Impacts of Delayed Drawdown on Aquatic Biota and Water Quality in Seasonal Wetlands

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Compliance with San Joaquin River water quality objectives may be improved by modifying wetland drawdown schedules to better coincide with San Joaquin River assimilative capacity. For salt, assimilative capacity is highest mid-March to mid-April when reservoir releases are made to aid salmon migration. Project data collected to date show phytoplankton concentrations can increase rapidly during the delayed drawdown period. Algae-grazing invertebrate densities also increased but not enough to completely suppress algal concentration increases.

The 178,000-acre Grassland Ecological Area in California's San Joaquin Valley is managed to provide over-wintering habitat to waterfowl on the Pacific Flyway. The major management activity is the fall flooding and spring drawdown of wetlands, timed to optimize the availability of forage vegetation and invertebrates for ducks and shorebirds. Wetland drainage contains salt, boron, and trace elements that are largely derived from imported surface water but concentrate during storage in the wetland impoundments and contribute to occasional water quality violations in the San Joaquin River (SJR) during dry years. Compliance with water quality objectives may be improved by timing wetland drawdown to coincide with high SJR salt assimilative capacity during mid-March to mid-April when reservoir releases are increased to aid salmon migration.

However, delaying wetland drawdown to improve compliance with SJR salinity objectives may have unintended impacts on the quality of the wetland resource for waterfowl overwintering. This project supplements a much larger scale, multi-year Modified Hydrology Study led by Grassland Water District (GWD), Lawrence Berkeley National Laboratory and the Department of Fish and Game (DFG) that is studying the impacts of delayed wetland drawdown on water quality, moist soil plant productivity, and wetland ecology. The current project attempts to quantify the rate of algae biomass increase during the delayed drawdown period and determine the factors that affect final algae biomass concentrations at selected sites within the study area. A complementary goal is to develop a rapid, repeatable field methodology for assessing algal ecology with minimum disturbance to wetland function. During the study, we have measured concentrations of phytoplankton and factors likely to control phytoplankton concentrations such as grazing invertebrate densities, nutrient concentrations, insolation, turbidity, temperature, and flushing rate.

The experimental sites chosen were three of six pairs of matched wetland basins (20-100 acres each) that are part of the larger Modified Hydrology Study. The wetlands selected were within the DFG Mud Slough (MS) and Los Banos (LB) Wildlife Management Areas and in the Ducky Strike (DS) Duck Club (within GWD). For each wetland pair, one was managed with a traditional March drawdown (MS-T, LB-T, DS-T); while for the other, drawdown was delayed up to one month (MS-D, DS-D, LB-D) to coincide with the period of high SJR assimilative capacity. Soil and water column samples were collected during the flooded periods at the inlets, outlets, and along transects. The transect lengths were limited to 100 m from shore in order to minimize bird disturbance; thus a majority of the wetland area could not be sampled. Data were stratified by vegetative cover, operating water depth, and hydraulic characteristics. Water quality analyses included total/volatile suspended solids, nitrogen (NH_4^+, NO_2^-+NO_3^-, organic), phosphorus (total, PO_4^{3-}), total organic carbon, alkalinity, turbidity, temperature, and pH. Planktonic and benthic invertebrates were identified and enumerated.

Data were collected between February and April, 2007. Identified phytoplankton were predominantly chlorophytes and diatoms. Zooplankton that feed on phytoplankton were found in abundance. Benthic invertebrates were also assessed to help explain the differences in algal concentrations between ponds. Microalgae concentrations increased substantially in MS-D and DS-D during delayed drawdown (170% and 320%), as did planktonic invertebrate densities (110% and 390%). Benthic invertebrate densities rose 40% on average. LB-D results did not match the other delayed drawdown wetlands; microalgae concentrations decreased 47%, while planktonic invertebrate densities increased approximately 4%.

For MS and DS, nutrient concentrations decreased during the delayed drawdown period, counter to salinity trends. NO_2^-+NO_3^- nitrogen concentrations were reduced in MS-T, MS-D, DS-T, and DS-D during the traditional flooded period; LB-T decreased, while LB-D remained unchanged. NO_2^-+NO_3^- nitrogen concentrations continued to decrease in all three wetlands during the delayed drawdown period. PO_4^{3-} phosphorus concentrations increased during the traditional flood period, while they decreased during the delayed flood period.

Of the factors potentially limiting phytoplankton concentrations, invertebrate grazing was likely the most important. Nutrients were not limiting in either the traditional or modified wetlands, as indicated by sufficient N and P of the algae. Likewise, inorganic C was not limiting, as indicated by pH (most <8.5 pH). Sunlight intensity was not significantly attenuated by water depth or turbidity.

A goal of the project is to develop a simple model of phytoplankton concentration in delayed drawdown wetlands that can be used with historical weather data to produce expected water quality probability distributions. Based on the results of the first year of sampling, three characteristics of the delayed drawdown wetlands suggest that such a simple model will be successful: (1) the short duration of the delayed drawdown period, (2) the presence of surplus nutrients, and (3) the predominantly batch-mode hydraulics of the wetlands. Although important, the density of algae grazing invertebrates appears to track the concentration of phytoplankton and thus may not need to be included as a variable. Vegetation density may be an important factor and requires further study.

Conclusions: Delaying wetland drawdown is one of several practices available to better manage salt in the SJR – the true merit needs to be assessed by measuring the direct and indirect secondary impacts of its implementation at all levels of the wetland ecosystem. In terms of the phytoplankton impacts, although wetland ecosystems are complex, a relatively simple model of phytoplankton concentration during delayed drawdown may be successful. Along with other information from the larger Modified Hydrology Study, an improved understanding of the consequences of delayed drawdown on wetland water quality and aquatic biota would help determine when and where delayed drawdown might be employed with minimal risk to wetland and river ecosystems.

Collaborative Efforts

This project is part of an interagency effort to study water quality and ecological impacts of delayed drawdown in the Grassland Ecological Area. Contributors to our research include John Beam, William Cook, and Ric Ortega of DFG, Laura Sparks of GWD, John Eadie of UC Davis, and Josephine Burns of Lawrence Berkeley National Laboratory.

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