Salmon Enhancement Scoping in Northern and Central B.C.

March 31, 2008

Kitimat Pilot Hatchery, 65 lb. 1979 brood Chinook, August 1984

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Executive Summary

This report contains a systematic identification and conceptual development of potential production-scale enhancement projects in Northern and Central BC. The purpose of the work in this contract was to stimulate more enhancement activity. It has already led to increased investments in 2008 by the Pacific Salmon Commission Northern Boundary Fund. Therefore the project has already shown results!

Approximately 104 potential projects were classified with respect to their relative merit and as to whether they can be rapidly adopted in the short term. Recommendations are provided with respect to "next steps" for each potentially viable project including feasibility studies where necessary. Emphasis has been placed put on potential projects that could be candidates for Northern Boundary Fund financial support.

Thirty-six potential projects merit early consideration by the Northern Boundary Fund if brought forward by suitable proponents. These have been classified in Classes A, A/B or B. The seven Class A projects are the most promising ones and can be pursued with little preliminary work. The 29 Class A/B and B projects require further verification through feasibility studies, but are believed to be worth pursuing based on the information available to us. (Some of these did receive funding for 2008.) Thirty-eight projects in Class B/C (9) and C (29) are "long shots" because of one or more of the constraints identified for enhancement in Northern BC. Classes C/D and D include over 30 potential projects or groups of projects that were previously evaluated by DFO in 1983 and some that were suggested in workshops, but all are probably not feasible in the near future.

Table 1. Numbers of potential projects within rating categories.

	Rating Category						
	A	**A/B**	**B**	**B/C**	**C**	**C/D**	**D**
Area	Best early prospects for production enhancement		Reasonable potential, but feasibility investigations required		Unlikely as short-term prospects		Suggested but not feasible
1			1	2			7
2			1	1	6	1	3
3		2	2		3		2
4		6	2	2	4	2	2
5					1		
6	2		1	1	3	1	3
7		2	3	1	4		3
8	2	3	3		8		1
9		1		1		4	
10	1			1		1	
South	2	1	1				
Total	**7**	**15**	**14**	**9**	**29**	**9**	**21**

Class A Projects

- Area 6 Integrated Production and Harvest Plan: Structured decision-making process
- Area 6 Kitimat Facility Fishway and Expanded Chinook Production
- Area 8 Snootli Facility Optimization Strategy (Funded 2008)
- Area 8 Saloomt Obstruction Alleviation
- Area 10 Nekite Spawning Channel Rehabilitation
- West Coast Vancouver Island Chinook Production from Robertson Creek and Conuma Facilities

Class A/B Projects

- Area 3 Tseax Pilot Hatchery (Funded 2008)
- Area 3 Zolzap Gravel Addition
- Area 4 Pinkut Creek Sockeye Optimization
- Area 4 Fulton River Optimization
- Area 4 Moricetown Fishway Major Repairs
- Area 4 Lakelse Sockeye Spawning Improvements (Funded 2008)
- Area 4 Slough Restoration and Access (Funded 2008)
- Area 4 Prince Rupert Chinook and Coho Enhancement
- Area 7 McLaughlin Bay CEDP 1M Chum Expansion (Funded 2008)
- Area 7 Bella Bella Area Stream Pilot Gravel Additions
- Area 8 Tarrant Creek (South Bentinck Arm) Chinook Enhancement
- Area 8 Quatelena River Fish Passage
- Area 8 Martin River Flow Restoration and Habitat Protection
- Area 9 Wannock River Chinook Predation Reduction Pilot Recon / Feasibility
- West Coast Vancouver Island Chinook Production from Nitinat Facility

Class B Projects

- Area 1 Naden Harbour Coho Enhancement Pre-Feasibility
- Area 2E Skidegate Lake Enrichment Feasibility
- Area 3 Vetter Creek Enhancement Feasibility
- Area 3 Upper Tseax Fish Passage
- Area 4 Kispiox Migration Improvements Upstream of Nangeese
- Area 4 Maxan and other Lake Storage
- Area 6 Kitimat River Sockeye Side Channel
- Area 7 Namu Sockeye Enhancement Feasibility
- Area 7 Kadjusdis River Enhancement Feasibility
- Area 7 Mussel River Slide Remediation Feasibility
- Area 8 Kwatna River Side Channels
- Area 8 Bella Coola River Sockeye Enhancement
- Area 8 Ocean Falls Demonstration Pilot Chinook Feasibility
- Area 13 Increased Chinook Production from Quinsam Facility

We were also asked to follow up on the most promising projects we identified early in the process by assisting some potential proponents in preparing 2008 concept proposals for the August 2007 deadline. We checked site conditions and worked with proponents for the Tseax Pilot Hatchery (Nisga'a Fisheries and LGL), Kitimat Facility Optimization (DFO – Appendix One), Atnarko Channel Rehabilitation, Saloomt Obstruction Removal, Snootli Facility Optimization, Tarrant Creek Chinook Enhancement (DFO and Oborne) and Nekite Channel Rehabilitation (Gwa'sala-'Nakwaxda'xw Nation, DFO and Rivers and Smith Inlet Salmon Ecosystem Planning Society - Appendix One). The authors also visited other sites and had discussions with DFO staff and facility operators that contributed to additional concept proposals to the Northern Boundary Fund in 2007.

DFO Snootli Facility, Bella Coola BC *May 23, 2007*

As production –scale enhancement projects must include an integrated harvest plan before initiation and / or some potential enhancement opportunities are not feasible without changes to existing fisheries; a new **integrated production and harvest plan** will usually be required when production comes on line and has been identified as a prerequisite to many potential enhancement projects in Area 6.

Only 35 potentially good enhancement projects (plus one SDM process) were identified for short–term implementation because there are significant constraints to enhancement in Northern and Central BC:

- Over the last 25 years the cost of enhancement activities has risen sharply, particularly in terms of construction costs, while the commercial prices for salmon have remained stable or declined. The costs in northern BC are also higher than in the south because of the isolated nature of many of the projects and limited road access to many potential enhancement sites.

- Enhancement potential is significantly impacted by low and/or erratic marine survival in many areas as well as other ecosystem conditions.

- Some of the remaining Northern net fisheries are currently conducted in areas (3, 4, 6) that intercept many stocks making it impossible to add to production without impacting wild stocks. Until harvest management is adjusted to be more selective, some potentially desirable and otherwise feasible enhancement cannot be undertaken. (e.g Area 3 and 6 chums).

- It is difficult to discretely enhance stocks at production levels that will create new fishing opportunities in areas where co-migrating wild stocks are present. This constraint particularly applies to large river systems like the Skeena with many stocks of the same or other co-migrating species or to the Kimsquit where chum enhancement is precluded by the presence of the very valuable Dean River steelhead.

- There is a lack of adequate funding for ongoing enhancement activities even if the Northern Fund provides short-term capital.

- Potential proponents are also impacted by a dearth of experienced staff in DFO and amongst other potential proponents. Lack of capacity is particularly an issue in remote coastal First Nations villages.

- Some existing DFO facilities have not been properly maintained and renewed and therefore are poor prospects for additional production.

- DFO has also lost significant capability to properly assess production benefits and costs so as to develop credible Benefit-Cost ratios for new or existing projects.

- The 2006 ***Laroque*** court decision has impacted cost recovery for enhancement activities. DFO also does not have a policy to permit sea ranching that would encourage private investment in locations where enhanced stocks could be harvested discretely in a terminal area.

- Lack of adequate brood stock and other biophysical constraints limit the application of enhancement techniques such as enrichment of several sockeye lakes and Chinook enhancement in desirable locations such as South Bentinck Arm.

- Provincial policy discourages colonization of hanging lakes and other potentially productive systems currently inaccessible to salmon on account of concerns for resident stocks.

Recommendations have been provided with respect to the projects selected that will not only further their development individually but also contribute to overall innovation and improvement. The Summary recommendations below are designed to facilitate development of more technically sound and beneficial enhancement projects for consideration by the Pacific Salmon Commission - Northern Boundary Fund. They are in abridged form as follows:

- Goal 3 of the Pacific Salmon Commission - Northern Boundary Fund should be restated and an increased funding "envelope" established for enhancement activities.

- The Pacific Salmon Commission - Northern Boundary Fund should institute a bilateral four-person technical review team with bioengineering expertise in habitat restoration and enhancement similar to the Southern Boundary Fund.

- DFO and the Pacific Salmon Commission should convene at least annual technical workshops in habitat restoration and enhancement technology and support training programs to develop capacity in enhancement techniques and identification of potential new projects.

- DFO and the province of BC should work together with stakeholders to reduce identified institutional and fisheries management constraints to new and increased enhancement projects where feasible.

- Innovative funding arrangements are required to reverse declining financial support for enhancement operations. An example is the possibility for co-investing in Fulton River power generation to gain operating revenue for supporting incremental production from existing or new facilities.

- DFO needs to significantly upgrade its capability to maintain, optimize production and properly assess / fine tune existing enhancement facilities as these measures are essential for a basically sound enhancement program capable of augmentation by the Pacific Salmon Commission - Northern and Southern Boundary Funds and other potential partners.

McLaughlin Bay C.E.D.P. Facility, May 23, 2007

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Pallant Sea Pens, Cumshewa Inlet June 28, 2007

Chapter One: Introduction

This report identifies and reviews salmon enhancement opportunities for Northern and Central BC (Canadian Statistical Areas 1 through 10 – Figure 1).

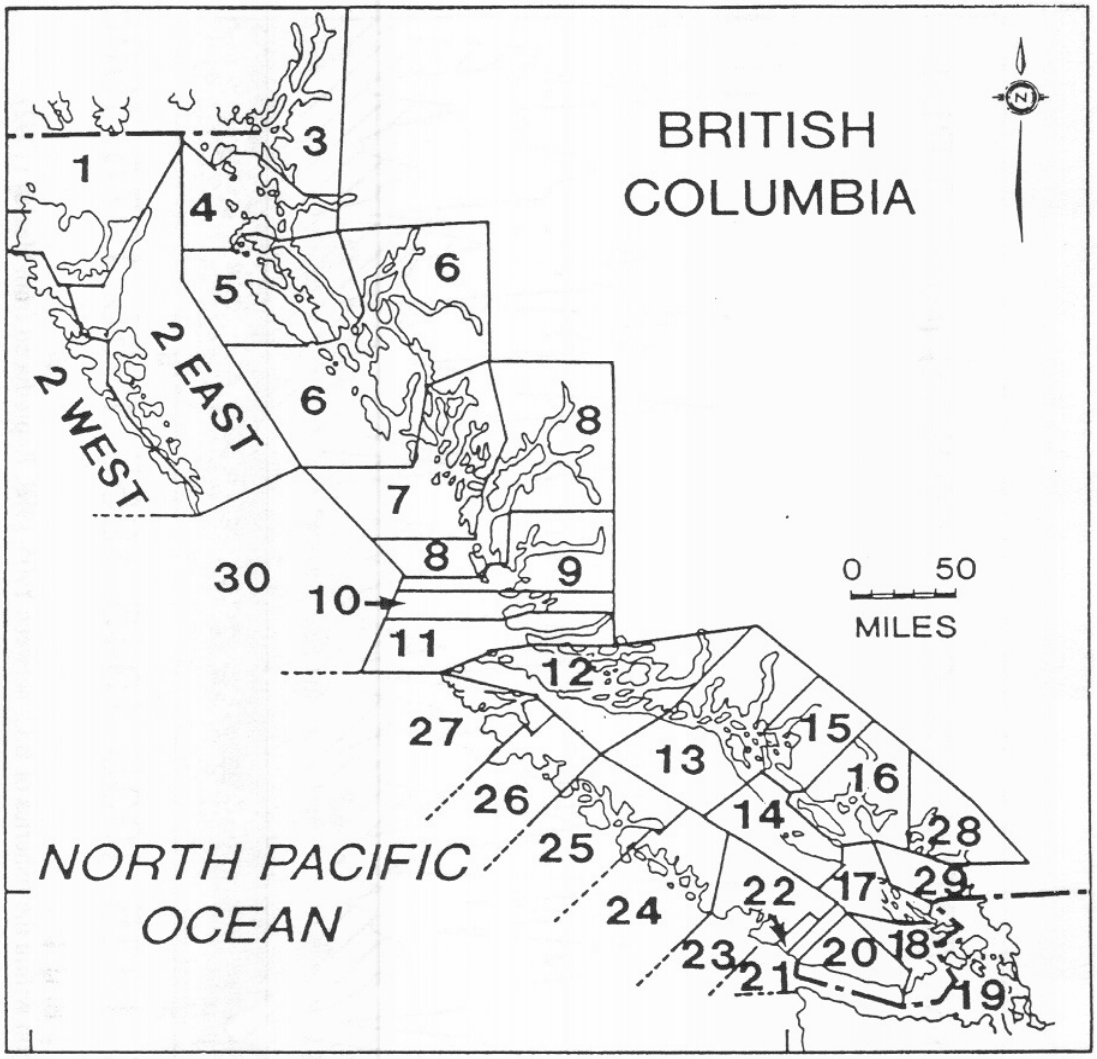


Figure 1. DFO Statistical Areas.

The study was carried out to provide an overview of the most promising enhancement projects that can be carried out over a moderate term (5 to 10 year) period.

Project activities are currently guided by Goal 3 of the Pacific Salmon Commission - Northern Boundary Fund, namely:

> "*Enhancement of wild stock production through low technology techniques rather than through construction of large facilities with high operating costs. This includes acceptable refinements to existing enhancement facilities that will increase the productivity of those facilities.*"

One of the key activities was a re-examination and updating of a DFO Enhancement Opportunities Project that was undertaken in 1983 by DFO staff (Lill et al. 1983). A recommendation is provided later in this report that Goal 3 needs to be restated in clearer terms that more properly reflects its intent.

Workshops and Consultations

During the project, a series of workshops were held with a view towards identifying relevant enhancement technologies and stream/river systems where they could be potentially applied. Attendees included key DFO staff in management and enhancement plus community representatives, First Nations and other fishing interests. During consultations, emphasis was placed on evaluating both the productive potential and the manageability of enhancement proposals. Workshops were held on the following dates including a presentation of the draft report on February 12, 2008. A number of revisions have been made in the final report including a significant reduction in the number of promising projects on account of fisheries management concerns.

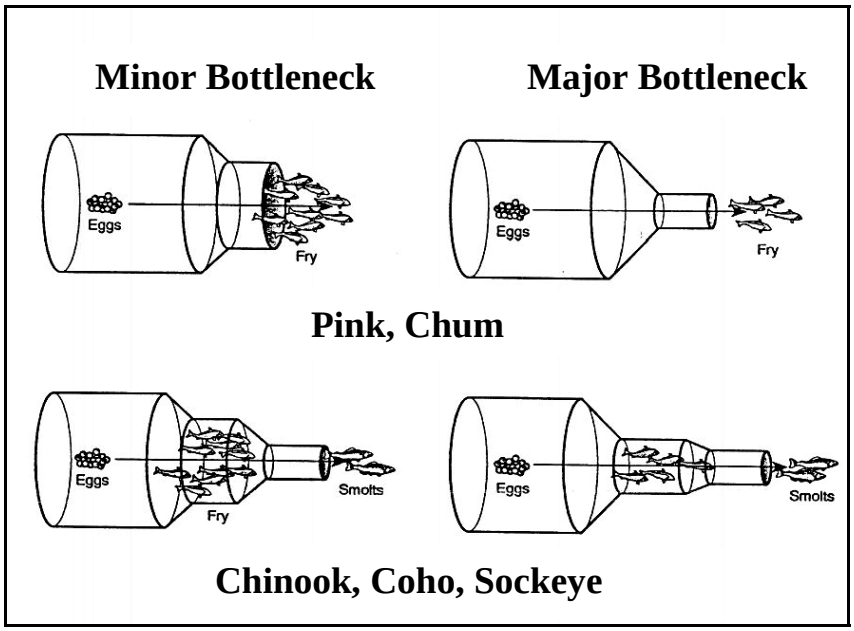
Workshop Location	Date	Areas of Primary Interest
Portland (Panel)	Feb 13'07	All
Vancouver	May 8'07	9-10
Bella Coola	May 23'07	7-8
Terrace	June 7'07	3-4
Prince Rupert	June 19'07	3-6
Haida Gwaii	June 29'07	1-2
Vancouver	Aug. 24'07	3
New Aiyansh	Sep. 15'07	3
Hazelton	Sep. 17'07	4
Vancouver (Panel)	Feb 12'08	All

Life-cycle Based Enhancement Strategies

During the workshop sessions and additional meetings with DFO staff in Vancouver, Terrace, Bella Coola and Prince Rupert, we encouraged participants to think "outside the box" when offering suggestions for enhancement projects.

Salmon – Life Cycle

"Bottleneck" Concept



We suggested that participants think in terms of reducing "bottlenecks" in the productivity of salmonids at each life stage rather than the usual technological terms like hatcheries, spawning channels etc. with full consideration of subsequent bottlenecks that might occur when more fish pass through that life stage to the next.

Too often enhancement activities do not produce desired results in terms of increased adult production. Key reasons include released fish are subject to subsequent predation or competition, food supplies are overtaxed and inadequate fisheries management does not take advantage of the extra production or over harvests co-migrating stocks. We also suggested that pulsed enhancement from year to year is a more natural situation than steady state production that can lead to a build up of predation and/or depletion of food supplies in receiving environments.

We offered the following listing of life cycle based strategies at the workshops.

Enhancement through Management

1. Reduce adult exploitation to produce more spawners in underutilized habitats
2. Reduce predation on returning spawners

Improve Adult Spawning Success

3. Eliminate or reduce migratory barriers
4. Control spawning densities
5. Improve flow conditions

Improve Incubation Survival

6. Improve incubation substrate
7. Improve winter flows

Improve Freshwater Rearing Survival

8. Improve cover and stream structure
9. Fertilize with nutrients
10. Reduce predation or competition
11. Promote colonization of productive areas

Improve Transition to Marine Environment

12. Bypass predation "pits"
13. Improve estuarine conditions
14. Hatchery release timing, volumes, size and condition

Improve Marine Survival

15. Extend hatchery operations to marine rearing and release
16. Marine ecosystem management – predators and competitors
17. Improve previously productive near shore marine nursery areas
18. Negotiate nursery "rights" in offshore areas

Enhancement Bio-standards

In evaluating potential production benefits from any enhancement project proposal, it is very important to estimate resulting adult fish production from the proposed project. For a scoping exercise of this nature, the most common approach is to develop bio-standards for the various technologies for each species group over large geographic areas.

Coastal Sockeye	Wild	Channel	Side Channel	Hatchery	Enrichment	Hatch + Enrich
Current Spawners	2	2	2	2	2	2
Fecundity	3000	3000	3000	3000	3000	3000
Egg / Fry	450	1500	885	2400	450	2400
Fry/Smolt	99	330	194.7	480	198	960
Smolt/Adult	4.5	14.9	8.8	21.6	8.9	43.2
Allowable Fishing / Pre-Spawn Mortality	2.5	12.9	6.8	19.6	6.9	41.2
Minimum Spawners	2	2	2	2	2	2

Coastal Chinook	Wild	Channel	Side Channel	Incub. Box	Hatchery
Current Spawners	2	2	2	2	2
Fecundity	5000	5000	5000	5000	5000
Egg / Fry	1250	2500	1475	4000	4500
Fry/Smolt	200	400	236	400	3600
Smolt/Fishery Recruit*	4.0	8.0	4.7	8.0	36.0
Allowable Fishing / Pre-Spawn Mortality	2.0	6.0	2.7	6.0	34.0
Minimum Spawners	2	2	2	2	2

Chum	Wild	Channel	Side Channel	Hatchery	Hatchery fed	Hatchery marine
Current Spawners	2	2	2	2	2	2
Fecundity	2800	2800	2800	2800	2800	2800
Egg / Fry	252	1680	336	2240	2520	2520
Fry/Fishery Recruit	3.6	13.4	4.7	17.9	40.3	45.4
Allowable Fishing / Pre-Spawn Mortality	1.6	11.4	2.7	15.9	38.3	43.4
Minimum Spawners	2	2	2	2	2	2

Coho	Wild	Incub.box	Hatchery fall	Hatchery smolt
Current Spawners	2	2	2	2
Fecundity	2500	2800	2800	2800
Egg / Fry	500	2240	2520	2520
Fry/Smolt	100	179.2	504	2016
Smolt/Fishery Recruit*	2.5	3.6	7.6	20.2
Allowable Fishing / Pre-Spawn Mortality	0.5	1.6	5.6	18.2
Minimum Spawners	2	2	2	2

Pink except QCI	Wild	Channel	Side Channel	Incub.box
Current Spawners	2	2	2	2
Fecundity	1500	1500	1500	1500
Egg / Fry	195	750		1200
Fry/Fishery Recruit	5.6	18.8	9.4	30.0
Allowable Fishing / Pre-Spawn Mortality	3.6	16.8	7.4	28.0
Minimum Spawners	2	2	2	2

Pink QCI	Wild	Side Channel	Incub.box
Current Spawners	2	2	2
Fecundity	2000	2000	2000
Egg / Fry	260		1600
Fry/Fishery Recruit	7.4	12.5	40.0
Allowable Fishing / Pre-Spawn Mortality	5.4	10.5	38.0
Minimum Spawners	2	2	2

The above standards are only intended to roughly illustrate the relative enhancement "power" of the various well - known common techniques. They were originally developed in 1983 except that the coho and Chinook bio-standards have been adjusted based on more recent information. (*The Wild Coho Biostandard shown above reflects a very healthy stream with relatively low escapement and ocean survival that is just holding its own.)*

Bio-standards for individual project proposals should be developed using the most current local information that is available. No attempt was made in this scoping exercise to quantify production or economic and social benefits for each potential project since comprehensive up-to-date information was not available.

Concept Proposals

We were requested to follow up on the most promising projects we identified early in the process by assisting some potential proponents in preparing 2008 concept proposals for the August 2007 deadline. This work was facilitated by field trips to Nekite and Bella Coola by Al Lill. We also followed up with a helicopter reconnaissance out of New Aiyansch. Al Lill also made a second visit to Kitimat.

Two of the papers that were drafted for the use of proponents are included in Appendix One.

Chapter Two: Scope and Definitions

Production – Scale Enhancement is the primary focus of this contract and includes potential enhancement projects that have the capability of making significant incremental contributions to fisheries. For the purpose of this contract we consider production scale enhancement requires a sufficiently large project to make a significant difference in harvest planning. Roughly speaking a hatchery must produce at least one million fed-fry or 500,000 smolts and a semi-natural channel must have the capacity for at least three to five million eggs for most salmon species. In some cases we recommend much smaller short-term **pilot scale enhancement** opportunities as a first step that are designed to lead to production-scale opportunities at a later date. A pilot project is an excellent choice when brood stocks will need to be built up sufficiently to support a full-scale operation. They are also a good idea to determine at lower cost if a new enhancement project will be viable with acceptable rates of returning adults.

Conservation enhancement is designed to improve productivity of weak stocks in mixed stock fisheries and is not the primary focus of this contract although such projects are fully considered under the PSC Northern Boundary Fund.

Habitat Restoration is designed to improve existing habitat productivity and usually does not result in sufficient incremental production to start or expand upon new fisheries. For the most part, it is not the focus of this contract except where it might increase accessible habitat through fish passage.

As production –scale enhancement projects must include an integrated harvest plan before initiation and / or some potential enhancement opportunities are not feasible without changes to existing fisheries; a new **integrated production and harvest plan** will usually be required when production comes on line and has been identified as a prerequisite to many potential enhancement projects in Area 6.

The 1983 Enhancement Opportunities Listings are discussed in this report because it was the last time that we are aware of that a comprehensive enhancement scoping exercise was completed with a Benefit-Cost economic analysis of all potentially viable enhancement projects.

However formal **Benefit-Cost Analysis** was not performed on the potential enhancement opportunities identified in this report for several reasons as follows:

a) Detailed costing and production benefits are not available for most of the opportunities identified and existing DFO SEP production bio standards, costing formulae and stock assessment information is not sufficiently up to date to be useful for this scoping exercise.
b) There has been so little new enhancement project activity in the last 25 years and construction costs have risen so rapidly in recent years that it would be impractical to develop costing standards that could be applied at the conceptual level of detail.

c) The complex DFO contribution to fisheries and economic Benefit-Cost computer model used in 1983 is no longer available and would be seriously out of date even if it was still operational
d) The PSC Northern Boundary Fund does not currently require a formal benefit-cost analysis for enhancement project proposals and tends to favour relatively small investments where the cost of doing such an analysis with currently available information would not be justified

In the **Project Classification System** that we have utilized in this report we have estimated potential economic performance informally based on projected high or low unit costs of production versus projected potential high or low expected economic benefits. There is a significant economy of scale in any enhancement project so projects with relatively low unit costs and relatively high valued production will perform much better economically than projects with relatively high unit costs and relatively low valued production. For the purposes of this report we consider Chinook and coho as high valued species, sockeye medium-value commercial but high value in First Nation fisheries and chum and pinks as low valued species. Steelhead has very high recreational value, but is also very expensive to produce in enhancement facilities.

Class A: significant information is available, excellent prospects, can be proposed for early implementation and deserve very serious consideration by the PSC Northern Boundary Fund.

Class B: more investigation is required, but could lead to a feasible project. Feasibility assessments deserve serious consideration by the PSC Northern Boundary Fund.

Class C: long shots on account of current government policies, manageability constraints in present fisheries, poor projected Benefit-Cost ratios, etc. The PSC Northern Boundary Fund should be very cautious about supporting feasibility assessments for these projects.

Class D: project ideas that we feel are not feasible now or in the foreseeable future.

It was felt that the potential for some projects lie between these ratings so we have classified them as A/B, B/C or C/D.

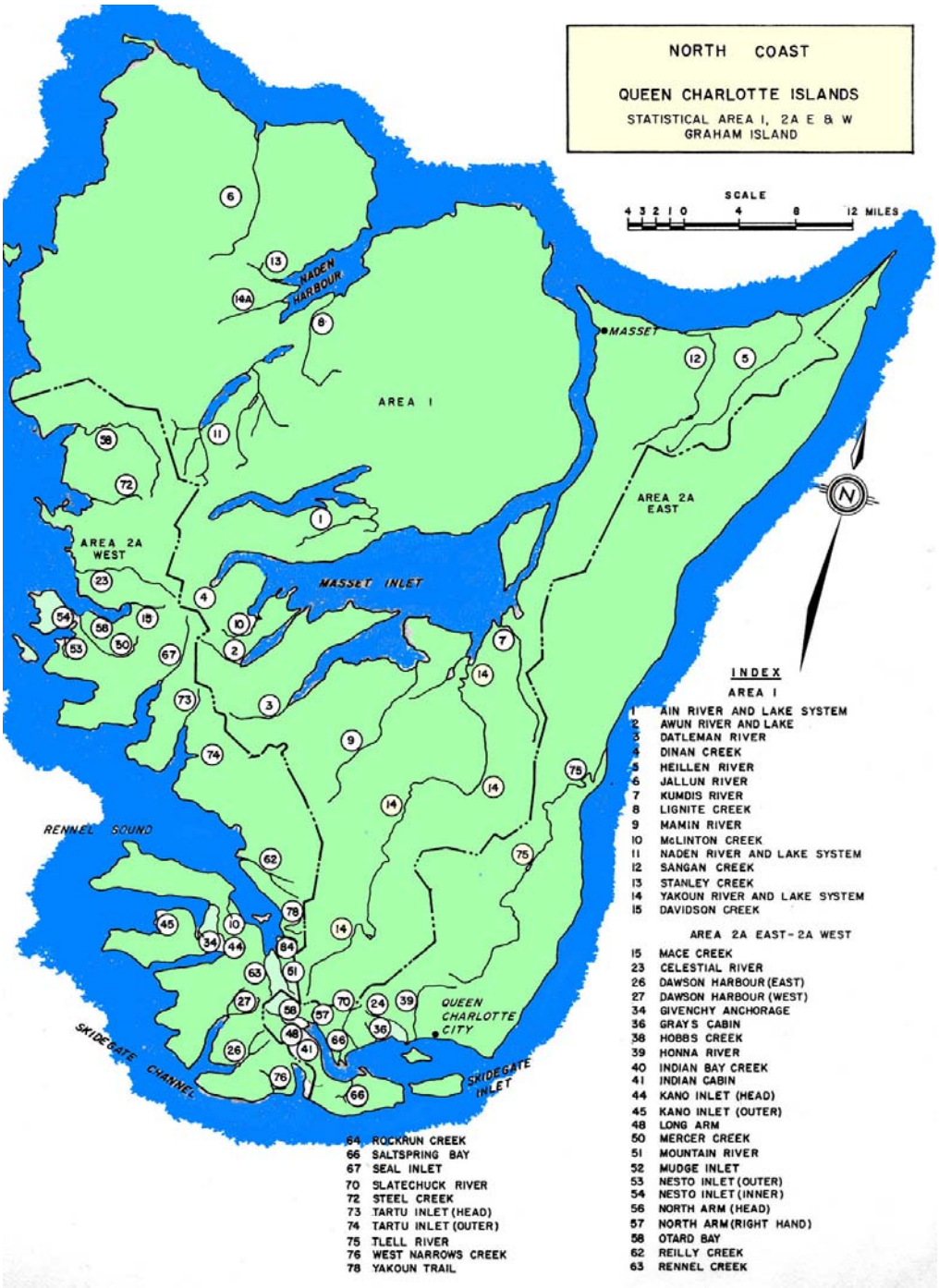
We have provided **Recommendations** on the basis of our current information about a potential project and not on the merits of any existing or future proposal made by a proponent.

Other Potential Production-Scale Enhancement Opportunities Identified in 1983

We have listed some potential projects identified in 1983, but did not examine them in detail. We believe that the ones we have listed in this group are not suitable for early investments in salmonid enhancement by the PSC Northern Boundary Fund or other potential sponsors.

Chapter Three: Production – Scale Enhancement Opportunities by Area

Area 1 and Northern Portion of Areas 2W and 2E - Queen Charlottes / Haida Gwai / Graham Island



We met with representatives of the Haida Nation and DFO in Skidegate to discuss potential projects in the area and also had discussions with DFO in Prince Rupert. Our overall assessment is that in Area 1, Masset Inlet tributaries have the best potential for production scale enhancement including increased Yakoun Chinook and increased sockeye production from local lakes. There may also be some longer term potential for coho enhancement from Naden Harbour streams. Detailed stock status and ecosystem parameter pre-feasibility studies are required in all of these cases. The Northern portions of Areas 2E and 2W do not have any currently documented potential for production scale enhancement.

1.1 Yakoun River Chinook Enhancement (Rating Class B/C)

After discussion with the Northern Panel on Feb 12, 2008, we downgraded additional potential enhancement on this stock until there is a fully integrated harvest and production plan developed. While we understand that there is some physical potential that could be realized, this stock is relatively healthy and has increased to near its natural production potential making it a lower priority for enhancement even if there was demonstrated production impediment that could be overcome by enhancement. Any physical enhancement potential would need to be demonstrated through careful planning – ideally through a partnership between the Haida and the local volunteers and recreational lodge operators currently involved in habitat restoration and enhancement activities through Salmon Unlimited (SU). Unfortunately we were not able to make contact with the Salmon Unlimited on our trip to the area so have no specific recommendations with respect to potential expansion capability of their facility. However we are impressed with materials provided outlining the extent of habitat restoration (especially with respect to restoring access) that has been accomplished in recent years.

RECOMMENDATION: An integrated harvest and production plan would be a prerequisite to enhancement following careful consideration of recent stock performance and physical enhancement potentials.

1.2 Graham Island Sockeye Enhancement Pre-Feasibility (Rating: Class B/C) - Ian, Ain, Awun and Yakoun Lakes

Within the next few years, we suggest that the PSC Northern Boundary Fund could consider supporting a review of past assessments of the sockeye producing lakes for potential enrichment and ecosystem adjustments (if stickleback or other predators / competitors are present). Such work could also include updated biophysical surveys of the potential of these lakes to support increased sockeye production, current stock status and future harvest opportunities. Yakoun Lake has the best potential – up to 80,000 sockeye 1983 estimate if stocks doubled but may need complimentary Chinook enhancement to be manageable). Ain Lake is the largest other possibility but its littoral zone is small and sockeye stocks are low. A short-term sockeye hatchery option may be a possibility if enrichment is considered feasible in order to kick-start fry production.

The paper on enrichment of Wahleach Lake by the Ministry of Environment might prove to be helpful in this situation. (Perrin et al. 2006). However these lakes already have cutthroat populations and it would need to be determined why they may not be keeping stickleback sufficiently in check.

RECOMMENDATION: The Haida Nation could do some background work including consultations internally and with DFO.

1.3 Naden Harbour Coho Enhancement Pre-feasibility (Rating Class B)

Naden Harbour is home to recreational lodges and the area has supported a considerable amount of logging in the past, but it is not connected by road to the rest of Haida Gwai. There is limited potential for production-scale enhancement, but some smaller projects could perhaps lead the way to larger scale activities later on. Coho would most likely be the species of choice, but we understand that they are a late run arriving in mid October and may not contribute much to local recreational fisheries. Early work could include any needed maintenance to the Naden fishway, obstruction removal on Lignite and Roy Creek and general stream rehabilitation in the area. A pilot facility may be practical on Naden River with a surface intake at the fishway. Net pens or small rearing ponds could perhaps be installed near recreational lodges.

RECOMMENDATION: Potential opportunities need further exploration locally.

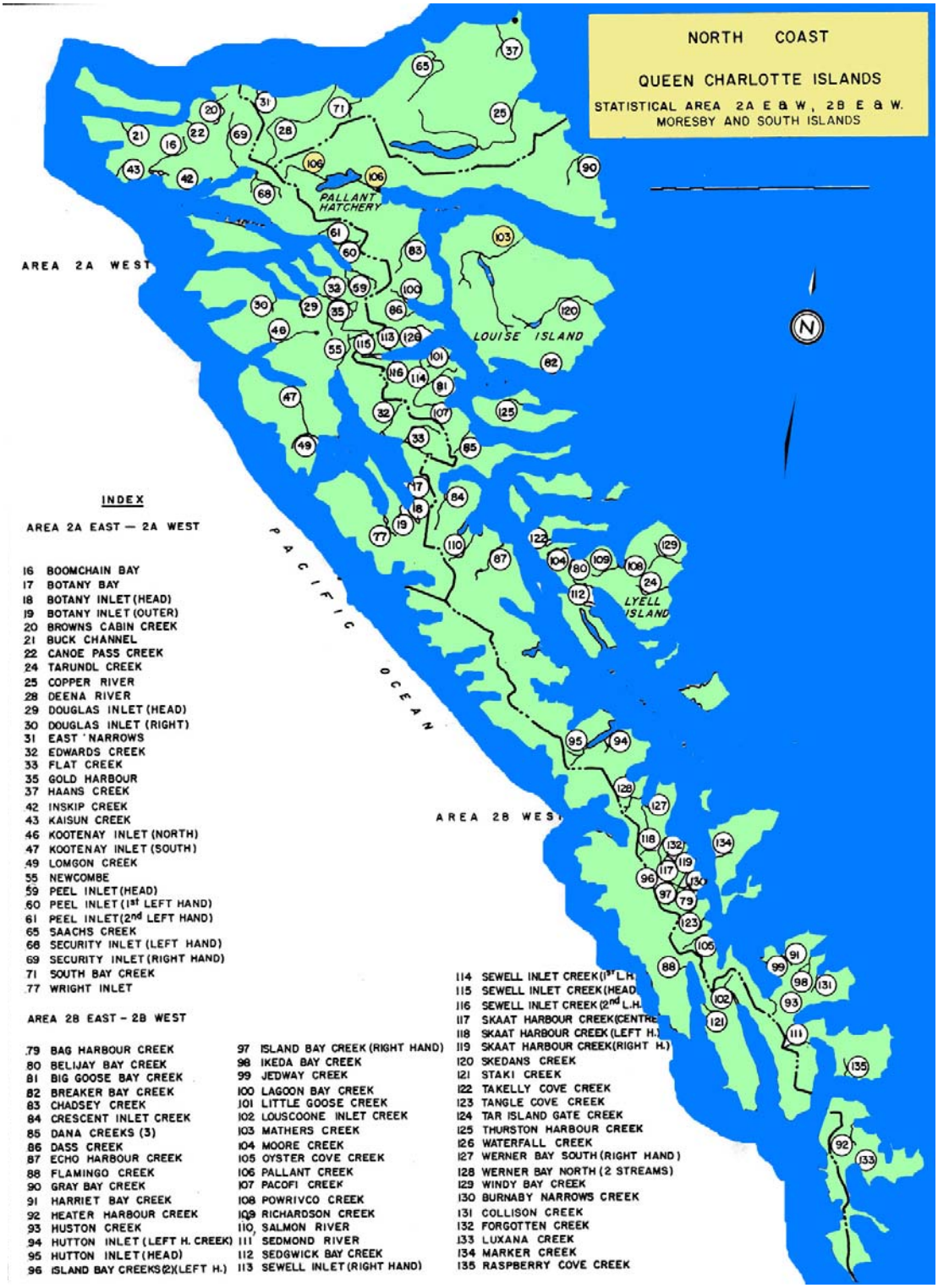
1.4 Van Inlet New Stock Development (Rating Class C)

Van Inlet is an isolated inlet in 2W that was identified at the Panel meeting on February 12, 2008 as a potential new stock development using marine pen rearing that wouldn't conflict with other stocks. It would require a suitable proponent to do some pre feasibility assessment, identify potential stocks, and negotiate an incubation / freshwater rearing arrangement at an existing hatchery for a potential pilot. Since the panel meeting, we have also received an indication that an independent power producer is interested in Van Inlet. If a power project was to proceed, the infrastructure and road access created would make this a much more viable site for an independent fish culture and pen rearing operation. However there are serious policy constraints similar to Tasu in Area 2W.

Other Enhancement Opportunities Identified in 1983 (Class D)

a) Naden Combination facility / channels – chum, coho, sockeye, pink
b) Mamin River facility – pink
c) Yakoun River facility – sockeye, Chinook, coho, pink, steelhead (not acceptable under current steelhead stream classification)
d) Awun facility – Ain, Dinan satellites – sockeye, coho, chum, pink
e) Ain facility – alternative to Awun, not as much potential
f) Tlell facility – coho (index stream – DFO will not support coho enhancement) and pink
g) Masset Inlet Fertilization (not technically feasible)

Southern portion of Areas 2W and 2E - Queen Charlottes / Haida Gwai
Moresby and Adjacent Islands



We made a site inspection of the Pallant facility with DFO and staff from the Haida Nation and followed up with a meeting in Skidegate. Discussions were also held with DFO in Prince Rupert and Vancouver. Our overall assessment is that the Southern portions of Areas 2E and 2W have limited potential for cost effective production scale enhancement in the foreseeable future as outlined below. Our main focus was on the Pallant facility and its future is clouded on account of the ***Laroque*** court decision against using proceeds from fisheries to pay for stock assessment and management work and possibly enhancement activities.

2E.1 Pallant Facility Optimization (Rating Class C)

The Pallant Creek facility on Cumshewa inlet is the only major facility built on the Queen Charlottes by the Salmonid Enhancement Program (SEP). A run of Chinook salmon has been established through a transplant of Quinsam stock. A satellite fence and egg take facility on Mathers Creek was also part of the original project but has since fallen into disrepair.

When SEP had severe budget constraints a few years ago, DFO decided to enter into an agreement with the Haida Nation to operate the facility. The Haida expanded chum production and continued with coho production and have made a number of improvements – notably larger incubation capacity and extensive net pens. However the infrastructure of the facility has several serious problems that should be rectified if it is to remain operational. Amongst these are resurfacing of concrete rearing ponds, building upgrades or replacements, fence upgrading and improved facilities to avoid excessive pre-spawning mortality of coho salmon. The operational budgets have been inadequate to feed all of the chum fry production to a proper release size. Time of release and the capacity of Cumshewa Inlet to accommodate expanded chum production are issues that need addressing.

Pallant Creek Fence and Rearing Ponds *-June 28 2007*

The facility has been much more successful in producing returns of coho than chums and ESSR coho revenues have been significant. The status quo is not sustainable for much longer.

We suggest that there are three possible courses of actions that could be taken:

1. Close the facility and restore the site to as near as natural condition as possible.
2. Scale down chum to a low level, but upgrade critical components of the facility to produce coho salmon with ESSR revenues utilized to help support operational costs. (DFO suggests Quinsam transplanted Chinook enhancement should also be discontinued.)
3. Develop a full optimization plan and obtain resources to revitalize this facility to produce both chum and coho. Considering the relatively poor performance of this facility in producing chums we don't believe that this is a viable option unless some investigations determine that survivals could likely be improved if production was scaled back and all chum releases fed to term before release. This alternative also requires that the Haida have the ability to cost recover from the Cumshewa Inlet fishery. If sea ranching was possible, other satelleting options could also be pursued to utilize more of the existing chum incubation capacity.

RECOMMENDATIONS: No Investment should by made by the PSC Northern Fund until the implications of the *Laroque* court decision with respect to enhancement facilities are determined and DFO and the Haida Nation decide on the future of this facility. If the facility is to concentrate coho production, consider sharing investments in reducing coho pre-spawn mortality and/or increasing coho production through a satellite net pen rearing operation on Skidegate Lake / egg take on Copper River. If the facility is to be comprehensively upgraded, consider sharing investments as above for coho and for determining optimum time and size of release for chum salmon and carrying capacity of Cumshewa Inlet as a prerequisite to any further work including upgrading fence operations

2E.2 Skidegate Lake Enrichment Feasibility (Class B)

Perhaps even more so than in Area 1, we suggest that the PSC Northern Boundary Fund should consider supporting pre-feasibility assessments of the increased sockeye production in Skidegate Lake / Copper River. This is a very important traditional harvest area for the Haida and could possibly support a small local commercial fishery near its mouth. Skidegate Lake has similar productive potential as Yakoun Lake – up to 80,000 sockeye (estimated in 1983) and could be fully manageable without any other enhancement.

RECOMMENDATION: The Haida Nation could do some background work including consultations internally and with DFO managers and science. If there is interest in proceeding, prepare a concept proposal for pre-feasibility work.

2W.1 Tasu Inlet Enhancement Feasibility (Class C)

Tasu Inlet has the only real potential for any production scale enhancement in Area 2W. This potential would be more economic and practical if a road connection was available directly from the existing network on Moresby Island and if there was still operational

infrastructure in the Inlet. However if economic conditions warrant it and especially if sea ranching becomes DFO policy, this could be a location for a discretely manageable terminal harvest opportunity. Native stocks are coho and chum with a few pinks. If a facility was built in Tasu, it would likely require rehabilitation of the 12" pumped supply to the old mine site.

RECOMMENDATION: Consider cost sharing of feasibility work once DFO policy permits sea ranching and a proponent with a good business plan comes forward with a concept proposal.

2W.2 Bottle Inlet Feasibility (Class C/D)

The Panel identified Bottle Inlet or other isolated inlets on north western Moresby Island in Area 2W for potential new stock development using marine pen rearing that wouldn't conflict with other stocks. To advance this project would require a suitable proponent to do some pre feasibility assessment, identify potential stocks, and negotiate an incubation / freshwater rearing arrangement at an existing hatchery for a potential pilot. There are serious policy constraints similar to Tasu in Area 2W and not even any old infrastructure to work with. Road access and/or an IPP partner could make a project more feasible.

RECOMMENDATION: Only consider cost sharing of feasibility work once DFO policy permits sea ranching and a proponent with a sound business plan comes forward with a concept proposal.

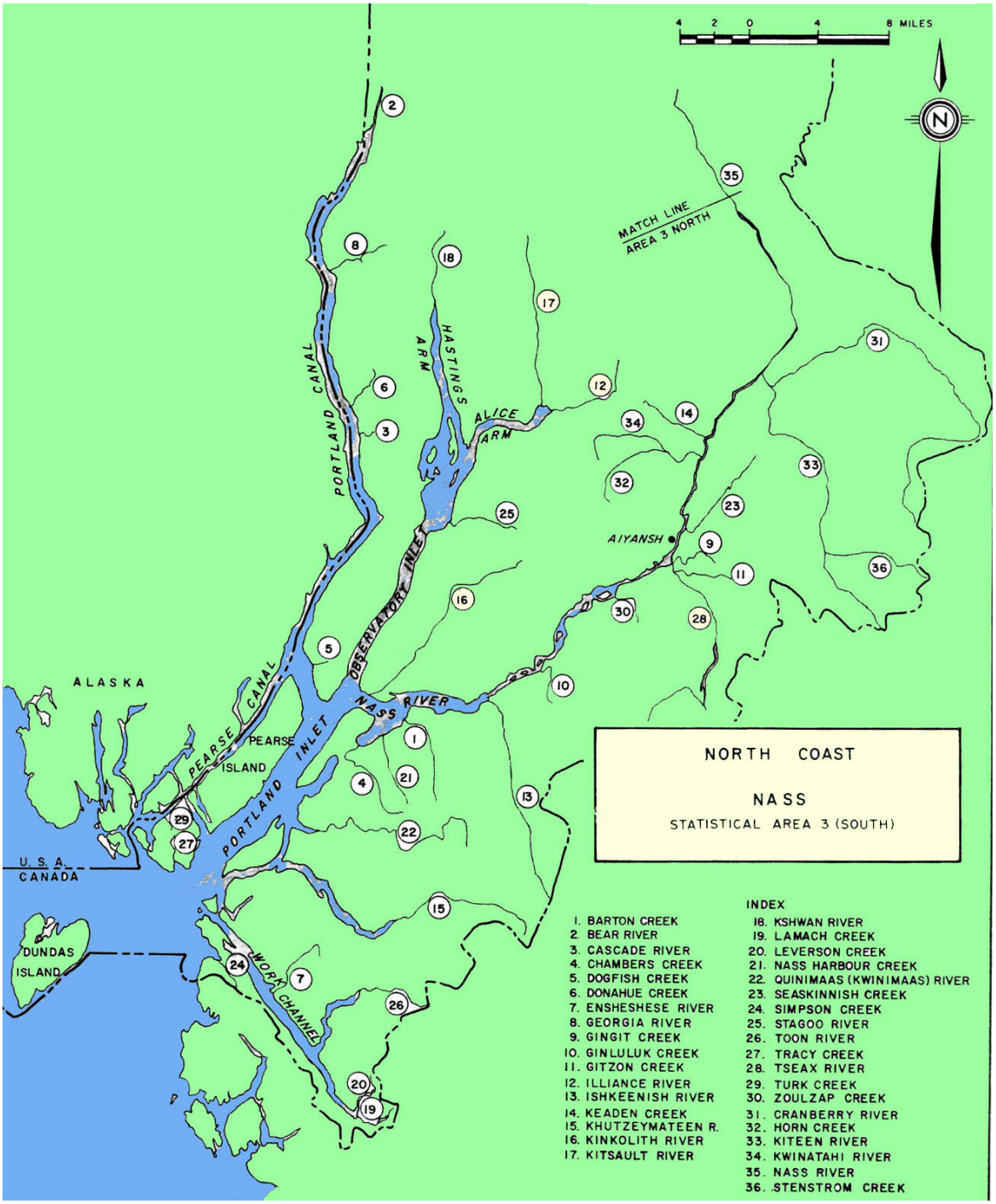
Other Potential Enhancement Opportunities Identified in 1983 for Areas 2E and 2W (South) - (Class C except as noted)

a) Deena Central Facility – Honna, Lagins, Indian Cabin and Tangle Cover satellites – coho, chum, pink when chum not available
b) Mathers facility and lake storage –chum and pink dependent upon Pallant decision
c) Pallant expansion opposite bank (Class D)
d) Pallant estuary rehab – breach causeway to reduce predation on chum and pink – partially dependent on Pallant decision (Class B/C)
e) Sachs Creek Incubation boxes for chum, pink and coho
f) Big Goose Creek falls removal for pink – in park (Class D)
g) Echo Hbr Creek – obstruction removal coho and pink – small scale in or near park (Class D)

As in Area 1, the above facilities would have long-term operational costs and their benefit to cost ratios would be unacceptable with current commercial values for chum and pink salmon. Any enhancement work in South Moresby National Park would be very problematic beyond absolutely necessary habitat remediation.

Area 3 - Nass and Adjacent Coastal Inlets

We met with Chief Harry Nyce and fisheries personnel from the Nisga'a as well as LGL consultants. A tour was conducted in the Nass Valley including a helicopter over flight from New Aiyansh eastward that unfortunately did not reach Kitsault / Alice Arm as planned because of adverse weather conditions.



Our overall assessment is that the Nass River is incredibly rich for salmon and steelhead production with excellent habitat including an intact estuary and has little overall requirements for enhancement work. The Nisga'a operate a very effective fisheries management program that is a well-deserved source of pride in their community. They are however interested in Chinook enhancement on Tseax and maintaining and improving the community hatchery at Kincolith. Area 3 does have some opportunities for cost effective production scale enhancement if commercial fishing patterns were to change in the future and the commercial value of chum salmon increased to previous levels or greater.

3.1 Tseax Pilot Hatchery (Rating Class A/B – pilot scale)

We assisted LGL Limited and Nisga'a Fisheries in developing a concept proposal for 2008 to do the preliminary work required in advance of re-establishing an enhancement project on the Tseax. It is proposed to utilize the site of a former coho incubation box and nearby pen rearing operation.

The incubation site has excellent potential for a reliable gravity-fed water supply and is close to New Aiyansh avoiding the need for new support buildings and can be easily checked under most weather conditions. Brood stock collection does not appear to be a serious problem although a secure adult holding facility will be essential. From our examination of the site, it appears that the amount of land at the correct elevation appears to be adequate for a pilot-sized facility, but might not be enough for a larger scale installation or for conventional raceways or earthen rearing channels. The initial intent is to use net pens in a small lake for adult holding and rearing as was done for coho so this should be satisfactory at the pilot scale envisaged initially. However at least one gravity-fed concrete or aluminum combination adult holding – juvenile rearing raceway should be planned for from the outset. Earthen channels should also be considered for rearing when production grows.

RECOMMENDATION: FULLY RECOMMEND

We believe that this project has considerable merit and should be supported by the PSC Northern Fund. Our only reservations revolve around the suitability of the site for expansion to a full production scale and in obtaining long-term operating resources beyond the current capacity of Nisga'a Fisheries.

3.2 Kincolith Hatchery Replacement / Revitalization (Rating: Class C)

We visited the Kincolith Community Economic Development (CEDP) facility and held discussions with the DFO Community Advisor and engineering staff in Terrace. We understand the primary enhancement purpose of this facility is to raise yearling Chinook smolts that are marked for stock assessment purposes, but small numbers of chum salmon are also enhanced when brood stock is available. Kincolith was connected by road to the rest of the Nass watershed about four years ago –many years after the facility was opened. The original construction was done on a relatively low budget, the site is poorly

located in terms of water supplies and the facility infrastructure is in very poor condition. There was evidence of a fire in the generator building and the water supply has frozen up in the winter several times resulting in significant production losses.

DFO staff. LGL Limited and Nisga'a Fisheries are all well aware of the deficiencies in this facility and collaborated on a concept proposal for 2008 to address the water supply issues at this facility. The local people like to have the facility close to the village so are not currently supportive of relocating it even if a better site could be found now that road access is available throughout the valley.

If this DFO - CEDP facility is to be continued as an enhancement site, it should be totally rebuilt to current codes and safety requirements with a reliable water supply. Staff training may need to be upgraded as well to ensure it operates properly and safely. Apart from the adult collection fence that appears to be satisfactory, there is nothing else on the site that is of sufficient value to argue for retaining the facility in its present location if a better site could be located. The value of the marking operation is seriously threatened by its unreliability. We also understand the stock is quite unique so marking does not assist in managing the rest of the Nass Chinook production. We understand marked Chinooks at Tseax would be a better indicator of Nass Chinook abundance in-season.

DFO has apparently obtained the resources to rebuild the Penny CEDP facility at a new site for Chinook marking purposes on the Upper Fraser at a cost of $6 Million. DFO should decide soon if the stock assessment benefit and future enhancement potential is worth a comprehensive infrastructure rebuild/ relocation as they have approved for the Penny project. A total rebuild / relocation is required soon at Kincolith, especially if it is to also serve later as a central production scale incubation facility for enhancing Chinooks and a portion of Area 3 Chum stocks. (See 3.3)

RECOMMENDATION: The PSC Northern Boundary Fund should be <u>wary of funding</u> partial upgrades to the existing facility without a comprehensive DFO review and revitalization plan that has ruled out relocation to a better site.

3.3 Area 3 Integrated Chum Enhancement (Class C)

When we met with the Canadian section of the Northern Panel in February 2007, a lot of interest was expressed in production –scale chum enhancement in Area 3. We began an exploration of enhancement potential with DFO and Nisga'a fisheries consultants LGL Limited who had done some preliminary work in the Kitsault area. However when we met with DFO fisheries management staff in Prince Rupert, we were advised that chum release is being required in Area 3 and 4 commercial seine and gillnet fisheries to conserve weak stocks in Area 3 and other areas. DFO fisheries managers were not confident that the conservation concern could be addressed through enhancement let alone add production for increased commercial opportunities. They pointed out that not all local stocks require conservation. For example although the Stagoo was considered a potential enhancement prospect by the Panel, it is one of the stronger stocks in the area and cannot be enhanced at the expense of the weaker stocks in mixed stock fisheries.

An additional problem is that chum prices are generally very low and not very attractive to many in the fleet especially if they have to travel long distances to an opening.

An integrated chum production and harvest plan in Area 3 could include two or three central incubation sites each serving several systems plus side channels on a few road - accessible rivers where these might be feasible. Egg take crews could travel to the various streams by boat and send specified numbers of eggs to one of the incubation sites. Following incubation, swim up fry could be transported back to sea net pens at the mouths of the donor streams where they would be fed until reaching optimum size of release. An upgraded facility at Kincolith could serve streams in Portland Canal and Work Channel. A new facility at Kitsault could serve the Stagoo and other stream northward in Alice Arm where side channels may not be feasible. (Bioengineering reconnaissance surveys in 1983 identified a potential hatchery site on the Kitsault and the old dam could possibly be rehabilitated to provide a gravity water supply for a hatchery. The new owners may be interested in a cooperative enhancement project with Nisga'a that could potentially enhance other species such as Chinooks.) There may also be some potential for a facility on the Bear River at Stewart to enhance Portland Canal chum stocks and other species, but it is cold and glacial.

The harvest component of the integrated plan would see a move towards more terminal opportunities where the three production areas within Area 3 could be discretely harvested without impacting stocks from each other or adjacent statistical areas.

At the Panel meeting on Feb 12, 2008, it was suggested that the existing causeway at Stewart be breached to improve chum access to the tide flats as a potentially worthwhile habitat remediation project

RECOMMENDATION: The PSC Northern Boundary Fund should <u>only consider conservation Chum enhancement and habitat remediation where feasible</u> in Area 3 unless fisheries management plans are changed to allow chum retention in Area 3 and the economics of chum enhancement improve to satisfactory levels.

3.3 Vetter Creek Enhancement Feasibility (Class B)

About 250 year ago a lava flow swept across the middle of the Nisga'a valley and cut off the Vetter Creek from the Nass River. The flow of this system does make its way underground to the Nass, but fish passage is impeded in both directions. This unique area is a tourist attraction and the Vetter could potentially support a resident stock of salmonids for recreational fishing. This could be an add-on to the Tseax project above. It may also be feasible although probably not culturally acceptable to open up the stream to Nass so it would support anadromous salmon production.

RECOMMENDATION: T**his is a very unique area and it should be up to the Nisga'a to decide if they want to pursue any enhancement options that might potentially be of interest to the PSC Northern Boundary Fund**

3.4 Nass Tributaries Fish Passage (Class B – Upper Tseax, D Seaskinnish and Fred Wright)

We explored two possibilities for fish passage on our helicopter reconnaissance that had been identified to us on Seaskinnish and Fred Wright Lake. Both systems appeared to be not feasible with very high barriers and limited upstream potential. We understand that the upper Tseax may be a partial barrier to steelhead and Chinook fish passage and there may be an opportunity to improve the situation with a bypass.

RECOMMENDATION: Feasibility work to determine if a barrier bypass on the Upper Tseax is worth pursuing

3.5 Lava Creek Gravel Addition - (Class A/B – pilot, Bruce Shepherd advice)

Lava Creek enters the Zolzap sidechannel and originates at the base of the western edge of the Tseax lava flow. This source probably has high water quality and buffered temperatures similar to the Vetter Falls spring (see Tseax Hatchery Opportunity # 3.1). The system supports good populations of coho, and sockeye spawn at the toe of the lava bed in very marginal substrate (lava shards). The downstream reaches (approx 1 km) of this creek are heavily influenced by beaver activity, and thus largely ponded. The system productivity is seen as limited by spawning habitat, despite having excellent rearing potential. Additions of more suitable spawning gravel could boost production of both coho and sockeye. Although not a major production opportunity, these sockeye are potentially unique in that they do not rear in a lake, and may be a relict population from a sockeye run blocked from accessing the upper reaches of the Tseax system by the lava (as may be sockeye that spawn in Gingit Creek upstream of eastern side of the lava flow).

RECOMMENDATION: Bruce Shepherd recommends phased pilot additions of spawning gravel suitable for both sockeye and coho

Other Potentially Viable Production-Scale Enhancement Opportunities Identified in 1983 (Class C)

a) Zolzap Creek side channel for Pink
b) Meziadin pilot facility – less practical alternative to Tseax
c) Meziadin Lake enrichment – very feasible but later rejected as unacceptable because of other weak sockeye stocks that would be adversely affected in mixed stock fisheries (Class D)

Area 4 – Skeena River and Tributaries

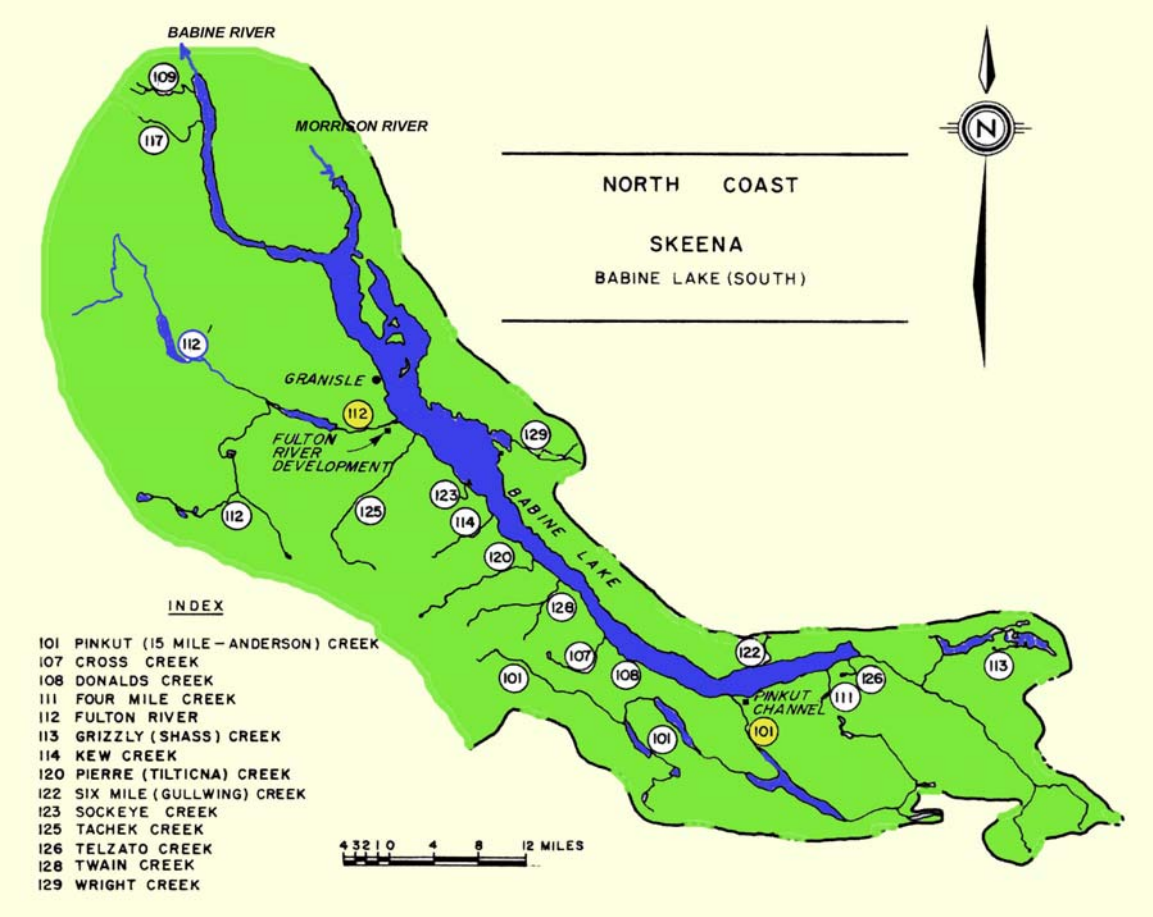
Assessing the potential for production-scale enhancement should be coupled with a major reexamination of management of mixed stock fisheries that we understand may proceed in 2008. The primary driver for mixed stock fisheries has been sockeye from the largest sockeye enhancement complex in B.C on Fulton River and Pinkut Creek. These facilities were built in the mid to late 1960s to overcome a lack of incubation capacity that was limiting the productive potential of Babine Lake for growing sockeye smolts. While controversial in terms of their potential impact on less productive sockeye stocks and other species such as steelhead in mixed stock fisheries, there is no doubt that they have made a major contribution to Skeena River fisheries in most years. The harvest rate in the Prince Rupert commercial fisheries has been lowered to reduce impacts on other stocks and large-scale terminal harvests have evolved in Babine Lake off the two major systems.

Our overall assessment is that the Skeena watershed (including Babine River and its tributaries) has some opportunities for additional cost effective production -scale sockeye enhancement if it can be harvested in accordance to whatever new fisheries regimes are developed. There is also some limited potential for production-scale enhancement of sockeye in other Skeena tributaries that could produce enough fish to provide both conservation and fishery benefits.

In terms of other species, there is considerable potential for larger habitat restoration projects focusing primarily on coho but potential fishery benefits are most likely to be more conservation orientated than creating new fisheries opportunities. Hatchery options for Chinook and coho are quite limited and very costly in this region on a unit production basis since there are no discretely manageable larger stocks coupled with identifiable high - quality production - scale enhancement opportunities. If more Chinook production is desired from the Skeena, it would be very worthwhile to seriously examine the feasibility of using and even expanding the currently underutilized Kitimat facility for cost-effective production-scale incubation and early rearing of Skeena tributary Chinooks as well as stocks in Area 6.

Potential chum and pink enhancement opportunities have also been identified previously and more could be developed in the Skeena drainage, but no new projects would likely carry satisfactory Benefit/Cost ratios under the current low market prices for these species.

Upper Skeena



DFO enhancement staff has expressed some interest in refining the current strategies at Pinkut Creek, rehabilitating the original smaller spawning channel at Fulton River and improving the distribution of enhanced stocks by increasing Morrison River stocks – the third largest system tributary to Babine Lake. There may also be some potential for increasing production of Babine Lake outlet stocks, but they are very healthy at present. DFO have explored the feasibility of a power generation project at Fulton River that would reduce overall enhancement operational costs for DFO in BC – potentially freeing up operations and maintenance dollars that could be applied to increased production through co-investments with the PSC Northern Boundary Fund and others.

The sockeye productive potential in the major Babine Lake producers – Pinkut, Fulton, Morrison and Babine Lake outlet / Babine River could potentially be adjusted so that they become more balanced in productive potential with increased local harvest opportunities. However conservation of other sockeye stocks and other species in the Skeena system must also be factored into an integrated approach.

4US.1a Pinkut Creek Sockeye Optimization (Rating Class A/B)

Sockeye are currently enhanced at Pinkut Creek through three methods – a large spawning channel on the shore of Babine Lake, by transporting adults above an impassible barrier by helicopter and by improving incubation water flows in both the channel and the river through a low head dam at the outlet of Taltapin Lake. The spawning channel also has a pumped supply from Babine Lake to reduce the incidence of frazel ice in the channel. There is a significant operational cost in keeping the Pinkut camp open in the winter months in order to maintain the pumped supply and keep the road ploughed into the site. We were advised at the Panel Meeting on Feb 12, 2008 that the creek intake has been plugged with ice in the last two years and channel production would have been lost if on-site personnel were not there to activate the alternative lake water supply to the channel.

If the channel production is no longer needed or if the risk of an occasional failure is acceptable, significant operational savings could be realized from no longer having to maintain staff on site all winter to activate and run the pumping operation and thereby reassign some operational costs to other higher priority enhancement. Pinkut winter conditions could also be remotely monitored from the central DFO facility at Fulton River and staff dispatched by helicopter if needed to service the pumping operation thereby reducing the need for plowing roads and maintaining two installations year-round.

RECOMMENDATION: DFO should review its recent experience at Pinkut and look for operations and maintenance cost savings that could be applied to enhancement activities elsewhere in Northern BC.

Fulton River Spawning Channel #2 and Counting Fence. Channel No. 1 in the background requires rehabilitation as egg to fry survival has dropped to about 15%.

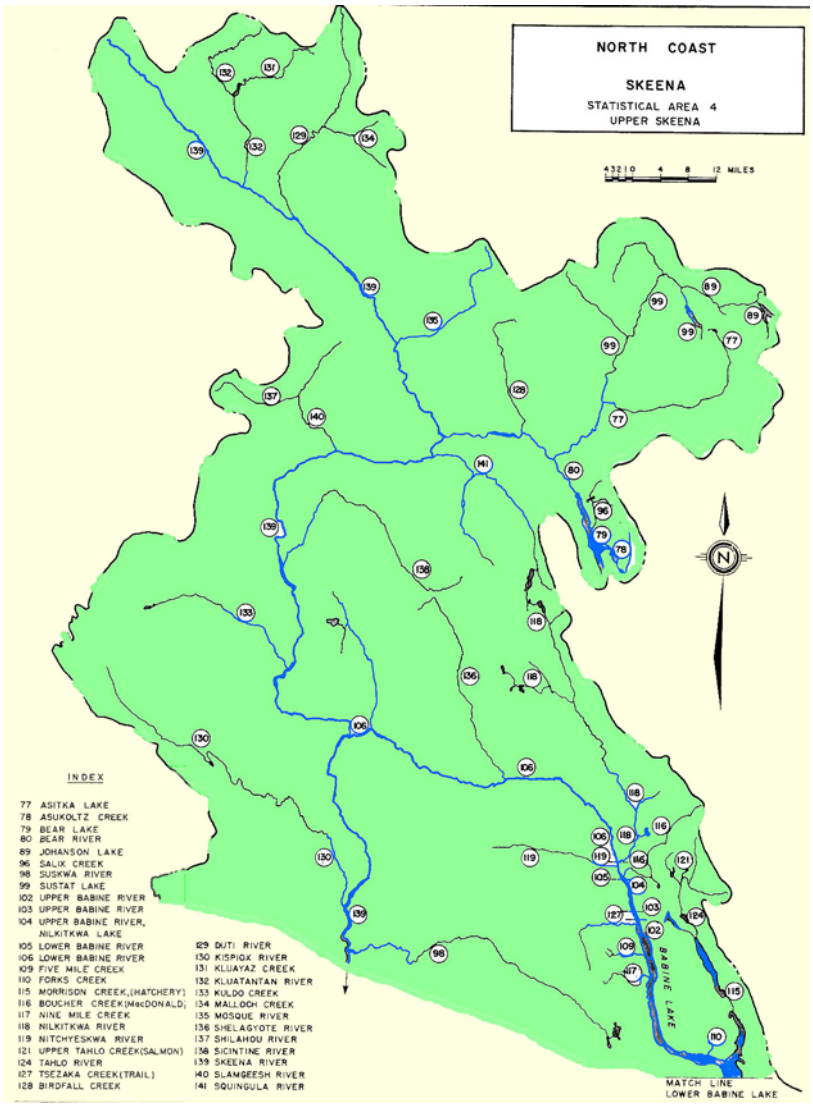
4US.1b Fulton River Optimization (Rating Class A/B)

Sockeye are enhanced at Fulton River through three methods – two spawning channels and improved flows in the Fulton River and for the larger spawning channel through a high head dam at the outlet of Fulton Lake. The original smaller spawning channel #1 constructed in 1965 is fed directly from a low diversion dam and short pipeline directly from the Fulton River while a two-mile long pipeline feeds the much larger channel #2 directly from the intake structure on Fulton Lake. From the outset of the project there were concerns about high water temperatures in the late summer in channel #2 but a very thorough investigation undertaken in the late 1960s by Al Lill determined that it was not feasible to modify water temperatures significantly. The narrow approach to the lake intake structure coupled with a sill in Fulton Lake means that selective withdrawl of colder water is not possible without a very long large diameter pipeline and a new deep diffuser-style intake in the main body of the lake. Another concern raised recently is that channel #1 is now producing at a very low level because it has not been cleaned for several years. There is very limited space for ponding contaminated water from a cleaning operation on this site and DFO needs to decide if the additional sockeye production from Channel #1 warrants its continued maintenance as a controlled high sockeye producer. It could be converted to operate semi-naturally with added wood complexing for improved coho and resident fish rearing.

DFO has also hired consultants to examine the feasibility of adding a hydropower installation to the Fulton complex. They came up with two options and one of these appears to be quite feasible, but DFO has not chosen to act on their report to date. There may be an opportunity for the PSC Northern Boundary Fund to co-invest in a power project with the view of obtaining a share of the revenue that it could apply to incremental operations and maintenance costs of future enhancement projects supported by the fund.

RECOMMENDATION #1: DFO should review its sockeye production requirements at Fulton River in the light of an overall Babine Lake production strategy and decide to either rehabilitate Channel #1 or turn it into a semi-natural uncontrolled side channel for wild coho, sockeye and resident stock production. The PSC Northern Boundary Fund should seriously consider supporting the preferred option if approached by DFO or another proponent working with DFO.

RECOMMENDATION #2: DFO and the PSC Northern Boundary Fund should explore the feasibility of co-investing in a hydropower project at Fulton River in order to realize annual revenues that could be applied to meet incremental operations and maintenance costs of enhancement projects supported by the Fund and operated by DFO or others working with DFO.



4US.1c Morrison River Sockeye and Coho Enhancement Feasibility (Rating Class C)

Sockeye are currently not enhanced at Morrison River although it was the site of a Dominion government hatchery in the 1930s. Extensive surveys were done on the 1960s and should be documented in DFO archives. There is excellent potential for some flow enhancement in Morrison River below Morrison Lake and a sockeye and coho spawning / coho rearing channel with a lake intake in the same area. It also might be practical to fertilize Morrison Lake by boat to help improve production of the stocks in the Tahlo (a tributary) that probably rear in Morrison Lake. There may also be some possibility of improving incubation conditions in the Tahlo tributary as part of a balanced enhancement strategy. Morrison River sockeye stocks were not enhanced in the 1960s with Pinkut and Fulton largely because the area was largely inaccessible by road and because of concerns for the stocks in Morrison Lake tributaries. Since then an extensive logging operation has taken place on the eastern shore of Babine Lake so access is much improved. In addition enrichment technology has also advanced and the capacity of local First Nations to undertake enhancement work has also improved considerably.

4US.1d Fort Babine Area Sockeye Enhancement (Rating Class C)

The 1983 enhancement opportunities report identified a possible 7000 sq. meter side channel site in the vicinity of Fort Babine. We have not followed up to determine if anything was done with this opportunity.

NOT RECOMMENDED: DFO advised that recent escapements in this area have been satisfactory and there is no need for enhancement at this time.

4US.2 Babine Chinook Enhancement (Rating Class C/D – production scale)

The Fort Babine C.E.D.P. Facility utilizes a low-demand pumped moist air incubation system followed by in-river incubation and rearing which is subject to periodic high sediment and temperature levels and occasional parasite problems. The system could accommodate other stocks. The facility has experienced some fish culture problems. The Fort Babine First Nation advised us at a September 17, 2007 workshop in Hazelton that they would be interested in expanding Chinook production. They currently rear 75,000 Chinooks to smolt size but would need extra rearing containers, expanded incubation on land w/ pump to alleviate disease to add capacity. They could rear 2g fry, in river (aluminum containers) and have potential to rear 60,000 more smolts. However an extra 60,000 smolts or fry will not bring facility output above a small pilot scale operation with limited potential for further expansion. Other infrastructure issues would also need addressing similar to Kincolith.

There is also potential to utilize the Fulton River hatchery facility to enhance coho and possibly Upper Babine, Morice and /or Bear Chinook salmon. This facility has run programs such as Morrison coho in the past. It currently has a capacity for 30,000 (12-15g) smolts or 80,000 (2g) fry. However no potential proponents currently have additional operational resources for production scale enhancement. Sockeye populations also pose a disease threat to expanded fish culture.

These projects do not appear to have sufficient potential (even in combination) to support production scale enhancement. Operational cost support and infrastructure improvements would be required from the PSC Northern Boundary Fund.

NOT RECOMMENDED: Not supportable at a production scale.

4US.3 Upper Skeena Tributaries Habitat Restoration (Class C)

There was some discussion at the Hazelton workshop on September 17, 2007 about the merits of habitat restoration initiatives alongside the old BCR abandoned roadbed alongside Bear Lake. The Skeena Fisheries Commission doesn't understand the Upper Skeena well enough to develop enhancement prescriptions at this time. They are currently collecting information on fish presence and species composition. Major potential restoration initiatives include sediment removal and fish passage at poor culverts. There was insufficient information available at the workshop to provide for any recommendations with respect to future work.

4US.4 Kispiox River Chinook Enhancement (Class C)

The Kispiox C.E.D.P. Chinook Hatchery that was closed in 1994 was reopened for a period until 2007 for conservation enhancement of Kitwanga sockeye.

NOT RECOMMENDED: DFO is not currently in support of Kispiox hatchery enhancement as Chinook are reasonably healthy and coho very healthy with little prospect for a discrete harvest opportunity.

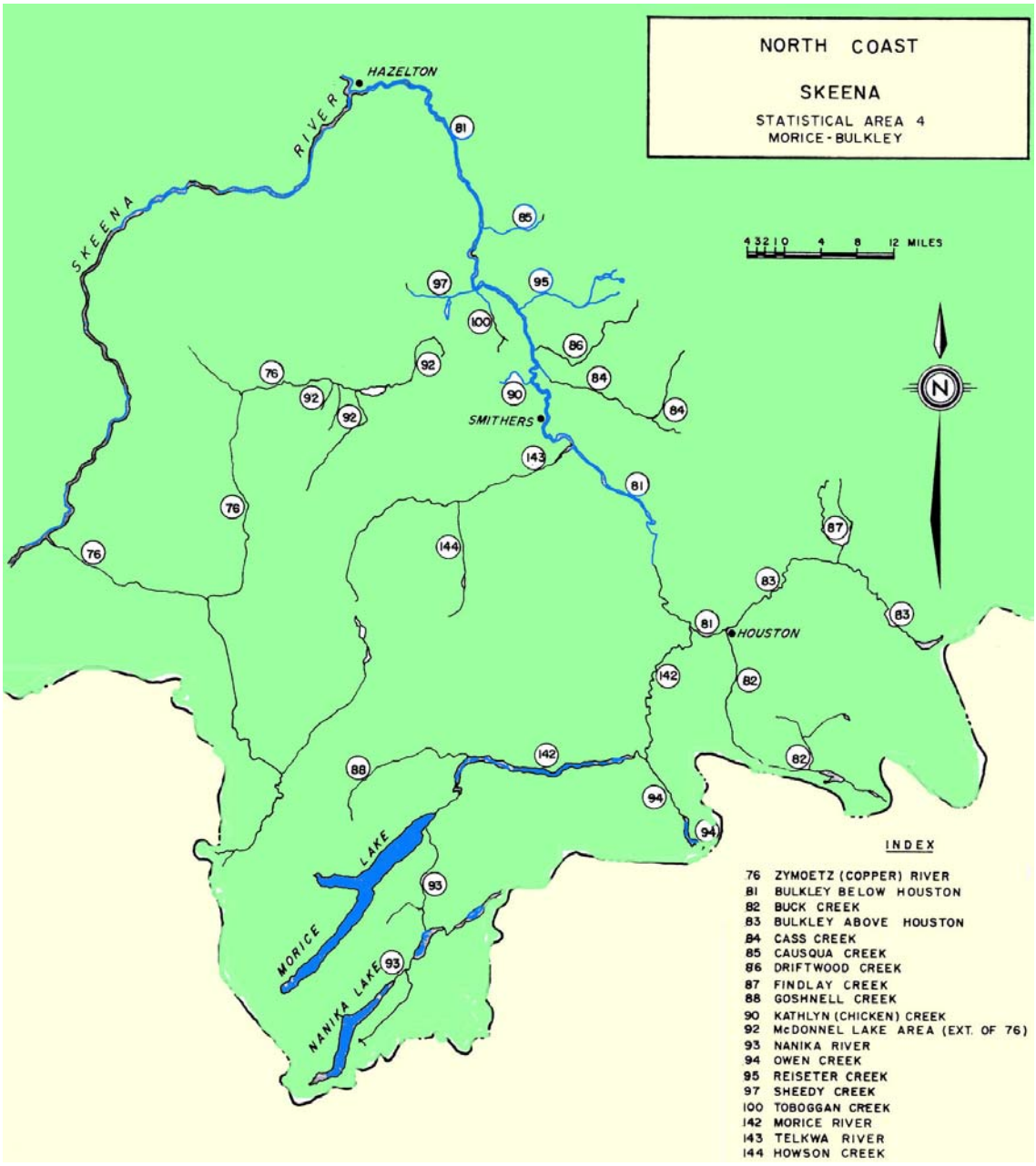
4US.5 Kispiox Pink Spawning Channel (Class D)

The 1983 Enhancement Opportunities Report identified a site surveyed on private land that was planned for a large SEP Phase One spawning channel (33,450 square metres) that was never built on account of manageability concerns. It would also not perform well in terms of Benefit/Cost with today's low prices for pink salmon.

4US.6 Kispiox Upstream of Nangeese Fishway / Blasting Obstruction (Class B/C)

The 1983 Enhancement Opportunities Report identified an excellent opportunity to overcome a 4-metre partial obstruction that would open up 30 km of habitat for Coho.

RECOMMENDATION: If opportunity has not been acted upon already, the file should be reopened.



Our overall assessment is that the **Morice – Bulkley** has very limited if any opportunities for additional cost effective production scale enhancement. A sockeye hatchery and incubation channel was operational on the Nanika system in the 1960s using a transplanted stock from Pinkut Creek on the Babine system, but it was not successful. It is our understanding that natural incubation conditions at the outlet of Morice Lake for both Chinook and sockeye are quite good, but not productive enough to generate enough fry to make enrichment of Morice Lake a viable enhancement opportunity.

The Nechako Plateau area (including the Upper Bulkley) is likely to be impacted by summer droughts and winter low flows as climate change continues so flow augmentation should be seriously considered for maintaining coho production.

We were told at the Hazelton workshop that addressing limiting factors (such as over-winter habitat for coho) will require feasibility and reconnaissance work (such as groundwater surveys) and improved stock assessment for both sockeye and coho. Workshop participants suggested that there should be good habitat restoration opportunities in the Upper Bulkley.

4MB.1 Maxan and other Lake Storage (Rating Class B)

One such opportunity identified in 1983 and not acted upon to our knowledge is provision of storage on Maxan Lake that feeds into the Upper Bulkley.

RECOMMENDATION: An experienced bioengineering team should undertake a comprehensive assessment of habitat restoration opportunities in the Upper Bulkley system including potential flow enhancement from Maxan Lake.

4MB.2 Morice - Nanika Sockeye Enhancement (Class B/C)

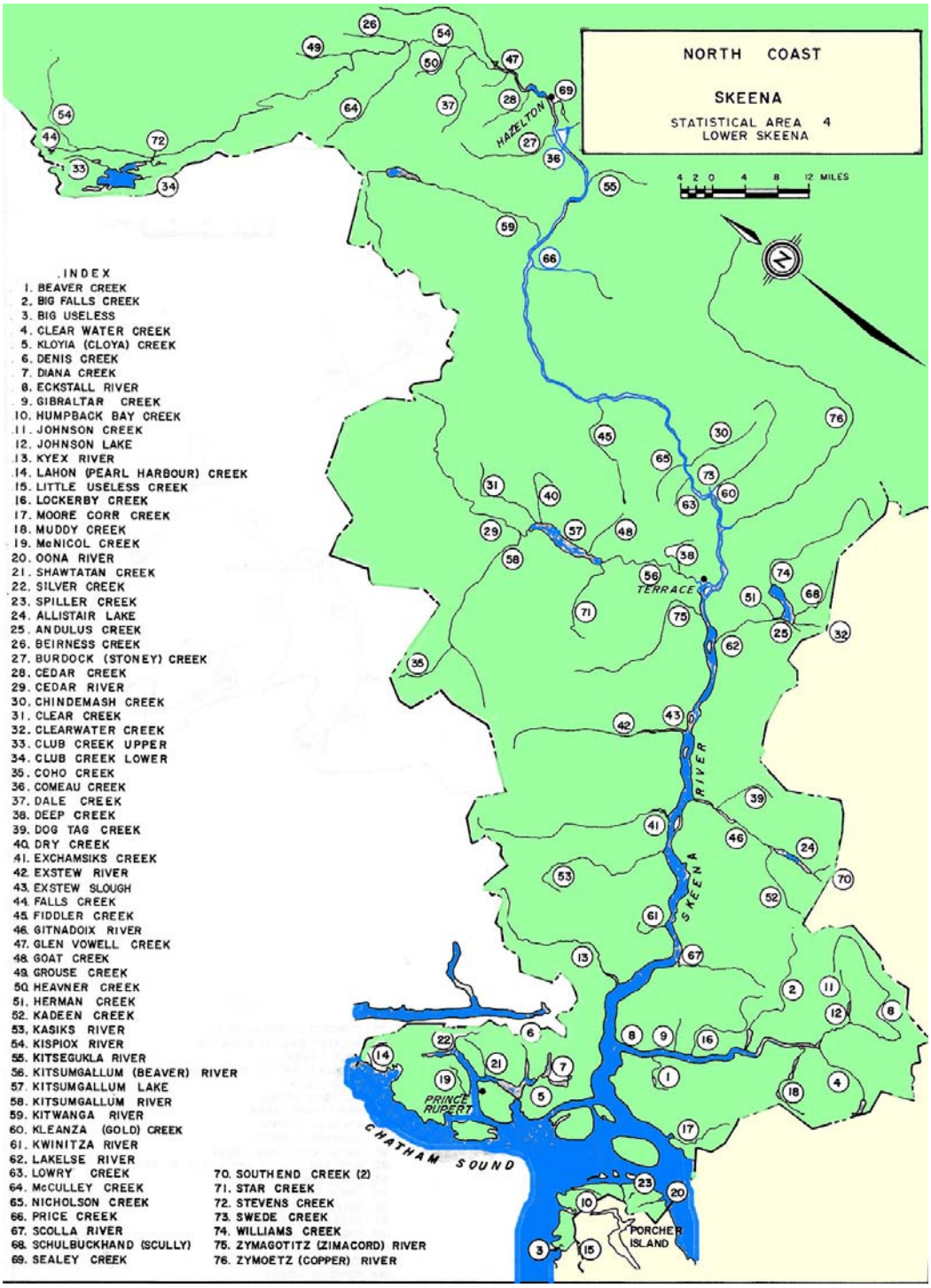
Production –scale enhancement of sockeye would require either a transplanted stock or preferably a long term pilot hatchery operation that would gradually build up sufficient fry production to justify enrichment along the lines of the successful program on Adams Lake in the Fraser. With erratic marine survival, such a project appears to be very high risk and should only be attempted if there are at least 250k eggs available in most years and resources for pilot lake pen rearing and/or spot enrichment to increase smolt survivals. There is also 4400 hectares of rearing potential rearing area in Nanika Lake and an excellent site for fishway to gain access IF sufficient adults could be produced to justify it.

RECOMMENDATION: DFO should review escapement records and its production objectives and possibly consider developing a long term program for enhancing Morice (and possibly Nanika Lake) sockeye stocks if required as an integral part of a balanced Skeena management and enhancement program. However poor past enhancement experience and limited adult populations coupled with recently erratic marine survivals need to be taken into account before proceeding.

4MB.3 Moricetown Fishway Major Repairs (Rating Class A/B)

We have been advised that a section of the floor of the fishway has been pushed up by frost heaves trapping fish underneath. An inspection is required at low water. This could potentially be a big project and a high priority for PSC Northern Boundary funding.

Lower Skeena



Our overall assessment is that the Lower Skeena also has very limited opportunities for cost effective production scale enhancement. There are major habitat restoration / protection projects under consideration that will help to maintain biological diversity and provide some incremental fish production.

4LS.1 Kitwanga Production-Scale Enhancement (Class C/D)

The Kitwanga River is primarily a pink producer and a spawning channel was proposed for SEP Phase One, but never implemented on account of marginal economics and manageability concerns. The relatively small sockeye stock has the been the subject of recent conservation efforts utilizing the former CEDP facility at Kispiox, but we understand the concept proposal for 2008 was rejected because the success of lake spawners are making this enhancement not worthwhile.

RECOMMENDATION: It does not appear that there is a viable production scale enhancement opportunity on the this system, but we have little information at this point to go on.

4LS.2 Lakelse Sockeye Spawning Improvements (Rating Class A/B)

The PSC Northern Fund has supported two years of improved sockeye spawning habitat feasibility studies at Lakelse. Lana Miller (DFO) says *"the Lakelse watershed has several potential opportunities for enhancing sockeye spawning and incubation habitat, believed to be the limiting factor in this system. A proposal to develop one of these options and continue feasibility studies for others has been funded by the PSC Northern Fund in 2008. Pilot spawning platforms (~1200m^2) will be placed in one of the Scully Creek channels on the Mt. Layton Hotsprings property in 2008 and monitored for sockeye utilization and incubation survival. Test pits along a potential groundwater channel on Williams Creek will be monitored to determine feasibility of channel construction in 2009. Test pits excavated in 2006 on Hatchery Creek will also be monitored for possible channel development. Finally, the feasibility of providing some surface water (flushing) flows to Scully Groundwater Channel (former main stem, now only receiving subsurface water) will be explored."* The scale of these projects is at the conservation level.

RECOMMENDATION: Recommend proceeding with further conservation – level work in 2009 (Year 3) if feasibility studies appear promising.

4LS.3 Kitsumkalum Chinook Enhancement (Class D)

The Kitsumkalum (Kalum) system at Terrace is well known for its large Chinooks. There have been community enhancement projects focusing on these fish in the past, but we understand that the only remaining project is on a low volume groundwater supply and it is remote with snowmobile access only in the winter months. There is a lot of local knowledge and experience in working with these fish so the need for more extensive feasibility field work should be minimal.

However DFO is opposed to Kitsumkalum Chinook enhancement since it is a long running Chinook key stream and the wild stock is currently very healthy. Otherwise, the reasonably close proximity to the Kitimat major facility would have made it an excellent potential candidate for a satellite Chinook enhancement operation.

NOT RECOMMENDED

4LS 4 Access and Slough Restoration (Class A/B but dependent upon major cost-sharing and fish production benefits)

Over the years, there have been a number of successful habitat restoration projects initiated by DFO and the Skeena Fisheries Commission as well as other partners along the Skeena that have opened up access (primarily for coho, pink and chum) to areas cut off by highway and railway construction. These projects are the current focus of the DFO Resource Restoration group in the North. Their focus is on restoring and protecting ecologically – valuable habits that will assist in maintaining biodiversity and such work should be encouraged. Staff has advised us that there are still several areas worth pursuing such as Andesite Creek Side Channel, which has a debris jam affecting pink and chum production. The 1983 opportunities report also identified Esker and Exstew sloughs for similar rehabilitation. All these works are potentially justifiable from the perspective noted above even if they won't create new fisheries benefits – the focus of this report.

The major project proposed for 2008 is continued rehabilitation of Exchamsiks Back channel. It is composed of two relatively large groundwater and wall-base meandering back channels located on the Skeena River floodplain, east of Exchamsiks River - 56 km west of Terrace. We did have an opportunity to look at the concept proposal for this project. Lana Miller (DFO) advises that "a considerable area is to be opened up and rehabilitated, (initial very rough estimate is 250,000 m^2). Using an estimated fish production benefit of 0.69 smolts/m^2 for off-channel ponds (Koning and Keeley, 1997), the area could produce up to 172,500 coho smolts. Adult coho returns could range from 5,175 to 10,350 given a marine survival rate of 3- 6% (J. Sawada. personal communication to Lana Miller, 2007)."

There are some systems including Mission Creek ($1.0M) and Chicago Creek (approx. $0.75M) where the cost of restoring access would be prohibitive unless almost all of the funding comes from the authority responsible for blocking the access in the first place. The fishery benefits are likely quite marginal even if funding could be secured from partners

RECOMMENDATION: The PSC Northern Fund should consider funding habitat restoration applications with well - documented significant potential fish production and strong partnering that could contribute to fisheries at a reasonable net cost to the fund.

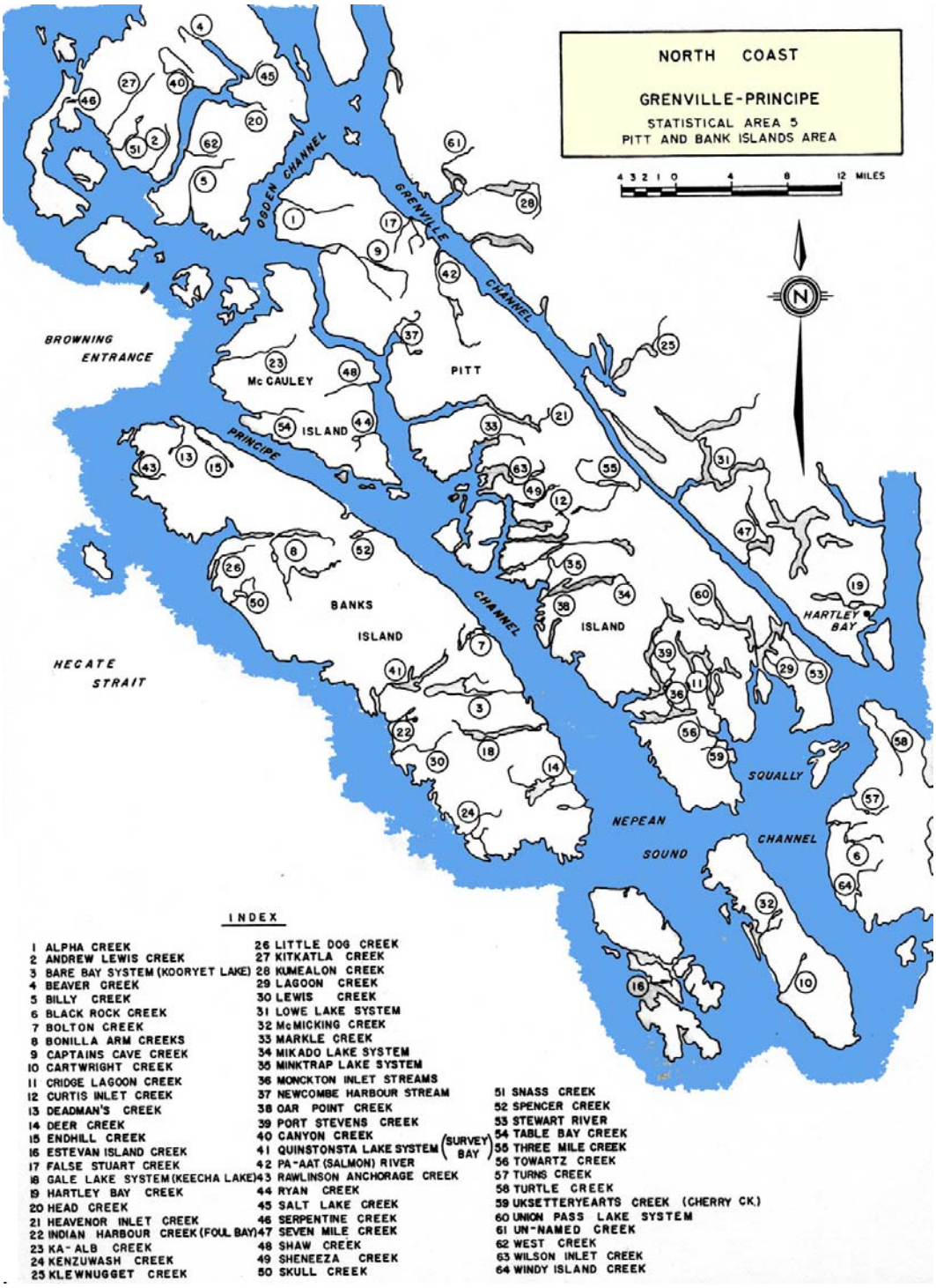
4LS.5 Prince Rupert Chinook and Coho Enhancement – (Class B)

Quite a bit of interest was expressed by the Panel and DFO in trying to create a recreational fishing opportunity close to Prince Rupert. There are no major salmon streams right in the harbour area itself and the closest significant producer is the Kloiya where a public involvement hatchery used to operate. We were advised that the coho there had high BKD. The Kloiya lands are owned by Port Edward and the buildings by Sunwave. The buildings are a liability and would need to be gutted and replaced. While Kloiya does have some potential, a completely new facility would have to be built and it would require paid staff making it pretty uneconomic at relatively low production levels. The DFO Community Advisor says it would be best to concentrate volunteer effort at the existing Oldfield hatchery in Prince Rupert, which is too small for production-scale enhancement as called for in this report.

It would appear that a reasonable option for addressing recreational fishing goals could be with a net pen rearing operation in Prince Rupert harbour using Chinooks incubated and reared at the Kitimat facility. The donor stock should come from Kloiya where there is fishway that could be the site of a potential adult holding / egg take operation. This could be an almost "put and take operation" depending upon how long the fish were held in saltwater. (Returns to areas adjacent of the net pens also could be enhanced using a morpholine imprinting/drip system, which has been used successfully in Alaska and Washington for this purpose.) If any of the adults attempted to spawn in the local creeks, eggs could be taken and incubated at Oldfield or Kitimat and the resulting smolts used for subsequent releases.

RECOMMENDATION: DFO should assess the potential for a net pen rearing option using Kloyia stock incubated and freshwater reared at Kitimat and saltwater reared in Prince Rupert Harbour. If this is deemed to be feasible technically, DFO should obtain community support for a pilot operation and potentially seek PSC Northern Fund support for partial funding.

Area 5 – Greenville-Principe



Our overall assessment is that Area 5 has very limited if any opportunities for cost effective production scale enhancement on account of the lack of major producers and the remoteness of the area. There is First Nation interest in sockeye and coho enhancement utilizing hanging lakes. We met in Prince Rupert with Chris Picard who has been active with PSC-supported projects in this area.

5.1 Hanging Lakes Sockeye Enhancement (Class C)

The PSC Northern Fund has been supporting an evaluation of the potential for colonizing hanging lakes for sockeye in Area 5 for two years and as of fall 2007, had a proposal on hand for a third year. The benefits of such a project from an ongoing production basis are questionable and there remains a major issue of provincial approvals for colonizing lakes currently occupied only by resident fish species.

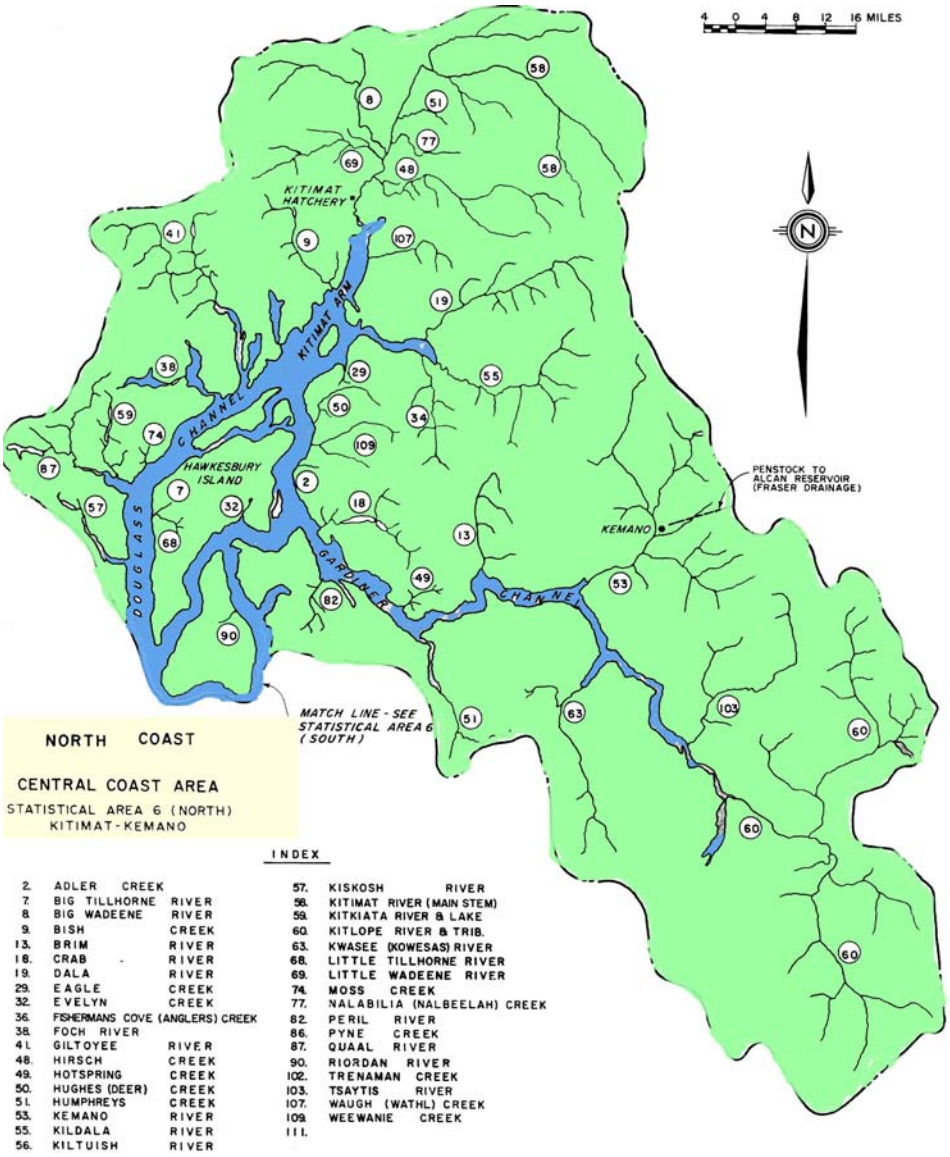
According to the review of the concept proposal for 2008, the proponents had originally planned to evaluate four hanging lakes but two (Sylvia Lake and Wyndam Lake) were dropped while Red Bluff and Batchelor Lakes were retained. Whalen Lake has been added to the proposed program as it was highly ranked in the preliminary hanging lake assessment completed for the Northern Fund in 2005 (Levy 2005).

The 1983 Enhancement Opportunities Report identified Lowe Inlet Lakes as the best bet for sockeye colonization (Weare, Camble, Simpson Lakes). However the Benefit/Cost ratios derived back in 1983 were very low for all candidates (0.6/1 and lower) so no action was taken. We expect a Benefit/Cost analysis done today would be even more unfavourable as costs have risen faster than benefits since 1983 in purely economic terms.

There is also the issue of an incubation facility being required to support fry outplants. The only existing SEP facility with a sockeye isolation unit is at Snootli. The ex – CEDP facility at Kispiox has been used for short –term sockeye enhancement. Both of these locations are a long distance from Area 5. It would likely be quite feasible to build a sockeye isolation unit at Kitimat especially if other hanging lakes in Area 6 are to be treated. A small local incubation box facility similar to those in Area 7 may also be a possibility. On account of the remoteness of the area and relatively small-scale production, unit production costs will be extremely high for all of these options.

RECOMMENDATION: Not recommended as a potentially viable production –scale enhancement opportunity. A low cost pilot project may continue to be supportable for either research or social perspectives.

Area 6 (North) – Kitimat / Kemano



The following is based on two trips to Kitimat facility and in depth discussions with DFO staff in Terrace, Prince Rupert and Vancouver.

Our overall assessment is that Area 6 (North) – particularly on the Kitimat River - has the most extensive opportunities for cost effective production scale enhancement in the North and Central Coast primarily because of the existence of the Kitimat major facility and excellent road access to most of the watershed.

Kitimat River Hatchery is located on Humphreys Creek adjacent to the Lower Kitimat River in the industrial area south of the city of Kitimat. The facility was built by SEP in the 1980s as central "satelliting" hatchery at a cost of almost $10Million – the most expensive of all SEP-built facilities. (Replacement value was estimated to be $16.1

Million in 2003 and would be much higher today.) It is an efficient no-frills facility that incorporates Japanese chum technology as well as North American practices and is designed to culture many different stocks in segregation and return them to their natal streams. The facility has ground (5-10 cfs) and surface water (>10 cfs) available, multiple rearing containers and reliable fish culture experience. The facility has the capacity to heat water for fish culture, building heat and de-icing of the river intake. Heated water is a by-production of the adjacent Eurocan Pulp and Paper Company mill.

Enhancement activity started in this area as a pilot hatchery at the Eurocan Pulp Mill to rebuild Chinook stocks, which had been impacted by fishing pressures and habitat instability from watershed development (mill construction and logging). The current objective of the Kitimat River Hatchery program is to rehabilitate indigenous stocks of Chinook, chum, coho and steelhead to support commercial, recreational and First Nations fisheries. Approximately 30-40% of the chum and Chinook returns to the rivers are of enhanced origin. Returns in recent years indicate that chum stocks have been rehabilitated. However, because of logging in various watersheds the stocks are vulnerable to regularly occurring high flow events.

The majority of Kitimat Chinook is harvested in non-target fisheries in Alaska (46%) and the North Coast Areas (11%). Targeted terminal marine (10%) and freshwater (36%) recreational fisheries harvests occur for Kitimat Chinook, which are much prized internationally by recreational anglers for their large size. Many tourists from B.C., Alberta and around the world travel to the Kitimat for marine and fresh water fishing of these large Chinook.

The chum fishery targets Kitimat River as well as passing stocks of chum in the approaches to Kitimat Arm and enhanced chum in Kitimat Arm. A significant in river sport fishery (13%) has also developed for these large bright chum.

The majority of Kitimat coho are harvested in non-target Alaskan fisheries (38%) and target marine and freshwater sport fisheries.

The recreational freshwater steelhead fishery is hatchery-mark only. Without hatchery production, this prized recreational opportunity would be catch and release only. The BC Ministry of Environment places a high value on the steelhead production as this is the second largest winter fishery in BC.

The facility has a capacity to release 11 million fed chum fry, 3 million Chinook smolts, 500,00 coho smolts, 50,000 steelhead smolts and 7,500 sea-run cutthroat smolts. In 2007 the egg take targets are less than half of these capacities for chum and Chinook.

We expect that an increase in operating resources could lead to reprofiling of fish production with limited capital infrastructure changes (i.e. involving conversion of Chum production capacity to other species). Increased utilization of Kitimat facility could be far more cost effective on a unit production basis than any other enhancement option in the North.

There is also ample land for a doubling of the infrastructure and the wells have been proven to be highly productive and reliable. It would also be relatively simple to add a sockeye isolation hatchery similar to Snootli or Inch Creek that could facilitate conservation enhancement on Lakelse and colonization of hanging lakes including the nearby Jesse Lake where road access should soon be available.

The facility was built to enhance satellite stocks in the Kitimat watershed including Hirsh Creek, plus Kildala, Dala and Bish Creeks in Kitimat Arm so does not have a fishway to allow for direct access by returning spawners. A fishway would allow for about $21K in operating costs to be reallocated to increased production.

6N.1 Area 6 Integrated Production and Harvest Plan SDM Process (Rating Class A)

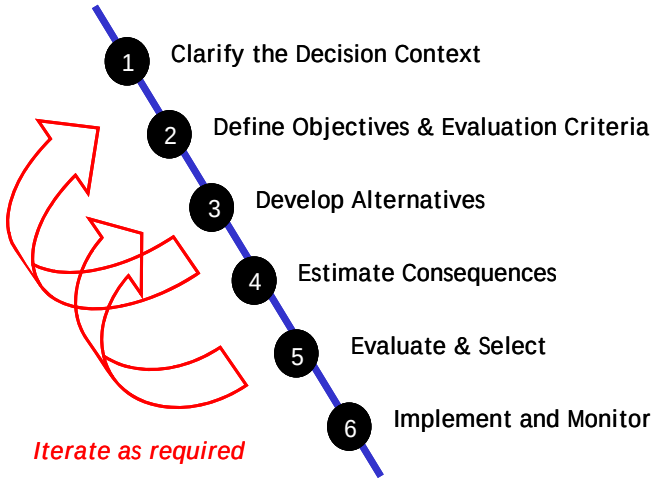
We strongly recommend that an integrated production and harvest plan should be developed for Area 6 as soon as possible. We expect that it will take about two years to complete. In the meantime, we feel that there are several enhancement projects that could still proceed that would: improve utilization of the Kitimat major facility and undertake some pilot work on sockeye enhancement.

DFO fisheries managers are not supportive of even maintaining let alone increasing chum enhancement in Area 6 because of by-catch concerns in the current commercial seine and gillnet fisheries in Area 3 - 4 and Area 6 (Gill Island). Changing commercial fishing patterns could open up terminal opportunities and create more viable enhancement projects, but might also impact on the recreational and First Nations fisheries in the area.

There are also policy issues about the application of enhancement and the DFO *Wild Salmon Policy* and potential sea ranching pilots, hanging lake sockeye transplants etc. that enter into the debate about production plans in this area as well as others in BC.

After considerable discussion with DFO staff in Prince Rupert, Kitimat and Vancouver, the only way that we can see to resolve these issues would be through a Structured Decision Making (SDM) process based on best available science involving all of the regulatory agencies and key stakeholders. SDM is a well – defined process that has proven itself in developing Water Use Plans in BC. It seeks a consensus amongst all participants on a management plan that is acceptable to all if not the first choice of any of them.

SDM is an organized approach to identifying and evaluating alternatives and making choices in complex decision situations. It uses rigorous methods developed in the decision sciences that are viewed as “best practice” in decision - making, particularly for decisions involving the integration of technical analysis (including scientific, socio-economic analysis) and traditional knowledge with value-based deliberations. The goal of a structured decision process in this context will be to identify and explore core trade-offs, inform committee deliberations, and ultimately achieve a consensus plan.



Structured Decision Making Steps

Decision - making is done by consensus among participants. Consensus is defined as a decision that all participants can accept, without having to agree to all details. Every effort is made to explore, understand and accommodate the interests of dissenting viewpoints. In forwarding a decision or recommendation in which there are dissenting viewpoints, these viewpoints should be included as well. Decision - making is conducted with the acknowledgement of linkages from and to other management processes.

RECOMMENDATION: We <u>strongly recommend</u> that DFO, PSC Northern Boundary Fund and other potential participants implement a SDM process with a qualified independent facilitator that is co-funded.

6N.2 Kitimat Facility Fishway and Expanded Chinook Production (Class A)

In 2003, the DFO Technical Support Division prepared a preliminary estimate of $241,000 for providing a fishway for direct access to the facility by Kitimat River Chinook and chums. Since these fish are now seined in a nearby pool, it is not expected that the wild-hatchery mix would change very much from the current distribution and there would be a considerable saving in seasonal labour as well as facilitation of ESSR fisheries for local First Nations.

We worked with facility manager Martin Forbes to develop a 2008 concept proposal (Appendix One) with updated costing for building a fishway and restoring some Chinook production. Mr.. Forbes and staff estimate that a fishway would result in savings of approximately $21K per year that could be reallocated into restoring some of the Chinook production eliminated by budget cuts – the highest priority being the former satelliting to the Kildala River. Also as discussed earlier, the unutilized capacity could be directed towards a number of different Chinook enhancement options involving other partners including stocks in the Skeena drainage such as Kloiya.

RECOMMENDATION: We recommend that DFO further develop plans for a fishway at Kitimat facility and bring back a new proposal for consideration by the PSC Northern Fund in 2008. We further recommend that Chinook production be restored to the Kildala and other systems utilizing the existing infrastructure at the facility as much as practicable. Ideally DFO should be prepared to cost-share the fishway construction and additional Chinook production to make the proposal more attractive for funding by the PSC.

6N.3 Kitimat River Sockeye Enhancement Feasibility (Rating Class B)

The 1983 Enhancement Opportunities Report identified a 5000 sq. metre side channel opportunity on the Kitimat River near MacKay Creek for enhancing river sockeye populations. Kitimat River sockeye populations would be of interest primarily to the Haisla First Nation as a potential food source, but could also generate a commercial fishing opportunity or possibly be used for a pilot transplant operation to Jesse Lake. The stock productivity is likely limited by the quality of the incubation and early rearing environments and also possibly by the estuary conditions at Kitimat. The life history of river sockeye populations is not well documented so some basic biological investigations should be undertaken to determine limiting factors and whether a side channel would be beneficial. The staff at Kitimat Hatchery has expressed concern about any sockeye fish culture in the watershed above the river intake in terms of the potential for disease transfer. This issue would also need to be addressed in any plans that are developed. Low densities and no intensive fish culture practices would likely minimize this concern.

RECOMMENDATION: We recommend that DFO work with the Haisla Nation to develop a PSC Concept Proposal that would undertake basic biological investigations with respect to factors limiting production of Kitimat River sockeye and to follow up with a prescription for a side channel project near MacKay Creek if it is deemed to be worthwhile by these investigations.

6N.4 Kitimat River Chum Channel Enhancement Feasibility (Rating Class B/C – long term)

The 1983 Enhancement Opportunities Report did not recommend chum semi-natural channel opportunities on the Kitimat River on account of lack of gravity flow potential and unstable river conditions. However there is the possibility of developing some improved habitat downstream of the Kitimat facility utilizing water from the hatchery outflow or direct from the existing intake. If the costs were low enough and a new fisheries regime was developed, semi-natural chum enhancement there could be a viable option in the future and potentially replace some of the production from the facility if space is needed for other species.

RECOMMENDATION: We recommend that DFO develop preliminary proposals for semi-natural chum enhancement immediately downstream of the Kitimat Facility as a part of the SDM exercise we have advocated under project 6N.1.

6N.5 Jesse Lake Sockeye Enhancement Pre-Feasibility (Rating Class C)

Jesse Lake is located southwest of Kitimat at the south end of Kitimat Arm and up until now has been inaccessible by road. There is a 6-metre obstruction at the lake outlet which precludes escapement into the lake itself and a very short section of river between the obstruction and saltwater. The outlet stream is not a documented salmon producer, but there have been reports of some salmon attempting to migrate upstream past the falls. The 1983 Enhancement Opportunities Report indicated that there are resident fish populations that could prove to be major predators on introduced salmon populations.

RECOMMENDATION: We recommend that some basic pre-feasibility work be considered to determine if there are any sockeye attempting to enter Jesse Lake and the status of resident fish stocks. It should also be determined what suitability Jesse Lake has for lake spawning if a sockeye population was introduced as well as the feasibility of alleviating the obstruction.

6N.5 Kemano / Gardner Canal Streams Enhancement Feasibility (Rating: Class C/D)

Since the Kemano power house has gone into service, water flows in the Kemano River have been greatly augmented resulting in a steady base flow and some increase in salmon production. There are some good physical enhancement opportunities such as spawning channels or side channels that could be implemented at Kemano and a town site where basic services are available. The water temperatures are cold, but suitable hatchery sites are likely available from Alcan. A pilot hatchery was recommended in the 1983 Enhancement Opportunities Report that could potentially lead to a major facility enhancing Chinook, coho, chums and pinks with satelliting to Kiltuish, Kitlope, Tezwa, Kowesas and Brim. However Kemano is in a relatively remote location and any local fishery would necessitate long travel times for fishermen to access. There are also concerns about other wild stocks in Gardner Canal such as Kitlope[1] that would have to be taken into consideration if only Kemano was enhanced. The stocks from this area also are impacted by existing fisheries in Areas 3,4 and 6.

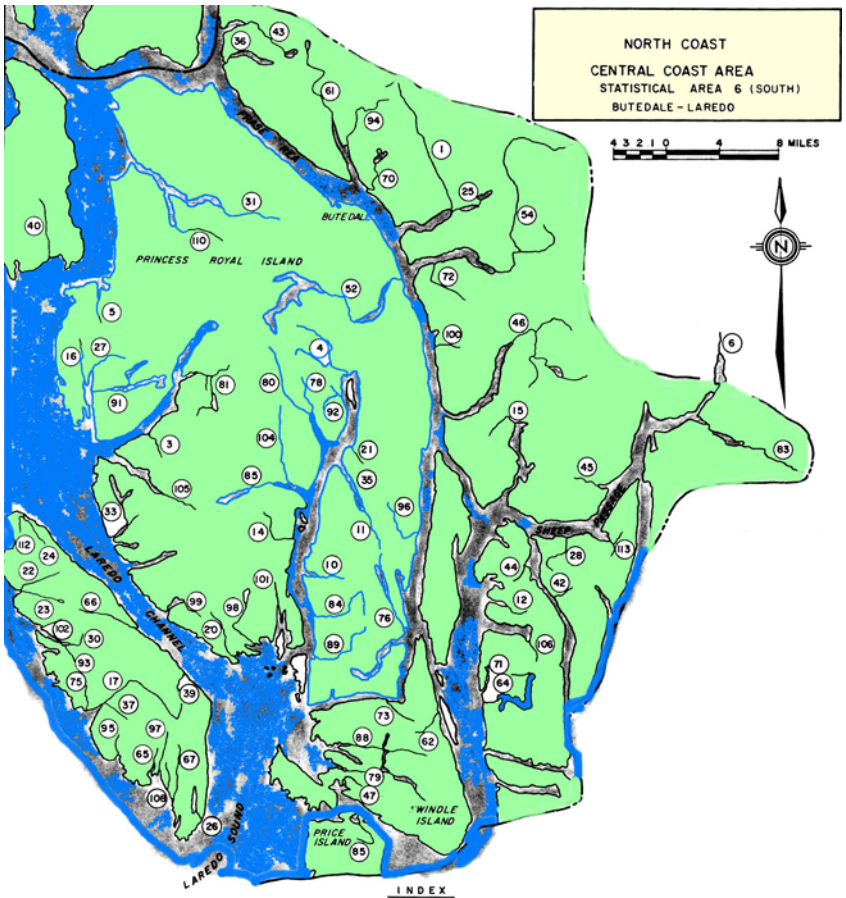
NOT RECOMMENDED Mixed stock management concerns re Kitlope etc. preclude additional harvest opportunities.

Other Potential Enhancement Opportunities Identified in 1983 (Class C except as noted)

Kitlope Facility – now a protected area (Class D)
Kildala Facility or Divided Channel for chums and pinks (more economic to reinstate production from Kitimat facility)
Hirsch Creek Channel / Facility for pink production (benefit/cost ratio is unfavourable)
Hirsch Creek fishway – falls at 10.5 km too high to be economic for fishway
Surf Inlet dam removal and access restoration – not feasible, no native stocks (Class D)

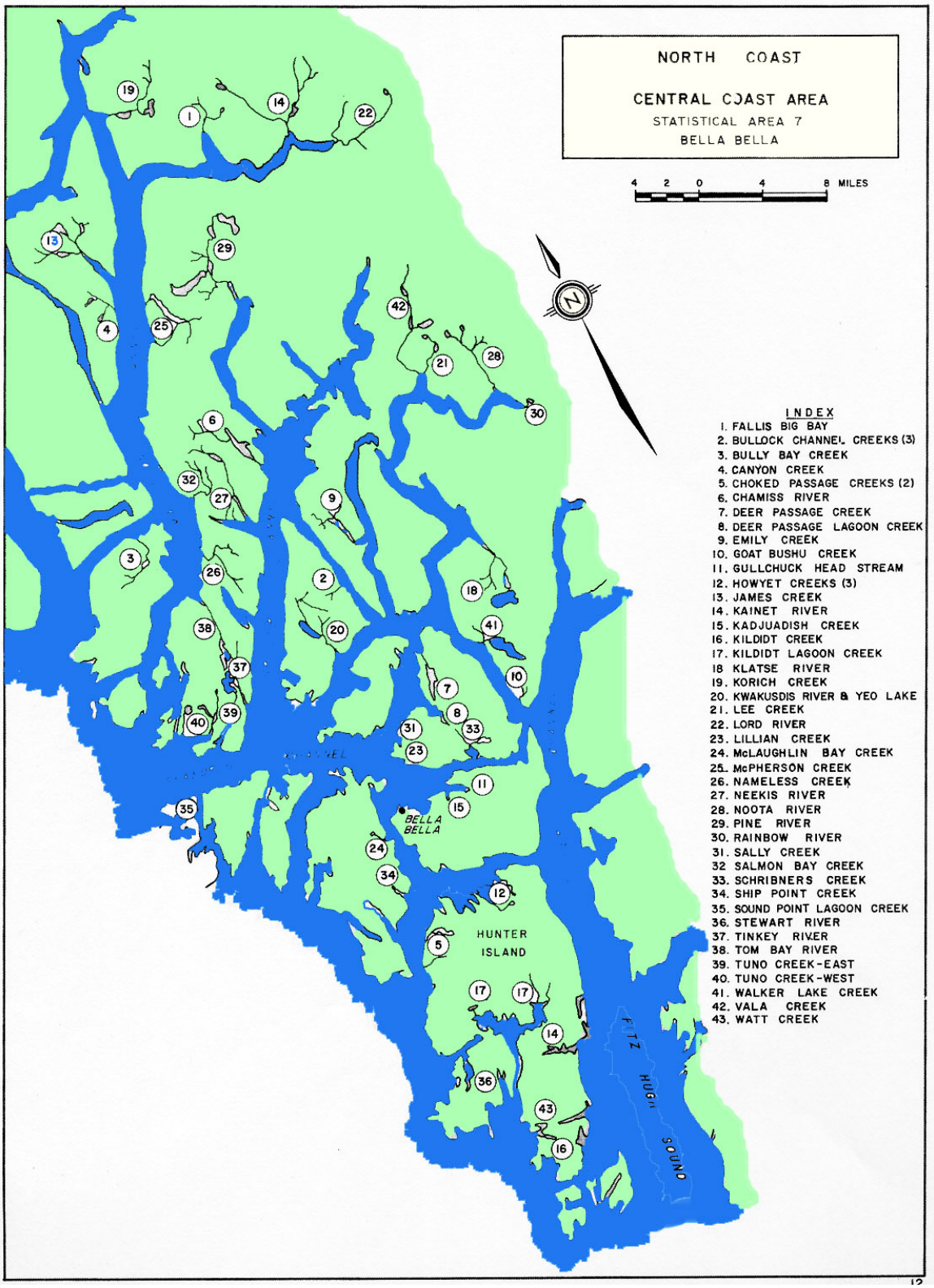
[1] It was noted by one of the Northern Panel members at the Feb 2008 meeting that some sockeye caught in Gardner Canal were a unique blue color, and were suspected to be Kitlope-origin stock

Area 6 (South) Laredo / Butedale



Our overall assessment is that Area 6 (South) has no opportunities for cost effective production scale enhancement on account of the remoteness of the area. To our knowledge there have been no practical projects identified since 1983 and any remaining infrastructure in Butedale is believed to be in very poor condition.

Area 7 – Bella Bella – Central Coast Inlets



The following is based on a flight to Bella Bella and site inspection of the McLaughlin Bay facility with DFO CA Sandie MacLaurin, an interview with the Tankeah Lake facility manager and a stream flight with Terry Palfrey, and a brief review of the DFO archives with respect to opportunities identified in 1983 as well as discussions with DFO personnel.

Our overall assessment is that Area 7 has very limited opportunities for cost effective production scale enhancement. There are two CEDP facilities in operation where modest expansions may be justified if the infrastructure, water supplies and staff capabilities warrant it. There is also one small AFS-supported sockeye hatchery operation based in Bella Bella.

Low prices and demand for pink and chum salmon impact particularly on the economics of working in the very remote potential sites previously identified in Area 7. However there is strong First Nation interest in sockeye production near Bella Bella for local consumption and the Kitasoo could potentially expand coho and chum production from their CEDP facility. The remaining infrastructure at Namu may be helpful in establishing a nearby sockeye enhancement opportunity.

Much of the area is protected so natural fish habitat conditions are not threatened. However many of streams in the Bella Bella area are naturally gravel deficient so a pilot project has been identified to address this shortcoming. A private investor has also expressed interest in remediating an old slide in the upper reaches of the Mussel River because he perceives it to be impacting on wild steelhead productivity.

7.1 McLaughlin Bay Heiltsuk CEDP 1M Chum Expansion (Rating: Class A /B - Provisional)

The McLaughlin Creek Hatchery is located on Campbell Island near Bella Bella, approximately 90 km west of Bella Coola. The Heiltsuk First Nation under contract to DFO operates the hatchery. Fall chum are not in need of rebuilding and are enhanced for fishing opportunities only. Coho are enhanced for local recreational fishing opportunities and to mitigate for the effects of the terminal chum fishery that incidentally catches some coho.

Chum are primarily caught in an Area 7 terminal directed chum fishery in Lama Passage and incidentally in the North and Central Coast interception fisheries. Small numbers of coho are caught in the Lama Passage chum fishery, North/Central BC commercial coho fishery, and in Alaskan fisheries. There is an increasing Hakai Pass and Bella Bella area coho sport fishery.

The funding committee accepted a 2008 concept proposal to double chum production from one to two million fed chum from this facility. The DFO Community Advisor believes that there is enough water to support increased production if the present strategy of incubation in freshwater plus direct transfer to sea pens is employed. However the water supply is very limited to 1 to 2 cfs and must be treated. There are sockeye and coho

above the intake. The infrastructure at this site is only in fair condition and badly needs refurbishment.

RECOMMENDATION: We provisionally recommend that chum production be expanded at this facility, but have concerns about the marginal water supply and the worn out infrastructure affecting its ability to produce consistently. We suggest that DFO be encouraged to invest in upgrading the infrastructure to ensure reliability before the PSC makes a long-term financial contribution to increased production.

7.1.1 Klemtu / Kitasoo CEDP Expansion (Rating: Class B/C - Provisional)

The Kitasoo CEDP project is operated by the Kitasoo Indian First Nation under contract to DFO at Klemtu in the Central Coast area. The original objective was to rebuild Klemtu Creek chum and coho stocks, but both stocks are now rebuilt. The chum are primarily caught in an Area 7 terminal directed chum fishery in Klemtu Passage and incidentally in the North and Central Coast interception fisheries. The Area 7 fishery incidentally harvests coho.

We did not visit this facility. DFO – SEP states that it has surface water only (1-2 cfs) and no room for expansion. The infrastructure is reported to be badly in need of refurbishment. Net pen rearing for additional coho production could be a viable option and the DFO community advisor supported a concept proposal in 2008 for a chum expansion that was not accepted on account of needing more work on the harvest side.

RECOMMENDATION: We provisionally recommend that consideration be given to some production increase at this facility if the harvest is manageable, but have concerns about the marginal water supply and the worn out infrastructure affecting its ability to produce consistently. We suggest that DFO be encouraged to invest in upgrading the infrastructure to ensure reliability before the PSC makes a long – term financial contribution to increased production.

7.2 Bella Bella Area Sockeye Enhancement Feasibility (Rating: Class B)

We had an opportunity to visit Bella Bella and talk to local people about the small AFS-supported enhancement project on Tankeah as well as other opportunities for sockeye enhancement in the area. The Heiltsuk put a high priority on sockeye production for food and ceremonial purposes for their large community in Bella Bella and would like to see expanded production.

The Tankeah operation involves remote incubation and rearing operations that are high risk and relatively small. Projects closer to the community would be more desirable for logistics and cost reasons, but would likely require higher infrastructure start up costs.

The Kadjusdis River system is quite close to Bella Bella and supports several salmon species including chum, pink, sockeye and coho. The 1983 Report identified potential for a major chum and pink facility and pen rearing in the estuary. DFO was to have repaired

the fishway there this past summer and there may be an opportunity to locate a pilot incubation sockeye facility and use floating raceways or net pens in the lake and /or estuary.

Namu also offers interesting possibilities for sockeye enhancement. Although a bit further from Bella Bella than Kadjusdis, there is some existing infrastructure that might be usable to reduce costs of an enhancement project.

RECOMMENDATION: We recommend that the PSC Northern Fund support the feasibility of enhancing sockeye at Kadjusdis and/or Namu if a qualified proponent working with DFO and the Heiltsuk brings forward suitable proposal(s).

7.3 Bella Bella Area Stream Pilot Gravel Additions (Rating Class A/B)

In 1983, 16 systems were identified as severely gravel deficient including Korich and McPherson Creeks plus Bottleneck Creek, Watson Bay Creek, Marg Cove and, Lagoon Creek across from Klemtu. It was estimated that pink salmon production could be increased by 88,00 adults and chums by 40,000 adults if an average of 2000 sq. metres were treated in each of the 16 streams. Gabions or boulder/log additions would likely be required to prevent the gravel from being washed away by storms. The Benefit/Cost of this proposal was expected to be excellent back then and should be viable today. There are barge operators and gravel producers on tidewater in Southern BC that could be approached to supply gravel for such an operation. A suitable proponent would need to have the services of qualified personnel to determine where gravel additions would be most beneficial and to provide appropriate prescriptions.

RECOMMENDATION: We recommend that a feasibility study directed at adding gravel to two to four streams as a pilot operation be supported by the PSC Northern Fund if a qualified proponent brings forward a suitable proposal.

7.4 Mussel River Slide Remediation Feasibility (Rating Class B?)

A prominent private citizen who believes that an “old” slide in the Upper Mussel system has adversely affected salmon and steelhead production in the system has approached PSF. This individual was prepared to provide a major donation for its remediation. An aerial spawning survey in August 2007 over the lower reaches did not detect any water quality problems but there could be a local upriver impact worth investigating by helicopter.

RECOMMENDATION: We recommend that DFO staff investigate this old slide site when flying the system for escapement purposes unless resources are made available for a special helicopter flight with an experienced engineer and biologist. The evaluation could investigate fish passage feasibility or possible implementation, habitat restoration prescriptions, low-tech facility water supply and site feasibility.

Other Potential Enhancement Opportunities Identified in 1983 (Class C)

Four central major enhancement facilities were identified in Area 7 – each with satellites to several other systems. Bioengineering reconnaissance was done and the results reported in archived files and in the 1983 report.

The most promising locations were:

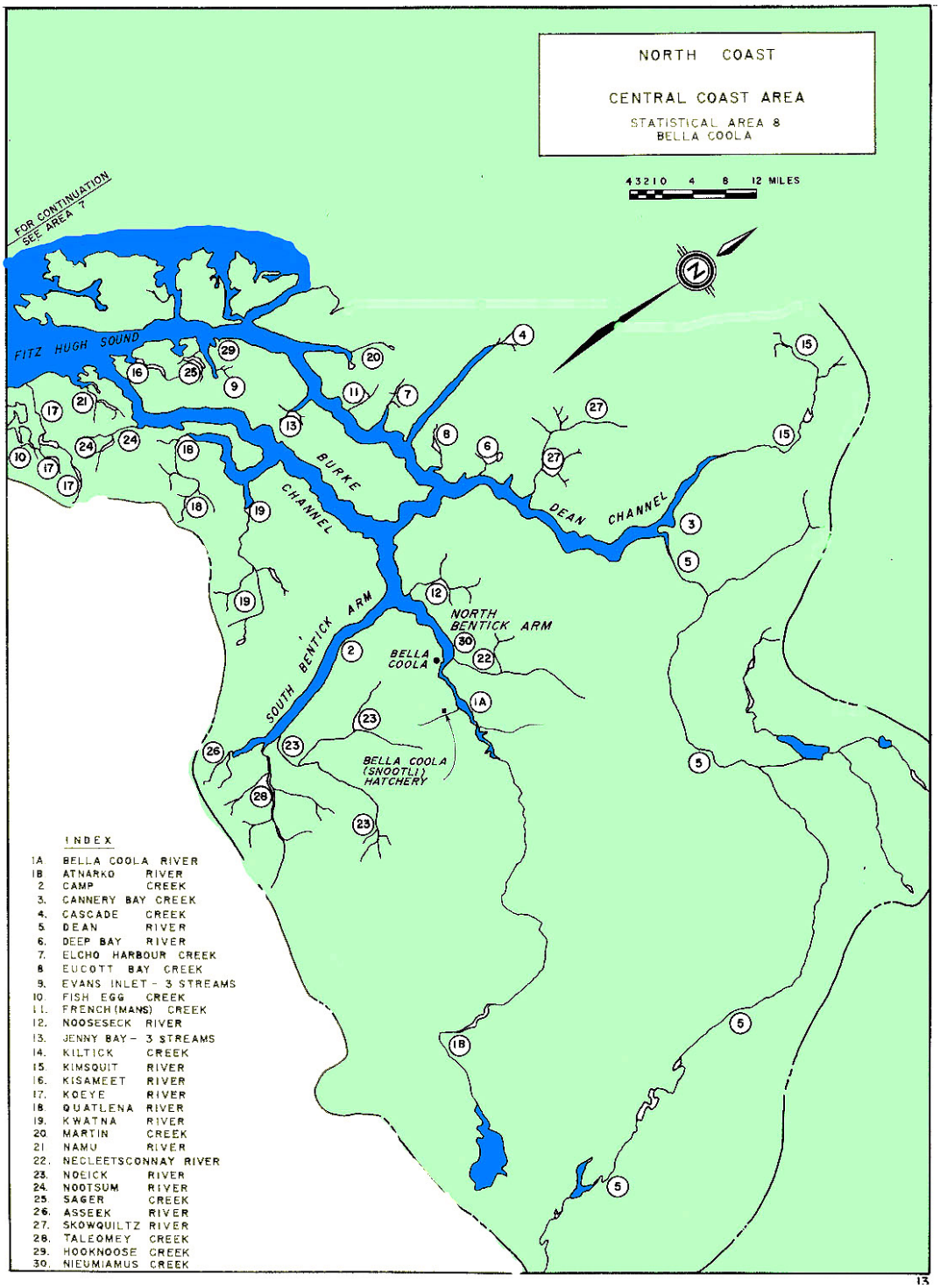
1. Kynoch Central (coho, chum, pink) – satellites/ colonization to Lard, Big, Mussel River, Poison Cove, Kouch Creek, McPherson Creek, Canyon Creek, Geish Creek, Gorilla creek, Windfall Creek, Duthie Creek;
2. Roscoe Inlet Central on Clatse (chum, pink, coho) – satellites to Quartcha, Lee, and Roscoe creek;
3. Neekas Central (coho, chum and pinks) – satellites to Windfall, Robinson, Tom Bay, James Bay, Salmon Bay, Nameless Bay, Tuno creeks, Tankeah, Hauser, Pine River;
4. Kadjusdis Central (chum, sockeye, pink) – satellites to Kwakjusdis, Gullichuk, Scribner, Cooper Inlet Creeks, Sip Point Creek, Hunter Channel creeks, McGee creeks

NOT RECOMMENDED: With low chum and pink prices and much of Area 7 in protected status, it is extremely unlikely that any of these projects would be viable today. The cost of construction is beyond the capacity of the PSC Northern Fund.

Other Potential Enhancement Opportunities Identified but rejected in 1983 (Class D)

Also identified but with marginal benefit/cost ratios were:
Walker Lake Creek Central facility (pink, chum) with a satellite to Goat Bushy Creek using a supply from a 12 metre falls;
Ingran and Ellersle Lake transplants / fishway later (sockeye and coho)
Carter River Central facility – alternate to Kainet

Area 8 Bella Coola / Central Coast



Our overall assessment is that Area 8 has some promising opportunities for additional production scale enhancement.

Our assessement is based on two visits to Bella Coola and flights to Bella Bella, Ocean Falls and a stream flight with Terry Palfrey, field and facility inspections with Sandie MacLaurin, Wayne Peterson, Russ Hilland and Neil Oborne and feedback from a public workshop in Bella Coola.

Snootli Creek Hatchery is located at the head of North Bentick Arm on the Bella Coola River near the town of Hagensborg. It is small-medium size facility – one of the earliest SEP facilities to use Japanese technology for chum production. An unmanned spawning channel and earthen rearing channels are located adjacent to the Atnarko River in Tweedsmuir Park. Facility has ground (3.6 cfs) and surface water (5 cfs) available, multiple rearing containers and reliable fish culture experience. The facility is a "satellite" facility, designed to culture many different stocks in segregation and return them to their natal streams. A separate satellite facility was built to culture individual sockeye stocks in isolation. The facility is currently working with community groups to re-build severely depressed Chinook stocks in Rivers Inlet and sockeye from Bella Coola and Lakesle.

Snootli Hatchery was designed to increase adult chum returns to various stocks on the Bella Coola River to increase fishing opportunities and mitigate the effects of spawning habitat loss in the Lower Bella Coola River and its tributaries. Chinook and coho enhancement began in response to declines associated with high exploitation in non-target (mixed stock) fisheries. The hatchery is also responsible for maintaining a pink spawning channel to buffer against the loss of natural production during high water events.

The majority of Atnarko Chinook is harvested in non-target fisheries in Alaska (30%) and the North Coast Areas (17%). The targeted terminal fisheries occur in Area 8 and include a gillnet fishery, First Nations FSC fishery and recreational fishery. Wannock River Chinook are exceptionally large bodied, red-fleshed fish, much prized by recreational anglers.

The chum fishery targets enhanced chum in North Bentick Arm. The hatchery has been very successful in providing a large, consistent commercial catch almost every year since operations began. An average of 109,000 (26%) chum have been harvested in Area 8 between 1985-1999.

8.1 Snootli Facility Optimization Strategy – Chinook, Coho, Pinks (Class A)

This strategy will involve four separate, but linked initiatives to allow the facility to culture 500k yearling Chinooks as per the previously approved PSC submission without excessive moving between containers which is hard on the fish and adds extra operating costs as well as realizing the full potential of the satellite Atnarko channel. It will be able to resume full production of coho and pink salmon as well as supporting the hatchery satellite semi-natural rearing operation in the upper portion.

a) Realign Atnarko River flow past the Atnarko Channel intake

A 2008 concept proposal was submitted by Neil Oborne and involves river training in February-March 2008 to allow the Atnarko channel to operate effectively. A bar has formed restricting flow past the intake and reducing flow into the channel to 15-20 cfs from the 50 to 70 cfs required. The proposal was conditionally accepted. With DFO assistance, Mr. Oborne should be able to provide all of the information requested.

b) New well on an adjacent lot to increase groundwater availability at Snootli Facility
c) One additional rearing channel for Chinook production
d) Improvements to the surface water supply to eliminate a disease pathogen

A 2008 concept proposal was submitted by Russ Hilland for items b), c) and d) and it was also conditionally accepted. The Snootli facility has a very experienced fish culture staff but does have some infrastructure constraints that this proposal will address. A semi-natural rearing option is not available at Snootli on account of a high water table and it would not be cost effective from operational and well –water perspectives to increase semi-natural rearing at Atnarko considering the distance to Snootli and lack of three - phase power at Atnarko for increasing well pumping capacity

DFO is fully involved in the design and implementation of both these projects.

FULLY RECOMMEND FOR 2008

8.2 Saloomt Obstruction Alleviation – Chinook, Steelhead, Coho (Class A)

The Saloomt River is a tributary of the Bella Coola and is receiving Chinook enhancement from the Snootli Facility. It is also an important Steelhead river but there is limited high quality habitat below what is believed to be a complete obstruction. There has been some blasting done already to alleviate this obstruction by DFO with the intention of opening up a considerable amount of high quality habitat for Chinook and steelhead. Additional returns are expected from hatchery operations so additional habitat would positively benefit self-sustaining runs at a higher level.

After discussion with Russ Hilland and Al Lill, a 2008 concept proposal was submitted by Neil Oborne to do the blasting in February. Unfortunately the funding committee rejected the proposal on the basis of insufficient data and a concern that the province would not support the project. However it is our understanding that the project would have received support from the province since it would benefit steelhead.

The concept proposal was for a low cost blasting operation and if it was done with an experienced person well-versed in adult fish passage requirements there is every reason that it should be successful in passing Steelhead under most flow conditions and should also pass Chinook under most flow conditions. There's a tradeoff here in terms of increasing the certainty of success with a more expensive installation and more detailed

formal documentation and the proposed low cost option that would likely be successful if undertaken by experienced people. Some provincial partnering could be expected through FIA.

RECOMMEND FOR 2009. **A new concept proposal should be submitted in 2009 that provides an estimate of the amount of quality upstream habitat to be opened up compared to what is available below the obstruction. Provincial endorsement and possible co-funding through FIA should also be obtained. The name and qualifications of the person experienced in fish passage who will be available to assess the obstruction before and after the work being done should also be provided.**

8.3 Tarrant Creek (South Bentinck Arm) Chinook Enhancement (Class A/B)

Tarrant Creek is a tributary of the Talomey River in South Bentinck Arm and it formerly supported a fairly large run of Chinook. DFO Fisheries managers and local fishermen are keen to see recovery of South Bentinck stocks as the basis for a sustainable local fishery and these stocks would also contribute in Alaska and to all northern fisheries. Chinook is the most desirable species for enhancement to a production scale in South Bentinck Arm because of its value and to provide additional productive capacity for these stocks in the face of mixed stock fisheries in the Bella Coola area and beyond. However in the course of early pilot enhancement work on the Talomey, some additional reconnaissance of opportunities for other species on the Talomey and other nearby rivers including the Noeick should be done.

After discussion with Russ Hilland and Al Lill, a 2008 concept proposal was submitted by Neil Oborne. The proposal involved some fry trapping in the spring of 2008 to gauge production from the 2007 spawners and timing and age composition info that will be used in the design of Chinook rearing habitat to increase capacity for yearling Chinook production. There would also have been an egg take of up to 100K Chinook eggs in the fall of 2008 and the fry planted back into the new rearing habitat as fry in the spring of 2009. The project should have been continued for one cycle to increase seeding of the system and to fully utilize the new habitat that has been created. It may be necessary to do some additional work to improve Chinook incubation conditions in the Tarrant Creek tail out in the Talomey River. It would also be desirable to increase protection in the fisheries to increase escapement over the same four-year period and to increase runs to improve egg take success.

Unfortunately the funding committee rejected the 2008 concept proposal as being five to ten years ahead of its time. However we feel that pilot scale enhancement needs to be done sooner rather than later especially as production is increasing from the Snootli Facility and these local stocks may be over-harvested in increased fishing effort targeted on Bella Coola stocks.

RECOMMEND FOR 2009: A new concept proposal should be submitted in 2009 that could be very similar to the 2008 Concept proposal (backdated one year) that addresses any concerns raised since within DFO. We also suggest that local

fishermen be recruited to provide their boats at cost so as to support the logistics required in this relatively remote area. The proponent should also seek other funding partners such as FIA and ensure the province has vetted the proposal.

8.4 Quatelena River Enhancement – Coho, Pink, Chinook (Class A/B)

The Quatelena drains into Kwatna Inlet – an area with excellent potential for an enhanced terminal opportunity possibly through a fishermen's co-op. A potential first project for consideration in 2009 or later would involve improvements to a chute that presently restricts passage under certain water conditions to 1.1 km of habitat. It could also include fieldwork to explore possibilities for a low-technology gravity –fed incubation facility that could be used to enhance Kwatna Inlet Chinook stocks and/or habitat improvements in the Quatelena above the chute.

RECOMMENDATION: Recommend for 2009 or 2010. A concept proposal should be sought from an experienced (preferably local) person with respect to fish passage feasibility or possible implementation, habitat restoration prescriptions, low-tech facility water supply and site feasibility. There should be full liaison with local DFO, MoE and Forest Service staff.

8.5 Kwatna River Side – Channel(s) – Chum, Coho, Steelhead (Class B)

The Enhancement Opportunities Report (Lill et al 1983) identified the Kwatna River as having considerable potential for both a hatchery facility and at least two spawning channels with direct river intakes. The system is the largest in Kwatna Inlet and one of the largest in Area 8 and supports most salmon species and steelhead. It has an excellent estuary and the impacts of past logging seem to be largely overcome and roads have been put to bed. It was probably a more feasible site for enhancement in 1983 than today as prices for pink and chum salmon have declined, the logging infrastructure has been removed and roads would require rehabilitation. The airstrip is also believed to be unserviceable, but the Kwatna is within easy boat access from Bella Coola and has the most potential outside of the Bella Coola River system itself. It could support enhanced terminal commercial and recreational fisheries that wouldn't impact significantly on passing stocks.

The most viable enhancement opportunities would probably be good side channel project(s) with a combination of direct and indirect intakes (using an array of perforated pipes to capture significant groundwater) to achieve consistent rearing flows and enough water to attract spawners. One project should ideally be sited in a reach adjacent to significant chum spawning so as to attract chums in preference to pinks. Side channel options further upstream should also be pursued that would benefit Chinook, coho and steelhead.

RECOMMENDATION: A concept proposal should be entertained from an experienced (preferably local) person and a fisheries engineer that is experienced in side channels with combination direct and indirect intakes. The feasibility /

conceptual design work should include basic surveys, digging test pits and restoring road access from tidewater so should be spread over two years with the more expensive work reserved for the second year assuming promising sites are identified in the first one.

It would be practical and cost effective to combine this project with the Quatelena work previously identified.

8.6 Bella Coola River System Sockeye Enhancement (Class B – pilot expansion; Class C - later stocking of Charlotte Lake))

The Nuxalk First Nation submitted a concept proposal in 2008 to scale up their existing operation with the view of expanding it in future to seeding inaccessible Charlotte Lake to take advantage of this lake's considerable potential for sockeye production as identified by DFO Science. Charlotte Lake is a very large hanging lake (66 km^2) on the Upper Atnarko River. It could support a population of 10 million fry (Shortreed et al. 2001). Any fisheries management/conflict with steelhead is unlikely since winter steelhead migrate later than sockeye. They proposed to utilize the existing sockeye enhancement facility (isolated) at Snootli Hatchery and to work cooperatively with DFO staff. In rejecting their concept proposal, the funding committee was concerned that the proposal might overtax staff capacity at Snootli and may also be confounded by poor marine survival that may be limiting sockeye production in this system. There are also provincial concerns about stocking Charlotte Lake to be overcome but that was not envisaged at this early stage.

We have consulted with Kim Hyatt from DFO Science on the issue of poor sockeye returns this year. There was poor performance coast-wide that was quite unprecedented in his experience. A number of causative factors could be at play including food availability and increased predation. However there is no evidence that we are aware of that the Bella Coola is facing unusual early marine survival problems similar to those experienced at Rivers Inlet. The Nuxalk First Nation amongst many others in the North Coast places its highest priority on sockeye and can be expected to bring partnered funding and in-kind staff to any project it proposes. The Snootli Hatchery staff is fully supportive of this work.

RECOMMENDATION: CONSIDER FOR 2009.
A new concept proposal could be supportable in 2009 that would be very similar to the 2008 concept proposal (backdated one year) as long as production is designed at an appropriate pilot scale with sufficient evaluation built-in to determine if the overall project has been successful. The relatively small first step project proposed may produce measurable benefits since the accessible portions of the Bella Coola supported much larger runs in the past. Innovative harvesting techniques are possible to reduce any concerns on impacts to other species.

Aquaculture Grow Out Facility, Ocean Falls -May 24, 2007

8.7 Ocean Falls Demonstration Pilot Chinook Facility (Class B)

There is an existing $16 Million aquaculture grow-out facility and an old dam previously used by the pulp mill plus an electrical generation plant located in Ocean Falls. There is also available crown land and supporting infrastructure that is unique in the Central Coast. The water temperature and quality regime is not optimal for fish culture necessitating some treatment, but the aquaculture operator has overcome these problems. (eg, seawater addition and recirculation system).

The existing infrastructure and gravity supply coupled with a potential terminal area in Cousins Inlet make this a very attractive opportunity for new stock enhancement without the management problems associated with other facilities. At this time no potential proponents have been identified. We would recommend that a relatively portable pilot scale facility be developed in cooperation with aquaculture operator, but it would need to be completely self-contained.

This project has been discussed with Ron Ginetz in DFO who has long experience with the aquaculture industry as well as conventional enhancement. He believes that it may be quite possible to engage the industry in a cooperative demonstration project and take advantage of the operator's expertise. It may even be possible to negotiate some short-term sharing of the treated water supply for a pilot.

HIGHLY RECOMMENDED with a suitable proponent

This may be the single most important and innovative enhancement / stock management pilot project that should be pursued in Canada by the PSC Northern Boundary Fund. It will require a proactive approach in selecting a suitable proponent as well as full DFO and provincial cooperation, but has immense future potential for producing significant returns that would be fully manageable in a set of discrete terminal commercial and recreational fisheries.

8.8 Martin River Flow Restoration and Habitat Protection (Class A/B)

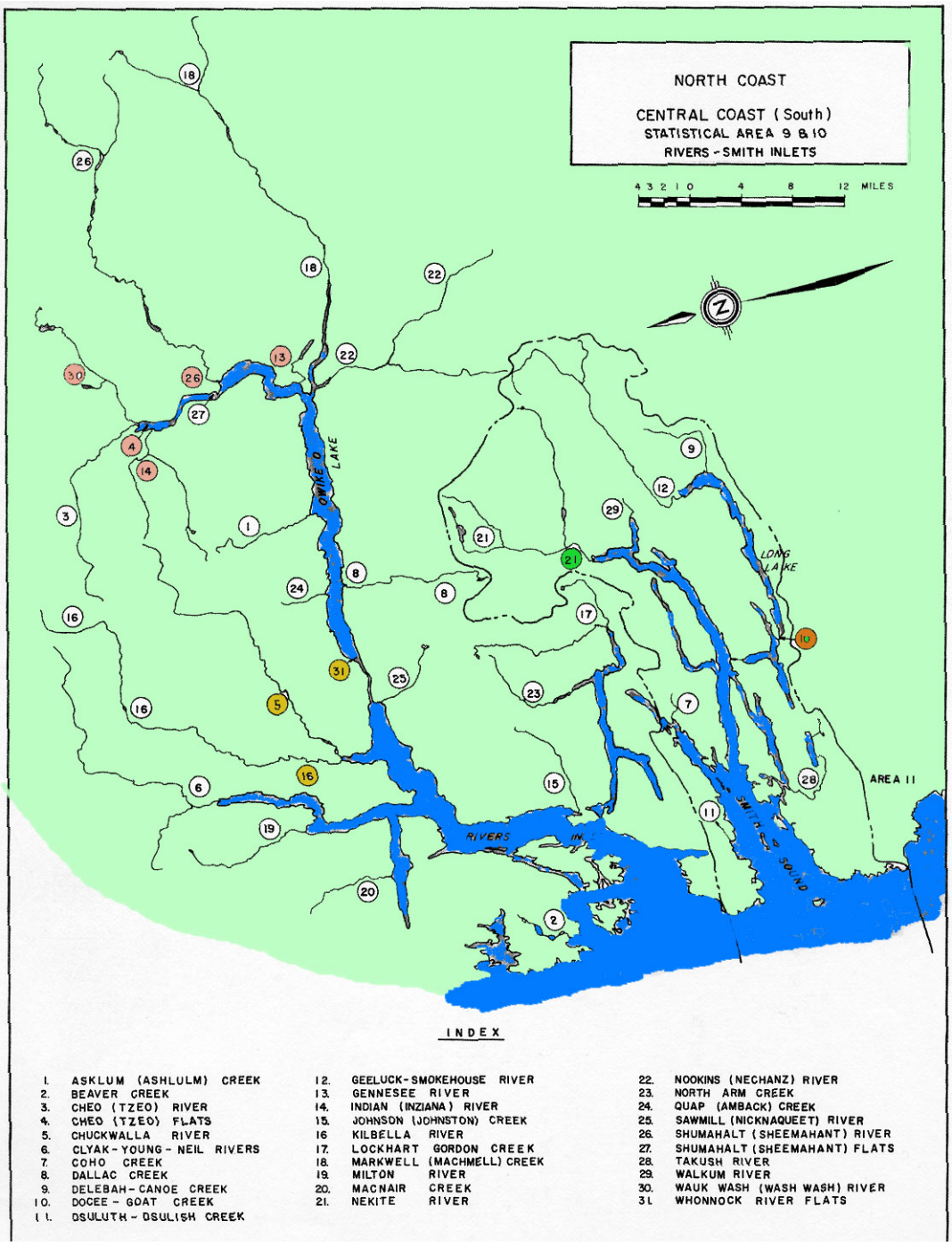
The Martin River flows into Cousins Inlet to the west of Ocean Falls and is road accessible near its mouth. Ex DFO Fishery Officer Lyle Enderud says this is a fantastic coho producer and its very valuable fish habitat is largely intact and needs to be fully protected if there is any expansion of housing development from Ocean Falls if the community is revitalized. There is a high elevation diversion tunnel from the Martin River to Link Lake that was installed to increase power production potential in Ocean Falls. While the Central Coast normally receives a lot of rainfall, with climate change there could be instances in the summer-fall months when flows could become quite low in the Martin River and it would be wise to eliminate any possible diversion as a precautionary measure. Since the pulp mill has shut down and the community at Oceans Falls is quite small, the need for this diversion has probably been eliminated and we recommend any water licenses still in place should be cancelled and the diversion blocked off.

RECOMMENDATION: Highly recommend a site inspection of the diversion and exploration of enhanced habitat protection or watershed acquisition by Nature Trust or another Foundation. It would be very desirable to reinstate the natural flow regime in Martin River and place protective reserve on its unique and very productive habitat to protect the system from encroachment by future development or logging. (This could also be a very good system for a wild coho index stream since it is close to the village of Ocean Falls and relatively accessible for monitoring.)

Other Potential Enhancement Opportunities Identified for Area 8 in 1983 and at the workshop in Bella Coola

- Kimsquit Central facility – not feasible on account of Dean River steelhead manageability concern (Class D)
- Hooknose Central facility (Class C)
- Sager Creek fishway (needs review likely Class C))
- Koeye Central facility = coho, chum, pink (Class C)
- Kwantna Combination facility/channels/Qautlena and Nootsum satellites Chinook, coho, chum, pink (Class C except side channels noted above)
- Nieumiamus Creek pens, satellite from Snootli chum. pink (Class C)
- Nooseeseck Chum satellite (Class C)
- Noeick Creek sidechannels and fishway – no access, too remote for an economic project for chum production (Class C)

Areas 9 and 10 Rivers and Smith Inlets



Our overall assessment is that Areas 9 and 10 currently have no opportunities for cost effective production scale enhancement with the exception of rehabilitation of the Nekite Spawning Channel. However there may be some possibilities for reducing seal predation and conducting habitat improvement for coho on Neechanz or other Owikeno tributaries.

Our assessement is based on a workshop in Vancouver and a flight to Long Lake and Nekite with a site inspection of the Nekite spawning channel with Karl Wilson from DFO, Vic Ewert and Doug McCorquodale plus members of the Gwa'sala-'Nakwaxda'xw Nation. We also conducted a brief review of the DFO archives with respect to opportunities identified in 1983 and held considerable discussions with DFO personnel.

Rivers and Smith Inlets have been the focus of considerable attention over the last several years on account of the crash of their sockeye populations from levels that formerly supported a very viable commercial fishery. Unfortunately it appears that near shore marine conditions are probably the cause of the collapse and are currently limiting production. Freshwater enhancement at least at this point in time seems to be questionable until the root causes of the decline and current low numbers are determined and solutions (if any) are found.

The large Chinooks returning to Rivers Inlet are highly prized by sports fishers and there continues to be a very high interest in increasing their numbers along with coho salmon which frequent many systems in the area including tributaries to Owikeno Lake..

9.1 Rivers Inlet Expanded Chinook and Coho Enhancement Feasibility (Rating Class C/D)

The local people in Rivers Inlet have been participating in a Chinook satelliting operation from Snootli hatchery and undertaking of conservation-scale enhancement of Wannock River Chinook. Previously a C.E.D.P hatchery operated on Wannock stocks, but was closed by DFO for a number of reasons including a very poor site and limited personnel capacity for year-round operation in the small village. A few years previous, there was also a Chinook facility on Chuckwalla / Kilbella operated by local lodge operators, but it too had a number of problems and was closed.

Not withstanding strong local interest in developing a year-round self-contained facility, we believe that the present satelliting operation from Snootli Hatchery has a number of distinct advantages and should be continued if Chinook and coho enhancement is desired at conservation or limited production scale levels. It offers opportunities for developing expertise locally under the guidance of Snootli staff and could be expanded to some degree as stocks recover.

Site conditions for a hatchery near Oweekeno village are not good and local capacity remains limited. The partnership with Snootli Hatchery does have fairly high transportation costs, but these pale by comparison with a year-round fully functional hatchery that would be extremely expensive to build and operate in this remote area with limited services and experienced personnel. For example the gravity water supply would probably have to be obtained from the former Dominion hatchery stream and piped under the Wannock River to a site near the village. The required expertise to manage the facility would probably have to come from non-resident staff that would work in one-week-on one-week-off shifts similar to the aquaculture facility at Ocean Falls and they would need

suitable housing while on site. We understand recent water testing as also confirmed problems with water quality.

We suggest that addressing other limiting factors such as seal predation may be more effective in increasing Chinook populations.

RECOMMENDATION: The PSC Northern Fund should be extremely wary of making any investments towards a new hatchery facility in Rivers Inlet and should encourage the local people to continue and potentially expand the present satelliting operation from Snootli and explore other non-hatchery approaches to increasing production of Chinook and Coho.

9.1.1 Rivers Inlet – Wannock Chinook - Seal Predation Deterrent Reconnaissance/ Pilot Feasibility (Rating Class A/B)

We suggest that addressing other limiting factors such as seal predation may be effective in increasing Chinook spawning success. Non-lethal means to discourage seal predators on both smolts and adults were evaluated in the Puntledge River in 2007 using an electric barrier (http://www.smith-root.com/). In two deterrence trials, seals reacted when a very mild electric barrier was turned on, and then vacated the area. As a result of these tests a full –scale operation was proposed and accepted for funding in 2008 by the PSC Southern Boundary Fund. We understand that Smith Root has also helped the PSC staff in dealing with seal predation in test net fisheries in the Fraser River.

On the basis of this promising work, a reconnaissance / feasibility assessment of a similar application could be worthwhile for the Wannock River in Chinook spawning areas or known locations where seals are feeding on adult Chinooks. It might even be feasible to use an electric field to reduce predation on migrating Chinook and sockeye smolts if it can be determined that seals congregate in certain areas where the smolts are migrating.

RECOMMENDATION: Basic reconnaissance followed by pilot feasibility trails if deemed worthwhile in the field.

9.1.2 Owikeno Lake Streams coho side channel bioengineering reconnaissance / feasibility surveys (Rating Class B/C)

A bioengineering team would be required to look for possible side channel or other habitat restoration projects on Owikeno Lake tributaries such as the Neechanz that is well known for large coho salmon. Many of the larger tributaries like Machmell have received heavy logging pressure but there may still be opportunities for low impact, low maintenance projects that would help to preserve and perhaps increase coho productivity.

At the Rivers Inlet workshop it was suggested that improved knowledge of logging impacts (site specific and cumulative) to freshwater and estuarine habitat was a high priority. All sensitive habitats in Owikeno and Long Lake watersheds should be identified and prioritized for protection and potential restoration. The emphasis was on

Chinook and sockeye with a lower priority for stream-rearing species like coho that would benefit from stream restoration and enrichment. There was little or no potential identified for production-scale enhancement using semi-natural techniques

RECOMMENDATION: In the long –term consider basic bioengineering reconnaissance by qualified and experienced restoration specialists followed by feasibility surveys if potential projects are identified.

Other Projects identified in 1983:

Rivers Inlet Chum Enhancement (Rating Class C/D)

Owikeno Lake Tributaries Sockeye Enhancement (Rating Class C/D)

a) Genesee Facility - gravity feed with float camp nearby

b) Channels on tributaries

c) Enrichment – upper basin

None of the above are recommended for early consideration

10.1 Nekite Spawning Channel Rehabilitation: (Rating Class A)

We assisted the Gwa'sala-'Nakwaxda'xw Nation in preparing a 2008 concept proposal for rehabilitating the long-neglected DFO chum spawning channel on the Nekite River at the head of Smith Inlet. This was in response to a DFO request to assist in initiating concept proposals for the most promising projects that we had identified early on in this contract. The Nekite stock can be fished selectively at the end of a long inlet so is an excellent prospect for a discretely manageable local fishery within reasonable distance from processing capacity in Port Hardy (Appendix One).

A very capable ex-DFO spawning channel operator was subcontracted by us to provide technical assistance and included in the site visit. Subsequently, Vic Ewert prepared very detailed cost estimates for us as well as the primary Gwa'sala-'Nakwaxda'xw Nation proponent and made preliminary arrangements with an experienced contractor to provide the required equipment by a barge service.

We are very impressed with the dedication of the Gwa'sala-'Nakwaxda'xw Nation who have been voluntarily providing stock assessment on the Nekite system for many years with their AFS resources. We are confident that long term evaluation and operation of this channel will be done at minimal cost to the PSC Northern Fund if they support a rehabilitation of the channel. As the channel is somewhat above the upstream range of wild chum salmon in low escapement years, some seining and adult seeding of the restored channel may be required to kick start production.

RECOMMENDATION: The Gwa'sala-'Nakwaxda'xw Nation should resubmit their concept proposal in 2008 and we strongly recommend that the PSC Northern Fund support channel rehabilitation if it is to be directed by DFO and a capable and experienced spawning channel specialist such as Mr. Ewert.

10.2 Long Lake Sockeye Enrichment / Predator Control Pilot: (Rating Class B/C)

Liquid fertilizer was applied by aircraft in Long Lake for many years as part of an aggressive enrichment program by SEP. The program was discontinued largely because of the unintended response by stickleback. The increase in stickleback populations offset much of benefits of increased sockeye growth and potential survival. We understand that an assessment of this program is underway by Steve Cox-Rogers in DFO.

As discussed in Chapter 4, there was a substantial increase in escapement in 2002 to 100,000 sockeye but the population crashed again to 4,000 escapement in 2006. This crash may have been the result of a combination of poor smolt recruitment from this escapement coupled with severely adverse conditions in the marine environment.

Following the Cox-Rogers assessment, it may be worthwhile to consider a pilot project utilizing a combination of stickleback control and boat-applied enrichment to improve freshwater productivity on the basis there was a limited marine density-dependent effect at play and more smolts out will produced more adults back even under adverse marine survival conditions. The successful Wahleach operation (Perrin et al. 2006) may provide useful guidance but it was on a much smaller lake in the eastern Fraser valley. This potential project has been ranked B/C because it would be wise to test the combination of stickleback control and enrichment on a smaller coastal lake that is more accessible and less costly to work on that Long Lake. (See further discussion under Constraints to Enhancement – Chapter 4). Dr. Kim Hyatt (Pers. Comm.) indicates to us that the marine response is an extremely complex issue and there is no ready answer to this question of density dependence. It could indeed be highly variable from year to year and the only way to find out is through pilot testing.

As noted above we are very impressed with the dedication of the Gwa'sala-'Nakwaxda'xw Nation who have been providing stock assessment on the Long Lake system for many years with their AFS resources. They should be quite capable of doing such a pilot augmentation to their existing Docee fence operation as long as they receive good technical support and a sound implementation and monitoring plan is developed. The Docee might also a good area for testing seal predation avoidance using electrical files as noted for the Wannock system in project 9.2

Canadian Southern Areas Contributing to Northern Boundary Fisheries

Conuma Hatchery Area 25 (Class A)
Robertson Creek Hatchery Area 22 (Class A)
Nitinat Hatchery Area 21 (Class A/B)
Quinsam Hatchery Area 13 (Class B)

The above major DFO facilities are the most significant contributors to Northern Boundary Sport and Commercial Chinook fisheries in Southern BC. A facility review undertaken by A. Lill in 2003 for DFO revealed that their production outputs have been severely constrained by budget limitations.

For a relatively low additional cost per adult expected in fisheries, the productivity of these facilities could be improved since their basic operating and maintenance costs and trained permanent staff are covered by DFO. The Quinsam Facility has been given a lower rating than the others because of relatively poor marine survival of returning Chinook salmon in recent years. This could be because of its location, release strategies and/or insufficient assessment to determine its true contribution to fisheries.

It was beyond the scope of the contract to examine in detail the potential for facilities outside of Areas 1 to 10. However production benefits have been reasonably well documented at least historically and excellent in-facility records are still being maintained. Therefore it should not be difficult for DFO to develop proposals for consideration by the Northern Boundary Fund that may be superior in terms of Northern Boundary fishery benefits to most new project proposals within Areas 1 to 10.

RECOMMENDATION: The PSC Northern Boundary Fund seriously consider proposals from DFO for acceptable refinements to these existing enhancement facilities that will increase the Chinook productivity of those facilities for the benefit of Northern Boundary fisheries.

Chapter Four: Salmon Enhancement Constraints

Only 36 potentially good enhancement projects were identified for short –term implementation because there are significant constraints to enhancement in Northern and Central BC (and limited additional bioengineering reconnaissance was possible under this contract.)

Weak Economics and Lack of Cost Recovery for Investors

Over the last 25 years the cost of enhancement activities has risen sharply, particularly in terms of construction costs, while the commercial prices for salmon have remained stable or declined. The costs in northern BC are also higher than in the south because of the isolated nature of many of the projects and limited road access to many potential enhancement sites.

Integrated enhancement and fisheries harvesting is predicated on the ability of participating commercial fishers to profit while engaging in the fishery. If the value of the harvest is less than the fishing costs (boat, fuel, nets) there is very little incentive to fish. Profitability is maximized by targeting high valued species like sockeye and Chinook. The relatively low value of pink and chum renders it more difficult to justify enhancement of these species unless the unit cost of production is very low (Figure 2).

Higher commercial prices coupled with the considerable value of recreational fisheries in Northern and Central BC to the economy of BC is making species like coho and Chinook more attractive candidates for enhancement activities provided that the unit cost of production is acceptable to achieve an acceptable Benefit/Cost ratio.

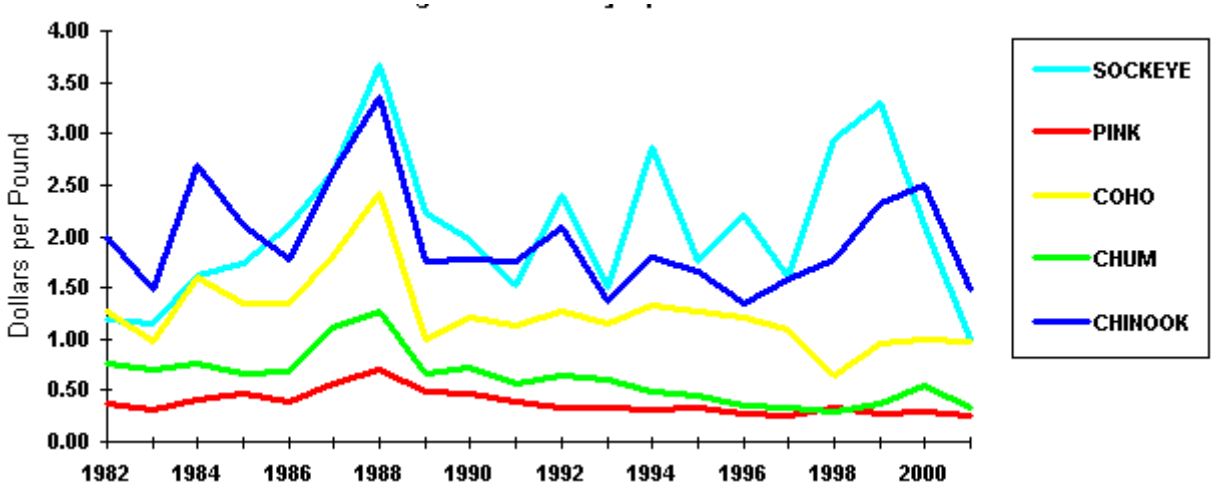


Figure 2. Average fish price by species between 1982 – 2001. Source: http://www.bcsalmon.ca/database/price/fishpric.htm

The 2006 ***Laroque*** court decision has impacted cost recovery for enhancement activities. This ruling prevents DFO from using quotas of harvested aquatic species in exchange for scientific surveys and stock assessment activities. The court ruled that such activities were illegal because the minister was in effect misappropriating resources that did not belong to him. ***Laroque*** appears to have significant cost-recovery implications for existing enhancement operations such as Pallant Creek and may preclude new similar pilots. Without cost recovery the case for investing in salmonid enhancement is considerably weakened and indeed it was a primary factor in the failure of DFO to secure resources for a second Phase of the Salmonid Enhancement Program in the mid 1980s. As a result many of the opportunities proposed in the 1983 report were never implemented in Northern and Central BC.

Salmon Ranching Policy

Canada also does not have a policy to permit salmon ranching that would encourage private investment in locations where enhanced stocks could be harvested discretely in a terminal area. Salmon ranching is defined in Smoker et al. (2000) as "an aquaculture system in which juvenile fish are released to grow, unprotected, on natural foods in marine waters from which they are harvested at marketable size". According to this definition, many SEP activities including hatchery operations are a form of ocean ranching. There is a key difference in ocean ranching between Canada and Alaska. In Canada, the enhancement fish contribute to common-property fisheries, while in Alaska, the fish are produced and harvested, in part, by private, non-profit corporations. Operating costs for these facilities are recouped from a special harvest of returning adult fish, called a cost-recovery harvest. In Canada, operating costs for hatcheries and other salmon enhancement facilities are covered by public funding administered by DFO.

In some cases, terminal commercial harvests of enhancement fish have been licensed in Canada via ESSR (Escapement Surplus to Spawning Requirements) fisheries run by First Nations. This type of fishery operates at the outlet of Babine Lake and has harvested up to 0.75 million fish annually. Most of the harvested sockeye originate at the Fulton and Pinkut Spawning Channels. However, there is presently no opportunity to utilize the proceeds from harvesting to support ongoing enhancement activities.

The new challenge for the development of a Canadian Ocean Ranching Policy is a legal one related to the ***Laroque*** decision noted above.

Capacity and Institutional Barriers

There is a lack of adequate funding for ongoing enhancement activities even if the Northern Fund provides short-term capital. During this contract we visited various SEP facilities including several hatcheries and two spawning channels. Reduced funding for these facilities has resulted in compromised production and performance. Some existing DFO facilities have not been properly maintained and renewed and therefore are poor prospects for additional production. Most if not all of the Community Economic Development Projects suffer from inadequate and / or unreliable water supplies as well as worn out infrastructure. (*SEP Internal Reviews including Lill 2003*)

Potential proponents are also impacted by a dearth of experienced staff in DFO and amongst other potential proponents. Lack of capacity is particularly an issue in remote coastal First Nations villages.

What should be the respective roles of DFO and the PSC Northern Fund in funding ongoing SEP infrastructure investments and operations? It seems appropriate for DFO to cover operational costs, but where modest investments in infrastructure could result in significant production gains, these projects be should be fully considered by the PSC Northern Fund. As presented in the previous section on Production-Scale Enhancement Opportunities, most of the best opportunities (A-list) involve renovations to existing DFO enhancement facilities.

Also as noted earlier in this report, DFO has also almost completely lost its capability to properly assess production benefits and costs so as to develop credible Benefit-Cost ratios for new or existing projects.

Formerly, there were few controls regarding the transfer and introduction of live fish into BC receiving waters. There is now a system in place to review all applications to move fish to ensure that the risks associated with transfers are minimized. Any such transfers are managed via a Federal-Provincial Fish Transplant Committee. Under the Canadian and BC guidelines, many forms of enhancement including sockeye fry outplanting (Levy 2005) would be considered high risk and would trigger a risk assessment. The committee makes recommendations based on the risks associated with the proposal. Where the risks are too severe, applications are rejected. Others may be approved after measures to mitigate the risks are put in place. (http://www.agf.gov.bc.ca/fisheries/ITC.htm)

The BC government has a Freshwater Fisheries Program Plan that articulates the provincial fisheries policy (http://www.env.gov.bc.ca/esd/documents/ff_program_plan.pdf). Elements of the policy include the provision of input to DFO on provincial values in support of fisheries management planning.

Salmon outplanting has been proposed for aquatic environments that are presently devoid of anadromous salmon, but which contain native species for which BC MOE is responsible. BC MOE personnel have raised concerns about the potentially adverse impacts of any such introductions on native species. A recommended approach to

addressing such issues is via risk assessment as described above. Key practices that should be followed include the prohibition of fish transfers where interactions with wild stocks are predicted and the adoption of disease-prevention inspections and practices.

The DFO *Wild Salmon Policy* has been stated by some to be a potential barrier to salmon enhancement in BC. However this position is not supported because as stated:

> "The Wild Salmon Policy does not preclude enhancement or cultivation, but provides a framework around which enhancement can occur. The use of enhancement is recognized in the policy as a tool to preserve populations at the greatest risk of extinction and as a means of meeting production objectives where it is possible to minimize the adverse affects on natural populations. In practice, this means that when rebuilding is the objective, enhancement will focus on returning the population to self sustaining status and will cease when rebuilding targets are met. When the objective is production, enhancement strategies will likely focus on providing distinct fishing opportunities in terminal or selective fisheries. Long-term enhancement may be required and may be limited to specific geographic zones."

Ecosystem Factors

Ocean Survival

Reduced marine survival of additional smolts produced through enhancement facilities severely compromises potential adult production and needs to be factored into every proposed project. A general rule of thumb previously used for production planning was that hatchery smolts would survive at 50% the rate of wild fish. This rate is completely acceptable if the overall marine survival remains high but recent evidence in southern BC indicates both wild and enhanced coho and Chinook smolts are surviving at considerably lower levels than the 1980s and the gap between wild and hatchery fish has widened. Ideally there would be adequate assessment of more than the few present indicator stocks to allow for "fine tuning" of enhancement strategies – particularly from hatcheries with significant ongoing investments in facilities and staff.

Variations in ocean survival directly influence both short- and long-term enhancement performance and there is an extensive literature on marine survival variation in salmon. There are positive patterns of covariation in survival rate among Fraser River sockeye stocks and Bristol Bay stocks but no evidence of covariation between these two regions or with stocks of other regions of B.C. and Alaska (Peterman et al. 1998; Mueter et al. 2002). Variations in sockeye survival rate operate at regional spatial scales, rather than at larger, ocean-basin scales. This can result in local trends in marine survival. Production from two adjacent sockeye producing systems on the Central Coast, Owikeno Lake (Area 9) and Long Lake (Area 10), drastically decreased in the late 1980's and early 1990's in response to reduced marine survival. The population crashes that took place in the 1990's are readily apparent in the DFO escapement data for these 2 areas (Figure 3). These declines occurred simultaneously with high sockeye production in other major producers including Babine Lake and Meziadin Lake.

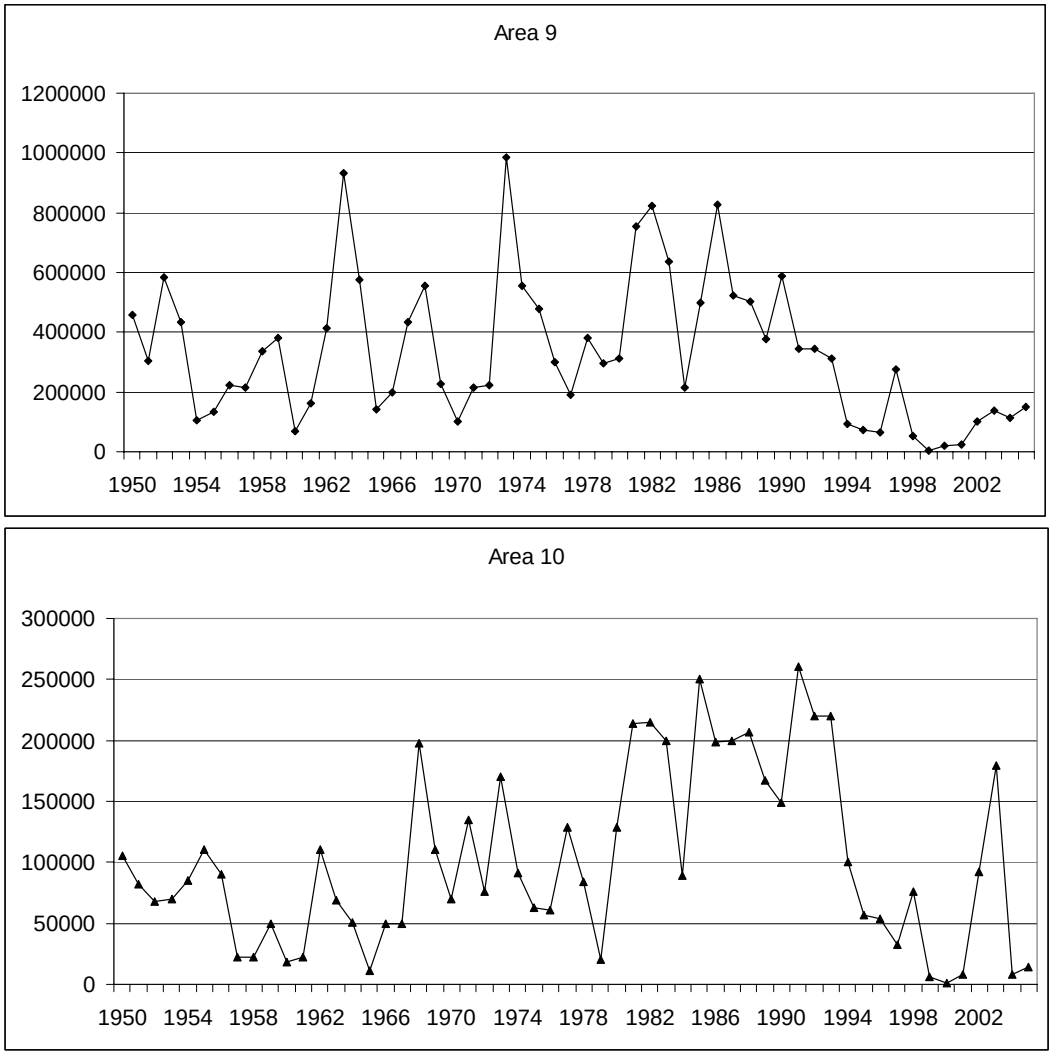


Figure 3. Sockeye escapement records for Areas 9 and 10. Source: DFO.

The high escapement to Area 10 (Long Lake) in 2002-2003 led to optimism that a commercial fishery could be supported in 2007. However, the 2007 returns were very low reflecting a reversal in the apparent recovery pattern (Steve Cox-Rogers, DFO, pers. comm.). Any sockeye smolts that migrated to the ocean in 2005 survived extremely poorly. The following production statistics and recruits per spawner were observed in Long Lake in 2007:

Brood Year	Brood Year Escapement	2007 Escapement 5/2	2007 Escapement 4/2	5 Year Old Recruits per Spawner	4 Year Old Recruits per Spawner
2002	92,000	16,700		0.182	0.013
2003	180,000		2,400		

Comparison of freshwater and marine survival trends (Figure 4) for Owikeno and Long Lake sockeye clearly shows that the decline in sockeye production was a consequence of decreasing marine survival. The freshwater survival of Owikeno Lake fry has been relatively stable since 1960, while the freshwater survival in Long Lake actually increased after 1990.

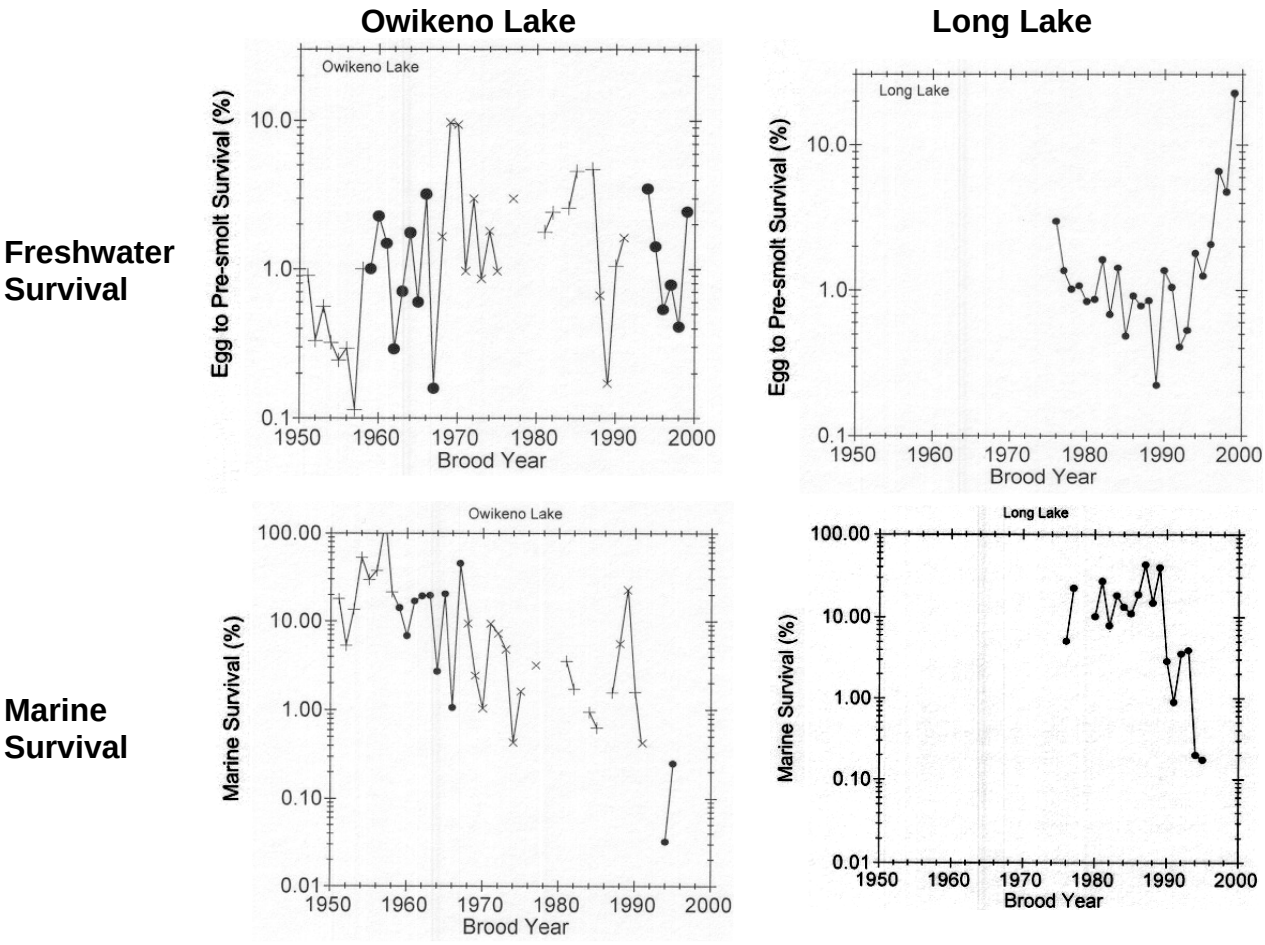


Figure 4. Trends in marine and freshwater survival of sockeye from Owikeno Lake and Long Lake. Note logarithmic Y-axes. Source: Rutherford and Wood (2000).

In contrast with the freshwater situation, marine survival of Owikeno and Long Lake sockeye declined substantially after 1990. Because the absolute population numbers in Owikeno and Long Lakes are presently so low, it will likely take a period of favorable marine survival conditions for the populations to recover to historic levels.

Insufficient Escapements for Viable Lake Fertilization

Experience has shown that lake fertilization can serve as an effective sockeye enhancement technique. There have been numerous lakes that have been fertilized in BC and Alaska and there is both direct and indirect evidence that lake fertilization can effectively produce more adult sockeye than untreated lakes under favourable conditions.

Fertilized lakes have shown a positive response at all trophic levels, with an increase in activity and doubling of bacteria abundance, increases of 50-60% in planktonic algae biomass (chlorophyll) and up to twofold increases in primary production and zooplankton biomass (Hyatt et al. 2004). This enhanced lake production has increased growth and survival of juvenile sockeye and increased smolt weights (>60%) resulting in larger adult sockeye returns with positive economic benefits (Stockner and Hyatt 1984). The Benefit-Cost ratio of lake fertilization is believed to be one of the best of currently available salmon enhancement techniques (Stockner and MacIsaac 1996).

Morice Lake in the Skeena River system provides an example of a lake where present escapements are insufficient to produce a viable response by sockeye to lake fertilization (Figures 5 and 6). Morice Lake is ultraoligotrophic with spring overturn phosphorus concentration of 1 μg/L (Shortreed et al. 2001). Major factors presently limiting juvenile sockeye production include insufficient escapement and the relatively low intrinsic productivity of Morice Lake.

The escapement history of sockeye to Morice Lake is shown in Figure 6. Spawner returns were strong during the 1940's and 1950's with annual averages of 70,000 sockeye. Since 1954, sockeye declined with annual average returns of between 1,700 - 9,000 fish. Escapement increased in the 1990s to an annual average of 32,000 sockeye, although since 1998, escapements have averaged less than 6,000 fish.

Currently, the lack of sockeye escapement to the Morice system is believed to be mostly due to fisheries overharvesting; average exploitation rates have been estimated as 53% (Rabnett 2006). The fish share similar run timing as the larger and more productive Babine sockeye stock making Morice fish vulnerable to overharvest. Since 2000, reductions in the exploitation rate have occurred in all fisheries and these reductions are expected to continue.

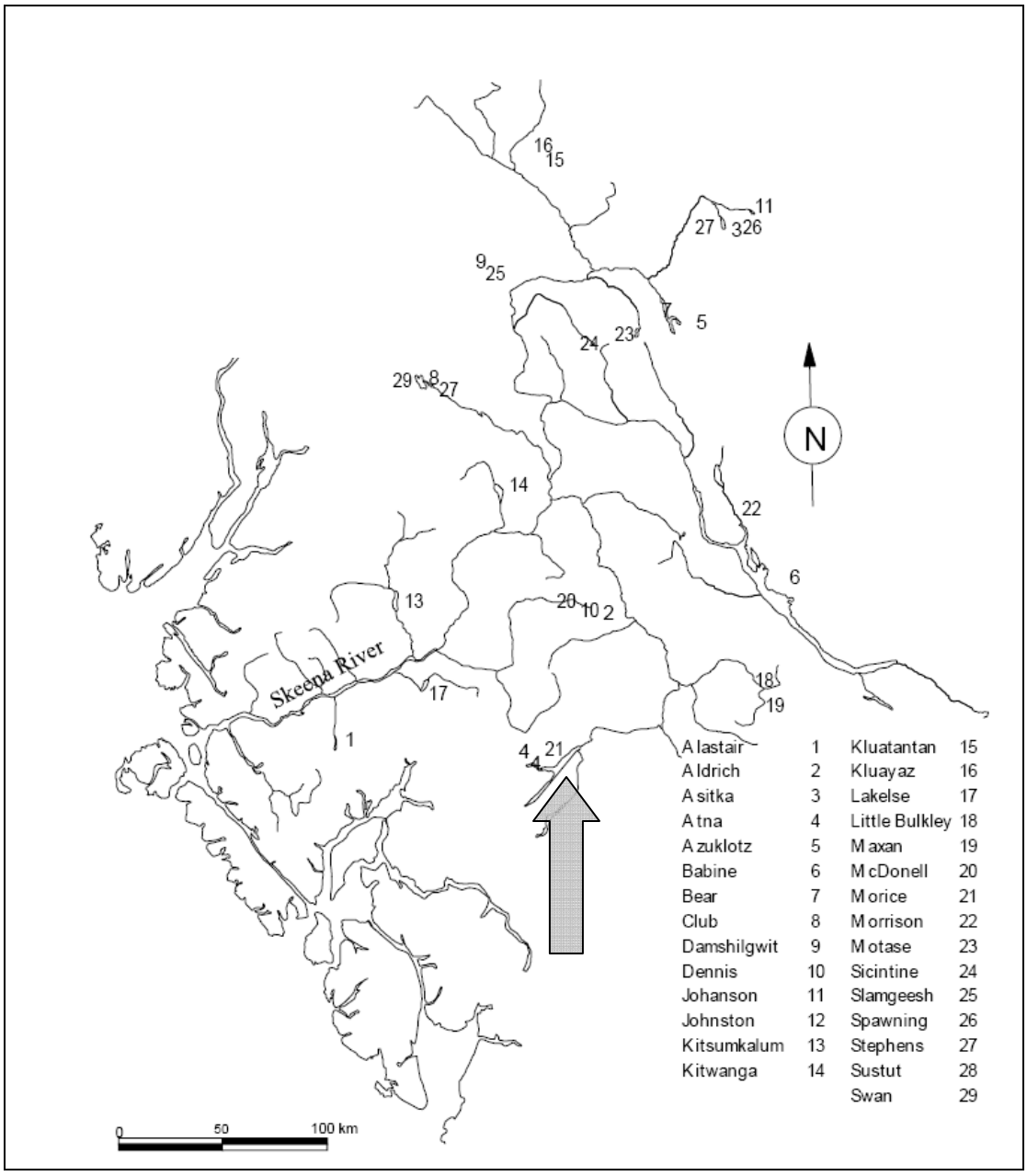


Figure 5. Location of Morice Lake in the Skeena River system. Source: Cox-Rogers et al. (2004).

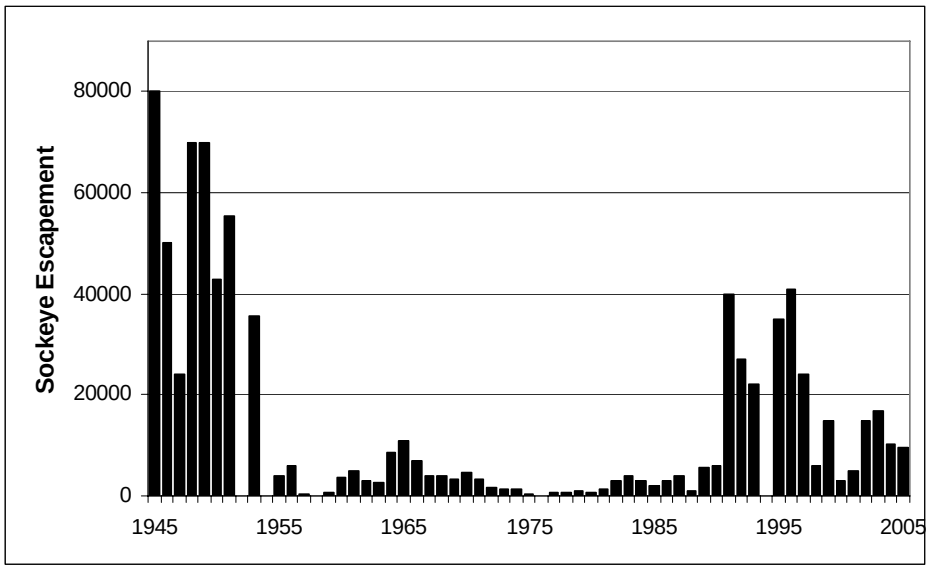


Figure 6. Morice-Nanika sockeye escapement between 1945-2005. Source: Rabnett (2006).

Rabnett (2006) described the fertilization history of Morice Lake. The lake was fertilized in 1980 (18 weeks) and 1985 (16 weeks). Morice Lake responded positively to fertilization with a 35% increase in phytoplankton biomass, and a 60% increase in zooplankton biomass. Fertilization was terminated following a review by Hyatt (1983; cited in Rabnett 2006) who concluded: "Given the information above, I believe we should stand by the position taken in 1981 that treatment of Morice Lake represents a long-shot for aiding sockeye stock recovery until such time as escapements increase to the point where recruiting fry are likely to exhibit pronounced food-limited growth patterns in-lake."

It therefore appears that fertilization of Morice Lake would be unlikely to produce substantial production benefits in this sockeye population. Escapement would need to increase above a threshold value before fertilization could be effective. We suspect that there are a large number of sockeye lakes in Northern BC where escapements are presently too low for their sockeye populations to respond positively to lake fertilization.

Stickleback Competition

In many lakes sticklebacks co-occur with juvenile sockeye. Experience has shown (Hyatt and Stockner 1985) that the benefits of fertilization can be reduced or eliminated in coastal lakes where pelagic sticklebacks are present due to food competition with juvenile sockeye. Many Northern BC sockeye lakes contain both sticklebacks and sockeye where the potential benefits of lake fertilization for sockeye could be negated. Examples include Owikeno Lake and Long Lake (Shortreed et al. 2001).

A biomanipulation pilot study (Perrin et al. 2006) in Wahleach Reservoir in Southern BC introduced triploid (infertile) cutthroat trout to prey on sticklebacks simultaneously with reservoir fertilization that was designed to benefit stocked kokanee. Between 1997 –

2000 when triploid cutthroat were introduced, stickleback density dropped by 94%, suggesting that it may be possible to reduce competition from sticklebacks via introductions of stickleback predators.

The use of fish predators to control sticklebacks needs to be undertaken with caution. Sticklebacks can fluctuate widely in abundance between years independently of piscivore predation for reasons that are largely unknown (Gislason et al. 1998; Hyatt et al. 2004). This confounds the interpretation of the Wahleach Reservoir study. Juvenile sockeye are also vulnerable to cutthroat trout predation and predator introductions could simultaneously undermine sockeye survival while reducing stickleback competition. To be effective for production enhancement in a large, northern sockeye lake, a massive number of triploid cutthroat would be required. In spite of these factors, it would be informative to undertake a biomanipulation pilot study in a relatively small sockeye lake which contains both sockeye and stickleback.

Marine Salmon Predators

Marine mammal predators include seals and sea-lions which forage on smolts and adult salmon at the mouths of spawning rivers. At Rivers Inlet, there are reports of seals consuming Chinook salmon, which can serve as a major impediment on Chinook enhancement activities in Area 9. In one study, seals in an estuary in Oregon consumed 21% (range = 3–63%) of the estimated prespawning population of coho salmon (Wright et al. 2007). The majority of the predation occurred upriver, at night, and was done by a relatively small proportion of the local seal population. Sea lion predation on salmon is also a problem mostly caused by relatively few individuals. The best known example is from the 1990's when five sea lions positioned themselves at the Ballard Locks in Seattle and consumed a large percentage of the steelhead run. Attempts to displace the problem animals were largely unsuccessful, and sea lions transferred to California successfully returned to Puget Sound after only a relatively brief period.

Various non-lethal means to discourage mammal predators were recently evaluated in the Strait of Georgia in an attempt to reduce seal and sea-lion predation using an electric barrier (http://www.smith-root.com/). Results showed that marine mammals are extremely sensitive to an underwater electric field, at levels well below those at which fish could be injured. Initial tests were performed on two captive seals at the Vancouver Aquarium to examine threshold responses in an experimental setting. During tests, the animals avoided the electrode end once the field was activated.

An underwater electrode array was deployed in the Puntledge River in 2007 to determine whether seals could be deterred from favored salmon feeding areas. In two deterrence trials, seals reacted when a very mild electric barrier was turned on, and then vacated the area. Testing showed that seals could be prevented from moving upstream past the barrier at a low power level. The ultimate vision of this type of approach is to deter seals from established feeding areas in rivers using non-lethal, low level electric fields.

A more comprehensive demonstration project has been proposed for a Columbia River Basin tributary where seal predation on salmon is substantial. This system (Figure 7) would employ SONAR to detect the marine mammal and trigger the electric barrier. It would operate by deterring seals while allowing fish migrations to pass. The system would operate only when the sonar component detected the presence of a marine mammal (based on lung and swimming pattern morphology), thereby deterring the animals while allowing fish migrations to proceed unimpeded and unharmed. Figure x shows a schematic of such a system.

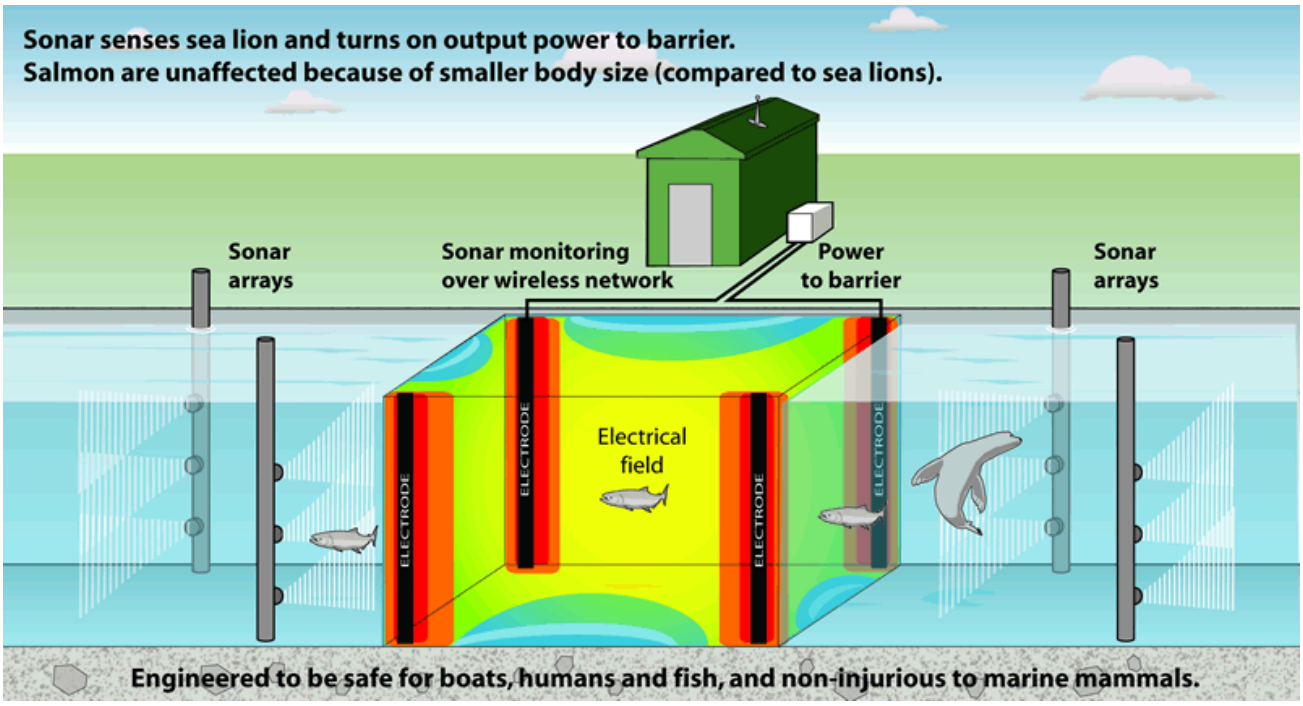


Figure 7. Integrated SONAR/electrical system for seal and sea lion deterrence in the Columbia River. Source: http://www.smith-root.com/news

Conduct of Fisheries

The ideal enhancement project would produce or augment a salmon run that can be harvested discretely in time and space so as to avoid interceptions of wild stocks. In practice, given the mixed-species, mixed-stock nature of most BC fisheries, this is usually not possible. It is mostly in terminal areas where discrete stocks of enhanced salmon can be uniquely fished. The greatest opportunity for selective fishing is adjacent to enhancement facilities, many of which are located in freshwater. The easiest system to harvest enhancement fish selectively is at the hatchery rack, but such an approach would require a significant restructuring of the present fishery.

It has been proposed that licensing of the salmon fishery be reformed and based on a system of Individual Transferable Quotas (ITQs). However, this system would not eliminate the mixed-stock harvesting issue unless there were fishing area restrictions attached to the license and timing controls in place to restrict the interceptions of wild stocks. It is questionable whether the adoption of ITQs would increase the manageability of the fishery and the ability to direct harvesting towards enhanced fish.

During this contract, we identified a number of potential production enhancement opportunities that are not presently viable due to mixed-stock harvesting constraints. For example, Area 3 has potential to support chum salmon enhancement (Gaboury and Bocking 2007) and during our workshops, we developed the concept of an integrated chum enhancement project involving hatchery production at Kincolith and early sea pen rearing at Stagoo and Kitsault. When reviewed by DFO Fisheries Managers, this proposal was not supportable in its present form because of concerns related to the interception of depressed wild chum stocks in Area 3 and elsewhere. Given the way that the seine and gillnet fleets presently operate, any such enhancement of chum stocks in Area 3 could have adverse impacts and would complicate chum management in this area. Similar wild stock management concerns were raised when we explored the potential for boosting chum enhancement in Area 6 via increased production from the Kitimat Hatchery.

In the face of a mixed-stock fishery, many production enhancement opportunities will be constrained.

Chapter Five: Conclusions and Summary Recommendations

The purpose of this scoping contract was to stimulate more enhancement activity utilizing Northern Boundary Funds. It is understood that Panel Members wish to see less emphasis on improved information and more on increased production. The work contained in this report has already led to significantly increased investments in 2008 so the project has already shown results.

By design, the previous section of the report focused on the constraints to salmon enhancement and does not consider the positive benefits of enhancement that have accrued in many local fisheries. Some of the constraints are outside of the influence of management decision-making (e.g. reduced marine survival) while others are amenable to management influence (e.g. policy development, fisheries restructuring). It is the conclusion of this review that enhancement opportunities will continue to be severely limited as long as the constraints feature strongly in Northern fisheries management and enhancement activities.

Project Recommendations

In order to minimize the constraints, the following approaches and innovative techniques were recommended in selected projects to revitalize enhancement efforts in Northern and Central BC:

- clear definition of management objectives on a watershed basis using Structured Decision Making approaches;
- integrated enhancement and management plans so potential production benefits can be realized with minimal impacts on wild stocks;
- optimized production from existing facilities;
- biomanipulation pilot studies including seal deterrence testing and lake introductions of infertile stickleback predators; and
- new projects including habitat restoration or completely isolated hatcheries with introduced stocks that can be fished discretely from wild populations.

It is recommended that the observations and advice noted after each project be accepted not only with respect to them individually but also as a suite of proposals that will facilitate building a robust enhancement program.

Northern Boundary Fund

Project activities are currently guided by Goal 3 of the Pacific Salmon Commission - Northern Boundary Fund, namely:

> "*Enhancement of wild stock production through low technology techniques rather than through construction of large facilities with high operating costs. This*

includes acceptable refinements to existing enhancement facilities that will increase the productivity of those facilities."

As currently stated this goal does not adequately provide for a technically sound enhancement strategy in Northern and Central BC that is fully integrated with long term harvest management plans that both protect wild stocks and allow for harvest of stocks generated through investments in enhancement activities. No trust fund wants to be burdened with ongoing commitments and the PSC Northern Boundary Fund is no exception. However there is little point in investing in feasibility studies, following through with implementing good projects and then having no ability to maintain and operate them in the future. This means that the fund needs to be very selective in which projects it allows to go forward to implementation after feasibility studies are completed and has to have the expertise available to them in making such decisions. (We understand the current screening and selection processes in the Northern Boundary Fund do not include Canadians who are biologists and/or engineers with experience and qualifications in enhancement and habitat restoration.)

It is recommended that Goal 3 of the Pacific Salmon Commission - Northern Boundary Fund be restated as follows:

"*Enhancement of wild stock production through technically sound, relatively low complexity, highly reliable and productive projects that are consistent with the experience and qualifications of the proponents and are (or will become) part of a long-term integrated production and harvest plan. This includes acceptable refinements to existing enhancement projects and fishways that will potentially increase the fishery benefits from those facilities. All projects should have low incremental operating and maintenance costs per adult expected using the most recent applicable bio standards and fishery information that is available."*

It is also recommended that an increased funding "envelope" be established for enhancement activities that would include some provision for ongoing incremental operations and maintenance costs of projects that are significantly contributing to Northern Boundary fisheries.

It is further recommended that the Pacific Salmon Commission - Northern Boundary Fund institute a bilateral four-person technical review team with bioengineering expertise in habitat restoration and enhancement similar to the Southern Boundary Fund. (The Canadian members could also be commissioned to locate and assist proponents in developing proposals for projects classified as A or B in this scoping report and in further reconnaissance for new projects with the potential to increase wild stock productivity and fishery benefits.)

Finally it is recommended that DFO and the Pacific Salmon Commission convene at least an annual technical workshop in habitat restoration and enhancement technology with the view of passing on advice and experience from those with expertise in semi-natural techniques such as groundwater-fed side channels and

stream restoration to recent staff in DFO and potential partners. Training programs to develop capacity in enhancement techniques and identification of potential new projects should also be seriously considered for cost sharing under the Pacific Salmon Commission - Northern and Southern Boundary Funds.

Institutional and Fisheries Management Constraints

We have noted a number of significant issues earlier in this report that are hindering development of solid enhancement project proposals. Chief amongst them was an obvious lack of clarity and coordination in terms of who is in charge of making changes to policy and the identification of champions for moving issues forward in the federal and provincial agencies responsible for fisheries, habitat and enhancement. Stakeholder interests are also changing with the increased concerns for First Nations interests and the diminished value of commercial salmon fisheries.

It is recommended that DFO and the province of BC work together with stakeholders to reduce identified institutional and fisheries management constraints to new and increased enhancement projects where feasible. This could be initiated at a conference and further investigated by a federal, provincial, commercial, sport and First Nations working group.

Existing Enhancement

To gain maximum value from investments in the relatively small annual budget in the Pacific Salmon Commission's Northern Boundary Fund, DFO must be in a position to accept an increased share of the costs – especially the ongoing operational and maintenance costs so the Funds investments can be "value-added." DFO also urgently needs to renew its bioengineering and assessment capability to even take full advantage of existing annual budgets let alone "new" money since much of their expertise has been lost through attrition in the last ten years and many of the remaining key staff are nearing or past retirement age.

It is recommended that DFO significantly upgrade its capability to maintain, optimize production and properly assess / fine tune existing enhancement facilities as these measures are essential for a basically sound enhancement program capable of augmentation by the Pacific Salmon Commission - Northern and Southern Boundary Funds and other potential partners.

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Appendix 1 – Concept Proposals for 2008 prepared to assist proponents with highly recommended projects

1. Area 6: Kitimat Hatchery Optimization (DFO)

Stage I Project Concept Form 2008

Name: Martin Forbes and Alan Lill P.Eng.

Affiliation: Manager, Kitimat Hatchery, Fisheries and Oceans Canada, and A.F. Lill and Associates Ltd.

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Phone: 250 639 9788
778-338-4366

Fax:

Project Title: Kitimat Hatchery Optimization – Fishway Construction and Chinook Expansion

Project Type:	***Check one***	**Estimated Amount Required:** ***Specify currency***
Improved information for resource management	☐	**$**
Habitat restoration	☐	**$**
Enhancement	X	**$ 479,500 Cdn**

Project Location: Kitimat BC

Start Date: **February 1, 2008** **End Date:** **December 31, 2008**

Provide a brief overview of the project; what is being proposed?

1. Design and construct a fishway so that returning Chinook, Coho and Chum adults to the Kitimat River can swim directly into the facility adult holding raceways thereby increasing its potential to achieve egg targets under adverse flow conditions in the Kitimat River and permitting reallocation of some operational costs into increased fish production in 2009 onward.
2. Adjust production targets to increase and diversify Chinook production beginning with the 2008 brood year. Temporarily reduce Coho production until additional incubation and rearing facilities are available.
3. Design additional incubation and rearing facilities for the increased Chinook production (to be constructed in time for the 2009 brood year.)

Relevance and Significance: Describe the relevance and significance of the project to the Pacific Salmon Treaty and the goals of the Northern Fund.

Chinook produced from this facility contribute significantly to northern boundary fisheries and the optimization plan will increase that production at low incremental operational costs.
This project is primarily directed to the Northern Panel's Goal 3 "acceptable refinements to existing facilities that will increase the productivity of those facilities".

Technical Merit: Describe the logic behind the design; the feasibility of the methodologies to be used and the appropriateness of the technical approach.

1.When the $9.6M Kitimat Hatchery facility was constructed in the mid 1980s, it was planned to include a fishway to allow some returning adults from the Kitimat River to swim directly into the facility. However it was cut for budgetary reasons and most Kitimat brood stock are seined from a pool near the facility. Ian Ross from DFO Engineering prepared a conceptual design and preliminary cost estimate for a fishway in 2003.

A fishway will reduce labour costs compared to seining all brood stock, increase probability of achieving egg targets under adverse flow conditions such as those experienced in 2007, decrease pre-spawn mortality from handling and also decrease chum incubation mortality. It is expected to save approximately $21,000 per year in casual labour costs that can be reallocated to increased Chinook production.

All brood stock caught in nets are then sorted and put into small holding pens. They are then handled again and put into a transport tank in a boat and taken across the river where they are handled again and put into a transport tank on a truck and taken up to the hatchery and put into a raceway. All this handling puts a lot of stress on the fish that then results in high pre-spawn mortalities (generally 10 - 20%). There are also higher incubation mortalities in the fish that are held the longest.

Most if not all of the returning fish that will use the fishway will be of hatchery origin, but most brood stock are currently seined on an island across from the hatchery resulting in a high percentage of hatchery-origin fish. A fishway will also create the fish culture potential to develop a Kitimat hatchery chum stock with different timing from wild stocks in order to create separation from weak stocks in mixed stock fisheries and create potentially higher commercial values through optimal harvest timing. Since the facility is currently underutilized for chum production, it would be very economical to increase production if a discretely harvestable stock could be created.

2. It is proposed to increase Chinook production from a total of 1.75 million 90-day smolts to 2.75 million. The extra one million smolts are expected to increase the facility's contribution to fisheries and escapement by approximately 15,000 adults at a 1.5% smolt to adult survival.

Kitimat Hatchery staff estimate the increased operational facility costs for fish food, hydro pumping costs and casual labour will be $33,500. The facility currently takes Chinook brood stock from only the Kitimat River and Hirsh Creek in the Kitimat drainage. To diversify Chinook production from outside of the Kitimat watershed, it is proposed to reinstate a Chinook egg take on the Kildala system for approximately one quarter of the one million total increase. It is estimated that this operation will cost approximately $28,000 made up of casual labour ($3,000), Helicopter time adults and fry release ($20,000), Camp maintenance, fuel/supplies ($5,000). The overall cost of $61,500 will be offset (in 2009/10 onward) by the $21,000 savings from the fishway for a net increase of $40,500 per annum –less than 5% of the facility annual operating and maintenance budget.

The facility will require additional incubation capacity and two large rearing raceways (or equivalent) to accommodate increased Chinook production. It is proposed to decrease Coho production from the 2008 brood year from 500,00 smolts to 100, 000 smolts to make space available until these facilities are constructed in 2009. The savings from decreased Coho production ($ 37,000) will partially offset the increased O and M costs for increasing Chinook production in 2008/09.(i.e. $61,500 – $37,000 = $24,500). (The fishway will not likely be completed in time for the 2008 brood year on account of habitat protection requirements.)
3.The Kitimat facility has adequate space for adding additional incubation and rearing facilities on its site. The design of these additional facilities should be done by August 2008 so a proposal can be prepared for construction in 2009. The projected engineering design cost is 10% of the preliminary estimate of $300,000 for these facilities.

Key Personnel: Identify key project personnel, the nature and extent of their role in implementation.

Martin Forbes, Manager Kitimat Facility, Fisheries and Oceans Canada - facility operations, design review
Al Lill P.Eng, President, A.F. Lill and Associates Ltd. – overall coordination and management
Dave Murray P.Eng. Kerr Wood Leidal Associates Limited (KWL) – engineering design and construction management (KWL have extensive experience with this facility)
DFO senior managers, engineers, biologists and Kitimat facility staff will be extensively involved in the design review process.

Measures of Success: Describe the specific objective standards, quantifiable criteria and quality control measures you will use to assess the actual performance of this proposal against expectations.

1. A fully functional fishway was completed for passage into the Kitimat facility from the river.
2. Increased Chinook smolt production undertaken as outlined
3. Engineering design work was completed for proposed 2009 construction
4. An effective project management process was implemented that ensured: all work was done as expeditiously and economically as possible; all affected parties were involved; all required approvals were obtained; any outstanding policy issues were resolved; construction work was properly coordinated with facility operations; potential cost sharing arrangements were explored for future years and a full reporting was made to the PSC.

Project budget outline: Provide estimates of line item costs for the following categories.

Wages and salaries	**$ 7,500**
Contract services	**$442,000**
Travel	**$ 13,000**
Supplies and materials	**$ 17,000**
Capital equipment	**$ 0**
Indirect costs	**$ 0**
Total	**$479,500**

Costs: Describe the proposed budget for this project, including appropriate details about the larger cost items, especially capital acquisitions.

1. Fishway construction (based on a 2003 estimate adjusted for inflation) $350,000*
2. Fishway engineering and contract management costs (KWL or other) $ 60,000*
3. Increased Chinook production – (DFO net) $ 24,500
4. Overall Coordination and Management (A.F.Lill and Associates)
   15 days @$800 plus travel to and from Kitimat / Prince Rupert (3 trips) $ 15,000
5. Design of Additional Incubation and Rearing Facilities for 2009 construction (KWL or other) $ 30,000*

Total PSC Contribution *$479,500*

In_Kind
DFO staff involvement and travel approx. $ 25,000
Facility overhead staff and support costs in proportion of total production- approx $250,000

*Preliminary estimates to be refined in the final submission. Actual construction costs will depend on many factors at time of tendering. Preliminary discussions have been held with Greg Brooke from DFO to undertake some of the engineering work as an in-kind contribution. Kerr Wood Leidal Associates Limited is committed to provide detailed construction cost estimates and engineering design and contract management costs in the detailed proposal if the project concept is accepted

2. Area 10: Nekite Channel Restoration (Gwa'sala-'Nakwaxda'xw Nation)

Stage I Project Concept Form 2008

Name: Doug McCorquodale[1], Karl Wilson[2], David Stevenson[3]

Affiliation: [1]Gwa'sala-'Nakwaxda'xw Nation, [2]Fisheries and Oceans Canada, [3]Rivers and Smith Inlet Salmon Ecosystem Planning Society

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Project Title: Nekite Spawning Channel Renewal

Project Type:	***Check one***	**Estimated Amount Required:** ***Specify currency***
Improved information for resource management	☐	**$**
Habitat restoration	☐	**$**
Enhancement	X	**$ 149,800** CDN

Project Location: Nekite River – Smith Inlet (Area 10) B.C.

Start Date: April 1, 2008 **End Date:** September 30, 2008

Provide a brief overview of the project; what is being proposed?

- Fisheries and Oceans Canada completed the construction of the Nekite Spawning Channel in 1986, primarily to increase chum production, but also to create coho rearing habitat. The channel has not been maintained since it was built and has significantly infilled with sand, fine sediments and organic materials. The Gwa'sala-'Nakwaxda'xw Nation has been monitoring escapements into the channel since 1996 and into the Nekite River as a whole since 2001.
- The proposal is to clean and restore the Nekite channel to increase egg to fry survival of chum, and to improve coho rearing conditions and to modify the settling basin to reduce the frequency of cleaning operations.

Relevance and Significance: Describe the relevance and significance of the project to the Pacific Salmon Treaty and the goals of the Northern Fund.

- Cleaning and restoration of the channel will result in an immediate and sustainable increase in chum fry and coho and steelhead smolt production and opportunities for harvestable surplus in an easily managed terminal area.
- Coho produced from the channel complexing will be harvested in Alaska and Canada.
- This project directly meets the Northern Panel's Goal 3 of "enhancement of wild stock production through low technology techniques".

Technical Merit: Describe the logic behind the design; the feasibility of the methodologies to be used and the appropriateness of the technical approach.

- The Nekite Channel was designed to hold approximately 7,200 chum spawners. It was thoroughly inspected on August 21, 2007 by the proponent, on site personnel, Karl Wilson from DFO, Victor Ewert of Redfish Services and Al Lill of AF Lill and Associates Ltd. Mr Ewert estimates the channel has degraded to less than 5% of its design productive capacity. However the intake and control valves are in excellent condition and there is a steel outlet structure and equipment on site for conducting downstream fry counts.
- A cleaning and renewal plan has been developed to be undertaken in the "fisheries window" in July 2008 to fully restore the channel to its original design productive capability for chum salmon and to make some improvements in and coho productive capacity. The settling basin also needs to be modified to increase its capacity and increase the time before the channel might need to be cleaned again.
- As the Nekite channel is located in a very remote area, all equipment and personnel will need to be barged in to landing approximately 11 km from the project site. The renewal operation is estimated to take approximately three weeks as it will be necessary to periodically stop cleaning operations to avoid undue suspended sediment flows into the Nekite River. A protective protocol similar to that followed at other DFO spawning channels will be followed.
- The materials in the settling basin will be removed and loaded into a truck to be taken to an off-site disposal area. The gravel will be cleaned within the channel itself using an excavator following similar procedures Mr. Ewert has used in numerous cleanings of other spawning channels. However there is no room on the confined site for a settling basin and therefore the option of pumping silty water to a settling basin has been ruled out as impractical for this site.
- Pre and post evaluation of the cleaning/ renewal operation will be carried out by the Gwa'sala-'Nakwaxda'xw Nation. Pending approval of this submission, the Gwa'sala-'Nakwaxda'xw Nation is committed to performing a pre-treatment juvenile emigration study on the channel during spring 2008. The objectives of the study will be to determine the current level of production within the channel, and to determine existing egg to fry survival levels. An accurate determination of current spawner utilization, and egg to fry survival will be possible, due to the existing adult enumeration program being conducted in 2007.
- Evaluation of treatment efficacy can be determined by emulating the juvenile emigration survey in the spring of 2009

Key Personnel: Identify key project personnel, the nature and extent of their role in implementation.

Doug McCorquodale – Fisheries Coordinator, Gwa'sala-'Nakwaxda'xw Nation: Project leader/co-coordinator responsible for pre and post biological evaluation.
Victor Ewert, Redfish Services – former Weaver Creek Spawning Channel manger and now a private consultant. Victor would manage all aspects of the cleaning operation and provide a post cleaning report detailing and justifying all costs incurred not to exceed the project budget.
Karl Wilson, DFO Resource Restoration biologist – liaison and approvals with DFO
Al Lill, P.Eng., A.F. Lill and Associates Ltd. was the Chief Engineer of the Salmonid Enhancement Program when the channel was built and is assisting in setting up this project as a part of the 2007 Enhancement Scoping Contract with the PSC Northern Fund. He will not be involved in the actual project itself if it is approved for implementation in 2008.

Measures of Success: Describe the specific objective standards, quantifiable criteria and quality control measures you will use to assess the actual performance of this proposal against expectations.

- Monitor adult escapement, egg deposition, incubation success and fry production pre and post cleaning operations.

Project budget outline: Provide estimates of line item costs for the following categories.

Wages and salaries	**$ 16,800**

Contract services	**$ 123,000**
Travel	**$ 2,000**
Supplies and materials	**$ 8,000**
Capital equipment	**$ 0**
Indirect costs	**$ 0**
Total	**$ 149,800**

Costs: Describe the proposed budget for this project, including appropriate details about the larger cost items, especially capital acquisitions.

Redfish Services have developed a preliminary estimate for the cleaning /renewal operation. An experienced contractor has been contacted and offered firm daily rates for the excavator, dump trucks and accommodation, crew transport package. Along with accommodation, the contractor will provide a boat for transport, a quad for on site use, a pickup truck to comply with WCB regulations and communications gear. The estimate below will be refined in the final project submission. Only actual costs will be charged up to the total maximum budget. *Barge service costs may be reduced to as low as $10,000 if a scheduled service can be used.

PSC Costs

Barge service for bringing in equipment and return to mainland*	$ 25,000.00
Cleaning and reshaping: Excavator & Operator, 23 days @ $1500/day	$ 34,500.00
Dump Truck s and Operators 23 days @ $1000/day	$ 23,000.00
Trash pumps for dewatering setting basins and pools	$ 3,000.00
Gwa'sala-'Nakwaxda'xw First Nation crew support , brushing, fish salvage prior to cleaning2x $200/day x 42 days, .	$ 16,800.00
Gwa'sala-'Nakwaxda'xw First Nation crew support costs	$ 2,000.00
Fuel for excavator, trucks etc.	$ 6,000.00
Transportation to the Site and Return	$ 2,000.00
Redfish Services Project management –35 days @ $500/day	$ 17,500.00
Contractor Accommodation, On-Site Transport (see notes)	$ 20,000.00
Total	$ 149,800.00

In Kind

Gwa'sala-'Nakwaxda'xw First Nation		
Supervising Biologist - 10 days @ $550/day		$ 5,500.00
Fisheries Technicians - 3 crew for 17 days @ $200/day		$ 10,200.00
Rental of sampling equipment (fyke nets), 17 days @ $50/day		$ 850.00
Satellite phone rental		$ 250.00
Accommodation – $50/day/person		$ 2,900.00
Transportation – 4 charter flights @ $685/flight, 1 sched @ $155		$ 2,895.00
Food – $125/day for 20 days	$ 2,500.00	
Administration Support	$ 5,000.00	
DFO		
Staff Support (Karl Wilson and DFO Habitat & Engineering)		$ 5000.00
Hydraulic sampling equipment 3 days @ $100/day	$ 300.00	
Total In Kind	$ 35,395.00	