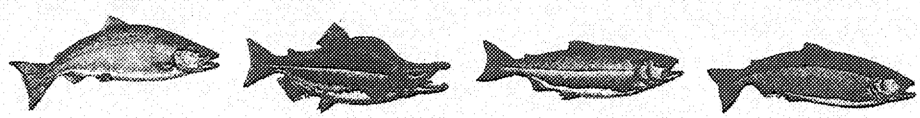
KING OF FISH

The Thousand-Year Run of Salmon



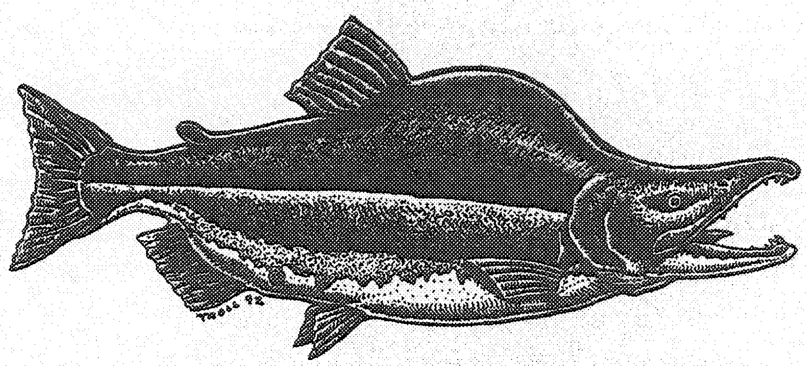
DAVID R. MONTGOMERY

Westview Press
A Member of the Perseus Books Group

CHAPTER

3

MOUNTAINS OF SALMON



You cannot step in the same river twice, for the second time it is not the same river.

Heraclitus (535–475 B.C.)

IN 2001, ALMOST A DECADE AFTER THE TRIP TO KENNEDY Creek in the early 1990s that hooked me into studying salmon streams, Phil Peterson gave me another opportunity to see salmon in the wild, this time along the headwaters of the Skokomish River on the southeast corner of the Olympic Peninsula. Phil had left the Timber, Fish, and Wildlife program for a position as a biologist with the Simpson Timber Company. We had continued to work together on the geomorphology of salmon and in the later 1990s I had helped Phil develop ideas for a habitat conservation plan for Simpson's tree farm. Unlike our visit to Kennedy Creek years earlier, our quarry this time was fossil salmon.

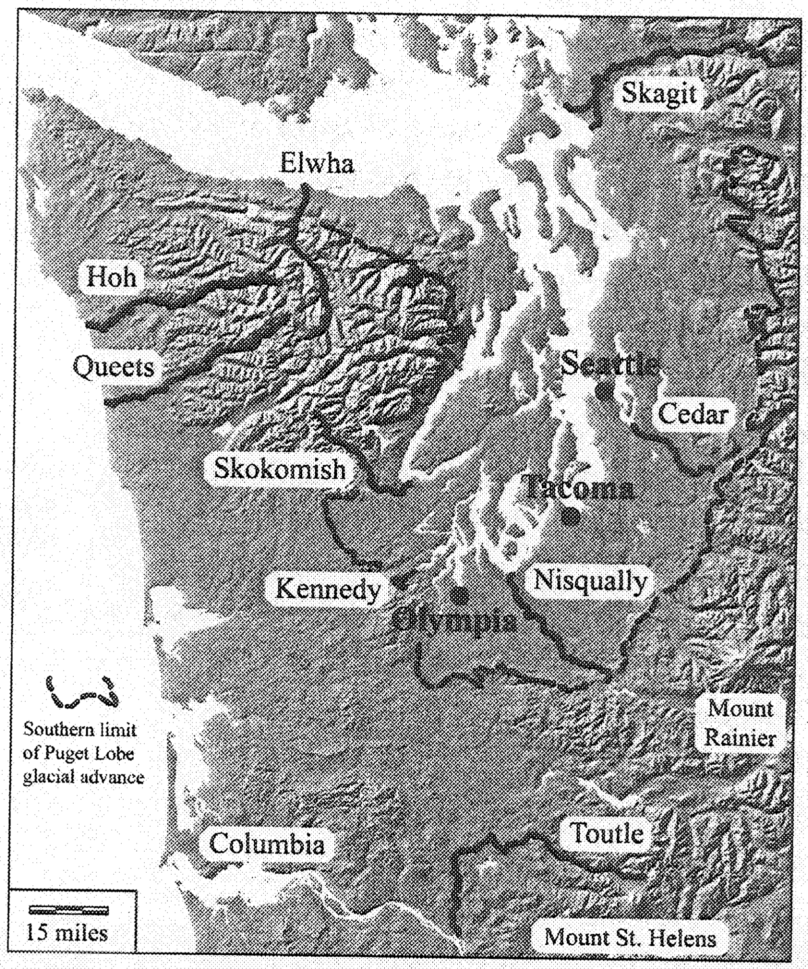
A local fisherman, Jeff Heinis, had noticed large fish fossils protruding from the bank of a remote reach of the river on Simpson Timber Company land. Phil followed up on the report and went out to see the fossils. Upon returning he called me to ask if the University of Washington had a paleontologist interested in salmon, and whether I was interested in helping interpret the deposit that contained the fossils. Phil was concerned that erosion of the riverbank could destroy the fossils during winter high flows. I referred him to the Burke Museum, the University of Washington's natural history museum, and its experienced fossil collectors and curators.

He then emailed me photos of the fossils. They were remarkable. The fish were quite large, and numerous. The outcrop of sediment that held the fossils was set in the bottom of a deep canyon, and the fossils were in lake deposits within the canyon. Layer upon layer of fine-grained sediment formed a series of small "steps" or terracettes down to the river's edge. Fossil fish lay in the sediment like pressed flowers. The photos revealed relatively complete skeletons and impressions of scales and other fine features that had been preserved when the fish settled into the soft mud at the bottom of the ancient lake.

This was too good to pass up. After all, fieldwork is one of the basic pleasures of geology. And Xena the dog would be appalled if I turned down an invitation to work along a stream or river where she could explore. So we piled into my truck and headed south to meet Phil in a Denny's parking lot in Olympia. After I introduced Phil to Xena, we transferred our gear into Phil's unmarked company truck and drove over Kennedy Creek, past Simpson's main office, and out to the floodplain of the Skokomish River.

The South Fork of the Skokomish begins in steep U.S. Forest Service land deep in the Olympic Mountains. On its way to Puget Sound, the river cuts through a narrow canyon and then traverses Simpson timberlands. After leaving the mountains, the river flows across a broad floodplain and deposits its gravel load. Farms and houses now cover the floodplain.

The North Fork of the river begins in Olympic National Park but is diverted into a tunnel that flows through a ridge directly to an arm of



Selected rivers and creeks of western Washington State.

Puget Sound, powering turbines along the way to light the city of Tacoma. This diversion means that less water now reaches the confluence with the South Fork. Downstream, the river completes its journey through the Skokomish Indian Reservation before emptying into the sound. We drove up along the river past the canyon on the South Fork and into the headwaters.

We reached the end of the road in late morning and parked on a broad upland that formed a surface a few hundred feet above the river, where a logging track became a foot trail. Well past the end of the road we started to descend a narrow path that led toward the canyon. As usual, Xena was in the lead scouting for good smells to savor and critters to chase. I could see how glaciers had planed into a gentle upland the landscape into which the river had then carved its canyon. At the edge of the canyon the terrain dropped over a series of terraces, the lowest of which formed a narrow valley bottom, to which Phil led us.

The fossil-laden outcrop was just upstream of where the canyon narrows. Apparently ice had dammed the river at some time in the distant geological past, creating a lake that entombed the fossils in its sediments. The terraces over which we dropped to get down to the river were like geological bathtub rings that recorded the progressive incision of the river after the ice retreated back down the valley and home toward Canada.

Xena lost no time in getting down to business, scampering down the riverbank and starting to paw at fossil salmon protruding from the bank. "Leave it!" echoed off the canyon walls. In response I got the soulful-brown-eyes treatment. But this was serious business. I responded with the coolest "Yes, I really mean it" that my eyes can muster.

The fossil salmon were best preserved in the lowest levels of the lake sediments, the earliest chapters of this geological story. Immediately below the lake sediment and its beautiful salmon skeletons lay the gravel of an ancient streambed. We collected sticks and wood in the lake sediments to be radiocarbon dated, a technique that measures the amount of carbon-14 (an isotope present in all living matter that is subject to radioactive decay) that is left in the organic material being dated. It turned out that all the carbon-14 maintained by living tissue had disappeared, indicating that the samples were older than 40,000 years—the limit of conventional radiocarbon dating. So the lake formed well before the last glacier overran Puget Sound less than 20,000 years ago.

Once back at the university I started inquiring whether anyone had studied glacial lake deposits around the Skokomish River. It turned out that in the next valley over, U.S. Geological Survey scientists had found million-year-old volcanic ash interbedded, or inter-layered, in deposits almost identical to those containing the fossil salmon. It seemed our lake had been formed about a million years and several glaciations ago, in the middle of the Pleistocene Epoch, the most recent 2 million years of geologic time. We had an outcrop that contained million-year-old salmon.

Not long after my first visit to the fossil site with Phil Peterson I met Gerald Smith, a renowned expert in salmon paleontology at the University of Michigan. Over dinner we discussed the evolution of salmon and I invited him to visit the Skokomish River site. The following summer, Jerry, Phil, and I returned to the site along with Bruce Crowley and Jim Goedert, senior fossil curators for the Burke Museum. While Bruce and Jim calved off great slabs of sediment to collect whole fish for exhibits, Jerry was on his knees with his face in the dirt painstakingly picking away at the outcrop. The finely laminated clay and coarser silts formed easily discernible bands (called varves) reflecting the alternation of slow fine-particle sedimentation in summer (clays) and more rapid sedimentation of coarser particles in winter (silts). After a couple of hours, Jerry rose and filled us in. The salmon were four-year-old sockeyes. Fossils of males and females together in the silty layers indicated that the fish had been on a spawning run when they died—for sockeye, it would have been in the fall.

That evening Jerry explained why he likes to examine little bits of bone rather than whole fish preserved on an intact slab cut from the rock. He can turn fragments around to examine them from all sides. He can see the details of their shape in three dimensions and pick apart the outcrop bit by bit to see how the ancient fish bones sit within the fine layers of sediment. Fossils stuck in a big slab of rock are beautiful, and ideal for display, but to Jerry they present just a single view—more like a photograph than the real thing.

A fundamental problem in understanding the evolution of salmon is that there is almost no fossil record of these fish. Most adult salmon die in mountain streams. As mountains erode, so do the river deposits that contain fragile salmon bones. Consequently, there is little geologic record of salmon streams, let alone salmon. For many years the evolutionary history of salmon was obscure because of this simple fact—there simply are not many salmon fossils. Finds of freshwater fish fossils, like those on the Skokomish, are few and far between.

One of the biggest puzzles for salmon paleontologists has been where and how the salmon survived during the repeated glaciations, ice ages, that characterized the Pleistocene Epoch. Historically, the conventional wisdom was that salmon in the Pacific Northwest rode out the ten or more glacial advances between 2 million and 10,000 years ago in ice-free areas in the Columbia River Basin as well as rivers in Oregon and California. In this view, salmon gradually spread from these sanctuaries after the ice melted. But there are other possibilities. Salmon also could have survived glacial times in ice-free areas along the coast of Washington, Alaska, and perhaps even British Columbia. Today, salmon inhabit rivers at the foot of modern glaciers in Alaska. Sea level was hundreds of feet lower at the height of glaciation, owing to the immense volume of water trapped in polar ice caps, and much of the now-underwater continental shelf was exposed. Perhaps salmon escaped the glaciers by simply moving downstream into rivers flowing across the continental shelf. Salmon can inhabit glacially fed rivers, and they inhabit rivers at the foot of modern glaciers in Alaska. Although this new view is gaining acceptance, it is not yet settled as to which stocks spread from which refuges after the glaciers melted off.

Enter modern technology. Genetic analyses are being used to sort out salmon populations with different histories. DNA sequencing techniques also allow a researcher to use the accumulation of minuscule genetic errors—mutations that pile up over generations at a relatively constant rate—as a clock to estimate when populations diverged. Sequence differences in genes from Atlantic and Pacific salmon indicate that they began to diverge from one another about 20 million years ago. This was a time when cooling of the Arctic Ocean isolated populations in the Atlantic and Pacific Oceans. Freezing of the polar seas below the tolerance of salmon imposed a barrier that prevented the commingling of salmon stocks in different oceans.

DNA sequencing of North American and Asian Pacific salmon shows that a little more than 10 million years ago the Pacific salmon started branching into clans. By 6 million years ago the five different species of Pacific salmon found in North America had separated both from the Asian salmon (*O. masou*), which is most like the ancestral Pacific salmon, and from each other.

But why are there so many species of Pacific salmon and only one Atlantic salmon? What led to the striking difference in the evolutionary tra-

Salmon family tree. Courtesy of Ray Troll.

jectories for salmon on the East and West coasts of North America? The dearth of fossil evidence for salmon evolution has led to a variety of arguments for the diversification of Pacific salmon from the common ancestor they shared with the Atlantic salmon. Conventional explanations invoke advance and retreat of glaciers as the trigger for isolation, diversification, and behavioral modification of local Pacific salmon stocks into distinct species. But why would this only occur in western North America? Glaciers affected not only both coasts of North America but also Europe and northeastern Asia. Why would an evolutionary response to glaciations have been restricted to just the Pacific side of the salmon family?

Genetic analyses of mitochondrial DNA show that the modern species of Pacific salmon evolved before the glaciers began advancing 2 million years ago. But even without sophisticated biochemical tools, the idea that the North American species of Pacific salmon evolved during the age of ice can be dismissed. Geologists have been finding fossils of the modern species of salmon in deposits that predate the earliest glacial advances.

Accumulating evidence shows that most of the differentiation leading to the modern species occurred long before the start of glaciation. The oldest known fossil of ancestral salmon, *Eosalmo driftwoodensis*, found in British Columbia, is from roughly 40 million years ago. The fossil record shows that the Pacific and Atlantic salmon had diverged by 20 million to 10 million years ago, during the Miocene Epoch. By 6 million years ago, the Pliocene Epoch, species resembling the modern sockeye, pink, and chum salmon were present in Idaho and Oregon. Genetic sequencing and analyses of mitochondrial DNA in modern salmon also suggest similar date ranges for the divergences in the salmon family. This is good news for those trying to solve the puzzle of what led to the different species of Pacific salmon. The fossil record and genetic analyses each independently confirm that speciation of the Pacific salmon occurred long before the glaciers began their cycle of advance and retreat. So much for the glacial theory of salmon evolution.

What about anadromy as a basis for explaining salmon evolution? One would hope that a fish would have a good reason to swim thousands of miles and shift from freshwater to the ocean and back again. Why not just stay put, relax, and skip that epic odyssey to sea? One idea invokes changes in the relative availability of food in terrestrial versus marine environments to explain speciation of the Pacific salmon. Global cooling between 40 million and 20 million years ago led to decreased primary productivity in temperate streams and to increased marine productivity—and supply of food for salmon—through enhanced upwelling of deep marine water. It's plausible, therefore, that going to sea and returning to spawn in freshwater streams or rivers evolved in concert with the oceans' becoming more productive and terrestrial streams' becoming less productive as the climate cooled. Climate-driven changes in food availability made going to sea a wise move as streams and rivers became depleted of nutrients in the cooler climate. Even in today's warm interglacial climate, the streams in the Pacific Northwest remain nutrient-limited. Development of a sea-going life cycle may simply reflect that the Miocene oceans provided richer feeding grounds for growing salmon than the streams in which they hatched.

Recent studies show that salmon, gaining well over 90 percent of their body weight at sea, carry vast quantities of marine-origin nutrients when they return to their home streams to spawn and die. Their rotting bodies nourish stream-dwelling insects that, in turn, feed young salmon the following season. Juvenile salmon have also been known to nibble on the rotting carcasses of their elders. In this way, anadromous salmon provide an organic inheritance for their offspring by fertilizing their home stream. Salmon carcasses also provide a huge infusion of nutrients to aquatic and streamside communities as they decay, get scavenged, and become incorporated into other organisms. In some places, fisheries managers now dump carcasses of hatchery-produced salmon into streams to promote the growth of wild salmon.

This infusion of nutrients into streams sustained a diverse, interdependent ecosystem. Scavengers pull almost half the carcasses of coho salmon from small streams on the Olympic Peninsula. Twenty-five to 90 percent of the nitrogen in the bones and hair of grizzly bears in the Columbia River basin came from marine sources. More than 90 percent of the nitrogen in Alaskan brown bears comes from salmon. Marine nitrogen brought up rivers in salmon even finds its way into streamside trees. Up to a third of the nitrogen in valley-bottom forests swam up the river as a fish. Trees growing along salmon-bearing streams grow up to three times faster than those growing along salmon-free streams. For Sitka spruce along streams in southeast Alaska this shortens the time needed to grow a tree big enough to create a pool, should it fall into the stream, from over three hundred years to less than a century. Salmon fertilize not only their streams but the huge trees that create salmon habitat when they fall into the water.

Evolution of an anadromous life cycle and the resulting transfer of nutrients from oceans to freshwater ecosystems is an important aspect of salmon biology. Salmon could never grow as large as they do in the nutrient-poor environment of freshwater rivers and streams. There just isn't enough food.

Thus anadromy explains some aspects of salmon's evolution; it does not, however, explain the different evolutionary trajectories of the Pacific and Atlantic salmon, since both are anadromous. We must look beyond global marine cooling and consequent changes in nutrient availability to explain why the Pacific salmon separated from the Atlantic salmon and split into the species we know today.

Geographic isolation is the usual explanation ecologists offer for speciation. At first glance such an explanation might seem to account for divergence of the Pacific salmon from the Atlantic salmon. But the use by the North American species of Pacific salmon of different habitats within the same river systems points to environmental change rather than geographic isolation as the cause of their divergence into distinct species. Across their overlapping geographic ranges, pink and chum salmon generally spawn in small streams near the outlet of a watershed; sockeye spawn in lakes and lake inlets; coho spawn in small tributaries; and chinook spawn in major rivers and large tributaries. The segregation of Pacific salmon into different portions of river systems suggests that they evolved in different kinds of streams to take advantage of different ecological niches in mountain drainage basins rather than from the physical isolation of local populations.

I believe that the answer to the puzzle of salmon evolution lies in the strikingly different history of the landscapes of eastern and western North America. Evolutionary histories of the Atlantic and Pacific salmon parallel differences in the topographic evolution of North America. The topography of the eastern coast of the United States is ancient compared to that of the West Coast. The Appalachian range formed when Europe slammed into and crumpled up the Eastern Seaboard of North America before the opening of the Atlantic Ocean, about 200 million years ago. The Appalachians approached their current form during the reign of the dinosaurs, about 100 million years ago. Since then they have been slowly eroding away. Geologically, not much happened on the East Coast of North America in the last 100 million years, and the topography of the region has remained fairly constant since long before salmon evolved.

In contrast to the stability of eastern North America, the topography of western North America has changed significantly since the salmon family split into its Atlantic and Pacific clans. At roughly the time of the Pacific salmon's original divergence from the Atlantic salmon in the Miocene, regional geologic changes literally fragmented longstanding landscape features, including a broad plateau extending from the Rocky Mountains to the Pacific Ocean. About 16 million years ago this plateau began to split apart, collapsing to form the Basin and Range topography in what is now Nevada. On the Western Seaboard, the Alaska, British Columbia Coast, Cascade, and Oregon Coast ranges and the Olympic Mountains all rose significantly during the period between 20 million and 6 million years ago. This coincides with the period between the divergence of the Pacific and Atlantic salmon and the evolution of the modern species of Pacific salmon.

The salmon and the topography of western North America appear to have evolved together in response to tectonic forces that drove mountain building along the West Coast. Certainly, geology is not the whole explanation: Glaciation and climate change undoubtedly played roles too. Local isolation resulting from glacial advances likely helped differentiate discrete populations of salmon, and climate influence is apparent in the evolution of anadromy in both the Pacific and Atlantic salmon. But a primarily geological cause for the evolution of the Pacific salmon could explain the strikingly different evolutionary trajectories for salmon on either side of North America.

How could topographic change have split the ancestral Pacific salmon into five new species? Topographic changes along the coast and in inland watersheds diversified stream conditions. Most salmon faithfully return and spawn in their home stream, leading to a high degree of reproductive isolation between populations in different rivers. Take this concept one step further and apply it also to salmon that spawn at different times or in different places in the same river system. Voilà, you have one of the fundamental preconditions for evolving a new species—reproductive isolation.

A small percentage of returning spawners stray, a behavior that can help recolonize streams after major disturbances such as volcanic eruptions and glaciations. Straying also allows salmon to rapidly occupy new habitats as they become available. With some straying behavior and strongly heritable traits, an increasing variety of stream environments within the same geographic area could provide a viable impetus for speciation.

It may take millions of years for geological processes to reshape the landscape so that a new species emerges. But extinctions can occur rapidly. Some species of salmon have already gone extinct. The largest of the salmon, the so-called sabertooth salmon (*Oncorhynchus rastrosus*), is already gone. These monstrous fish grew to enormous lengths of up to 10 feet and weighed as much as 350 pounds. They thrived in the Pliocene, before the cold climate of the Pleistocene set in. Apparently they did not survive the transition to the glacial world.

Although salmon have had some evolutionary dead ends, they are in fact well equipped to take advantage of new environments. Like weeds colonizing a vacant lot, salmon produce lots of offspring that can move into new or empty niches. A spawning pair will produce thousands of eggs, and even though relatively few offspring make it back to spawn again, it is enough. In a population that was neither growing nor shrinking two adults should return on average for each pair of spawners. Tom Quinn, a prominent salmon ecologist at the University of Washington, compiled studies that examined the survival rate of salmon from one life stage to another and concluded that when not subject to fishing pressure or limited by habitat availability, four to six wild salmon return on average for every pair that spawned. This higher-than-replacement rate of return indicates that, left to themselves, salmon populations will tend to expand to fill the available habitat or until they become so numerous that competition for space or food limits their numbers.

The retreating glaciers of Alaska's Glacier Bay National Park provide the setting for an ongoing experiment in how fast salmon can colonize new streams. The ice front surveyed by Captain Cook in the late 1700s retreated more than 50 miles by the 1980s, exposing raw valley bottom and new streams on the valley sides. Streams closest to the modern ice have been exposed for decades, whereas areas closest to the original ice front have been free of ice for over two centuries. Once the streambed stabilized enough to be colonized by algae and then invertebrates, salmon began moving into the new streams. Those exposed for only a century were already full of sockeye, pink, and chum salmon.

In some circumstances salmon adapt rapidly to changes in established river systems. For example, an unintended experiment was conducted in the early 1900s when the outlet of Washington's Cedar River was redirected into Lake Washington to facilitate navigation, flood control, and development. Sockeye salmon need a river system that includes a lake, so fisheries managers transplanted sockeye into this new habitat. Some of the sockeye introduced into the Cedar River basin began spawning on beaches in Lake Washington and others spawned in the Cedar River. After just a matter of decades, the fish spawning in these different locations are becoming genetically distinct from each other.

If salmon can colonize new streams and evolve that fast, then why can't reintroduction of salmon in places where they have been wiped out eventually reestablish viable, naturally reproducing runs? For such efforts to prove successful the landscape must be able to support the salmon's basic life-cycle requirements—these can't change on demand. Salmon will not thrive if there is no gravel in which to bury their eggs, if eggs are scoured out of streambeds, if there is no cover to hide young salmon from predators, if pollutants poison the water, or if lack of oxygen stifles embryo development. Obviously, even the most successful reintroduction program would fail if salmon are thrust into a world that no longer supports the basic needs of all salmon. But the more subtle adaptations of salmon to the specific conditions of their home stream means that the survival of transplanted salmon also depends on an environment that has the critical characteristics of the rivers and streams in which those salmon evolved.

As Heraclitus noted, it is obvious that streams are dynamic environments. Floods can move a river around on its floodplain, and local processes of bank erosion can fill in or create new pools during even modest storms. It is also obvious that the Pacific salmon are resilient to the natural disturbances of rivers and streams in the Pacific Northwest. After all, salmon evolved and thrived in these channels. Yet it remains difficult to determine how to characterize and evaluate the natural disturbance regime (pattern)—for rivers change over a very wide range of time scales. The sudden disturbance of a pool drying up in a summer drought can kill a local population of juvenile salmon and a landslide can wipe out the salmon in an entire tributary, just as the long-term "disturbance" of a rising mountain range can help create new species.

According to the naturalist and author Richard Buck, one needs no special training to see how river conditions can literally shape salmon. In his 1993 book, *Silver Swimmer*, this avid fisherman and leader in salmon conservation efforts described how the conditions in different rivers favor distinct body styles among Atlantic salmon. Contrasting Canadian salmon from different rivers, Buck noted that deep, fast rivers have large, powerful fish, whereas small rivers have smaller, stocky fish. Similarly, he found that among Scottish rivers the wide slow-moving River Tweed has large bulky salmon, whereas swift highland streams host "lean and well-formed" salmon.

Buck also described differences in tail and fin size of salmon from rivers of different character, comparing the shape of salmon he caught in Norway's Laerdal River to those he caught in New Brunswick's Restigouche River. The Laerdal River salmon are "long, taut, and compact," with huge fins and a large tail well suited for running up the turbulent rapids that characterize the river. In contrast, the Restigouche River salmon are "full-bodied, broad, and chunky," well-suited for life in the "big, wide, deep, relatively slow-moving river."

Even among the Atlantic salmon, natural selection favors development of body forms best suited for the hydraulics of a salmon's home river. The Atlantic salmon have a diverse gene pool that acts as a genetic reservoir upon which evolutionary processes can act, and provides resilience to some environmental changes. Similar physical and genetic diversity in their ancestors probably enabled diversification of the Pacific salmon in response to their changing environment.

The rivers of the Pacific Northwest continued changing as the mountains rose and the glacial ice advanced, only to melt away and advance again and again. For almost two thousand years, from about 18,000 to 16,000 years ago, Puget Sound rivers were overrun and dammed by a massive wall of ice, the Puget Lobe of the Cordilleran Ice Sheet, which rose three times as high as Seattle's Space Needle. In parts of Puget Sound the ice was thick enough to depress the Earth's crust by hundreds of feet. Once the mountain of ice disappeared the land rebounded skyward. During the first 6,000 years after glaciers began melting, sea level rose hundreds of feet, gradually flooding coastal areas and lowland valleys before more or less stabilizing about 5,000 years ago. Certainly these events rearranged the landscape, but the changes occurred slowly. Over time, the total amount of freshwater salmon habitat increased as sediments shed from the rising land extended river valleys and estuaries out into Puget Sound.

The dynamic, geologically young landscape of the Pacific Northwest is not a quiet, safe place. Yet salmon thrived in prehistoric times even though large disturbances disrupted river ecosystems time and time again across the Pacific Northwest. Volcanoes of the Cascade Range grew and blew themselves apart in catastrophic eruptions. Hot volcanic mudflows, known as lahars, obliterated rivers and filled up valley bottoms. Mount Rainier shed massive lahars that swept down river valleys, burying everything in their path.

At least one of these lahars reached the present-day Elliot Bay, near downtown Seattle. During construction of a new park just upstream from the Port of Seattle along the Duwamish River, backhoes revealed that the valley bottom consisted of a massive sand layer resting atop estuary-bottom mud. This was odd. Marshes are not usually lined with nice clean sand. Even more curious was that the sand contained distinctive minerals from Mount Rainier, over 50 miles away. Brian Atwater, a geologist with the U.S. Geological Survey, knew that I had worked on similar deposits in the Philippines and thought I would enjoy seeing what they had unearthed along the Duwamish River. He was right.

The walls of Brian's trench displayed relationships that revealed these sands had been deposited by the river and had rapidly buried an ancient tidal flat, in the process preserving delicate vegetation on the entombed marsh surface. The most reasonable interpretation was that the sand represented the downstream end of a massive lahar. Brian pointed out that when the top of these sands was compared with those of similar deposits across the valley it indicated that they came from the same lahar, which not only buried the river but filled in the entire valley. He also found that old maps of the area show that the modern terrace formed by the lahar was the dry spot selected by the Denny party for its initial settlement at Seattle in 1851.

Other Cascade volcanoes produced similar catastrophic lahars. Massive lahars from Mount Baker and Glacier Peak killed off salmon in the rivers down which they sped. Most of the delta of the Skagit River was formed during a single massive lahar that extended the valley bottom miles out into Puget Sound, creating space for new river reaches as it went.

The decimation of the North Fork of the Toutle River by the 1980 eruption of Mount St. Helens dramatically revealed the awesome power of catastrophic events to reshape Pacific Northwest rivers. Just minutes after Mount St. Helens erupted, the Toutle River filled with boiling mudflows, obliterating life from a river once teeming with salmon. Amazingly, within just a few years salmon were already finding their way back up the river, demonstrating that salmon can quickly start to recolonize even a massively disturbed river. This rapid return to a devastated river demonstrates the advantage of a life history that includes spending several years at sea, providing a reserve of new colonists already programmed to repopulate decimated areas. As the Toutle River gradually cleans itself of volcanic debris it gradually is becoming once again a cold-water, gravel-bed river hospitable to salmon.

For millennia the salmon of the Pacific Northwest weathered large disturbances like volcanic eruptions because only a small portion of their range was affected by any one event, and such disturbances were not sustained for long periods of time. Salmon still at sea could recolonize a river after a disturbance that only lasted for a short time. As long as refuges remained from which repopulation could occur, the small percentage of individuals that stray from their home streams would eventually recolonize even catastrophically disturbed environments, such as those cooked by lahars or frozen beneath glaciers. When these wanderers found suitable empty habitats they spread to new streams. Straying behavior also builds resilience to catastrophic disturbance into a population. In a dynamic and often dangerous environment, the long-term stability and success of the species depended on the reserve of salmon out at sea and these wayward salmon—as long as disturbances and disasters were not too widespread and did not occur too often.

Volcanic eruptions are not the only disturbances that affect Northwest rivers. Along the region's coastline the earth's crust beneath the Pacific Ocean is being pushed under North America. Rocks scraped off the colliding plates pile up to form the coastal mountains. Once the slab of oceanic crust sinks deep enough it starts to melt and the rising magma feeds the volcanoes of the Cascade Range. About every five hundred years the entire coast from Northern California to Canada lurches toward New York all at once in an earthquake that releases more power than that locked in our nuclear arsenal. The associated ground shaking can trigger massive landslides that can dam rivers.

During past superquakes, huge amounts of sediment were introduced into rivers and streams when whole mountain sides collapsed. Massive landslides can dam rivers and block salmon as effectively as any man-made dam. Large landslides have dammed even the mighty Columbia River in the distant past. Although it is hard to know for how long they may have been locked out, salmon may have had to recolonize the interior Columbia River basin after landslide dams blocked their access to and from the sea. The resulting effects on fish may not be quite as severe as volcanic incineration, but large earthquakes do pose another source of disturbance for river ecosystems in the Pacific Northwest.

More frequent and less dramatic disturbances also affect the salmon. Big storms trigger floods that transform the river environment both during and sometimes even after the event. Where do fish go in floods when the river becomes a raging torrent that can take out a bridge? Even a large fish has no chance against such a current. So they hug the banks, burrow into the streambed, or cruise out into the shallower water spilling onto the floodplain. In case they don't make it, having several generations at sea at any one time acts as a hedge against the destructive effects of violent floods. Forest fires can also trigger large pulses of sediment into river systems that, in turn, can change the depth to which streambeds scour and fill, which can crush or entomb salmon embryos buried in the gravel. Low summer flows during droughts can wipe out entire classes of juvenile salmon as they become stranded in pools that dry up. The strategy of spending three to five years at sea not only provides salmon with access to more food than available in their home stream, but also buffers salmon populations against the perils of life in the Pacific Northwest's dynamic rivers and streams because at any one time, multiple generations are at sea.

Strangely enough, disturbance events that can decimate one generation of fish also over the long run help create the best habitat for future generations. Side channels that provide safe refuges for salmon during flooding of the main channel are themselves formed during floods. A large tree trunk falling into a river can cause local scour that excavates salmon embryos developing within the gravel—a negative—but the new pool also provides excellent habitat for the next years' juvenile salmon. The dynamic nature of their environment should lead us to expect salmon populations to exhibit substantial year-to-year variability.

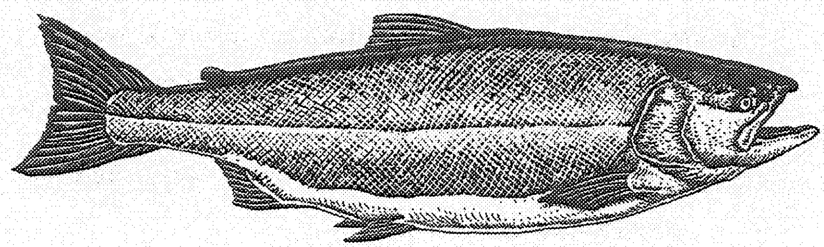
This brings up a troubling question. If salmon are resilient enough to withstand extreme events like massive landslides, volcanic mudflows, and glaciations, then why are they going extinct across much of their range today? Recent changes in the landscape must be rendering rivers unable to sustain them. The fossil salmon of the Skokomish River are ghost icons, reminders that in just over a century, humans managed to do what repeated onslaughts of ice, in places half a mile high, could not accomplish. Will salmon repeat their ice age comeback after the human age? To recolonize a river buried by ice, degraded by human actions, or depopulated through natural disturbances, salmon must survive in protected refuges from which to spread during more favorable times.

It is sobering to think that salmon could take the worst nature could throw at them for millions of years—from floods to volcanic eruptions—but that little more than a century of exposure to the side effects of Western civilization could drive them to the edge of extinction. Humans and salmon survived together for thousands of years on both coasts of North America. Was their coexistence possible simply because there were fewer people in the region—or were Native American cultures adapted to sustain salmon fisheries?

CHAPTER

4

SALMON PEOPLE



If the salmon could speak, he would ask us to help him survive. This is something we must tackle together.

Bill Frank, Jr., Chairman, Northwest Indian Fisheries Commission, 1991

AS THE U.S. CORPS OF DISCOVERY, LED BY MERIWETHER Lewis and William Clark, made its way down the Columbia River in the fall of 1805, the explorers were more impressed with the extent of native salmon fishing than with the fish themselves. After crossing the Rocky Mountains, the near-starving expedition traded with the Nez Percé for dried salmon. Unaccustomed to this rich, oily diet the Corps of Discovery immediately got bogged down as its members suffered from dysentery. Though they traveled down the Columbia during the fall salmon runs when the river was full of fish, the explorers repeatedly traded with the locals for dogs to eat. The natives must have thought these strange visitors were crazy.

The native population of the Pacific Northwest was less than a hundred thousand at the time of first contact with Europeans. About ten thousand people are thought to have lived in western Washington. Salmon outnumbered people by at least a thousand to one.

Even though salmon accounted for most of the native diet, the total annual catch was no more than a few million fish across the region before European contact. Though it is presumptuous to interpret, reconstruct, or evaluate Native American fisheries management after so much has changed in the region over the past 150 years, we can say with some certainty that the role of salmon in Native American cultures certainly differed from that in the region today. Several million people now live in and around Seattle alone, and the population of Washington State is projected to reach 6 million in the near future. Today there are more people than wild salmon in the state.

Native American salmon management was oriented around river systems and their watersheds because the geography of river systems organized settlement patterns. Salmon were abundant at river mouths and along major rivers. So villages tended to be located at major river outlets or good fishing sites, such as those on Puget Sound and along the Columbia River. Native Americans limited harvests and allowed large numbers of spawners to return to the rivers. Most native cultures in the region prohibited disturbance of spawning salmon, often levying stiff penalties for transgressions.

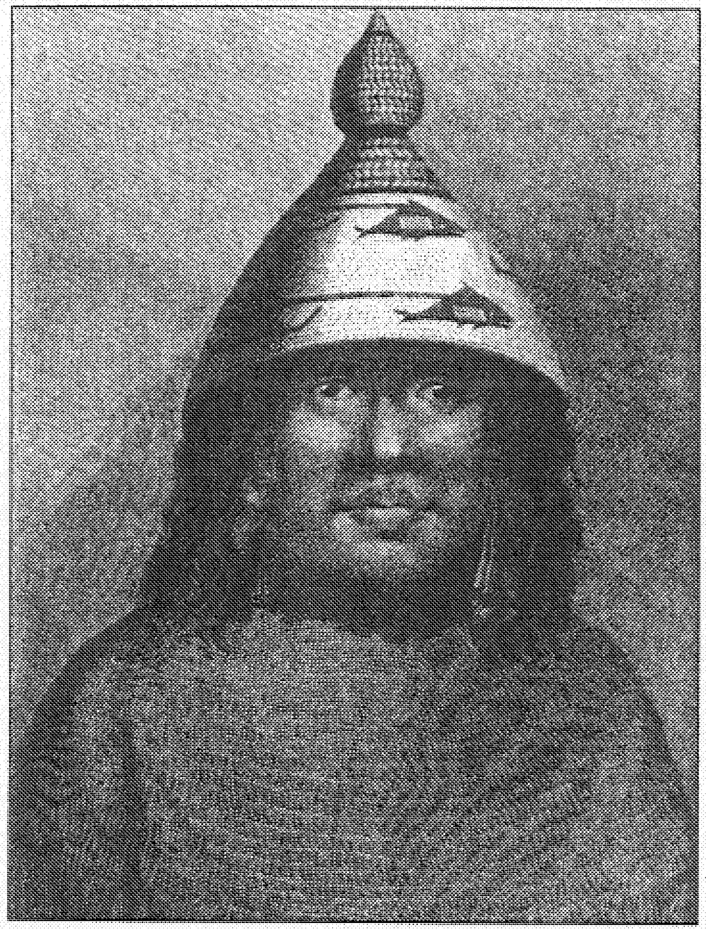
Above almost all else, native peoples valued access to their salmon fishery. Salmon were essential. In negotiating the loss of their ancestral lands, the Puget Sound and Columbia River tribes insisted on preserving their fishing rights and access to fishing grounds. Presumably, they believed that such access implied continuation of fish runs capable of being fished. Tribal negotiators were suspicious of both treaties and the government agents coercing them to sign them, but they could not have imagined that wild salmon could be nearly exterminated in little more than a century. The legacy of the Indian treaties means that the modern political landscape surrounding salmon-recovery efforts includes not only the directives of the Endangered Species Act but also interpretation of federal treaty obligations.

Native Americans came to the Pacific Northwest in several waves of immigration, the first over 10,000 years ago when glaciers were retreating from North America. Diets of the earliest arrivals were quite varied in coastal areas, and dependence on salmon increased inland from the coast. Intensive salmon fishing on the Columbia River dates from at least 8,000 to 9,000 years ago. Salmon bones recovered from archaeological sites in southern British Columbia indicate that salmon were an important part of the native diet 6,000 years ago. Great quantities of salmon bones in the upper layers at these sites indicate that native cultures relied on salmon even more once sea level stabilized about 5,000 years ago. From that time until the late nineteenth century, salmon habitat reached its maximum extent and quality in the Pacific Northwest.

Evolving native cultures developed greater dependence on salmon as the abundance of salmon habitat, and presumably salmon, increased in the postglacial world. Many salmon runs not only survived being the targets of native fisheries for thousands of years, but actually thrived under human predation. Fishing nets dating from 3,000 to 500 years ago attest to the antiquity of salmon fishing in western Washington and British Columbia. Native American cultures also evolved and adapted to dependence on salmon runs. The various species of Pacific salmon evolved along with the landscape as well as the Native American cultures and communities of the region.

Sediment cores extracted from lakes on Alaska's Kodiak Island reveal evidence of broad swings in the prehistoric abundance of salmon. After spawning, sockeye that return to the lakes die and their rotting carcasses leak nitrogen that becomes incorporated into fine sediments on the lakebed. The relative abundance of the isotope nitrogen 15 (^{15}N) in the lake sediments indicates the relative proportion of nitrogen derived from marine sources. So if you pull a sediment core up from a lakebed, the ^{15}N concentration in each layer provides an estimate of the amount of nitrogen imported from marine waters by salmon or other anadromous fish. Date the layers in the core and you have a paleo-salmon meter.

The Kodiak Island lake cores record variations in salmon abundance over the past 2,000 years. Large swings in salmon abundance coincide



An engraving made in 1778 shows a Nootka woman of Nootka Sound, British Columbia, with woven hat and a cedar-bark cape.

with both archaeological records of cultural change and climate variability. Low Alaskan salmon abundance prior to A.D. 800 coincides with warm ocean conditions in the northeastern Pacific. As the northern Pacific subsequently cooled, Alaskan salmon abundance increased. At this time, the human population in the region also increased and shifted to greater reliance on salmon fishing. Sustained high abundance of Alaskan salmon after A.D. 1200 corresponds to cool periods of glacial advances in southeast Alaska. Over the past several thousand years, large-scale climate variability influenced salmon abundance and thereby affected the development of native cultures.

Shorter-term changes also affect salmon abundance. In particular, a twenty to thirty-year cycle in ocean conditions in the North Pacific, called the Pacific Decadal Oscillation, corresponds to dramatic shifts in salmon production in Alaska and the Pacific Northwest. Curiously, changes in Alaskan salmon abundance are out of phase with salmon abundance in the Pacific Northwest and California.

When Alaskan salmon production is high, the Pacific Northwest and California salmon runs are low, and vice versa. This pattern is caused by the effect of oscillations in sea surface temperature in the middle of the ocean on coastal upwelling and marine productivity. During cold phases in the Pacific Northwest, enhanced upwelling of cold, nutrient-rich bottom waters along the coast produces lots of krill and sustains an arctic fauna with few predatory competitors for salmon. During warm phases, in contrast, krill production is lower and coastal waters are full of predatory tropical species that compete with salmon for a smaller supply of food. Natural salmon production, therefore, has a boom-and-bust cycle tied to long-term shifts in ocean temperature and the productivity of coastal waters.

Over the past century the slowly varying pattern of ocean temperature that affects marine productivity, and salmon abundance, has reversed several times. In the Pacific Northwest, conditions were bad for salmon from 1925 to 1947, good from 1947 to 1977, and then bad again from 1977 to about 2000. Right on schedule, marine conditions have improved dramatically for Pacific Northwest salmon over the last several years, indicating that a new shift to better marine conditions has probably started. With this new switch we should expect cooler ocean temperatures and high marine productivity in the near future.

How could one reliably catch a consistent number of salmon from a population of fish characterized by large natural swings in numbers? Native American systems of salmon management imposed cultural restrictions on harvests that ensured they took less than half the available fish. In contrast, modern Euro-American salmon managers harvested as much as 90 percent of the runs, a practice that has not proved sustainable. Large natural variations in salmon abundance mean that the only safe long-term strategy for sustaining salmon fisheries is to limit harvests to a fraction of the overall run size—the Native American model of salmon management.

The development and evolution of salmon fishing by the Lummi tribe in northern Puget Sound provides interesting contrasts and parallels to the role of salmon in aboriginal cultures on the Atlantic coast, where salmon were not as central to the culture and livelihood of most native peoples. Around northern Puget Sound salmon formed the basis of a way of life. Daniel Boxberger, an anthropologist who has worked with the Lummis, observed that whenever Lummis get together, conversation inevitably drifts toward salmon fishing. Salmon were and are the primary foodstuff and occupy a central position in Lummi spiritual and social life.

Before 1855, when the Lummis and the U.S. government signed the Treaty of Point Elliott, which created the Lummi Reservation, salmon fishing provided subsistence for a dispersed network of small, local communities. The Lummis traveled seasonally between sites for salmon fishing, shellfishing, and plant gathering. Early fishing practices benefited entire villages and clans rather than individuals, and no individual had control of the fishery or the means to exploit it. Villages consisted of independent houses, each composed of individual families united by kinship to other houses. Salmon fishing was the most important means of subsistence for the pre-contact Lummis, with estimates of per capita salmon consumption ranging from one to almost two pounds per day. At the time of the treaty the Lummis had twenty-six houses dispersed around North Puget Sound, with a total population estimated at 700 to 800 individuals. Hence, the pre-contact fishery in the Lummis' territory caught a quarter of a million to a half a million pounds of salmon. If each fish weighed about ten to twenty pounds, this would account for an annual harvest of somewhere between 10,000 and 50,000 salmon.

A typical house consisted of an owner and his sons, brothers, and male cousins and their families. Allegiance fell to the house in which one resided, but there was substantial intermarriage among houses throughout northern Puget Sound. This resulted in a complex social web among settlements in the region. The primary bond between the aboriginal inhabitants of the Puget Sound was a shared language and culture. Political units that we know as tribes developed only after the treaties were signed and native communities were relocated to reservations.

The aboriginal economy included free access to fishing locations within a family's kinship network, which for most Lummi families extended throughout much of northern Puget Sound. Although access to fishing was generally open to all, some locations were held in trust by certain individuals for a larger kin group. In particular, fish weirs, traps that spanned rivers, and reef nets in coastal areas could be used only with the permission of the owner, unless one had contributed labor and materials toward their construction. Fishing with methods that did not require extensive labor was unrestricted. Anyone could troll for salmon in a river or on Puget Sound.

Though ownership of reef net sites was an inherited right, the owner was obliged to select crew members from his extended family and housemates. Fish were divided among the crew, and the owner of the site traditionally ensured that the needs of the crew were met before his own. After the crew had enough fish, the owner took the rest. According to Boxberger, the literature does not mention what would happen if there had not been enough fish to satisfy the crew. Salmon shortages apparently did not occur.

Many in the region believed that the salmon lived in five great houses deep in the sea, one for each kind of salmon. Once a year the salmon would journey from their ocean abode to pay their respects to their terrestrial brothers, providing a gift of rich food. Shown the proper respect they would return to the rivers year after year. Like any guest, they would not come back if treated poorly.

Throughout the Pacific Northwest and as far south as the Sierra Nevada in California, the return of salmon was an important annual event marked by a ceremony in which the first fish caught was honored as the First Salmon and either was shared among community members or was ritually eaten by a shaman. In most ceremonies, the bones of the First Salmon were carefully returned to the water. Ideally, the spirit of this ambassador salmon would tell other salmon how respectfully it had been treated and encourage others to allow themselves to be captured.

Restraint was a fundamental characteristic of Native American salmon fishing. Cultural constraints on salmon fishing practices allowed for adequate protection of spawners. Interviewed for a legal case in 1942, Sextas Ward, a ninety-year-old Quileute Indian who was a child when the treaties were signed, recounted: "When the Indians had obtained enough fish they would remove the weirs [salmon traps spanning a river] from the river in order that the fish they did not need could go upstream and lay their eggs so that there would be a supply of fish for future years " (quoted in Swindell 1942, 222).

In another account of pre-treaty fishing practices from the same series of interviews, a seventy-nine-year-old Umatilla Indian named James Kash Kash, who was born about 1863, testified: "It was customary for the Indians not to catch the salmon in the tributaries until after they had spawned for the reason that they knew there would be no salmon in the future if they did not permit the females to lay their eggs to be hatched and available in future years" (Swindell 1942, 305).

Throughout the region ritualized limitations on the duration, and therefore the intensity, of fishing institutionalized safeguards against overexploiting salmon. For example, on the Northern California coast, catching salmon for general consumption was forbidden at the start of the spring salmon runs. The salmon season opened for general fishing only after a ceremonial period following ritual preparation and eating of the First Salmon. The waiting period lasted from several days to weeks.

Along the Klamath River fish weirs were built in the ten days after the first salmon passed and then were dismantled after ten days of fishing. In addition, weirs were opened each night to allow salmon to pass upstream until fishing resumed the next day. Some weirs even had open gaps to allow passage of some salmon at all times.

The anthropologists Sean Swezey and Robert Heizer described salmon fishing practices on the Northern California Coast as a cultural adaptation that provided for sustainable fishing: "The 'restraining effect' extended by ritual restrictions concerning salmon fishing appears to have been a widespread phenomenon—and there is no evidence that native populations ever seriously overfished the salmon runs" (Swezey and Heizer 1993, 323–324).

Swezey and Heizer concluded that in pre-contact times California salmon were

> . . . a seasonally abundant and renewable commodity which required intelligent and competent organization and control of fishing practices to en-

> sure efficient harvest. . . . [R]itual specialists directed and controlled fishing and dam building activities, regulated the opening of the salmon fishing season, and managed the use of the spawning runs. . . . The anadromous fish resource was perhaps the most intensely managed and ecologically manipulated food resource among these aboriginal societies. (1993, 327)

In many areas the Native American fishery provided a substantial return for intense effort during the salmon run. In some areas, the catch provided food to last the whole year.

Salmon were preserved by smoking or by drying to make jerky, which could keep for several years. The native population along the Columbia River dried enough salmon to support trade with people from the interior and coastal areas. Radiocarbon dates from piles of salmon bones excavated along the Columbia indicate substantial Native American salmon fishing since shortly after both Europe and North America thawed out from beneath glacial ice.

The native population along the Columbia River at the time of Lewis and Clark's voyage of discovery has been estimated as 50,000, with an annual catch of about 20 million to 40 million pounds of salmon. This catch conservatively translates into 1 million to 2 million fish. The Northwest Power Planning Council (an entity that was created by congress under the Northwest Power Act of 1980 with a mandate to implement an interstate program to protect and enhance Columbia River salmon runs) estimates that the pre-contact annual runs on the Columbia varied from 11 million to 16 million salmon. Native fishing, therefore, appears to have accounted for somewhere between 5 and 20 percent of the runs. Although just a modest proportion of the run size, this still made for a substantial fishery. Lewis and Clark reported passing more than a hundred native fishing stations on their way down the Columbia River. Even with such intensive operations, the native population sustained a society based on the fishery as old as the agricultural societies along the Tigris and Euphrates rivers in the Middle East.

Post-contact, new and exotic diseases decimated native peoples, especially as the frequency of contact with Europeans increased after 1820. By the 1850s, the growing European population surpassed and began to displace the shrinking native populations in Oregon and along the Columbia River. By 1851, the Native American population along the Columbia River fell to just one sixth the size of the pre-contact population. Furthermore, the European expansion began to separate the Native Americans from their fisheries. George Catlin, an artist who visited the region at this time, commented on the destitution of the native population along the Columbia River when deprived of access to salmon:

> The fresh fish for current food and the dried fish for their winter consumption, which had been from time immemorial a good and certain living for the surrounding tribes—is now being "turned into money," whilst the ancient and real owners of it may be said to be starving to death; dying in sight of what they have lost, and in a country where there is actually nothing else to eat. (1959, 144)

Already ravaged by new diseases, the native population was at a serious disadvantage in dealing with the new arrivals. Plans for a transcontinental railroad had been brewing in Washington, D.C., since Asa Whitney introduced a resolution in Congress in 1845 endorsing building a railroad to the Pacific. Competition was intense between southern and northern interests wrestling over the proposed routes for the railroad. Secretary of War Jefferson Davis pushed for a southern route. Isaac Stevens, who in 1853 led the surveying party charged with exploring possible routes between Michigan and Puget Sound, was the champion of the northern route. Later that year Stevens was appointed governor of the newly created Washington Territory and was also appointed superintendent of Indian affairs for the new territory. The U.S. government officially recognized aboriginal land ownership, and so in order to build the railroad, and open the territory for the settlers it would bring, the government needed to acquire title to the new territory. Stevens's primary mission was to eliminate aboriginal land ownership as quickly as possible.

In 1854 and 1855 Stevens traveled around Washington Territory negotiating a series of treaties with native groups. (In the end, ironically, given Steven's haste to grab land, the Civil War delayed plans for the railroad.) Although the twenty-six tribal reservations in the State of Washington together cover less than 8 percent of the state, the United States Senate did not ratify many of the treaties until 1859, four years after they were signed, because of concerns that Stevens had been too generous with the Indians. Today the federal government retains ownership of 29 percent of the state, and timber companies own many times the area of all the reservations combined. What did the Indians get in return for the 92 percent of the Washington Territory that they relinquished to the U.S. government in the treaties? A few cents per acre, the promise of government protection, and the right to keep fishing for salmon.

Some question how honorably Governor Stevens conducted treaty negotiations. At Stevens's insistence, the treaties were negotiated in Chinook, a trading jargon with at most a few hundred words in common use drawn from a mix of Indian languages, English, and French. Owen Bush, a member of the governor's staff, later recalled, "I could talk the Indian languages, but Stevens did not seem to want anyone to interpret in their own tongue, and had that done in Chinook. Of course it was utterly impossible to explain the treaties to them in Chinook" (Meeker 1905, 208). Bush and others also wondered how well Stevens's translator, Colonel Benjamin F. Shaw, knew the Indian languages.

But Stevens knew what he wanted. He'd had the treaties drawn up in advance. First and foremost, he wanted to clear the title to the land and concentrate the Indians in one or two relocation areas to open the territory for settlers. Stevens warned the Indians that the government could not protect them from the deluge of settlers coming over the horizon unless they relocated to reservations. Though many Indian leaders were dissatisfied, they eventually signed the treaties. Stevens told them that if they refused to sign, legions of settlers would overrun them anyway. In describing the negotiation of the Stevens treaties, William Compton Brown, a retired superior court judge from eastern Washington who interviewed Yakima tribal members in the early twentieth century, wrote that "haste, high pressure, and no little chicanery on the part of the whites was predominant throughout the meetings from start to finish" (Brown 1961, 64).

Though Stevens was authorized to relieve the Indians of their lands, he realized that there could be no agreement without assuring their continued right to fish in their accustomed places. Once reconciled to forfeiting most of their land, the primary interest of the tribes lay in securing and protecting their right and ability to catch salmon. Stevens knew that the Indians were far more willing to move and accommodate new neighbors than they were to stop fishing for salmon. The treaties uniformly included language preserving fishing rights: "The right of taking fish, at all usual and accustomed grounds and stations, is further secured to said Indians in common with all citizens of the Territory" (Minot, 1855, 1133).

No matter how well or clearly the various treaties were translated into the Indian languages, there remained a simple underlying inequity. The Indians knew that there were plenty of salmon to share and had no reason to believe there might not be in the future. There had always been plenty in the past. The government Stevens represented knew of the depletion of salmon in England and along the Atlantic seaboard. Stevens not only orchestrated the negotiations but he also knew the game they were playing.

Today this may seem like irrelevant ancient history, but the treaties still provide the legal basis for federal sovereignty over the region, as well as tribal fishing rights. I first became aware of the treaty language when Hiram Li, a biologist from Oregon State University, asked the governor's Salmon Recovery Office to provide us with copies of the treaties at the first meeting of Washington's Independent Science Panel that I was appointed to in 1999, and which was charged with reviewing the state's salmon recovery program. Taken by surprise, the governor's office arranged for a lawyer from the state attorney general's office to come to our next meeting and explain the treaties to us. What we heard convinced me that the treaties implied that government had a responsibility to preserve salmon runs through habitat protection and land use restrictions if necessary. In further discussions we quickly discovered that this was not the question that the state wanted us to be asking.

The treaties did specify that the Indians were to share the right to fish for salmon with the settlers, but did not guarantee the tribes an equal footing for competing with commercial salmon fishers. After the introduction of cannery technology made salmon exports from the region a viable enterprise, most of the fish processed by Puget Sound canneries initially came from Indian fishing. But as commercial fishing became increasingly profitable, and competitive, natives were rapidly squeezed out of business by lack of access to capital. Banks would not lend money to finance acquisition of fishing boats to reservation Indians because they had no collateral. They could not use their reservation lands as leverage because the federal government held these lands in trust. The right of access to ancestral salmon fishing sites did not guarantee the ability to participate in commercial fishing.

Lacking the capital needed to apply their skills to the developing commercial salmon fishery, Native Americans were outpaced by technological change in their ancestral industry. In short order, large numbers of white-owned salmon traps patterned after those used for Atlantic salmon on the East Coast began to displace native fishermen. These traps were ingenious devices consisting of a submerged fence of twine or galvanized wire mesh connected to piles driven into the bed of Puget Sound or a river. Fish were directed into the maze through openings in the structure that guided them into progressively smaller pens from which they could be scooped with dip nets. Such traps were extremely efficient, cost-effective, and profitable. Those in place in 1900 yielded lucrative profits that could more than double an investment in a single season.

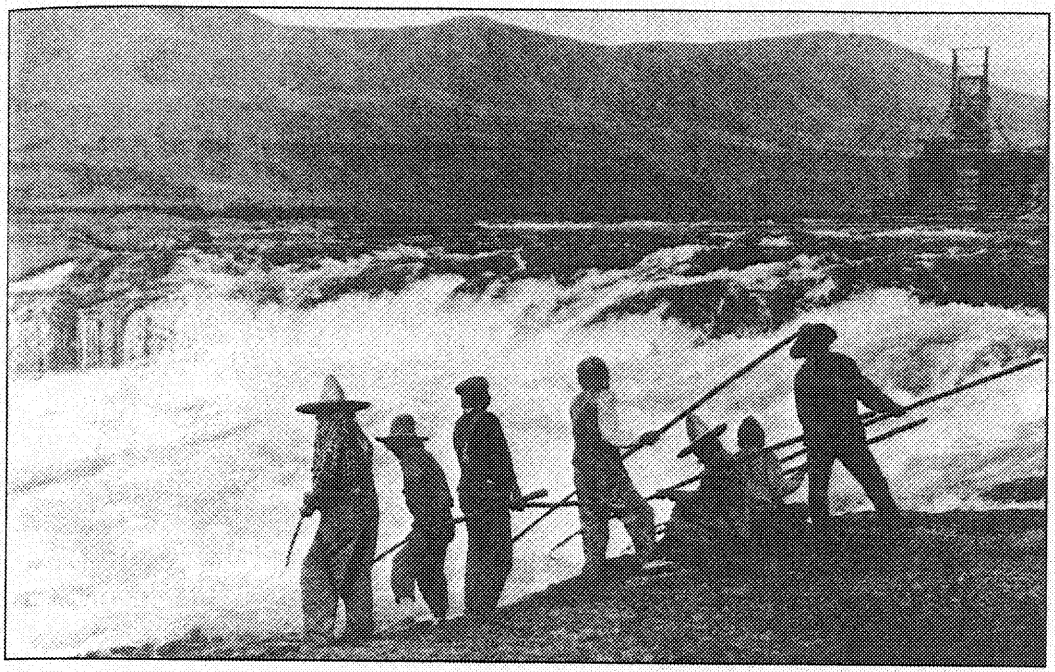
Naturally the traps multiplied. In the first decade after their introduction, the number of fish traps on Puget Sound grew tenfold. Many cannery-owned traps were located on, near, or directly in front of traditional native fishing sites. At Point Roberts, for example, Indian fishing accounted for less than 5 percent of the salmon harvest by 1895. A perennial source of contention, fish traps were outlawed in Oregon in the 1920s and in Washington in the 1930s.

As fish traps declined, power boats came to dominate commercial salmon fishing on Puget Sound. New vessels towed nets that could be drawn together like the drawstrings on a purse, trapping everything inside. By 1935 the State of Washington licensed almost a thousand power fishing vessels annually. Native Americans had become all but excluded from commercial salmon fishing.

Just as important as the lack of access to capital and the rapid technological change in the fishery was the political situation, as the federal Bureau of Indian Affairs aggressively sought to reduce native salmon fishing. Bureau policy stressed agricultural development and discouraged fishing. The State of Washington also worked to curtail Indian fishing. Given the central place that salmon fishing occupied in native cultures of the region, it is not surprising that efforts to curtail Indian fishing proved controversial. Expansion of the commercial fishing industry and then competition for a declining salmon harvest led to conflict over the meaning of the Indians' exclusive right to fish within tribal reservations, and especially their right to fish off-reservation at their usual and accustomed places. For a century much of the State of Washington's effort at restricting salmon fishing was directed at tribal fishermen, even as changes in technology and fishing gear progressively reduced the proportion of the salmon harvest taken by Native Americans.

Beginning in 1894 the Lummis petitioned the federal government to protect their access to fishing grounds from encroachment and displacement by white fishermen. In 1897, C. H. Hanford, a federal judge with ties to the local fishing industry, ruled that under the Treaty of Point Elliott native fishermen retained equal rights but did not have special privileges protecting their access to particular locations over the interests of other citizens. The ruling encouraged the state to restrict Indian fishing. To this day, the no-special-privileges argument pops up on talk radio and in state politics.

Some abuses of Indian treaty rights were flagrant enough to spur federal action. In the 1890s two brothers, Lineas and Audubon Winans, operated a state-licensed fishing operation on homesteaded land near Celilo Falls. The Winans brothers forcibly prevented Yakama Indians from crossing their land to reach their traditional fishing grounds. The Winanses must have been shocked when the local U.S. attorney charged them with violating the treaty signed by Yakama tribal leaders and Governor Stevens in 1855. The Indians lost in the lower courts, which ruled that the treaty only guaranteed Indians rights equal to



Columbia River area Indians fish with spears at Celilo Falls, Oregon, ca. 1910.

those of white citizens, and therefore that their treaty-protected right to access fishing grounds could be superseded by state licenses and federal homestead grants. An appeal of the lower-court ruling landed before the U.S. Supreme Court in 1905.

In a scathing opinion, the Supreme Court backed the Indians.

> [I]t was decided [in the lower court] that the Indians acquired no rights but what any inhabitant of the territory or state would have. Indeed, acquired no rights but such as they would have without the treaty. This is certainly an impotent outcome to negotiations and a convention which seemed to promise more, and give the word of the Nation for more. . . . [T]he treaty was not a grant of rights to the Indians, but a grant of rights from them. . . . No other conclusion would give effect to the treaty. (*United States v. Winans*, 1905, 380–382)

The Supreme Court ruling further held that the transition from territory to statehood did not nullify Indian fishing rights. Nonetheless, the ensuing legal battles over the scope and nature of Indian fishing rights focused on the tension between federal treaties and state laws.

From the beginning of this legal war, federal courts upheld and protected Indian fishing rights, while state courts curtailed or limited those rights. State court defeats for Indian fishing rights were generally overturned when appealed to federal court. Still, the fight dragged on for a century.

One of the first regulations enforced by the State of Washington's Department of Fisheries, created in 1890 to regulate the salmon and other fisheries, was to ban the use of nets in streams. By then this had become the primary method of Indian fishing because traps built and operated by canneries had displaced Indian fishing from coastal areas up into rivers and streams. The Department of Fisheries took this step because the Indians' river fishing, now in plain sight of the general public, undermined state fisheries managers efforts to protect the few fish that made it past the commercial traps. This arrangement guaranteed conflict over Indian fishing by placing Indians last in line, and squarely in the public eye, in the fight over a declining resource. Public anger over Indian fishing grew, and the state began to enforce fishing regulations on the reservations even though the treaties protected on-reservation fishing from state regulation.

As commercial fishing began to deplete salmon stocks, enforcement of regulations occurred mostly in the rivers, rather than in open water. Because Indians lacked access to capital to buy commercial fishing boats, Native American fishing remained relegated largely to rivers. Regulatory practices compounded the disadvantage the Indian fishermen faced. Fishing seasons were timed to coincide with open-water runs and to end when salmon entered the rivers, leaving the Indians no time or place to fish. Refusing to allow even a subsistence Indian fishery, the state announced it would arrest any Indians fishing in defiance of state law—whether on or off their reservations. The manner in which the state regulated salmon fishing helped turn public opinion against Indian fishing.

Publicity surrounding tribal defiance of state fishing regulations fueled longstanding perceptions of Indian fishing as contributing to declining salmon runs. Yet in 1935, the first year that the state kept records, Indians caught less than 2 percent of the total salmon catch. The powerboat fleet hauled in 90 percent. According to state records, the entire Indian catch for Puget Sound from 1935 to 1950 accounted for less salmon than taken by the commercial fishing fleet in one typical year during the same fifteen-year period. Nonetheless, the state continued to blame deterioration of salmon stocks on Indian fishing. For example, in 1959 the Washington State Department of Fisheries blamed Indians for undermining salmon-recovery attempts, stating, "The effort on most Indian fishing streams has increased tremendously over the past several years and the results of many a protective regulation on commercial and sport fishing has served merely to fill an Indian net" (Washington State Department of Fisheries 1959, 221).

Although the state directed substantial effort toward censuring Indians for their perceived role in depressing salmon runs, it did not limit entry into the commercial fishery of Puget Sound, and thus the fishing fleet continued to grow. In addition, the state continually maximized the allowable harvest by the state-licensed commercial fishermen and did not allow for any river-based fishing. Consequently, the Indians took salmon after the full catch allowed by fisheries managers had already been harvested. Instead of accounting for Indian harvest in their planning, which would have required some commensurate lowering of the limit for commercial fishing, the state cultivated public support to eliminate Indian fishing. By 1961, the state acknowledged the perilous state of its salmon but continued to emphasize control of the Indian fishery.

> It does no good to talk of how many salmon there used to be, or that Indian treaties supposedly guaranteed Indians the right to take fish in perpetuity, or argue about who or what has reduced those salmon runs to their present state. The important thing is that our salmon runs are now dangerously low and in many cases are even to the point of facing extinction in the very near future. (Washington State Department of Fisheries 1961, 178)

Despite such prescient rhetoric, the Washington State Department of Fisheries continued to grant increasing numbers of commercial fishing licenses. The number of gill-net licenses issued by the state increased fourfold between the early 1950s and the 1970s. The sport fishery in Puget Sound also mushroomed during this time. By the early 1960s more than half a million salmon were being taken annually by the recreational fishery, which by then had surpassed the Indian fishery.

In 1970, the federal government on behalf of western Washington tribes that it had signed treaties with sued the State of Washington, alleging that commercial salmon fishing had come to exclude treaty-protected fishing by Native Americans. The landmark case, and the subsequent opinions that it produced, bear the name of Judge George Boldt, a no-nonsense federal district court judge who ruled that the treaty language "in common with" meant that the treaty tribes were to share equally with non–Native American citizens of Washington State the opportunity to take fish at their usual and accustomed places. Judge Boldt's 1974 ruling, which was upheld by the U.S. Supreme Court in 1979, held that the treaty tribes were entitled to half of the salmon harvested in their traditional fishing areas.

The initial Boldt decision was a bombshell. The idea that the salmon harvest was to be shared equally between the treaty tribes and the other citizens of the state of Washington was unexpected. The fishing industry was stunned. Indian fishermen had previously taken a small fraction of the catch, and now they were entitled to half of all the salmon harvested in the state. Violence erupted as non-Indian fishermen fumed that the Boldt decision would destroy their livelihood. Few wanted to admit that the collapse of commercial salmon fishing was just a matter of time anyway as long as salmon runs continued declining as a result of overfishing, habitat degradation, and the blocking of rivers and streams. In the end, the tribes finally secured their treaty rights just as the commercial fishery for wild salmon virtually expired.

Because Indian fishing was such a small component of the overall fishery at the time of the Boldt decision, many in the general public believe the decision as *giving* half of the fish to the tribes, and the media often portray the issue the same way. But the court concluded that through the treaties the tribes originally *reserved* the right to half the salmon and *granted* the citizens of the United States the privilege of taking the other half. In 1905, the U.S. Supreme Court in ruling against the Winans brothers had confirmed that federal treaties supersede state law, and finally almost a century later the issue of Indian fishing rights appeared to be settled.

Or was it? The tribes, state, and federal government returned to court dozens of times in the four years after the initial Boldt ruling. During the appeals and challenges, federal courts ordered state agencies to implement the Boldt decision, but state politicians instructed state agencies to manage salmon against federal directives. After four years, following what one appellate judge characterized as one of "the most concerted official and private efforts to frustrate a decree of a federal court witnessed in this century," Judge Boldt assumed jurisdiction over the salmon fishery and the Coast Guard was called in to enforce federal fishing regulations (*Puget Sound Gillnetters v. United States District Court*, 1978, 1126). The next year, the U.S. Supreme Court upheld the Boldt decision and the state was forced to recognize the treaty tribes as comanagers of the salmon fishery. After the Boldt ruling, Congressman Lloyd Meeds and Senator Slade Gorton of Washington repeatedly introduced bills to reduce or eliminate tribal treaty rights.

When he adjudicated the case brought by the federal government over tribal fishing rights, Judge Boldt separated the issue of protecting the habitat necessary to produce salmon from whether the treaties guaranteed the tribes a particular share of the harvest. Having ruled in favor of a tribal right to half the salmon harvest, Judge Boldt died before settling the habitat question. The issue ended up before the Honorable William Orrick, another federal district court judge. In his 1980 ruling Judge Orrick stated, "The most fundamental prerequisite to exercising the right to take fish is the existence of fish to be taken." He ruled that the treaties provided the tribes with the guarantee that state and private interests must refrain from degrading salmon habitat to an extent that would deprive the tribes of their "moderate living needs." (*United States v. State of Washington*, 1980, 203)

Fearing wholesale erosion of their ability to permit land uses that harmed salmon, the state appealed. An eleven-judge panel of the Ninth Circuit Court of Appeals in San Francisco vacated Orrick's ruling, deciding that it was improper for the court to rule on the habitat issue without an actual on-the-ground controversy over some project or particular action. Deciding the appeal on a procedural technicality, the panel did not address the legal basis of Orrick's conclusion. The issue remains unresolved.

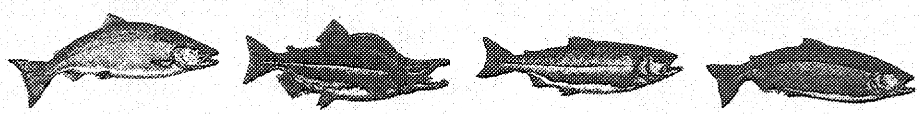
Non-Indians sometimes complain about Indians' being granted special rights. But unlike emigrant communities that came to America voluntarily, Indian tribes are recognized by the federal government as sovereign nations with whom the government negotiated international treaties. Those treaties are still in effect, and they provide the legal foundation for incorporating much of the western states into the United States. Furthermore, as Judge Boldt and others have noted, it is the Indians who granted rights to the federal government, not the other way around.

Some state politicians and citizens may feel that Indian treaties that predate the existence of the state shouldn't carry much weight. But it is the federal government's obligation to honor the treaties. The State of Washington can no more unilaterally abrogate the Stevens treaties than it can revoke the Anti-Ballistic Missile Treaty or the Geneva Conventions on the conduct of warfare. No matter how much situations or conditions change, obligations under these treaties do not change with the political winds.

Tribal treaty rights are an emotional, volatile issue that will likely be fought over for years to come. How these issues play out will have a central role in the future of salmon. Native American salmon management in the Pacific Northwest was practiced historically on a river-by-river basis and was characterized by institutionalized restraint to ensure that relatively high numbers of fish would make it back up a river to spawn. This combination helped sustain native fishing for thousands of years. By the time Governor Stevens secured his treaties, this was not the case in the homeland of my ancestors, where salmon were already in trouble and a salmon crisis was raging. The fall of Pacific Northwest salmon had clear precedents half a world away.

KING OF FISH

The Thousand-Year Run of Salmon



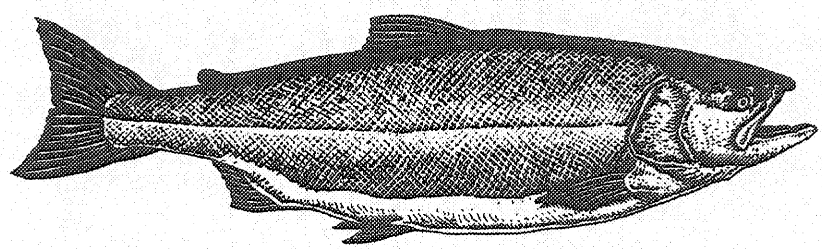
DAVID R. MONTGOMERY

Westview Press
A Member of the Perseus Books Group

CHAPTER

9

POWER FOR THE PEOPLE



Roll along, Columbia,
You can ramble to the sea.
But river, while you're rambling
You can do some work for me.

Woody Guthrie, "Roll, Columbia," 1941

IN 1992, A SOCKEYE SALMON NAMED LARRY SWAM FROM the sea heading home to Idaho's Redfish Lake, up and over fish ladders at thirteen dams without eating. Like his ancestors, Larry traveled upstream at an average rate of 1 to 2 miles an hour, hugging the banks in water generally less than 30 feet deep. In the 1890s thousands of sockeye made this journey up the Columbia and then the Snake river to return to Redfish Lake.

Lonesome Larry was the only sockeye that made it back to Redfish Lake in 1992. Since he came alone, the National Marine Fisheries Service had a surprise waiting for him. Instead of a nice female to spawn with, he was clubbed on the head and had his sperm squeezed out of him by technicians to fertilize hatchery fish from which the agency hoped to revive his kind. Larry himself, the last wild Redfish Lake sockeye salmon, ended up as a display on the wall of a museum managed by a dam construction company that built many of the dams Larry swam over.

In 2002, on our way from Seattle to a writing retreat in Boise, Xena and I paralleled Larry's thousand-mile trip up the Columbia and Snake rivers. We drove it in a day, stopping for lunch along the way.

Trapped in the rain shadow of the Cascade Range, the Columbia Plateau of eastern Washington is dry, really dry. But unlike many deserts, it is fertile because of the wind-delivered silt that covers much of the plateau. You just need to add water to grow a lot of crops, and now, dams and irrigation ditches tap eastern Washington's big rivers (the Columbia and its major tributary the Snake) to water an ocean of grain in the middle of an arid plateau. More than half a century since the first dam was built, the irrigation system that transformed the high desert of eastern Washington into a productive breadbasket has become an untouchable regional entitlement.

The Columbia River was the logical physiographic boundary between the United States and British territories in the Pacific Northwest. In fact, the Hudson's Bay Company even established a British presence north of the Columbia River at Fort Nisqually prior to American settlement. The location of the border remained contentious until 1846, when the British relinquished their claim to what is now Washington State. Why did the British yield this area so easily?

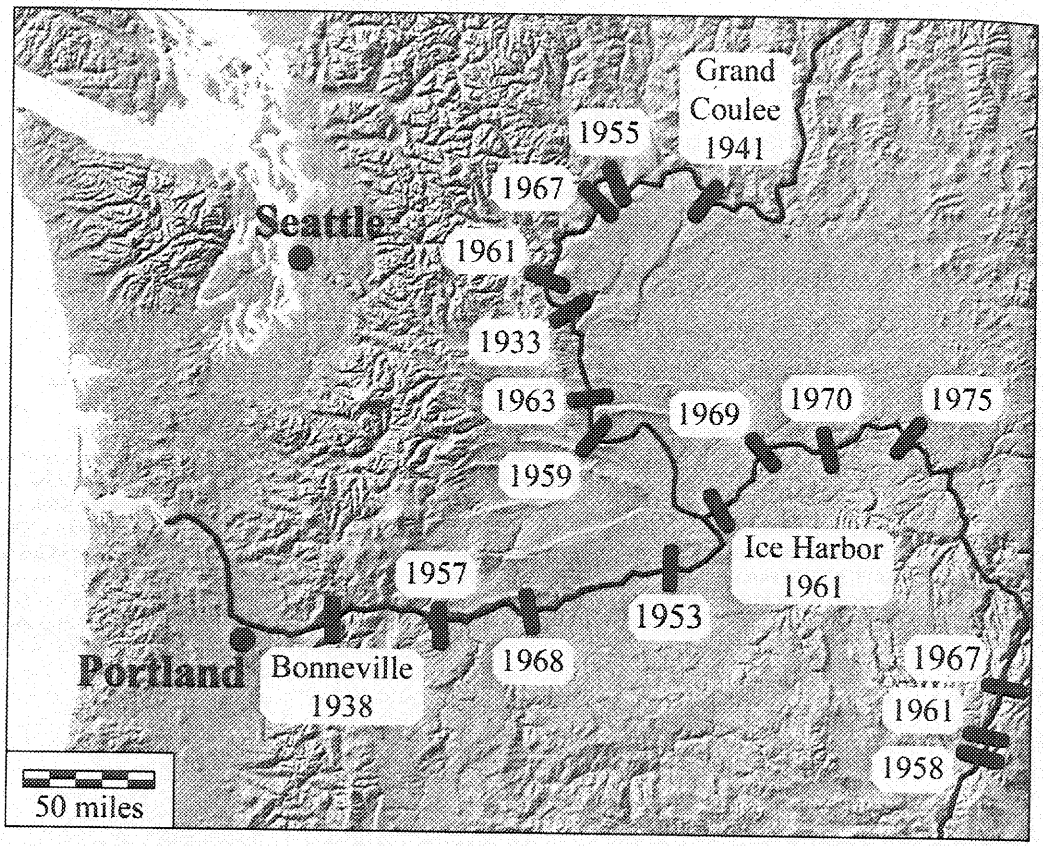
One story holds that Washington is U.S. territory because Columbia River salmon would not take a fly. The brother of Sir Robert Peel, the British prime minister, was serving in the British Navy at Victoria, British Columbia, at the time of the settlement. Despite repeated attempts, this gentleman at the edge of the empire apparently had no luck in fly-fishing on excursions up the Columbia. Writing to his brother the prime minister, he is said to have advised him that that Columbia River salmon were too stupid to take a fly and that the river "wasn't worth a damn."

Named after the first ship to sail up the river in 1792, the Columbia is the fourth largest river in the continental United States (behind the Mississippi, Colorado, and Rio Grande). Draining 260,000 square miles of temperate rainforest, mountains, and high desert, with headwaters in Canada and Idaho, the Columbia River crosses through arid eastern Washington and skirts around the Cascade Range to head for the coast through a narrow gorge at The Dalles, just east of Portland, Oregon. The Columbia is an ancient river, older than the Cascade Range, having cut its way across the rising mountains millions of years ago before the range grew to its present height. The river is older than the Pacific salmon.

The west and east slopes of the Cascades are different worlds. Winds coming off the Pacific Ocean deliver the rains responsible for the Pacific Northwest's soggy reputation. But the rain stops at the Cascades, wrung from the winds by the high peaks along the crest of the range.

Twenty million years ago, before the Cascades rose, eastern Washington was forested, much like western Washington. The rising mountains formed a topographic barrier that cast a growing rain shadow across eastern Washington. The forests east of the rising range wilted away as the Columbia Plateau dried out, so that today Ponderosa pine forest on the east slope of the range yields to sparse scrub on the Columbia Plateau. Incised in a canyon cut slowly over 15 million years, the Columbia River hoards its water as it flows past the uplands without sharing a drop.

The free-flowing Columbia had its own seasonal rhythm. Spring snowmelt turned the river into a raging torrent. David Douglas, a Scottish botanist who canoed up the river in June 1825 (and for whom Douglas fir is named), described the Columbia in the middle of the snowmelt season as exceedingly powerful, making upstream travel slow and arduous. The river level varied so much through the year that dramatic features such as Celilo Falls were exposed only in late summer and early fall—the rest of the year they were submerged beneath rapids. Today you need scuba gear to find the location of the old falls beneath water impounded behind Bonneville dam. Other than between the sea and the lowest dam, the last free-flowing stretch of the



Locations of dams on the Columbia and Snake rivers.

Columbia runs through the Hanford nuclear reservation. The modern Columbia is more like a long string of lakes than a river.

Was damming the Columbia a good deal? Naturally, the answer depends on whom you ask. To the farmers on the irrigated plateau it was a great deal. Cheap power produced by the turbines at the dams and water diverted from the river still fuel the economy of eastern Washington and much of Oregon and Idaho. It was a disaster for the Indians and the salmon. Celilo Falls, where people had fished for over eight thousand years, slipped beneath the water. As more and more dams were built, the salmon that provided the livelihood for the original inhabitants of the Columbia River basin began to disappear.

Settlers who came to the West Coast knew of the role of dams in decimating salmon runs in New England and Europe. There was no desire to repeat these stories. In 1848, the Oregon territorial constitution proclaimed that the rivers and streams "in which salmon are found or to which they resort shall not be obstructed by dams or otherwise, unless such dams or obstructions are so constructed as to allow salmon to pass freely."

Meeting in its first session a few years later, the newly formed Washington State Legislature also passed laws making it illegal for anyone to block salmon from running up a river or stream. Though the intent of such laws seems clear, they were generally ignored or circumvented in short order.

In the early 1900s a large number of dams were built to supply water and power for western Washington's growing population. The city of Seattle, for one, dammed the Cedar River in 1901 to provide water for the growing metropolis. Built without provision for fish passage, the dam stood in unchallenged violation of state law for over a century. Other dams soon followed to provide water and power. Enforcement of fish-passage laws was lax as the Washington Department of Fisheries kept busy regulating the expanding fishing fleet and building an extensive network of hatcheries.

As dams started to proliferate across the region, fishing interests voiced concern about the potential impact on the salmon fishery and called for enforcement of fish passage laws. In 1903, a critic sounded the alarm in the *Pacific Fisherman*:

> The matter of harnessing the waters of our rivers by the immense dams that are being built across them for power, irrigation and milling purposes is sure to jeopardize the fishing industry of this state; for, as a general thing, they are building dams across the most desirable streams. . . . These are almost complete barriers to the salmon ascending the streams. The present law requires that in event of the construction of such dams that a fish-way be left so that the fish may ascend. . . . Immediate steps should be taken to remedy the matter. (5)

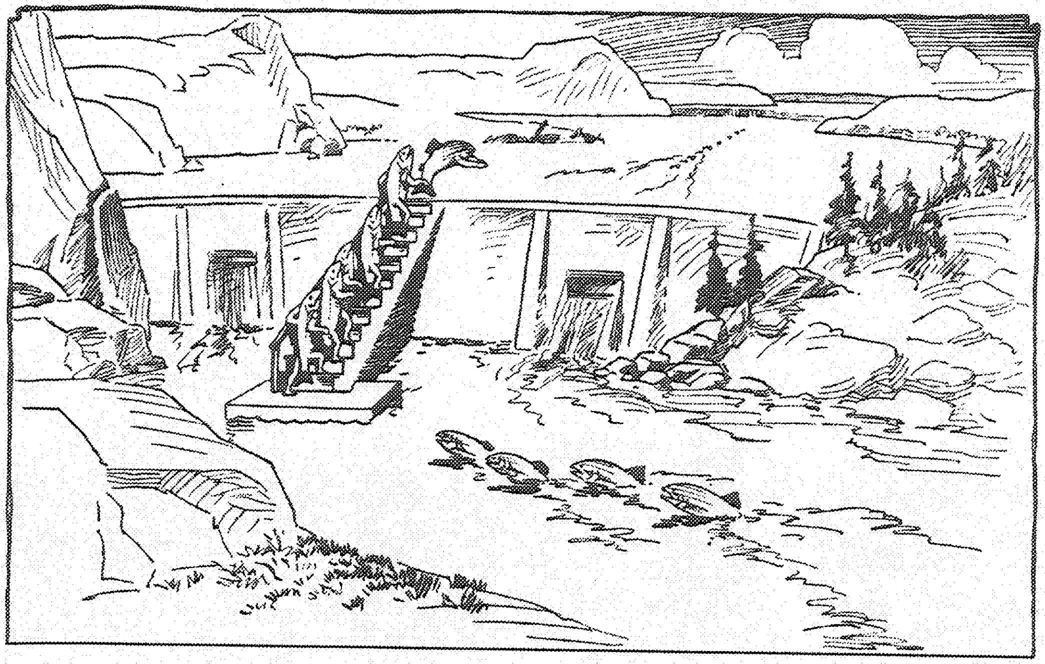
Although it was illegal to block salmon from ascending a river, dam building remained an attractive proposition.

Dams on the Elwha River in Olympic National Park provide the classic case of enduring, illegally constructed dams. Located on the northern end of Washington's Olympic Peninsula, the Elwha harbored all five North American species of Pacific salmon, including legendary monstrous chinook that reached over 100 pounds. The river flows from the interior of the Olympic Mountains through a narrow gorge before dropping to empty into the Strait of Juan de Fuca. The opportunity to dam the river at the gorge to produce power (for markets not yet then in existence) led Thomas Aldwell, a Canadian with backing by Chicago investors, to dam the Elwha. Built between 1910 and 1913, Aldwell's first dam lacked both provision for fish passage and a solid foundation. It failed because of engineering shortcomings but was soon rebuilt, again without the required fish passage.

This illegal fish barrier created a political problem for the newly elected governor of Washington, Ernest Lister. His creative fish commissioner, Leslie Darwin, came to the rescue. Darwin proposed to Aldwell's company that they build a fish hatchery instead of a fishway. Although this would not satisfy the law, Darwin saw a novel way around this technicality. He suggested that if the company built a hatchery that was physically connected to the dam, then the dam could be considered an official, state-sanctioned fish obstruction for the purpose of supplying the hatchery with eggs. Governor Lister liked the idea so much that he persuaded the state legislature to endorse building hatcheries instead of providing for fish passage at new dams.

Completed in 1915, the Elwha hatchery turned out to be a complete failure and was abandoned in 1922. But the precedent had been set, as dams began to multiply and hatcheries became the backbone of state fishery management. Many hatcheries were positioned to block native salmon from moving upstream past the hatchery in order both to help round up returning adults and collect their eggs and to keep fish from getting into and fouling the water supply used by the hatchery.

At the opposite end of the Olympic Peninsula, the city of Tacoma built Cushman Dam in 1926, blocking the North Fork of the Skokomish River. The lack of fish ladders—or even a hatchery under Darwin's novel interpretation of the law—did not impede the project. Virtually the entire upper river was diverted through tunnels to cross beneath a ridge, pass through turbines, and then spill into Hood Canal. Although the flow diversion drained the North Fork above the bypass,



"Too bad the poor fish can't do this!" An illustration from 1936.

the Washington State Department of Fisheries didn't challenge construction of the dam or take legal action against the city of Tacoma.

In other cases, fishing interests mobilized to fight against potential barriers to fish passage. Fisheries agencies were particularly alarmed when a private company, the Washington Irrigation and Development Company, applied for a license to dam the Columbia River at Priest Rapids in January 1924. Noting that at least half the Columbia River salmon spawned upstream of the proposed dam, federal and state fisheries interests submitted a brief opposing the dam to the Federal Power Commission, which was the licensing authority for dam building. Predicting disaster for the salmon and thousands of people dependent on them should the dam be built, they entitled their brief *Save the Columbia River Salmon*. Despite these efforts, less than a decade later the first dam, Rock Island, was built across the Columbia.

The effects of the adverse impacts of water diversions on salmon were well known in the Pacific Northwest. In 1916 a U.S. Bureau of Fisheries agent named Dennis Winn had investigated the effects of irrigation ditches on salmon losses in central Washington's Yakima River. Winn found that during the critical downstream July migration of juvenile salmon, more than 90 percent of the river's flow was diverted into irrigation ditches. He counted an average of twenty fish per acre in the fields. Later, Charles Pollock, the Washington State supervisor of fisheries, concluded in his 1932 annual report to the state legislature, "Practically all established power and irrigation projects have already taken a large toll on fish life" (28).

In 1937, a report of the U.S. commissioner of fisheries identified the effects on the downstream migration of juvenile salmon of water diversions for agriculture as threats to the Columbia River salmon:

> With the rapid development of agriculture and the increase in acreage requiring irrigation, practically all the major streams in eastern Washington have been tapped for irrigation purposes. These streams and their tributaries have in the past supported excellent runs of salmon and steelhead trout, but now only fragments of the former runs remain. It is evident, then, that these unscreened ditches and canals, and similar irrigation systems in Oregon and Idaho, constitute one of the many factors destructive to the fisheries of the Columbia and that steps must be taken to prevent this loss. (1937, 52)

The commissioner went on to state that he saw the problem as one of enforcement, rather than inadequate laws or regulations: "Laws of the States of Washington, Oregon, and Idaho contain provisions for the screening of irrigation canals. . . . For various reasons, economic and otherwise, the provisions of these State laws have not been uniformly enforced in such a manner as to provide for the screening of all or even a substantial part of the existing irrigation diversions" (53–54). Though the laws remain on the books, unscreened irrigation ditches continue to take a toll on migrating salmon throughout the region.

The year after the commissioner's report, biology professor Henry Ward investigated the effects of dams, flow diversions, and hydraulic mining for the Oregon Department of Geology and Mineral Resources. Ward found that dams constructed to produce electricity both impede the upstream migration of adult salmon and endanger juvenile salmon on their way downstream as they pass through turbines. He noted that dams raised the temperature in the sluggish water upstream of dams and that water temperatures in fishways approached the upper limit at which salmon could survive. Ward further noted the effect of unscreened irrigation ditches on migrating juvenile salmon.

> Young fish have been watched often entering such ditches, moving freely down the current, accumulating in deeper holes when the water was cut off, or found dead in irrigated fields. They are seen in miners' settling basins or power-plant reservoirs, are torn to sheds [*sic*] in turbines. . . . It is immaterial whether the diversion ditch serves a power plant, an irrigation project, a mining enterprise or some other purpose, the fish, young and old, which enter it are condemned to destruction. While the number tempted to enter at any particular moment may be small, it must be remembered that such ditches work day and night until shut off and the total count of fish destroyed is unquestionably large. (Ward 1938, 9)

Irrigation diversions on the Rogue River, like those on the Yakima River decades before, lacked screens to keep salmon out of the fields, even though Oregon state law stipulated that diversion ditches be screened to prevent fish from entering. Ward considered unscreened irrigation diversions to represent a needless waste of fish. Enforcement of laws requiring screens on irrigation diversions remains a sensitive issue in the Pacific Northwest.

Although planners thought about the problem of getting salmon upstream to the spawning grounds, and thoughtfully designed salmon ladders seemed to work pretty well (when maintained), the problem of juvenile migration back to the sea remained vexing. Getting fish over a dam seemed like a simple engineering problem, but survival of juvenile salmon during downstream passage through a series of lakes and dams was more complicated. Though solutions were elusive, the problem was recognized as critical to the survival of healthy salmon runs. Still, dam operators on the Columbia neglected to make allowances for getting juvenile fish down the river in the time that they are physiologically adapted to make the journey.

Juvenile salmon evolved to ride downstream on the Columbia's swift current during spring floods. They are genetically programmed to mature so that when they get to the bottom of the river system, they are ready for the physiological changes that allow them to survive the transition to salt water. If they are forced to swim through lakes rather than roll along on a mighty current, the going is too slow. If the trip takes too long, they mature too fast, and many die before they reach the sea.

Society's gradual decision in effect to run the Columbia River as a giant power generator involved changing the timing of peak flows and otherwise profoundly altering the seasonal rhythm of the river. Peak runoff does not coincide with peak electrical loads in the Pacific Northwest. So power generators on the Columbia store water behind dams during spring high flows and release water during periods of high demand for electricity. Dam operations changed the Columbia from a river with high spring flows that helped speed juvenile salmon down to the ocean into a long series of lakes that slowed this crucial migration. For all the expenditure and planning for allowing salmon to make it over or around dams on their way upriver, operating dams so as to facilitate the equally crucial downstream migration remained a low priority.

Turbines also kill salmon. An estimated 10 to 15 percent of downstream-migrating juvenile salmon that go through the turbines of power-generating dams are killed at each dam. For stocks from rivers low on the Columbia system, and which only pass through one or two dams, this is not such a big deal. But for stocks from the upper Columbia River basin it becomes a very big deal. With just a 10 percent loss at each dam, a population that ran through ten dams would lose two thirds of the original run; 15 percent mortality at each dam would result in only one out of five fish making it past ten dams.

In 1927, Congress directed the Army's Corps of Engineers to study the development potential of the Columbia River basin. Four years later, the corps reported that there were ten promising locations for dams to provide for water power, flood control, and irrigation. The following year, Franklin D. Roosevelt, who was running for the presidency, promised a cheering crowd in Portland, Oregon, that the next hydroelectric development supported by the federal government would be on the Columbia River. Any concern over the potential impact on the salmon paled against the Depression era promise of a revitalized regional economy.

In 1933 construction started on the Bonneville and Grand Coulee dams, projects that were viewed as emergency public works whose primary purpose was providing jobs and stimulating a stagnant economy. Bonneville Dam was intended to improve navigation on the Columbia, and so it was to be operated by the Army Corps of Engineers. Grand Coulee Dam was built to provide irrigation for arid eastern Washington and was to be operated by the Bureau of Reclamation. Hydropower was a secondary reason for building both dams.

Some attempts were made to mitigate fisheries concerns during development of the Columbia River. Bonneville Dam, located low on the Columbia, was built with a fish ladder. In contrast, Grand Coulee Dam, located in the upper reaches of the basin, is an utterly impassable 550-foot high structure that would dwarf Egypt's Great Pyramid. The plan for solving the fish problem for Grand Coulee was to catch the salmon from above the dam and release them into tributaries below the dam. The fish were to adapt to these more conveniently located rivers.

Before construction of Grand Coulee Dam, about 5 percent of the Columbia River salmon spawned upstream of the proposed dam site. Fish from these runs were experimentally transplanted to below the dam site in the Okanogan, Methow, Entiat, and Wenatchee rivers. At first the experiment appeared successful, and fisheries managers were lulled into optimistically thinking that transplantation could be relied on throughout the Columbia River basin. Later attempts at transplantation were less successful, and the number of new sites to transplant salmon into kept declining as the basin developed.

The initial plan for developing the Columbia River did not include provisions for fish passage. Nonetheless, the Army Corps rejected the idea of a high dam at The Dalles, on the lower Columbia River because such a dam would block and thus destroy salmon runs on virtually the entire Columbia River system. In 1936, the Corps of Engineers recommended postponing proposals to dam the lower Snake River, arguing that such efforts should wait until the effects of the Columbia River dams on the salmon had been ascertained. Two years later, however, in an about-face orchestrated by shipping and agricultural interests, the Corps released a new report that advocated damming the Snake River. Now focused on turning swift rapids into easily navigable lakes to aid shipping between Lewiston, Idaho, and the Pacific Ocean, the Corps presented a proposal to build a series of dams connected by locks.

The 1937 Bonneville Project Act created the Bonneville Power Administration (BPA) to market power from the new dams. The act directed the BPA to encourage power use and give preference in power sales to public utilities. The mighty Columbia presented an enormous source of power and could produce far more energy than the region demanded. So the BPA kept rates low to encourage power consumption. Lacking customers, they built a market by constructing transmission lines so that rural areas were electrified within a decade, which dramatically improved the quality of life for people throughout the region. As part of its publicity campaign it hired a young folksinger, Woodie Guthrie, to compose songs extolling the dams and the power they would bring. Meanwhile, the U.S. Bureau of Reclamation developed plans to build dams all along the Columbia, Snake, and Willamette rivers.

From the start there was concern over the potential effect of hydroprojects on Columbia River salmon. In commenting on the proposed Bonneville Dam, the Stanford University biology professor Willis Rich pointed out that those proposing the dams had not determined whether provisions for the passage of fish past the dam would be successful. He expressed concern as to whether salmon would actually scale the fish ladders designed for the dams. But doubts about the potential effects on salmon were waved aside with assurances that fry from hatcheries would more than make up for any loss.

In 1933, the year that the first Columbia River dam was completed, a real estate developer, Frank T. Bell, was appointed United States commissioner of fisheries. Prior to his appointment, Bell promoted development of the Columbia River basin and in particular the construction of Grand Coulee Dam. Bell was an effective mouthpiece for development interests, who even as the dams were being constructed wrote, "[W]e have no reason to believe that the Columbia River salmon are in danger of extinction. We feel confident that the preservation of the great national resource of Columbia River salmon is assured" (Bell 1937, 46). Was Bell's overconfidence due to misplaced faith in fish ladders? Or hatcheries? Or was he just blowing smoke?

Concern over the potential impacts of plans to develop the Columbia River basin led Congress to direct Commissioner Bell to assess the effect of Bonneville Dam on salmon runs. His official report to the U.S. Senate Committee on Commerce acknowledged that the dam would present "a barrier which, if not surmounted, will destroy the major portion of the fish supply . . . [and] affect perhaps 75 percent of the total salmon supply of the region" (U.S. Commissioner of Fisheries 1937, 2). The commissioner allowed that there was substantial uncertainty in how the delay in traveling upstream due to passing the dams might affect salmon runs, stating, "While this delay is probably not serious when only one or two dams are involved, no one can say at the present time what may happen if the salmon are required to surmount nine dams" (U.S. Commissioner of Fisheries 1937, 51).

Commissioner Bell recommended increasing support for research on the natural history and ecological requirements of Columbia River salmon because

> faced with the emergency presented by the construction of Bonneville and Grand Coulee Dams, fundamental information has been found to be so incomplete that vast programs of development were of necessity undertaken without assurance of their possible effects on the fish supply. . . . As a result, aside from blind restriction of commercial activity, the protection of individual runs menaced by virtual extinction must at the present time be left to chance. (75–76)

This is a striking admission on the part of the commissioner of fisheries that he was powerless or unwilling to delay the Corps' program of dam building or was uninterested in trying to do so. The plan to protect Columbia River salmon was to trust in chance.

During the Depression, the need for power and jobs trumped uncertainty over potential effects of dams on salmon. Even so, in 1938, a year after receiving the commissioner's report, Congress passed the Mitchell Act, authorizing and funding measures to protect Columbia River salmon while the Columbia River was developed. The Mitchell Act gave the federal government authority to construct salmon hatcheries, funding of research to facilitate conservation of the fishery, construct and maintain habitat improvements, and "all other activities necessary for the conservation of fish in the Columbia River Basin." In granting such broad authority, Congress was not authorizing the extinction of the Columbia River salmon.

Yet despite the Mitchell Act, the agencies operating the dams that followed did not adjust operations to facilitate salmon migration. Although no one made an explicit decision to sacrifice salmon to power development, operation of the system ensured that outcome. Routinely adopting optimistic assumptions about the potential effects of projects and operations on salmon, and invoking the need for more study before making changes they did not desire, agencies running the dams sacrificed the Columbia River salmon by giving top priority to navigation, irrigation, and hydropower.

This implicit decision did pay some dividends. Whatever else one may think of the impact of the Columbia River dams, they helped win the Second World War, which was fought as much in factories as on battlefields in Europe, Africa, and Asia. As bombs reduced European cities to rubble, unscathed factories in the United States increased production until by the war's end the logistical balance was profoundly lopsided in favor of the Allies. Nowhere was this imbalance greater than in the production of the airplanes that destroyed the capacity of the Axis nations to wage war. The BPA played a decisive role in winning the war of production and in transforming the United States from an agricultural society into a global superpower.

In December 1939, just three months after Hitler invaded Poland, the BPA signed a contract to supply cheap public power for an ALCOA (Aluminum Company of America) plant in Vancouver, Washington. With Hitler overrunning Europe, Congress approved President Roosevelt's request to dramatically increase U.S. aircraft production to a staggering 50,000 planes per year. The 5-billion-dollar Defense Appropriations Act of June 1940 led to half a billion dollars in defense contracts going to the Pacific Northwest. By June 1943, war production was using more than 90 percent of the power generated by BPA's dams. Now there was a market for BPA power. The tamed Columbia River fed aluminum plants that supplied shipyards and aircraft plants building naval and aerial armadas. The war also fueled efforts to construct additional dams on the Columbia.

Fisheries agencies supported building the Dalles Dam because inundation of Celilo Falls was seen as a way to end Indian fishing. Samuel J. Hutchinson, the regional director of the U.S. Fish and Wildlife Service, considered elimination of the Indian fishery at Celilo Falls a good reason to build the dam at The Dalles because "the beneficial effects [of the dam] would compensate for the detrimental conditions that exist there at present. In brief, it would be easier for the fish to go over a ladder in the dam than to fight their way over Celilo Falls. The Indian commercial fishery would be eliminated and more fish would reach the spawning grounds in better condition" (Cone and Ridlington 1996, 206).

A 1958 U.S. Fish and Wildlife Service report on the Columbia River fishery development program called "the inundation of Celilo Falls in the Columbia River near The Dalles, Oregon . . . a memorable event. Removal of this partial barrier by backwater from The Dalles Dam eliminated forever an intensive historic Indian fishery" (1958, p. 3). In the same report, however, the Fish and Wildlife Service acknowledged that though they viewed the Indian fishery as a threat needing to be eliminated, they wanted to foster the growing sport fishery through supplementation and management of the fishery.

A decade after passage of the Mitchell Act, the U.S. Fish and Wildlife Service and the three states of the Columbia River basin—Oregon, Washington, and Idaho—agreed to a program of fishery enhancement measures. In its 1948 report recommending construction of the Dalles and John Day dams, the Army Corps of Engineers concluded that an aggressive fishery-development plan on the lower Columbia River was needed to maintain commercial salmon runs. Most of the measures proposed had a familiar ring to them: removal of barriers to fish passage, construction of fishways, pollution abatement, and more hatcheries. But two new elements were also agreed upon: Runs at risk would be transplanted to new locations, and fish refuges would be established where salmon preservation would be paramount. A backup plan to ensure survival of salmon seemed within reach on the Columbia.

The plan for developing the upper Columbia River basin called for maintaining the Cowlitz River in Washington State as a salmon sanctuary. But Tacoma City Light was eyeing the Cowlitz as a way to meet its own growing demand for electrical power. In late December 1948, the city of Tacoma applied to the Federal Power Commission for licenses for two dams on the river. The utility proposed a novel solution for getting salmon over the downstream dam, which was to be twice as tall as any dam with a successful fishway ever built. The fish were to start climbing over the dam on a fish ladder. At the top of the ladder, only partway up the dam, they would be trapped and transferred via a tramway to trucks that would haul them the rest of the way over the dam. Unconvinced that this approach would actually work, state fish and game agencies blocked the license needed to build the project. In 1949, the State of Washington passed a law prohibiting dams taller than 25 feet on all but two tributaries of the lower Columbia River. Undeterred, the Federal Power Commission dismissed these concerns and issued licenses for both Cowlitz river dams in November 1951, confident that with ingenuity and effort, the salmon problem could be solved.

But that is more easily said—or even mandated—than done. For no one branch of the regulatory system can get a handle on the problem. Salmon cross all of our jurisdictional boundaries, meaning that everybody controls a piece of the salmon puzzle but no one is in charge of putting it together. Swimming up through estuaries and big rivers into smaller streams—sometimes literally into somebody's backyard—their welfare is impacted by the decisions of all levels of government. The decisions of federal agencies, states, counties, city councils, and the actions of individual property owners all influence the productivity of salmon habitat.

The overlapping authorities across a dizzying array of jurisdictions are rarely coordinated and often act at cross purposes such that even broad laws passed by Congress that specifically mandate the protection of salmon are undermined or thwarted by citizens or other governmental agencies. The problem of a complex and confusing overlap of jurisdictions fostered uneven and poor enforcement of laws and federal regulations that contributed to the gradual decline of salmon across the Pacific Northwest.

It certainly didn't help the salmon that they were a low priority for the agencies running the Columbia River. The 1945 Rivers and Harbors Act, which adopted the Army Corps of Engineers' plan for the Snake River, required that the project allow salmon "free access to their natural spawning grounds." As in the Mitchell Act, such wording shows that Congress did not intend development of water projects in the Columbia River basin to exterminate salmon runs. While developing the river, the Army Corps of Engineers repeatedly expressed its intent to conserve salmon "to the maximum practicable extent," to have its operations result in "minimum interference" with salmon habitat, and to incorporate into its projects "the best possible means for passing salmon upstream and downstream." However well intended, such considerations were always an afterthought, resulting in minor adjustments to plans tailored to achieve higher priorities.

Alvin Anderson of the Pacific Marine Fisheries Commission, writing in 1950, described in "Shall We Have Salmon, or Dams, or Both?" the imbalance between the influence of fishery interests and government agencies promoting development of the Columbia River dams.

> Yes, it is possible to have salmon and dams when the lobby and legislative actions for the salmon are as strong as the lobby and legislative actions for the interests destroying salmon. . . .
>
> The practice of turning down a specific project because it would mean the loss of the salmon resource has carried such vicious implications to political representatives as to force their acquiescence, and even their pressure, for the instigation of disastrous projects.
>
> Dam construction consistently indicates the expenditure of large sums of money which turn the wheels of the cement, steel, transportation and other industries. . . . Strength of representation from these demands finds fishery representation a weak opponent. (449–51)

In the early 1950s, fearing a rerun of New England's salmon debacle, regional fish and game agencies delivered a joint statement to the Northwest Governors' Power Policy Committee in which they argued for a cautious approach to dam building: "Within the last century salmon runs in the New England states were unhesitatingly sacrificed for the purpose of industrial development. In many cases the salmon would now have greater value, if they existed, than the industries which replaced them" (Netboy 1958, 101).

But commercial interests wanting to transform Lewiston, Idaho, into a major shipping port were pushing efforts to turn the wild Snake River, the largest tributary of the Columbia, into a series of placid reaches that barges could navigate. In 1945 Congress authorized construction of Ice Harbor Dam, the cornerstone of the Corps of Engineers' plan for a series of dams along the river. The battle over funding raged for years, and at first, fishery interests managed to block allocation of funding to construct the dam.

Testimony before the House Appropriations Committee captures the debate over the proposal to include funding to begin construction of Ice Harbor Dam in the federal budget for fiscal year 1953. Representative Louis C. Rabaut of Michigan interrogated Brigadier General C. H. Chorpening, the chief of the Army Corps of Engineers: "The Congress has disapproved this project so many times that it has gotten to be a habit. What has happened between last fall and now that causes you to request this item again?" (U.S. House of Representatives, 1952, Part I, 177)

Chorpening replied that nothing had changed, and then proceeded to read a classified letter off the record. The key difference was that this time around the proposal invoked the need to supply power to the Hanford works of the Atomic Energy Commission. Representative Homer D. Angell of Oregon, a major proponent of the dam, argued that delay in constructing Ice Harbor Dam would handicap national defense (Part I, 270).

General Chorpening testified that the benefit-to-cost ratio for the proposed dam was less than 1.2 to 1, an unimpressive estimate that did not include any accounting for lost salmon. In addition, without the navigation benefit from the dam, which could only accrue if all four of the other proposed Snake Rivers dams were built, the cost of Ice Harbor Dam would equal its projected benefit. After presenting the Corps's analysis, Rabaut asked Chorpening about the annual value of the Columbia River salmon catch, which at the previous year's hearing the Corps had testified was worth $8 million—more than the value of the annual benefits expected from the dam. In response, Chorpening steadfastly maintained that "there will be no difficulty at this project in the proper handling of the fish problem" (U.S. House of Representatives, Part I, 178), although he acknowledged that "there is the killing of the little fry going downstream; we have not been able to solve that" (Netboy 1958, 76). Once again, the plan was to figure something out later.

William Hagen, the man in charge of salmon propagation for the U.S. Department of Commerce's fisheries development program on the Lower Columbia River, testified that 15 percent of the downstream migrating juvenile salmon were killed at Bonneville Dam. The director of the Oregon Game Commission, P. W. Schneider, the chairman of the Fish Commission of Oregon, John C. Veatch, and Oregon's director of fisheries, Arnie J. Suomela, all testified that a 15 percent mortality on downstream migrating juvenile salmon at each of the four proposed Snake River dams would wipe out three quarters of the Snake River salmon. This would seriously alter the Corps's benefit-to-cost ratio.

Schneider summarized the position of the fishery interests. They did not oppose the development of water resources in the Columbia River basin but felt that the dams that did not endanger salmon runs should be built first, if only to buy time to better determine how to solve the fish problem. Schneider said, "We sincerely fear that the construction of these lower Snake dams at this time would doom for all practical purposes a major portion of the Columbia runs" (U.S. House of Representatives, 1952, Part 2, 33).

Veatch and Suomela pointed out that the Columbia and Snake river salmon were well worth protecting, pleading, "The Nation simply must not repeat the mistakes that have needlessly destroyed some of its resources" (U.S. House of Representatives 1952, Part 2, 36).

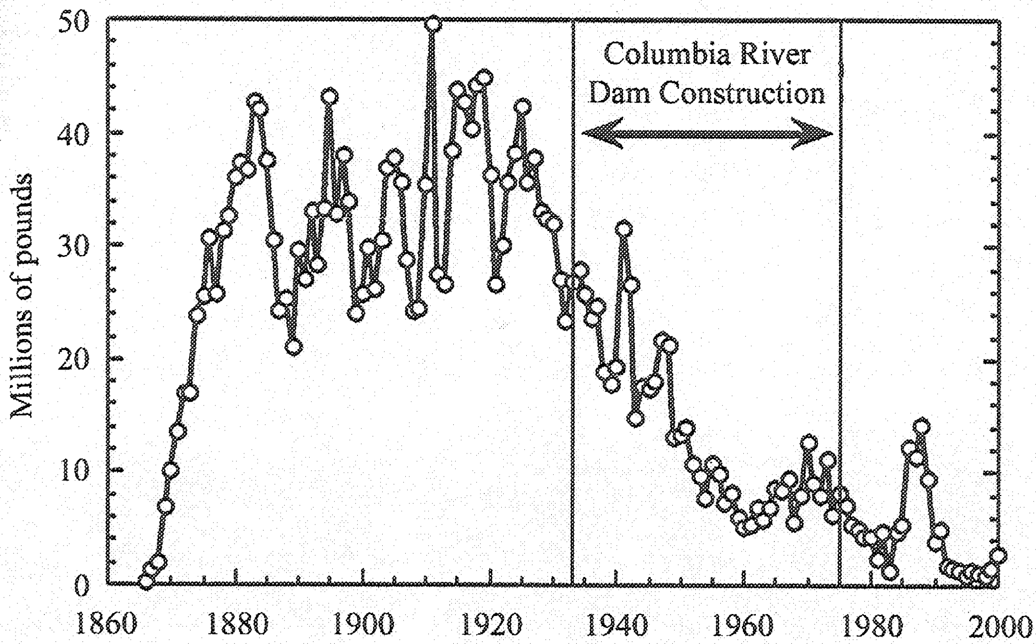
Once again, the House Appropriations Committee rejected funds for construction of Ice Harbor Dam. The chairman of the House Committee on Appropriations, Representative Clarence A. Cannon of Missouri, offered an eloquent explanation of the majority opinion:

> The construction of this dam means eventually the complete extinction of a species of salmon which thereafter can never be resuscitated or recreated. Only God in His infinite power and wisdom can create a new species of animal life, and when that is once destroyed there is no power on earth that will reproduce it. . . . The total extinction of life for all time to come is something we cannot even contemplate, regardless of the need for power for the few years that will be required to develop some method of avoiding this permanent restriction of an important food supply. (U.S. House of Representatives, 1952, Part 2, 879)

Support for federal power projects in the Northwest stalled until Democrats regained control of Congress in 1955. By clever parliamentary maneuvering, Northwest Democrats avoided further hearings and outmaneuvered Republican opposition to the dams. Senators Warren G. Magnuson of Washington and Wayne L. Morse of Oregon convinced a joint Senate-House conference committee to slip $1 million for Ice Harbor into the 1956 Army Civil Works Appropriation bill. The first domino on the Snake River fell, and dams started marching up the river.

Because loss of fish could not be predicted accurately in advance, the fears of fisheries interests always took a backseat to development interests. You *could* predict (and bank on) the value of increased power or irrigation or shipping. Given that fishing interests could not demonstrate in advance how any one dam, let alone a whole series of dams, would affect the number of salmon, their concerns were discounted. Such problems create policy biases in which risky actions continue until uncertainty is eliminated—something that can be quite difficult to do even with well-organized and -funded studies.

The last of the Army Corps of Engineers' dams on the Snake River, Lower Granite Dam, came on line in 1975. When a severe drought in 1977 threatened disaster for salmon runs in the upper Snake River



Graph showing annual salmon catches on the Columbia River, 1860 to 2000.

basin, political pressure forced the reluctant Army Corps and the BPA to release flows from dams to support downstream migration of young salmon. The agencies maintained, however, that they had no authority to spill water over the dams for anything other than power production.

The following year the National Marine Fisheries Service started to evaluate whether to list certain runs of Columbia River salmon under the Endangered Species Act.

As conflict grew between those demanding more electrical power and those interested in protecting dwindling salmon runs, Congress passed the Northwest Power Act in 1980. The act directed federal agencies operating the Columbia River power system to "treat fish and wildlife as a co-equal partner . . . on a par with power needs." Under the 1980 act, the Northwest Power Planning Council (NPPC) was created to implement an interstate program to protect and enhance Columbia River salmon runs, and other wildlife. Congress mandated that the NPPC use the "best available scientific knowledge" and favor biological interests over economic ones. Congress also mandated that the NPPC improve salmon survival through increased flow releases capable of meeting "sound biological objectives." The idea of giving salmon equal, let alone a higher priority than power production promised to revolutionize operation of the Columbia River hydropower system. In the wake of the Northwest Power Act, the National Marine Fisheries Service optimistically suspended their initial review of possible Endangered Species Act listings for Columbia River salmon.

The lofty rhetoric and promises of fish-friendly operations proved hollow. The Corps of Engineers refused to implement NPPC recommendations for salmon passage and dam operators consistently failed to provide water flows needed for salmon conservation as recommended by agencies and tribes. Instead, dam operators treated reservoir refilling as a higher priority than salmon and reduced the amount of water dedicated to aiding downstream migration of Snake River salmon. Instead, juvenile salmon were to be trucked and barged around the dams.

How was that possible? The Northwest Power Act required all interests to give the protection of salmon highest priority. How could a law passed by Congress become impotent so quickly? Perhaps through the creation of an administrative system with the power to decide that driving salmon around dams constitutes not only a scientifically credible way to accommodate the needs of migrating salmon but employs the "best available science."

By the early 1990s the Columbia River runs had dwindled from 11 million to 16 million fish prior to European settlement to about 2 million fish supplemented by over 100 million hatchery-raised fry released into the river each year. With wild runs continuing to decline, the National Marine Fisheries Service was petitioned to list the three Snake River stocks and one Columbia River stock under the Endangered Species Act. In 1991, just four sockeye salmon, three males and a female, returned to spawn at Redfish Lake. Finally convinced that the situation was dire, the federal government listed the Snake River sockeye as endangered. They acted just in time to welcome Lonesome Larry back to Redfish Lake in 1992. Listing of chinook salmon soon followed.

Endangered Species Act listings of salmon in the Columbia River basin led the Northwest Power Planning Council to adopt a new strategy for managing the fisheries in December 1992. State and Tribal fisheries managers recommended increasing flows past dams to assist juvenile salmon migration. The new strategy adopted by the NPPC recommended studying the potential to draw down reservoir levels on the Snake River dams to facilitate salmon migration. Implementation of revised flow management would begin in 1995 if the measures proved economically feasible. Power interests of course challenged the benefit of increased flows, arguing that the uncertainty of the benefits mandated maintenance of the status quo.

In the meantime the National Marine Fisheries Service certified that dam operations represented no threat to the Snake River salmon, even though the agency acknowledged that 70 to 90 percent of juvenile salmon would die trying to get past the dams. Although this no-jeopardy opinion was rejected as arbitrary and capricious by a federal judge, the ESA listings had little effect on the operations of the Columbia and Snake River dams. In rejecting the NMFS opinion, District Judge Malcolm Marsh, in deciding a suit brought by the Idaho Department of Fish and Game against the National Marine Fisheries Service, declared, "Instead of looking for what can be done to protect the species from jeopardy, NMFS and the action agencies have narrowly focused their attention on what the establishment is capable of handling with minimal disruption" (1994, 900).

Environmental groups under the umbrella of the Northwest Resource Information Center sued the Northwest Power Planning Council over its salmon strategy, and in 1994 a three-judge panel of the Ninth Circuit Court of Appeals ruled that the NPPC had violated the Northwest Power Act by ignoring recommendations from fisheries, agencies, and Indian tribes. In their ruling they stated, "The Council's approach seems largely to have been from the premise that only small steps are possible, in light of entrenched river user claims of economic hardship. Rather than asserting its role as a regional leader, the Council has assumed the role of a consensus builder, sometimes sacrificing the Act's fish and wildlife goals for what is, in essence, the lowest common denominator acceptable to power interests" (*Northwest Resource Information Center v. Northwest Power Planning Council* 1994, 1395).

Even with longstanding concern over protecting salmon runs, and a chorus of warnings about the effects of dams on fish, only near the end of the period of dam building, in the 1960s, did concern over salmon actually stop plans for a dam. In the late 1950s, power companies proposed building High Mountain Sheep Dam, just below the Snake River's confluence with the Salmon River. The Department of the Interior contested the application for a license because the dam would destroy the salmon runs of the Salmon and Clearwater rivers. Nonetheless, the Federal Power Commission approved the proposal in 1964. Secretary of the Interior Stewart Udall directed the Department of the Interior to take the unusual step of suing the Federal Power Commission to block the dam.

Such open warfare among federal agencies was unprecedented. But by the time the case reached the U.S. Supreme Court, Udall's concerns seemed justified: three dams built by the Idaho Power Company had already extinguished salmon runs on the upper Snake River. In a decision written by Justice William O. Douglas, the Court sided with Udall, noting, "The importance of salmon . . . in our outdoor life as well as in commerce is so great that there certainly comes a time when their destruction might necessitate a halt in so-called 'improvement' or 'development' of waterways. The destruction of anadromous fish in our western waters is so notorious that we cannot believe that Congress . . . authorized their ultimate demise" (*Udall v. Federal Power Commission* 1967, 437–438).

This decision put a halt to construction of High Mountain Sheep dam, but it did not end the fight over the lower Snake River dams; three more were eventually built by the Army Corps of Engineers between 1969 and 1975. The lower Snake River dams brought the number of major dams built on the Columbia River system between 1933 and 1975 to eighteen, an average of one every other year.

In its original plan for the Snake River, the Army Corps of Engineers did not plan for dams to provide year-round navigation. They anticipated a two-month period when navigation for most vessels would be blocked by ice or floods. This period is very similar to what is being sought today to facilitate downstream migration of juvenile salmon on the Snake River system. But the original plan is now viewed as an unacceptable economic hardship. Convinced that water spilled is water wasted, dam operators consistently worked on the assumption that salmon losses would be offset by hatchery production and therefore that inconvenient changes in dam operations were not really necessary anyway.

In 1995, in response to the ESA listing of Snake River salmon stocks, the National Marine Fisheries Service (NMFS) asked the Army Corps of Engineers to study the possibility of removing the lower Snake River dams. In the Army Corps report completed after four years of studying the problem, the U.S. Fish and Wildlife Service concluded that dam removal would best provide the highest certainty of saving the fish. Scientists from other agencies, including NMFS, also recommended dam removal. Oregon's Governor John Kitzhaber astounded the region's political establishment by calling for breaching the four Snake River dams. In May 2000, an internal draft of the NMFS plan instructed the Army Corps to begin planning to remove four lower Snake River dams. But by December 2000, when the NMFS issued its final plan, the focus had changed to delaying a decision on dam removal for at least eight years and instead relying on pilot projects, voluntary habitat improvements to be done by state, tribal, and private groups, and transporting fish around dams in trucks and barges.

Environmental and fishing groups sued the federal agencies in 2001, alleging that the NMFS plan relied on unspecified future actions to reduce impacts of habitat, hatcheries, and harvest, but ignored the impacts of the dams themselves, which even the NMFS plan acknowledged jeopardized survival of salmon stocks listed under the Endangered Species Act. In a May 7, 2003, opinion rendered in Portland, U.S. District Judge James Redden ruled that the NMFS plan failed to adequately protect endangered salmon runs because the actions relied upon in the plan were "not reasonably certain to occur." Advocates of dam removal tried to spin the decision as backing their agenda. Oregon Senator Gordon Smith fired back in a May 15 press release vowing to do everything in his power to block moves to breach the dams. Judge Redden is reported to have said, "I have a recurring nightmare that we're still talking up here about the fish problem and somebody catches the last one."

In the summer of 2001 there was a series of power outtages in California, and water intended to supplement flows to help downstream salmon migration was instead spilled during peak demand periods to sell power to California at astronomical prices. Yet this was a low-water year when the extra flows were critically needed by the salmon. Even after Endangered Species Act listings, the downstream migration of juvenile salmon remains a lower priority with those running the Columbia River power grid than does cashing in on power deregulation.

Columbia River salmon were sold down the river for the promise of cheap electricity. Fulfilling this promise, the BPA dams on the Columbia River system transformed the economy of the Pacific Northwest, helped win the Second World War, and turned the dry interior of the region into some of the most productive farmland on the planet. Yet today the region has skyrocketing power rates, and both salmon and power are expensive. To be sure, the taming of the mighty Columbia River catalyzed regional development, albeit at the price of now legendary salmon runs. Similarly, twentieth-century forest clearing, rural development, and urbanization led to equally deadly changes to many other salmon rivers throughout the Pacific Northwest.