Farmington Bay Report – Corixid Predation on Brine Shrimp

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This report deals with preliminary studies of phytoplankton and corixid predation on brine shrimp conducted in Farmington Bay. Water, phytoplankton and corixid samples were collected from Farmington Bay, Great Salt Lake, on September 2, 2005.

Phytoplankton studies.

Methods. Inocula (water from Farmington Bay) was collected from four locations (between UDWR bird refuge and sewage inflow at south end of Farmington Bay, just past the sewage inflow, halfway between sewage inflow and Antelope Island Causeway, and at the Antelope Island Causeway breach). Water was collected just below the surface and filtered through plankton netting to eliminate zooplankton grazers. No brine shrimp were observed in the netting or in the water. The inocula was used to initiate all phytoplankton experiments to examine environmental effects of temperature, salinity and nutrients on phytoplankton production and composition.

Three different salinities (15, 25, and 45 ppt), two temperatures (10ºC and 30ºC), and three different nutrient levels (low – only lake nutrients in the inocula, medium -- added nutrients at 50 μm N + 3.2 μm P, and high – added nutrients at 250 μm N + 16 μm P) were used in experiments. Saline solutions for experiments were a mixture of NaCl rock salt and Instant Ocean (ratio of 1.5:1). Salinity was measured using a 1.000/1.220 specific gravity 300-mm hydrometer at 20ºC. Ten ml of inoculate was placed in 400 ml of saline solution in 500-ml Nalgene® bottles. Using a Wheaton® 0.2-2 ml micropipette, three different levels of a nutrient solution (P in the form of P_2O_5, 69.6%, and KH_2PO_4, 30.4%; N in the form of NH_4NO_3, 49.6%, $CaNO_3$, 46.8%, and NNO_3, 3.5%) were added to the bottles. The nutrient solutions had a molar Redfield Ratio (Redfield 1958) of 16:1 (N:P), the ratio of nutrients in phytoplankton cells at balanced growth. Low nutrient treatments received no nutrient solution, medium nutrient treatments received 0.2 ml of nutrient solution, and high level nutrient treatments received 1.0 ml of nutrient solution. Each treatment combination of nutrient/temperature/salinity had three replicate bottles.

The saline solution, inoculum, and nutrient mixture in each Nalgene bottle were thoroughly mixed, 35 ml was extracted and placed in a 50 ml test tube with a test tube cap. The test tubes were used to measure phytoplankton production and the Nalgene bottles were used at the end of the experiment for enumeration of phytoplankton species. Two hundred and sixteen test tubes and bottles comprised the experiment.

Nalgene bottles and test tubes were placed at random positions in rectangular trays and kept in an environmental chamber at constant temperature, with a light dark cycle of 12hr/12hr under 20 watt Gro-Lux fluorescent bulbs. Trays were rotated 90^o every two days to minimize any effects due to shading by other bottles/tubes in the tray. In addition, bottles and test tubes were lightly shaken every other day to assure mixture of the brine solution.

Contents of the test tubes were used to measure phytoplankton primary production (change in chlorophyll-*a* over time) using a Turner Designs TD 700 fluorometer (*in vivo* fluorescence).

Flourometer readings were taken when the test tubes were first filled and then every two days until the chlorophyll-*a* concentration in each test tube asymptoted (>2 consecutive measures without an increase in chlorophyll-*a*). Using these data, the rate of primary production (growth) and time to maximum chlorophyll-*a* concentration was determined. Once chlorophyll-*a* concentration asymptoted, nutrients were assumed to be depleted and a 25-ml subsample of brine was extracted from the corresponding Nalgene bottle and preserved with Lugol's solution for analysis of phytoplankton species composition.

Counting and identification of phytoplankton was performed using a microscope and Palmer-Maloney counting cell. The 25-ml sample in Lugol's solution from each bottle was uniformly mixed and a subsample was placed in the counting cell. The abundance of each phytoplankton species was estimated by counting several viewing strips (one diameter length) of the counting cell at a magnification of 250 × and obtaining a mean value. For species identification, a magnification of 400 × was used when identification at 250 × was not possible. The number of cells per milliliter for each species was obtained using the proper conversions. Cell volume for each species was determined by applying cellular dimensions to formulae for solid geometric shapes most closely matching the shape of the cells. Cellular biomass for each sample was then determined by multiplying number of cells of each species by its mean cell volume.

Results and Discussion. The phytoplankton production data have been completed. However, the phytoplankton composition analysis is still underway, because the species from Farmington Bay are almost entirely different from our previous cataloging of species from the Great Salt Lake's South Arm. This identification is requiring considerable taxonomic work.

The phytoplankton production data are presented here for maximum chlorophyll-a and analyzed using ANOVA (Table 1). All treatments and interactions were found to be significant.

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
TEMP	1.82E+07	1	1.82E+07	25.885	0.0001
SALINITY	2.53E+07	2	1.26E+07	17.979	0.0001
NUTRIENTS	3.27E+07	2	1.63E+07	23.265	0.0001
SITE$	7823744.641	3	2607914.88	3.712	0.013
TEMP*SALINITY	2.54E+07	2	1.27E+07	18.093	0.0001
TEMP*NUTRIENTS	2.72E+07	2	1.36E+07	19.348	0.0001
TEMP*SITE$	7414529.44	3	2471509.813	3.518	0.017
SALINITY*NUTRIENTS	4.79E+07	4	1.20E+07	17.053	0.0001
SALINITY*SITE$	1.27E+07	6	2116113.036	3.012	0.008
NUTRIENTS*SITE$	1.17E+07	6	1944893.209	2.768	0.014
TEMP*SALINITY*NUTRIENTS	4.67E+07	4	1.17E+07	16.605	0.0001
TEMP*SALINITY*SITE$	1.43E+07	6	2390219.674	3.402	0.004
TEMP*NUTRIENTS*SITE$	1.19E+07	6	1980374.051	2.819	0.013
SALINITY*NUTRIENTS*SITE$	2.35E+07	12	1959302.355	2.789	0.002
TEMP*SALINITY*NUTRIENTS*SITE$	2.47E+07	12	2059510.16	2.931	0.001
Error	1.01E+08	144	702566.55		

To simplify these results, the major effects are presented in Fig. 1 and 2. First, as might be expected, maximum production with the nutrients from the inocula were lowest before the influx

of sewage, greatest just after the influx of sewage and diminishing as distance from the sewage influx increased (approach to causeway) (Fig. 1a). Furthermore, the addition of nutrients (Fig. 1b) as expected increased production; however, the diminished response at the location halfway between sewage inflow and the causeway is anomalous. Finally, even at the Antelope Island Causeway (Fig. 1c), phytoplankton production and the response to added nutrients was less than the response measured in my lab's earlier studies of the South Arm (Chad Larson, MS Thesis, Utah State Univ., 2004).

Comparing results from Farmington Bay with our earlier results from the South Arm (Fig. 2a), it is observed that the main effects of temperature, salinity and nutrients are similar in both locations (temperature having less of an effect is not shown). An interesting result is that Farmington Bay and the South Arm exhibit comparable production at the highest nutrient levels, but Farmington Bay has much greater production at low nutrients (Fig. 2b). This indicates that the addition of nutrients has diminishing impacts as nutrient levels increase. In addition, increasing salinity has a greater effect in Farmington Bay than in the South Arm (Fig. 2c). I suspect that this is due to much greater changes in phytoplankton composition being observed in Farmington Bay. Preliminary phytoplankton composition results indicate that Farmington Bay contains many species of chlorophytes and cyanobacteria that are less tolerant to salinity and these are replaced by more tolerant species as salinity increases.

The main point is expected – Farmington Bay is nutrient-rich compared to the South Arm. While the effects of temperature, salinity and nutrients are similar between Farmington Bay and the South Arm, the intensity of responses differs between the two portions of the Great Salt Lake. These differences are likely a result of very different phytoplankton composition in the inocula from Farmington Bay and the South Arm.

Corixid predation studies.

Methods. Corixid functional responses (brine shrimp density vs. number killed per unit time by corixids) were measured at different salinities and temperatures (Chad Mellison, MS Thesis, Utah State Univ., 2000). As part of the current study, corixid functional responses were studied at two of the same temperatures (10 and 30^{o}C) and the same range of nauplii (3 – 150/400 ml) and adult (1 – 12/400 ml) brine shrimp densities, but lower salinities (15 and 25 ppt). Each temperature/salinity/brine shrimp density had 25 replicates (25 – 500 ml bottles containing 400 ml of saline solution).

Corixid predation is estimated by multiplying the appropriate functional response (temperature/salinity/brine shrimp density) by corixid densities measured by UDWR in Farmington Bay. This value was then compared with the ability of brine shrimp to replace these losses at the appropriate conditions (temperature/salinity/density).

Results and Discussion. Preliminary results for corixid predation on brine shrimp populations in Farmington Bay are compared with studies from the South Arm (Fig. 3).

There is no evidence that corixid predation can impact brine shrimp numbers in the South Arm (Chad Mellison, MS Thesis, Utah State Univ., 2000). However, data on brine shrimp reproduction and survival at lower salinities (Gary Belovsky and Chad Larson, Annual Report to

UDWR, 2002) and preliminary results from corixid predation rates at lower salinities (this study) indicate that corixid predation begins to approach what is needed to limit brine shrimp populations. This potential limitation emerges more from lower brine shrimp reproduction and survival at low salinities than increased corixid predation rates and densities at lower salinities.

Figure 1. Maximum chlorophyll-a measures (FSU – fluorescence units) for Farmington Bay water samples from September 2, 2004. a) Maximum values observed with nutrients only provided by the inocula (low level) at the four locations in Farmington Bay. b) The effects of increased nutrients on maximum values at the four locations in Farmington Bay. c) Comparison of the maximum values with nutrients from the Antelope Island Causeway and the South Arm. All error bars refer to standard errors.

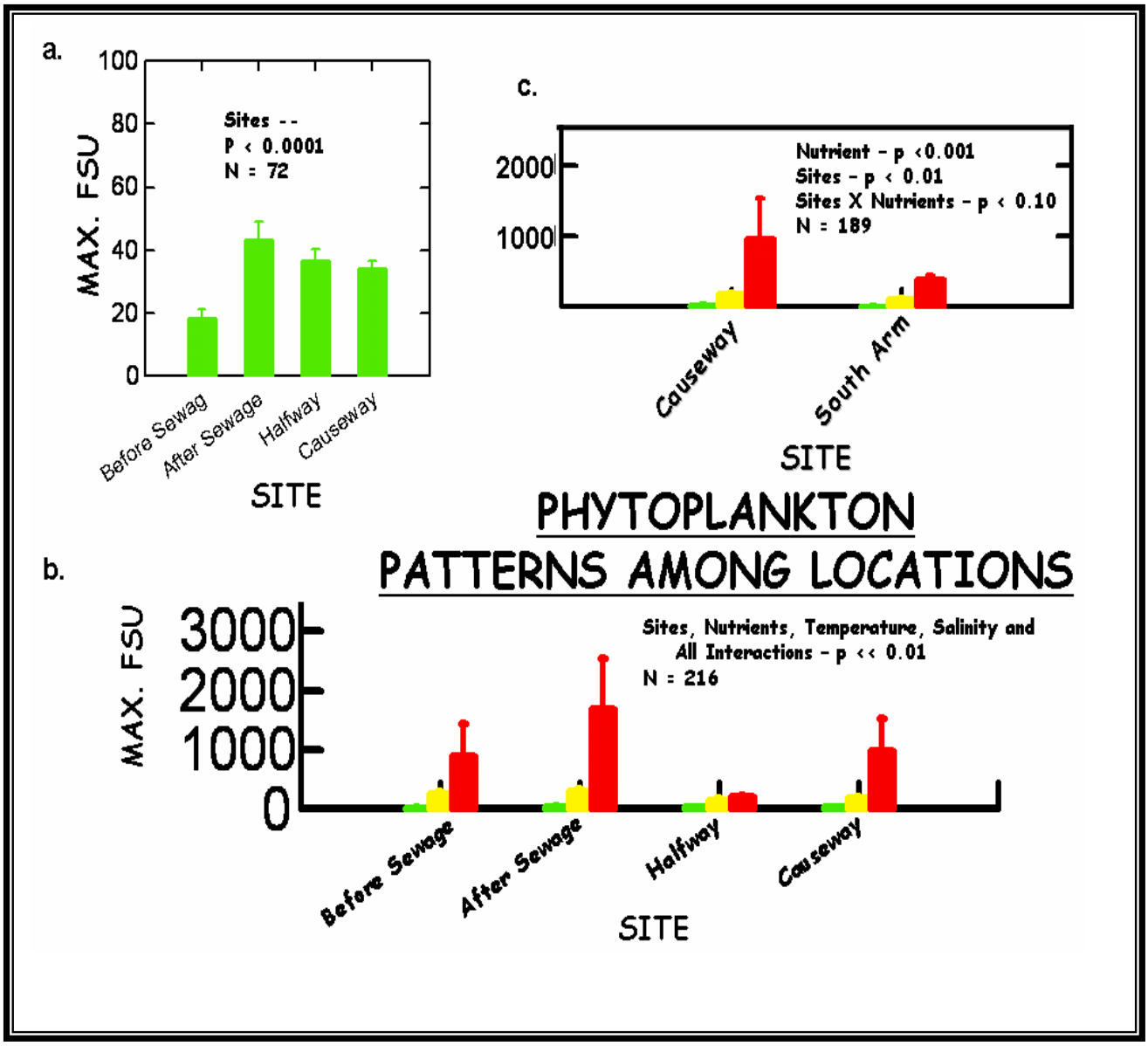

Figure 2. Maximum chlorophyll-a measures (FSU – fluorescence units) for Farmington Bay water samples from September 2, 2004 are compared with South Arm results (Chad Larson, MS Thesis, Utah State Univ., 2004). a) Presentation of results from the two studies. b) The effect of nutrients on maximum production is presented as regression lines. c) The effect of salinity on maximum production is presented as regression lines.

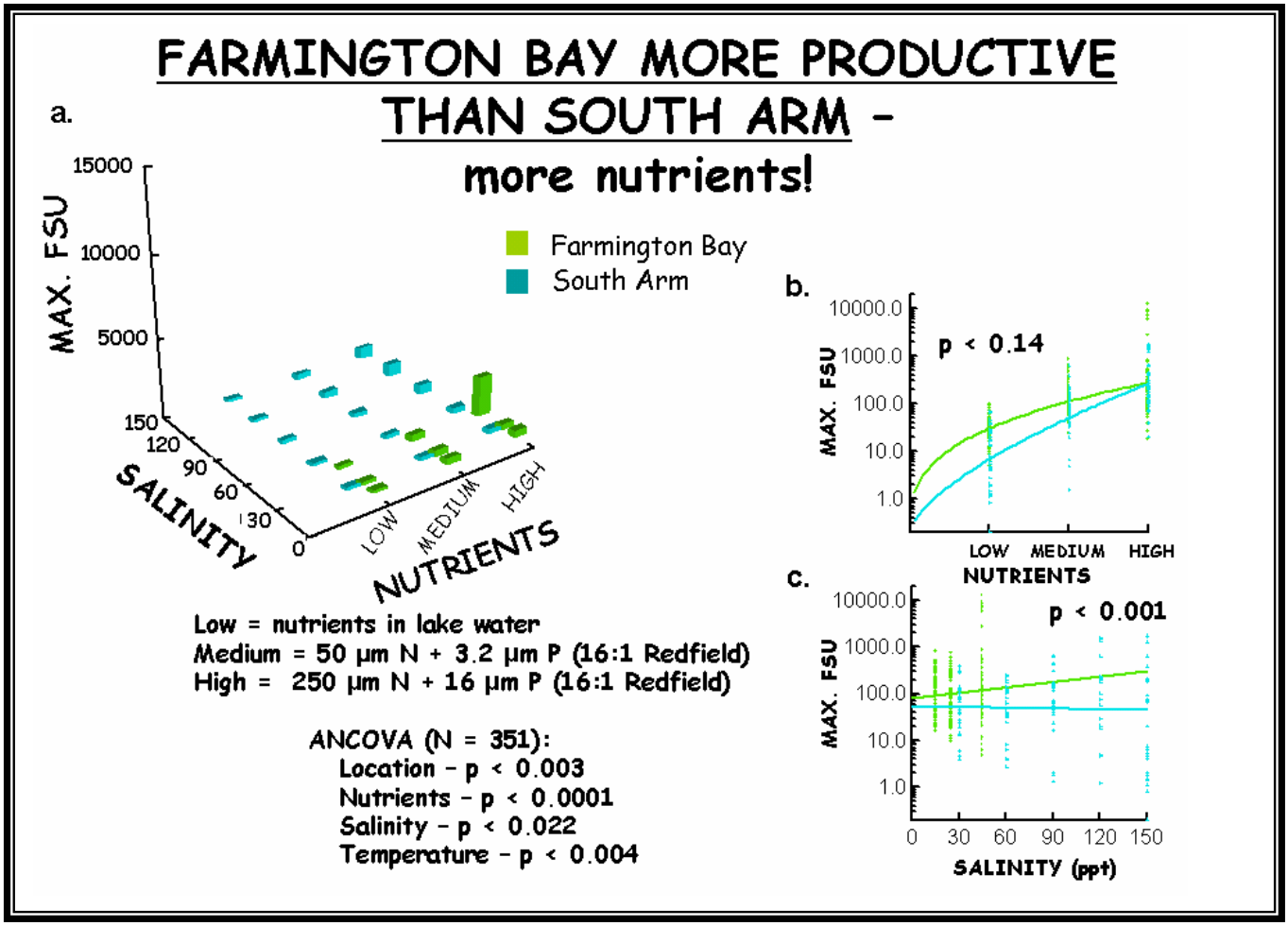

Figure 3. Comparison of projected corixid predation on brine shrimp from the South Arm versus Farmington Bay.