Effects of Human Management Decisions on Reservoir Methane Emissions

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Reservoirs are a significant source of methane

- Methane (CH_4) is a greenhouse gas 20-30x more powerful than carbon dioxide
- Reservoirs (impoundments located behind dams) contribute 15-50 Tg of CH_4 to the atmosphere[1-2]
- Previous work shows human-managed water level changes, such as drawdowns, are an important control on reservoir methane emissions[1,3]

Fig 1. Reservoir drawdowns coincide with an increase in emissions of CH_4 bubbles[1]

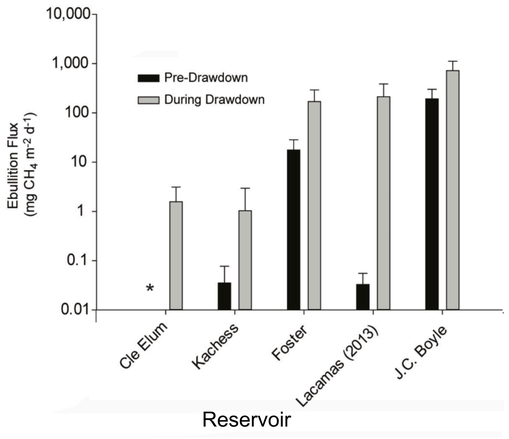
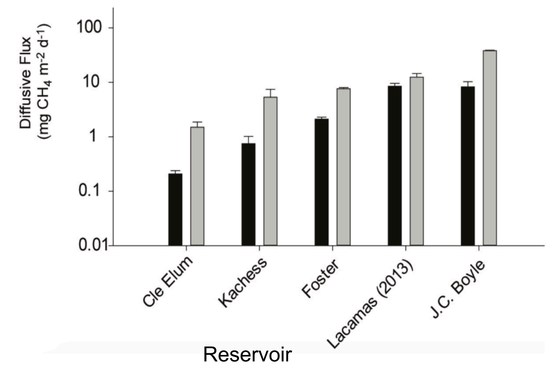


Fig 2. Reservoir drawdowns coincide with an increase in emissions of diffusive CH_4[1]



How do human management decisions affect methane production, oxidation, and emissions in reservoirs?

Do reservoir drawdowns trigger higher CH_4 emissions?

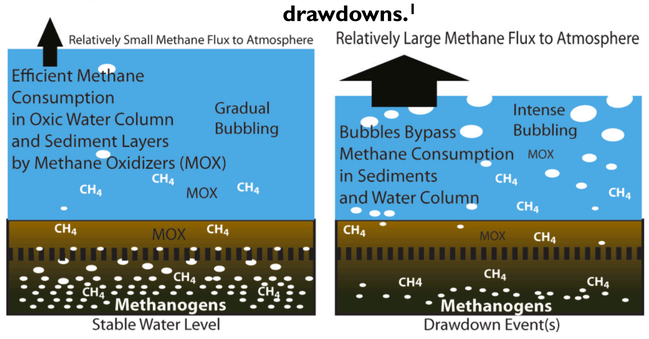
Study Sites:
- Lacamas Lake, WA
- Keno Reservoir & JC Boyle Reservoir, OR

Methods:
- Analyze C isotopes in dissolved & bubble CH_4
- Compare emitted CH_4 isotope values before, during, and after drawdown (Lacamas)
- Compare emitted CH_4 isotope values between two reservoirs with different water level management (Keno & JC Boyle)

Expected results:
- Emitted CH_4 during drawdowns will be isotopically lighter than stable periods because less methane oxidation is taking place

Implications:
- Clarify whether or not drawdowns—a human activity—contribute to higher CH_4 emissions or just change the timing of natural CH_4 emissions

Fig 3. CH_4 bubbles may be bypassing oxidation during drawdowns.[1]



How does drawdown timing affect CH_4 emissions?

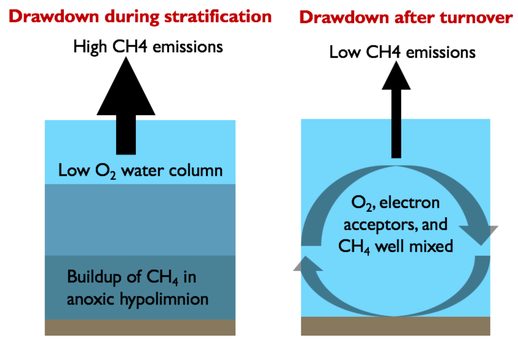
Study Site:
- Lacamas Lake, WA

Methods:
- Compare CH_4 emissions from drawdowns before turnover with emissions from a drawdown performed after turnover

Expected results:
- Fall turnover mixes possible electron acceptors for methane oxidation with CH_4 in an oxygenated water column, encouraging methane oxidation and thus lowering emissions

Implications:
- If changing drawdown timing lowers CH_4 emissions, reservoir managers can schedule drawdowns accordingly to minimize greenhouse gas emissions

Fig 4. Drawing down after reservoir turnover may lower CH_4 emissions.



How much CH_4 is outgassed versus oxidized during summertime spill in the Columbia River mainstem?

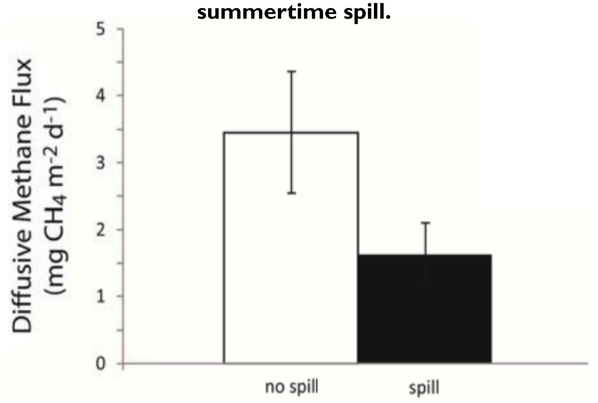
Study Site:
- Bonneville Dam, OR/WA
- The Dalles Dam, OR/WA

Methods:
- Construct a CH_4 budget for before and during spill
- Use a conservative tracer (Rn, Cl^-, Br^-) to track CH_4 during spill
- Compare CH_4 oxidation rates before and during spill

Expected Results:
- The majority of the CH4 lost during spill will be outgassed rather than oxidized due to turbulence at the spillway.

Implications:
- How CH_4 is lost through the system determines whether it is released as CH_4 (a powerful GHG) or CO_2 (a less powerful GHG)

Fig 5. Lower diffusive CH_4 emissions during summertime spill.



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References
[1] Harrison, J., Deemer, B., Birchfield, M. K., & O'Malley, M. T. (2017). Reservoir water-level drawdowns accelerate and amplify methane emissions. *Environmental Science & Technology*, 1-24.
[2] Bastviken, David, Tranvik, Lars J, Downing, J. A., Crill, P. M., Enrich-Prast, A., Luyssaert, S., Battin, T. J., et al. (2011). Freshwater methane emissions offset the continental carbon sink. *Science, 331*(6013), 50.
[3] Maeck, A., Hofmann, H., & Lorke, A. (2014). Pumping methane out of aquatic sediments; Ebullition forcing mechanisms in an impounded river. *Biogeosciences, 11*(11), 2925-2938.