

## INSIDE

Farmed fish on the loose.....	3
The threat of Atlantic salmon invasion.....	3
Potential vectors of parasites and disease.....	4
The risk for national forests.....	5

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# Science

## FINDINGS

*"Science affects the way we think together."*

Lewis Thomas

100<sup>th</sup> ISSUE100<sup>th</sup> ISSUE

## FARMED ATLANTIC SALMON: POTENTIAL INVADER IN THE PACIFIC NORTHWEST?



British Columbia Salmon Farmers Association

Occasionally storms damage aquaculture pens and thousands of fish escape into marine bays and fjords. This has raised concerns that farmed salmon may interact with and potentially harm native fishes. The industry has begun using double-walled pens to reduce the likelihood of escapes.

*"Farm-raised salmon now outnumber wild fish nearly 85 to one. As wild stocks dwindle, this legendary sport fish has become the veritable chicken of the sea."*

—Fen Montaigne,  
National Geographic

Throughout the world, salmon is increasingly what's for dinner. In the past 15 years, consumption of salmon has doubled, and nearly all of the increase has come from the culture of Atlantic salmon. Salmon farming is now a \$2 billion-a-year industry annually serving up 2.6 billion pounds of fish. Clusters of open-net aquaculture

pens churning with salmon can be found in cold marine bays from Norway to Chile, and several countries in between.

There are now approximately 130 salmon farms along the Pacific Northwest coast. Most produce Atlantic salmon, although a few farms also raise native Chinook or coho. Atlantic salmon dominate the industry, even in the Pacific, because the most productive stocks for farming were originally developed in Norway, where marine net-pen aquaculture evolved during the 1960s. And, like most agricultural commodities, Atlantic salmon have been optimized for fast, consistent production. In fact, in the time it would take

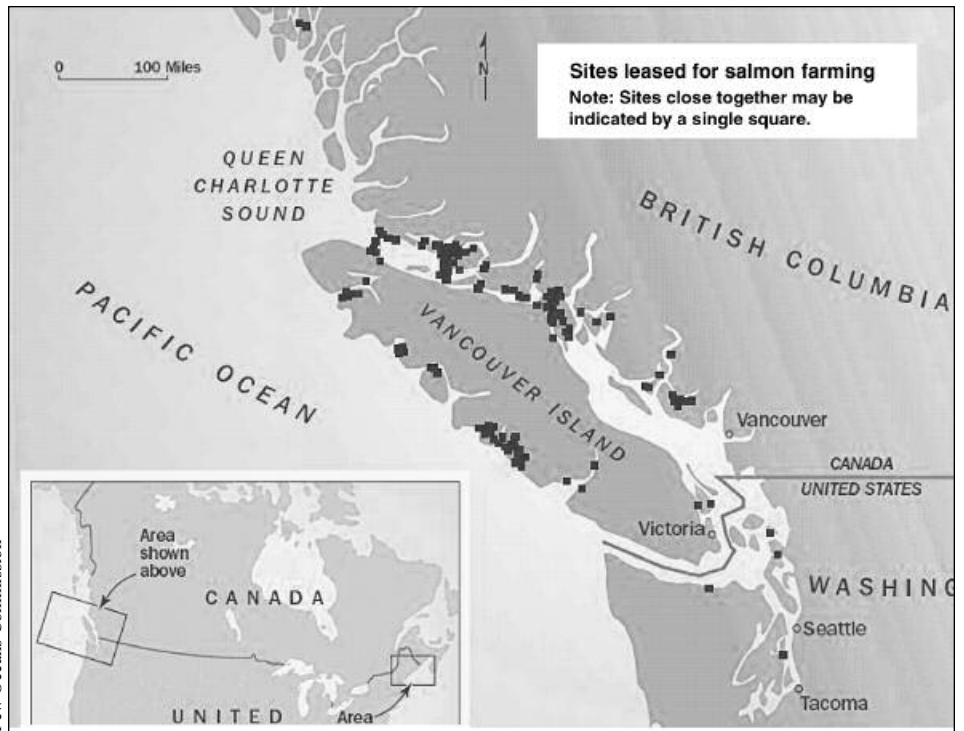
### IN SUMMARY

Commercial farming of Atlantic salmon in marine net-pens has become a booming industry. At present, approximately 130 salmon farms exist along the Pacific coast of North America. Most of these farms are in cold marine bays within British Columbia, where farmed salmon have become the province's most valuable agricultural export. Each year, thousands of farmed Atlantic salmon escape their pens, and could potentially impact native fishes. The PNW Research Station has recently examined the risk of population establishment by escaped Atlantic salmon in the Pacific Northwest, and assessed the potential implications of invasions for native fishes inhabiting streams within national forests.

The short-term risk of Atlantic salmon invasions appears to be low and is limited to a few areas in northwest Washington and southeast Alaska. However, long-term risks may be substantial if fish continue to escape from marine rearing pens or freshwater hatcheries. The two greatest threats appear to be that Atlantic salmon could transmit a serious disease or parasite to native fishes, and that escaped salmon could eventually adapt to local conditions, leading to self-sustaining populations. If Atlantic salmon populations are eventually established, this species' preference for swiftly flowing stream habitats could facilitate competition with currently at-risk species such as steelhead.

## KEY FINDINGS

- In the last 15 years, more than 1 million Atlantic salmon have escaped from Washington and British Columbia farms, including freshwater hatcheries and marine rearing pens. Although adult and juvenile Atlantic salmon have been observed in many Washington and British Columbia streams, evidence for successful reproduction of feral populations is presently limited to a few streams on Vancouver Island.
- Overall, the current risk to national forest streams from Atlantic salmon invasion is low and is largely confined to watersheds in northwest Washington and southeast Alaska that are within a few hundred miles of marine pens and freshwater hatcheries.
- Juvenile pink and chum salmon migrating near some net-pens have been severely harmed by sea lice, a marine parasite. This suggests that salmon farms could influence salmon and steelhead populations in national forest streams during the marine phase of their life cycles, although the extent of the risk is unknown.



There are more than 130 Atlantic salmon farms along the Pacific Northwest coast. British Columbia is now the world's fourth largest producer of farmed salmon.

some wild Pacific salmon to become 6-inch fingerlings, farmed Atlantic salmon can be grown into 10-pound, harvest-ready fish.

According to Pete Bisson, salmon farming is still relatively rare along the Pacific coast of the United States. "In 1990, net-pen salmon farming was outlawed in Alaska, where capture fisheries dominate the economy of many coastal towns. The coasts of Oregon and California do not possess the sheltered, cold-water fjords needed for net-pen rearing, and salmon farming operations have not been economically viable there. There are a few salmon farms in Washington's Puget Sound and the Strait of Juan de Fuca—all owned by a single corporation."

In contrast, salmon farming has become a major force in British Columbia's economy. Farmed salmon represent British Columbia's most valuable agricultural export, and the province has become the world's fourth largest farmed-salmon producer. Atlantic salmon make up 85 percent of the farmed fish produced in British Columbia, and approximately 90 percent of those fish are exported to the United States. Chile,

however, remains the leading farmed-salmon exporter to the United States.

Within British Columbia, farming operations continue to expand despite a very public debate regarding the environmental merits and risks associated with its practice. On one hand, salmon farming has the potential to reduce fishing pressure on wild salmon populations, which are already in dire straits as a result of habitat loss, dams, pollution, and dozens of other insults. Advocates of the practice assert that salmon farms can efficiently produce large quantities of healthy seafood at low cost without harvesting imperiled native species.

On the other hand, there is the possibility that escaped salmon would interact with and potentially harm native fauna, or that Atlantic salmon farms would serve as epicenters for parasite and disease transmission to wild salmon and trout. These possibilities raised concerns that salmon farming could affect wild salmon populations on federal lands in Alaska, Washington, and Oregon. Bisson, who is a research fish biologist at the PNW Station in Olympia, Washington, has recently

completed an analysis of the potential threat posed by the Atlantic salmon farms to native fishes and streams on the national forest system. His work focused on two primary concerns: escapes and disease.

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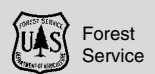
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## FARMED FISH ON THE LOOSE

**T**he majority of salmon that escape from farming operations do so during large storms that damage the pens and enable some or all of the fish contained within them to swim free,” explains Bisson. In recent years, however, the industry has begun using double-walled pens, whose outer barrier is much more resistant to large logs that tear through the nets and much better at keeping out the seal and sea lions that often congregate around the farms.

“In most cases, the job of reporting escapes is left to the farm operator, who may be reluctant to report the true number of escaped fish,” says Bisson. “Therefore, the accuracy of reports is uncertain, and, quite likely, the number of fish claimed by salmon farmers to have escaped is underestimated.”

Based on the reported escapes alone, between 1996 and 1999, more than ½ million fish escaped from Washington salmon farms. In British Columbia, records indicate that between 1991 and 2002, a total of 452,049 Atlantic salmon escaped from farms. It is difficult, however, to know what proportion of the total escapes these numbers represent. For example, there are many years in which there are no escapes on record, despite the fact that maturing Atlantic salmon were captured by commercial and sport fisheries.

## THE THREAT OF ATLANTIC SALMON INVASION

**T**he proliferation of Atlantic salmon farms in the Puget Sound and British Columbia in the 1990s, coupled with repeated escapes of large numbers of farmed fish, initiated concerns that unintended populations of this species could invade watersheds where native salmon and steelhead were sharply declining,” says Bisson.

Like Pacific salmon, Atlantic salmon spawn in the fall. This fact troubles scientists and fish managers because, in the event the farmed salmon become established, farm-reared fish may interact with native fish during spawning season and disrupt breeding behavior. Young steelhead trout stand to be most affected by any newly established populations of feral fish. They prefer the same fast-moving, gravelly substrate as Atlantic salmon, which heightens the possibility of competition for food and feeding territories throughout their freshwater life histories. Many steelhead populations are already



*It has been estimated that 0.5 to 1 percent of juvenile Atlantic salmon “leak” from pens each year and are never seen again. This represents tens of thousands of fish.*

In addition to mass escapes during storms, some fish are stocked in net-pens but are never seen again. These fish are termed “leakage,” and it’s assumed they jump out of the pens or swim through the mesh openings in the nets. According to research in British Columbia, 0.5 to 1 percent of fish leak out of pens.

“This is not an insignificant number,” Bisson says. “For Atlantic salmon farms in Washington and British Columbia, such an

escape rate would amount to tens of thousands of fish per year.”

Some escaped salmon are caught by sport or commercial fishers in marine and freshwater environments, and others are observed in rivers during spawning surveys. Every year, Atlantic salmon are taken incidentally in commercial fisheries in the Gulf of Alaska, an area that lacks salmon farms. Others that escape simply remain near the pens, feeding on fish-meal pellets that manage to pass through the nets uneaten. But most escaped salmon are never seen again.



U.S. Fish and Wildlife Service

*Currently, less than 1 percent of at-risk streams are surveyed for Atlantic salmon. As it only takes a few individuals to establish a breeding population, monitoring programs will need to be expanded to reduce the risk of invasion.*

imperiled, and the last thing they need is increased competition from an introduced species.

“Evidence that escaped Atlantic salmon have established self-sustaining populations on the Pacific coast of North America is mixed,” says Bisson. “Despite detection efforts by the environmental community, natural resource agencies, and the salmon farming industry, there have been only a handful of reported cases of feral Atlantic salmon reproducing in the wild.” The cases that have been reported

have been on Vancouver Island in British Columbia. At least for now, there have been no substantiated accounts of reproducing Atlantic salmon in west coast U.S. streams.

For the most part, escaped salmon don’t travel too far. Therefore, based on the existing location of Atlantic salmon farms and records of escaped Atlantic salmon sightings, streams on four national forests may be at risk for this potentially invasive species: the Tongass and Chugach National Forests in Alaska, and the Olympic and Mount Baker-

Snoqualmie National Forests in Washington. Of course, to know for certain the status of feral salmon, we’ll have to look more closely. “Less than one percent of British Columbia’s streams possessing potential Atlantic salmon habitat have been surveyed for this species, and the same is surely true for Alaska and Washington. Therefore, the current status of self-reproducing populations of Atlantic salmon in the Pacific Northwest—if any exist—is largely unknown,” cautions Bisson.

## POTENTIAL VECTORS OF PARASITES AND DISEASE

Atlantic salmon are known to be vulnerable to a variety of diseases and parasites, particularly when raised in hatcheries or aquaculture facilities,” explains Bisson. Typically, diseases are treated in the hatchery using antibiotics and antiviral vaccinations, or by bathing fish in a disinfecting solution. However, farm-derived diseases and parasites have been a huge problem in Europe, where infected feral salmon have entered rivers to spawn and decimated wild fish populations.

Thus far, however, there have been no reports of diseases or parasites from salmon farms invading freshwater ecosystems within the Pacific Northwest. It’s a different story within marine waters. Close quarters within aquaculture pens frequently results in eruptions of sea lice. These naturally occurring parasites are found at low levels on virtually all salmon; however, they thrive near marine salmon farms where uneaten food and fish waste can accumulate. When the density of sea lice is high, they can attach themselves to wild fish swimming in the vicinity of net-pens and, at high infestation rates, can be debilitating or lethal.

According to Bisson, some studies have reported that 90 percent of the wild juvenile salmon sampled in the region around many British Columbia salmon farms possessed sea lice at a density greater than the purported lethal level for infestation. Declines of these species have been directly associated with the proliferation of nearby farming operations. In contrast, juvenile salmon sampled from areas without salmon farms possess few sea lice.

“So serious has the sea lice problem in British Columbia become that a public

forum on salmon farming in 2001, called the Leggatt Inquiry, recommended that all

net-cage salmon farms be removed from coastal British Columbia waters,” says Bisson.



David Suzuki Foundation

*Sea lice from Atlantic salmon farms are believed to be a serious problem for wild pink salmon swimming near the net pen.*

## THE RISK FOR NATIONAL FORESTS

Having reviewed all the available information, Bisson believes that the short-term risk to national forest streams from Atlantic salmon invasions remains low and is limited to a few forests in northwest Washington and southeast Alaska.

“However, the long-term risks may be substantial if fish continue to escape from marine rearing pens or freshwater hatcheries,” he says. “The two greatest risks appear to be that Atlantic salmon may introduce a serious pathogen to native populations, and that escaped salmon will eventually adapt to local conditions as selection favors the survival and reproduction of a few individuals.”

“It only takes a few individuals to survive and reproduce in the wild for this to become an issue,” says Bisson. “They don’t have to do it perfectly. A slow initial rate of establishment could result in a pattern of expansion similar to that observed in other nonnative aquatic plants and animals, in which a prolonged early colonization period is followed by a rapid phase of exponential growth as breeding populations adapt to local conditions.”

Current programs to monitor the establishment of Atlantic salmon in the Pacific Northwest are inadequate. The province of British Columbia remains engaged in surveying streams, but the total number of streams being sampled is still only a fraction of those where Atlantic salmon could invade. Alaska and Washington also have invested only a minor effort. For now, the majority of the annual records still consist of sport catches, which are not very reliable.

“Improvements in monitoring programs could occur by implementing a statistically valid sampling design in streams where Atlantic salmon could potentially be

### FOR FURTHER READING

Bisson, P.A. 2006. Assessment of the risk of invasion of national forest streams in the Pacific Northwest by farmed Atlantic salmon. Gen.Tech. Rep. PNW-GTR-697. Portland, OR: United States Department of Agriculture, Forest Service, Pacific Northwest Research Station. 28 p.



British Columbia Salmon Farmers Association

Salmon farming is now a \$2 billion-a-year industry annually serving up 2.6 billion pounds of fish.

present,” says Bisson. “Additionally, many agencies, tribes, and environmental organizations operate smolt traps to monitor salmon production in Pacific Northwest river basins. Training field technicians to identify Atlantic salmon and collect any that turn up in the traps would take advantage of existing, and continuously funded, sampling programs.”

“Should juvenile Atlantic salmon be found in a stream, the watershed can immediately be targeted for intensive surveys to determine the distribution of juveniles within the

system and their potential impact on native species. Depending on the results of these studies, the stream may become a candidate for an Atlantic salmon eradication program,” he says.

*“We now live on a human dominated planet. The growth of the human population and the growth in amount of resources used are altering Earth in unprecedented ways.”*

—Jane Lubchenco



### LAND MANAGEMENT IMPLICATIONS



- Current programs to monitor the establishment of Atlantic salmon in the Pacific Northwest are inadequate. The province of British Columbia remains engaged in surveying streams for this species, but the total number of streams being sampled is still only a fraction of those where Atlantic salmon could invade. Natural resource agencies in Alaska and Washington also have not invested a major effort in surveying for this species, and it appears that the majority of the annual records consist of sport catches, which are not very reliable.
- Improvements in monitoring programs could occur by implementing a statistically valid sampling design in streams where Atlantic salmon could potentially be present. Additionally, many agencies, tribes, and environmental organizations operate smolt traps to monitor salmon production in Pacific Northwest river basins. Training field technicians to identify Atlantic salmon and collect any that turn up in the traps would take advantage of existing sampling programs.
- If juvenile Atlantic salmon are found in a stream, the watershed can be immediately targeted for intensive surveys to determine the distribution of juveniles within the system and their potential impact on resident and native salmon species.

### WRITER’S PROFILE

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## SCIENTIST PROFILE



PETE BISSON leads an aquatic research team at the Forest Service's Pacific Northwest Research Station. He is based in Olympia, Washington. He worked as an aquatic biologist for the Weyerhaeuser Company for 21 years prior to joining the Forest Service in 1995.

Bisson's research includes stream habitats and food webs, riparian zone management, and a variety of conservation issues related to aquatic ecosystems. He holds affiliate faculty appointments at the University of Washington, Oregon State University, and the University of Idaho, and has served on two National Academy of Sciences committees: one on Pacific salmon and the other on watershed management. He has edited books on watersheds, river restoration, Pacific salmon, and sea-run cutthroat trout. Bisson is currently vice-chair of the Independent Scientific Review Panel for the Columbia River Basin, a committee of scientists that provides technical oversight to one of the Nation's most ambitious ecological restoration programs.

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