

## 2019 Fast Facts Reference Guide

### The Fast Lane

*Hydropower keeps our air and environment clean.*

*Hydropower is affordable for communities and businesses.*

*Hydropower benefits our economy and provides jobs to the region.*

*Hydropower is renewable, relying on the cycles of rain and snowfall.*

*Hydropower programs support fish and wildlife and protect their future.*

*Hydropower acts like a giant, clean battery, helping us to add more solar and wind generation.*

### NW Hydropower by the Numbers

**14,000,000** | The approximate number of US households that could be served by the Northwest's hydroelectric output in an average year.<sup>i</sup>

**34,300** | The total generating capacity of Northwest hydroelectric dams in megawatts.<sup>ii</sup>

**16,200** | The yearly average output of megawatts by Northwest hydroelectric dams.<sup>iii</sup> For comparison, that is roughly sixteen times Seattle's annual electricity need.

**80%** | Hydro's share of the Northwest's carbon-free annual electricity production.<sup>iv</sup>

**47%** | Hydro's share of the Northwest's total average annual electricity production.<sup>v</sup>

**40%** | Northwest hydro's contribution to the *nation's* hydroelectric production.<sup>vi</sup>

**0** | There are no carbon emissions generated by hydropower production.

### Frequently Asked Questions

We want everyone to love Northwest hydropower as much as we do. There are complex issues that surround hydropower, as with any other form of energy generation, and finding answers can be difficult. To make things easier, we provided scientifically backed answers to some of the frequent questions people have about hydropower.

*Question: Are fewer salmon returning to dammed rivers compared to free-flowing rivers?*

*Answer:* Nearly all rivers along the entire North Pacific Coast—from southeast Alaska to southern Oregon—are experiencing similar or worse trends in Chinook salmon returns when compared to the lower Columbia and lower Snake rivers. This applies to coastal inland rivers in British Columbia and the Puget Sound as well. These poor returns are being observed in rivers with dams and without dams, and even includes rivers with nearly pristine habitat.<sup>vii</sup>

(Chinook, sockeye, and steelhead are the three species that are experiencing these lower returns. Other salmon species, like chum and pink, have remained more stable.)

*If dams aren't the problem for salmon survival, what is behind the salmon population declines?*

**Answer:** Scientists theorize the problem is occurring in the ocean. A recent peer reviewed study shows that roughly 85% of the total historical vegetated estuary area for the West Coast have been lost. Losses were highest for major river deltas.<sup>viii</sup>

Some scientists have also pointed to the growing numbers of seals and sea lions, which feed on the fish, as behind the declines.

Others say the warming and acidifying of the ocean is killing off the prey that the salmon depend on.<sup>ix</sup> There is strong evidence that ocean conditions, including ocean temperatures, are an important predictor of adult salmon returns.<sup>x</sup>

*Question: Did the lower Snake River dams cause Snake River Chinook and sockeye to become threatened?*

**Answer:** After the last federal dam on the Snake River was completed in 1975, adult salmon returns dwindled, so many people believed it must be the fault of the dams. However, during the same timeframe, ocean conditions dramatically shifted from cooler-than-normal temperatures to warmer-than-normal temperatures.<sup>[i]</sup> This type of shift is a leading indicator of reduced adult salmon returns.<sup>[ii]</sup>

*Question: Do hydroelectric dams lead to significant mortality for salmon?*

**Answer:** Data shows that fish survival past modernized dams can be as good or better than naturally flowing rivers.<sup>[iii]</sup> Technological improvements at dams, including scientifically engineered fish ladders and surface passage systems—like removable spillway weirs—help fish safely navigate the dams.

*Question: Are Southern Resident orcas being harmed by the existence of the lower Snake River dams?*

**Answer:** Southern Resident orcas spend most of their time in the coastal inland waters of the Salish Sea. As a result, a NOAA Fisheries analysis showed that Chinook from the rivers that feed into Salish Sea—not the Columbia or Snake rivers which drain directly into the Pacific Ocean—are the top priority salmon stock for Southern Resident orcas.<sup>xi</sup>

While the Columbia and Snake rivers saw a record number of adult Chinook salmon returns this past decade, Chinook populations critical for orcas did not rebound.<sup>xii</sup> Biologists have indicated that due to geography and timing, Snake River salmon are not the “key limiting resource or prey” for Southern Resident Orcas.<sup>xiii</sup>

Scientists point to a loss of habitat and a population explosion of seals and sea lions in the as contributing factors to the struggles of these the salmon that orcas feed on.<sup>xiv</sup> Researches also identified the measurable amounts of prescription and illicit drugs and other chemicals found in Salish Sea salmon populations as cause for concern.<sup>xv</sup> Highlighting the pollution problems in the Puget Sound, a University of Washington professor has noted that Northern Resident Orcas feed on the same Chinook populations as Northern Resident orcas, but Northern Resident orcas are growing in number.<sup>xvi</sup>

NOAA Fisheries found that the hatchery Chinook in the Columbia and Snake river basins more than compensate for fish lost as a result of dams in terms of availability for orca whales.<sup>xvii</sup>

*Question: Is hydropower an important part of our clean energy future?*

**Answer:** Hydropower is essential to our region’s bold clean energy goals. The State of Washington just passed Senate Bill 5116 into law. The law commits the state to a path for no coal generation by 2025 and 100% clean energy by 2045<sup>xviii</sup>. Washington recognizes hydropower as a critical source of generation in order to meet this goal.<sup>xix</sup>

Similarly, Oregon is contemplating its own climate action. The city of Portland set a 100% carbon-free goal within its borders, and individual utilities in the Northwest are embarking on similar efforts.

Hydropower is critical to the region’s ability to meet these goals because it is carbon-free and because of its energy storage capabilities. Dams store energy in the form of the water built up behind the dams. When the water is released through turbines, electricity is generated. This ability to store and quickly release energy allows hydropower to fill in the gaps for intermittent resources, like wind and solar power, which balances the grid.

**Question: Can batteries become a substitute for hydropower in the Northwest?**

**Answer:** Batteries and Northwest hydropower operate on much different scales. Currently, the largest planned battery in the Northwest (planned for operation in 2021) will be able to release 30 megawatts of electricity for four consecutive hours<sup>xx</sup>. That size of battery represents an exciting development for our region. However, in comparison, the lower Snake River dams can generate up to 2,650 megawatts over a period of 10 hours per day for five consecutive days.<sup>xxi</sup> That is enough electricity to power roughly 2 million homes during heat waves or cold snaps.

With thousands of megawatts of coal and natural gas-fired generation set to be retired in the Northwest over the coming decades due to climate concerns, we will likely need all of our existing hydropower, plus new sources of energy paired with batteries, to keep up with regional electricity needs. Rather than comparing batteries to hydropower, it will be important to use a combination of both.

**Question: Has dam breaching been an effective method for recovering wild salmon?**

**Answer:** There are examples of dams being removed where modern fish bypass systems weren’t in place and where it was easier to remove the dams than to modernize them, such as the Elwha River in Washington.<sup>xxii</sup> That said, according to the Washington Policy Center, the Elwha River hasn’t shown improvement in overall salmon returns or in wild adult salmon returns, post-dam breaching.<sup>xxiii</sup> The communities along the Elwha also haven’t seen an increase in tourism or fishing.

**Question: Would breaching dams on the lower Snake River be helpful to salmon there?**

**Answer:** Dam breaching is likely ineffective where major fish passage improvements have already been made, such as on the lower Columbia and lower Snake rivers. Since 2001, the U.S. Army Corps of Engineers has invested close to \$2 billion in new fish-passage technology at these dams.<sup>xxiv</sup> They’ve even developed new advancements that are a model for hydroelectric dams around the world. As a result, NOAA Fisheries has found that the operation of these dams is unlikely to jeopardize endangered salmon, steelhead, or orcas.<sup>xxv</sup>

There are also some concerns about what dam breaching might look like for salmon in the Snake River. It is likely that there would be a severe decrease in water quality from the increased flow of pollution and sediment. Prior studies done by the U.S. Army Corps of Engineers surrounding the 2002 EIS suggest that toxic chemicals and sediment would be released into the river following dam breaching, leading to

lower water quality. It is safe to assume that more toxins have built up since then, along with pollution and plastic, and that their release could have a negative impact on salmon recovery.<sup>xxvi</sup>

**Question: Are Northwest dams creating dangerous river temperatures for fish?**

**Answer:** Climate change is causing warming ocean and river temperatures that can be harmful to fish.<sup>xxvii</sup> Damaging water temperatures can and do occur both in free-flowing rivers and rivers with dams. As an example, due to record high water temperatures, approximately 466,000 adult fish perished in the undammed Fraser River before reaching their spawning grounds in 1994.<sup>xxviii</sup>

The science is mixed on the direct effect that dams have on river temperatures. A 2003 EPA study indicated that dams may exacerbate temperature issues on the rivers, but a 2002 study performed by Pacific Northwest National Laboratory showed that dams within the Columbia and Snake river basins moderate extreme water temperatures.<sup>xxix</sup>

The PNNL study concluded that, "...the reservoirs decrease the water temperature variability. The reservoirs also create a thermal inertia effect that tends to keep water cooler later into the spring and warmer later into the fall compared to the un-impounded [i.e., free-flowing] river condition."

A graph from the study, representing conditions at Ice Harbor Dam helps to [illustrate](#) the effect of dams on water temperatures.

**Question: Can dams offset the effects of warmer water temperatures?**

**Answer:** Dams with large storage reservoirs can help mitigate warmer downstream temperatures. Cold water from Dworshak Dam just upstream of the Snake River is released each summer to cool the water temperatures downstream.<sup>xxx</sup>

Climate change is major driver of dangerous temperatures that warm rivers. Pulling out carbon-free resources—like hydroelectric dams—may worsen that problem long-term.

**Question: Are dams slowing down juvenile travel times on the lower Snake and lower Columbia rivers?**

**Answer:** Data show that juvenile salmon typically migrate from the Lower Granite Dam located near the Idaho-Washington border through the Bonneville Dam near Portland, Oregon in approximately two weeks.<sup>xxxi</sup> This is only a few days longer than their migration without the dams.

**Question: Have the Northwest's hydroelectric dams resulted in significant habitat loss for salmon?**

**Answer:** The building of dams and other human-related activities are a significant source of habitat loss for salmon. Specifically, hydroelectric dams on the Columbia and Snake rivers have contributed to habitat loss for key species, mainly Chinook, sockeye, and steelhead. That said, hydropower-funded programs have helped to restore and protect that same important habitat. In 2018 alone, the Bonneville Power Administration spent over \$123 million on habitat restoration and protection programs. BPA has spent close to \$17 billion since 1981 on fish and wildlife-related activities.<sup>xxxii</sup>

**Question: Have dams created a haven for salmon predators?**

**Answer:** Salmon predation has become a major factor up and down the Pacific coast and is not limited to rivers or dams.<sup>xxxiii</sup> Protections put into place for birds and marine mammals have allowed these salmon predator populations to expand in the past few decades. To support their greater numbers, salmon predators, such as sea lions, have invaded areas where they weren't previously observed,

including rivers. To help counter this problem, anti-predation programs are in place to protect salmon.<sup>xxxiv</sup> Still, predation remains an area where more work needs to be done.

*Question: Are Northwest dams a source of methane gas?*

*Answer:* Northwest dams and reservoirs do not create significant methane emissions.<sup>xxxv</sup>

*Question: How effective are hatcheries and habitat restoration efforts?*

*Answer:* While several salmon stocks are still endangered, data show that the Columbia and Snake River are producing significantly improved numbers of juvenile salmon.<sup>xxxvi</sup> According to NOAA Fisheries, "...the Columbia and Snake Rivers may now produce more juvenile salmon than they did prior to dams and development, when hatchery fish are included."<sup>xxxvii</sup> Adult returns also saw significant improvements in the last decade, but poor ocean conditions reduced those numbers once again. Like the Snake River, undammed rivers from Southern Oregon to Alaska are seeing worsening returns of adult salmon, which is a cause for concern.

*Question: Who uses hydropower?*

*Answer:* Almost every electric utility customer in the Northwest uses at least some amount of hydropower, since it produces roughly half of the region's electricity. The Bonneville Power Administration markets most of the most hydropower in the Northwest. BPA's customers are mostly not-for-profit organizations, like cooperatives, municipalities, and public utilities.<sup>xxxviii</sup> Generating clean, affordable energy is important to these organizations. They also aid in protecting cities and homes from flooding, providing irrigation for farms, enabling low-carbon transportation in the form of barging, allowing for recreation, and aiding in fish passage.<sup>xxxix</sup>

Still have questions about Northwest hydropower? Contact us and we'll help you find the answers you're looking for.

## **The Hydropower System's Many Attributes**

### **Renewable and Clean**

- Hydropower is the original renewable resource for the Northwest. Dams store water from melting snow and rainfall in reservoirs. The weight of water stored behind the dams creates water pressure. That pressure is put to work when the water pushes past turbines to generate electricity. This flowing water produces energy over and over as it moves downriver through multiple dams.
- Northwest hydropower produces no carbon emissions, thereby significantly reducing the total carbon footprint of the region's energy production.<sup>xi</sup>
- The Columbia and Snake River dams have enabled a 465-mile marine highway that allows for environmentally friendly barging of cargo.<sup>xii</sup> Barging on the Snake River alone keeps as many as 135,000 semi-trucks and 35,000 rail cars from transporting goods through the Columbia River gorge annually.<sup>xiii</sup>
- As noted earlier, hydropower represents approximately 80% of our region's carbon-free energy. With bold clean energy goals and the move towards electric vehicles, hydropower has become an even more important part of our future.

## **Flexible, Reliable, and Affordable**

- Northwest hydropower acts as a massive, clean battery for wind and solar power. We can store renewable energy (in the form of water) behind the dams when demand is low and then release it when demand is high. In this way, hydropower helps the region add even more renewable power to its resource mix.<sup>xliii</sup>
- Hydropower helps to stabilize our region's power grid by providing voltage support in areas where power wouldn't otherwise flow. This is especially true of the lower Snake River dams, which support the 500-kilovolt transmission lines that run from western Montana to eastern Washington.<sup>xliv</sup>
- Our region's early investment in hydropower has created an important source of clean, affordable energy for communities and businesses.
- Like wind for wind power and solar for solar power, the water that fuels hydropower is not subject to price fluctuations. This characteristic helps maintain a relatively consistent cost for those who depend on hydropower to provide electricity to their homes and businesses.

## **Enables Agriculture**

- The reservoirs behind dams provide an important source of irrigation for large areas of Northwest agricultural land that would otherwise be too dry to farm. Six percent of the Columbia River basin's yearly runoff is used to irrigate about 7.8 million acres of Northwest farmland.<sup>xlv</sup> Northwest farmers make productive use of this irrigation through sustainable agricultural practices.
- Hydroelectric dams on the Columbia and Snake rivers provide vital navigation for the barges used by inland farmers to share their goods with the Northwest and the world.<sup>xlvi</sup>
- The Columbia River trade corridor supports over 50 million tons of foreign trade at a value of over \$24 billion annually. The Columbia River is the nation's number one wheat export gateway and number two for corn and soybean exports. It is the third largest grain export gateway in the world, as well as the West Coast's leader in mineral bulks, wood exports and is a significant auto import and export gateway.<sup>xlvii</sup>
- The Northwest is also a major producer and exporter of other vital crops such as apples, potatoes, corn, peas, alfalfa, hay, and grapes.

## **Supports Jobs**

- Some of the largest tech companies in the world have located facilities in the Northwest due to carbon-free, low-cost power.<sup>xlviii</sup> As noted above, most of that power is produced by hydroelectric resources. This influx of facilities has led to the creation of new jobs and community infrastructure such as parks and schools.<sup>xlix</sup>
- More traditional industries have also located in the Northwest because of our hydropower resources. Industries such as paper, chemical, food processing, and manufacturing represent hundreds of thousands of Northwest jobs. Today, they continue to rely on clean, low-cost hydro to remain competitive in international markets.<sup>i</sup>
- Tourism from river cruise ships brings \$15-\$20 million annually to local economies.<sup>ii</sup>

## **Protection from Natural Disaster: The 1948 Vanport Tragedy & the 1996 Pineapple Express**

It is hard to imagine it now, but prior to the construction of dams on the Columbia and Willamette rivers, Portland and many other river towns were subjected to severe flooding. The problem reached a critical point, when a city was wiped from the map.

Constructed in 1942 (near modern-day Delta Park) Vanport, Oregon was established to house the laborers who were helping the US wartime effort. However, on Memorial Day of 1948, the town's 18,500 residents lost their homes in just minutes as the Columbia River washed away all that they owned. In total, 15 residents perished in the flood.

Following the disaster, the Army Corps of Engineers responded by developing a reservoir storage plan for the Columbia River Basin, using hydroelectric dams to control the excess water.<sup>lii</sup>

Nearly 50 years later, in 1996, a "Pineapple Express" of warm rains hit record mountain snowpack in the Northwest. A flood reminiscent of the Vanport disaster threatened to destroy the homes and businesses of Portland and near-by river towns. But through dam operations on the Columbia, Snake and Willamette rivers, the Columbia was kept two feet lower than it would have been without the dams. Estimates showed that flood control operations saved the region over \$1 billion in damage.<sup>liiii</sup> More importantly, it kept communities along the river safe from what would have otherwise been a devastating natural disaster.

### **Lower Snake River Dams—An Irreplaceable Benefit**

The four federal dams on the lower Snake River provide clean, renewable energy to meet Northwest power needs, stabilize the region's transmission system and fight climate change. Despite some statements indicating that they are easily replaced, the facts show that they are invaluable to our region.

- An entire community of Washingtonians depend on the Snake River dams for their electricity needs. Almost 300,000 people live in the Tri-Cities areas of Kennewick, Pasco and Richland.<sup>liv</sup> Because of transmission constraints throughout the region, the Snake River dams provide a critical local source of reliable power and voltage for this part of the state.<sup>lv</sup>
- Ice Harbor Dam (and its interaction with the McNary Dam reservoir downstream) provides a crucial source of drinking water for Tri-Cities communities.<sup>lvi</sup> It also enables irrigation for 60,000 acres of farmland in central and southeastern Washington. Agriculture would be significantly harmed, and communities would face more severe drought conditions without these dams.<sup>lvii</sup>
- The lower Snake River dams account for over 10% of the federal system energy supply and generate enough electricity—on average—to annually power a city the size of Seattle.<sup>lviii</sup>
- The lower Snake River dams help in dealing with power emergencies such as regional shortages due to extreme weather conditions. They can power roughly two million homes during heat waves or cold snaps.<sup>lix</sup>
- The Lower Snake River dams provide up to one quarter of BPA's operating reserves.<sup>lx</sup> Reserves represent the additional generation that utilities are required to hold in case of unexpected changes in generation or electrical demand. BPA is required to hold these reserves to ensure the reliability of the grid and to balance other renewable resources, like wind and solar power.

- Given today's commercial technology, some of the most likely replacements for the generating capabilities of the lower Snake River dams—including their 24/7 ability to respond when needed—would be carbon-emitting power plants. In a 2016 assessment, the Bonneville Power Administration estimated that replacing the lower Snake dams with highly efficient natural gas generation would increase the region's carbon dioxide emissions between two and 2.6 million metric tons annually. That number is the equivalent of the emissions of nearly 421,000 cars on the road each year.<sup>lxi</sup>
- Nearly 10% of all U.S. wheat exports are transported through the Lower Snake River dams.<sup>lxii</sup>

## **Caring for our Salmon**

- Northwest families and businesses help fund fish and wildlife mitigation through their electricity bills. As mentioned above, BPA has spent close to \$17 billion since 1981 on fish and wildlife-related activities.<sup>lxiii</sup> Approximately a quarter of the Bonneville Power Administration's wholesale power rate goes to Fish and Wildlife related programs.<sup>lxiv</sup> For customers who buy their power from a BPA-sourced utility, around 10-15% of their typical utility bill goes towards these programs.<sup>lxv</sup>
- As part of the Columbia Basin Fish Accords, approximately \$100 million a year since 2008 has gone towards the Northwest states and tribes. The money is used for improvements to habitat in river tributaries and the Columbia River estuary to repair and enhance spawning and rearing grounds for salmon.<sup>lxvi</sup> As a result, 968,621 acres of habitat has been protected, treated, or maintained, 7,236 miles stream have been protected or improved, 397 barriers have been improved or removed, and 37.3 billion gallons of water have been protected and conserved each year.<sup>lxvii</sup>
- New fish protections have been put into place at all eight lower Columbia and lower Snake River dams. Examples of protections include fish bypass systems, such as removable spillway weirs (i.e., slides) that keep fish from entering the turbines. These new structures have increased the survival of juvenile salmon. The survival rate past each dam ranges from 93 to 99%, depending on the fish species.<sup>lxviii</sup>
- The Corps of Engineers also installed permanent cooling systems for fish ladders at Lower Granite Dam in 2016 and at Little Goose Dam in 2017. These systems pull cool water from lower reservoir depths and distribute the water into the fish ladders.<sup>lxix</sup>
- As part of the Flexible Spill Agreement, hydroelectric operations on lower Columbia and lower Snake rivers have been modified to increase the spill of water over the dams in certain hours of the day. This agreement seeks to move young fish downstream faster.<sup>lxx</sup> Young fish are also barged around dams to help them avoid turbines and predation.
- The newest NOAA Fisheries Biological Opinion suggests that operating the dams is unlikely to jeopardize threatened salmon and steelhead. Further, no effects were observed on green sturgeon or Southern Resident killer whales.<sup>lxxi</sup>

## **Trends Going Forward**

Many factors have contributed to declines in Northwest salmon populations. By the 1940s, Columbia River salmon runs were in serious decline. There were many causes — harvest in the lower river took a huge toll between about 1870 and 1920, for example.<sup>lxxii</sup> By the time Bonneville Dam's construction was completed in 1938, adult salmon returns numbers were already at crisis levels.<sup>lxxiii</sup> However today,

improvements at the dams, habitat restoration, and hatchery reforms are working together to benefit salmon.

- While salmon returns vary greatly year-to-year, this past decade saw a major increase in the number of adult salmon that returned to the Columbia and Snake rivers, including record and near-record salmon runs compared to historical records that date back to 1938.<sup>lxxiv</sup> That said, in more recent years, rivers from Southern Oregon to Southeast Alaska have all seen low return rates for adult Chinook salmon, which is a cause for concern. Because most of these rivers are free flowing (not dammed), many scientists believe that changing ocean conditions are playing a major role.
- The Pacific Ocean was shifting from several years of unusually warm conditions toward a cooler and more productive state. That unusually warm state was caused by an extreme marine heatwave known as The Blob, which was first documented in 2014 and was declared over by 2018. A similar marine heatwave was detected in the summer of 2019. This new heatwave has not reached the magnitude of The Blob and it is unclear if it will persist, but the effects are likely to have a direct negative impact on salmon populations.<sup>lxxv</sup>

**Who We Are**

*Northwest RiverPartners is an alliance of farmers, utilities, ports, and businesses that promotes the balance of the various benefits of our rivers. These benefits include fish and wildlife, clean and renewable hydropower, energy affordability, economic opportunity, irrigation, flood control, and river commerce.*

*Together, our nearly 100 members represent more than 4 million electric utility customers, thousands of farmers and employees, and large and small businesses that provide hundreds of thousands of jobs for communities across the Northwest.*

**Members**

Asotin County PUD	Midstate Electric Cooperative
Associated Oregon Industries	Missoula Electric Cooperative
Association of Washington Business	Modern Electric Water Company
Benton PUD	Monmouth, City of
Benton Rural Electric Association	NORPAC Paper Company
Big Bend Electric Cooperative	Northern Lights, Inc.
Bonnors Ferry, City of	Northern Wasco County PUD
Burley, City of	Northwest Food Processors Association
Cascade Locks	Northwest Requirements Utilities
Central Electric Cooperative, Inc.	Okanogan County Electric Cooperative
Central Lincoln PUD	Okanogan County PUD No. 1
Chelan County PUD	Orcas Power & Light Cooperative
Clallam County PUD	Oregon Forest Industries Council
Clark Public Utilities	Oregon Trail Electric Cooperative
Clatskanie People’s Utility District	Oregon Wheat Growers League
Clearwater Power Company	Oregon Farm Bureau
Columbia Basin Development League	Pacific County PUD No. 2
Columbia Basin Electric Cooperative	Pacific NW Utilities Conference Committee
Columbia Power Cooperative Assoc.	Pacific Northwest Waterways Assoc.
Columbia River PUD	Parkland Light and Water Company
Columbia Rural Electric Assoc.	PNGC Power
Consumers Power, Inc.	Port of Clarkston
Coos-Curry Electric Cooperative	Port of Lewiston
Cowlitz County PUD	Port of Pasco

Douglas Electric Cooperative Energy Northwest Fall River REC, Inc. Flathead Electric Cooperative Forest Grove Light and Power Grant County PUD Grays Harbor County PUD #1 Harney Electric Cooperative Hermiston Energy Services Hood River Electric Cooperative Idaho Consumer-Owned Utility Assoc. Idaho County Light & Power Idaho Falls Power Industrial Customers of NW Utilities Kapstone Paper Kootenai Electric Cooperative Lane Electric Cooperative Lewis Clark Valley Chamber of Commerce Lewis County PUD Lincoln Electric Cooperative Lost River Electric Coop, Inc. Lower Valley Energy Mason County PUD No. 1 Mason County PUD No. 3	Port of The Dalles Port of Walla Walla Raft River Rural Electric Cooperative Ravalli County Electric Richland, City of Rupert, City of Salem Electric Skamania County PUD #1 Surprise Valley Electrification Corp. Tacoma Power The Boeing Company Tillamook PUD Umatilla Electric Cooperative United Electric Cooperative Vera Water and Power Vigilante Electric Cooperative, Inc. Wasco Electric Cooperative Washington State Farm Bureau Washington State Hay Growers Association Washington State Potato Commission Wells Rural Electric Company West Oregon Electric Cooperative Whatcom County PUD No. 1
---	---

**Northwest RiverPartners 9817 Northeast 54th Street, Suite 103  
• Vancouver, Washington 98662 • 360-839-2525**

For additional resources, go to [www.nwriverpartners.org](http://www.nwriverpartners.org)

###

---

### Sources

- <sup>i</sup> [NW Power & Conservation Council--Power Supply](#)  
[US Energy Information Administration-FAQs](#)
- <sup>ii</sup> [NW Power & Conservation Council--Power Supply](#)
- <sup>iii</sup> [NW Power & Conservation Council--Power Supply](#)
- <sup>iv</sup> [NW Power & Conservation Council--Power Supply](#)
- <sup>v</sup> [NW Power & Conservation Council--Power Supply](#)
- <sup>vi</sup> [NW Power & Conservation Council--Power Supply](#)  
[US Energy Information Administration--Today in Energy](#)
- <sup>vii</sup> [3/30/2018 Outdoor Life "Why are Alaska's chinook salmon runs crashing? It's a big mystery that a salty group of researchers aim to crack"](#)  
[12-3-2018 CBC News "More than a dozen B.C. chinook salmon populations in decline, scientists say"](#)  
[12-28-2017 Anchorage Daily News "Southeast Alaska's king salmon are disappearing, and fishermen are grappling with the consequences"](#)  
[NOAA Fisheries Fact Sheet: Southern Resident Killer & West Coast Chinook Salmon](#)
- <sup>viii</sup> [Insights into estuary habitat loss in the western United States using a new method for mapping maximum extent of tidal wetland](#)
- <sup>ix</sup> [12-3-2018 CBC News "More than a dozen B.C. chinook salmon populations in decline, scientists say"](#)
- <sup>x</sup> [NOAA Northwest Fisheries Science Center Outlook for Salmon Returns](#)

- 
- [i] [University of Washington PDO Index](#)  
[The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow-moving catastrophe or deeper failure?](#)
- [ii] [NOAA Northwest Fisheries Science Center Outlook for Salmon Returns](#)  
[SalmonRecovery.gov--Citizens Guide](#)
- [iii] [Survival of Migrating Salmon Smolts in Large Rivers With and Without Dams](#)  
[Proceedings of the National Academy of Sciences of the USA - Ocean and dam influences on salmon survival](#)  
[Survival of Migrating Salmon Smolts in Large Rivers with and Without Dams](#)
- xi [NOAA Fisheries Fact Sheet: Southern Resident Killer & West Coast Chinook Salmon](#)
- xii [NOAA Fisheries Fact Sheet: Southern Resident Killer & West Coast Chinook Salmon](#)  
[Encyclopedia of Puget Sound - Study says predators may play major role in chinook salmon declines](#)  
[Protecttheharvest.com - news](#)
- xiii [To Save Orcas, Removing Snake River Dams May Not Be The Answer, Feds Say](#)
- xiv [NOAA Fisheries Fact Sheet: Southern Resident Killer & West Coast Chinook Salmon](#)  
[Encyclopedia of Puget Sound - Study says predators may play major role in chinook salmon declines](#)  
[Protecttheharvest.com - news](#)
- xv [2/23/2016 Seattle Times, "Drugs found in Puget Sound salmon from tainted wastewater"](#)  
[2017 Defenders of Wildlife "CONNECTING THE DOTS: Orcas, Salmon, and Toxic Chemicals in the Salish Sea"](#)  
[How toxic food and toxic water could be killing the killer whales](#)
- xvi [Will cutting salmon out of our diets save the Puget Sound orcas?](#)
- xvii [NOAA Fisheries Fact Sheet: Southern Resident Killer & West Coast Chinook Salmon](#)  
[NOAA Northwest Fisheries Science Center: Technical Memo](#)
- xviii [4/23/19 KIRO 7 News Seattle](#)
- xix [WA Senate Bill 5116](#)
- xx [Portland General Electric Wheatridge Renewable Facility Webpage](#)
- xxi [Bonneville Power Administration Fact Sheet: A Northwest energy solution: Regional power benefits of the lower Snake River dams](#)
- xxii [NOAA Northwest Fisheries Science Center: Elwha River](#)
- xxiii [The myth of Elwha Dam removal's success](#)
- xxiv [Bonneville Power Administration Fact Sheet: Many Paths to the Ocean](#)
- xxv [2019 NOAA Fisheries Biological Opinion](#)
- xxvi [Army Corps of Engineers 1999 "Lower Snake River Juvenile Salmon Migration Feasibility Study"](#)  
[Amount of trash found in Columbia River cleanup surprised some local divers](#)
- xxvii [Climate change effects on stream and river temperatures across the northwest U.S. from 1980–2009 and implications for salmonid fishes](#)  
[2-28-2019 New York Times, "The World Is Losing Fish to Eat as Oceans Warm, Study Finds"](#)  
[epa.gov climate change indicators](#)
- xxviii [Foreman, M & B. James, C & C. Quick, M & Hollemans, Peter & Wiebe, Edward. \(1997\). Flow and Temperature Models for the Fraser and Thompson Rivers. Atmosphere-ocean](#)  
[US Army Corps of Engineers - Lower Snake River Dams](#)
- xxix [Summary: Regional Scale Simulation of Water Temperature in the Columbia River Basin](#)  
[Richmond, et al: Regional Scale Simulation of Water Temperature and Dissolved Gas Variations in the Columbia River Basin](#)
- xxx [Army Corps of Engineers - Dworshak Dam Water Releases](#)
- xxxi [University of Washington--Columbia Basin Research--Data Access in Real Time](#)
- xxxii [2018 Columbia River Basins Fish and Wildlife Program Costs Report](#)
- xxxiii [Encyclopedia of Puget Sound - Study says predators may play major role in chinook salmon declines](#)  
[Protecttheharvest.com - news](#)
- xxxiv [Govtrack.us "Endangered Salmon and Fisheries Predation Prevention Act"](#)
- xxxv [US Army Corps of Engineers--Response to Methane Study](#)
- xxxvi [NOAA Fisheries Fact Sheet: Southern Resident Killer & West Coast Chinook Salmon](#)  
[University of Washington--Columbia Basin Research--Data Access in Real Time](#)
- xxxvii [NOAA Fisheries Fact Sheet: Southern Resident Killer & West Coast Chinook Salmon](#)  
[SalmonRecovery.gov--Citizens Guide](#)

---

[University of Washington--Columbia Basin Research--Data Access in Real Time](#)  
xxxviii [bpawatch.com](#)

[NW Power & Conservation Council - BPA Electricity](#)  
xxxix [NW Power & Conservation Council—Dam History](#)

xl [PNUCC Issue Paper "The Value of Hydropower to the Northwest Grid"](#)

xli [US Army Corps of Engineers CRSO EIS](#)

xlii [Waterborne Commerce of the US Army Corps of Engineers Institute for Water Resources - Waterborne Commerce of the United States - Calendar Year 2017 - US Pacific Coast](#)  
[5/9/2019 capitalpress.com--"Snake River Dams: Setting the Record Straight"](#)

xliiii [PNUCC Issue Paper "The Value of Hydropower to the Northwest Grid"](#)  
[BPA.gov "Integrating renewables: The perfect partner"](#)

xliiv [PNUCC Issue Paper "The Value of Hydropower to the Northwest Grid"](#)  
[Bonneville Power Administration Fact Sheet - Value of the Snake River Dams](#)

xlv [Foundation for Water & Energy Education -- Irrigation](#)

xlvi [WA Grain Association "Wheat Facts"](#)

xlvii [Pacific Northwest Waterways Association](#)

xlviii [5/14/2019 US News & World Report "Why Washington is the Best State in America"](#)

xlix [Microsoft 'pays it forward' to help fund several programs in Grant County](#)  
[6-15-2016 Puget Sound Business Journal "Microsoft's LinkedIn acquisition could have big benefits for a tiny Washington town"](#)

l [5/14/2019 US News & World Report "Why Washington is the Best State in America"](#)

li [Port of Clarkson, Wanda Keefer](#)

lii [NW Power & Conservation Council -- Flooding](#)

liiii [2/5/16 OregonLive "Remembering Oregon's epic 1996 flood: 20 years ago"](#)

liiv [Tri-Cities Business News.com May-2018 "Tri-cities population climbs 1.7 %"](#)

liv [Bonneville Power Administration Fact Sheet: A Northwest energy solution: Regional power benefits of the lower Snake River dams](#)

lvi [City of Richland, Washington](#)  
[Culligan Water](#)

lvilvii [Columbia-Snake River Irrigators Association](#)  
[12/9/16 Hydroworld.com "Groups want Trump to weigh in on breaching Snake River hydropower dams"](#)  
[9/5/2018 Tri-Cities Herald "Tri-City economy would crumble without Snake River dams"](#)  
[Foundation for Water & Energy Education -- Irrigation](#)

lviii [Bonneville Power Administration Fact Sheet: A Northwest energy solution: Regional power benefits of the lower Snake River dams](#)

lix [Bonneville Power Administration Fact Sheet: A Northwest energy solution: Regional power benefits of the lower Snake River dams](#)

lx [Bonneville Power Administration Fact Sheet: A Northwest energy solution: Regional power benefits of the lower Snake River dams](#)

lxi [Bonneville Power Administration Fact Sheet: A Northwest energy solution: Regional power benefits of the lower Snake River dams](#)

lxii [5/9/2019 capitalpress.com--"Snake River Dams: Setting the Record Straight"](#)

lxiii [2018 Columbia River Basins Fish and Wildlife Program Costs Report](#)

lxiv [BPA 2019 Infographic "How Bonneville spends a dollar of its power revenue"](#)  
[NW Power & Conservation Council Columbia River Basin Fish and Wildlife Program Costs Report](#)

lxv [Assumes a general industry rule that power costs represent roughly half of residential end-user costs](#)

lxvi [BPA Fact Sheet: Columbia Basin Fish Accords](#)  
[10/15/2018 gorgeradio.com " Fish Accords Renewed"](#)

lxvii [Columbia River Inter-Tribal Fish Commission summary on Columbia Basin Fish Accords](#)

lxviii [SalmonRecovery.gov--Citizens Guide](#)

lxix [8/8/2018 Idaho County Free Press "Dworshak Reservoir release set to keep tailwater cool"](#)  
[US Army Corps of Engineers - Lower Snake River Dams](#)  
[US Army Corps of Engineers - Cooling Water Mechanisms](#)

---

lxx [BPA.gov "Flexible spill agreement aims to benefit salmon and hydropower"](#)

lxxi [2019 NOAA Fisheries Biological Opinion](#)

lxxii [NW Power & Conservation Council - Commercial Fishing Impacts](#)

lxxiii [NW Power & Conservation Council - Dam Impacts](#)

[NW Power & Conservation Council - Grand Coulee Dam: Impacts on Fish](#)

lxxiv [9/23/2015 Seattle Times "Columbia River Chinook Returns Shattering Records...."](#)

[University of Washington--Columbia Basin Research--Data Access in Real Time](#)

lxxv [New Marine Heatwave Emerges off West Coast, Resembles "the Blob"](#)