University of Utah and Collaborators

2013 Willard Spur Nutrient Cycling Research Plan

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2013 Willard Spur Nutrient Cycling Workplan

Introduction

In 2013, the Willard Spur nutrient cycling research team is continuing to assess the natural temporal variability of nutrient concentrations and biological processes and productivity in the Willard Spur, the primary goal being to identify sensitive biological indicators for the onset of submerged aquatic vegetation (SAV) senescence. With respect to biological indicators; in 2012, branch density, % cover of SAV, and % cover of epiphytes were identified as sensitive indicators of vegetation response to nutrient loading. In 2013, these indicators will be assessed earlier in the season and with greater frequency, in order to better characterize the early season onset of SAV senescence. With respect to nutrient amendments; in 2012, nutrient amendments were added to both the sediment and water column. In 2013, amendment will be made only to the water column in order to reflect the introduction of nutrients to the water column via outflow from the Perry Willard Regional Wastewater Treatment Plant (PWRWTP). Eliminating the sediment amendments from the work plan allows the team to focus efforts and to maintain the originally-proposed budget. The water column will be sampled every two weeks beginning in mid-April; whereas, sediment parameters will continue to be monitored monthly. Nutrient fluxes will be analyzed in areas closer to the PWRWTP outfall than the treatment plots. Nutrient limitation will be determined using spikes of nitrogen, phosphorus, and combined nitrogen and phosphorus. Similar to 2012, open bottom and closed bottom chambers will be used.

Site Design Changes in 2013

In 2013 the nutrient cycling team will focus only on water column nutrient loading. Four 6 m x 20 m plots will be constructed perpendicular to flow in the Willard Spur; three water column amendments and one control. The three treatment plots will be separated by 20 m, just as in 2012. The control plot will be located 50-100 m upstream (east) of the treatment plots. In addition to the control plot we will sample sediment and water outside of plots. For the ambient site we will place a post about 30 m upstream of the control plot that will allow attachment of kayaks and canoes for sampling, without disturbance of the sediment-water interface.

The 2013 target concentrations (Table 1) for the high and medium high amendment plots are equivalent to the high and low amendments during 2012. In 2013, a low target concentration has been added (one-eighth and one-half the high and medium targets, respectively. The high and medium amendment plots will have the same mass of fertilizer as the high and low water column amendment plots in 2012, which was approximately 300 lbs and 76 lbs of fertilizer, respectively. The low amendment will have about 36 lbs of fertilizer.

Table 1: Summary of fertilizer amendments

Water Column Amendments	Total Mass of Fertilizer in Plot (kg)	PO_4-P Target Concentrations (mg/L)	Dissolved N Target Concentrations (mg/L)
High	152	0.4	2.5
Medium	36	0.1	1.1
Low	18	0.05	0.5

In contrast to 2012, where fertilizer-filled mesh bags were suspended from ropes strung across the plots, in 2013 the fertilizer bags will be suspended from wooden stakes (approximately 60 cm long) driven 30 cm into the sediment. This will be done to avoid stringing ropes through the water column, on which debris in the water column accumulates. The number of stakes per plot will depend on the mass of fertilizer to be deployed in each plot, between 9 and 19 stakes placed in 5 20-m rows extending across the plots.

The water temperature in April 2012 was between 40 and 50 °F. At these temperatures, the slow release Osmocote fertilizer used in 2012 does not release significant amounts of nutrients. Osmocote releases significant nutrients when the water temperature rises above 60 °F.

In 2013, in order to maintain a constant source of nutrients in the water column through a range of temperatures, a mixture of fertilizers will be used. About 10% (by mass) of the fertilizer mixture will be urea (46-0-0 NPK ratio), which releases nutrients rapidly, since this fertilizer is not polymer coated and is released directly through microbial activity and dissolution. Another 30% of the fertilizer mixture will be polymer-coated urea (39-0-0 NPK ratio), which is designed to more slowly release nitrogen, for approximately 45 days. The remaining 60% of the fertilizer mixture will be Osmocote Smart Release fertilizer (19-6-12 NPK ratio) which is designed to release nutrients for 3 to 4 months.

In 2012 it was found that ^{15}N isotopic signatures allowed determination of propagation of nutrients into the water column, sediment, and plants. In order to allow this determination for the fertilizer mixture described above, it is important that the $\delta^{15}N$ values for the various fertilizers in the mixture fall within a narrow range. Fortunately they do (between -0.3 and -1.1).

To further explore subtle signals of the onset of SAV senescence that were observed in May/June 2012, the test plots will be installed in early April 2013, and sampling will begin in mid April. Attachment ropes will allow visual division of each test plot into quarters during sampling, and sampling (water column and sediment) will be performed randomly from three of the four quarters of each plot during each sampling event. Sediment samples will be collected once per month while the water column will be sampled twice per month.

The temporal and spatial frequency of sampling will be assessed in July to determine whether adjustments are necessary.

Table 2: Summary of 2013 sampling plan.

Sediment	April A	May A	May B	May C	June A	June B	July A	July B	August A	August B
USUAL Lab										
Soft P, Ammonia and Nitrate, LOI		X		X		X		X		X
W.P. Johnson Lab										
Total and Methyl Mercury		X		X		X		X		X
SIRFER Lab										
C/N isotopes, % weight C/N, C:N ratio		X		X		X		X		X
Water Column										
Field Parameters*										
pH, conductance, temperature, DO, alkalinity	X	X	X	X	X	X	X	X	X	X
Utah State Health Lab										
Carbonaceous BOD*										
Total Nutrients; ammonia, nitrite + nitrate, phosphorus, TKN										
Filtered Nutrients; nitrite + nitrate, total nitrogen, dissolved phosphorus	X	X	X	X	X	X	X	X	X	X
General Chemistry; sulfate, alkalinity, turbidity, carbonate solids, TVS, TSS, TDS										
W.P. Johnson Lab:										
Total and methyl mercury*	X		X		X		X		X	
Major anions	X	X	X	X	X	X	X	X	X	X

* - one sample collected or measurement per plot

Sediment: Sampled once per month.

Analyses of sediment sample are listed below.

- **Utah State University Analytical Laboratories**
  - Sediment Nutrients
    - Soft Phosphorus (available P) (S7a)
    - Ammonia and Nitrate (S8d)
    - Loss On Ignition (S12b)
- **University of Utah: Johnson Lab**

    - Total and Methyl Mercury
- **University of Utah: Ehleringer lab**
    - Sediment Nutrients
        - C/N isotopes
        - % weight C/N
        - C:N ratio

Water Column: Sampled twice per month.

Analyses of water column sample are listed below.

- **Field Parameters** (YSI Probe and Hach kit): One measurement per treatment/control plot
    - pH
    - Conductance
    - Temp
    - Dissolved Oxygen
    - Alkalinity

- **Utah State Health Lab:** Three samples per treatment/control plot except for carbonaceous BOD which is 1 sample per treatment/control plot
    - Carbonaceous BOD
    - Non-filtered Nutrients
        - Ammonia
        - Nitrate/Nitrite
        - Total Phosphorous
        - TKN
    - Filtered Nutrients
        - Nitrate/Nitrite
        - Total Nitrogen
        - Dissolved Phosphorous
    - General Chemistry Parameters
        - Sulfate
        - Alkalinity
        - Turbidity
        - Carbonate solids
        - TVS
        - TSS
        - TDS

- **University of Utah Laboratories**
    - Total and Methyl Mercury: One sample per treatment/control plot
    - Major Anions (Ion Chromatograph): Three samples per treatment/control plot
        - PO_4^{2-}, NO_3^-, NO_2^-,Cl^-, SO_4^{2-}, Br^-, F^-

Vegetative Response as Biological Indicators

Vegetative Percent Cover of SAV and macrolagae change seasonally and in some cases, prematurely or excessively in nutrient enriched impounded wetlands of Great Salt Lake (Hoven and Miller 2009; Hoven 2009, 2010 a and b; and Hoven et al. 2011). In this study, percent cover will be determined of SAV, surface mat, epiphytes (as loosely associated and / or attached macroalgae on SAV) and BDS (biofilm / diatoms, sediment) at 5 randomly located 1m^2 quadrats within each treatment from April through June (number of sample periods vary and are listed below). Vegetation percent cover will be determined following the approved SOP for the project or during turbid conditions via core samples. Percent cover SAV and epiphytes were identified as a sensitive indicators during 2012 in nutrient amended plots on Willard Spur (Hoven et al. 2013).

SAV branch density will be determined April (or as soon as plants are established) through June (number of sample periods vary and are listed below) at the 5 quadrats per plot. Branch density has demonstrated earlier predictive capability of SAV die-off than percent cover determinations (Hoven et al. 2011) and was identified as a sensitive indicator during 2012 in nutrient amended plots on Willard Spur (Hoven et al. 2013).

To determine available plant food for waterfowl, direct measurement of food production and linkage to beneficial use (Hoven 2010b; Hoven et al. 2011), drupelet and tuber biomass of SAV (as g (dw) m^2) will be collected once during June at 5 quadrats per plot. The biomass cores will be rinsed on site but outside of the plot. This metric was not identified as a sensitive indicator during 2012 in nutrient amended plots on Willard Spur, however, monitoring the productivity of this important food source relative to other GSL wetlands may be important (Hoven et al. 2013).

SAV leaf tissue nutrient content (CNP): To determine the fate of biologically available nutrients, three composite samples of the dominant species of SAV in each treatment plot will be collected for leaf tissue carbon (as total organic carbon and $\delta^{13}C$), nitrogen (as total nitrogen and $\delta^{15}N$), and phosphorus (as total phosphorus) analyses following similar methods outlined in Hoven (2010c). Intensive collections will occur: 1x in April (baseline), twice during May, once during early June (cost and adequate sample depending) to reflect pre-senescence and redistribution of nutrients by the plants. There will be a total of 3 replicates per plot per sample period when adequate sample is available. Because of difficulty in collecting adequate sample for drupelets and tubers during 2012 and because leaves showed uptake of nitrogen sourced from the Osmocote (through $\delta^{15}N$ analysis) rather than the other tissues, we will focus on leaf tissue. The key questions at hand are: 1) are there differences in nutrient levels in the leaf tissue among treatments; 2) if there are different levels, do they correlate with biological response(s); and 3) if different levels of C, do they correlate with percent cover of epiphytes and/or BDS? Assuming there will be

differences in epiphyte and/or BDS loads among treatments, we will be able to compare SAV leaf carbon assimilation with $\delta^{13}C$ signatures. Of course, we use the term "epiphytes" loosely here as they are typically composed of filamentous macroalgae that are not actually attached to the SAV leaves.

Epiphyte $\delta^{15}N$ and $\delta^{13}C$ analysis: Epiphytes will be collected as 3 replicates per plot one time when adequate sample material is present during May / early June. If adequate material is not present, replicates will be composited for analysis. Stable isotope analysis may offer insight to differences in carbon assimilation associated with different responses to nutrient enrichment of the water column and linkage to water-born sources and cycling of nitrogen. Epiphytes were indicative of an early biological response during 2012 (Hoven et. al 2013) and stable isotope analysis may indicate that nutrients released into the water column are readily assimilated by algae. Further, if the epiphytic load develops rapidly on the SAV again this year, stress on SAV may be implicated.

Observations critical for documenting the general condition of the surrounding site and photodocumentation will be recorded monthly once visual estimates commence at the 5 quadrats per plot.

Light penetration through the water column and aquatic vegetation will be determined (weather permitting) April through June at the 5 quadrats per plot using LI-COR LI-193 underwater spherical quantum sensor as described in Hoven (2010c). Although shading did not correlate with SAV die-off in nutrient enriched impounded wetlands of Farmington Bay (Hoven et al. 2011), nor in Willard Spur nutrient amended plots during 2012 (Hoven et al. 2013) Willard Spur, monitoring light penetration is useful in defining growing condition for the plants.

2013 List of Biological Indicators (1x in April, 4x in May, 2x in June*)
% Cover SAV
Branch Density
% Cover Epiphytes

Supportive Indicators (1x in April, 4x in May, 2x in June*)
% Cover Surface Mat
% Cover BDS
Light penetration

Nutrient Cycling Supportive Data
Leaf tissue CNP and $\delta^{15}N$ (1x in April, 2x in May, 1x in June)
Epiphyte $\delta^{15}N$ (1x in May)

* Provided there is a detectable response during May; otherwise, up to 4x during June if delayed response occurs, followed by 1 to 2x during July.

Analyses of Sediment Diatom Assemblages

As part of the 2012 University of Utah Willard Spur nutrient cycling study, phytoplankton assemblages from each treatment were analyzed during July, August, and September. Algal specimens were identified and enumerated at the specific level when possible, and otherwise at the generic level. Statistical analysis of phytoplankton assemblages showed separation between assemblages most strongly associated with seasonality, and less obviously impacted by treatments. The 2012 nutrient cycling study did not, however, include the identification of diatoms to the specific level, a process which involves more intensive processing and analysis time than 'soft algae' samples. The intent of the 2012 UUWS phytoplankton analysis was to ascertain the overall composition of algal assemblages and to observe any correlating changes in those compositions with each amendment. An analysis of diatoms at the specific level may have shown different patterns between assemblage similarity and correlations with treatments and seasonality.

The algal category "pennate diatoms," was dominant in all treatments in all months in which phytoplankton samples were analyzed in the 2012 study. Furthermore, diatoms in samples collected during September were not only dominant, but were significantly more abundant in the water column than in samples collected in earlier months. This finding warrants a species level diatom analysis in order to determine variation in assemblages and to assess the significance of the September bloom. Sediment material was collected in 2012 and archived for potential future analysis of diatom assemblages. This material will be processed and analyzed for diatom community composition as part of the 2013 nutrient cycling study.

Eight 2012 UUWS samples have been selected for diatom analysis to include identification and enumeration at the specific level. Material from control and 'high' samples collected during May, July, September, and October will be processed using nitric acid digestion, which removes organic material and leaves diatom specimens with clean silica cell walls, allowing generic and specific taxonomy. Specimens will be preserved on permanent slides and slides will be archived. This process will allow species level identification and enumeration of diatom assemblages from bottom sediments collected from these selected treatments from the 2012 enrichment study. The results will provide a sediment diatom dataset for the statistical analysis of possible correlations between variation in diatom assemblages with treatments, seasonality, and other environmental variables.

Response of sediments and water column in Willard Spur when spiked with nutrients using prototype chambers

Nutrient fate in Willard Spur Wetland Water column will be determined by spiking a known volume of the water column with predetermined concentrations of nitrogen and phosphorus. The experimental protocol will also include control tests in which case the water column will not be spiked with nutrients. Furthermore, these tests will be conducted using two different configurations of chambers; in one configuration, the chambers will be open at the bottom to measure the fate of nutrients as a result of various biogeochemical activities occurring in the water column and in sediments and, the second configuration will have chambers closed at the bottom to measure nutrient dynamics/fate in the water column only. The nutrient dynamics in chambers will be monitored by taking samples over 10-hour time period. For the first 5-hour, all chambers will be exposed to the sunlight and samples will be collected at every 45~60 minutes. For the next 5-hour time period, the chambers will be covered with a black plastic bag to isolate them from the sunlight and to measure dark respiration. At the beginning of the dark respiration, the chamber may be spiked with known concentrations of nutrients (table 1&2) again depending upon the measured concentrations at the end of light period. A total of 8-chambers will be installed at a time, on two different occasions, where chambers will receive either low (Table 1) or high (Table 2) concentration nutrient additions.

Table 1: Matrix of experiments with low concentrations of nutrients

Type of chamber	Amendment	Target Concentration	Comment
Sed+WC	None	Background	In duplicate
WC only	None	Background	In duplicate
Sed+WC	(N+P)- low	0.1 mg P/l+0.5 mg-N/L	In duplicate
WC only	(N+P)- low	0.1 mg P/l+0.5 mg-N/L	In duplicate

Table 2: Matrix of experiments with high concentrations of nutrients

Type of chamber	Amendment	Target Concentration	Comment
Sed+WC	None	Background	In duplicate
WC only	None	Background	In duplicate
Sed+WC	(N+P)- high	0.5 mg P/l+2.5 mg-N/L	In duplicate
WC only	(N+P)- high	0.5 mg P/l+2.5 mg-N/L	In duplicate

In summary, the nutrient concentrations used will simulate the targeted low and high concentrations which were used in the summer of 2012 by this project team. The water column will be spiked with combined concentrations of both nitrogen (N) and phosphorus (P). The target N will be supplied as equal concentrations of ammonia (NH_4Cl) and nitrate ($NaNO_3$), calculated as N. Phosphorus will be supplied as $KHPO_4$.

During the experiments, we will monitor dissolved PO_4-P, NO_3-N, NO_2-N and NH_3-N.IF DWQ insists, we will plan to measure TKN as well but the samples will be sent to State Health Lab. Total and volatile solid and dissolved organic carbon (using shimadzu TOC machine) will also be measured during chamber installations periodically. QA/QC plan for sample collection, storage and transportation will be followed. We will employ the QA/QC plan which is available at DWQ's web site.

Outcomes: We expect to answer the following questions.

1. Are nitrification and denitrification contributing to nitrogen fate in Willard Spur?
2. What is the relative contribution of sediments and water column towards the fate of nutrients?

Deliverables:

A draft report will be prepared summarizing objectives, methods, assumptions, analytical results, observations, a discussion about the outcomes listed above and pertinent link to the University of Utah nutrient cycling study, and recommendations for future work. It is assumed that the draft report will be submitted for review by DWQ and the Willard Spur Science Panel. A final report will be completed that incorporates and addresses review comments and will be submitted to DWQ.

Schedule:
Work will be completed during the period of June-July 2013 provided there will be enough accessibility to sites. A draft report will be submitted by August 15, 2013. It is assumed that review comments will be returned within 30 business days. A final report will be submitted to DWQ by October 30, 2013.

References

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