Fraser River Integrated Sockeye Spawning Initiative

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Introduction

I attended the Fraser River integrated Sockeye Spawning Initiative (FRISSI) meetings on January 21 and 22, 2009 under contract to UFFCA. FRISSI has been around for several years, and has been used to set "Total Allowable Mortality" or TAM rules for timing aggregates of Fraser sockeye. I attended several initial meetings of this process on behalf of the Marine Conservation Caucus (MCC), however, the MCC withdrew from this process when it was clear that DFO was unable or unwilling to address substantive concerns provided in writing (attached).

The FRISSI process is represented by DFO as a Wild Salmon Policy (WSP) implementation pilot for Fraser sockeye. At the heart of the process is what salmon biologists call Stock/Recruit analysis.

Stock Recruit analysis

Stock Recruit analysis looks for a useful relationship between the abundance of a spawning stock of salmon, and the number of their offspring that survive to enter fisheries ('recruits'). Dr. Bill Ricker, working at the Biological Station in Nanaimo argued that salmon stocks were highly productive when freshwater habitat capacity was not limiting, but less productive when populations approached or exceeded the carrying capacity of their freshwater habitats. Dr. Ricker cited competition and disease as possible mechanisms.
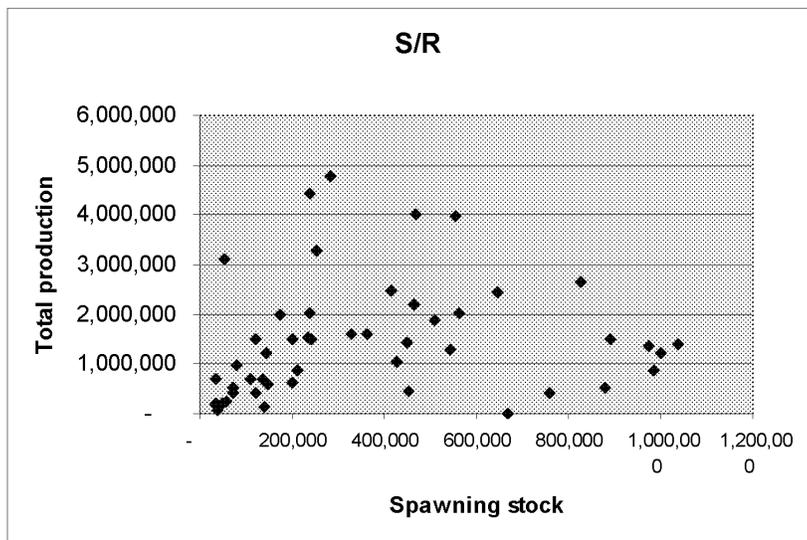

Figure 1 SR plot for Chilko sockeye showing a dome shaped relationship

1

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Declining productivity at larger run sizes leads to a 'dome shaped' relationship (Figure1). Ricker's arguments were very much in tune with the theories of the day, and offered a 'rigorous' scientific approach to the problem of deciding how many salmon to harvest from any given salmon stock in any given year, but the analysis was dependant on several critical assumptions, and a long time series of observations unavailable for many salmon stocks. Even when 'good' data are available, the SR data for many Fraser sockeye CU's does not demonstrate a dome shaped relationship (Figure 2).
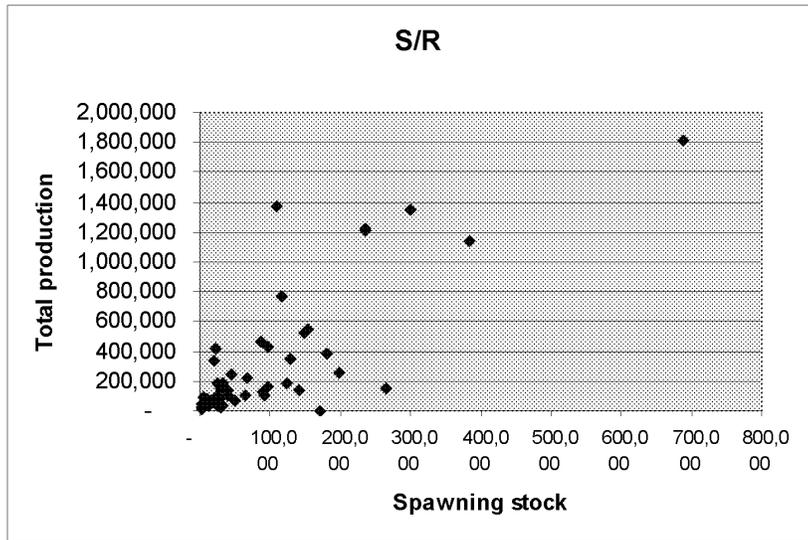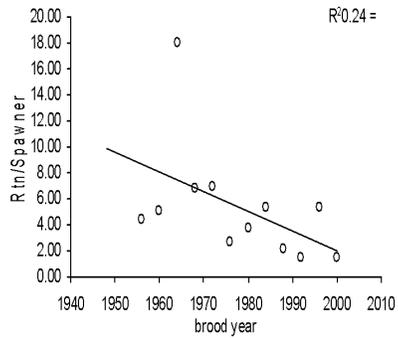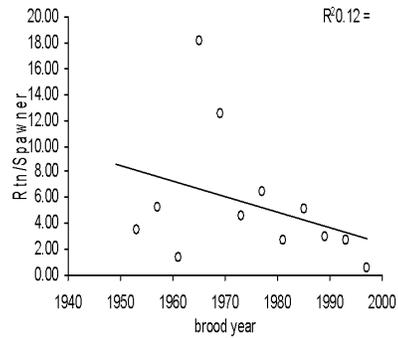

Figure 2: SR plot for early Stuart sockeye showing no decline in productivity at larger run sizes

Providing the relationship between stock and recruitment is stable over time, fitting a SR relationship to the data for a particular salmon stock can be used to define Maximum Sustainable Yield or MSY. The number of recruits produced by each spawner is expected to decline as spawner abundance increases, but traditional SR analysis assumes and requires that there is no increasing or decreasing trend in productivity independent of spawner abundance.
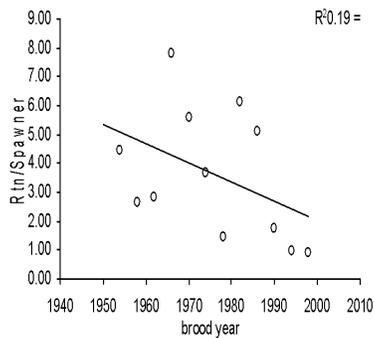
When the productivity of salmon populations shows a time trend that is independent of changes in spawner abundance, a SR relationship provides harvest managers with little useful information. The problem is most significant when productivity of a salmon stock is declining. In Stock Recruit terms, declining time trends in productivity mean that the 'maximum sustainable yield' is steadily decreasing and cannot be defined. From a conservation perspective, until the declining trend in productivity stops, it is impossible to argue that there is any long term sustainable yield available for harvest. Biologists call time trends in salmon productivity unrelated to stock abundance a 'loss of stationarity'.
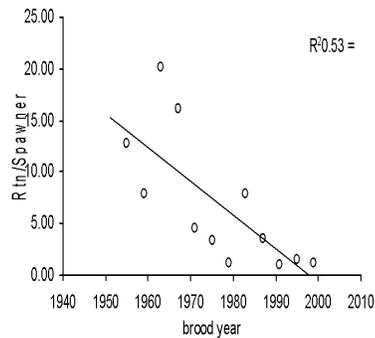
2

$R^2 = 0.24$
$R^2 = 0.12$

Rtn/Spawner — brood year (2004 cycle early Stuart)

Rtn/Spawner — brood year (2005 cycle early Stuart)

2004 cycle early Stuart   2005 cycle early Stuart

$R^2 = 0.19$
$R^2 = 0.53$

Rtn/Spawner — brood year (2002 cycle early Stuart)

Rtn/Spawner — brood year (2003 cycle early Stuart)

2002 cycle early Stuart   2003 cycle early Stuart

Figure 3: time trends in productivity (recruits per spawner) for early Stuart sockeye by cycle line.

There are many examples of loss of stationarity for Fraser sockeye, but Early Stuart sockeye are a good example. Since early Stuart sockeye are also declining in abundance, the declines in productivity over time cannot be attributed to declining productivity at larger run sizes. A detailed review of the stationarity of Fraser sockeye populations is beyond the scope of this report, but certainly not beyond the scope of the FRISSI.

Escapement estimation bias
At small run sizes (less than 25K) the number of Fraser sockeye spawners is (by policy) usually estimated using visual methods, while at larger run sizes mark and recapture methods are usually employed. Recent data presented by DFO assessment staff suggests that visual estimates are generally biased low, while Mark Recapture (MR) estimates tend to be biased high (because missed marks, lost tags and tag induced mortality can all lead to over estimation of large returns). In some cases the positive bias of MR estimates can be substantial. Together these two sources of bias, if significant, can lead to overestimation of productivity at smaller run sizes, and an overestimation of MSY.

3

Miss-allocation of fish to stock

In developing a SR data set, it is necessary to attribute the catch to the stock of origin. Until relatively recently, the PSC used scale pattern analysis to determine the stock composition of the catch. When very abundant stocks migrate with much less abundant stocks, the errors in determining stock of origin of more abundant stocks can swamp less productive stocks. For example imagine two stocks migrating together, one (stock A) with 4 million members and the other (stock B) with 10 thousand members. Let's assume for this example that both stocks are harvested at 50%. 2 million fish from stock A and 5,000 fish from stock B are harvested. If 1% of the scales from both stocks are miss read and allocated to the other stock in error, then 1% of stock A's catch will be allocated to stock b and vice versa (1% of 2 million or 20,000 fish will be added to stock B, while stock B will lose 1% of 5,000 or 50 fish which will be added to stock A. The catch of A will be estimated at 1,980,050, while the catch of B will be estimated as 24,950. The catch of A is underestimated by less than 1%, while the catch of B is overestimated by almost 500%. This is both an exaggeration and an oversimplification to illustrate a point, but errors in estimating the stock composition of the catch can lead to significant and important errors in estimating run size of small stocks, and these errors can have lead biologists to dramatically overestimate the productivity of small sockeye populations, which in turn could lead fisheries managers to over estimate the capacity of small stocks to withstand fishing pressure, leading to fisheries plans that can drive smaller sockeye populations to extinction.

Beyond SR analysis

Lack of data

Approximately 44 sockeye Conservation Units (CU's) spawn in the Fraser drainage. DFO has a SR time series of data for only 19 of these CU's. The 'goodness of fit' for SR relationships for some of the 19 stocks where data are available suggests that the relationships are very weak. Using data from 19 stocks to represent 44 stocks presents problems. The stocks for which we have data tend to be the more abundant and more productive stocks. It is impossible to know whether the stocks for which little or no data are available have productivities similar to or very different from those stocks for which data are available.

Inappropriate assignment of stocks to timing groups

In setting TAM rules for Fraser sockeye, the FRISSI uses the SR relationship in a forward simulation model to estimate the yield (catch) and escapement from selected stocks within each stock aggregate, and to estimate the likelihood that the individual stocks (CU's) within each aggregate will drop below levels considered (in the model) to result in a conservation concern. It is assumed that all the stocks within each timing aggregate have the same run timing and are equally vulnerable to each fishery. In reality, we know that Fraser sockeye stocks within the same run timing group can and often do

4

have very different run timing. Depending on the number and timing of fisheries, individual Cu's within a timing group can be harvested at very different rates.

Overlap between managed stock aggregates.
In reality, the Fraser sockeye run is made up of 40 or more genetically distinct stocks. The earliest stocks begin to enter the Fraser in Late June, and last of the late sockeye are still entering the river in September. Migration timing changes from year to year and appears to be undergoing longer term shifts as well. Timing or management aggregates are not biological entities, but are constructed for the convenience of managers regulating mixed stock ocean fisheries. Early Stuart sockeye entering the Fraser headed to the Stuart are mixed with the earliest of the early summer sockeye, the majority of early summer stocks migrate along with the first of the major summer runs, and so do most of the 'late' sockeye. Obvious problems with the assignment of stocks into aggregates were discussed by Dr. Jim Woodey in 1996, during his tenure as Senior Biologist for the PSC (attached). Dr. Woodey recommended modifications to the stocks included in each group to better reflect their run timing and to improve management control. In the 13 years since Dr. Woodey's memo, little has changed.

The mystery of cyclic dominance
Some (but certainly not all) Fraser sockeye stocks demonstrate strong cyclic dominance. The typical pattern for cyclic stocks is two strong years (dominant year and sub-dominant year) followed by two weak years (off cycle years). Despite endless speculation, science cannot explain the causes cyclic dominance, or understand the factors that influence its intensity. Since cyclic dominance can have a profound effect on the productivity and stability of sockeye populations, we often fit SR models that mimic cyclic dominance (cycle line interactions). Our lack of understanding of the causes of cyclic dominance, and the factors that might lead to the breakdown, re-establishment or change in the dynamics of cyclic dominance for a particular stock is cause for concern when evaluating a stocks longer term response to fishing pressure, or speculating about how a stock might respond to a particular fishing strategy in the future (which is exactly what FRISSI does).

Performance of First Nations fisheries
In the upper Fraser there is a clear relationship between the abundance of sockeye, and the sockeye food, social and ceremonial harvest. In many areas of the Fraser only a few stocks are available to some First Nations communities to meet their food needs, and the abundance of sockeye needed to support food fisheries may be significantly higher than the levels suggested by DFO and the FRISSI process to protect stocks from extinction. In addition to setting minimum benchmarks to protect Fraser sockeye populations from extinction, it may be appropriate to set minimum abundance levels by geographic area to protect First Nations food fisheries.

5

Loss of biodiversity: the mixed stock problem
Harvesting productive and less productive stocks at the same time leads to a difficult compromise. Strong stocks may be under harvested and large escapements may lead to reduced future yield. Weak stocks may be over harvested and may decline in abundance or in some cases disappear altogether. Both Ricker and Larkin have observed that MSY is not a concept that can be applied to mixed stock fisheries without loss of biodiversity. In the context of commercial mixed stock ocean fisheries, the less productive stocks disappear, and stronger stocks thrive, and often this allows fishing pressure to rise and yields to increase in mixed stock fisheries. Many biologists consider the extinction of weaker stocks to be an inevitable consequence of aggressive mixed stock fishing. Unfortunately, some of the less productive CU's may be of particular importance to First Nations in terminal areas of the Fraser, and these First Nations may consider the 'inevitable' loss of their fish to support mixed stock harvesting to be an infringement of their aboriginal rights.

Consultation
The FRISSI process is dominated by harvesting interests supported by a technical group to do the modeling and analysis. I believe it is essential that the people guiding the FRISSI process understand exactly what the models are doing, and what the strengths and weaknesses of the data and the models used might be. At each meeting that I have attended, participants regularly comment that they do not fully understand the technical issues, and then proceed to comment on the models and their application to the management of Fraser sockeye. I question the ability of fishers to provide the FRISSI technical team with appropriate guidance when they may not understand what the models are doing, or the strengths and weaknesses of the data.

Non Technical modifications to TAM rules
Tam rules set by DF are already leading to overfishing of less productive stocks. In practice fishing pressure is increased significantly above the levels set out in TAM rules for what might be called "practical' considerations. Last year, the shape of the TAM curves was changed to avoid abrupt changes in harvest policy as the run approaches lower benchmarks. For late sockeye, the FRISSI models recommend that late sockeye not be harvested at current levels of abundance. Nevertheless, the TAM rule has been set to allow 20% of late sockeye to be harvested in order to gain better yields from summer stocks. These harvests are, by definition, unsustainable, and have been unsustainable for many years.

What did PSARC say about FRISSI?

PSARC has reviewed the proposed methodology applied to two of the strongest Fraser CU's. The comments that follow are taken directly from the PSARC salmon subcommittee report (attached). These comments mirror some of the most significant concerns already expressed. It is my view that these concerns have not been adequately addressed. Please note that that PSARC only looked at the application of the model to

6

two of the most abundant Fraser sockeye CU's (out of more than 40 Fraser CU's). The forward simulations, TAM rules, the make up of management timing aggregates and application of TAM rules to manage complex overlapping aggregates with incomplete data was NOT part of the review.

"the Subcommittee noted that data for Chilko and Quesnel are some of the best available and there was concern about how the model would deal with systems for which the data are poorer. The Authors responded that there would be increased uncertainty in the model results for these systems."

"the Subcommittee felt that effort should be expended to collect information sufficient to apply the method; in other words, for many systems, the current level of data collection would be inadequate to determine if the harvest rules would be effective."

"The Subcommittee was concerned about the choice of stock-recruit relationship used to describe population dynamics. There may be a false expectation of future production from the model if the simple Ricker approach to describe stock dynamics is incorrect because ecological relationships have a meaningful influence on production".

"The Working Paper was accepted with revisions. The Subcommittee concluded that the Working Paper does provide the basis for developing an analytical tool to allow the Fraser River Sockeye Spawning Initiative to develop optimal harvest rules. Subsequent work should focus on aggregates and their components. The Subcommittee noted that soliciting preferences for the value function will be difficult and requires careful planning. Also, it is not clear how the method will manage the designatable units in cases with sparse stock-recruit data. Finally, the framework should be able to deal with changing climate and consider aspects of the Wild Salmon Policy and SARA. Revisions should include the Reviewer's suggestions dealing with alternative forms of the value function. The Subcommittee also concluded that dispensatory mortality effects, implementation error and maxi-min objectives be considered in the revised Working Paper."

Conclusions and Recommendations

There are multiple and significant possible sources of error and uncertainty in the FRISSI process and its application. I consider the loss of stationary, lack of data for the majority of CU's, and the assumptions around the makeup of run timing or management aggregates and the assumptions around the impacts of fisheries on these aggregates to be the most critical immediate concerns. Taken in aggregate the sum of these uncertainties and assumptions make nonsense of these models, and lead to management advice that, when applied, could significantly damage Fraser sockeye stocks and First Nations fishing interests. There are good reasons to question whether the FRISSI process is even capable of providing defensible advice to harvest managers, but the current process clearly does not.

7

I recommend that the FRISSI undergo a through and independent scientific review considering:

1.) loss of stationarity
2.) data quality and bias
3.) under-represented stocks
4.) make up of timing aggregates
5.) cyclic dominance
6.) TAM rule implementation error (within and between aggregates)
7.) Loss of biodiversity
8.) Impacts of TAM rules on FSC harvests

The ongoing modification of the TAM rules to allow unsustainable harvests (ie 20% harvest of lates) also needs careful oversight. Finally, DFO needs to give some thought to how to engage stakeholders in highly technical processes. People that don't understand what FRISSI is doing are not in the best position to understand how this process might affect their interests, or indeed, their rights. That DFO is unable to explain the FRISSI process in a way that the invited stakeholders can all understand is cause for grave concern. That DFO would press ahead with the implementation of FRISSI in the absence of such stakeholder understanding, and in the face of strong and unresolved technical criticism suggest the deliberate and purposeful manipulation of the consultation process.

8