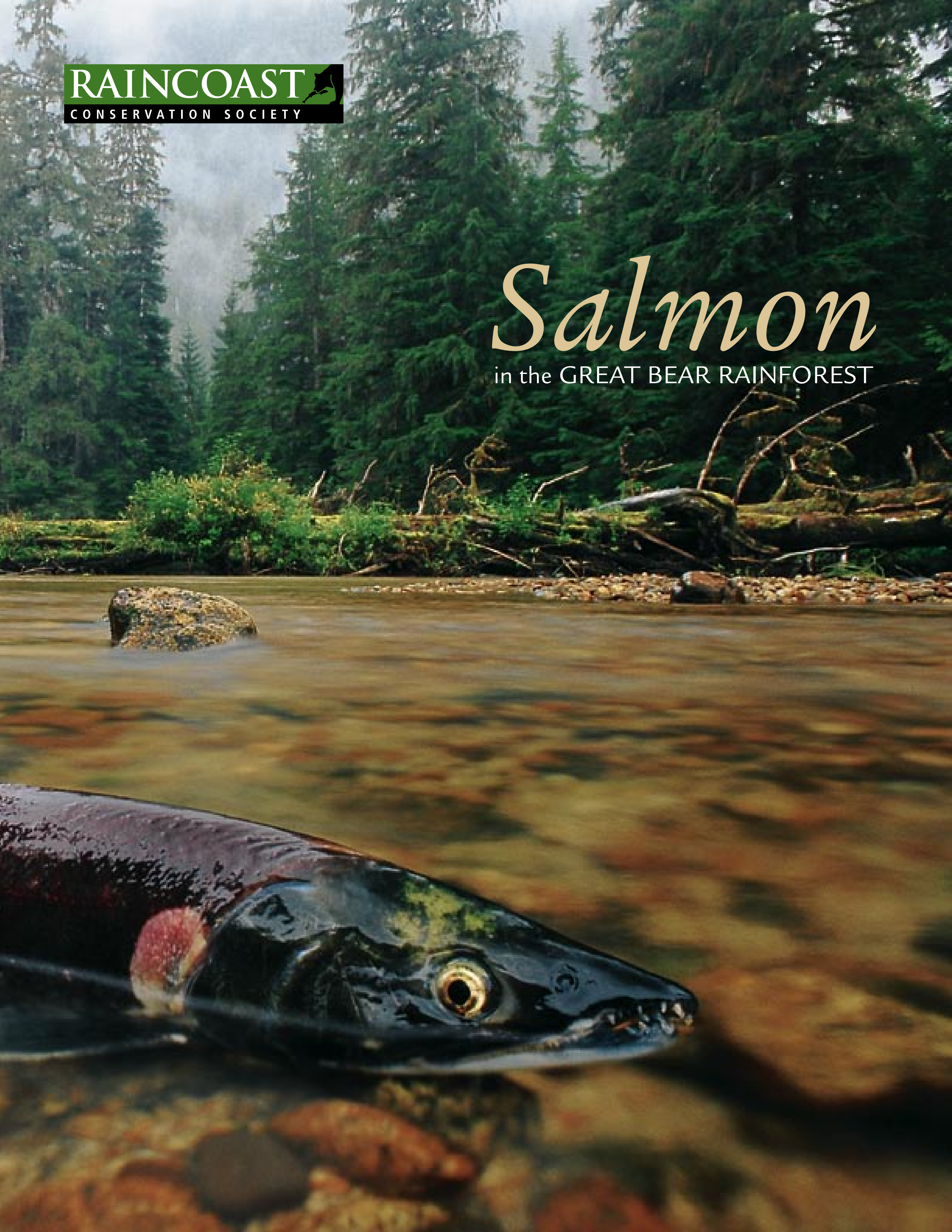
RAINCOAST CONSERVATION SOCIETY

Salmon in the GREAT BEAR RAINFOREST



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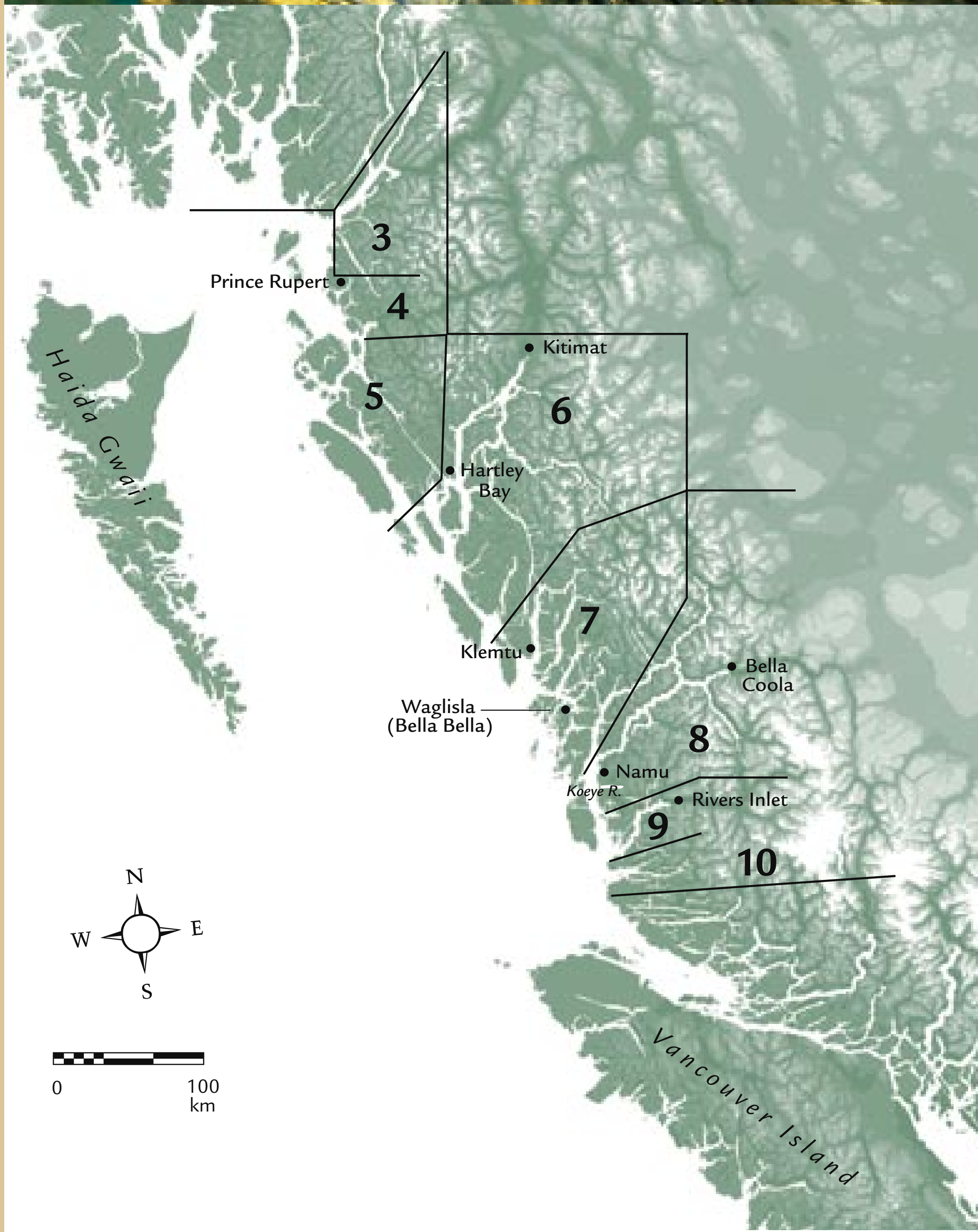
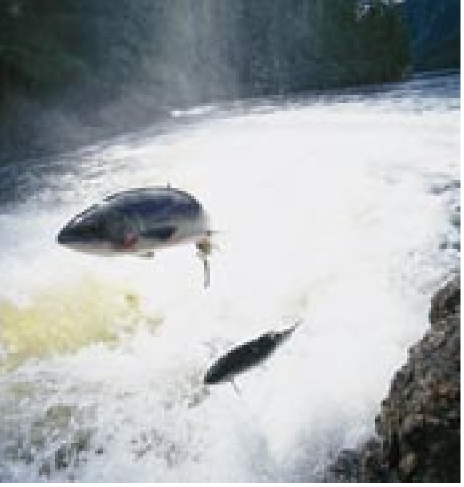


Figure 1

Fisheries management areas 3-10 on the north and central coasts of British Columbia, an area often referred to as the Great Bear Rainforest.



Up to 80% of the yearly nitrogen in the ancient trees that grow along salmon rivers is derived from salmon nutrients.[17]

Salmon Without Borders

Over 190 species of plant and animal benefit from salmon,[1] including killer whales, sharks, sea lions, seals, otters, bears, loons, mergansers, heron, kingfishers, aquatic and terrestrial insects, algae, mosses, terrestrial herbs, shrubs and ancient trees.

Salmon transcend diverse habitats throughout their lifecycle. They move between sea and stream. They pass from water to air in extraordinary leaps to overcome raging waterfalls. When they die, they are carried from water to land where their bodies return nutrients to the forests. Salmon are the link that brings distant ecosystems together. They are the connection between ocean and rainforest, herring and spruce, cultures past and present. They also tie communities and countries together, for they know no international boundaries.

The return of the salmon has been observed and revered by cultures around the northern hemisphere for many thousands of years. Salmon are a symbol of knowledge and of perseverance, and when they return to the rivers of their birth it is a time to celebrate the rejuvenation of life.

It is also a time to eat. Over 190 species of plant and animal benefit from salmon,[1] including killer whales, sharks, sea lions, seals, otters, bears, loons, mergansers, heron, kingfishers, aquatic and terrestrial insects, algae, mosses, terrestrial herbs, shrubs and ancient trees to name a few. Some coastal animals synchronize their high-energy demands with the arrival of the spawning salmon. For example, time of reproduction is delayed among minks so that the burden of nursing their young falls during the salmon spawning season.[2] Coastal bears obtain up to 90% of their total annual dietary requirements[4] during the salmon run, laying down essential fat stores prior to hibernation. Bears, gulls, eagles, seals and sea lions congregate by the thousands to take advantage of this food source; just a few of many coastal species that depend on this annual nutritional surge to meet their dietary protein requirements.[1,3]

The central and north coast of British Columbia (BC), an area known as the Great Bear Rainforest (see Fig. 1) is home to over 2,500 salmon runs.[5] Many of these rivers remain fully intact, offering a unique opportunity to study the complex interactions between salmon and these ecosystems. However, salmon in the Great Bear Rainforest are faced with the same threats that have depressed and extirpated salmon populations throughout the Pacific Northwest: loss of habitat, high human predation, misguided management, and enhancement activities. If we are to reverse this trend in the Great Bear Rainforest, a fundamental shift must occur in how we manage salmon and impact their habitats. ■

[1] Cederholm, C.J., D.H. Johnson, R.E. Bilby, L.G. Dominguez, A.M. Garrett, W.H. Graeber, E.L. Greda, M.D. Kunze, B.G. Marcot, J.F. Palmisano, R.W. Plotnikoff, W.G. Pearcy, C.A. Simenstad, and P.C. Trotter. 2000. Pacific Salmon and Wildlife—Ecological Contexts, Relationships, and Implications for Management. Special Edition Technical Report, Prepared for D.H. Johnson and T.A. O'Neil (Managing directors), Wildlife-Habitat Relationships in Oregon and Washington. Washington Department of Fish and Wildlife, Olympia, Washington.

[2] Ben-David, M. 1997. Canadian Journal of Zoology 75(3):376-382.

[3] Darimont, C.T. and T.E. Reimchen. 2002. Canadian Journal of Zoology 80: 1638-1642.

[4] Hilderbrand, G.V., S.D. Farley, C.T. Robbins, T.A. Hanley, K. Titus, and C. Servheen. 1996. Canadian Journal of Zoology 74: 2080-2088.

[5] A run is a salmon population that returns to a specific river over a particular time period.

The importance of protecting the diversity of small salmon streams is even greater in the face of unknown variables such as global climate change.

Small Streams, Big Importance

Evidence of nutrients derived from salmon carcasses has been found in vegetation as far as 500m from the stream bank.[9]

On the islands and coastline of central and northern BC, many small streams weave their way through the forest and empty into the ocean. These streams, some of which are no longer than a kilometer or two, help form a vital corridor for the annual influx of nutrients to coastal watersheds via the return of spawning salmon. Predators line stream banks to access this protein source—a food supply that might not otherwise be available on small islands or other fragmented habitats.[6] Bears and wolves carry salmon carcasses away from the stream and deliver nutrients to the forest floor.[7, 8] These nutrients enrich the surrounding landscape,[9, 10, 11] allowing it to support higher levels of diversity,[12, 13, 14] which in turn increases the resilience of the ecosystem. As spawning density increases, so does the penetration of marine-derived nitrogen into the watershed,[11,13] which translates into greater diversity and growth rate of plants,[13,15] greater diversity and density of insects,[12] and greater diversity and density of birds.[16] Neekas Creek, a small stream near Bella Bella, has up to 60,000 chum

6 Darimont, C.T., M.H.H. Price, N.N. Winchester, J. Gordon-Walker and P.C. Paquet. 2004, Journal of Biogeography 37:1-11.

7 Hilderbrand, G.V., T.A. Hanley, C.T. Robbins and C.C. Schwartz. 1999. Oecologia 21:546-550.

8 Reimchen, T.E. 2000. Canadian Journal of Zoology 78: 448-457.

9 Ben-David, M., T.A. Hanley and D.M. Schell. 1998. OIKOS 83: 47-55.

10 Bilby, R.E., B.R. Fransen and P.A. Bisson. 1996. Canadian Journal of Fisheries and Aquatic Sciences 53: 164-173.

11 Bilby, R.E., E.W. Beach, B.R. Fransen and J.K. Walter. 2003. Transactions of the American Fisheries Society 132: 733-745.

12 Hocking, M.D. and T.E. Reimchen. 2002. BMC Ecology 2:4.

13 Mathewson, D.D., M.D. Hocking, and T.E. Reimchen. 2003. BMC Ecology 3:4.

14 Wilkinson, C.E., M.H. Hocking, and T.E. Reimchen.2005. Oikos 108: 85-98.

15 Helfield, J.M. and Naiman, R.J. 2001. Ecology 82: 2403-2409.

16 Christie, K.C. and T.E. Reimchen. Canadian Field-Naturalist (submitted)

salmon spawning per kilometre of stream,[17] which is likely the highest density of spawning chum in British Columbia.[18]

BC's salmon populations harbour diverse and unique genetic adaptations that are vital to the survival of the species, particularly during times of environmental change. During the last ice age, which reached it's peak approximately 15,000 years ago, salmon spawning and rearing habitat was very limited along the ice-bound coastline of BC.[19, 20, 21] As the ice retreated, numerous lakes, rivers and streams began to flow and were subsequently colonized by salmon. These colonists underwent rapid evolutionary change in response to the unique conditions of each new habitat, and today their descendents continue to adapt to local conditions, further diversifying the Pacific salmon family. The hundreds of small salmon runs in BC are a huge reservoir of genetic adaptations that increase the ability of salmon to overcome adversities such as climate change and disease. These adaptations have taken thousands of years to evolve and cannot be replaced once they are gone. Therefore, the loss of even a single run, no matter how small, represents a drop in species resilience.

Some small streams are not suitable spawning grounds for adult salmon because they lack spawning gravels, water volume or flow requirements. However, these streams can still provide important rearing habitat for juvenile salmon. Some species (particularly coho, which spend from one to four years rearing in freshwater streams) will leave their natal streams in favour of less populated streams nearby.[22,23] In this way, the fish gain access to additional resources and more juvenile coho survive in total. Therefore, small streams may enhance the productivity of larger, neighbouring systems by providing additional rearing habitat for juvenile salmon.

[17] Reimchen, T.E. 2001. Ecoforestry 16:13-17.
[18] Hocking, M. Ph.D. candidate, Biology Department, University of Victoria. (pers. comm.)
[19] McPhail, J.D. and C.C. Lindsey. 1970. Bulletin of the Fisheries Research Board of Canada 173: 381 pp.
[20] Wood, C.C., B.E. Riddell, D.T. Rutherford and R.E. Withler. 1994. Canadian Journal of Fisheries and Aquatic Sciences 51 (Suppl. 1): 114-131.
[21] Smith, C.T., R.J. Nelson, C.C. Wood, and B.F. Koop. 2001. Molecular Ecology 10: 2775-2785.
[22] Sandercock, F.K. 1991. Life history of coho salmon (Oncorhynchus kisutch) In Groot, C. and L. Margolis (eds.). Pacific salmon life histories. UBC Press. Vancouver, British Columbia. Pp. 395-446.
[23] Otto, R.G. and J.E. McInerney. 1970. Journal of the Fisheries Research Board of Canada 27:793-800.

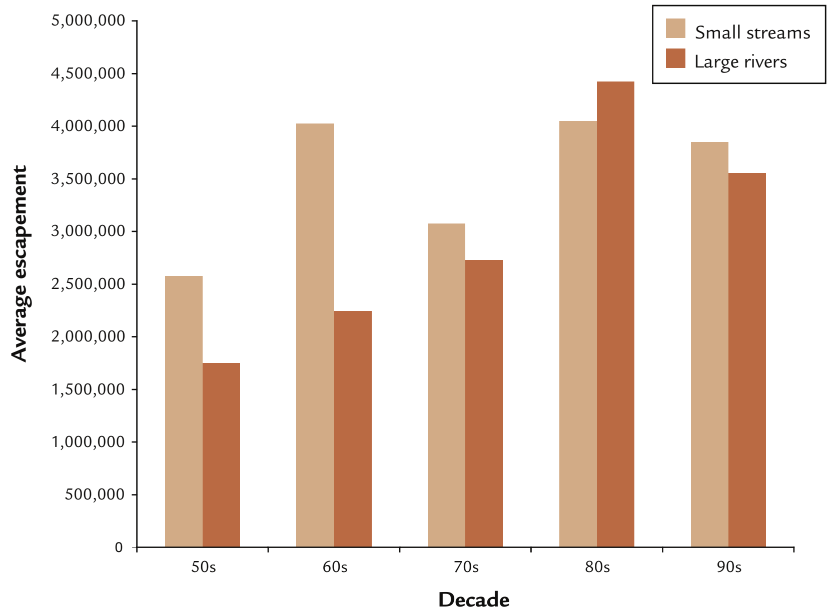
Small Streams, Big Importance…

Despite their importance, small streams are often overlooked. They are afforded the least protection under federal and provincial law, they are not given full consideration in fisheries management and very few resources are allocated to monitoring them. Salmon presence in many of these streams remains undocumented. As a consequence, small salmon runs, which play a vital ecological role in coastal ecosystems and contribute significantly to the overall genetic diversity of Pacific salmon, are in danger of extirpation. ■

Figure 2

Combined, small salmon streams contribute substantially to the overall numbers of salmon returning to the Great Bear Rainforest. For this comparison, large rivers include Nass R., Skeena R. and all salmon runs within Rivers Inlet and Smith Inlet. All species have been combined for the graph. Spawning channels and other enhancement activities in the Skeena River have increased sockeye production in this large system to a point where over 50% of sockeye in the Skeena are from enhanced stocks.

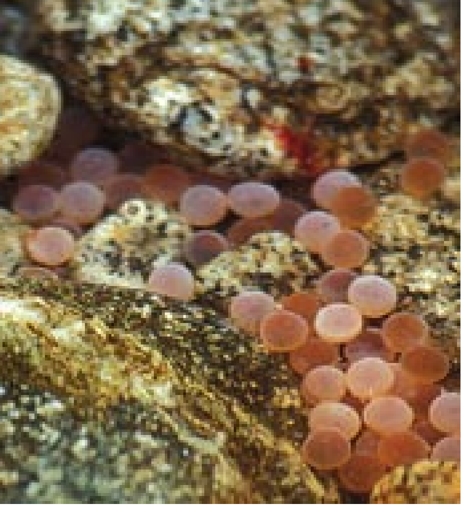
* Escapement is a term used in fisheries to refer to the portion of fish that escape the commercial and recreational fisheries to reach their freshwater spawning grounds.



The Koeye River

The Koeye (pronounced "Kway") River watershed lies within the Great Bear Rainforest just south of Namu (a historical Heiltsuk village site and home to a cannery facility from 1893 until the late 1980s). The Koeye River is nearly 22 kilometers long and drains approximately 18,000 hectares of pristine land before it empties into Fitz Hugh Sound. It is a place where humans have lived for 10,000 years and where grizzlies still come to fill their bellies with salmon. The name comes from the Heiltsuk word "Kvai" which means "the place rising above the water". It is a cultural centre for the Heiltsuk and Owikeeno Nations and one of the most important salmon streams on BC's central coast.

The Koeye River will be used throughout this document as an example of how issues such as over-fishing, mixed stock fisheries and inadequate monitoring are negatively affecting streams on the central and north coast of BC.



A Conservation Unit (CU) is a group of wild salmon sufficiently isolated from other groups that, if lost, is very unlikely to recolonize naturally within an acceptable timeframe (e.g., a human lifetime).[24]

A Matter of Genes

The complexity of salmon species is reflected in many stages of their life cycle. There is variability in:

- timing of adults returning to the rivers
- time of spawning
- preference for spawning habitat (e.g., gravel size)
- body size and shape as a result of predation pressure and the unique flow environment of the habitat
- egg size with different habitats
- time spent in freshwater as a juvenile (0-3 years)
- time spent at sea (1-4 years)

To truly protect the diversity of salmon, all of these levels of complexity must be considered.

Adapted from Hilborn et al. 2003. PNAS 100(11): 6564-6568.

While most salmon return to their natal streams to spawn, some fish occasionally stray into other river systems and breed with the neighbouring population. The genetic exchange that results from these wanderings reduces inbreeding and promotes genetic diversity within and across populations, which strengthens the resiliency of the species. Also, because smaller populations are more vulnerable to extirpation than large ones, immigration effectively boosts the size of smaller populations and helps them endure unfavorable conditions.[25] This complex pattern of genetic exchange is a critical component of the evolutionary history of salmon in BC. Therefore, protection for this scale of diversity within the species is critical to its continued survival.

The Department of Fisheries and Oceans (DFO), in its Wild Salmon Policy,[24] proposes to manage salmon at the level of Conservation Units (CUs), which take genetic diversity into consideration. CUs will be monitored and assessed against selected benchmarks, and if abundance is low or there is significant deterioration in the distribution of spawning populations within the CU, a range of management actions may be taken.[24] However, if social and economic costs of protecting a CU are deemed too high then conservation measures will not be implemented. One example is DFO's failure to list Sakinaw and Cultus Lake sockeye under the Species At Risk Act (SARA), populations that were listed as endangered in 2002 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Developing CUs is an important step toward conserving salmon and their evolutionary legacy. However, while small salmon runs are ignored and economics remain an overriding priority, the genetic diversity of salmon in BC continues to be diminished. ■

[24] Fisheries and Oceans Canada. 2005. A Policy Framework for Conservation of Wild Pacific Salmon.

[25] Hilderbrand, R.H. 2003. Biological Conservation 110: 257-266.

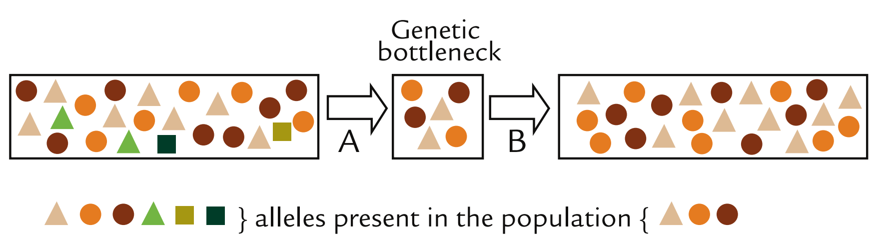


Figure 3

When salmon populations decline in abundance (A), as a consequence of habitat loss, disease or other factors, they are forced through a genetic bottleneck. Though the population may recover to original numbers (B), much of the unique genetic material (alleles) in the original population may have been lost (modified with permission from J. Leonard).

Since 2001, 46% of logging in the Great Bear Rainforest and Haida Gwaii has taken place in the region's most productive salmon bearing watersheds.

David Suzuki Foundation, Canada's Rainforests Status Report 2005.

Clear-cutting Salmon

Riparian forests (i.e., forests adjacent to rivers and streams) have four ecologically crucial functions: (1) to hold the soil and under-lying rock together, (2) to provide a source of large, fallen trees that create channel structure and in-stream habitat, (3) to provide a continued source of energy through leaf litter, and (4) to moderate stream temperatures.[27] Therefore, when riparian forests are cut down the ecology of local streams changes dramatically. The extent to which these changes affect juvenile salmon depends on the species of salmon and how long it spends in the freshwater habitat. Smaller streams will be more sensitive to these changes.[28] In addition to the importance of trees

[27] Hicks, B. J.2002. Gravel galore: Impacts of clear-cut logging on salmon and their habitats. In Harvey, B. and M. MacDuffee (eds.). Ghost Runs: The future of wild salmon on the north and central coasts of British Columbia. Raincoast Conservation Society. Victoria, BC.

[28] Chamberlain, T.W., R.D. Harr, and F.H. Everest. 1991. Timber harvesting, silviculture and watershed processes. In W.R. Meehan (ed.) Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society, Special Publication Number 19. Bethesda, Maryland.

[29] Paquet, P.C., C.T. Darimont, R.J. Nelson, and K. Bennett. 2004. A critical assessment of protection for key wildlife and salmon habitats under the proposed British Columbia Central Coast Land and Resource Management Plan. Raincoast Conservation Society.

[30] Harvey, B. and M. MacDuffee (eds.). 2002. Ghost Runs: The future of wild salmon on the north and central coasts of British Columbia. Raincoast Conservation Society. Victoria, BC.

in the riparian zone, forest cover throughout the watershed regulates the volume and timing of water flow to the stream. In a coastal temperate rainforest, where rainfall is in excess of 2-3m/year, changes in hydrology are particularly important to streams and the salmon that inhabit them.

Currently proposed land use plans provide little protection for salmon habitat on the central and north coasts,[29] with only 20-30% of salmon watersheds receiving complete protection. Logging has already occurred in 58% of the salmon watersheds DFO frequently assesses here.[30] ■

The Koeye River

The Koeye River watershed remains intact despite the encroachment of clear-cut logging from all sides. Work is underway to protect the forests of the Koeye River, but even this will not guarantee the protection of the salmon that live in its waters.

Escapements in the Koeye River have been estimated for the last couple of decades by flying the river in a fixed-wing aircraft. This technique makes it difficult to estimate chum as they are masked by the high number of pinks that are also in the river. Coho can't be estimated using this method once they have reached the upper spawning grounds.

Enderud, L. Fisheries Management Coordinator, Fisheries and Oceans Canada (Pers. Comm.).

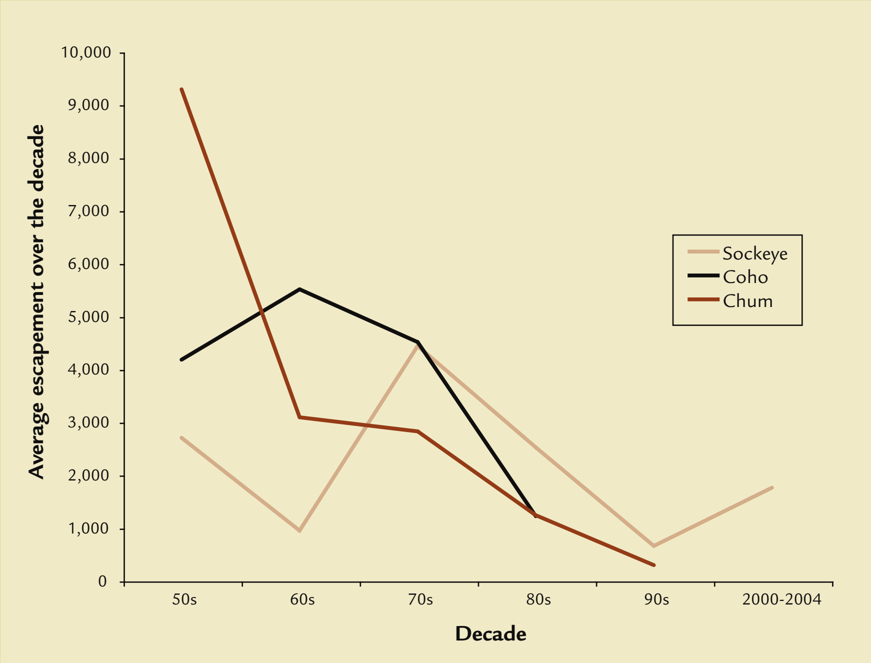


Figure 4

Escapements in the Koeye River have been declining for some species. Coho and chum appear to have suffered the greatest decline, but we don't know how bad these declines have been due to sparse monitoring over the last two decades. Coho have not been enumerated in the Koeye River since 1985 and chum have not been enumerated since 1999, when 100 individuals were estimated. This is a far cry from the 15,000 counted in 1970.

The best example of fish abundance increasing as a result of reduced fishing pressure, was during World War I and World War II. When fishing effort in the North Sea was reduced to near zero, biomass more than doubled.

Harvesting the Oceans

In the 1960s, the abundance of Pacific herring declined coastwide as a result of repeated overfishing with harvest levels exceeding 80%. This led to the collapse and eventual closure of the fishery in 1967. In 1992, cod populations off the east coast of Newfoundland collapsed. Over 40,000 people lost their jobs and coastal communities are still trying to recover. The marine ecosystem is still in a state of collapse. DFO managed these fisheries with the same models they use today to manage Pacific salmon. Will the fate of Pacific salmon be the same as Atlantic cod?

Humans are the major predator of life in the oceans. Our exploitation rates have led to the collapse of fish stocks around the globe.[31] In natural systems, predators rarely take more than 10% of a prey species,[32] and this prey base is often made up of weak, young or very old animals. This leaves the reproductive adults to breed.[33,34] In contrast, the fishing industry targets these reproductive adults. This can seriously impact the overall health and survivability of both present and future fish populations.

The best example of fish abundance increasing as a result of reduced fishing pressure was during World War I and World War II, when fishing effort in the North Sea was reduced to near zero. Groundfish biomass increased between two- and four-fold within a few years.

The models currently used in fisheries management prescribe extraction rates that far exceed those seen in nature. For example, exploitation rates of coho salmon on the west coast of Vancouver Island have ranged from 40-80% since 1975, with an average of 75%.[35] At present, these fish are not harvested to any substantial level since the populations

The remains of Wadham's Cannery in Rivers Inlet.

have undergone a severe crash, and considerable measures are needed to prevent local and regional extirpation. It is true that exploitation rates in some fisheries are dropping, but this is in direct response to diminishing salmon returns and does not represent a shift in management policy. Exploitation rates of 40-60%, which are almost unprecedented in natural systems, are still common. ■

[31] Pauly, D., V. Christensen, J. Dalogaard, R. Froese, and F. Torres. 1998. Science 279: 860-863.

[32] Reimchen, T.E. 2002. Some considerations in salmon management. In Harvey, B. and M. MacDuffee (eds.) Ghost Runs: The future of wild salmon on the north and central coasts of British Columbia. Raincoast Conservation Society. Victoria, BC.

[33] Temple, S.A. 1987. Ecology 68(3): 669-674.

[34] Errington, P.L. 1947. The Quarterly Review of Biology 21 (2): 144-177.

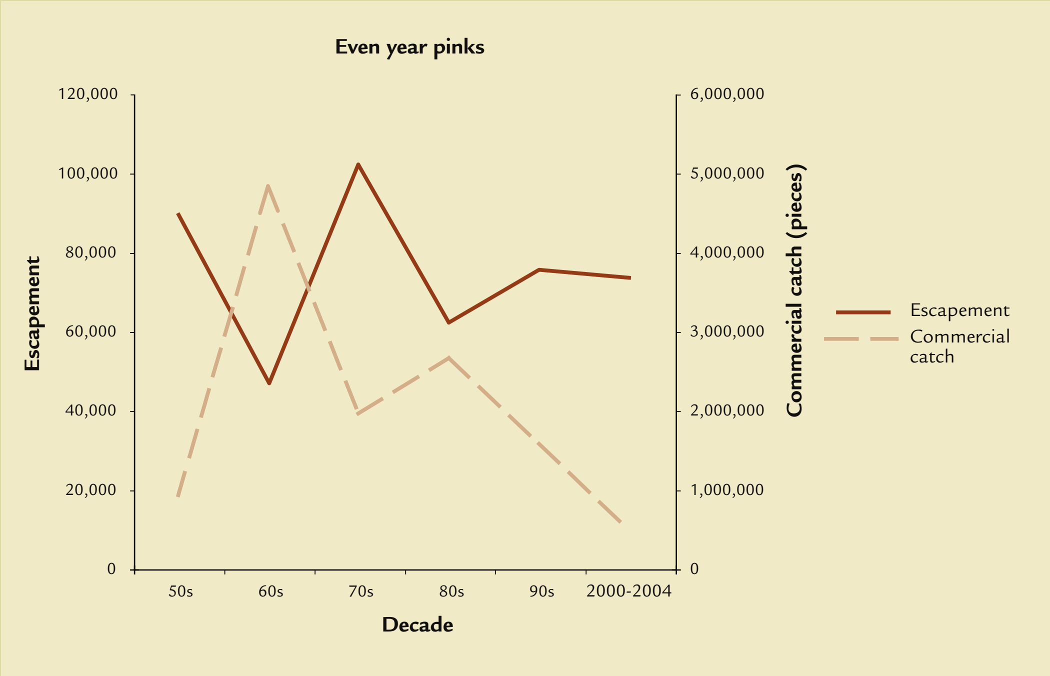
[35] Department of Fisheries and Oceans. 2002. West Coast Vancouver Island Coho. DFO Science Stock Status Report D6-06.

The Koeye River

Salmon returning to the Koeye River are caught as part of the mixed-stock fishery that targets the Bella Coola/Atnarko River returns. Heiltsuk community members catch sockeye returning to the Koeye River as part of their subsistence fishery. It is likely that fishing pressure is part of the reason for declines in salmon returning to the Koeye River.

Figure 5

Despite the fact that the Koeye River contributes very little to the commercial catch of pink salmon in management area 8, there is a strong, negative correlation between the decadal averages when plotted together. Though correlation is not evidence of causation, it would appear as though even-year pink runs in the Koeye are greatly impacted by the Area 8 commercial catch, whether as a result of a targeted fishery or mixed-stock fisheries.



Pan Fish hatchery in Ocean Falls, BC.
S. Temple photo

Fifteen years ago there were 50 fish farm companies in BC. Today, that number has dropped to 12, and five multinationals control 80% of BC's salmon farm sites.[35] Between 1990 and 2000, commercial landings of BC wild salmon declined by over 80%, while output from salmon farming increased over 80%.[36]

Pen Perils

In 2002, the BC Liberal government lifted the moratorium on new salmon farms. That same year, pink salmon returns in the Broughton Archipelago (the area with the highest density of salmon farms in BC) fell from over 3.5 million to only 147,000. This dramatic decline added fire to the debate over open-net cage salmon farms and their impacts on local ecosystems and migrating wild salmon.[37]

Wherever salmon farms have existed (Norway, Scotland, Ireland, Canada, Chile), there have been negative impacts on local ecosystems. These include the introduction of exotic species (e.g., escaped Atlantic salmon in Pacific waters), local disease, parasite enhancement and transfer (e.g., sea lice) and waste pollution.[38,39] Both the federal and provincial governments refuse to recognize the existing scientific data revealing the impacts of salmon aquaculture. Thus, the debate continues despite clear scientific evidence that open-net cage salmon farms can pose a significant risk to the health of wild salmon.[40,41,42]

Open-net cages allow captive farmed salmon to interact with migrating wild salmon. This becomes a serious issue considering the propensity of salmon farms to concentrate and transfer parasites and disease into the local environment.[40,42] A good example of this is sea lice, a common parasite on adult salmon that naturally occurs in low frequency on juvenile salmon. When juvenile pink and chum salmon leave the rivers in the spring, they make their way through estuaries and near-shore environments. In 2001, 2002 and 2004, studies in the Broughton Archipelago found that over 80% of pink and chum salmon juveniles sampled near salmon farms had lice levels greater than 1 louse per fish.[40] Previous studies of European salmonids indicate that around 1 louse/gram of fish body weight is lethal. To date, no information has been gathered on the lethal lice levels for juvenile pink and chum salmon, yet given their average weight of 0.5 grams when they leave the rivers, 1 louse per fish may be fatal. ■

Raincoast, in partnership with local communities, First Nations and universities, is contributing to the science of sea lice and their interactions with wild salmon. The data we gather will help us understand the natural relationship between sea lice and juvenile salmon in areas without salmon farms. The research also examines this relationship in areas with salmon farms. The resulting baseline research will help us measure the impacts of salmon farms on the health of juvenile salmon.

[35] Cox, S. 2004. Diminishing Returns. Raincoast Conservation Society, Victoria, BC.

[36] Gross, M.R. 2002. Net Risk: assessing potential impacts of fish farming on BC's wild salmon. In Harvey, B. and M. MacDuffee (eds.). Ghost Runs. Raincoast Conservation Society.

[37] Gardner, J. and D.L. Peterson. 2003. Making sense of the salmon aquaculture debate. Prepared for the Pacific Fisheries Resource Conservation Council. Vancouver, BC.

[38] Bjorn, P.A. and B. Finstad. 1997. Nordic. J. Freshw. Res. 73:60-72.

[39] Grimnes, A. and P.J. Jacobsen. 1996. Journal of Fish Biology 48: 1179-1194.

[40] Morton, A., R. Routledge, C. Peet, and A. Ladwig. 2004. Canadian Journal of Fisheries and Aquatic Sciences. 61: 147-157.

[41] Krkosek, M., A. Morton, and J.P. Volpe. 2005. Transactions of the American Fisheries Society 134:711-716.

[42] Krkosek, M., M. A. Lewis, and J.P. Volpe. 2005. Proceedings of the Royal Society of London Series B (in press).

Figure 6

Salmon farm tenures on the north coast of BC sit at the mouth of the Skeena River, the second largest salmon run in BC. Petrel Point and Anger Anchorage are fully approved fish farm sites, while the site at Strouts Point is pending approval as of August 2005. The remaining proposed fish farm sites have been identified by fish farm companies as suitable locations to pursue in the future.

Fish farms, approved or pending approval — Proposed fish farm sites — Salmon bearing stream systems

0 10 20 km

Farm locations: BC MAFF, April 2004.
Salmon Streams: BC FISS Projection: BC Albers Equal Area
Map courtesy of J. Ardron, Living Oceans Society.

The Koeye River

There is also the threat of exotic species invasion. Just north of the Koeye River, in Ocean Falls, lies North America's largest fish farm hatchery. It has the capacity to produce up to 10 million Atlantic salmon smolts a year.

C. Williamson photo

There are no fish farms in the immediate vicinity of the Koeye River, however, the proposed expansion of salmon farms on the coast means that juvenile fish leaving the Koeye River on their northward migration will be at greater risk from disease and parasitic infection. Though there has been considerable research on the movement of juveniles along the continental shelf and off-shore, the near-shore migration routes of juvenile salmon are poorly understood.

Raincoast, in collaboration with the Heiltsuk, is working to fill this knowledge gap by characterizing near-shore habitats and migration routes that juvenile salmon follow as they leave the streams in Roscoe Inlet, northeast of Bella Bella (Waglisla). This study will improve our understanding of the environmental cues and characteristics of juvenile salmon migration routes. This knowledge will go a long way towards predicting the potential impact of fish farm sites on out-migrating salmon.

"In reality, many salmon stocks would be in trouble if it weren't for the thorough old-time field experience of a few managers with a lot of dedication..."

Ralph Nelson, Creek walker (Salmon Patrol)

Monitoring Salmon on the Coast

In 1992, DFO launched the Aboriginal Fisheries Strategy (AFS), with the goal of providing a framework for the management of fishing by Aboriginal groups for food, social and ceremonial purposes. One of the AFS objectives is to insure First Nations have the resources to do the creek-walking in their traditional territories. As an example, the Kitasoo Fisheries Technicians based out of Klemtu, do most of the creek-walking in their local area, but do not have the resources to enumerate all of the systems as well as carry out their other duties.

Reliable assessment and monitoring of fish populations is at the core of sustainable fishery management. Annual surveys of spawning salmon numbers help us understand the cycles of salmon abundance in BC waters and prevent the over-harvest of weak populations. Fisheries managers refer to the number of fish that escape the fishery and return to the river to spawn as the "escapement". Collection of escapement data began in the early 1900s and was carried out by the Salmon Patrol, which consisted of fisheries staff and local river guardians known as "creek walkers". These dedicated individuals

N. Temple photo

hiked up the local streams often in adverse conditions, documenting salmon abundance throughout the spawning season. Many creek walkers resided in cabins situated along major rivers, from which they gained an intimate knowledge of the salmon and systems in the area assigned to them. It also enabled them to watch the estuaries and dissuade poachers at the mouth of the river.

In the 1970s, fixed-wing aircraft and patrol boat-based surveys replaced many of the original creek walkers. By the 1980s, many creek walker cabins lay vacant and by the 1990s there were none. The Salmon Patrol still employs creek walkers on the coast. These individuals have been walking the same rivers and creeks for decades, and their intimate knowledge of the areas makes them an important link between wild salmon and management policy.

Federal budget cuts over the last two decades have led fisheries managers to limit their monitoring efforts to the most commercially important runs. As a result, visitation to salmon streams plummeted by 47% between 1985 and 1999.[43] In 1999, the Auditor General of Canada stated that lack of monitoring and assessment was eroding the salmon resource base and that there was no information on 40% of BC's salmon stocks.[44] In spite of the Auditor General's report, stock assessment by the Department has been further reduced.

Throughout the 1990s, an average of 28% of central and north coast salmon streams were visited at least once. However, less than 10% of the streams were visited often enough to determine the status of the local population. This average is likely an overestimate since surveys conducted by the Heiltsuk Nation and Raincoast have identified salmonids in over 100 streams within Heiltsuk Traditional Territory that have never been documented for fish presence by DFO. This would suggest that there are

[43] Harvey, B. and M. MacDuffee (eds.) 2002. Ghost Runs: The future of wild salmon on the north and central coasts fo British Columbia. Raincoast Conservation Society. Victoria, BC.

[44] Auditor General of Canada. 1999. Chapter 20 – Fisheries and Oceans – Pacific Salmon: Sustainability of the Fisheries. In 1999 Report of the Auditor General of Canada.

The Koeye River

The Koeye River is very tannic, or tea-coloured, as a consequence of tannins being released from the vegetation. This makes it particularly challenging to count fish in the river and could affect the accuracy of the counts.[45]

[45] Enderud, L., Fisheries Management Coordinator, Fisheries and Oceans Canada (Pers. Comm.).

Monitoring in the Koeye River was relatively consistent until around 1995. Since then, pink salmon are the only species that have been regularly counted. Sockeye have been enumerated in 7 of the last 10 years, while chum have only been counted twice. Coho have seen the greatest reduction in monitoring, as they are more difficult to enumerate high in their spawning grounds without someone on the ground actually counting them. A local guardian estimated coho abundance regularly until 1992.[45] Since 1995, no data exist for coho in the Koeye.

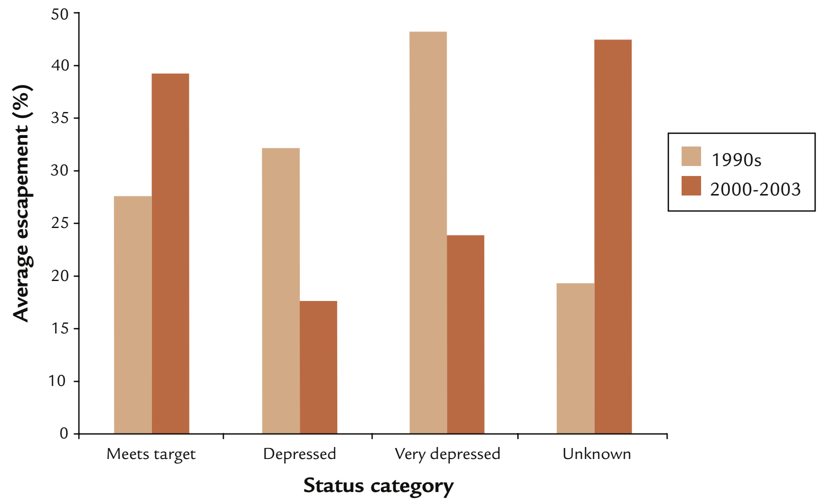
many more salmon runs on the coast than currently described, and that DFO's monitoring and enumeration efforts are only reaching a small fraction of them.

Funding local guardians to properly monitor specific territories must become a significant component to fisheries management. People within local communities often have knowledge of these areas that goes back many generations. Hence, communities have historical knowledge of changes in the resource over time. Heiltsuk Fisheries director, Jack Larsen,[46] says it would take 12 fully trained guardians within their territory to enumerate salmon streams, watch for poachers and monitor other fisheries such as the shellfish and spawn-on-kelp fisheries. Today, there are only two guardians. ■

[46] Larsen, Jack, Director of the Heiltsuk Fisheries Program (Pers. Comm.).

Figure 7

Compared to the 1990s, fewer indicator systems are being monitored regularly and many fall into the "unknown" category. Unfortunately, it is systems that are depressed or very depressed that have dropped from monitoring programs. This results in the biased view below. Remove the unknown category from the graph and it would appear as though salmon runs on the coast have improved since the 1990s. In reality, many streams are not monitored once they fall well below escapement targets.



Myths about hatcheries de-boned

There is evidence that suggests salmon population enhancement initiatives have caused a net decrease in wild salmon abundance.[47] The introduction of hatcheries was intended to "*...add to the overall production and compensate for reductions in salmon stocks caused by human and other impacts....*"[48] However, despite the release of millions of fry in BC each year, salmon numbers continue to decrease.

Wild salmon are threatened by enhancement activities in three ways:[49]

1. fisheries that target enhanced runs can inadvertently over-fish smaller wild runs,
2. hatchery-reared fry can compete with wild fish for resources, and
3. hatchery fish that hybridize with wild fish can introduce "domesticated" genotypes into the wild gene pool that reduce the fitness of the population.[50,51,52,53]

Hatcheries are not a sustainable solution for improving declining stocks.[49,54]

[47] Pacific Fisheries Resource Conservation Council. 2000. "Wild Salmon Policy" and the future of the Salmonid Enhancement Program: The Response of the Pacific Fisheries Resource Conservation Council. Vancouver, BC.

[48] Gardner, J., D.L. Peterson, A. Wood and V. Maloney. 2004. Making Sense of the Debate about Hatchery Impacts: Interactions Between Enhanced and Wild Salmon on Canada's Pacific Coast. Vancouver, BC: Prepared for the Pacific Fisheries Resource Conservation Council.

[49] Harvey, B. and M. MacDuffee (Eds.). 2002. Ghost Runs: The future of wild salmon on the north and central coasts of British Columbia. Raincoast Conservation Society. Victoria, BC.

[50] Reisenbichler, R.R. and J. McIntyre. 1977. Journal of the Fisheries Research Board of Canada 34: 123-128.

[51] Campton, E.E., F.W.Allendorf, B.J.Behnke, F.M. Utter, M.W. Chilcote, S.A. Leider and J.J. Loch. 1991. Transactions of the American Fisheries Society 120: 816-827.

[52] Hindar, K., N. Ryman and F. Utter. 1991. Canadian Journal of Fisheries and Aquatic Sciences 48: 945-957.

[53] Reisenbichler, R.R. and S.P. Rubin. 1999. ICES Journal of Marine Science 56: 459-466.

[54] Lorenzen, K. 2005. Philosophical Transactions of the Royal Society: Biological Sciences 360: 171-189.

[55] Slaney, T.L., K.D.Hyatt, T.G.Northcote and R.J.Fielden. 1996. Fisheries 21(10):20-35.

The Salmon Index

Number of canneries in Rivers Inlet at the peak of the fishery (1917): **14**

Number of canneries in Rivers Inlet after 1957: **0**

Number of gillnetters in mouth of Rivers Inlet at the peak of the fishery: **1,000-1,500**

Number of gillnetters in mouth of Rivers Inlet in 2005: **0**

Distance of ocean migration:
Pink salmon: **5,556-7,408 km**
Sockeye salmon: **15,000 km**

Daily migration of a homing sockeye: **46-56 km**

Olfactory sensitivity:
Salmon are able to detect **1 part chemical substance in 80 billion parts of water**

Salmon can see a broader range of colours than humans:
Number of colour photoreceptors in salmon
4 (uv, blue, green and red)
Number of colour photoreceptors in humans
3 (blue, green and red)

The state of salmon runs in BC:[55]
Of the 5,507 salmon and trout stocks that have enough data for assessment:
142 stocks have disappeared since 1900
mainly due to habitat destruction from logging, urbanization and hydroelectric power

624 are at high risk of extinction
78 are at moderate risk of extinction
230 are of special concern

Average number of salmon a bear can eat in a day:
up to 30 (depending on species of salmon)

The price of salmon in BC (in Canadian dollars):

Species	Price per pound at peak (~1988/1989)	Price per pound in 2003
Sockeye	3.66	1.15
Pink	.48	.25
Coho	2.41	.99
Chum	1.26	.33
Chinook	3.35	1.30

C. Williamson photo

Since 2001, only 8% of small fish-bearing streams flowing through logging sites were fully protected.

David Suzuki Foundation, Canada's Rainforest Status Report 2005.

From Science...

To learn more about our research visit www.raincoast.org.

Raincoast's work on wild salmon in BC is part of a coordinated effort among many diverse groups to reform fisheries management. In collaboration with First Nations, coastal communities and academics, Raincoast is conducting on-the-ground research focused on three critical threats to salmon: habitat loss, over-exploitation and aquaculture expansion. Using a science-based approach we are revealing the shortcomings of conventional management policy and the true impacts of human activities. Our goal is to use this evidence to change the way wild salmon and their habitats are managed.

With the results of our projects, we will be able to:

1. increase protection of watersheds from land use activities such as logging and mining,
2. demonstrate the need to reduce extraction rates of fisheries, and
3. demonstrate the threat that sea lice from open-net cage fish farming pose to wild salmon.

to Solutions...

No salmon stream ignored.

Small salmon runs that are exploited in mixed-stock fisheries but are not monitored can no longer be ignored by fisheries management. The ecological contribution of small salmon runs to coastal ecosystems and to the genetic resilience of the species must be recognized and reflected in provincial and federal regulations.

Protection for salmon streams and their watersheds.

Full watershed protection, through the regulation of industrial activities, is absolutely necessary to ensure the survival of wild salmon and the salmon-dependent species that live in these ecosystems.

Investment in future salmon generations.

We are drawing heavily upon our "salmon savings account" without thinking about the future. Human exploitation rates of salmon need to reflect those seen in natural predator-prey relationships. As a first step, harvest levels should not exceed 50% on any population, and in the case of depressed populations (i.e., those not meeting escapement targets), harvest levels should not exceed 10%. Finally, there should be no commercial harvest on populations considered threatened or at risk of extinction.

Optimal escapements as opposed to escapement targets.

Salmon are the "life blood" of coastal ecosystems. They play a major role in the cycling of nutrients and more than 190 species depend on them each year. Therefore, escapement targets must be set that recognize the overall needs of the ecosystem. Management of the fishery must be improved to ensure that these optimal escapements are reached.

Appropriate monitoring of salmon populations.

Standardized monitoring programs on the coast must be comprehensive, non-biased and include partnerships with local interest groups. Adequate and reliable resources must be allocated to these programs.

No fish farm expansion in the Great Bear Rainforest.

The decision to promote salmon aquaculture as it is currently practiced is a political move with no scientific basis. The data show that exotic species invasion, disease, parasites and pollution are just some of the issues that plague salmon farming on the coast. DFO can no longer ignore the scientific evidence and must follow through on its primary mandate of protecting wild salmon by halting the progress of salmon aquaculture in the GBR. ■

S. Temple photo

The Future of Wild Salmon

We cannot solve the problems we have created with the same thinking that created them.

Albert Einstein

Management of Pacific salmon is particularly challenging as a consequence of their complex life histories and migratory behaviour. These species undertake extensive oceanic migrations and pass through streams that begin far inland and stretch all the way to the Pacific Ocean. In Canada, jurisdiction falls to different levels of government depending on the habitat in question (freshwater, near-shore oceanic or off-shore). Internationally, treaties and agreements guide salmon management between countries. Lack of communication and collaboration among the various levels of government is partially responsible for the mismanagement of salmon in BC.[56]

Pacific salmon have been evolving within coastal ecosystems for millions of years. They exhibited great resiliency by surviving through long periods of glaciation and ultimately re-colonizing and adapting to new habitats after the glaciers receded. However, humans are now changing the face of coastal ecosystems so quickly that salmon don't have time to adapt. With so many threats, policies concerning wild salmon must take a firm stance and make conservation a priority. Sadly, current policies guiding fisheries management are weak and designed to maximize short-term human benefit, at the cost of long-term abundance and diversity of wild salmon populations.

Raincoast is conducting rigorous scientific research in order to reform the way salmon are managed in BC. Since conservation concerns arise faster than scientific research is capable of finding answers, we also promote a precautionary approach to salmon management. The conservation of the species should be the primary concern of any management program. Wild salmon need many voices to speak on their behalf to ensure that they continue to be a rich and healthy part of our culture and our ecosystem. ■

[56] Auditor General of Canada. 2004. Chapter 5 – Fisheries and Oceans Canada – Salmon Stocks, Habitat, and Aquaculture. Report of the Commissioner of the Environment and Sustainable Development to the House of Commons.

The future of the Koeye

The situation in the Koeye River illustrates the need for change in salmon management. Three species have been declining since the 1970s. Target escapements for sockeye have not been met since 1937, though pink salmon escapements were on target during the 1990s. No one knows when chum and coho last met escapement targets. Since terrestrial habitat loss is not a factor in this decline (there has been no logging in the watershed) and poor ocean survival has likely not persisted for this entire period, over-fishing must be seriously examined as the root cause of the decline.

It is difficult to make inferences from salmon escapement data in the Koeye River for several reasons:

- Counting and reporting methods have changed with time, creating inconsistencies and decreasing accuracy of the data
- Tannic water conditions in the Koeye make it difficult to accurately estimate the number of fish in the river
- Limited resources prevent regular enumeration

Raincoast's Wild Salmon Research Team

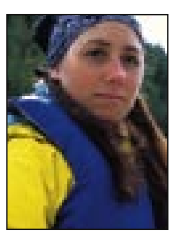
NICOLA TEMPLE Coordinator of the Wild Salmon Program, Nicola has a Master of Science from the University of Victoria, where she investigated the effects of clipping the adipose fin from salmonids. She has taught laboratories in ecology and ichthyology and has worked as a facilitator. Nicola has been leading the field work for the stream surveys and has been actively involved in trying to shape federal policies to conserve wild salmon.

MISTY MACDUFFEE Co-author and editor of *Ghost Runs*, Misty has spent considerable time researching the status of wild salmon and working for their protection in both damaged and pristine environments on the BC coast. She is currently leading the historic salmon abundance project, which is using stable isotope analysis and invertebrates buried in lake sediments to rebuild past trends in sockeye abundance.

COREY PEET A Master of Science student at the University of Victoria, Corey is conducting sea lice research on the central coast as well as on western Vancouver Island and the southern Gulf Islands. He has given many talks on his research to public interest groups, at conferences and in coastal communities, working to educate people on the impacts of sea lice on juvenile wild salmon. Corey is the lead scientist for Raincoast's sea lice research program.

CHRIS WILLIAMSON A new resident to Waglisla (new Bella Bella), Chris has a Master of Science in Environmental Biology and Ecology in which he investigated how invading species cause diet shifts in native fishes using stable isotope analyses. He has extensive field experience spanning from desert streams in Mexico to coastal streams in temperate rainforests of Canada. Chris coordinates the juvenile salmon migration studies and is also Raincoast's Great Bear Rainforest Aquaculture Campaigner.

The wild salmon projects would not happen if it weren't for the support and guidance of Raincoast staff Chris Genovali, Ian McAllister, Robin Husband, Stephen Anstee, Brian Falconer, Heidi Krajewsky, Loredana Loy, Karen McAllister, Faisal Moola, past staff Michelle Larstone and Theresa Rothenbush, and volunteers Cara Hunt, Rick Husband, and Marnie Phillips.



Nicola Temple

Misty MacDuffee

Corey Peet

Chris Williamson

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RAINCOAST CONSERVATION SOCIETY

The Raincoast Conservation Society is a non-profit organization promoting research and public education with the goal of protecting and restoring coastal rainforest ecosystems and their interdependent life forms. Using the principles of conservation biology and on-the-ground field research, we strive to better understand the region's lands, seas and wildlife to assist local communities, conservation planners, and government agencies design and implement sustainable land and marine use plans.

For an in-depth analysis of the status of wild salmon in The Great Bear Rainforest, please see *Ghost Runs: The Future of Wild Salmon on the North and Central Coasts of British Columbia*. B. Harvey and M. MacDuffee (eds.), 2002. Prepared for the Raincoast Conservation Society. Victoria, BC. ISBN#0-9688432-1-2. Available as a pdf file at www.raincoast.org. Printed reports are available on a cost recovery basis.

To learn more about the five multinational corporations that control BC's salmon farming industry, please see *Diminishing Returns* by Sarah K. Cox. 2004. Prepared for the Coastal Alliance for Aquaculture Reform. Victoria, BC. Available as a pdf file at www.raincoast.org. Printed reports are available on a cost recovery basis.

You can help...

Our salmon program would not be possible without public support. Monetary and equipment donations are gratefully accepted. Visit www.raincoast.org to make a donation on-line with your Visa or Mastercard. Indicate that you want your donation to go directly toward salmon research on the coast. Contact our Victoria Office for further information about equipment needs.

Raincoast Conservation Society
Victoria Office
PO Box 8663
Victoria, BC
Canada V8W 3S2
Phone: 250.655.1229
Email: greatbear@raincoast.org

Bella Bella Office
PO Box 26
Bella Bella, BC
Canada V0T 1B0
Phone: 250.957.2480

www.raincoast.org