An Update to the 2016 Paper "The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas"

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Introduction

Scientists are increasingly studying and recognizing the significant amount of greenhouse gas (GHG) emissions from hydropower reservoirs. Indeed, "[n]umerous studies have demonstrated that hydropower reservoirs have the potential to produce high amounts of [methane], despite initially being considered carbon-free energy sources".[1] In fact, ten percent of reservoirs have emission factors larger than the CO_2 emissions from natural gas combined cycling plants.[2]

The 2016 paper "The Lower Snake River Reservoirs Generate Significant Amounts of Methane, a Potent Greenhouse Gas" reviewed scientific research on the topic including "Greenhouse Gas Emissions from Reservoir Water Surfaces: A New Global Synthesis" (Biosciences, 2016). This paper attempted to estimate the global production of greenhouse gases by hydropower reservoirs and identify the best predictors of emissions from reservoirs. The second publication reviewed, titled "Evaluating Greenhouse Gas Emissions from Hydropower Complexes on Large Rivers in Eastern Washington" (Pacific Northwest National Laboratory, 2013) measured and compared greenhouse gas emissions from Priest Rapids Dam Complex on the Columbia River reservoir and Lower Monumental Dam Complex on the Snake River against a free-flowing section of the Columbia River.

The two papers reviewed were used in conjunction with data specific to the Lower Snake River (water temperature, surface area, velocity, trophic state, and surrounding land use), to estimate the GHG production attributable to the reservoirs formed by the four lower Snake River dams.

The estimated yearly output of the Snake River Dams in the 2016 paper was 50,744 metric tons of $CO2_e$. However, new findings increase this output to over 80,000 metric tons, roughly equivalent to a natural gas power plant generating 165 MW. These emissions are not trivial and certainly not "0" as many entities would like the public to believe.

The New Findings

Pacific Northwest National Laboratory (PNNL) more recently published another paper titled "Methane Ebullition in Temperate Hydropower Reservoirs and Implications for US Policy on Greenhouse Gas Emissions" (PNNL, 2017).[3] This paper focused on the ebullition pathway (bubble transport through

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[1] Miller BL, Arntzen EV, Goldman AE, Richmond MC, Pacific Northwest National Laboratory (2017) *Methane Ebullition in Temperate Hydropower Reservoirs and Implications for US Policy on Greenhouse Gas Emissions.* Environmental Management 60:615-629, at p. 615. doi 10.1007/s00267-017-0909-1.
[2] Hertwich EG. (2013) *Addressing biogentic greenhouse gas emissions from hydropower in LCA*. Environmental Science and Technology 47: 6904-9611.
[3] *See* footnote 1.

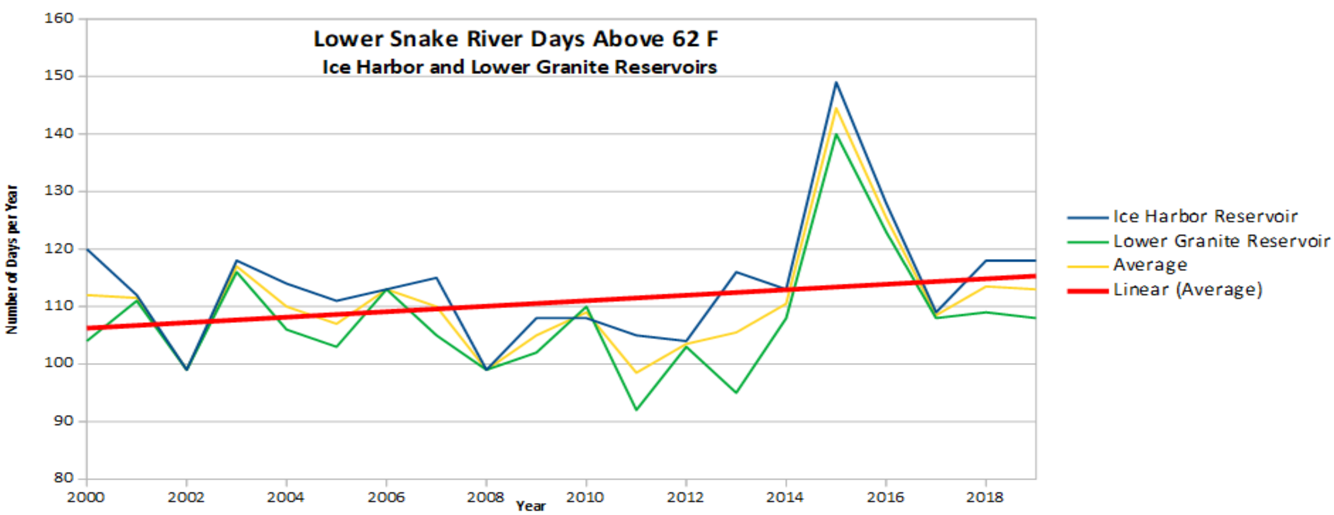
the water column) for methane to reach the atmosphere as this pathway accounts for more than half of CH_4 (methane) emissions originating from reservoirs.[4] Scientists conducted further research on Lower Monumental Reservoir, Priest Rapids Reservoir, and the undammed Hanford Reach on the Columbia River.

The paper made several key findings:

- Both the Lower Monumental and Priest Rapids reservoirs were found to have oxic[5] conditions and ranged from the mesotrophic to eutrophic state (conditions favorable to aquatic plant growth needed for methane production).
- Emissions from ebullition in Lower Monumental reservoir during the summer months ranged from 7.5 to 984.3 mg CH_4 m^{-2} d^{-1}, with a mean value of 521 mg CH_4 m^{-2} d^{-1}, which is 60% higher than the mean value of 324 mg CH_4 m^{-2} d^{-1} measured for Lower Monumental in the previous study.

An Update - Lower Snake River Temperature Trends

River temperatures above 17 C (62 F) are ideal for vegetation growth necessary for methane generation. A recent review of 2000-2019 water temperature data for all four lower Snake River dams reveals an increasing trend in the number of days above 62 F each year. It also shows that as water passes through each reservoir, the water temperature increases and the number of days the water is above 62 F also increases. The number of days >62 F at the furthest downstream reservoir, Ice Harbor, is greater than at Lower Granite, the furthest upstream. This is in part due to its proximity to a tributary of colder water coming from the mountains.



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[4] Deemer BR, Harrison JA, Li S, Beaulieu JJ, DelSontro T, Barros N, Bezerra-Neto JF, Powers SM, dos Santos MA, Vonk JA (2016) *Greenhouse gas emissions from reservoir water surfaces: a new global synthesis*. BioScience 66:949–964. doi:10.1093/biosci/ biw117.

[5] ox·ic/ˈäksik/*Adjective* - designating a process or environment in which oxygen is involved or present.

Data Source: Columbia Basin Research. (May 2020). University of Washington. River Environment Graphics & Text. Available from http://www.cbr.washington.edu/dart/query/river_graph_text.

In 2019, the average number of days above 62 F of the four reservoirs was calculated to be 113, or a 7% increase over what was used in the 2016 paper to calculate GHG emissions (106). The 2016 paper also produced conservative results because it used temperature data from Lower Granite reservoir - the coolest of the four reservoirs - to calculate yearly GHG emissions.

Recalculation of Lower Snake River Reservoir GHG Emissions
Methane ebullition rates from the 2017 PNNL paper in combination with the most recent lower Snake River temperature data can be used to calculate a revised yearly total GHG emission value from the four lower Snake River dams and reservoirs.

The surface area of the reservoirs with a depth of 10m or less of water remains the same (10,415 acres). The daily ebullition rate is increased from 324 mg CH_4 m^{-2} d^{-1} to 521 mg CH_4 m^{-2} d^{-1}. The rate of CO_2 diffusion (342 mg CO_2 m^{-2} d^{-1}) is unchanged from 2016. The number of days per year above 62 F is increased from 106 to 113. With these revised values, the total greenhouse gas emissions of the lower Snake River are the equivalent of *86,053 metric tons of* CO_2. This is 70% greater than what we calculated in 2016. For comparison, the PSE Encogen natural gas-fired plant in Whatcom County WA generates 165 MW according to PSEs website and emits 96,443 metric tons CO_2, according to EPA's GHG emissions sources website.[6]

Climate Change Will Lead to Increased GHG Emissions
Higher temperatures and fluctuating precipitation rates from global climate change are exacerbating wildfires, lowering water levels, decreasing land productivity, and accelerating the extinction of salmon and other keystone species, among other environmental concerns.[7] Heat-induced outcomes such as an increase in water temperatures above which is needed for algal growth, contribute to climate change in a positive feedback loop. As waters warm, alga have the potential to increase, increasing the release of methane from the water column where they decompose, contributing to a further increase in temperature. Between 1960 and 2015, water temperatures in the Snake River have increased by an estimated 1.4°F.[8]

Well aware of the climate crisis and these at-risk ecosystems, 55 scientists signed a letter to Pacific Northwest policymakers in October 2019 arguing that the only way to keep future temperatures down in the Snake is to breach their dams. Using a 2003 EPA climate model[9], the scientists explain that "the four lower Snake Dams could affect temperatures up to a potential maximum of 6.8° C/12.2° F."[10] The May 2020 EPA TMDL for Temperature in the Columbia and Lower Snake Rivers

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[6] https://ghgdata.epa.gov/ghgp/main.do# by clicking on Washington and scrolling on map to Bellingham.
[7] https://static1.squarespace.com/static/50c23e29e4b0958e038d6bd6/t/59108701d1758e85c59c9614/1494255363873/USRT+Chinook+Salmone+Sho-Pai+Climate+Summary+Sheet+Final.pdf
[8] https://www.epa.gov/climate-indicators/snake-river)
[9] https://www.columbiariverkeeper.org/sites/default/files/2015/07/Preliminary-Draft-TMDL-Draft-6-30-03-editing-9-5-03.pdf
[10] https://srkwcsi.files.wordpress.com/2019/12/2019-scientists-letter-re-snake-climate-final.pdf

reports that the lower Snake River dams currently inflate the surrounding water temperature by .7 to 3.2°C during the summer and fall seasons.[11] Temperatures differences as a result of the dams along with warming trends will not only be continuously contributing to the further warming of the planet, but is proving disastrous for salmon and steelhead, species that need water below 68^{0}F (20^{0}C) to survive.

According to a March 2020 EPA analysis, Snake River water temperatures are most strongly determined by the temperature of the surrounding air due to the river's expansive width and multiplicity of flow-impounding barriers.[12] Since 1960, the Snake River's mainstems have warmed by 1.5°C ± 0.5°C, a trend which is projected to increase throughout the coming decades. The report references two studies, Isaak et al. 2018[13] and Yearsley 2009[14], which predict that river temperatures in the great Columbia River basin region will increase by 1°C to 5°C by the end of the century. The report also recognizes that the average temperature in Lewiston has increased by 0.22°C per decade since 1970.

Over the next 50 years will hydropower reservoirs be contributing more CO_2 to the atmosphere than remaining coal and natural gas plants? Could the hydro system become as unsustainable as fossil fuel based forms of energy? If so, strategies to reduce GHG emissions will need to include dam removal and river restoration. An understanding of projected GHG emissions for underperforming dams, such as the four on the Snake, may add to the case for breaching as a means to recover salmon. Certainly, the labels of clean and carbon free cannot accurately be used to distinguish this form of energy.

[11] https://www.epa.gov/columbiariver/tmdl-temperature-columbia-and-lower-snake-rivers
[12] https://www.epa.gov/sites/production/files/2020-05/documents/r10-tmdl-columbia-snake-temperature-appendix-g.pdf
[13] https://www.fs.usda.gov/treesearch/pubs/56060
[14] https://www.researchgate.net/publication/253875291_A_semi-Lagrangian_water_temperature_model_for_advection-dominated_river_systems