocks of the assessment framework are strongly influenced by a wide range of policies, departmental initiatives, and legal obligations. Figure A1.1 shows the conceptual flow of information from the general policy context to strategic assessment plans that address particular priorities:

- The policy context for Fraser sockeye can be characterized by four major topic areas. The Wild Salmon Policy (WSP) focuses on conservation of wild Pacific salmon populations, Aboriginal Rights and Treaties reflect the distinct and evolving role of First Nations, Pacific Fisheries Reform emphasizes sustainable benefits and their distribution, and the Pacific Salmon Treaty covers management responsibilities and international obligations.
- Based on this policy context, the we identified a comprehensive set of assessment objectives. In a sense, this captures a wish list of everything we would like to achieve through resource assessment. For example, flowing from the WSP one of the assessment objectives is to “determine the status of conservation units”.
- Based on these assessment objectives, we developed an inventory of potential threats and information gaps, using qualitative risk evaluations. The criteria and evaluation methods used to develop this inventory have to be well grounded in the assessment objectives. Continuing the example, we propose a combination of indicators to evaluate the current status of a conservation unit.
- This inventory of potential threats and information gaps serves as a consistent but flexible starting point for the development of strategic assessment plans. Each particular planning process (e.g. different initiatives, budgets, or agencies) can apply the appropriate policy filter to the compiled evaluations, identify assessment priorities, and identify problem areas which need to be dealt with in some form. Continuing the example, current information is insufficient for evaluating status for several CUs. A strategic plan needs to be developed for first determining whether these really are distinct functional units of sockeye, and then completing some preliminary status evaluation for those that truly are CUs.

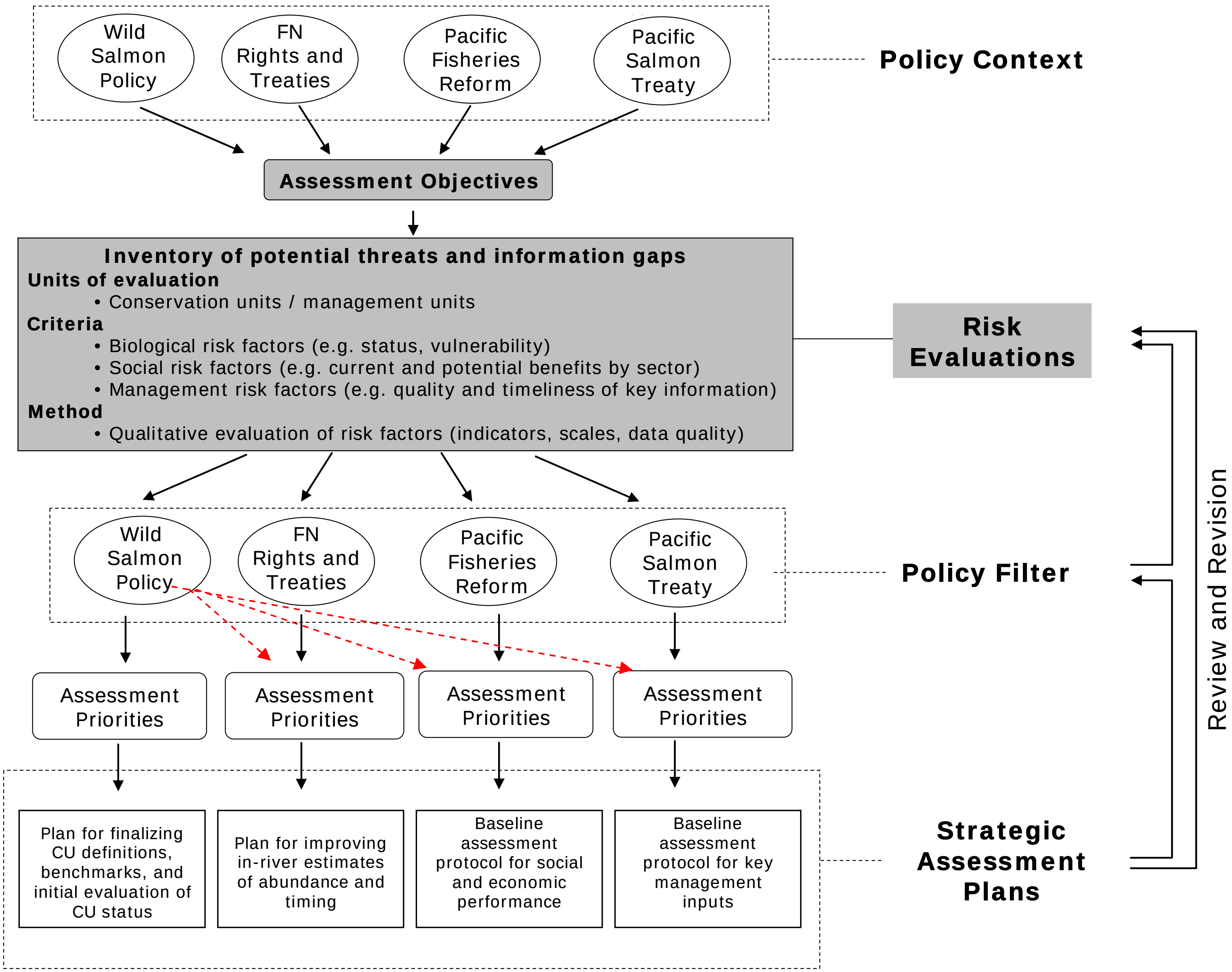


Figure A1.1: Building blocks for a resource assessment framework for Fraser sockeye. (Shaded boxes indicate initial focus of this project)

Appendix 2: Management context

This Appendix outlines the management background for the assessment of Fraser River sockeye resources.

A2.1 Policies and Initiatives

Overview

The task of resource assessment is to provide decision makers with the data and tools to better achieve the management objectives defined by an evolving body of policies. For Fraser sockeye, the policy context can be characterized by four major topic areas: Canada's Wild Salmon Policy, Aboriginal Rights and Treaties, the Canada-US Pacific Salmon Treaty, and the Pacific Fisheries Reform initiative. The Wild Salmon Policy (WSP) defines conservation goals and action steps for ensuring the sustainability of wild Pacific salmon, and is currently in the initial stages of implementation. Aboriginal Rights and Treaties reflect the distinct and evolving role of First Nations in the harvest and management of Fraser Sockeye. The Pacific Salmon Commission and the Fraser River Panel operate under the auspices of the Canada-US Pacific Salmon Treaty and are responsible for the in-season management of Canadian and US Fraser sockeye fisheries in "Panel" waters in southern BC and northern Washington State. The Pacific Fisheries Reform (PFR) initiative focuses on the Canadian domestic benefits, both social and economic, derived from fisheries resources, how those benefits can be accessed, and how they will be shared.

As part of these emerging policies, the year-to-year management of Fraser sockeye has shifted away from a production-based approach with exploitation rate of 70%-80% on abundant stocks to a conservation-focused approach. Exploitation rates have been reduced to protect stocks that are less productive, less abundant, or both.

Wild Salmon Policy

The Wild Salmon Policy (WSP) defines conservation goals and action steps for ensuring the sustainability of wild Pacific salmon, and is currently in the initial stages of implementation:

- *"The goal of the Wild Salmon Policy is to restore and maintain healthy and diverse salmon populations and their habitats for the benefit and enjoyment of the people of Canada in perpetuity."*
- *"This policy goal will be advanced by safeguarding the genetic diversity of wild salmon populations, maintaining habitat and ecosystem integrity, and managing fisheries for sustainable benefits."*
- *"Conservation of wild salmon and their habitat is the highest priority for resource management decision-making."*
- *"Resource management processes and decisions will honour Canada's obligations to First Nations."*

Canada's Policy for Conservation of Wild Pacific Salmon (DFO, June 2005)

To be consistent with the WSP, we evaluate Fraser sockeye populations at the level of conservation units (CUs), which capture one or more populations that are closely connected and function independently of other populations. However, some evaluation criteria apply at coarser or finer resolutions, such as management units aggregating several CUs, or individual populations within a

CU. Refer to *Units of Evaluation* and *Data Sources* on page 7 for more information. We used a the most recent list of CUs (DFO 2009a), recognizing that it may be revised in the future through scientific review and public consultation.

The WSP includes examples of benchmarks that could be used to determine CU status, but definitions have not been finalized at this point. The indicators and evaluation scales we developed for risk inventory are consistent with the intent of the examples in the Policy, and will be updated as the technical details of WSP implementation evolve.

Aboriginal Rights and Treaties

Aboriginal fisheries occur in a distinct and changing setting. This section briefly explains some of the terminology and administrative structure. All quotes are taken from Treaty and Aboriginal Policy Directorate website (http://www.pac.dfo-mpo.gc.ca/tapd/links_e.htm), which discusses all of these topics in more detail, and links to additional information available on-line (e.g. court decisions, treaties, reports)

- *"In 1990, the Supreme Court of Canada released its decision in R. v. Sparrow. In this landmark decision, the Court held that, after conservation and other "valid legislative objectives", Aboriginal rights to fish for food, social and ceremonial purposes have priority over all other uses of the fishery. The Court also held that infringements of Aboriginal rights must be justified and that part of the justification analysis involves an assessment of whether adequate consultation has occurred."*
- *"As an interim response to the R. v. Sparrow decision, DFO in 1991 created the "Aboriginal Co-operative Management Program" to test possible approaches to Aboriginal fisheries issues on a one-year basis. The response was successful in that Aboriginal people became involved in the design and implementation of fisheries management, habitat restoration, fish enhancement and catch monitoring activities. This involvement resulted in DFO launching the "Aboriginal Fisheries Strategy" (AFS) in 1992."*

Objectives for the Aboriginal Fisheries Strategy include:

- *" Provide Aboriginal groups with an opportunity to participate in the management of their fisheries."*
- *"Allow Aboriginal groups to improve their skills and capacity to manage the fisheries in which they participate."*
- *" Contribute to the economic sustainability of Aboriginal communities through fisheries-related activities"*
- *"Provide a foundation for the development of treaties and self-government agreement."*
- *"Allow Aboriginal groups to test innovative fisheries-related economic opportunities, such as aquaculture and studies of markets, processing methods and product quality"*

Two reports provide complementary perspectives on treaties and collaborative management of salmon fisheries:

- *Our place at the table: First Nations in the B.C. Fishery* *www.fns.bc.ca/pdf/FNFishPanelReport0604.pdf*
- *Treaties and Transition* *http://www.dfo-mpo.gc.ca/Library/280188.pdf*

DFO and First Nations are increasingly collaborating on stock assessment projects, and an important element of the evaluation framework was to develop some practical format for documenting and incorporating the relevant concerns and priorities of First Nations. Draft versions of the framework and preliminary results were presented in several workshops with First Nations fisheries staff, and feedback received during these meetings was incorporated into the final draft.

Secwepemc Fisheries Commission (SFC) staff participated in a pilot project for capturing First Nation's stock assessment priorities. During a 1-day workshop we developed a draft template for scoring the relative importance of conservation units as well as the current performance of those CUs that are locally important. The template has now been offered other First Nations technical staff for review, and will be revised based on further feedback. The preliminary importance and risk scores provided by SFC staff are used here for illustrative purposes, and are subject to revision at any time.

<u>Pacific Salmon Treaty</u>

The Pacific Salmon Treaty (PST) was originally ratified in 1985, and revised in 1999. The PST (Article VI) establishes Canada-United States cooperation on the management of Fraser River sockeye and pink salmon and provides the operational context for assessment activities. It specifies:

- *Roles and responsibilities of the Parties and the Commission:* The Pacific Salmon Commission and the Fraser River Panel operate and are responsible for the in-season management of Canadian and United States Fraser sockeye and pink salmon fisheries in “Panel” waters in southern British Columbia and northern Washington State. Fisheries and Oceans Canada is responsible for providing pre-season forecasts of return abundance and pursuant to Article IV.3, Canada is also responsible for establishing Fraser River sockeye and pink salmon escapement targets for the purpose of calculating total allowable catches and establishing domestic catch shares.
- *International sharing agreements*
- *A hierarchy of conservation objectives*
- *General assessment responsibilities.* These are defined in several places throughout the treaty (e.g. Chapter 4 of Annex IV, Diplomatic note of Aug 13, 1985), and include the following:
    - The Fraser River Panel is responsible for collecting in-season information on catches within the Panel area, collating information provided by the Parties outside of the Panel area, conducting test fishing on Fraser River sockeye and pink salmon, collecting data on up-river escapements at Mission Bridge and Hell’s Gate, and conducting studies to identify and discriminate between races of Fraser River sockeye and pink salmon harvested in the fisheries including specification of samples required from upriver sections of the Fraser River and from sites outside of the Panel area.
    - DFO is responsible for collecting and sharing in-season catch data outside Panel waters, post-season catch and escapement data (by time, area, species and gear type).

This shared responsibility of planning and conducting stock assessment requires close coordination between the PSC and DFO. The risk evaluations and priorities identified through this project form an important basis for coordinated planning, and are intended to streamline the review process for project proposals under the PSC's Restoration and Enhancement Fund. For example, we are developing a list of questions to be added to the standardized evaluation of project proposals submitted to the Southern Endowment Fund. These questions will highlight which CUs directly and indirectly benefit from the proposed project, what their current status is, and how the project addresses broad-scale information gaps. A draft template is available upon request from framework@solv.ca

Pacific Fisheries Reform

The Pacific Fisheries Reform (PFR) initiative focuses on the social and economic benefits derived from fisheries resources, how those benefits can be accessed, and how they will be shared: The goals of PFR are:

- *Full economic and social potential of the resource is achieved.*
- *First Nations' fishing interests are defined and reconciled with the interests of all Canadians.*
- *There is public, market and participant confidence that the fishery is sustainable.*
- *Participants are self-reliant and able to self-adjust.*
- *Participants are treated fairly and equitably and are involved in decision-making and share accountability for the conduct of the fishery.*
- *Costs of management are shared by those who benefit from the harvest.*
- *All fishery participants enjoy certainty and stability necessary for business planning.*
- *Equitable treaty-based fisheries are achieved.*

A Discussion Paper on the Implementation of Pacific Fisheries Reform (DFO, September 2005)

All harvesters are taking a growing role in the assessment of Pacific fish stocks. This framework is intended to support collaborative assessment initiatives by establishing a consistent, risk-based rationale for prioritizing projects, and sharing the collected information efficiently.

A 2.2: Assessment objectives

This section summarizes proposed assessment objectives based on the policy context described in the previous section, and identifies assessment requirement that flow from these objectives.

Overview

We identified five over-arching assessment objectives for Fraser sockeye, in rough order of priority, and subject to review:

- Determine the status of conservation units.
- Predict biological consequences of human activities.
- Proactively participate in the development and application of the resource management process.
- Improve understanding and explanation of the biological system through adaptive learning.
- Improve service delivery.

In a sense, this captures a wish list of everything we would like to achieve through resource assessment. Strategic planning of resource assessment activities requires that each project is clearly linked to one or more of these objectives and the risk-based evaluations serve as a reference for establishing that connection. For example, we identify those conservation units for which current status can't be evaluated due to information gaps. Proposed projects can then be prioritized based on the risks and information gaps they address.

Objective 1 - Determine the status of conservation units

The Wild Salmon Policy provides guiding principles for case-specific status evaluation using trends in abundance and distribution to evaluate status relative to conservation benchmarks.

Resource assessment needs to build and maintain the information base necessary to evaluate the status of all conservation units and detect any threats to sustainability in a timely manner.

- Develop standardized indicators of CU status.
- Define conservation benchmarks for each indicator.
- Assess current status relative to benchmarks.
- Monitor trends in indicators of CU status.

Objective 2 - Predict biological consequences of human activities

The precautionary approach identified in both the Wild Salmon Policy and Pacific Fisheries Reform requires that the management of Fraser sockeye anticipates potential future threats to conservation or sustainable benefits.

Resource assessment needs to build and maintain the information base and analytical capacity necessary for the development and application of predictive models.

- Monitor harvest and non-harvest activities.
- Identify acute and chronic threats to each CU, and develop a research plan to investigate the causal mechanisms.
- Assess biological implications of alternative harvest strategies.

Obj. 3 - Proactively participate in the development and application of the resource management process

As part of Pacific Fisheries Reform, the management process for Fraser sockeye will further shift towards stakeholder participation and stable sharing arrangements.

Resource assessment needs to build and maintain the analytical capacity to supply the necessary information to the management process.

- Anticipate the information needs for the evolving management process.
- Evaluate alternative management strategies and account for uncertainty in the biological and management systems.

Obj. 4 - Improve understanding and explanation of the biological system through adaptive learning.

Resource assessment needs to foster constant learning and revise assessment programs in response to changing information.

- Identify knowledge gaps.

- Identify sources of uncertainty and alternative hypothesis that affect the expected performance of alternative harvest strategies (e.g. capacity estimates, cyclic dynamics).
- Design assessment programs and recommend management strategies that help discriminate among alternative hypotheses and reduce sources of uncertainty.
- Build up a data legacy of consistent records for future researchers that allows for better understanding of population dynamics and environmental mechanisms.

Objective 5 - Improve service delivery.

Resource assessment needs to foster constant improvement in the cost-effectiveness and timeliness of assessment programs.

- Develop and implement technological advances in assessment tools.
- Develop clear quality standards for assessment activities (e.g. known precision).
- Regularly review the performance of assessment activities relative to quality standards.
- Maximize the value of information from the entire suite of assessment activities (e.g. extent of coverage vs. precision).
- Ensure institutional accounting.
- Streamline information flow from data collection to decision making.

Appendix 3: Evaluation scales for Biological Risk Factors

Risk Factor 1: Status

Criterion 1: Trend in abundance

Indicator: Change in escapement over last 3 generations	
Exact Definition: Slope in 4 yr running geometric mean of escapement over last 12 years	
Severity scale • Not declining (1) < 0 • Slightly declining (2) < 30% • Moderately declining (3) < 50% • Strongly declining (4) < 70% • Severely declining (5) > 70%	**Uncertainty scale** Based on quality of aggregate escapement estimates • Very Low (1) = census or mark-recapture for at least two years of every generation in the last 3 generations • Low (2) = More than 5 obs. in last 3 gen. with at least 2 in last gen, at least visual calibrated with fence • Moderate (3) = 5 or more obs in last 3 gen based on visual estimate, and at least 2 in last generation • High (4) = 5 obs in last 3 generations, with at least 1 obs. in last generation • Very High (10) = Insufficient information for evaluating severity
Comments: Alternative measures were explored and identified similar trends. A range of trend measures is displayed under "CU Snapshot" in the interactive decision support tools.	

Criterion 2: Cycle line decline

Indicator: Largest observed decline by cycle line	
Exact Definition: Geometric mean of two most recent cycle escapements divided by geometric mean of escapement 3 and 4 cycles ago	
Severity scale • No decline (1) > 75% • Some decline (2) <75% • Strong decline (3) < 50% • Very strong decline (4) < 25% • Extreme decline (5) < 10%	**Uncertainty scale** • Very Low (1) = census or mark-recapture estimate for last 4 cycle escapements • Low (2) = at least 3 observations from the last 4 cycle escapements, at least visual calibrated with fence • Moderate (3) = at least 3 observations from the last 4 cycle escapements based on visual estimate • High (4) = at least 1 observation 3 and 4 cycle ago, and at least 1 obs. in last 2 cycles • Very High (10) = Insufficient information for evaluating severity
Comments:	

Criterion 3: Abundance

Indicator: Abundance	
Exact Definition: Avg. escapement over last 4 years (Geometric Mean)	
Severity scale	**Uncertainty scale**
• Abundant (1) > 100k • Moderately abundant (2) > 10k • Low (3) > 1k • Very Low (4) > 100 • Extremely Low (5) <100	• 3 or more obs with census or mark recapture = Very low (1) • 3 or more obs at least visual calibrated with fence= Low (2) • 3 or more obs =Moderate (3) • High (4) = at least 2 observations in last 4 years • Very High (10) = Insufficient information for evaluating severity
Comments:	

Criterion 4: Distribution across populations in a CU

Indicator: Distribution of abundance across populations in a CU	
Exact Definition: Decline in abundance criterion if most abundant population were lost (avg over last 4 years)	
Severity scale	**Uncertainty scale**
• Diverse (1) = no change in abundance indicator, • Moderately concentrated (3) = excludes more than half CU abundance • Strongly concentrated (5) = drop 1 grade in abundance indicator (>90%)	Based on quality of escapement estimates for populations in CU, details to be determined
Comments:	

Criterion 5: Abundance relative to long-term average

Indicator: Recent average / overall average	
Exact Definition: Average escapement over last 4 years / overall average escapement (Geometric Mean)	
Severity scale	**Uncertainty scale**
• Near avg. (1) > 75% • Below avg. (2) <75% • Low (3) <50% • Very low (4) <25% • Extremely low (5) <10%	• 3 or more obs with census or mark recapture in last gen & 30+ add. obs= Very low (1) • 3 or more obs in last gen with fence-calibrated visual est. & 30+ add. obs= Low (2) • 3 or more visual obs in last gen & 30+ add. obs= Moderate (3) • 2 obs in last gen & 10+ add. obs = High (4) • Less than 2 obs in last gen OR less than 10 additional observations (10)
Comments:	

Criterion 6: Recent abundance relative to largest observed abundance

<table>
<tr><td colspan="2">Indicator: Recent generational average. / largest 10yr average</td></tr>
<tr><td colspan="2">Exact Definition: Avg. escapement over last 4 years / highest 10yr running average (Geometric Mean)</td></tr>
<tr><td>Severity scale
• Near highest (1) > 75%
• Below highest (2) <75%
• Low (3) <50%
• Very low (4) <25%
• Extremely low (5) <10%</td><td>Uncertainty scale
• 3 or more obs with census or mark recapture in last gen & 30+ add. obs= Very low (1)
• 3 or more obs in last gen with fence-calibrated visual est. & 30+ add. obs= Low (2)
• 3 or more visual obs in last gen & 30+ add. obs= Moderate (3)
• 2 obs in last gen & 10+ add. obs = High (4)
• Less than 2 obs in last gen OR less than 10 additional observations (10)</td></tr>
<tr><td colspan="2">Comments:</td></tr>
</table>

Criterion 7: Abundance relative to current capacity

<table>
<tr><td colspan="2">Indicator: Recent abundance relative to current capacity</td></tr>
<tr><td colspan="2">Exact Definition: % of observations in last 12 years with abundance outside of +-75% of capacity</td></tr>
<tr><td>Severity scale
• At Capacity (1) < 25%
• Near Capacity (2) < 40%
• Below/above Capacity (3) < 60%
• Significantly below/above Capacity (4) < 80%
• Severely below/above capacity (5) < 100%</td><td>Uncertainty scale
• Quantitative estimate of capacity for all life stages (1)
• Quantitative estimate of capacity for more than 1 life stage (2)
• Quantitative estimate of capacity for 1 life stage (3)
• Quantitative estimate covering multiple CUs (4)
• Insufficient information for evaluating severity (10)</td></tr>
<tr><td colspan="2">Comments: Currently approximate capacity using an estimate of escapement that maximizes sockeye smolt production (Smax) based on the photosynthetic rate (PR) of the rearing lake. Smax for lakes with multiple timing groups this estimate is partitioned based on recent avg. contribution to escapement.</td></tr>
</table>

Criterion 8: Abundance relative to potential capacity

<table>
<tr><td colspan="2">Indicator: Recent abundance relative to potential capacity</td></tr>
<tr><td colspan="2">Exact Definition: TBD</td></tr>
<tr><td>Severity scale
• TBD</td><td>Uncertainty scale
• TBD</td></tr>
<tr><td colspan="2">Comments:</td></tr>
</table>

Criterion 9: Abundance relative to TEK

Indicator: Recent abundance relative to capacity indicated by traditional ecological knowledge	
Exact Definition: TBD	
Severity scale • TBD	**Uncertainty scale** • TBD
Comments:	

Risk Factor 2: Vulnerability

Criterion 10: Productivity

Indicator: Productivity	
Exact Definition: Average recruits / spawner over 3 generations	
Severity scale • Very Good (1)>5 • Good (2) > 3 R/S • Moderate (3) > 2 R/S • Low (4) >1 R/S • Very low (5) = 1 R/S or less	**Uncertainty scale** • Very Low = census / mark-recapture estimate for last 4 years (1) • Low = visual estimate calibrated with fence for last 4 years (2) • Moderate = visual estimate for at least 3 of last 4 years (3) • High = visual for 2 of last 4 years (4) • Very High = One or no observation in last 4 years (10)
Comments: Quality of catch data tends to mirror quality of escapement data	

Criterion 11: Diversity - Life History

Indicator: Diversity - Life History	
Exact Definition: Number of populations in the CU	
Severity scale • Many (1) >= 10 • Several (2) >=6 • Few (3) >= 4 • Very few (4) >=2 • Single (5) = 1	**Uncertainty scale** • Uncertainty score based on extent and consistency of survey coverage. Initially assigned MODERATE across all CUs
Comments:	

Criterion 12: Diversity - Genetic

Indicator: To be determined	
Exact Definition: To be determined	
Severity scale	**Uncertainty scale**
• To be determined	• To be determined
Comments:	

Criterion 13: Sensitivity of critical habitat

Indicator: To be determined	
Exact Definition: To be determined	
Severity scale	**Uncertainty scale**
• To be determined	• To be determined
Comments:	

Criterion 14: Overlap with CU of high harvest potential

Indicator: Overlap with CU of high harvest potential	
Exact Definition: Expert Judgment	
Severity scale	**Uncertainty scale**
• Little overlap (1) • Some overlap (3) • Fully mixed (5)	• To be determined
Comments: Preliminary evaluation based on overlap with Summer run as follows: Early Stuart = 1; late early summers: 3, early Early summers = 2 , because early-timed early summers less vulnerable" (two groups Nadina/Gates and Seymour/Scotch); true lates: 2, early lates 3	

Criterion 15: Variability in abundance

Indicator: Variability in abundance	
Exact Definition: Coefficient of Variation in avg. escapement (4 yr-running Geometric Mean)	
Severity scale	**Uncertainty scale**
• 0 = Highly Stable (1) • 0.5 = Moderately stable (2) • 1 = Average Variability (3) • 2.0 =Moderately Variable (4) • 3.0 = Highly Variable (5)	• 50 or more obs = very low (1) • 40 or more obs = Low (2) • 30 or more obs =Moderate (3) • 10 or more obs = High (4) • 9 or fewer obs = Insufficient info (10)

Criterion 16: Cyclicity

Indicator: Cyclicity	
Exact Definition: % of recent 4-year abundance in most abundant cycle line	
Severity scale	**Uncertainty scale**
• Even (1) < 30% • Slightly cyclic (2) <45% • Moderately cyclic (3) < 60% • Highly cyclic (4) < 75% • Extremly cyclic (5) > 75%	• 3 or more obs with centsus or mark recapture = Very low (1) • 3 or more obs at least visual calibrated with fence= Low (2) • 3 or more obs =Moderate (3) • 2 obs = High (4) • 1 or no obs = Insufficient info (10)

Risk Factor 3: Direct Human Impact

Criteria 17-20: Targeted harvest, incidental harvest, harvest induced, non-harvest

Indicator: Mortality rate	
Exact Definition: Avg. mortality rate over last generation	
Severity scale	**Uncertainty scale**
• Very low (1) < 10% • Low (2) < 30% • Moderate (3) <50% • High (4) <70% • Very high (5) = 70% or more	• Very Low = census or mark-recapture estimate for last 4 years (1) • Low = visual estimate calibrated with fence for last 4 years (2) • Moderate = visual estimate for at least 3 of last 4 years (3) • High = visual for 2 of last 4 years (4) • Very High = One or no observation in last 4 years (10)
Comments: Quality of catch data tends to mirror quality of escapement data	