Filename: Effluent from Wastewater Treatment Facilities Improve Bird Habitat
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Does Nutrient-Rich Effluent from Wastewater Treatment Facilities Improve Food Resources for Migratory Birds in Farmington Bay Wetlands, Great Salt Lake?

Draft Report

To
Wasatch Front Water Quality Council

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Introduction

Great Salt Lake and its wetlands are designated as a Hemispheric Site within the Western Hemisphere Shorebird Reserve Network, signifying the vital importance of habitat complexity and function necessary to support roughly ten million migratory and resident aquatic birds annually as many migrate from breeding grounds as far north as the Arctic Circle and return to wintering areas as far south as Argentina (UDWQ 2014, Sorensen et al. 2020). Under the federal Clean Water Act (CWA) and Utah state law, Utah Department of Water Quality (UDWQ) is responsible for 'restoring and maintaining the physical, chemical, and biological integrity' of GSL, and because of its uniqueness and wide diversity of habitats, UDWQ has designated GSL its own 'beneficial use-protection class', divided into five subclasses that include wildlife protection of "a quality sufficient for waterfowl, shorebirds, and other water-oriented wildlife, including their necessary food chain" (UDWQ 2014).

Several wastewater treatment facilities (WTF) provide large amounts of essential nutrient rich freshwater directly or indirectly into wetlands of Farmington Bay, GSL including South Davis Sewer District (SDSD), Salt Lake City (SLC), Central Davis Sewer District (CDSD), and North Davis Sewer District (NDSD). As examples, NDSD effluent alone provides on average 20 to 22 million gallons per day (MGD) of treated wastewater to a sheetflow wetland in the northeastern portion of Farmington Bay. SDSD nutrient rich effluent feeds impounded wetlands ponds of the Farmington Bay WMA via State Canal. Water in FBWMA ponds supports very high densities of benthic invertebrates that are a critical food resource that shorebirds and waterfowl depend on. SLC nutrient rich effluent helps support tens of thousands of migratory birds after it enters FB via the Oil Drain Canal.

As are all WTFs in the US, WTFs that discharge into Farmington Bay are mandated by the CWA and UDWQ beneficial use to protect waterbirds and other water-oriented wildlife including their food resources. OreoHelix Ecological and the Wasatch Front Water Quality Council have been conducting ecological studies on these wetlands and surrounding wetlands for close to a decade and have found that effluent influenced wetlands of Farmington Bay are some of the most productive of GSL wetlands and perhaps in the world (Richards et al. 2020, and this report).

Justification

Up until this point during our ecological research on Farmington Bay wetlands, we have not conducted a thorough literature review or synthesis of the importance of nutrient rich wastewater treatment facility effluent on waterbirds and their food resources. This preliminary review demonstrates such importance and justifies reevaluation of potential reduction of nutrient loads and diversion of effluent water away from these internationally important wetlands.

Literature Review

This review focuses on a handful of papers that we have read and their citations that focus on treatment effluent importance on waterbirds and their food resources throughout the world and specifically for GSL wetlands.

Wetlands and Estuaries outside of GSL

One of our most important findings from our literature review from wetlands and estuaries outside of GSL, is that it appears that many cities and wastewater treatment facilities throughout the world manage their effluent to maximize benthic invertebrate production in order to improve wetland and estuary habitat for waterbirds with the understanding that high levels of nutrients are essential (Rogers et al. 2007, and others). For example, large numbers of shorebirds, including long distance migratory species that breed in northern Asia rely on effluent from The Western Treatment Plant (WTP) of the City of Melbourne, Australia. This treatment plant is subject to international agreements to protect migratory birds and their habitats and are among the principal biological assets that contributed to the site being listed as a wetland of international significance under the Ramsar Convention. Melbourne Water manages the WTP and is required to conserve habitat for shorebirds, while meeting core commitments to treat wastewater (Rogers et al. 2007).

Rogers et al. (2007), reported of the risk that shorebird habitat values in tidal flats (estuaries) would decline if nutrient levels from adjacent effluent outfalls were reduced through a government directed Environment Improvement Project. Melbourne Water examined management options to offset any such change in shorebird habitat values to meet its obligations to protect shorebird habitat under legislation, including the Australian Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (Rogers et al. 2007). Results of studies were considered sufficient to confirm that there was a positive relationship between nutrient rich effluent, benthic invertebrates and shorebird abundance at the WTP (Rogers et al. 2007).

Melbourne Water of the City of Melbourne, Australia is proud of their contribution to providing a haven for tens of thousands of birds stating that, "the Western Treatment Plant's lagoons have become great bird habitat, with leftover nutrients attracting plenty of insects to eat and water available all year round" (https://www.melbournewater.com.au/water-data-and-education/get-involved/get-active-water/birdwatching/bird-species-western-treatment).

It has been well documented for at least forty years that many benthic invertebrate species especially common and opportunistic species (such as chironomid larvae), increase in abundance and biomass in response to increased organic loading (Weston, 1990; Beukema, 1991; Cardell, Sarda` & Romero, 1999; Savage, Elmgren & Larsson, 2002) and that wading shorebirds are likely to forage mostly on abundant macrozoobenthos in nutrient-enriched areas (Van Impe, 1985; Burton & Armitage, 2005; Burton, Fuller & Eaton, 2005, Alves et al. 2012). In addition, studies have documented a reduction in numbers or changes in behavior or in site use of bird species following the reduction of organic loading in estuaries (Weber and Haig 1997; Pounder, 1976; Campbell, 1984; Green et al., 1993; Raven & Coulson, 2001; Burton et al., 2005; Alves et al. 2012). Also, the literature is extensive with studies that show positive relationships between shorebird density and prey biomass and prey density, and how shorebird predation reduces prey abundance/biomass/ prey size. See Appendix 1for some of this literature.

GSL Wetlands

Northern vs. Southern Impounded Wetland Ponds

Benthic invertebrate densities are consistently greater in southern GSL impounded wetland ponds that are primarily influenced by nutrient rich water from State Canal than in northern ponds with lower nutrient inputs (Figure 1, Table 1) (Richards 2014, Armstrong and Wurtsbaugh 2019).

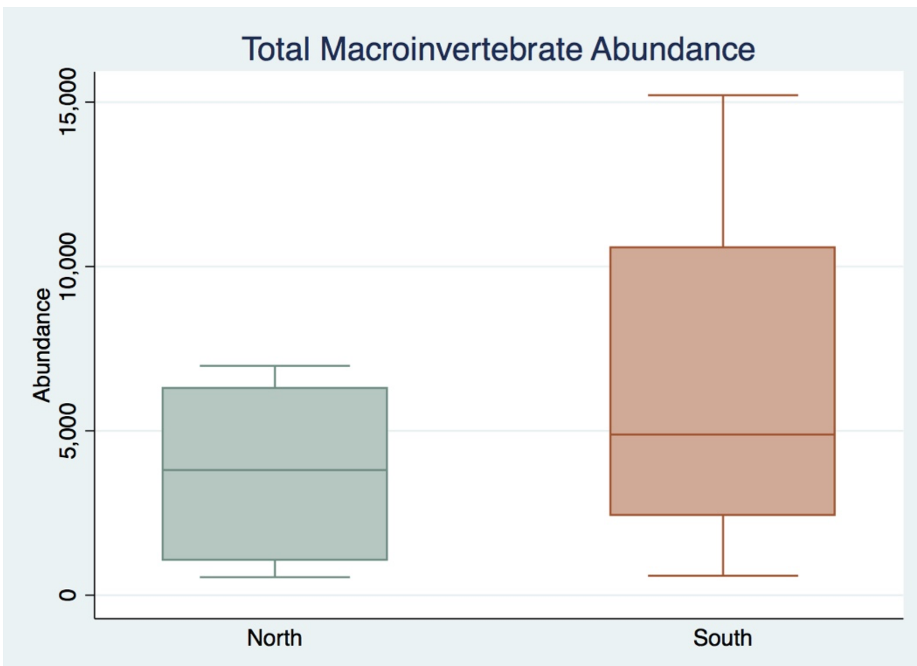

Figure 1. Total taxa abundances in northern and southern ponds. W-M-W rank test Z = -1.46; p-value = 0.15

Table 1. Descriptive statistics of total taxa abundances in northern and southern GSL impounded wetland ponds. See Richards 2014 for more information.

	Mean	Std. Dev.	Median	Max	Min	1Q	3Q
North	4,415	4,039	3,806	15,988	548	1,066	6,282
South	11,410	19,866	4,888	110,880	592	2,436	10,565

Farmington Bay South

We have observed densities and biomass of benthic invertebrates in the southern portion of Farmington Bay to be very high compared to other locations in the Bay and other locations in GSL, with densities in the southern portion of FB having as many as 75,000/m^2 on SAV in deeper waters (> 1 m)(Richards et al. 2020, and unpublished data). Armstrong and Wurtsbaugh (2019) reported that, "The southern-most station in Farmington Bay had the highest instantaneous benthic macroinvertebrate biomass (26.5 g/m^2) in the month of June. In contrast, the highest benthic invertebrate biomass value obtained in Bear River Bay was 18.9 g/m^2 at station 1 in June."

Shorebird densities are also consistently much greater in the vicinity of the confluence of the main flow of FB with the Oil Drain canal which transports nutrient rich effluent from the SLC wastewater treatment facility (Figure 2) than in more northern portions of FB, other than the NDSD influenced wetlands (Richards and Miller personal observations).

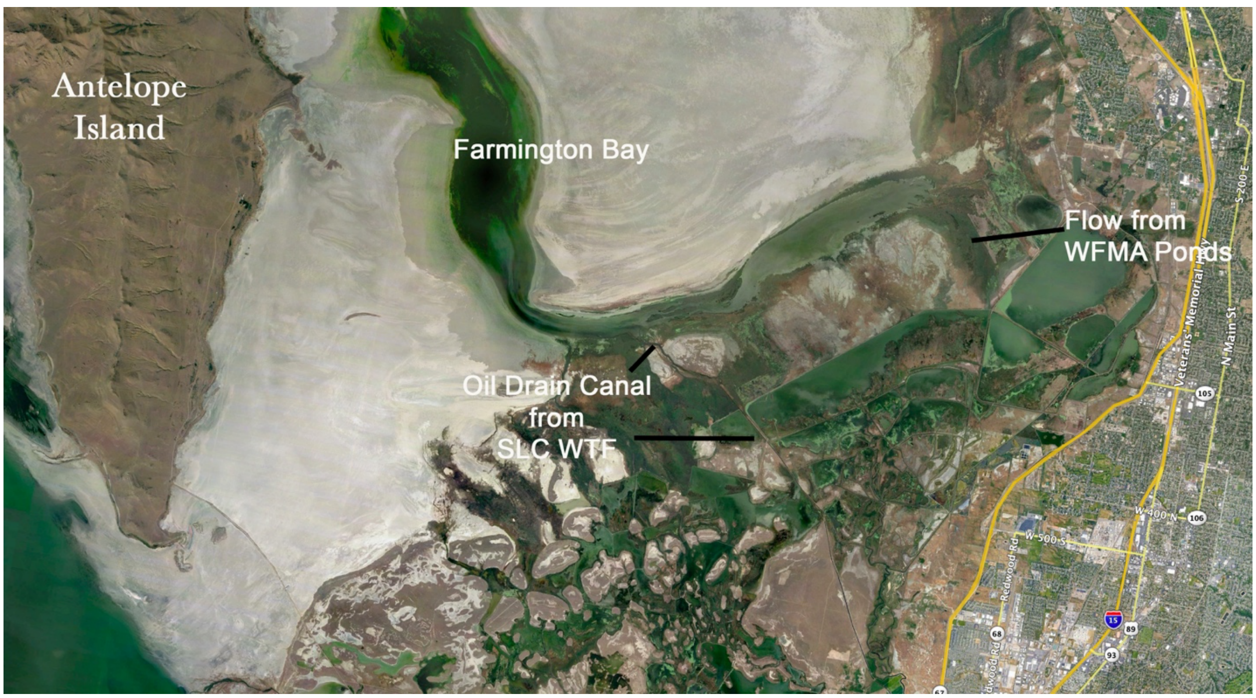

Figure 2. Southern portion of Farmington Bay showing flow of water from WFMA (State Canal) flowing north and then west joining Salt Lake City effluent dominated water from Oil Drain Canal and then flowing northward.

FB Benthic Invertebrate Biomass

It appears that for the most part, GSL managers assume that overall, GSL wetland invertebrate biomasses are much lower than what we have found in our research. The Great Salt Lake Shorebird Conservation Strategy (2012) for managing waterbird foraging habitat assumed a weighted average invertebrate biomass of only 0.97 g m^{-2} (Figure 2).

Foraging Habitat Objectives

Estimate of Invertebrate Density

Habitat Guild	Acres at 4200 Elevation	Invertebrate Density Assumption (g/m²)	Reference/Basis for Assumption
I-Emergent wetland	50,960	2.00	Loesch et al. (2000); Vermillion & Ortego (2009)
II-Hemi-marsh	23,810	2.00	Loesch et al. (2000); Vermillion & Ortego (2009)
III-Open Water	240,120	0.77	Huener (1984); Huener & Kadlec (1992)
IV-Mudflat/Playa	204,400	0.79	Andrei et al. (2009)
Shoreline	13,480	1.60	Collins (1980); Wurtsbaugh (2009)
Total	532,770		
Weighted Average		**0.97**	

Figure 3. From Great Salt Lake shorebird conservation strategy. Accounting for migratory shorebird habitat needs at one of North America's Great Ecosystems. Great Salt Lake Issues Forum. May 10, 2012. http://www.fogsl.org/issuesforum/2012/wp-content/uploads/2012/05/Paul_AvianWest_GSLShorebirdConservation.pdf. Note: References/basis for assumption citations have not been added to the literature citation in this report.

In addition, Obernuefemann et al. (2013) found that average biomass during May in a South Carolina managed wetlands was approximately 1.2 g m^{-2}. Collazo et al. (2002) estimated invertebrate biomass at coastal managed wetlands at Pea Island NWR, NC and Merritt Island NWR, FL of 5.74-6.44 g m^{-2} and 0.45-0.63 g m^{-2}, respectively. The US Shorebird Conservation Plan for the Southeast-Caribbean region assumes that average benthic invertebrate biomass in foraging habitats is 2.4 g dry mass m^{-2} and that the dominant prey item of shorebirds in the region is chironomid larvae.

Except for the Pea Island wetlands, the values presented above, including for GSL wetlands are much lower than what we have reported for NDSD sheetflow wetlands that had an overall mean = 3.38 g m^{-2} (Figure 4) and a mean = 5.68 g m^{-2} inside bird exclosure cages (Table 2). However, consistent with the US Shorebird Conservation Plan for the Southeast-Caribbean region, the dominant prey item for shorebirds of Farmington Bay is also chironomid (midge) larvae (Richards et al. 2020).

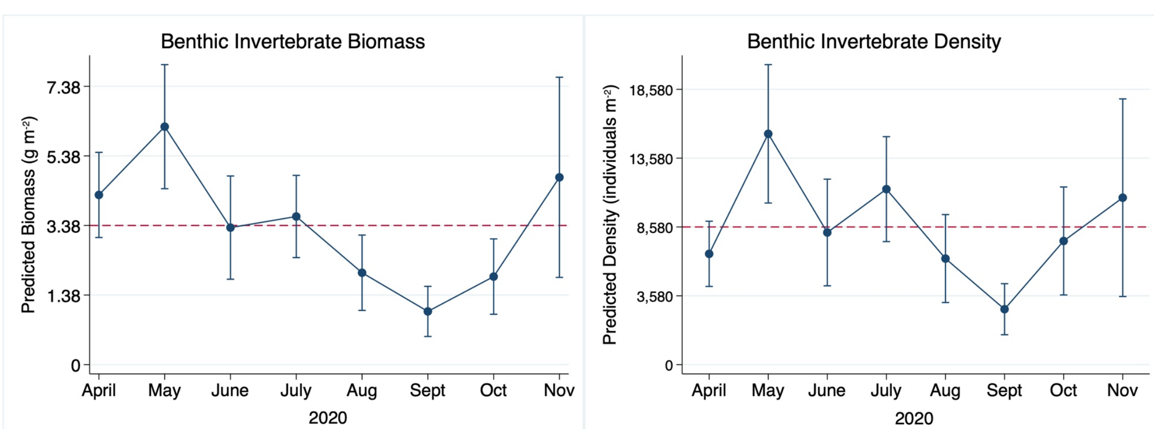

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Figure 4. Predicted benthic invertebrate biomass (g m^{-2}) and density (indiviudals m^{-2}) from April to November 2020 based on negative binomial regressions and marginal predictive analyses. Mean and 95% Cis shown. Red dotted line is the mean value. From Richards et al. 2020.

Table 2. Differences in benthic invertebrate biomass (g m^{-2}) between inside and outside of bird exclosure cages from April to June 2020. Differences are assumed to be from bird predation outside of exclosure cages, prior to any potential cage effects. From Richards et al. 2020.

	Mean (g m^{-2})	50th (g m^{-2})	75th (g m^{-2})	90th (g m^{-2})
Inside	5.68	5.50	8.55	10.72
Outside	3.18	2.32	3.62	6.25
Difference	**2.50**	**3.18**	**4.93**	**4.47**

Conclusion

From this preliminary and limited literature review and our professional experience and research (Richards et al. 2020), we conclude that nutrient rich effluent from wastewater treatment facilities supports greater densities of benthic invertebrates than waters with lower nutrient concentrations, which in turn helps support greater abundances of migratory shorebirds and waterfowl. These nutrients provide an essential service to help ensure population viability of many species of waterbirds that utilize these effluent dominated wetlands. The Clean Water Act and UDWQ designated beneficial uses require such protection. UDWQ, wastewater treatment facilities, and other management agencies should follow the lead of other countries in maximizing waterbird food resources and protection of internationally important wetlands of Farmington Bay.

Recommendations

Given the importance of our findings, we recommend the following:

1. Continued review and analysis of pertinent literature.
2. Increased collection of benthic invertebrate secondary production and standing crop biomass data from Farmington Bay, particularly the southern portion of the Bay. We are planning on installing at least three bird exclosure cages in the southern portion of the Bay in early 2021 to supplement our bird cage study on the northern portion.
3. Increased bird count estimates in FB, particularly the southern portion.
4. Timely dissemination of findings to managers highlighting the importance of continued nutrient addition to FB via WTF effluent.

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Appendix 1. Additional Readings

Positive relationship between shorebird density and prey biomass

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