Project 2A
Preliminary Study of Concentration and Effects of Selenium in Benthic Zone of the Great Salt Lake

CONTRACT WITH:	Utah State University
PRINCIPAL INVESTIGATOR:	Dr. Wayne Wurtsbaugh
CONTRACT VALUE:	$29,674
SCHEDULE:	April 1, 2006 through September, 2006 (elapsed time: 6 months)

Project Objective

The project objective is to determine selenium concentrations in the benthic food web components leading to the birds of interest. Please see Data Quality Objectives for Project 2A for further detail.

General Assumptions

1. All work completed as part of this scope of work will follow UDWQ's Quality Assurance Plan protocol. Samples will be shipped to the laboratory selected by UDWQ following required protocol. Cost of laboratory analysis is not included in this scope of work.
2. All necessary clearances/permits to complete the work specified herein will be acquired prior to and maintained for the length of the work. All access will be properly coordinated and permission obtained.
3. Safety is of the essence. Health Health & safety protocol will be identified prior to field work begins and followed.

Scope of Work

Task 1. Preparation of Workplan, Budget Estimates, and Data Quality Objectives

Prior to executing Project 2A, a workplan and the associated components (i.e., budget, required protocols, etc.) as well as Data Quality Objectives will be prepared and then reviewed by the Great Salt Lake (GSL) Science Panel, Utah Division of Environmental Quality, technical advisors, and GSL Steering Committee. This task also includes participation in study team meetings, conference calls, and other tasks on an as-needed basis.

Deliverables

1. Draft and Final Data Quality Objectives for Project 2A (completed by 4/28/2006).
2. Workplan including scope of work, projects costs, project schedule, health & safety plan, protocols for (1) collecting samples, (2) collecting, handling, and shipping samples (completed by 5/26/2006).

Task 2. Sample the periphyton and brine fly populations in the benthic zone of the Great Salt Lake to determine Se concentrations and mass in these pools

Background

Brine flies (*Ephydra cinerea* is dominant with some *E. hians* present) are an important component of the food web in the Great Salt Lake and are likely important for nesting birds. Only a single study has been done on the brine flies in the lake (Collins 1980). Collins found that fly larvae and pupae densities were highest on the calcified biostromes in the lake that provide solid substrates. Mud substrates were secondarily important, and few flies were found on sand substrates. During his study, sand occupied the most area of the littoral zone of the lake, followed in importance by biostromes. Based on a map shown in Collins (1980) biostromes occupy 22% of Gilbert Bay's littoral zone and cover 41 km^2. Given the expected large rise in water levels in the Great Salt Lake this spring, biostromes are expected to occur at depths of about 1.5 to 6 meters in the lake. Larval brine flies feed on periphyton and perhaps detritus sedimenting to the littoral zone. Artemia may also feed on detrital matter in the benthic zone, as this behaviour has been observed in laboratory colonies when food is limiting in the water column. The selenium bioaccumulation pathway in the benthic food web would thus be:

$Water_{Se}$ → $Periphyton/detritus_{Se}$ → Brine fly $larvae/pupae_{Se}$ +? $Artemia_{Se}$ → Bird $food_{Se}$

We emphasize that understanding this flow path of selenium will also lay the groundwork for understanding other metals such as mercury that may be addressed subsequent to the development of the selenium standard for the Great Salt Lake.

Brine flies are an important component of bird diets foraging in hypersaline systems. Herbst (in press) studied bird (including Black-necked Stilts) use of prey in hypersaline ponds in California and concluded that nearly 90% of all feeding was on brine flies, with the remainder on Artemia and corixids. Brine flies (*E. hians*) have also been shown to be an important component of the diet of California gull chicks at Mono Lake, CA. In two years of study, Wrege et al. (2001) found that flies represented 15-40% of the meals given to chicks, whereas Artemia were 13-48% of the meals. Flies, however have a higher nutrient value per individual prey item when compared to Artemia (Herbst 1986). At Mono Lake, fly larvae and pupae were the dominant forms given to chicks, with adult flies being relatively unimportant. Gull use of Artemia and brine flies was highly variable both within and between years, and likely reflects temporal variation of these two prey and other alternative prey. Artemia in the Great Salt Lake can be abundant in April and May (Wurtsbaugh and Gliwicz 2001) when bird nesting commences, but the timing is likely highly dependent on spring temperatures in the lake. The timing of brine fly abundance in the Great Salt Lake is not known. Collins (1980) studied the flies only from June through August, but based on the abundances of the larvae and pupae in June, he suggested that these forms were available in April and May, and consequently we expect that they will be an important part of the diet of birds during the nesting period.

The relative timing of Artemia and brine fly population development, as well as that of alternative terrestrial foods, will critically affect selenium uptake by birds, as brine fly prey may have lower selenium concentrations than those present in Artemia. In a preliminary analysis of the Great Salt Lake, Adams (unpublished 2005) found that brine flies had only 36% of the selenium present in Artemia, and Herbst (in press) found that selenium was undetectable in brine flies in saline ponds, whereas Artemia had concentrations ranging from 5-15 mg/kg dry weight. For example, if brine flies are the dominant prey of birds in the early spring when egg development is occurring, reproductive impairment may be reduced as compared to a situation where the birds rely exclusively on Artemia. Consequently, it will be important to document both the timing of brine fly population development in the Great Salt Lake, as well as the concentrations of selenium in larvae and pupae.

Objectives

Although a multi-year study will be necessary to understand selenium bioaccumulation via the benthic food web, this scope of work only includes a preliminary study with two main objectives. First, brine fly and periphyton samples will be taken from stromatolites, sand and mud substrates to measure their selenium content only one time during the year. This would be done in June when the birds are still nesting, and when brine fly abundances are thought to be high. The brine fly samples can be compared with those that have washed to shore that will be collected periodically in Project 1. Secondly, we will test methods for quantitatively sampling the brine flies from the stromatolites, mud and sand substrates. Stromatolites will be sampled at three depths during this initial sampling in order to determine whether a single depth can subsequently be used for longer-term sampling. If the results in 2006 warrant additional analyses, annual cycles of brine fly and periphyton abundances could be studied in 2007 and perhaps in 2008.

Activities

Although phytoplankton and Artemia have been studied extensively in the Great Salt Lake, the benthic community has not. Consequently, we will need to test protocols that have been used elsewhere and adapt them to our local conditions.

Brine flies will be sampled on the hard stromatolites by SCUBA divers using a vacuum pump sampler similar to that of Voshell et al. (1992). The sampler consists of an inverted plastic canister with a port and glove attached to the side of the canister so that a diver can agitate the substrate. A hose attached to the bucket allows the sample to be brought to the surface with a hand-powered pump and collected in a net. This methodology has proved successful for sampling benthic invertebrates in another large lake (Ratcliff and Wurtsbaugh, in preparation).

Periphyton will be sampled for both chlorophyll content (a surrogate for living algal biomass) and selenium concentrations. Techniques must be standardized across sites to allow comparisons based on the living periphyton layer, with the exclusion, as much as possible, of underlying inorganic substrates. Stromatolite periphyton may be sampled by breaking off sections of the hardened stromatolite material, a method that has proved effective previously (Marcarelli et al. 2005). The selenium content of the stromatolite periphyton will be determined from samples that limit the inclusion of non-algal material. On the mud and sand substrates we will use a Polar dredge to collect both periphyton and brine flies. The periphyton will be scraped off a known area of the surface layer of each sample; results will be presented both as biomass (computed as chlorophyll a per m2) and selenium concentration (per weight of sediment) from a subsample of the discrete surface layer (as opposed to sampling the

underlying sediment). At each station brine fly adults will be collected with a net held over the water while the boat cruises forward.

Larval and pupal stages of brine flies will be identified, counted and measured with a dissecting microscope at a USU laboratory. In Gilbert Bay we expect to find only the brine fly *Ephydra cinerea* , but it is possible that a species that prefers lower salinities, *E. hians*, could also be present. Larvae and pupae will be separated and subsamples frozen for subsequent selenium analyses. Approximately 2000 larvae will be needed to obtain the 1 g dry weight of tissue required for Se analyses. Benthic material will be analyzed for chlorophyll with ethanol extraction and a fluorometer, and organic matter content will be analyzed by combustion of a dried sample at 550 C. The relative proportions of the organic carbon and chlorophyll will provide a useful measure between sites as to the relative abundance of periphyton and detrital carbon. A portion of the organic material will be dried and frozen for subsequent selenium analyses.

Duplicate samples or internal spikes of selenium will be completed on 10% of the samples collected. The samples will be carefully processed with chain of custody considerations and analyzed in a certified commercial laboratory utilizing hydride generation/atomic fluorescence spectrometry. Analytical methods to be used by all the groups are still being discussed.

Assumptions

1. In 2006 we will sample in only June in two regions of Gilbert Bay near where birds (Project 1) and brine shrimp (Project 2B) will be sampled. In this preliminary study we will sample stromatolites (3 depths in each region), mud, and sand substrates. Based on results of Collins (1980) and Herbst (1990) we expect to find considerable variability in the abundances of brine flies at different stations. The results of the preliminary study in 2006 will allow us to design statistically robust sampling methodologies in subsequent years if this line of research continues.
2. The estimated level of effort and number of samples is documented in the Contract.

Deliverables

1. Samples, including QA/QC samples, as listed in the Contract, delivered to laboratory selected by UDWQ per sampling protocol.
2. Interim report on methodology (completed by June 30, 2006).
3. Final report including documentation of activities, methods, assumptions, data evaluation, recommendations, and conclusions completed as part of this task to meet data quality objectives (completed by 9/1/2006).

References

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TABLE 1. PROJECT SCHEDULE
Project 2A, Preliminary Study of Concentration and Effects of Selenium in Benthic Zone in the Great Salt Lake
Great Salt Lake Water Quality Studies, 2006

Year 1 Preliminary Analysis of Benthic Food Web

1. Milestones, Deliverables and Schedule	**Year 1--- 2006**									
	March	**April**	**May**	**June**		**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Activities and *milestones*											
1.1. Purchase equipment and supplies											
***Milestone**: Supplies and equipment delivered & equipment operational.*											
1.2. Establish sites in consultation w/ bird group											
Substrates evaluated											
Test underwater sampling equipment											
***Milestone**: Locations and methods confirmed*											
1.3. Sample benthic substrates											
Collection of brine fly samples											
Collection of Water samples											
Collection of Periphyton samples											
Milestone: Methodology documented											
***Milestone**: Selenium analysis completed*											
1.4 Project #2A Annual Scientific & Financial											
1.5. Project #2A Year-two Project Proposal											
Deliverables			Equipment List, SOPs, Detailed Sampling Design		Interim Report on methodology		Final Report and Financial Report	Proposal			