BC-TO-ALASKA TRANSBOUNDARY SALMON: CONFLICT, ENHANCEMENT, MORAL HAZARD, PAPER-FISH AND FOLLY

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ABSTRACT

Enhancement of British-Columbia-to-Alaska Transboundary Rivers is a vast potential prize to all concerned. However, despite funding commitments in the Pacific Salmon Treaty, that program is at great risk of always being more potential than real. The cooperation needed to make this program work has been and continues to be grievously eroded by short-term self-interest (moral hazard), Alaskan's fears that they will give up real fish for a share in paper fish (e.g. fish that exist only in official reports) and the folly that has bureaucrats managing these projects when they have little or no stake in their success and a history that does little to inspire confidence. This paper reviews the history of conflict over, management of, and mismanagement of BC-to-Alaska Transboundary River salmon, examines the potential gains from enhancing those stocks, and looks at approaches to contracting responsibility for and rewards from that enhancement so as to mitigate the harm from moral hazard, paper fish, and folly.

Keywords: Salmon, Sockeye, enhancement, out-plantings, transboundary, stakeholders, B/C, velocity barrier, conflict, moral hazard, bureaucrat, management, folly

HISTORY

The PST (Pacific Salmon Treaty), signed in 1985, resulted from negotiations initiated in the early decades of the 20th Century by Canada and the USA, and is mandated to manage conflict in the management of Transboundary salmon stocks and other highly migratory salmon stocks. The US interest in Fraser River salmon is based on the early to mid-20th Century when they assisted in enhancing the stocks after blasting to expand rail service caused the 1913-14 Hell's Gate slide that destroyed many Fraser River runs.

In the late 1970s, Canada encouraged commercial salmon fisheries on Canadian watersheds that flow through Alaska into the North-East Pacific. At that time, the focus of Canada's Department of Fisheries and Oceans (DFO) was primarily on Fraser River Sockeye—creating Canadian fresh-water fisheries on transboundary stocks was likely done to create bargaining chips that could be sacrificed to reduce US interception of Fraser River and other stocks of BC (British Columbia) origin migratory salmon. Fishers pioneering the freshwater fisheries on Northern BC Transboundary Rivers doggedly persist and the frictions between USA and Canadian fisheries have been increased rather than reduced.

History – International Law and the Pacific Salmon Treaty

Sea-run salmon stocks from the west-coast of North-American migrate into the North-Pacific Ocean—some as far south as Hawaii and Asia to the west. The USA (with assistance from Canada) uses the moral suasion of international law and US economic might to protect salmon originating in Alaska, Canada and the Lower 48 States from interception by most foreign fishers.

Many salmon, originating in Canada or the Lower 48 States, return via Alaska's EEZ before entering Canada's EEZ.[1] UNCLOS (Article 66, 1994b) vests "states in whose rivers anadromous stocks originate [with] …the primary interest in and responsibility for such stocks." In contrast to the clear status of most salmon stocks, the status of those originating in BC watersheds flowing to Alaskan estuaries is less clear. The issues are made more complex because, while both the USA and Canada acknowledge international law, neither had ratified UNCLOS 1994 (UN Convention Law of the sea) as of 31 July/00 (Berrill, 2001).

The PST is negotiated by the federal Canadian and US governments and the state governments of Alaska, Washington, Oregon, California and Idaho to manage Eastern-Pacific salmon. However, annual talks on the PST operating terms failed from 1994-98—Canada was unwilling to accept, what its representatives interpreted as, Alaskan aggression in interpreting and implementing Alaskan rights to fish Canadian-origin salmon. Gould (1993, pp.71-72) projects that 75 percent of the 1992 Alaskan catch of 1.2 million Sockeye at Noyse Island was "Canadian fish bound for the Skeena or Nass Rivers" and that the remainder probably included other Canadian-origin salmon from the Fraser River and the Transboundary rivers.

Alaska-legislated use of large-mesh nets in its fisheries is another source of irritation—it *high-grades* transiting Canadian stocks of larger more valued fish and leaves smaller, net-marked fish for Canadian fishers. Thus, fair allocation of the salmon needs to be value based (Helgason, 1989). Alaskan high-grading of stocks may impose other costs (i.e. consistently taking larger fish from a breeding population creates a predisposition for small fish and that hurts everyone, in the long run—Ricker, 1976; Northcote and Larkin, 1989; Hershberger, et al., 1990, Wright, 1991a, Chapter 5, pp.21-23 and 1994a, p.199).

In 1999, annual terms were again settled on the PST (Hedley, 2004a and 2004b)—including provisions and (courtesy of Alaska) the financial means to enhance Transboundary salmon stocks. However, great care is needed to ensure that this enhancement program generates more than paper fish and that its benefits are fairly and reasonably distributed instead of being captured by a *spiral* of competitive theft and/or incompetence by the more-aggressive and less-socially-responsible stakeholders and contractors.

ENHANCEMENT MANAGEMENT

The DFO and ADF&G (Alaska Dept. of Fish & Game) *Precautionary Approach* is not appropriate in salmonid enhancement. Holling (1984, p.213) asserts that enhancement "needs to be viewed as a series of large-scale perturbation experiments[—]…enhancement facilities should be set up to provide information as well as an increase in catch, perhaps even sacrificing some of the latter for the former."

Enhancement – Strategic Objectives and Means

Strategic objectives need to be set and published ahead of time and data should be gathered and reported fairly and promptly to stakeholders (e.g. publish it on the internet). In the absence of such openness, it is all too tempting to paint a bulls-eye after shooting the arrow and claim to be perfectly on target.

Strategic objectives appropriate to enhancement would include:

- ☑ **Enhancement must be a value-adding process** – All too often, enhancement projects expend millions of dollars of resources to generate fish that only exist in reports or have an average cost that far exceeds their social value. Winton (1991, pp.84, 94, 102 and 112), showed that one cohort of adult hatchery Chinook salmon (i.e. adult salmon include harvest and spawner escapement) with an economic value of $40-$100 each, had a production cost of well over $435 per fish.[2] Also, claims of enhancement output must take into account any crowding-out of weaker wild stocks (Pearse, 1982; Peterman, 1990, p.7).
- ☑ **Net benefits from enhancement must be fairly allocated among stakeholders**—this means identifying the stakeholders along with the size and nature of their stake—a list of stakeholders would include the:
  - **Federal Governments** of Canada and the USA,
  - **State/Provincial/territory governments** of Alaska, BC, Washington, Yukon, Oregon, California, Idaho, and (possibly) Alberta.
  - **Aboriginal Peoples** with traditional interests in the Transboundary River systems.
  - **Commercial Fishers** of Alaska, BC, Washington, Oregon, and California.
  - **Food (Subsistence) Fishers** of Alaska, BC, Washington, and Yukon.
  - **Sport fishers** of Alaska, BC, Washington, Oregon, and California.
  - **Fisheries Management Bureaucrats** of Alaska, BC, and Yukon.
- ☑ **The allocation of net enhancement benefits should reward accomplishment and discourage failure and/or defection**. If shares are not tied to contribution, the resulting game playing can destroy the entire wealth making enterprise via threat, counter-threat and called bluffs. Thus, stakeholders behaving badly towards the enhancement enterprise should suffer accordingly and in a way that is fair and clear to all.

The means to achieve the above objectives should include measurable success in such things as:

- **Increasing the Net Numbers of Fish** available to the stakeholders.
- **Increasing the Quality of Fish** available to the stakeholders.
- **Increasing the Knowledge Base** to improve future decision making.
- **Creating and Maintaining a Management-Information-and-Control System.**

Enhancement – Ways to Create the Means

Just as it is important to distinguish between the objectives of enhancement and the means, it is vital that the means not be confused with the ways to attain those means. Holling (1984, p.213) notes enhancement involves "…a series of large-scale perturbation experiments…" There are a number of ways to perturb the stocks and/or the environment to increase the net numbers and/or quality of fish available to stakeholders (Fedorenko and Sheperd, 1986; Sheperd, et al., 1986, Wright, 1994a):

☺ **Best-Practices Review**– involves auditing current practices, comparing them with *Best Practices*, determining the benefits and costs of improving the current practices. Three areas need to be reviewed:

a) **Management Practices** – Escapement numbers, planned escapements, timing, ability to adapt to with-in-season changes, etc.

b) **Gear-Practices** – Ideally, all fish killed by a gear should be landed. However, some gears have high by-kills (i.e. unlanded fishing mortality; Wright, 1994a, 1994b, 1998a, 1998b; Wright and Gould, 1996; Wright and Panek, 2000) and need to be managed with due care.

c) **Fisher-Practices** – Handling practices and/or changes in fish allocations (to higher value uses).

☺ **Out-Planting of Eggs and/or Fry**

a) **Temporary** -- can establish new stocks or to supplement weak stocks until their numbers rise (Blackett and Davis; 1970; Blackett, 1979; Withler, 1982).

b) **Perpetual** -- can maintain stocks in areas of a watershed blocked by a velocity barriers such as falls, rapids, or dams (Wright, 1989a, 1989b, and Wright et al, 1992).

☹ **Hatcheries** – establish and maintain artificial stocks that can be costly to maintain (Winton, 1991), can harm wild stocks (Pearse, 1982; Peterman, 1990, p.7), and often prove to be cost-ineffective (Pearse, 1982; White, 1988; Shaffer, 1989; Winton, 1991). Wright (1994a, p.224; Anderson, J. 1985) noted that fry from one DFO project (from the early 1980s) cost 33¢ each compared with private hatchery costs (Alaska, Washington State and Stikine River, BC) of around 5¢ per fry (or 15.2 % of DFO's costs).

☺ **Volunteering or Colonization** – is where excess spawners seek under or unused spawning grounds to found new stocks. The cost of this process is usually low and, per the Hell's Gate slide (Fraser River, BC) and Kemano River diversion (BC) experiences, the outcomes can be surprisingly good.

☺ **Spawning Channels** – work well, if spawning capacity is a limiting factor to an otherwise productive watershed (Fraser and Fedorenko, 1983). Innovation in this area could significantly reduce costs.

☺ **Lake Fertilization**

a) **Perpetual** – can produce extraordinary results in systems that are feed limited during the crucial alevin-to-fry transition (Robinson and Barraclough, 1978; Stockner and Costella; 1980; Hyatt and Stockner, 1985; Furnell and Brett, 1986; Wood, et al., 1987; Balkwill, 1991).[3]

b) **Temporary**– may be effective in shocking a lake out of a bifurcation—from a low Sockeye productivity zooplankton mix to one more favorable to Sockeye production.

☺ **Stream Grooming** is very situation dependent (Wright, 1994c) and can yield excellent results, with what often appear to be contradictory approaches.

😐 **By-passes** – can be costly to build and maintain in the rough and tumble rivers of BC/Alaska. Further, by-pass projects should be assessed, not against the value of the stock created but against the net cost savings of by-passing annual out-plantings (Blackett, 1987).

Salmonid enhancement relaxes a binding constraint in a dynamic system and the choice of enhancement technique depends on which constraint is currently most binding. As a result, approaches that work well in one place and time may disappoint in others. Also, any enhancement technique eventually suffers from diseconomies of scale because changing a system makes other factors more binding—further relaxing non-binding limiting factors has little effect (Peterman, 1982 and 1984; McDonald and Hume, 1984).[4]

Peterman (1990) found adult returns to be a nonlinear function of outgoing smolts. Thus, enhancement results must be carefully monitored so as to facilitate either a shift to alternate enhancement modes or a downshift to a more sustainable and safer enhancement level. Smolt size is a good indicator of stress in a system (Ryall, 1985, Koenings and Burkett, 1987; Kyle, et al, 1988).

REVIEW OF PRACTICES ON TRANSBOUNDARY RIVERS

A formal exhaustive review of current practices on the five major salmon-producing Transboundary River systems would be costly in terms of time and money. This cursory study is drawn from the authors' decades of experience with *value-for-money* auditing, enforcement, fisheries, and fishery management—and is tempered with their specific experiences on the Stikine River. Best-Practice Reviews are always controversial in that they focus on lapses from ideals—ignoring the, possibly many, instances of success.

Review of Best Management Practices

There are a number of Best-Management-Practice failures evident on the Stikine River System that may be indicative of failures on other Transboundary River systems.

- **Managing Spawning-Ground Escapement Numbers** – Table 1 displays an unsettling consistency in DFO's problems in managing escapement to a target. The short-run economic activity lost because of over escapement during 1989-2003 was $6.64 million and $1.23 million of that loss occurred in 2003.

Table 1: Stikine River Escapement (Adapted from TTC, 2004, pp.1-2, Appendix B.28, and Table 2)

	Tahltan Lake Sockeye Run			Stikine Mainstem Sockeye Run		
Year	**Actual Escapement**	**Less Target of 24,000***	**Short-run Cost @ $20/fish**	**Actual Escapement**	**Less Target of 30,000****	**Short-run Cost @ $20/fish**
1989	**8,316**	**(15,684)**	**$ n.a.**	**45,099**	**15,099**	**$301,980**
1990	**14,927**	**(9,073)**	**n.a.**	**22,495**	**(7,508)**	**n.a.**
1991	**50,135**	**26,135**	**522,700**	**44,879**	**14,879**	**297,580**
1992	**59,907**	**35,907**	**718,140**	**65,393**	**35,393**	**707,860**
1993	**51,610**	**27,610**	**552,200**	**71,792**	**41,792**	**835,840**
1994	**39,511**	**15,511**	**310,220**	**34,636**	**4,636**	**92,720**
1995	**31,577**	**7,577**	**151,540**	**42,850**	**12,850**	**257,000**
1996	**38,161**	**14,161**	**283,220**	**45,852**	**15,852**	**317,040**
1997	**12,105**	**(11,895)**	**n.a.**	**37,436**	**7,436**	**148,720**
1998	**12,268**	**(11,732)**	**n.a.**	**19,175**	**(10,825)**	**n.a.**
1999	**10,319**	**(13,681)**	**n.a.**	**6,071**	**(23,929)**	**n.a.**
2000	**5,670**	**(18,330)**	**n.a.**	**10,132**	**(19,868)**	**n.a.**
2001	**14,761**	**(9,239)**	**n.a.**	**40,855**	**10,855**	**217,100**
2002	**17,340**	**(6,660)**	**n.a.**	**27,155**	**(2,845)**	**n.a.**
2003	**53,333**	**29,333**	**586,660**	**62,293**	**32,293**	**645,860**
Total			**$3,124,680**			**$3,519,720**

* This is the mid-point of the actual target range of 18,000 to 30,000 pieces (TTC, 2004, p.1).

** This is the mid-point of the actual target range of 20,000 to 40,000 pieces (TTC, 2004, p.1).

The long-run over-escapement losses include reduction in future runs (Ricker, 1975) mostly 3 to 6 years later. Future loses from the 2003 over escapements are estimated at roughly $2.2 million/year (Appendix A, part II b: 199,320 – 89,284 = 110,036 pieces at $20 each)—roughly double the short-term losses. Including long-run effects, potential losses from the 1989-2003 management errors are likely $20 million ± $4 million ($6.65 x 3). Without improved management, there are likely to be $51 million ± $21 million in losses over the next 15 years. Resolving these issues is equivalent to generating **170,000 ± 70,000 new fish per year**.

Appendix C indicates that several Stikine River fishers are correct when they assert that actual escapement numbers appear to be more a function of the current run size than of any plan. As noted in Appendix C, managing escapement as a fraction of the current run can be immensely damaging and costly to a fishery.

- **Planning Escapement Spawning-Ground Numbers** – The 2003 Tahltan Lake and Stikine Mainstem escapement targets are, respectively 24,000 ± 4,000 and 30,000 ± 10,000. Based on Appendix A, it may be prudent to reduce those targets to, respectively, 18,000 and 20,000 pieces—Ricker (1975) proved that in terms of salmon-spawners ***less can mean more***. The idea that Tahltan Lake output is spawning constrained is supported by the failure of five years of lake-fertilization trials in the late 1980s (Stockner and Hyatt, 1985). If these estimates are valid, planning errors removed 16,000 pieces from fishers and reduced regional economic activity by $320,000 in 2003 and, combined, the 1989-2003 short-run losses are $3.06 million.

  The long-run effects of this issue need to be disentangled from those of the previous section. However, resolving these issues is equivalent to producing **30,000 ± 10,000 pieces/year** or $600,000 ± $200,000.

- **Managing Escapement Timing to the Spawning Grounds** – Prudent fisheries managers are careful to ensure the pattern of escapement does not disrupt the with-in-year mix of the stock being managed. The current practice of gross over-escapement favors late-running fish (e.g. as later entrants to the spawning grounds nest and spawn they disrupt the nests of earlier spawners and greatly reduce the survival of earlier-spawner eggs) and (at least in theory) the fishery could be crowded into the latter part of the season.

- **With-in-Season Management** – recognizes that plans set at, or before, the start of a season, usually must be adjusted to the actual conditions during the season. Table 1 and discussions with Stikine River fishers indicate there is substantial scope for improvement in the with-in season management on the Stikine River.

  One fisher recounted that in 2000, when Tahltan Lake escapement was around 5,670 pieces, DFO cut Fishing by 2 days at the tail-end of the Tahltan Lake run—that action was reputed to have added 56 fish to the escapement but cost the fishers 4,000 fish from the then strong Stikine Mainstem run. If DFO had cut fishing by two days during the main run of Tahltan Lake fish, thousands of fish would have been added to the Tahltan escapement. Increasing the escapement by 1.0 % cost DFO bureaucrats little or nothing, but imposed an $80,000 cost on fishers and processors (roughly $1,400/fish added to the Tahltan escapement).

  The use of linear regression models "…to predict run size from cumulative CPUE fisheries (TTC, 2004, pp. 9-10) is disturbing—it has long been recognized that such models are not particularly reliable (Henderson. et al., 1987, pp.266-272; Woodly, 1987, pp.367-375). One severe issue is that the CPUE can be a curvilinear function of effort, especially of soak time in the set-gill-net fishery (see Figure A3 in Appendix A). Another issue is that test fishery data becomes less reliable when the test fisher is changed—e.g. from a middle-aged female high-liner to a pre-teen boy.

  Figure C1 (Appendix C) shows that Stikine River fisheries managers have been very adept at maintaining the exploitation rate around 50 percent—even though the optimum exploitation rate for the Tahltan Lake run appears to be 85 % ± 5 %. However, this exploitation rate should be reduced for runs below 100,000 fish so that escapements average 17,500 ± 2,500 Sockeye.

- **Boondoggle Management** – occurs when a government funds promised for one use (e.g. managing or enhancing a resource) are redirected to cross-subsidize social and/or political concerns.

  Illuminating the costs of the 2003 Tuya terminal fishery boondoggle requires the resources of a Royal Commission and/or the Auditor General's Office. However, interviews with Stikine River fishers indicate that DFO subsidized that fishery by $100,000 in cash, $45,000 in helicopter use, supplied other in-kind services such as: office and support staff, office and facilities use, transportation, communications, and logistics) likely worth another $145,000, EI (employment insurance) payments and administrative funding associated with this project are likely $250,000 and DFO has spent hundreds of thousands of dollars in engineering and feasibility studies (on spending even more to change the area of the blockage to make fishing easier).[5] Thus, roughly $750,000 was spent to catch 7,031 fish that sold for $23,000.

  These boondoggle, fish cost over $100 each had a fair-market value of $3.27 each.[6] The private gain of fishers was $53.05/fish ($100,000 in wages plus $200,000 in EI plus $50,000 in associated administration, plus $23,000 in revenues for a total of $373,000) for fish that if caught in the Stikine Mainstem would have generated from $10.00 to $30.00 each (depending on the fishers situation and possible EI claw-backs) less the out-of-pocket fishing costs cost (e.g. food, fuel, repairs, and maintenance).

  As a basic principal, fisheries should be value-adding rather than value-deducting enterprises. The Tuya terminal fishery is a value-deducting enterprise that grossed 3¢ per dollar spent (a loss of 97¢ per $1.00).[7] As previously noted, the exact costs of this Boondoggle are difficult to uncover, but if those costs are half of the estimate, or even a tenth, then the value loss is still, respectively, 94¢, or 70¢ per dollar spent, and the basic truth remains—this boondoggle is a value-deducting enterprise.

DFO management-and-control services often appear to be tendered more as boondoggles—serving *social and political expedience* rather than on the *cost-efficiency* in *effectively-getting-the-job-done*. For example, the sample tagging of returning fish provides vital information on run sizes and non-fishing mortalities. However, there appear to be few controls to ensure that returned tags were appropriately planted in fish.

- **Compounding Management Errors** – In complex systems, the number and effect of management errors tend to accumulate geometrically rather than additively. For example, the massive over-escapements of Tahltan Lake fish (Table 1) directly lead to a perceived need to mop up significant numbers of terminal fish at the Lower Tuya River blockage. The DFO decision to deal with the wasted-terminal-fish symptom of the problem, instead of seeking to understand and resolve its causes, compounded its mismanagement and created opportunities to transfer fish and management and other funds for social or political reasons.

  The Tuya Lake wasted terminal fish can be reduced by careful timing of more harvest effort. Specifically, while the Stikine Mainstem run is basically constant through-out the Sockeye fishing season, both the Tuya Lake and Tahltan Lake runs pass through the Stikine Mainstem in nearly identical (in terms of timing) normal-bell-shaped distributions with a distinct peak and two tails. However, the Tuya run appears to be more susceptible to fishing effort than the Tahltan run (i.e. the exploitation rates of the two stocks were, respectively 0.5875 and 0.4455). Per the analysis in Appendix B, if the Tahltan Lake escapement target of 24,000 pieces had been met, the over escapement of Tuya run would likely have been reduced from 15,085 pieces to between 241 and 2,507 pieces—which would have provided Alaskan and Stikine Mainstem fishers and processors with another $252,000-$297,000 in revenues from Tuya fish and reduced costs to Canadian taxpayers by $750,000.

  If the Tahltan Lake escapement had been set at 15,000 pieces, the over escapement of the Tuya Lake run would likely have been reduced to between 0 and 1,020 which would have provided Alaskan and Stikine Mainstem fishers and processors with another $281,000-$302,000 in revenues from Tuya fish and reduced costs to Canadian taxpayers by $750,000. Resolving these issues is worth $277,000 ± $25,000/year or **roughly equivalent to 14,000 ± 1,400 new fish**.

- **Buffering** – Salmon stocks are sufficiently robust to survive periodic under-escapements. Specifically, there is significant overlap from year to year in that some smolts leave in year one and others in year two and the ocean period varies from two to four years. Over-escapement tends to be more of a serious issue, especially for spawner constrained stocks—more spawners does not always mean more salmon.

- **Summary: Annual Cost of Less than Best-Management Practices** – appears to be $2 million in short-run economic activity plus $2 million in losses from reduced future runs, with an expected variance of around 50 percent. In the absence of essential improvement, management errors over the next 15 years are expected to cost $65 million ± $30 million. **Resolving the less-than-best-management practices on the Stikine could provide an equivalent of 215,000 ± 100,000 fish per year.**

Review of Best Gear Practices

There are a few areas where Gear-Practice failures can be improved on the Stikine River System:

- **Set-Gillnet By-kill** – Most Stikine River fish are harvested by river-drift-gillnets. However, a significant number (≈ 20 %) are caught with set-gillnets. As Wright and Gould (1996; Wright, 1994b, 1998b) note, two basic problems with set-gillnets are they can kill many times more fish then are landed from them and their quality of landed fish can be much lower than that from river-drift-gillnets. When they became aware of this problem, many Stikine set-gillnet fishers switched to either *hot picking* their nets or picking them within 2-4 four hours. As a rough estimate, if 15 percent of the landings were done by fishers not trying to avoid by-kill and if on average those fishers killed 4-6 times the fish they landed then **35,000 ± 9,000** (58,784x.15x4±1) fish were killed but not landed. This estimate translates to a loss of economic activity of $700,000 ± $175,000 a year. When the by-kill of the food fishers and the vast numbers of set nets in other subsistence fisheries in all Transboundary Watersheds, and the Yukon River are considered along with the ocean commercial harvests of those stocks in Alaskan waters, this loss becomes truly shocking—a loss of many hundreds of thousands of Transboundary salmon per year is likely.

- **Non-traditional Gear** – offers an opportunity to reduce fishing costs, increase quality, and reduce by-kill (Wright 1994a; Copes et al., 1994). Experimenting with such gear may be costly but it is not a boondoggle. Requiring *hot picking* or the *avoidance of set-gillnets*, if possible, is a desirable common practice in all area fisheries.

Review of Best Fisher Practices

There are a few areas where Fisher Practices can be improved on the Stikine River System:

- **Set-Gillnets and By-kill** – *Hot picking* set-gillnets or picking within four hours can greatly reduce the incidence of by-kill and improve the quality of landed fish.
- **Icing and *Gilling* Landed Fish** – dramatically increases the landed quality of fish and are already done by many Stikine fishers, but are not common practices in all area fisheries.
- **High-Grading** – As noted in section 1.2, high-grading by Alaska fishers is an ongoing irritant for Canadian fishers and is likely a source of damage to the stock—this practice should be reviewed.

Out Plantings of Eggs and/or Fry

Has proven successful in Tuya Lake and was a great success in Fraser Lake (Kodiak Island, Alaska) per: Blackett and Davis (1970), Blackett (1979), Blackett (1987), Koenings and Burkett (1987), and Kyle, et al. (1988). It was suggested by Wright, et al. (1992) that: "Including Tuya Lake, the Stikine watershed potential for Sockeye *out-planting* enhancements is likely between 25 and 50 million fry. If other species (chinook, Coho and steelhead) are included, the potential is likely much higher".

Each out planting equivalent to 5 million fry could generate from 220,000 ± 120,000 adult Sockeye and out plantings equivalent to 25-50 million fry could generate another 500,000 to 3,500,000 adult Sockeye —creating economic activity of $10-$68 million. There also appear to be out-planting opportunities in the Alsek, Tatshenshini, Greater Taku, and Whiting watersheds. As noted in Section 2.2, many of these opportunities involve portions of the river system isolated by velocity barriers (e.g. falls, rapids, or dams). The upper Iskut River (joins the Stikine River) has a greater potential for Sockeye production than most area watersheds. A hydro development planned for that river's main velocity barrier may become the means to greatly increase the accessibility of the area to colonizing Sockeye. An immediate out-planting program may smooth and accelerate benefits and mitigation agreements with the developers may make the incremental costs of a *fish ladder* or other by-pass more favorable than scaling up out-plantings. Extrapolating from the Stikine/Iskut River estimates, **a full enhancement program on Transboundary Rivers could produce 5-50 million new adult Sockeye salmon each year and generate $100 million to $1 billion in economic activity.**

Volunteering/Colonization – involves making the best of a bad situation.

As noted previously, 7,031 of the 13,328 piece Tuya Lake over escapement were taken in terminal fisheries and the other 6,297 pieces went looking elsewhere for under or unused spawning grounds. This volunteerism may create future benefits from an otherwise bad situation of wasted fish

While it was sensible to start the Tuya stock from Tahltan Lake stocks, it seems foolish to continue that practice when there are salmon trying to return to Tuya Lake—e.g. given time, an isolated Tuya Lake stock will develop unique characteristics that suit it to its system, but this will never happen if DFO keeps using out plantings from Tahltan Lake (see Marshall, et al., 1987).

Other Forms of Enhancement

Enhancement involves identifying the factor that most limits output in a salmon-producing system, then experimentally relaxing that factor until other factors become limiting, and then serially relaxing each current most-limiting factor until an optimal salmon output is achieved. Thus, enhancement is a dynamic process with each success or failure openning up new possibilities.

MANAGEMENT AND CONTROL OF ENHANCEMENT

Enhancing the BC/Yukon:Alaska Transboundary Rivers is a rich potential prize to its stakeholder groups. However, the history of the region and of stakeholder agreements warns that such projects need protection from the ravages of moral hazard, paper fish, and folly.

Protection from Folly

The *Precautionary Approach* favored by DFO and ADF&G is unsuited to enhancement. Holling (1984, p.213) asserts: enhancement "needs to be viewed as a series of large-scale perturbation experiments[—]… enhancement facilities should be set up to provide information as well as an increase in catch, perhaps even sacrificing some of the latter for the former." Excessive caution will entomb Transboundary-River enhancement in endless preliminary studies and risk speculation. Measured risk and reasonable mistakes are a cost of *boot strapping* to enhancement success.

In terms of learning from past mistakes, as previously noted, improved management on the Stikine River system could enhance regional economic activity by $4 million ± $2 million/year—equivalent to 215,000 ± 100,000 pieces of Sockeye/year. These gains can be thought of as Management-Practices Enhancement.

Improving gear use/types and fisher practices can secure gains of many hundred thousands of dollars a year—equivalent to many tens-of-thousands-of-pieces of Sockeye. These gains can be thought of as Gear/Fisher-Practices Enhancement.

A good protection from folly is to empower a semi-independent board to oversee enhancement-managers (one per river system) in the Transboundary Region. Ideally, the actions of the Board and Enhancement Mangers will be reviewed annually, on a rotating basis (3 year terms), by the Auditor General's Office (or equivalent) of Canada, USA, BC, and Alaska.

Protection from Moral Hazard and Paper-Fish

Those responsible for enhancement should have a significant stake in its success. Fisheries bureaucrats get their salary even if a project fails and are often more interested in maximizing budgets (Niskannen, 1971) or leading *the quiet life* by minimizing complaints from politically powerful lobby groups (Posner, 1974) or some mix of goals (Peltzman, 1976).

The first step in optimizing enhancement outcomes is to structure incentives and rewards of management so that all are committed to the success of the enhancement. The second step is to make data gathering, analysis and performance assessment independent of management so it is more difficult for line managers to obfuscate the presence of, consequence of, and/or responsibility for sub-optimal performance. It is therefore essential to separate enhancement management from fisheries management and enforcement—however, an arbitration-and-oversight process is needed to quickly and effectively resolve any conflicts.

Much of the enhancement needs to be done in the traditional territories of Canada's First Nations. In return for their ongoing goodwill, these people and their leaders expect to participate in the largess from enhancement. Goodwill from prepaid fees, commissions, or stipends will likely fade at least as fast as the money is spent. Thus, an inter-locking system of royalty payments linking payments/fees to specific accomplishments and tying producers to fishers is needed to provide security. While the details of such a system depend on the outcome of negotiations, they may include a royalty advance to First Nation bands of a few cents per smolt produced from their traditional lands, followed by a much larger piece-royalty per landed adult fish (less the smolt-royalty advance). The royalties could be funded by a landing fee charged to fishers and processors of enhanced fish—ocean-landed fish may have a higher landing fee than landings from the Stikine Mainstem and terminal landings may warrant little or no landing fees. Further, terminal landings would offer little or no landing-royalty but DFO should pay a management-failure fee per terminal-or over-escaped-fish (on the spawning grounds) to reflect the future harm from such failures—the fees should compound if an error persists across two or more years. The performance focus of inter-locking-royalty/payment systems makes paper-fish a non-issue, rewards accomplishment and discourages failure and/or defection of all key players—including the fishery managers and bureaucrats.

SUMMARY AND RECOMMENDATIONS

The commercial salmon fisheries on Canada's portion of the BC-to-Alaska Transboundary Rivers were born from, and contributed to, conflict over salmon in the Pacific North-West. It is hoped that the

enhancement provided for in the most recent Pacific Salmon Treaty will ease some of the strain in negotiating the annual terms in future agreements. However, this study suggests that careful planning, control and due diligence are needed to ensure that benefits anticipated from the proposed enhancements are not dissipated, squandered, and/or appropriated.

Enhancement on each watershed should be supervised by one manager who is accountable to, and draws his/her authority from, an autonomous board that has sole responsible for overseeing the Transboundary enhancement. Performance of the watershed-enhancement managers should be judged against their cost-effectiveness in meeting enhancement goals that are agreed on in advance, but adjusted in consideration of actual conditions—including the fisheries-management outcomes on each watershed.

The importance of fisheries-management outcomes can be seen in a summary of this study's review of the enhancement opportunities on the Stikine River:

a. **Management-Practices Enhancement** -- can enhance harvests by 215,000 ± 100,000 Sockeye/year ($4.3 million ± $2 million in economic activity) and reduce management costs/subsidies by $750,000/year.

b. **Gear/fisher-Practices Enhancement** -- can enhance harvests by 35,000 ± 9,000 Sockeye/year (e.g. $700,000 ± $180,000 in economic activity) but may increase management enforcement costs.

c. **Physical Enhancement** – as out plantings and other types of physical enhancement throughout the Stikine/Iskut watershed can add 2.0 million ± 1.5 million Sockeye each year ($10 million to $70 million in economic activity) but will increase management costs, risks, and exposure to moral hazard.

Extrapolating from the Stikine River analysis, enhancement of BC-to-Alaska Transboundary Rivers is a vast potential prize with a potential to produce 5-50 million new adult Sockeye salmon per year ($100 million to $1 billion in economic activity). If the Yukon River is added, the prize becomes very much larger and reducing by-kill throughout the region may add many more hundreds of millions of dollars.

Resolving the management effects listed in a and b (above) could have increased the Stikine River 2003 Sockeye harvest to 227 percent of the actual harvest ((215+35)/(117.381-7.031)). Based on that estimate, management practices can deplete harvests by roughly two thirds (1 - 110/250). Thus, management folly is an important risk that must be scrutinized, exposed, and brought under control before the full benefits of a salmonid enhancement program can be realized.

APPENDICES A, B, & C are available on request.

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ENDNOTES

[1] The EEZ (Economic Enforcement Zone) is usually from shore to 200 miles (UNCLOS, Article 57, 1994a)

[2] Winton's cost estimates are very conservative—he used accounting costs with no adjustment for what was, at that time, a significant inflation effect. While DFO vigorously repudiated Winton's analysis, Wright (1994a, pp.216-224) found strong support for Winton's conclusions in the fisheries academic community and DFO's own data.

[3] Newly hatched salmon (alevins) have a yolk sac attached. Within a few days of an alevins becoming active, its yolk sac is used up and the alevin must make the transition to fry (e.g. hunting, eating and free swimming).

[4] This is Peer's Law -- ***The solution to the problem, changes the problem*** (Lyall, 1986; Rawson, 2002, p.186)

[5] Because the Tuya and Stikine are rough and tumble rivers, subject to spring-flood-driven boulders (Volkswagen-sized and larger), massive logs/trees, and huge root boles, any enhancement on the Tuya should be good for one or two seasons before being shattered, in-filled, undercut, or by-passed by a channel shift.

[6] What do you call someone who pays $106.67 per fish to produce fish worth $3.27 each and will pay even more next year? -- Answer: **A Canadian Taxpayer!**

[7] Low B/C ratios are a common DFO problem—Wright (1991b, p.344) notes that when the LEP (Lake Enrichment Program) are excluded, Pearce's (1982, p.50) "…estimate of average B/C ratio for SEP [Salmon Enhancement Program] falls from the inclusive average of 1.3:1 to a dismal 0.17:1." However, 3¢ is a new low for B/C ratios.