UTAH LAKE PHOSPHORUS CYCLE: BIOTA AS TEMPORARY STORAGE SINKS DRAFT USING PRELIMINARY FOODWEB DATA AND A BRIEF LITERATURE REVIEW

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Technical Memo

DRAFT USING PRELIMINARY FOODWEB DATA AND A BRIEF LITERATURE REVIEW

To
Wasatch Front Water Quality Council
Salt Lake City, UT

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INTRODUCTION

There is much interest in generating mass balance phosphorus (P) budget models for Utah Lake to be used to develop nutrient criteria for the lake. Model developers are using estimated values based on sediment resuspension, water column concentrations, atmospheric deposition, and tributary and wastewater inputs to populate their models. Unfortunately, model developers are ignoring phosphorus levels residing (sinks) and recycling (sources) in the biota of Utah Lake. This is a gross mistake. Any complete and useful phosphorus cycle model for Utah Lake needs to incorporate phosphorus sinks and sources in the biota or the model will be incomplete and results misleading.

We are developing the first ever foodweb model for Utah Lake and have preliminarily estimated biomasses of major members of the lake's biota based on analysis of available data (Richards 2022). These estimates along with values of phosphorus concentrations reported for several freshwater fish taxa were used in this memo to roughly estimate total annual static phosphorus levels (sink) in the biota of the lake.

METHODS

Biomass estimates of Common Carp (*Cyprinus carpio*) were made by Walsworth, Wallace, and Landom (2022) from data accumulated from 2009 to 2021. We estimated biomass of the other major organisms (N = 78) in several reports that were summarized and incorporated into Richards (2022) food web model draft report in preparation. Richards (2022) biomass estimates were reported as tons km^{-2} and for this analysis transformed to the entire lake at an estimated 400 km^2. Concentrations of phosphorus (P) in Utah Lake fishes, including carp, were estimated at mean = 0.0375 based on two hours of web-based literature review and two papers (Boros, Jyväsjärvi et al. 2012, De Andrade Santos, Terra et al. 2016). These values ranged from 1.9 - 2.9% P for roach (Family Cyprinidae, minnow) to 3 - 6 % P for Loricariidae (largest family of catfish, including familiar aquarium fish *Plecostomus*). P concentrations for all other biota were estimated at half that of fishes, mean = 0.019.

RESULTS

Mean carp biomass was by far the greatest of all other organismal biomass in Utah Lake at an estimated 30,000 tons. All other biota biomass other than carp used in Richards (2022) foodweb model was estimated at 31,200 tons. This translates to roughly 1,359 tons of phosphorus in carp and 790 tons of phosphorus in other organisms for a total of 2,149 tons of P in living biota (sink), not including detritus.

DISCUSSION

Data used in this analysis were available data dependent. Organismal biomasses were estimates as was the estimate of 0.0375 for fishes and 0.019 phosphorus for non-fish biota. Taxon specific P concentrations are available from scattered sources throughout the literature but were not used at this time due to time and funding constraints. Also, the range of carp biomass estimates from Walsworth, Wallace, and Landom (2022) models translated into a range from a low of 653 to up to 2,603 tons P (mean 1,359 tons).

The primary reason that carp biomass was much greater than all other organismal biomass was because carp are long lived, large organisms and Utah Lake is ideal carp habitat (Richards and Miller 2017, 2019). Carp can live for over 30 years and reach > 4 kg in Utah Lake. Consequently, a substantial amount of P is tied up in adult carp and other large fish (Appendix 1). Contrarily, other organisms with fast growth rates (i.e., production to biomass ratios for example phytoplankton, zooplankton, early life stage fishes) have lower standing crop biomass than carp but process and cycle P much more rapidly within the lake ecosystem (Appendix 1 and Richards 2022). This cycling process is constantly occurring, seasonally dependent, and both taxon specific and food web interaction strength dependent (Richards 2022).

Because P is tied up in biomass, biota constitute a sink for P in the lake depending on life cycles. Carp for example are generally a relative long-term sink on an annual basis. Contrarily all zoo-biota are also sources of P for phytoplankton via excretion and mortality decomposition (Richards 2022).

Richards (2022) estimated detrital snow[1] at roughly 2000 tons. This could equate to 38 tons of P falling from the water column to the sediments annually which then can be utilized by benthic feeding organisms, including carp and catfish (Richards 2022).

Also, many other organisms were not included in the Richards (2022) foodweb model including microbes, pico- and nano plankton. Estimates of their biomass and P concentrations were not available at the time of writing of this memo but are assumed to be substantial.

In future iterations, Richards (2022) foodweb models can be modified to use P as the currency unit rather than biomass (tons km^{-2}). These modified models can then be used to trace P throughout the food web as biota assimilation uptake, store, and excrete P, and to predict future outcomes based on desired nutrient management options.

CONCLUSION

The roughly 2,149 tons of P in Utah Lake living organisms acting as sinks in P cycling should be considered accurate but with low precision. Regardless, the exclusion of P in living organisms in

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[1] Detrital snow is the continuous shower of mostly organic detritus, primarily phyto- and zooplankton falling from the upper layers of the water column in Utah Lake. It is a significant means of exporting energy from the light-rich photic zone to the aphotic zone below.

the lake from mass balance models can have substantial influence on model outcomes and management decisions. It is highly recommended to, at the minimum, incorporate organismal P sink concentrations in final models. Future models can then trace P throughout the foodweb and provide managers with more useful and informative models than are available at this time.

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Appendix 1. Estimated biological sink biomass, proportion P, and total P (tons) in Utah Lake. Biomass estimates from Richards (2022), P concentrations from Boros et al. (2012) and De Andrade Santos et al. (2016).

Group name	Biomass in habitat area (t/km²)	Approximate area (km2)	total biomass in lake (tons)	Estimated Proportion P	Total P in lake (tons)
Bacillariophyta	0.372	400	148.8	0.019	2.83
Chlorophyta	0.4	400	160	0.019	3.04
Cryptophyta	0.495	400	198	0.019	3.76
Cyanophyta	1.49	400	596	0.019	11.32
Dinophyta	3.696	400	1478.4	0.019	28.09
Euglenophyta	0.685	400	274	0.019	5.21
Benthic Algae	0.05	400	20	0.019	0.38
Macrophytes	0.01	400	4	0.019	0.08
Epiphytes	0.05	400	20	0.019	0.38
Asplanchinida	0.05	400	20	0.019	0.38
Bosminidae	0.05	400	20	0.019	0.38
Brachionidae	0.05	400	20	0.019	0.38
Canthocamptidae	0.01	400	4	0.019	0.08
Ceriodaphnia	0.08	400	32	0.019	0.61
Chydoridae	0.02	400	8	0.019	0.15
Cyclopidae	0.2	400	80	0.019	1.52
Daphnia	0.1	400	40	0.019	0.76
Diaptomidae	0.08	400	32	0.019	0.61
Ilyocryptidae	0.05	400	20	0.019	0.38
Laophontidae	0.01	400	4	0.019	0.08
Leptodoridae	0.008	400	3.2	0.019	0.06
Macrothricidae	0.05	400	20	0.019	0.38
Moinidae	0.01	400	4	0.019	0.08

Sididae	0.05	400	20	0.019	0.38
Acari	0.0015	400	0.6	0.019	0.01
Amphipoda	0.075	400	30	0.019	0.57
Chironominae	3.37	400	1348	0.019	25.61
Coleoptera	0.05	400	20	0.019	0.38
Corbicula sp.	0.05	400	20	0.019	0.38
Corixidae	0.05	400	20	0.019	0.38
Decopoda	0.05	400	20	0.019	0.38
Glossiphoniidae	0.05	400	20	0.019	0.38
Isopoda	0.05	400	20	0.019	0.38
Lymnaeidae	0.05	400	20	0.019	0.38
Physa sp.	0.05	400	20	0.019	0.38
Odonata	0.05	400	20	0.019	0.38
Oligochaetes	0.55	400	220	0.019	4.18
Ostracod	0.005	400	2	0.019	0.04
Tanypodinae	1.04	400	416	0.019	7.90
BlackBullhead1	0.2	400	80	0.0375	3.00
BlackBullhead2	1	400	400	0.0375	15.00
BlackBullhead3	6.49	400	2596	0.0375	97.35
BlackCrappie1	0.06	400	24	0.0375	0.90
BlackCrappie2	0.284	400	113.6	0.0375	4.26
BlackCrappie3	4.691	400	1876.4	0.0375	70.37
Bluegill1	0.073	400	29.2	0.0375	1.10
Bluegill2	0.5	400	200	0.0375	7.50
Bluegill 3	5.061	400	2024.4	0.0375	75.92
GreenSunfish1	0.05	400	20	0.0375	0.75
GreenSunfish 2	0.25	400	100	0.0375	3.75
GreenSunfish 3	0.5	400	200	0.0375	7.50

ChannelCatfish1	0.1	400	40	0.0375	1.50
ChannelCatfish2	3	400	1200	0.0375	45.00
ChannelCatfish3	3	400	1200	0.0375	45.00
Channel Catfish 4	0.001	400	0.4	0.0375	0.02
CommonCarp1	0.1	400	40	0.0375	1.50
CommonCarp2	5.5	400	2200	0.0375	82.50
CommonCarp3	85	400	34000	0.0375	1,275.00
Fathead Minnow1	0.05	400	20	0.0375	0.75
FatheadMinnow2	0.2	400	80	0.0375	3.00
FatheadMinnow 3	0.5	400	200	0.0375	7.50
June Sucker 1	0.15	400	60	0.0375	2.25
JuneSucker2	0.75	400	300	0.0375	11.25
JuneSucker 3	0.61	400	245.52996	0.0375	9.21
NorthernPike1	0.0005	400	0.2	0.0375	0.01
NorthernPike2	0.001	400	0.4	0.0375	0.02
NorthernPike3	0.001	400	0.4	0.0375	0.02
Northern Pike 4	0.001	400	0.4	0.0375	0.02
Walleye1	0.07	400	28	0.0375	1.05
Walley2	0.5	400	200	0.0375	7.50
Walleye3	0.206	400	82.4	0.0375	3.09
Walley 4	0.01	400	4	0.0375	0.15
WhiteBass1	1	400	400	0.0375	15.00
WhiteBass2	1.35	400	540	0.0375	20.25
WhiteBass3	11	400	4400	0.0375	165.00
White Bass 4	0.01	400	4	0.0375	0.15
YellowPerch1	0.2	400	80	0.0375	3.00
YellowPerch2	0.4	400	160	0.0375	6.00
YellowPerch3	0.458	400	183.2	0.0375	6.87

DetritusSnow	5	400	2000	0.019	38.00
Detritus	1	400	400	0.019	7.60
Total	152.89		61,155.53		2,148.61