SFCWA State and Federal Contractors Water Agency

FACT SHEET

Phytoplankton Production and Nutrient Transformations in Shallow Water Wetland Habitats (14-21, 14-22, and 14-23)	
Deliverables: Initial and final fact sheets, project raw data, one draft journal article describing the study and results, one presentation at an international conference, and one presentation to SFWCA representatives, designees and staff.	
Status: Sampling completed. Data analysis completed. Draft manuscript complete and submitted. Data online. Study presented at conference. Briefing for Technical Team on 3-7-16	
Primary Investigator: Brian Bergamaschi	**Recipient Organization:** U.S. Geological Survey
Project Cost: $147,500	**SFCWA Funding:** $107,400
Partners: USGS Cooperative Water Program, USGS Bay-Delta Program, USGS Western Region, California Maritime Academy, San Francisco State University, US Bureau of Reclamation, Sacramento Regional County Sanitation District, Interagency Ecological Program	

Introduction

Under the Bay Delta Conservation Plan (BDCP), up to 100,000 acres of wetland restoration is proposed for the San Francisco Estuary Delta to improve habitat conditions and protect endangered species, with about 50% of this wetland area slated for the Cache Slough region (Draft BDCP, 2012; Appendix E4). Two of the primary objectives of these wetland restoration efforts are (1) the production and export of particulate organic carbon (POC) in the form of phytoplankton, and (2) mitigation of wastewater-derived nutrients. However, the production and export of phytoplankton and consumption of nutrients within Delta tidal wetlands has not been well quantified.

Objective

In this study we sought to better understand the controls on phytoplankton abundance and distribution in the northern Delta, an area of the SFE with numerous wetlands and shallow water habitats thought to be important to imperiled native fish species and where a change in phytoplankton community structure has been observed in the last two decades. The objective of this study were (1) to improve our understanding of the separate and combined effects of residence time, light availability, nutrients, and contaminants on phytoplankton abundance and type, and (2) to investigate the extent to which interactions with tidal wetlands leads to increases in the abundance and export of phytoplankton. The principal approach of the study was to sample across the strong spatial variability typically found in this area and compare that variation to field observations and to phytoplankton growth in enclosures initiated with ambient water from the area. Spatial variation was characterized both by mapping nitrate and water quality parameters and by discrete sampling.

Results

We used the marked spatial variability in nutrient and phytoplankton abundance observed across a large extent of freshwater tidal wetlands in the northern reaches of the Sacramento-San Joaquin Delta, CA USA to examine the effects of residence time, light availability, nutrients and contaminants on the pattern of phytoplankton abundance and composition. We characterized spatial variation in phytoplankton abundance using chlorophyll-a concentration and direct counts, and characterized the phytoplankton size and community structure through size fractionation (5 µm cutoff), visual identification and pigment analyses while also documenting the spatial variation in constituent concentrations and biogeochemical rates using a combination of high resolution mapping, synoptic sampling, Lagrangian sampling, ammonium, nitrate and carbon uptake measurements, and enclosure studies. We found that areas characterized by high residence times and low ammonium concentrations corresponded to areas with higher chlorophyll concentrations, but that phytoplankton communities in these areas were composed mostly of small cells and had an elevated abundance of cyanobacteria, showing that lower ammonium alone will not lead to production of large phytoplankton. These areas also had elevated nitrate uptake, declining nitrate concentrations and isotopic evidence of wastewater-derived nitrogen utilization. Together these lines of evidence suggest that access of the phytoplankton community to nitrate resulted in neither the observed distribution in phytoplankton size distribution nor the taxonomic composition. Chlorophyll abundance was low where nitrate uptake potential was near zero; in these locations the phytoplankton community had a higher fraction of large cells and diatoms relative to other locations despite still being dominated by small cells, suggesting that elevated ammonium did not lead to a greater proportion of small cells or cyanobacteria. The spatial distribution of light availability and pesticides as well as results from enclosure studies indicated that these factors also were not dominant controls on the observed distribution in phytoplankton abundance, size, and taxa. These results challenge our conceptual models and indicate that additional investigations are necessary to understand how phytoplankton production in shallow water and tidal wetland systems will respond to current ongoing and future projected changes in nutrient concentrations and forms, water temperatures, and water clarity.

Conclusions

1. Lower ammonium concentrations did not favor the accumulation of diatoms, chrysophytes or other larger phytoplankton cells in a way that altered the phytoplankton community structure.
2. Higher proportions of large cells were found in areas with higher ammonium concentrations, indicating that the presence of elevated ammonium did not lead to an increased proportion of cyanobacteria and other small cells.
3. Despite evidence that the phytoplankton community had access to nitrate in the landward areas of the north Delta, the phytoplankton community structure in these areas was dominated by small cells and cyanobacteria, indicating the ability of the phytoplankton community to use nitrate did not appreciably affect the phytoplankton taxonomic distribution during our study.
4. Light and temperature were not dominant controls of phytoplankton abundance and community structure.
5. Enclosure studies initiated with water and seed stock from both high- and low- ammonium areas showed comparable growth rates similar to those projected by productivity models, indicating neither contaminants nor ammonium in the water were together or independently adversely affecting phytoplankton production or suppressing diatom production.
6. Results indicate that residence time could be a dominant control on the abundance and size distribution of phytoplankton, with longer residence times corresponding spatially with a higher abundance of chlorophyll, smaller cells and cyanobacteria.
7. The results demonstrate that current phytoplankton productivity model based on light and nutrient availability need to be reevaluated and revised and that the improved models need to be incorporated into physical models that include temperature and residence time.

Relevance

The wetland at Liberty Island is often highlighted as meeting the functional requirements of a successful wetland restoration project because of favorable light and nutrient availability but our results challenge these factors as explanation for the variation in phytoplankton production and biomass. To achieve the goals of pelagic fish habitat restoration identified in BDCP, it is critical to resolve the functional properties of wetlands that export bioavailable POC to pelagic habitats. Additionally, high-frequency measurements at temporal and spatial scales, demonstrated by high-speed mapping and fixed stations, can provide valuable information about biogeochemical processes occurring in dynamic systems such as the North Delta to better inform those making water-management decisions.

Next Steps

This study shows that additional work is necessary to quantify interactions between controls on phytoplankton production. High-speed mapping measured strong gradients of biogeochemical constituents in the North Delta that were not detected at fixed continuous monitoring stations but may be relevant to phytoplankton production and community composition. Understanding the processes that drive these spatial distributions, under different flow regimes, are important especially in light of future upgrades to the Sacramento wastewater treatment plant that will dramatically lower nutrient supply to this area. Future mapping exercises can assist with interpretation of continuous monitoring data, guide wetland restoration in the Delta and lead to the development of quantitative models of wetland support of pelagic habitats.