Lit Review of Aquaculture and Lakes

Variables in our data: Alkalinity, Calcium? (CA), Chloraphyl A, Chloride? (CL), Conductivity, Dissolved Inorganic Carbon (DIC), Dissolved Organic Carbon (DOC), Potassium (K), Magnesium (Mg), MN, Nitrate (NO3), PARTC, PARTN, PARTP, PH, Sulfate (SO4), Total dissolved nitrogen (TDN), Total dissolved phosphorus (TDP), Nitrogen Dioxide (NO2), TSS, TDS, Turbidity

Not ideal data (not many records)

General aquaculture methods:

* Rainbow trout (*Oncorhynchus mykiss*, Wallaum) obtained from Linwood Trout Hatchery, Ontario, Canada (Azevedo et al., 2011)
  + 10000 female rainbow trout stocked in 2003 and 2004
  + Raised for 167 days (2003) and 155 days (2004)
  + Hand-fed to near-satiety twice a day (morning and dusk)
* “Two production trials were carried out between May and October 2003 and 2004 in Lake 375, an oligotrophic double basin (north and south basins) lake located at the Experimental Lakes Area (ELA), northwestern Ontario, Canada (49°44′43.61″N, 93°47′15.56″W). This lake was the object of frequent monitoring over two decades and long term pre-cage (1982–2002) mean TP and TN values (mean ± SD, n = 314) of 6.3 ± 4.5 μg L− 1 and 245.2 ± 92.0 μg L− 1, respectively were available. The lake has a surface area of 23.2 ha and maximum depth of 26 m (in the south basin), respectively. Fish were raised in a 10 m × 10 m cage that was anchored in the north basin of the Lake 375 over approximately 15 m of water, with the cage net extending approximately 10 m into the water column.” (Azevedo et al., 2011)
  + May through October 2003 and 2004
  + L375: Oligotrophic lake with SA 23.2 ha and max depth 26 m
  + Rainbow trout raised in 10 m x 10 m cage going 10 m deep into water column
* Fish fed a commercial trout diet (Martin Mills Profishent) (Azevedo et al., 2011)

Individual measurements:

* Dissolved phosphorus: primary nutrient of interest (Azevedo et al., 2011)

Possible ideas:

* Use the extrapolated data and time series to compared against MECP standards for waste outputs from cages
  + Can other water chemistry measurements be indicative to nutrient output and tell about the quality of systems that aquacultures are being placed in?
  + Are the MECP guidelines exceeded in the lake/are expected to be exceeded in the future if the aquaculture were to continue?

**Estimation of waste outputs by a rainbow trout cage farm using a nutritional approach and monitoring of lake water quality (Azevedo et al., 2011)**

<https://doi.org/10.1016/j.aquaculture.2010.12.001>

* Solid and dissolved P and N could lead to environmental degradation
  + Env compliance of cage culture operations generally assessed by measuring nutrient concentrations in water to ensure that target water quality criteria are met (set by gov – MECP in ON)
    - ON: take depth-integrated water samples for total P 30 m from each side of the cages and at two remote reference stations eleven times during ice-off period (Boyd et al., 2001)
    - However, these measurements may not be sufficient
* It’s difficult to differentiate bw farm-loaded, natural, and other anthropogenic nutrients
* Dissolved phosphorus: primary nutrient of interest
  + Taken up rapidly by bacteria and phytoplankton and removed to sediments
  + ~ 7.3 kg of P released into the env for every tone of fish produced in rainbow trout production
  + Over 60% of waste P is particulate and settles quickly ( > 6 cm/sec)
    - Most fecal matter that is generated in the epilimnion (where cage is) will settle to the sediments so it’s unavailable for algae or detected by epilimnetic water monitoring (our data) until thermal mixing occurs
* This project looked at relationship bw predicted waste outputs (Fish-PrFEQ model) and measured water chemistry parameters
* No significant differences in N and P measured in epi or metalimnion near the cage vs 400 m away (fig 6)
* Fish-PrFEQ models predicted: ammonia should inc from less than 10 ug/L before aquaculture to more than 250 ug/L in 2003 and over 300 ug/L in 2004
  + Not detected
  + Inc in nitrite/nitrate from less than 2 ug/L to more than 19 ug/L
    - At least part of ammonia added as fish waste was converted into nitrite/nitrate
* Models predicted: TDP (total dissolved phosphorus) should inc from less than 5 ug/L before to 25 ug/L in 2003 and over 35 ug/L in 2004
  + Not detected
* Discussion: 4.2 Water chemistry and nutrient status of the lake
  + Fish-PrFEQ model predicted an inc of NH4 and TDP by more than 10x background levels
    - Not confirmed by measurements
    - Lower ammonia likely due to Nitrogen transformations
      * Inc in nitrite/nitrate suggests that excreted fish waste (ammonia) converted into nitrate
  + Sig change in SUPN but also observed in reference lake (L373)
  + Dissolved N and P and suspended N and P lower than expected
    - Likely bc of immediate sedimentation of solid waste and uptake of dissolved N and P by algae and bacteria (High inc in Chl A due to lots of primary productivity?)
      * Look at Findlay et al., 2009 (<https://doi.org/10.1139/F09-121>)
  + Reflux of nutrients form sediments: some TDP inc in water were higher than TDP added as fish waste due to internal loading of P in sediments and settled solid waste
  + Expected to have an inc in nutrient concentrations in lake due to aquaculture, but not measured or observed
    - Nutrients don’t behave conservatively (as the model predicts) but is rapidly taken up and transformed
    - Ecological effects related to nutrient loading were observed
      * Inc in phytoplankton biomass and chlorophyll A (Bristow, 2006 and Findlay et al., 2009)