Death by a thousand cuts:  
the importance of small streams on the North and Central Coasts of British Columbia

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**Preface**

This document has been prepared in response to an increased focus by government on the management and monitoring of large salmon runs at the expense of the health of small salmon runs in coastal British Columbia. This paper will emphasize the role of small salmon runs in the overall structure and genetics of salmon populations in addition to their role in healthy functioning ecosystems; it is not intended to refute the importance of large salmon runs.

Before proceeding, we should define what we mean by the term *small stream*. The province of British Columbia recognizes nine major systems: the Columbia, Fraser, Liard, Mackenzie, Nass, Peace, Skeena, Stikine and Taku Rivers (see Figure 1 for map of DFO management areas). For the purposes of this report, we recognize everything outside of these rivers as small streams. Unfortunately, this definition is complicated by the fact that there are thousands of small streams in the headwaters of these large watersheds feeding into these rivers. The health of these small rivers is vital to the health of the downstream waterways and has been well documented (see Meyer et al. 2003 for review). However, the focus of this document is on small streams that connect directly with the ocean. These small streams are common among the broken topography of coastal ecosystems, but have received comparatively little attention. Combined, these small streams are habitat for a considerable proportion of the salmon biomass in British Columbia and likely a far greater proportion of salmon genetic diversity.
Introduction

“A single stream may appear insignificant as a producer of wild fish. But together, the thousands of small streams in British Columbia account for a large amount of fish production. Healthy streams are valuable, but they are fragile. They are easily damaged by poor logging practices, pollution, and urban development. Small streams are vital to fish and must be saved from abuse.” — Small Streams, SEP Fact Sheet, Fisheries and Oceans Canada

Despite the recognition of small streams as vital salmonid habitat, Fisheries and Oceans Canada (DFO) has largely ignored small systems to focus on management of larger, more productive rivers. Wild salmon managers are faced with deciding where limited human and financial resources should be focused, and the trend over the last forty years has been to decrease or eliminate monitoring and enforcement of smaller systems in favour of a few large commercial runs such as the Fraser, Skeena, and Nass rivers. Between 1985 and 1999 enumeration of salmon streams declined 47% and only 10% of streams on the north and central coasts of BC have reliable enumeration data for the last 50 years (Thompson and MacDuffee 2002). Although the biomass and economic benefits of concentrating management efforts on large systems are justified, this approach has come at a cost to the health of small streams, which have equally important genetic and ecological values, as well as an historical importance to First Nations food fisheries.

Small streams are the corridors to an annual influx of nutrients provided by spawning salmon, which enrich diversity and enhance productivity in coastal ecosystems. They allow predators to access a dependable protein source that might not otherwise be available and they are important habitat for juvenile salmon. In addition, each small population has the potential to add to the genetic diversity of Pacific salmon, which is vital in the face of environmental change. Creeks and small rivers along the coast are under threat of habitat destruction and their salmon runs are subjected to over-harvesting, just as are larger systems. Smaller streams, however, have the disadvantage that their status is largely unknown and many runs remain undocumented. In addition, small
populations are more vulnerable than larger runs, and are therefore at greater risk of extirpation (Lande 1993; Routledge and Irvine 1999). Loss of small salmon populations is eroding salmon genetic diversity and population structure; this threatens short-term productivity and long-term survival of BC salmon.

**Ecological considerations**

The importance of salmon in coastal ecosystems has only recently been appreciated and the complexity of these systems is still not fully understood. Over 190 species directly use salmon (Cederholm et al. 2000). Nutrients from consumed salmon are returned to the watershed, particularly through vectors such as bears (Reimchen 1994, 2000; Hilderbrand et al. 1999a), enriching the ecosystem and increasing biodiversity. The predictability of this annual influx of nutrients to the terrestrial ecosystem has shaped the ecological strategies of organisms that have co-evolved with wild salmon (Darimont et al. 2003). Many coastal species depend on this annual nutritional surge to meet their dietary protein requirements (Darimont and Reimchen 2002) and measures of fitness (e.g., body size, litter size, population density) are often correlated to the availability of this resource (Hilderbrand et al. 1999b).

Small rivers and creeks allow increased access to salmon for many predators. Individual fish have less chance of being captured in wider and deeper waterways as there are more escape opportunities afforded by larger habitats (Quinn et al. 2003), which means that proportionally the predation is less in wider rivers and creeks (Quinn et al. 2001). Small streams also provide feeding opportunities for younger bears and other species that may not be up to the competitive interactions that often occur at high density spawning sites where fishing efforts are maximized. Those predators that do feed at these small systems will then transfer those nutrients into the surrounding watershed.
The penetration of marine derived nitrogen into the watershed is correlated with spawning density, with higher densities translating to greater enrichment of the surrounding ecosystem (Hocking, personal communication; Mathewson et al. 2003). Though smaller streams do not support the same salmon biomass as rivers such as the Taku, Stikine, Skeena or Fraser, they often support high spawning densities. Neekas River, near Bella Bella, has a spawning density of 24,000 salmon/km (Mathewson et al. 2003) and a density of chum approaching 71.63 kg of salmon/m, which is likely the highest density of chum on the BC coast (Hocking, personal communication).

Even small salmon runs enrich the surrounding ecosystem (Cederholm et al. 2000) and the wide distribution of smaller creeks and streams increases biodiversity on a broader scale. Chum and pink salmon are the most widely distributed species, often found in smaller populations in smaller systems (Figure 2 and 3). These smaller runs enrich the riparian vegetation and increase biodiversity (Hocking and Reimchen 2002; Mathewson et al. 2003) in areas such as islands, which are unable to support large river systems. This influx of salmon to small isolated islands also mitigates foraging constraints for large coastal predators, such as wolves, that inhabit these naturally fragmented habitats (Darimont et al. 2004, Paquet et al. In press).

Smaller systems far outnumber larger systems for all salmon species (Figure 4). Combined, these systems add significantly to the overall productivity of salmon resources on the coast (Table 1). Individually, these systems have unique floral and faunal associations based on the abiotic factors (e.g., topography, exposure, water chemistry) that are characteristic of the specific creek or stream. Each small system is an island of biodiversity, with unique interactions and associations that add to the diversity of coastal ecosystems. Loss of small salmon streams on the coast could have implications that far exceed our current understanding of these interactions and ultimately disentangle this web of biodiversity.
**Genetics**

Sound conservation policy for any species should be firmly rooted in an understanding of evolution and biology. In British Columbia, salmon evolution and biology has been greatly shaped by periodic ice ages, the last of which ended approximately 15,000 years ago. During these ice ages most of the habitat used for spawning and rearing was ice bound and not usable. During the last ice age, salmon survived in small ice-free areas of coastal BC as well as in larger areas in the Pacific Northwest and Alaska (McPhail and Lindsey 1970; Wood et al. 1994; Smith et al. 2001). All contemporary BC salmon populations are derived from these sources.

When new populations are founded by a small number of individuals, as occurred when new salmon habitat became available in BC after the last ice age, they contain only a subset of the genetic diversity contained in the founder population. Thus, although some of the larger river systems in BC and Alaska currently support large numbers of salmon, these populations contain only a portion of the genetic diversity found in locales where salmon have been persisting for longer periods. Therefore, remnants of refugial populations scattered along the coast of BC that persist to the present day, albeit small in size, retain a significant proportion of evolutionary legacy of the species. These populations should be of high conservation concern.

The existence of “sea-type” sockeye (Wood et al. 1987) in coastal BC and Alaska is an illuminating example of an important evolutionary characteristic that is retained in present day sockeye, but only present in remnant refugial populations. Sea-type sockeye are adapted to spawn in cold, turbid glacial streams such as those that would be found during an ice age. Rather than rearing in a freshwater lake, as do most contemporary sockeye populations, sea-type sockeye fry migrate quickly to sea after hatching. This characteristic allows sockeye populations to persist
during glacial periods and provides a source for repopulation of habitat made available by receding ice sheets (Wood et al. in prep). A similar variation in life history strategy exists in chinook (stream- and ocean-type) (Taylor, 1990; Healey, 1991) and may have similar consequences during glacial periods. Remnant refugial populations are also likely to have other characteristics essential for long-term survival of the species.

Salmon populations have evolved considerable genetic adaptations since the last ice age in response to local habitat differences in physical and biological parameters. This “local adaptation” allows for high productivity across a range of habitats and accounts for the historically high production of salmon in BC. The hundreds of small salmon runs of BC constitute a huge reservoir of genetic adaptations, any one of which may be key to the survival of salmon through times of environmental change. Since each of these adaptations has taken thousands of years to evolve, individual salmon populations with unique characteristics cannot be replaced once they have been extirpated. Loss of even a single run, no matter how small, can be an irreversible loss of genetic diversity.

Although salmon are recognized for their ability to return to their natal stream to spawn, some fish stray into other river systems and spawn with the resident population. Therefore, salmon runs do not exist in isolation from other salmon populations, but are linked to each other by a complex pattern of dynamic population exchange. This straying between populations is important because it promotes genetic exchange, which prevents inbreeding and bolsters the size of populations that may be experiencing a population down turn. Populations connected through immigration can persist at carrying capacities much lower than those of isolated populations (Hilderbrand 2003). Interdependence of salmon runs established over the past 15,000 years is critical to the health and survival of salmon along the coast. The loss of a single population can catalyze the unraveling of these critical interactions leading to wide population and resilience declines.
Freshwater rearing habitat

Some small systems are not suitable spawning grounds for adult salmon because of substrate type, water volume, or seasonal variations in flow, but they can still be important rearing habitat for juvenile salmon. Compared with larger systems, small creeks are usually more susceptible to fluctuations in temperature and water flow; however, they may offer greater habitat complexity and invertebrate richness (Minshall et al. 1985), which are important factors for young salmon.

Small streams may enhance the productivity of larger neighbouring systems by providing additional rearing habitat for juveniles. Coho are territorial in freshwater rearing habitat and if juveniles are unable to maintain a territory they are often displaced downstream (Sandercock 1991). These fish may make their way back upstream, but they may also migrate out of their natal streams along the shore in the low salinity surface waters to nearby systems to rear (Otto and McInerney 1970). Some individuals have a tendency to migrate to nearby systems despite an abundance of habitat in their natal streams; these fish are called nomads (Sandercock 1991). This variation in life history provides access to more resources for salmon rearing and thus more juvenile coho would survive than the natal stream capacity could support. Preliminary findings from the spring 2004 field season suggest the presence of coho and Chinook nomads in small coastal streams. These streams were previously undocumented for the presence of salmon and while they are not used for spawning, they are being sought out by fry for rearing. Work to further document this activity will continue in fall 2004 and 2005.
Summary

The economic and biological value of large salmon runs is undisputed. Each year millions of salmon travel hundreds of kilometers to spawn in the headwaters of the Fraser River and deliver nutrients to the 233,000 km² of watershed lands that drain into this system. Large systems, such as the Fraser, Skeena, Stikine, and Taku rivers, are the main contributors to the overall biomass of salmon in British Columbia and are critical to the future of wild salmon.

Unfortunately, the importance of small streams has not yet reached the same level of recognition. Small streams provide an annual surge of nutrients into coastal ecosystems across a vast spatial scale. They provide essential habitat to juvenile salmon and an easily accessible and predictable food source to countless coastal species. These small populations of salmon also retain significant genetic diversity that provide wild salmon the adaptability needed to overcome environmental adversity, such as climate change.

The loss of small streams would have widespread ecological and genetic costs. The associations between salmon and coastal ecosystems have evolved for millions of years and to upset this network would have implications that extend beyond our current understanding of these systems. Dwindling populations will erode the genetic diversity of wild salmon and place the long-term future of salmon at risk. Many of these small systems remain pristine, but are threatened by overharvesting and habitat loss. It makes sense from a biological and economic standpoint to protect these systems now, before enhancement and restoration are required and before these significant ecological and genetic costs are realized.
Figure 1. DFO management areas of the Pacific Region (Fisheries and Oceans Canada, 2004). Management areas 7 and 8 lie within Heiltsuk Traditional Territory.
Figure 2. Spatial distribution of chum salmon streams in Heiltsuk Traditional Territory. Legend values represent mean escapement from 1985-1994.
Figure 3. Spatial distribution of pink salmon streams in Heiltsuk Traditional Territory. Legend values represent mean escapements for 1985-1994.
Figure 4. Frequency distribution of salmon streams in Heiltsuk Traditional Territory based on mean escapement from 1985-1994.

A) Chum salmon

B) Pink salmon
C) Coho salmon

![Coho salmon graph]

D) Chinook salmon

![Chinook salmon graph]
E) Sockeye salmon

![Graph showing frequency of escapement for Sockeye salmon.](image)
Table 1. The total escapements (all species combined) for all the small rivers combined in DFO management areas 6 and 7 compared with the escapements for the Skeena river illustrate that the combination of these small salmon runs has a significant contribution to the overall biomass of salmon in British Columbia. Declining escapements over time may be a reflection of reduced effort in stock assessment and/or decreased salmon returns.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area 6 &amp; Area 7 combined escapements</th>
<th>Skeena River escapements (Area 4)</th>
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<tbody>
<tr>
<td>1954</td>
<td>1,264,975</td>
<td>1,229,540</td>
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<tr>
<td>1964</td>
<td>2,626,484</td>
<td>2,337,898</td>
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<tr>
<td>1974</td>
<td>1,149,225</td>
<td>1,175,979</td>
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<tr>
<td>1984</td>
<td>1,142,473</td>
<td>2,208,950</td>
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<tr>
<td>1994</td>
<td>833,508</td>
<td>1,333,259</td>
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References


