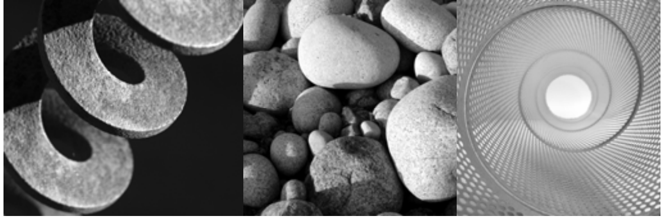

GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Snake River Fall Chinook – A Model Analysis:

Risks of Extinction or Recovery under Current Harvest Practices

Submitted to:
Columbia-Snake River Irrigators Association (CSRIA)
3030 West Clearwater #205-A
Kennewick, WA 99336

Submitted by:
John J. Pizzimenti, Ph.D.
Charles M. Paulsen
Timothy R. Fisher

August 1, 2008

Table of Contents

1.0 Background

The completion of seven large multipurpose dams on the lower and middle Snake River around 1970 eliminated significant spawning habitat for Snake River Fall chinook (SRFC) in the mainstem, blocked even more habitat upstream and added significant mortality to juveniles and adults where fish passage was provided. SRFC numbers were already low from the previous 30 years of dam operations in the lower Columbia and from excessive commercial harvest prior to the dams.

After 100 years of decline, SRFC were listed as needing a recovery plan under Endangered Species Act (NOAA, 1992). Columbia and Snake river dam owners and other river users were asked to help mitigate and contribute to recovery (NOAA, 2007a). Federal dam owners identified four areas of potential recovery focus: Hydro, Habitat, Hatcheries and Harvest. Known as the “Four H’s” (NOAA, 1999), during the past 30 years, the majority of mitigation has been borne by the dam owners and rate payers. They have focused primarily on the hydro and secondarily the hatchery H’s by building improved passage and many new hatcheries. Habitat mitigation began in the 1950’s but probably represents a small percentage of the money thus far spent on the Hydro H (*Columbia Basin Bulletin,* 2008). Further, it has been difficult to demonstrate measurable salmon population benefits from habitat improvements, but this is a work in progress.

Harvest is a treaty right and involves multiple nations and legal jurisdictions. Recently, harvest levels of SRFC were modified from upwards of 60-70 percent of returning adults harvested to 42-48 percent including ocean and in-river, sport and commercial, Tribal and Non-Tribal fisheries (*cf.* Table 1, Mc Kern). From 2000-2006, the majority of salmon were harvested first in the ocean and then in the river by commercial operations. Sport harvest was between 2-6 percent of the total catch and about twice that for fish that enter the Columbia River (WDFW and ODFW data, *in* McKern, 2007). Columbia basin salmon harvest is also difficult to monitor and enforce but improvements are being made *(cf.* Harza, 1997).

Annually, about 300 million juvenile hatchery salmon are being released in the Columbia Basin. They represent the overwhelming majority of the recruitment source. The loss of natural spawning fish including SRFC has been largely replaced by hatchery fish. SRFC are now being supplemented by fish from the Lyons Ferry hatchery but also include other hatchery and wild strays. Hatchery produced lower Columbia chinook as well as SRFC are outnumbering wild fish and according to the Hatchery Scientific Review Group are contributing to further decline of naturally produced fish (HRSC, 2007).

In sum, river users have spent billions in the past three decades, most visibly on Hydro, but also on Hatcheries and Habitat (CBB, 2008a). Although some study has focused on Harvest (*cf*. Norris, 1997; 2000) and NOAA began reducing fall chinook harvest levels after listing, our model suggests that more drastic reduction is needed to achieve recovery within 20 years. Harvests of upriver bright (URB) chinook are near 50 percent down from historic levels in excess of 70 percent. The most recent BiOp driven recommendation is for a 30 percent reduction of ocean harvest but a flexible increase in river harvest will effectively produce an overall harvest rate of about 43 percent. (NOAA, 2008; CBB, 2008b). As we will show, even if these new reductions are implemented, they preclude SRFC recovery in the foreseeable future.

The Northwest Power Planning Council mandated a study of Columbia basin salmon harvest practices and science and this was completed by its Independent Science Assessment Board in 2005 (ISAB, 2005). The ISAB report identified many important issues including inadequate data collection, modeling, monitoring and enforcement of harvest regulations.

The reasons Harvest has not been leveraged more effectively are both complex and simple. In simple terms, treaties with Native American tribes and with other nations and states complicate regulation, monitoring and management. These problems are further complicated because salmon migrate thousands of miles of ocean coastline; and they mix with stronger stocks that are harvested (mostly hatchery fish but in the case of SFRC, Hanford reach fish). Additionally our fishing industries both Native American and secular have been unable or unwilling to change fishing methods, such as the use of fish wheels and tangle nets, so as to protect weak stocks like SRFC (*cf*. HRSC, 2007). The goal to segregate wild and hatchery fish biologically or functionally has been elusive. So wild fish, including listed species, continue to be harvested.

This paper will show that unless harvest on SRFC is reduced significantly, there is a 90 percent chance that populations will be at or below current levels in both the near term (2020) and long term (2100). On the other hand, if we do cut harvest, there is a 75 percent chance the population will quadruple in the near term (2020) and possibly reach density dependent limiting size by 2040. This assumes no further changes in hydro or habitat but it does assume major hatchery reform. To repeat, unless harvest is cut significantly, in spite of the additional $900,000,000 BPA has committed to Habitat in the next 10 years (Columbia Basin Bulletin, 2008a), SRFC populations will most certainly (90 percent chance) be at current or diminished levels after the $900,000,000 is expended. But if we cut harvest, there is great likelihood that by 2020 (75 percent chance) these populations will have quadrupled in size, even if we do nothing further to improve habitat.

Examination of 1 percent and 5 percent probability percentiles of future populations reinforces the need to act. These outlier percentiles show near certainty that populations will increase continuously upward if harvest is cut; but with *status quo* harvest, there is near certainty that they will continue to decline toward extinction. The longer that population levels remain depressed, the greater the likelihood of extinction (NOAA, 2007b). Data and projections in this paper suggest harvest curtailment may represent the single most cost effective measure we have left to ensure the continued existence and recovery of un-aided reproducing fall chinook in the Snake River.

2.0 Methods

2.1 Description of the Data and Model

We constructed a Population Variability Analysis life-cycle model to simulate likelihood of future population trends of SRFC as described by Paulsen *et al.* (2007). The model code is provided in Appendix 7.0. The outputs from the model are shown in graphs but are available in original Excel spreadsheets. The PVA model output resembles NOAA's method of extinction risk but is intended to assess likely population trajectories in near-time (to 2020) and long-term (to 2100).

The data are population counts of adult SRFC passing Lower Granite Dam from 1975 to 2000, and estimates of marine and freshwater harvest from 1976-2005 Pacific Marine Fish Commission. The data are from agency sources cited in Appendix 6.0. These data enable estimates of annual variation in the numbers of recruits produced from previous year's spawners. Each year, contingent upon all mortality factors, there is a spawner count and a subsequent recruitment of the next generation. The amount of variation is partly driven by environmental factors, human factors and by random events that cannot be seen or easily measured (usually called error variance). In extremely good years, spawners can produce as many as 20 recruits each (very rare) or a very small fraction near zero (also rare). Any level above one recruit per spawner, the population is growing; any less that one recruit, it is declining. A ratio of one means the population is replacing itself, neither growing nor declining.

Note that the analysis is not entirely appropriate if one were interested mainly in extinction risk, as opposed to the distribution of future spawners and recruits for the population. Extinction analyses often consider autocorrelation, quasi-extinction thresholds, and other technical matters that we ignore in this simple simulation, because we do not think these complications will materially affect the results.

2.2 Model Assumption

In simulating the future, we assumed the characteristics of the past variation will be reflective of the future, i.e. the same spawner recruitment variation, same dams and ocean conditions of 1975-2000 to represent the future. As in games involving chance, future outcomes are based on past experience if we don't change the rules or our playing behavior. If we can win at cards on average more often than we lose, we will never go broke; however that assumes an infinite pile of chips to sustain us through rare periods of extended bad luck (losing streaks). If we have a small pile of chips, a short run of bad luck could mean we are broke (extinct). This fact is important because if the population declines to very low numbers, the risk of extinction increases.

The model enables us to simulate both future population extinction and recovery probabilities, where the latter is usually defined as the expected average number of returning spawners over multiple years (e.g., 2000 spawners on average over 10 years). And the former is the frequency of multiple tries that we run out of spawners (go broke) before the year 2020 or the year 2100.

As in simulating future trends, our population model assumes that the past 25 years, including periods of good and bad conditions would be the same in the future…no better, no worse. That is, the number of adult progeny measured as adults passing upstream of Lower Granite Dam in future will be similar to historical population fluctuations over the past 25 years including the high variability experienced. Simulating averages alone will not enable us to predict probability of growth or decline or extinction because these partly depend on population size and annual luck (survival variation).

2.3 Starting Point of Future Projections

Our starting point is the current state of the population in the year 2006 (the latest adult data available). We simulated three scenarios: (1) continuation of the *status quo* (2) elimination of all SRFC harvest and (3) 2008 recommended cuts to ocean harvest. Note that since each spawner may recruit for the following 5 years, our last recruit data are from 2005 and the last spawner counts from year 2000. We chose 1975 as the starting point as that is when reliable counts began at Lower Granite Dam, our control point of the population counts. The spike in population size beginning in 1995 is generally attributed to ocean conditions as other stocks of Columbia basin salmon have correlated shifts in abundance. However, the model does not rely on specific causal elements of variation; it only assumes that past variation will be reflected in the future. This includes the improved ocean conditions of the late 1990's as well as poor drought conditions experienced from 1975 to 2000.

2.4 Harvest Levels

We modeled two simple options: continue with the current plan of removal (about 50 percent) or eliminate this artificial take completely (zero harvest). Although we could set harvest at any number, we chose zero because we did not know what to expect, so we chose the maximum possible restraint. We recognize that eliminating harvest is politically unlikely and possibly unenforceable, but our goal here is to demonstrate to ourselves, our odds for the future. After initial model runs, NOAA recommended further ocean harvest reduction by 30 percent (i.e. approximately 7 percent total harvest reduction along with some flexibility to increase in-river harvest). We modeled this scenario but note that implementation may be many years away. Also, note that we model a zero harvest scenario starting in 2006; actual implementation could only start after 2009. If new harvest levels are implemented, it is possible to back-cast with the model to determine if it is reasonably calibrated to actual results. We did check 2006 results and they are within model error variance. Additional recruit data will be available soon to assess accuracy of near term model results.

2.5 Density Dependence

Standard population models assume there is an upward limit to population size limited by the environment. This is known as density dependence. The data demonstrate that there is no density dependence currently. For SRFC, statistical tests for Ricker-type density dependence (i.e., models of the form $\ln(R/S) = a - bS + e$, where R = recruits, S = spawners, e is estimated process error, and “a” and “b” are estimated parameters) did not reveal any density dependence in the 26 years brood years of data (1975-2000). Although habitat may constrain recruitment at some high levels sometime in the future, for now, we assumed this to be zero because there is no evidence in historic data for density dependence. We set an artificial limit of 100,000 spawners before the population starts limiting itself but this does not affect the model results. Our modeling showed that this artificial ceiling of 100,000 could be exceeded as soon as year 2040 with the median level for recruitment assuming harvest is eliminated immediately. The current SRFC population is around 2500 to 3000 spawners annually.

2.6 Hatchery Supplementation

The naturally spawning population of wild SRFC is currently supplemented by (1) allowing some hatchery produced adults to spawn upstream in the river and (2) outplanting Lyons Ferry juveniles upstream of Lower Granite Dam. This outplanting program began about 1995 and has led to more hatchery fish than wild fish in recent populations (Figure 1). These hatchery fish are usually tagged (adipose-clipped) so that the returning adults can be identified, counted at Lower Granite and then either allowed upstream to spawn or returned to Lyons Ferry to continue the “supplementation” program. Untagged hatchery-origin fish can be identified by reading scales, taken from a subsample of the run at Lower Granite Dam. Protocols are defined in the recovery program. Since hatchery production is not needed to sustain unlisted populations if harvest is controlled and since the Endangered Species Act is actually about continuation natural reproduction in the wild, it is by both definition and lack of necessity (as the model will show) that we discontinued the Lyons Ferry supplementation in the model. Thus the model data do not use hatchery origin fish for future projections.

2.7 Comparison with other H’s

While it would be useful to investigate how changes in hydro operation and configuration might change juvenile downstream survival, that is not possible at present. This is because an unknown proportion of Snake fall chinook overwinters in the hydrosystem (Connor *et al.*, 2005). As a result, reach survival estimation (done routinely for spring/summer chinook and steelhead) is not possible. Nor can one say with any certainty what proportion of the fall run would be affected by changes in hydro operation, transport regimes, habitat improvements *etc*. Therefore, we chose not to simulate the effects of changes in the hydro or habitat changes on fall chinook abundance and persistence. In the future, comparisons to further hydro or habitat improvements might be possible. Arguments that other H’s may be traded for harvest is irrelevant to this exercise since we have no data assess this question; hence we simply mathematically eliminate them and assume that things get no better, nor worse in the system and only assess SRFC harvest as a tool to further goals for recovery.

3.0 Results

3.1 Overview of Results

The following eight graphs provide synoptic pictures of population changes over the recent past and the near future for specific percentiles of probability. In order to estimate these, we use random generation of the scenario described in the model. Each run made 10,000 simulations (games played). The percentiles represent what percent of the 10,000 outcomes exceeded a specific result over time.

To recap, we assumed that future recruits per spawner (R/S) would be similar to the past, and that R/S would be log-normally distributed. Furthermore, we assumed an arbitrary upper limit of 100,000 spawners, above which additional spawners did not produce additional recruits. The resulting population viability analysis (PVA) model is therefore a simple log-normal projection, after doing the requisite bookkeeping to account for age-at-return, assumed to be an average of brood years with complete aging data. Future variation in R/S is assumed to be the same as in the past.

For the base-case harvest scenario, we simply assumed that adult recruits to Lower Granite would, on average, have the same R/S as in the 1975-2000 data. For the no-harvest case, we assumed that ocean harvest only affects fish in the year they return to the Columbia, and that upstream survival would be the same as in the past five years (*cf*. Section 6.0, Data Appendix for details). For both scenarios, following the 2000 and 2004 Biological Opinions, we assumed that all hatchery supplementation ceases in future.

3.2 Historic Recruitment of SRFC

Figure 1 shows the recruitment of spawners and natural spawners at LGR from 1975 to 2000. Note that natural spawning numbers have been declining in an irregular sawtooth pattern downward and now make up the minority of recruits. Fall chinook from other hatchery stocks including Umatilla have strayed upstream of Granite Dam since the 1980's. Beginning in 1995, Lyons Ferry hatchery began a supplementation program of juveniles out-planted upstream of Granite Dam. The hatchery component of returning adults is now primarily from the Lyons Ferry hatchery. These adults are either transported back to the hatchery from Granite Dam or allowed to migrate upstream and spawn naturally. Their in-river juvenile and adult recruits would be counted as "natural". However, our model discounts the hatchery origin adults as described in the Methods Section 2.0.

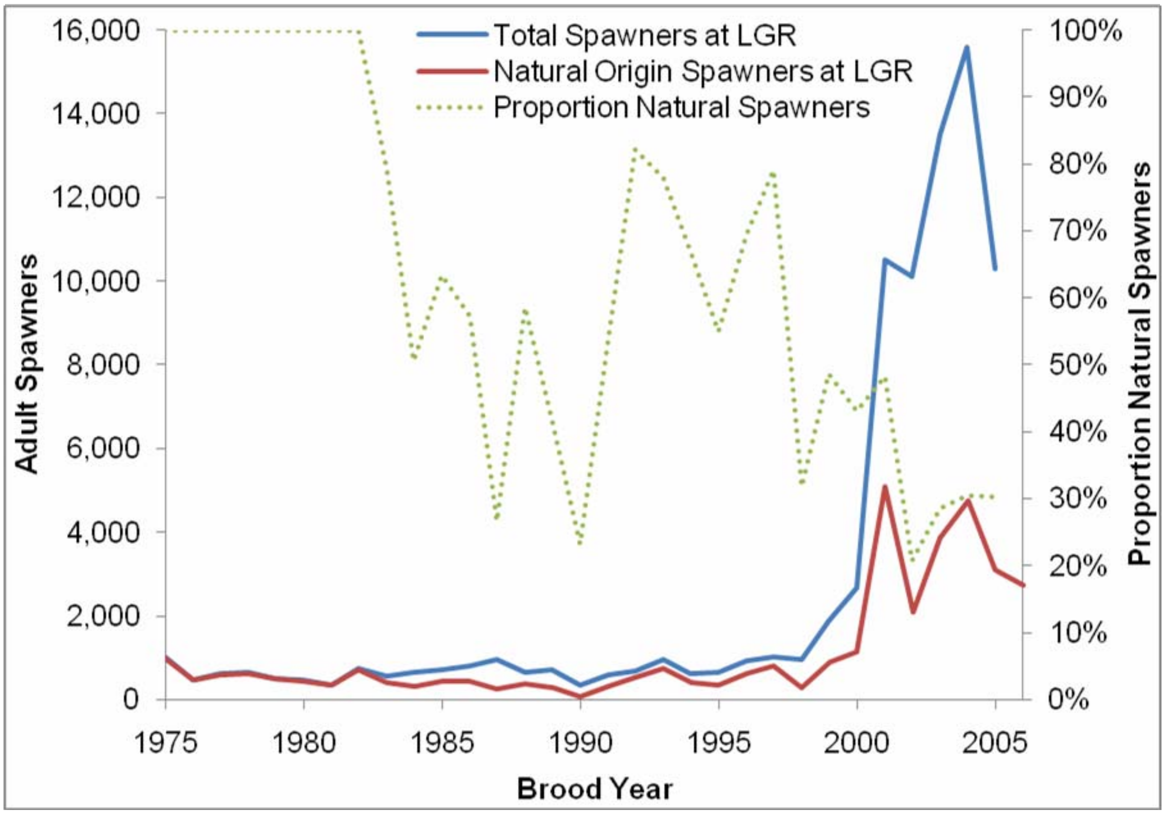

Figure 1. Spawners of hatchery and natural origin, Snake River fall chinook, 1975-2005.

Figure 2 shows the book keeping of the historic levels of adult recruits to the mouth of the Columbia, to Lower Granite Dam and the total recruitment including ocean harvest. Note that from 1975 to about 1994, the population was bumping along at less than 2000 recruits. The population expanded to about 8000 recruits of which about 4000 (50 percent) are harvested in the ocean and in the Columbia River. This expansion is attributed primarily to ocean conditions but the cause is irrelevant. The model simulates two alternatives: (1) either continuation of harvest as in the past (about 50 percent) or (2) its complete elimination, *i.e.* no harvest. Of course, the second alternative immediately doubles the number of spawning fish (and recruits) leading to a rapid recovery of returning recruits in just a few years (see Figure 6 below).

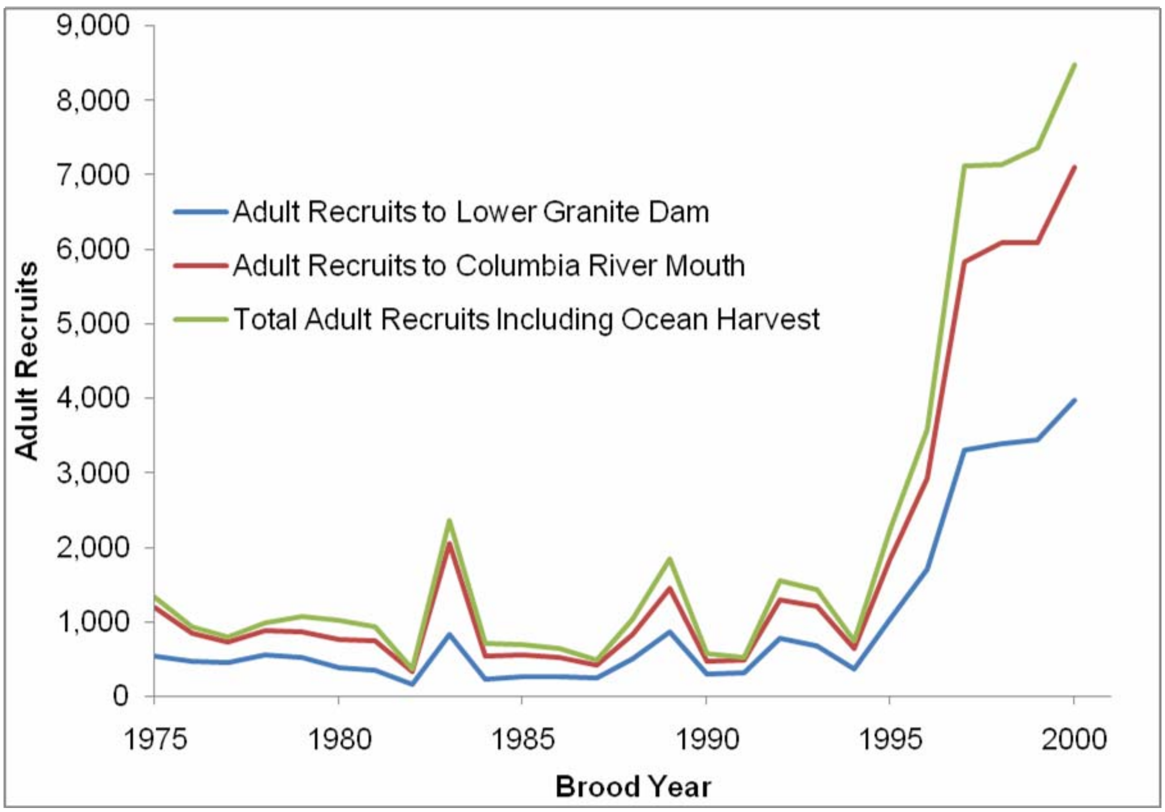

Figure 2. Adult recruits, brood years 1975-2000.

Figure 3 shows the numbers of recruits per spawner historically. Note that when the data fall below the line of one recruit per spawner, the population declines in size. With harvest, about half the historic period has led to recruitment levels less than the replacement rate, i.e. in declining numbers. If we were to remove harvest, every year for the past 26 years would show a recruitment level greater than one in most every year (green line). This suggests that in the future, without harvest, the population will almost certainly be growing. The model will bear this out.

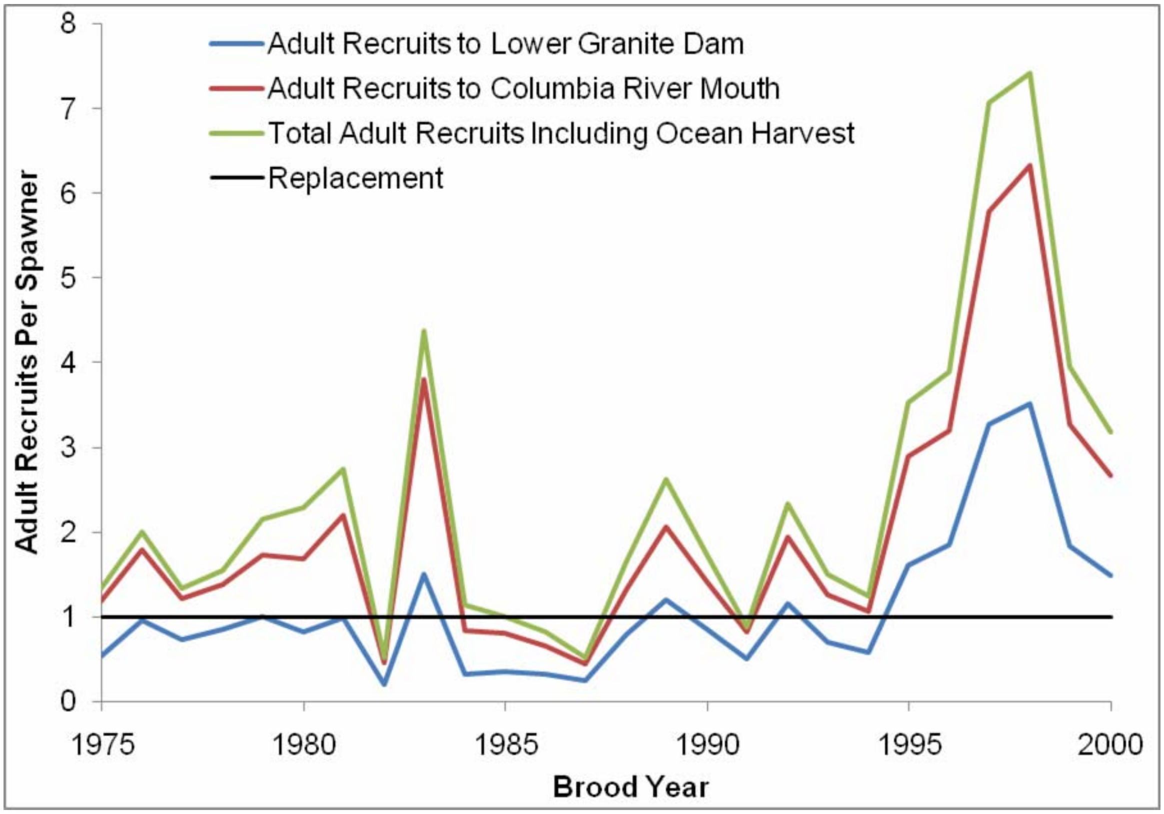

Figure 3. Adult recruits per spawner (R/S), 1975-2000. R/S greater than one implies that the stock replacing itself, R/S less than one that it was declining. Note that recruits per spawner are always higher if one applies in-river and ocean harvest to the spawner population (green line).

Figure 4 shows the historic number of recruits per spawner versus the number of spawners. There is no correlation, positive or negative between spawner population and subsequent recruitment level. If recruitment were being limited by population size (density dependence) we would expect to see a declining slope with fewer recruits per spawner at higher population sizes. This is the basis of eliminating density dependence from our population model.

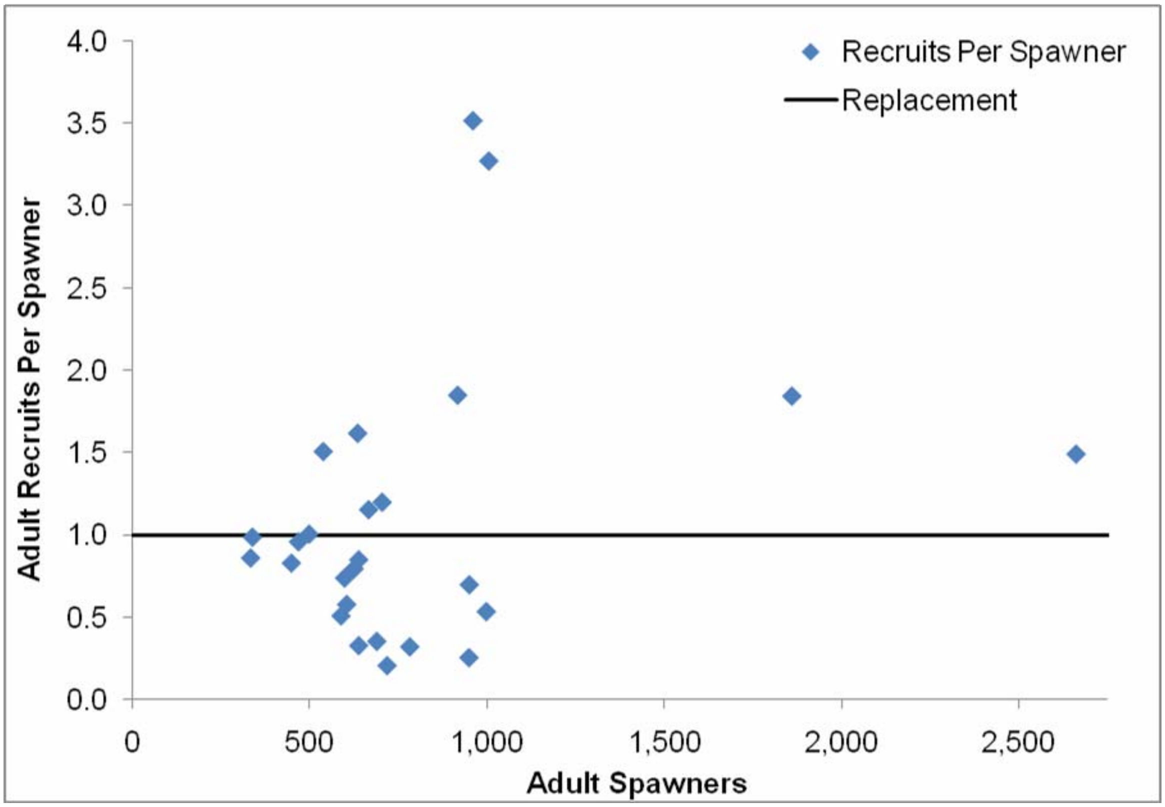

Figure 4. Adult recruits per spawner at Lower Granite Dam. No density-dependence is apparent in the graph, i.e. there is no slope (no correlation between variables).

3.3 Future Population Trends

Figure 5 shows PVA model projections from 2000-2020 if harvest levels are maintained at today's levels of 50 percent (both ocean and river combined). Note: the Interior Columbia TRT (2007) set 3000 as a draft recovery level for this ESU. There is only a 1 percent chance that the population will show regular increasing levels in the future. Most scenarios (90 percent) show flat to declining populations not achieving the 3000 spawner level by 2020. Instead there is more than a 50 percent chance that numbers will decline closer to extinction levels by 2020.

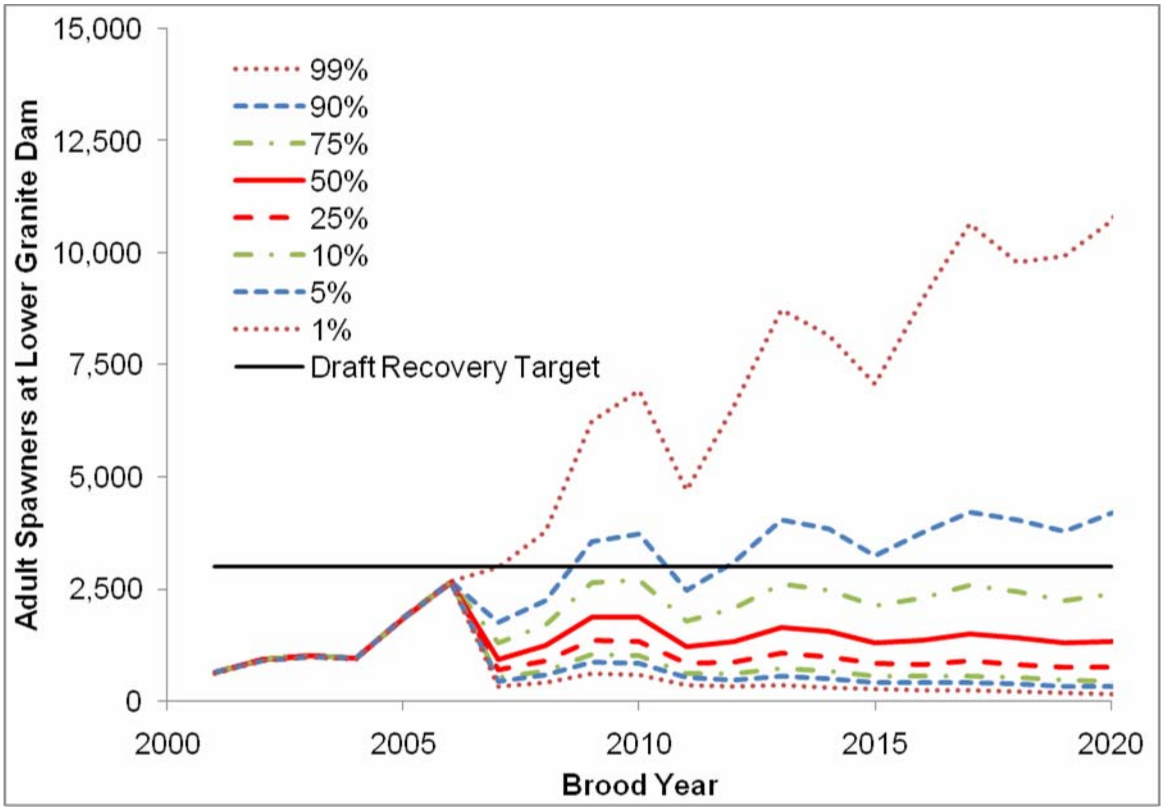

Figure 5. PVA projections, 2000-2020, base case marine and freshwater harvest rates. The Interior Columbia TRT (2007) set 3000 as a draft recovery level for this ESU (NOAA, 2007b).

Figure 6 shows that if harvest is eliminated, there is a 90 percent chance the population will be delisted by 2020 and only a 10 percent chance that the population will not have at least doubled in size.

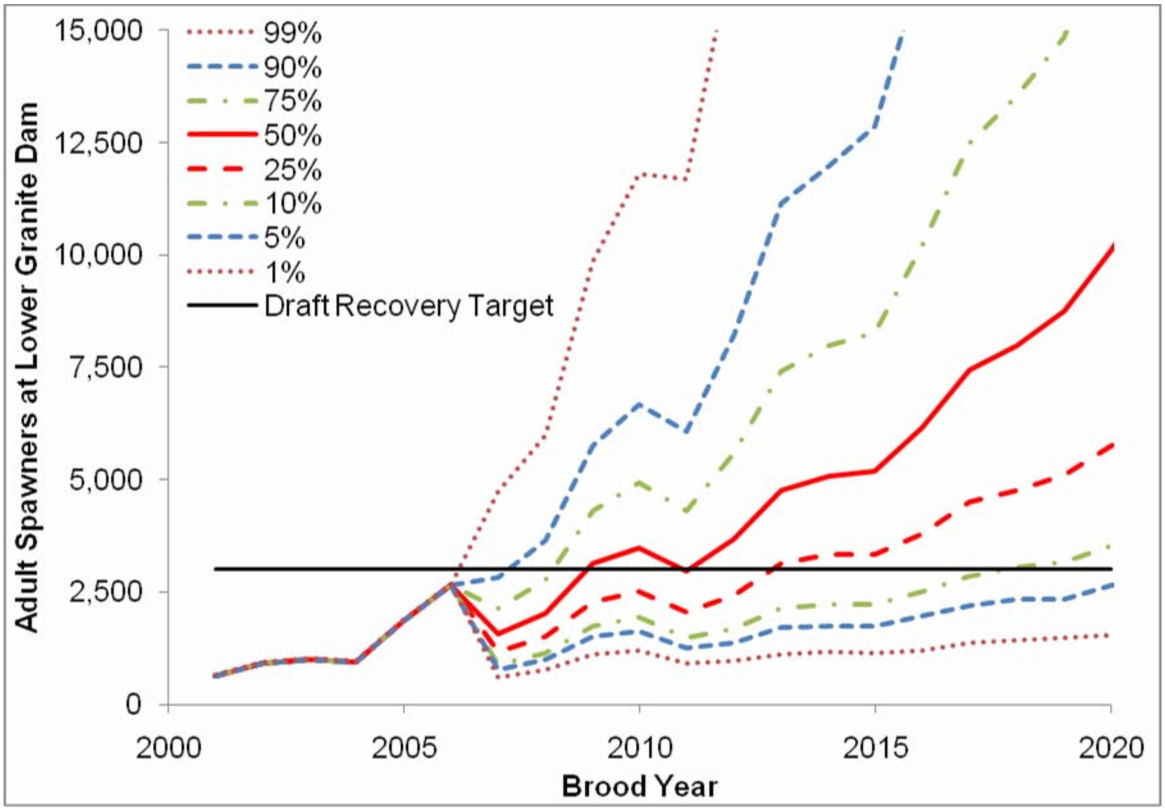

Figure 6. PVA projections, 2000-2020, no harvest scenario.

The data in Figure 7 show the worst case for continuing harvest at current levels or most improbable scenarios eliminating harvest. Continuing harvest shows that populations could decline to near extinction i.e. drop to about 20 percent of current listed levels in less than 12 years. Without harvest, the populations, even in the poorest scenarios (runs of bad luck), will continue to expand and grow.

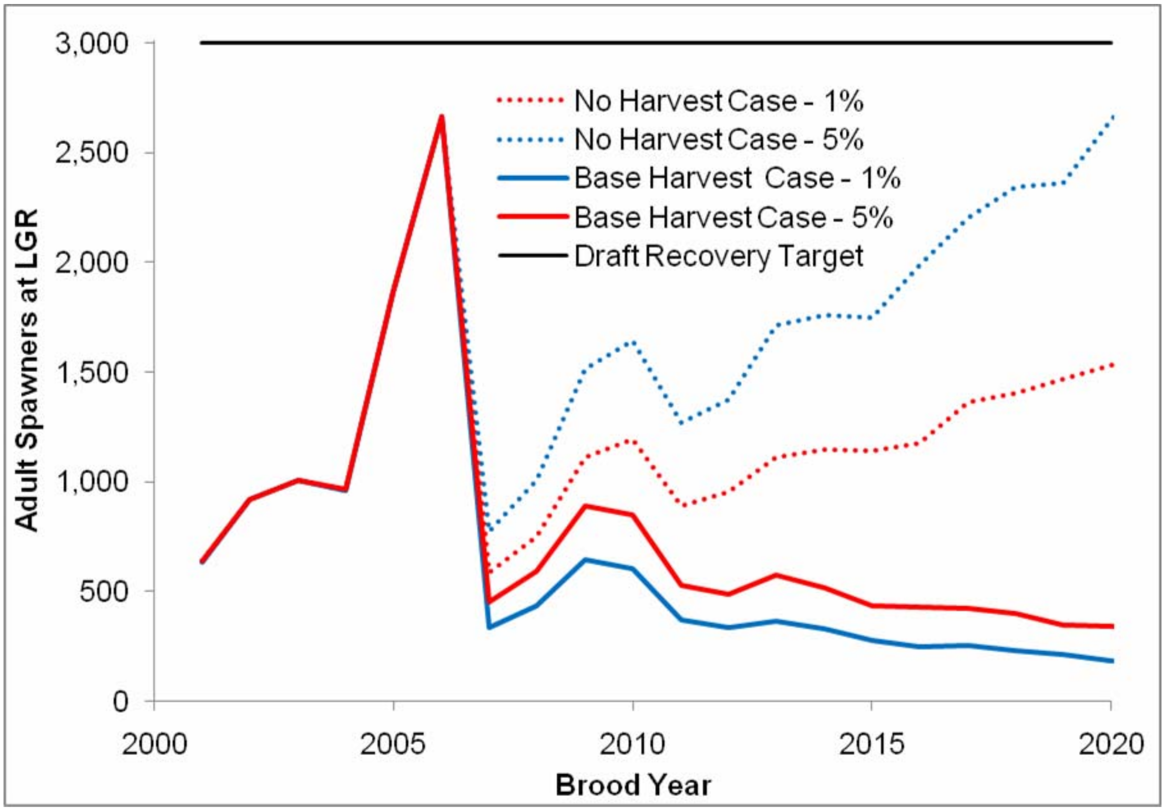

Figure 7. 1st and 5th percentiles for base-case and zero harvest scenarios, 2000-2020.

Figure 8 shows median spawners at Lower Granite, base case and no-harvest scenarios. It shows that the median probability expectation with harvest suspended, the population would reach 100,000 spawners by 2040. The actual leveling out point would be controlled by carrying capacity which was artificially set at 100,000. Continuing with the *status quo* the expectation is a smaller population than currently exists.

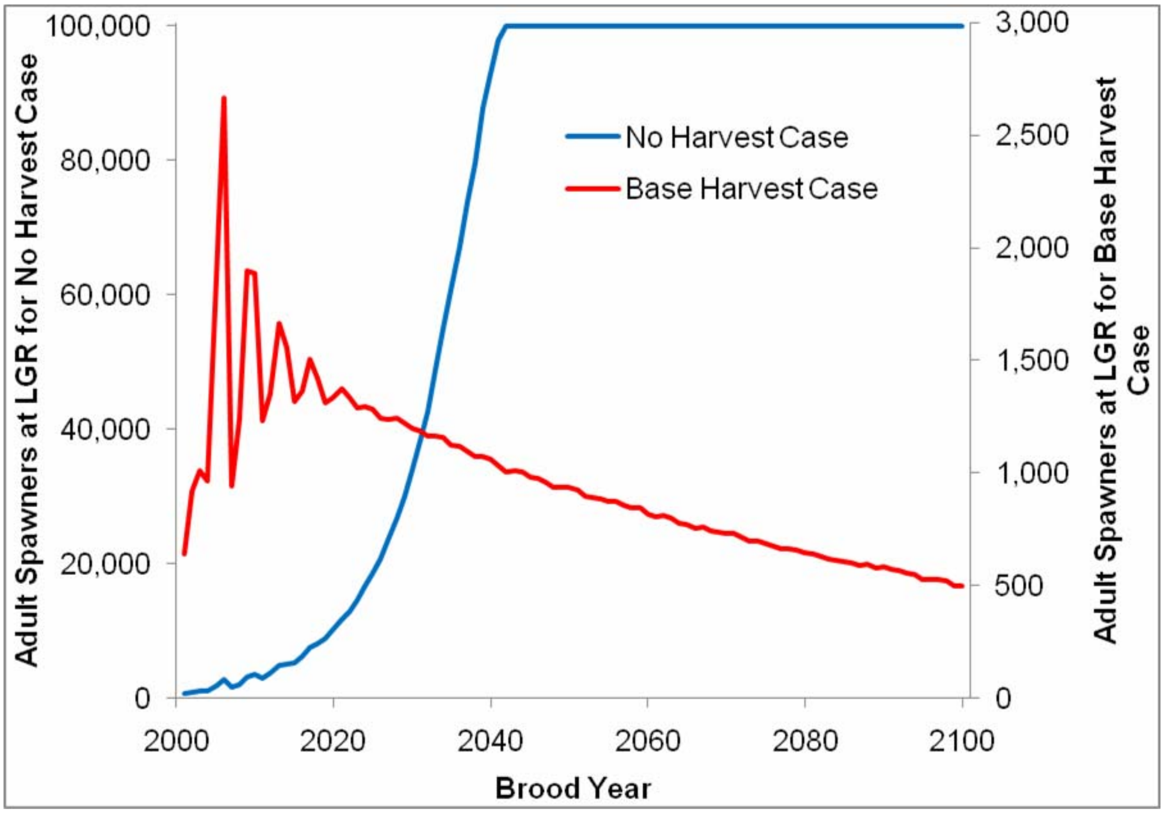

Figure 8. Median spawners at Lower Granite, base case and no-harvest scenarios

During model preparation, agencies including the Pacific Salmon Commission (PSC) negotiated a 30 percent reduction of the current ocean harvest of SRFC with Canada (CBB, 2008b). The actual total harvest reduction would be equivalent to less than 8 percent. We modeled that out-come assuming implementation shown in Figure 9. This suggests that the population will on average be expected to increase to 2000 spawners in 2020, be delisted by 2050 and reach 6000 spawners by 2100. Since the 2008 agency recommendation also allowed an increased river harvest during years of large returns the graph may overestimate the recovery rate. With no harvest, the population would be delisted in about 2-4 years after implementation (*cf.* Figure 6 where the 50 percent line crosses 3000 fish) versus 40 years or more to delist with the new recommendation.

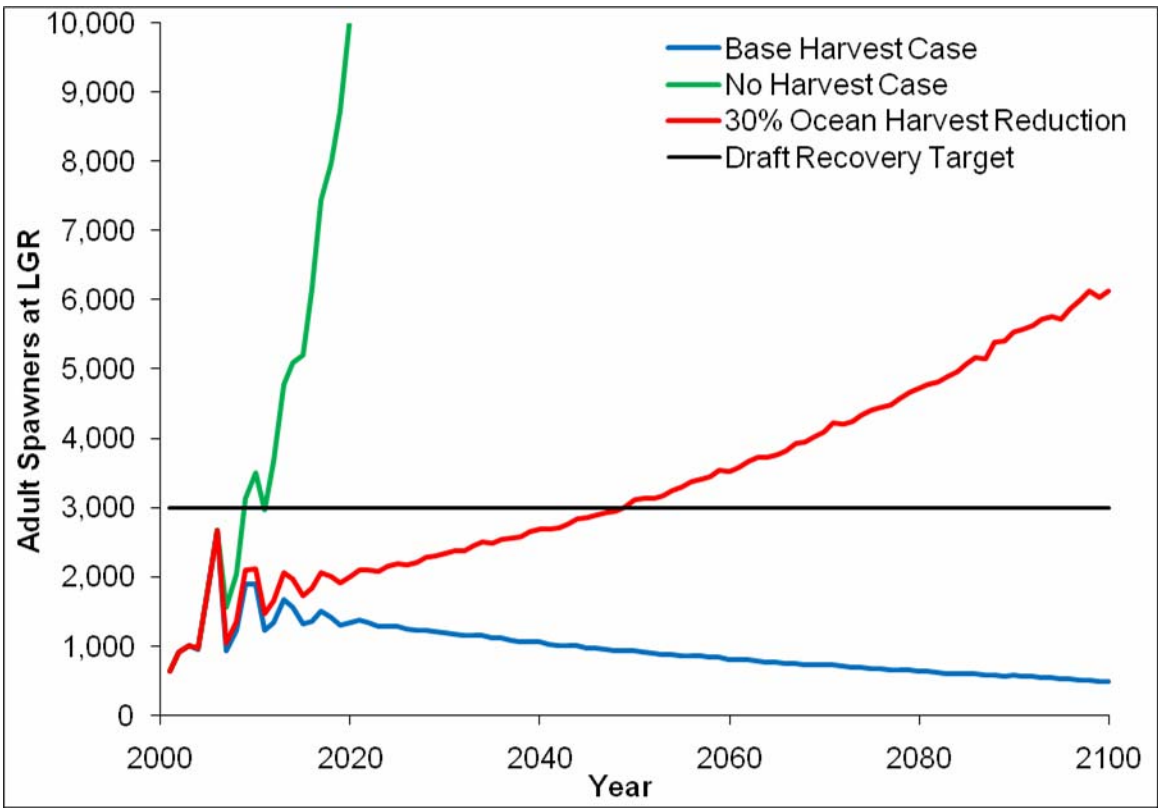

Figure 9. Median spawners - base case, no harvest anywhere, 30 percent ocean reduction, 2000-2100.

4.0 Discussion

4.1 Lessons Learned

Models are not reality, but they provide a simplified structure and hence understanding of it. We have developed a relatively simple model of continuing or discontinuing harvest using a Monte Carlo simulation of population change similar to that employed in Paulsen *et al.* (2007). We recognize that we do not know what conditions will prevail in the Columbia Basin for salmon in 2020 or 2040. We have assumed in this model that they will basically mirror the past except for how we manage harvest. Whether other conditions improve or decline, the lessons learned from this harvest model will still apply. Whether they are sufficient or necessary will only be known after the fact. To do nothing about harvest and assume that other factors such as Habitat or more Hydro fixes will suffice is to risk losing all the chips in the game. In fact, most studies of other H's have indicated that without Harvest regulation, the other H's are unlikely to recover listed stocks. Hatchery solutions are at best, antithetical to the ESA according to NOAA's Biological Opinion (*op. cit.)* and may actually harm the population.

4.2 Comparisons with Hydro

For the past 15 years, there has been debate about whether habitat, hydro or hatcheries should be improved. Considerable money has been and will continue to be invested in hydro. Significant measurable progress has been made at the dams for enhancing adult and juvenile survival. It remains to be seen whether future investments there will have diminished return on investment. Much of the low hanging fruit appears to have been picked. Recent discoveries about juvenile survival (Conner *et al., op. cit*) suggest that survival may be higher than supposed since some percent of the late migrants overwinter in the hydro reservoirs and have high survivals as adult recruits. Norris (1997) provided a simple spreadsheet model to evaluate strategies and tradeoffs among dam improvements and harvest. Eventually, we can do a cost-benefit analysis of the hydro investment and returns and the harvest investment and returns. But in our view, we may have reached an asymptote, with hydro improvements unlikely to facilitate recovery without further harvest constraints.

4.3 Hatcheries

We are dependent on hatcheries to produce most salmon, including SRFC. The creation of artificial runs of fish has actually ecologically interfered with naturally produced fish (HRSC, 2007). Hatchery fish and the enormous investment in infrastructure and labor have politically interfered with recovery as they have become the drug of preference for the aliment and tend to be self preserving as they involve jobs. Continued production of hatchery fish, especially those that mix with wild fish, will likely lead to further the decline of naturally reproducing stocks. Hatchery production numbers overwhelm wild fish numbers, compete with them and preclude management for natural reproduction. SRFC could be the demonstration that shows that recovery not only precludes the need for hatcheries, it more than replaces it and eliminates a large cost of production. But those lost facilities and jobs will be a problem that needs to be addressed as part of the problem, if wild fish are the real goal.

4.4 Weak Stocks and Strong Stocks

SRFC migrate in the same corridor at the same time as upriver bright fall chinook (URB) headed for the Hanford Reach of the mid-Columbia River. Both stocks are of similar size and biology except for spawning location. The Hanford stock represents the primary harvest fish of the Zone 6 Tribal fishery and the lower Columbia commercial fishery. It also is an important component of both upper and lower river sport harvests. A reasonable assumption is that whatever the harvest rate of the URB will also be the incidental harvest rate for SRFC. Thus to abandon harvest of the SRFC requires abandonment of the URB harvest with current harvest methods. The region has discussed alternative means for segregating strong and weak stocks via live catch methods enabling segregated harvest of strong stocks. The same applies to segregating hatchery fish by either location or fishing method.

Recovery of ESA listed stocks such as SRFC is in direct conflict with harvest management as currently practiced. At present, both harvesters and conservationists have legal mandates to do what they do. The PVA model suggests that compromises of limited harvest restrictions are likely to lead neither to recovery, nor to converting weak stocks into sustainably harvestable populations. If recovery is to be achieved with some degree of SRFC in a reasonable period of time, say less than 20 years, it will be important to reconcile these conflicts. It will also be important to reconcile the legal rights to harvest. Norris (2000) provides some technical approaches to allocating harvest restrictions among diverse and dispersed harvesting entities and to achieving escapement levels needed to reach and sustain specific population levels.

4.5 Habitat

No one would disagree that salmonids need freshwater habitat to complete their life cycle. Yet we know of no studies that show habitat is the limiting factor for current SRFC population levels. Although increasing habitat via fish passage into blocked areas is a noble idea, we simply do not know whether this will be an effective means to achieve recovery, much less a cost effective one (see comments of Jim Martin, in Columbia Basin Bulletin, 2008). Reintroductions of salmon upstream of Round Butte Dam in 2007 will be a telling experiment on the cost : benefit of such actions and should be watched carefully for results. As we attempt to repair damaged habitats and reopen blocked areas, we continue to degrade others just by human population expansion alone (*cf*. Lackey, 2008); so it is unclear whether the net benefit will tip in the positive direction for salmon habitat in the future. Habitat is a good goal but we are unaware of compelling evidence, models or experience to show it will be as effective as harvest restriction, to quickly rebuild stocks in the next 20 years.

4.6 Why Harvest is Important Now

The data show that wild populations are small and in a decline. We have the capacity to quickly change decline into growth using harvest because it assumes no improvement in any other factor of the past, only the *status quo* in other H's. The model shows we would double SRFC recruitment annually if we place a moratorium on harvest and do nothing else to Hydro, Hatcheries or Habitat. If this were an investment goal in financial terms, it would be equivalent of doubling annual income and investment capital every five years for at least 20 years.

4.7 Policy Issues

We have not tried to estimate what level of harvest might be a "compromise" between 50 percent and zero; that is for the political arena. We did model the newest "compromise" offered in the framework of the 2008 BiOp. And it is clear that it produces a very weak population response. We do know that even if a moratorium were to be employed and populations built up to some larger base than today's, it is not possible to return to the harvest levels of today without simply turning those curves upside down, at least with all other things being the same as today. Thus, the idea of going on a "crash diet" today, with the plan to return to our old eating habits after we lose weight is a fools' errand. We need to change our harvest behavior in a permanent way, at least until we can implement habitat expansion and improved harvest methods to emerge.

As already mentioned, hatchery fish are an impediment to wild SRFC and likely many other listed stocks for reasons already cited. If hatchery stocks are not isolated from wild fish, they will swamp them by sheer numbers as the data demonstrate with Lyons Ferry fish and SRFC. The conflict with the "hatchery economy" and the questions of where those facilities and jobs go will also need resolution.

4.8 Conclusion

This model shows that if we eliminate harvest of SRFC, we can expect recovery to occur surprisingly rapidly, possibly within 3-5 years and reach carrying capacity within 20-30 years. If we continue with *status quo* harvest the populations will almost certainly decrease over time. After SRFC recruitment is sufficiently strong, then it would be appropriate to design harvest regulations and methods that would keep SRFC strong, sustainable and forever off the ESA species list. NOAA recognizes that current harvest levels are too high and they have mandated a 30 percent reduction ocean harvest. But even if that is implemented, recovery will not likely occur for 40 years after implementation. A complete hiatus on harvest suggests SRFC will "recover" to 3000 spawners in less than a decade.

5.0 Literature Cited

(CBB) Columbia Basin Bulletin, 2008a. "New Columbia River Basin Salmon Recovery Strategies Released". Posted on Monday, May 05, 2008.

(CBB) Columbia Basin Bulletin, 2008b. Fish Pact: Harvest Reductions In Canada, Alaska Would Boost Columbia Basin Stocks. Posted Friday, May 30, 2008.

ISAB, 2005. Report on Harvest Management of Columbia Basin Salmon and Steelhead. Independent Scientific Advisory Board, Northwest Power and Conservation Council, Columbia River Basin Indian Tribes and NOAA Fisheries. Portland, Or.

Connor, W. P. *et al.*, 2005. Two Alternative juvenile life history types for fall Chinook salmon in the Snake River Basin. Trans. Amer. Fish Soc.134:291–304.

Harza Engineering Company, 1997. An Evaluation of the cost-effectiveness of BPA Enhanced Funding of the Columbia Basin Law Enforcement Council's (CBLEC) efforts to protect endangered fish and wildlife in the basin Columbia Basin. Report to Bonneville Power Administration funded by Northwest Power Planning Council, Portland, Or.

HRSC, 2007. The Columbia River Hatchery Reform Steering Committee, "Preview of Key Findings for Lower Columbia River Hatchery Programs", July 18, 2007, HR Review Group. http://www.hatcheryreform.us/prod/Portals/_default/Documents/Status%20Report%20to%20Steering%20Committee%207-23-07.pdf

Lackey, Robert. 2008. Delusional Reality about West Coast Salmon. Greenversations. Delusional Reality about West Coast Salmon. Greenversations. Official Blog of the U.S. Environmental Protection Agency. Posted on July 11th, 2008 - 10:30 AM. http://blog.epa.gov/blog/2008/07/11/realityaboutsalmon/

McKern, J., 2007. Estimated returns and harvest of Columbia River fall chinook 2000 to 2007. Unpublished Report to Columbia-Snake River Irrigators Association, Kennewick, WA.

NOAA, 1992**.** Snake River Fall-Run Chinook ESU Threatened. www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-opulations/Chinook/CKSRF.cfm

NOAA, 1999. Federal Agencies Release Four-H "Working Paper" On Salmon Recovery In Pacific Northwest www.publicaffairs.noaa.gov/releases99/nov99/noaa99r160.html

NOAA, 2005. NOAA Technical Memorandum NMFS-NWFSC-66 Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead June 2005. www.nwfsc.noaa.gov/assets/25/6226_08302005_132955_brttechmemo66final2.pdf

NOAA, 2007a. Biological Opinion and EFH Conservation Recommendations: Agriculture - Grazing, Irrigation; Forestry-Vegetation; Restoration-Fish Passage, Waterway; Transportation-Road/highway. Reinitiation of Habitat Improvement Program (HIP II) Programmatic, Columbia R. Basin: Bonneville Power Administration, Portland June 2007.

NOAA, 2007b. NW Fisheries Science Center IC Technical Review Team Variability Criteria.
www.nwfsc.noaa.gov/trt/trt_documents/ictrt_viability_criteria_reviewdraft_2007_body.pdf)

NOAA, 2008. Final Columbia-Snake Basin Biological Opinions.
www.nwr.noaa.gov www.Salmon-Hydropower/Columbia-Snake-Basin/Final-BOs.cfm

Norris, James G. 1997. A Simple Spreadsheet Model for Evaluating Recovery Strategies for Snake River Fall Chinook Salmon. Unpublished manuscript. Fisheries Research Institute, University of Washington, Seattle, WA 98195

Norris, James G. 2000. Defining Equivalent Exploitation Rate Reduction Policies for Endangered Salmon Stocks. *In Sustainable Fisheries Management: Pacific Salmon.* CRC Press LLC

Paulsen *et al.*, 2007 Measure twice, estimate once: Pacific Salmon population variance analysis for highly variable populations. Trans. Amer. Fish Soc. 136:356-364.

PATH. 1998. Plan for Analyzing and Testing Hypotheses (PATH): Final Report for Fiscal Year 1998. D. R. Marmorek, C. N. Peters, and I. Parnell, ed. Report to Bonneville Power Administration by ESSA Technologies Ltd. Vancouver, BC, Canada.

6.0 Data Appendix

We used data specific to SRFC for the run reconstruction. Data used for the reconstruction is contained in the spreadsheet “Snake FAC BY Data 6-27-08.xls”. The individual columns are described below.

Column A “Brood Year”: The year in which the parent stock returned to freshwater and spawned.

Column B “Spawners @ LGR”: All adult fall Chinook spawners of ages 3-6 (where age 0 = year of spawning of the parent stock), that passed Lower Granite Dam in each Brood Year. Jacks (age 2) are ignored in this run reconstruction. Values are from the "Adult Spawners" column in Sheet “BRT” of “Snake FAC BY Data 6-27-08.xls” (the spreadsheet filename will not be repeated further). This sheet is a SRFC run reconstruction from NOAA Fisheries’ Biological Review Team’s spreadsheet “Chinook datasets 11_14_07 for dist.xlsx” received from Tom Cooney of NOAA Fisheries. We assume that this is an update of the SRFC ESU analyses in NOAA Fisheries’ 2005 Status Update of All Federally Listed ESUs (URL: http://www.nwfsc.noaa.gov/assets/25/6226_08302005_132955_brttechmemo66final2.pdf).

Column C “Natural Run Spawners @ LGR”: Adult spawners (of all ages) of natural origin that passed Lower Granite Dam in each Brood Year. Values are from the " Broodstock=natural run" column in Sheet “BRT”. We assumed that this column represents the brood (spawners) in each Brood Year that is composed of fish that were the progeny of natural spawning above Lower Granite (the parents could have been either hatchery or natural origin fish).

Column D “Prop. Natural Spawners”: Proportion of adult spawners in each Brood Year that were of natural origin (Col. C Natural Run Spawners / Col. B Total Spawners).

Columns E-H “Adult Spawner Return (Wild Recruits from BY Spawners)”: The proportion of adult recruits of natural origin of each age (ages 3-6), by age, from the parent stock (Col. B Spawners @ LGR) in each Brood Year. The proportions are arranged such that the proportion of recruits of each age class is placed in the Brood Year in which these fish returned (i.e., the Return Year). For example, in Brood Year 1975, the age 3 recruits (which returned to freshwater in 1978) represented 31.7 percent of the total recruits that returned in 1975. Additionally, recruits produced by each brood are placed in the year in which the fish returned to spawn; for example, the 1975 brood produced the age 3 recruits in the Brood Year 1978 row. These values are from Sheet “BRT” Columns K-N, “Unmarked adults only age composition”. Note that these proportions differ substantially from the *Pacific Salmon Commission’s Chinook Technical Committee* dataset (Table 8 in Sheet “Sn FAC Harv”;

included for comparison with the BRT run reconstruction). We do not know the methods used to calculate either of these datasets, so we used the BRT data for consistency. Also note that the BRT used average proportions for recruits produced from the 1975-1985 and 2000-2004 broods (yellow highlights).

Columns I-L "Ocean Exploitation Rate": The exploitation rate (see PATH 1998 for the methods used) from Columns I-L in Sheet "PATH", (source: PATH 1998; Table 3.1.2-2), that is applied to the fish of each age class (ages 3-6) in each brood year (we ignored exploitation rates for age 2 fish). These values are arranged by the calendar year in which they are applied. We assumed that PATH integrated natural mortality by age per PSC (1988) and catch mortality (PATH 1998; pp. 100-103). The exploitation rate is an estimate of the proportion of fish of each age class that were either harvested in the ocean fisheries (primarily fisheries from the northern Oregon coast northward to the fisheries of the west coast of Vancouver Island, BC, Canada) or died before reaching the next age (i.e., age-specific ocean mortality rates). This sheet is Table 3.1.2-2 in the aforementioned report.

Columns M-T "In-River Harvest Rates": The proportion of adult fish of each age class harvested in mainstem Columbia and Snake River fisheries, arranged in the same manner as the ocean exploitation rates. These rates are in Sheet "HR", columns B-E. We obtained these rates from the Pacific Salmon Commission Chinook Technical Committee (URL: http://www.psc.org/about_org_committees_technical.htm). spreadsheet "Snake FAC harvest 1975-2003 08-02-05.xlsm", PATH (PATH 1998; Columns F and G in Sheet "PATH"), and the US v. Oregon Columbia River Compact Fall Status Reports (URL: http://wdfw.wa.gov/fish/crc/crcindex.htm) for 2005-2007. See Sheet "HR" for a detailed explanation of the sources used for each return year. We used the total harvest rate (orange highlights) when separate in-river harvest rate estimates for Columbia River harvest zones 1-5 (below Bonneville Dam) and 6 (Bonneville Dam to McNary Dam) were not available.

> **Columns M-P "**CR Zones 1-5 Harvest Rate": The estimated in-river harvest rate by age class for fish harvested in CR Zones 1-5.
>
> **Column Q-T "**Total (highlighted) or CR Zone 6 Harvest Rate": The estimated in-river harvest rate by age class for fish harvested in CR Zone 6.

Column U "BRT Brood Returns": For comparison with Column AB total brood returns to Lower Granite. The return of adult spawners to Lower Granite Dam from each brood. Values are from Sheet "BRT" Column V "Brood Returns". The BRT calculated the production of adult spawner recruits of each age from each brood as the product of the proportion of adult recruits for that age class and total natural recruits produced by each brood (Column U "Natural Run"). For example, the 1975 brood of 1,000 naturally produced spawners produced 32 percent of the 640 natural spawners from the 1978 brood (age 3 fish), 49 percent of the 500 spawners in 1979 (age 4), and 18 percent of the 450 spawners in 1980 (age 5), for a total of 529 adult recruits at Lower Granite.

Columns V-W "Adult Col. & Snake R. Survival": The estimated survival of adult SRFC from Bonneville Dam on the Columbia River to Lower Granite Dam on the Snake River. These estimates are from Sheet "Conv Rates" Columns J and K "Adjusted Conversion Rates" for adults (wild and hatchery) that were transported as juveniles. These survivals are estimates based on PIT tag detections of known origin adults (excluding one-ocean jacks) that as juveniles migrated in-river or were transported in barges.

> **Column V "**BON-MCN": 84.8 percent survival rate for adults from Bonneville Dam to McNary Dam.
>
> **Column W "**MCN-LGR": 87.8 percent survival rate for adults from McNary Dam to Lower Granite Dam.

Columns X-AD "Brood Returns to LGR @ Age": The calculated production of adult recruits to Lower Granite Dam (ages 3-6 and total) from natural spawners for each brood. We used the BRT methods described for Column U above. Also the calculated recruits per spawner (in natural and logarithmic units).

> **Columns X-AB:** Age 3-6 and total recruits at Lower Granite.
>
> **Columns AC and AD:** Calculated recruits at Lower Granite per spawner in natural and logarithmic units.

Columns AE-AK "Columbia Mouth Recruits at Age": The calculated production of adult recruits to the mouth of the Columbia River (ages 3-6 and total) from natural spawners for each brood. Back-calculated for each age class from brood returns to Lower Granite, adult upstream survival rates (Columns V and W), and In-river harvest rates (Columns M-T). Also the calculated recruits to the Columbia mouth per adult spawner (in natural and logarithmic units).

> **Columns AE-AI:** Age 3-6 and total recruits to the Columbia River Mouth.
>
> **Columns AJ and AK:** Calculated recruits to the Columbia River Mouth per spawner in natural and logarithmic units.

Columns AL-AR "Total Recruits Including Ocean Harvest": The calculated production of adult recruits to the Pacific Ocean before ocean harvest takes place (ages 3-6 and total) from natural spawners for each brood. Back-calculated for each age class from Columbia Mouth recruits (Columns AE-AH) and ocean exploitation rates (Columns I-L). Also the calculated recruits to the Pacific Ocean per adult spawner (in natural and logarithmic units).

Columns AL-AP: Age 3-6 and total recruits including ocean harvest.
Columns AC and AD: Calculated total recruits including ocean harvest per spawner in natural and logarithmic units.

7.0 SAS Code Appendix

```
*** read_BY_data_2nd_simuls_NOHARVEST.sas;
title1 "D:\userfile\Pizzimenti 2008-06\
read_BY_data_2nd_simuls_NOHARVEST.sas";
options linesize=133 pagesize=60;
options sysprintfont = "SAS Monospace" regular 8;

data forregs;

  infile "D:\userfile\Pizzimenti 2008-06\Snake FAC BY Data 6-12-08 06-13
really.csv" dsd lrecl=200 pad;

  input brood_yr
    tot_spawners : 10.
    wild_spawners : 10.
    prop_age_3 : 10.
    prop_age_4 : 10.
    prop_age_5 : 10.
    prop_age_6 : 10.
    Brt_recs_to_LGR : 10.
    bon_mcn_surv : 10.
    mcn_lgr_surv : 10.
    tot_lgr_recs : 10.
    col_riv_recs : 10.
    tot_ocn_recs : 10. ;

  if brood_yr > 0 ;


  lgr_ln_r_s = log(tot_lgr_recs / tot_spawners );
  Recs_to_LGR_No_Harvest = tot_ocn_recs * bon_mcn_surv * mcn_lgr_surv ;
  Ln_Recs_to_LGR_No_Harvest = log(Recs_to_LGR_No_Harvest / tot_spawners) ;


  Prop_nat_spawners = wild_spawners / tot_spawners ;
  constant = 1;


run;
proc sort;
  by constant;
run;
proc summary nway data=forregs;
  class constant;
  var lgr_ln_r_s  Ln_Recs_to_LGR_No_Harvest ;
  output out = variances
  mean = lgr_ln_r_s_MU  Ln_Recs_to_LGR_No_Harvest_MU
  var = lgr_ln_r_s_Var  Ln_Recs_to_LGR_No_Harvest_Var  ;
run;
```

```
proc sort;
  by constant;
run;
proc print data = variances;
run;
data forsim1;
  merge forregs variances (keep = constant  lgr_ln_r_s_MU
Ln_Recs_to_LGR_No_Harvest_MU lgr_ln_r_s_Var  Ln_Recs_to_LGR_No_Harvest_Var
);
  by constant;
  if brood_yr > 1994;
  in_year = brood_yr;
run;

proc sort;
  by in_year;
run;
proc print;
run;

data forsim2;

  array sp(100) sp1-sp100;
  array totrec(100) totrec1-totrec100;
  array rec_3_(100) rec_3_1-rec_3_100;
  array rec_4_(100) rec_4_1-rec_4_100;
  array rec_5_(100) rec_5_1-rec_5_100;
  array rec_6_(100) rec_6_1-rec_6_100;

  retain   sp1-sp100

      rec_3_1-rec_3_100
      rec_4_1-rec_4_100
      rec_5_1-rec_5_100
      rec_6_1-rec_6_100

      totrec1-totrec100
      lgr_ln_r_s_MU  Ln_Recs_to_LGR_No_Harvest_MU
      lgr_ln_r_s_Var  Ln_Recs_to_LGR_No_Harvest_Var
          prop_age_3  prop_age_4  prop_age_5  prop_age_6 ;

  set forsim1;
  by in_year;

  do i = 1 to 100;
      sp(i) = . ;
      totrec(i) = . ;
      rec_3_(i) = . ;
      rec_4_(i) = . ;
      rec_5_(i) = . ;
      rec_6_(i) = . ;
  end;
```

```
  if first.in_year then do;
    year = in_year;
    i = year - 1994 ;
    sp(i) = tot_spawners ;
  end;

  output;
  keep year sp1-sp100
       lgr_ln_r_s_MU  Ln_Recs_to_LGR_No_Harvest_MU
       lgr_ln_r_s_Var  Ln_Recs_to_LGR_No_Harvest_Var
    prop_age_3  prop_age_4  prop_age_5  prop_age_6 ;
run;
proc print;
  var  year sp1-sp7
       lgr_ln_r_s_MU  Ln_Recs_to_LGR_No_Harvest_MU
       lgr_ln_r_s_Var  Ln_Recs_to_LGR_No_Harvest_Var
    prop_age_3  prop_age_4  prop_age_5  prop_age_6;
run;
data forsim3;

  array sp(100) sp1-sp100;
  array totrec(100) totrec1-totrec100;
  array rec_3_(100) rec_3_1-rec_3_100;
  array rec_4_(100) rec_4_1-rec_4_100;
  array rec_5_(100) rec_5_1-rec_5_100;
  array rec_6_(100) rec_6_1-rec_6_100;

  retain   sp1-sp100

       rec_3_1-rec_3_100
       rec_4_1-rec_4_100
       rec_5_1-rec_5_100
       rec_6_1-rec_6_100

       totrec1-totrec100
       Ln_Recs_to_LGR_No_Harvest_MU
       Ln_Recs_to_LGR_No_Harvest_Var
            prop_age_3  prop_age_4  prop_age_5  prop_age_6 ;
  ***** set forsim2;

do igame = 1 to 10000;
  do i = 1 to 6;
    set forsim2 point = i;
       year = i + 2000 ;
       r_s = exp ( Ln_Recs_to_LGR_No_Harvest_MU +
sqrt(Ln_Recs_to_LGR_No_Harvest_Var)*rannor(1234567)) ;
       totrec(i) = sp(i) * r_s ;
       ******totrec(i) = sp(i) *
            exp ( Ln_Recs_to_LGR_No_Harvest_MU /**+
sqrt(Ln_Recs_to_LGR_No_Harvest_Var)*rannor(1234567)**/ ) ;
       rec_3_(i) = totrec(i) * prop_age_3 ;
       rec_4_(i) = totrec(i) * prop_age_4 ;
```

```
       rec_5_(i) = totrec(i) * prop_age_5 ;
       rec_6_(i) = totrec(i) * prop_age_6 ;
       r3 = rec_3_(i) ;
       r4 = rec_4_(i) ;
       r5 = rec_5_(i) ;
       r6 = rec_6_(i) ;
       pred_sp = sp(i) ;
       recruits = totrec(i);
       output ;
  end;
     do i = 7 to 100;
       year = i + 2000 ;
       r_s = exp ( Ln_Recs_to_LGR_No_Harvest_MU +
sqrt(Ln_Recs_to_LGR_No_Harvest_Var)*rannor(1234567)) ;
       sp(i) = rec_3_(i-3) + rec_4_(i-4) + rec_5_(i-5) + rec_6_(i-6) ;
       if sp(i) > 100000 then sp(i) = 100000;
       totrec(i) = sp(i) * r_s ;
       ****totrec(i) = sp(i) *
            exp ( Ln_Recs_to_LGR_No_Harvest_MU /**+
sqrt(Ln_Recs_to_LGR_No_Harvest_Var)*rannor(1234567)**/ ) ;
       if sp(i) < 2 then totrec(i) = 0 ;
       rec_3_(i) = totrec(i) * prop_age_3 ;
       rec_4_(i) = totrec(i) * prop_age_4 ;
       rec_5_(i) = totrec(i) * prop_age_5 ;
       rec_6_(i) = totrec(i) * prop_age_6 ;
       r3 = rec_3_(i) ;
       r4 = rec_4_(i) ;
       r5 = rec_5_(i) ;
       r6 = rec_6_(i) ;
       pred_sp = sp(i) ;
       recruits = totrec(i);

       output;
       keep igame year pred_sp recruits r3 r4 r5 r6 r_s;
     end; ** i-loop;

end; ** igame ;
  stop;
run;
/**********proc print;
  id igame year;
run;
**********/
proc summary nway data = forsim3;
  class year;
  var pred_sp ;
  output out = sim_out_summary
  min = spwan_min
  p1 = spawn_sim_01st
  p5 = spawn_sim_05th
  p10 = spawn_sim_10th
  p25 = spawn_sim_25th
```

```
  median = spawn_sim_50th
  p75 = spawn_sim_75th
  p90 = spawn_sim_90th
  p99 = spawn_sim_99th
  max = spawn_max
  ;
run;
proc print data = sim_out_summary(drop = _type_ _freq_);
  id year;
run;
```

8.0 Data for SAS Code

Brood Year	Spawners @ LGR 5/	Wild Spawners at LGR	Adult Spawner Return	0	0	0	BRT Brood Returns 4/	0	0	0	0	0
0	0	0	Wild Recruits from BY Spawners 1/	0	0	0	0	Adult Col. & Snake R. Survival 6/	0	0	Columbia Mouth Recruits at Age	Total Recruits Including Ocean Harvest
0	0	0	Age 3	Age 4	Age 5	Age 6	0	BON-MCN	MCN-LGR	Total	Total	Total
1975	1000	1000	0.316585	0.494676	0.175036	0.013702	528.7189	0.848	0.878	533.3777	1182.82	1337.755
1976	470	470	0.316585	0.494676	0.175036	0.013702	440.4092	0.848	0.878	450.275	838.1724	939.9974
1977	600	600	0.316585	0.494676	0.175036	0.013702	436.6792	0.848	0.878	442.5439	725.9338	799.2913
1978	640	640	0.316585	0.494676	0.175036	0.013702	538.7213	0.848	0.878	543.1609	881.5781	983.1279
1979	500	500	0.316585	0.494676	0.175036	0.013702	496.3745	0.848	0.878	502.3762	859.989	1071.669
1980	450	450	0.316585	0.494676	0.175036	0.000883	372.4394	0.848	0.878	372.8359	756.277	1028.438
1981	340	340	0.316585	0.494676	0.035683	0.000622	335.2634	0.848	0.878	335.4207	744.2095	928.9785
1982	720	720	0.316585	0.019608	0	0	147.4683	0.848	0.878	147.4683	329.4724	369.9294
1983	540	428	0.943826	0.894118	0.429391	0.020045	808.0057	0.848	0.878	813.9191	2049.167	2357.614
1984	640	324	0.10526	0.411039	0.103327	0.008014	208.3748	0.848	0.878	208.9999	530.6206	721.1239
1985	691	438	0.15957	0.538334	0.221071	0.02711	234.7739	0.848	0.878	243.395	555.1157	689.5654
1986	784	449	0.338293	0.577991	0.307038	0.014063	242.5178	0.848	0.878	250.2381	511.6681	640.2112
1987	951	253	0.192924	0.412396	0.169922	0.002055	239.4772	0.848	0.878	241.0019	416.994	494.481
1988	627	368	0.253455	0.512305	0.168265	0.02774	486.7066	0.848	0.878	497.9692	822.4799	1031.564
1989	706	295	0.303711	0.735845	0.327964	0.001085	845.8876	0.848	0.878	846.2672	1453.288	1851.899

Brood Year	Spawners @ LGR 5/	Wild Spawners at LGR	Adult Spawner Return	0	0	0	BRT Brood Returns 4/	0	0	0	0	0
1990	335	78	0.093836	0.381655	0.124006	0.031227	267.9802	0.848	0.878	287.9343	471.0885	575.3014
1991	590	318	0.26264	0.421186	0.023009	0.038285	268.7499	0.848	0.878	299.2629	478.3124	517.7992
1992	668	549	0.453724	0.663623	0.234686	0.001868	769.9033	0.848	0.878	770.4748	1289.791	1550.79
1993	952	742	0.28214	0.507274	0.201534	0.018837	646.2544	0.848	0.878	663.3022	1198.17	1426.139
1994	606	406	0.219755	0.209103	0.104609	0.013702	333.8015	0.848	0.878	349.5319	644.9414	751.9679
1995	637	350	0.587495	0.640989	0.175036	0.013702	960.81	0.848	0.878	1030.46	1842.808	2240.377
1996	919	639	0.235564	0.494676	0.175036	0.013702	1670.782	0.848	0.878	1699.489	2930.083	3577.122
1997	1007	797	0.316585	0.494676	0.175036	0.013702	3244.58	0.848	0.878	3297.416	5817.612	7111.866
1998	962	306	0.316585	0.494676	0.175036	0.013702	3320.489	0.848	0.878	3385.657	6083.522	7127.551
1999	1862	905	0.316585	0.494676	0.175036	0.01	3403.189	0.848	0.878	3434.279	6081.592	7351.788
2000	2664	1148	0.316585	0.494676	0.12	0.01	3946.513	0.848	0.878	3973.973	7093.153	8474.562