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COMPOSITION OF PHYTOPLANKTON COMMUNITIES AND THEIR CONTRIBUTION TO
SECONDARY PRODUCTIVITY IN CAROLINA BAYS ON THE SAVANNAH RIVER PLANT
Year Three Report

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This three-year collaborative project with Savannah River Ecology Lab (SREL) has an overall goal to determine the importance of phytoplankton (microscopic algae) as a component of the food chain base in SRS Carolina Bays (shallow temporary ponds endemic to the Southeastern U.S.). The importance of zooplankton (microscopic crustacean herbivores) to the early life stages of amphibians in these Carolina Bays has been determined by previous investigators (Taylor et al., 1988, 1989) and ongoing SREL studies. Prior to the SCSC research, detailed studies of phytoplankton and their importance to the base of Carolina bay aquatic food webs had not been determined. Results from the present SCSC project nearing completion will accomplish the objectives of: 1) determining seasonal changes in bay phytoplankton abundance and species composition; 2) quantifying the relative importance of phytoplankton as seen in $^{13}\text{C}/^{12}\text{C}$ stable isotope ratios; 3) measuring gross and net primary productivity and 4) analyzing the relationships between changes in water chemistry, zooplankton abundance, and phytoplankton abundance.

Carolina bays represent critical habitats for a whole class of vertebrates at SRS, the amphibians. Results from our project detailing the seasonal dynamics and productivity of SRS bay phytoplankton will advance our understanding of ecological energetics within Carolina bay systems. These results will also help determine the potential impact that these minute, but productive plants can have on SRS biota beyond the bounds of these aquatic ecosystems. New questions generated by this DOE funded SCSC research could prove valuable to SRS wetlands mitigation efforts as well as to improving our understanding of the role of phytoplankton in CO_2 cycling, and other bay ecosystem functions. Additionally, expanded opportunities for minority students to gain experience in environmental research will be provided. Nine different SCSC students and graduates have already worked as assistants in our previous DOE research work.

A Renewal Proposal for two new years of funding has been submitted along with this YEAR 3 Report to address important new questions relevant to DOE wetlands management strategies. The new questions for research are:

- 1) What effect does nutrient enrichment (fertilizing during wetlands restoration) have on phytoplankton communities?
- 2) What is the relative use of atmospheric CO_2 versus CO_2 derived from in-situ decomposition by phytoplankton in Carolina bays?
- 3) What effect does the extended hydroperiod for Carolina bays during 1991 have on phytoplankton community dynamics?

SUMMARY STATUS OF YEAR ONE OBJECTIVES:

All field work on YEAR THREE objectives has been completed and laboratory analyses are in their final stages. Considerable progress has also been made in statistical analyses and computer graphics for final reports and manuscripts.

Progress for each of the Proposal YEAR THREE objectives is summarized below along with summaries for supplemental objectives. Detailed discussions of methodology and results are found later in the report.

Objective: Determine relative contribution of phytoplankton production to Carolina Bay food webs.

All historical SREL phytoplankton samples (1984-1985) have been counted and computerized. All 1989 and 1990 samples for Flamingo, Ellenton, and Rainbow bays have also been counted and computerized. Analyses of 1991 phytoplankton are still continuing.

All phytoplankton and zooplankton tissue samples have been collected, processed, and analyzed for $^{13}\text{C}/^{12}\text{C}$ using GC mass spectrometry at Coastal Sciences Laboratories, Inc.. Analyses comparing $^{13}\text{C}/^{12}\text{C}$ ratios in phytoplankton to simultaneous zooplankton samples are being completed. From these results final conclusions will be made concerning phytoplankton and zooplankton trophic relationships.

During 1991, phytoplankton and zooplankton tissue samples were only collected during winter. Spring and summer samples were not collected due to the high number of $^{13}\text{C}/^{12}\text{C}$ samples collected from laboratory microcosms and bay macrophytes. These additional samples required the remaining funds budgeted for stable isotope analyses. Spring zooplankton and phytoplankton tissue samples had been collected previously in 1990.

Objective: Establish relationships between phytoplankton abundance changes and zooplankton dynamics.

Phytoplankton and zooplankton samples have all been counted for 1989 and 1990. Samples collected during 1991 are still being counted and analyzed. Historical SREL phytoplankton sample results are being compared to published zooplankton findings by SREL researchers Taylor and Mahoney (1990). Conclusions will be presented in the project completion report and will relate potential consumption of phytoplankton by zooplankton to changes in phytoplankton abundance.

Objective: Determine seasonal importance of phytoplankton to overall Carolina bay production.

Seasonal changes in phytoplankton biomass in Ellenton, Flamingo, and Rainbow bays are being analyzed and related to zooplankton abundance. The relative importance of phytoplankton to overall bay primary production is being developed from the results of light and dark bottle experiments.

Objective: Complete all statistical analyses, graphics, and preparation of manuscripts.

Statistical analyses of field and laboratory data using SAS are progressing towards completion of the final report and manuscript.

Objective: Develop recommendations with regard to Carolina bay mitigation activities.

Recommendations and further research questions relevant to SRS wetlands mitigation and restoration activities will be presented in the final report.

Supplemental Objective: Count all zooplankton in the phytoplankton samples collected during 1989 and 1990 for three taxonomic groupings, calanoid copepods, cyclopoid copepods, and cladocera.

All zooplankton in the phytoplankton samples collected during 1989 and 1990 have been counted for three taxonomic groupings, calanoid copepods, cyclopoid copepods, and cladocera.

Supplemental Objective: Collect additional phytoplankton and zooplankton tissue samples for $^{13}\text{C}/^{12}\text{C}$ analysis. Samples were not collected during winter (due to algae culturing experiments) or during the summer (due to dry bays) during 1990. Funds budgeted for this work in 1990 will be carried over to sample these seasons during 1991.

Additional samples were collected during winter. Summer samples were not collected because our budgeted total of $^{13}\text{C}/^{12}\text{C}$ samples was taken up by additional microcosm phytoplankton samples and microcosm and bay macrophyte tissue samples.

Supplemental Objective: Additional phytoplankton samples will be collected at 1 to 2 month intervals to document species composition for $^{13}\text{C}/^{12}\text{C}$ samples and to evaluate year to year variability in phytoplankton dynamics.

All samples have been collected and are presently being counted and computerized.

Supplemental Objective: Light and dark bottle primary productivity sampling will be conducted during winter, spring and summer.

Light and dark bottle primary productivity sampling was conducted for Ellenton and Flamingo bays during July 1991. Results were similar to the spring results of 1990. Winter and spring 1991 light and dark bottle studies were not conducted due to staff time limitations involved with $^{13}\text{C}/^{12}\text{C}$ analyses.

Supplemental Objective: Ellenton bay will be sampled for detailed dissolved oxygen distribution with depth as summer approaches. Samples during 1990 revealed anoxic conditions in some areas as early as late May.

Ellenton bay was flooded to deeper levels than at any time in our study. The shallow water conditions observed during anoxic events in 1990 were not repeated. These measurements were not conducted due to logistical problems.

Methodologies:

Phytoplankton Sampling.

Phytoplankton samples were collected and counted according to the same methodologies as described in the YEAR ONE Report. Three phytoplankton samples were collected just below the water surface at each station using 0.5 liter bottles. Samples were immediately preserved with an acid-Lugol's solution. In the laboratory each sample was successively concentrated by fluid

volume reductions following gravity settling of the plankton. The final settled sample was collected on the coverslip bottom of a plankton counting chamber using the Utermohl technique (Utermohl, 1931, in Wood, 1971) and counted on an inverted microscope at 1000x total magnification under oil immersion.

Phytoplankton and Zooplankton Tissue Collection for Stable Isotope Analyses.

A total of 75 liters of water were collected for each sample taken at a station. Four samples were collected for each station on a given date, yielding a total of 300 liters of water per station.

A two-step filtration process along with microscopic separation for the zooplankton and centrifugation for the phytoplankton was used to separate the tissues. Sample water was initially passed through a series of three nitex nylon mesh sieves (63, 35, and 20 μ) each covering an end of a stacked series of threaded PVC pipe couplings (183 mm OD). The filtrate was collected in a 25 liter carboy and saved for further separation of phytoplankton. Zooplankton and detrital particles were found to be nearly completely retained on the 20, 35, and 63 μ meshes. For this reason the suspended particles in the filtrate were assumed to be nearly all phytoplankton. (This assumption was validated by microscopic examination of phytoplankton samples, however a low percentage of small detrital particles could still be in this filtrate.)

Each phytoplankton tissue sample was removed from suspension by pumping 50 liters of original filtrate through a 2.0 μ mesh tangential flow filter (acroflux capsule) using a centrifugal pump with a maximum pressure head of 15 psi (Micropump). The filter retentate was next centrifuged to concentrate the algae for later freeze drying in preparation for GC mass spectrometry analysis. (Retentate not immediately centrifuged was stored at 5°C.) These phytoplankton samples represent the combined tissues of several algae species, however the species percent composition was enumerated by microscopic counts.

Zooplankton samples were collected from the 63 μ mesh sieve only and frozen until time for further analysis. The mixture of zooplankton and detritus from the 63 μ sieve was later subdivided using metal soil sieves (53, 150, and 355 μ mesh). The most abundant crustacean zooplankton did not pass through to the 53 μ sieve and debris collected on this sieve was discarded. These samples were divided into taxonomic groups and dried for later GC mass spectrometry analysis.

Gross and Net Primary Productivity.

Standard light and dark bottle methodology (APHA, 1985) was used to determine gross and net primary productivity. This method compares the volume of oxygen consumed in respiration with the volume of oxygen produced in photosynthesis as determined by the Winkler method (APHA, 1985; Wood, 1970) for measuring dissolved oxygen. One station at Flamingo bay and Ellenton bay were measured for primary productivity during July 1991. Five replicate samples were collected for each station at both the surface and midwater depths. Solar radiation data will be obtained from SREL recording stations to be used along with other environmental measurements to help analyze changes in observed photosynthesis.

$^{13}\text{C}/^{12}\text{C}$ Analyses.

Oven dried phytoplankton and zooplankton samples were analyzed by GC mass spectrometry. These analyses were conducted contractually by Coastal Science Laboratory, Inc. of Austin, Texas.

Preliminary Results and Project Status:

Total phytoplankton abundance in Flamingo bay was greatest during early spring 1989, declined during spring and summer, but increased again during early fall (Figure 1). Most of this phytoplankton density was composed of genus *Chlamydomonas* sp. (Figure 2). Ellenton bay demonstrated a similar decline in phytoplankton numbers during midspring 1989, but increased in density during midsummer (Figure 3). As observed in Flamingo bay, much of this variation was due to changes in *Chlamydomonas* sp. numbers (Figure 4). In Flamingo bay the blue-green alga *Anabaena* sp. was low in concentration throughout the 1989 flooded season until August (Figure 5), however the diatom *Pinnularia* sp. displayed a pattern of abundance similar to *Chlamydomonas* sp. (Figure 6). In Ellenton bay *Pinnularia* sp. peaked during early summer (Figure 7) and *Anabaena* sp. reached highest densities in late spring (Figure 8).

For zooplankton in Flamingo bay, the calanoid copepods were higher in early and late spring (Figure 9), similar to the cyclopoid copepods (Figure 10). Cladocera in Ellenton bay were highest in numbers during May 1989 (Figure 11), while cladocera in Flamingo bay displayed patterns similar to Flamingo bay cyclopoid copepods (Figure 12).

Laboratory experiments exposing *Chlamydomonas* sp. cultures to known mixtures of $^{13}\text{C}\text{-CO}_2$ and $^{12}\text{C}\text{-CO}_2$ seem to indicate that some isotope preference may exist during photosynthesis, however these results have not been analyzed statistically yet (Figure 13). Phytoplankton samples collected for Flamingo bay indicated that a seasonal change in isotope ratios may be occurring in algae tissues, however further analyses are being conducted to determine whether this may also be due to species shifts (Figure 14).

Figure 1. Total phytoplankton abundance in Flamingo bay in 1989.

Figure 2. *Chlamydomonas* sp. density in Flamingo bay in 1989.

Figure 3. Total phytoplankton abundance in Ellenton bay in 1989.

Figure 4. *Chlamydomonas* sp. density in Ellenton bay in 1989.

Figure 5. *Anabaena* sp. density in Flamingo bay in 1989.

Figure 6. *Pinnularia* sp. density in Flamingo bay in 1989.

Figure 7. *Pinnularia* sp. density in Ellenton bay in 1989.

Figure 8. *Anabaena* sp. density in Ellenton bay in 1989.

Figure 9. Calanoid copepod density in Flamingo bay in 1989.

Figure 10. Cyclopoid copepod density in Flamingo bay in 1989.

Figure 11 Cladocera density in Ellenton bay in 1989.

Figure 12 Cladocera density in Flamingo bay in 1989.

Figure 13. Uptake of stable carbon isotopes by laboratory *Chlamydomonas* sp. cultures.

Figure 14. Stable carbon isotope ratios for phytoplankton sampled in the field during 1989.

REFERENCES:

- APHA. 1985. Standard methods for the examination of water and wastewater. 16th ed. American Public Health Association. Washington. 1268 p.
- Taylor B.E., G.A.Wyngaard, and D.L.Mahoney. 1990. Hatching of *Diaptomus stagnalis* eggs from a temporary pond after a prolonged dry period. Archiv fur Hydrobiologie. 117: 271-278.
- Wood, R.D. 1971. Hydrobotanical methods. Univ. of Rhode Island. Kingston. 176 p.

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