Do Drought Conditions Increase Nutrients and Productivity in the Northern San Francisco Estuary?

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The extreme drought conditions experienced by California will impact estuarine water quality and productivity by increasing most nutrient concentrations due to decreased dilution from freshwater flow. However anthropogenic nutrient inputs from wastewater treatment will likely stay similar to non-drought conditions as a result of permitting and management practices. A publication in 2014 observed increased chlorophyll in the Bay/Delta related to the drought. To further investigate the consequences of extreme climate conditions on the different forms of nutrients and lower trophic levels of the pelagic food web of the northern San Francisco Estuary to establish if this was a repeatable response, we carried out temporally and spatially intensive cruises from 2012 to 2015 for comparison with data collected in earlier, normal or wet years. We hypothesized that during drought conditions phytoplankton biomass and production would increase in response to elevated nitrate and longer residence time. To provide a mechanistic interpretation of any observed changes in biomass, phytoplankton nutrient and carbon uptake rates were measured in addition to monitoring of nutrients and chlorophyll. Cruises were made across 13 stations that spanned salinities of 0 to 25, between Isleton in the Sacramento River and Central San Francisco Bay. In 2014, nutrients were elevated to levels not seen in recent history and four phytoplankton blooms, rare in this system, were observed. These blooms were evaluated for community composition and were dominated by diatoms, although one bloom in the shoals also had abundant chlorophytes. Higher productivity was measured during these blooms than in prior years. Blooms near the confluence of the Sacramento and San Joaquin Rivers primarily took up ammonium while blooms downstream in Suisun Bay took up both ammonium and nitrate. The interaction of anthropogenically derived nutrients with changes in climate (e.g. droughts) needs to be considered in decision making and resource management practices.

Keywords: drought, nitrate, phytoplankton,

Poster Topic: Primary Productivity

The Influence of Irradiance and Nutrients on the Growth of Two Diatoms Isolated from Northern San Francisco Bay

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Irradiance has long been hypothesized to exert a negative control on phytoplankton productivity and biomass accumulation in San Francisco Estuary. More recently, it has also been suggested that nitrogen type and concentration can exert a negative control on phytoplankton by selectively promoting certain taxa over others. Because investigations typically examine the impact of irradiance or nitrogen source separately, it's not clear which parameter exerts the greatest influence, or how the two parameters interact to impact phytoplankton. We isolated the diatoms *Thalassiosira weissflogii* and *Entomoneis paludosa* from Suisun Bay into pure monocultures in order to examine the interactive influences of varying irradiance simultaneously with varying the nitrogen type and concentration on phytoplankton productivity and growth. These freshly isolated strains were maintained at concentrations of nitrogen similar to concentrations at the time of isolation until the growth experiments were performed. Here we present the results of a nutrient-irradiance matrix with ammonium and nitrate additions varying from 20-1000 µmoles N L^{-1} and irradiance levels varying from 25 to 600 µmol photons m^{-2} s^{-1}. Effects on phytoplankton physiology were determined from measurements of photosystem II yield (F_v/F_m), ^{14}C primary productivity, cell abundance, and growth rates. The specific questions addressed with these experiments were: 1) Does changing the irradiance have a similar effect on phytoplankton growth as changing the nitrogen source or concentration? 2) Does changing the irradiance effect growth of phytoplankton using nitrate versus those using ammonium differently? And finally, 3) is the ammonium toxicity threshold of diatoms affected by irradiance?

Keywords: Diatoms, Growth Rate, Primary Productivity, Irradiance, Ammonium, Nitrate

Poster Topic: Primary Productivity

Temporal Trends of Benthic and Pelagic Primary Production in Historical Marshes

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Pelagic primary production has been well studied in the San Francisco Estuary (SFE), however there is much to learn about benthic photoautotrophs (i.e. the microphytobenthos), and their role as contributors to overall ecosystem function. Studies from other temperate estuaries suggest that the microphytobenthos has considerable impact on carbon cycles. This study aims to quantify primary production by both pelagic and benthic photoautotrophs at two historical SFE marshes, China Camp State Park (San Rafael, CA) and Rush Ranch (Suisun Marsh). These two sites differ in many environmental parameters including salinity, turbidity and hydrology. However both are reserved for recreational use only and are thus exposed to similar impacts. Primary production rates were assessed monthly (Mar-Sept 2015) using ^{13}C tracer incubations. Pelagic and benthic primary production rates were compared taking into account the differences in habitat afforded each group (i.e. the pelagic zone has more volume while mudflats support higher concentrations of algae). The results from this study will lead to increased understanding of how SFE wetland carbon cycling is impacted by both pelagic and benthic primary producers and how the food web quality of these areas might be affected by this cycling.

Keywords: Primary Production, Phytoplankton, Microphytobenthos, Food Web, Carbon Cycling, Wetlands, Marshes

Poster Topic: Primary Productivity

The Response of Bay Delta Phytoplankton Communities to Wastewater Ammonium Inputs and Changes in Irradiance

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The Bay Delta ecosystem exhibits unusually low levels of productivity, given the high levels of inorganic nutrient loading to the system. It has been suggested that anthropogenic ammonium (NH_4^+) loading inhibits nitrate (NO_3^-) uptake and growth of diatoms, thereby preventing blooms. From May 5-May 9, 2015, we conducted experimental manipulations and water column profiling research in the Bay Delta to assess the ecological effects of anthropogenic nutrient loading in the lower Sacramento River on phytoplankton growth, community structure, and dissolved inorganic nitrogen (N) uptake rates. We collected surface water at three locations, two located above and one below the Sacramento Regional wastewater treatment plant's diffuser pipe and incubated water for 48 hours. Experimental treatments included control, $+NH_4^+$ to 60 µM, $+NO_3^-$ to 7.5 µM, and added whole wastewater effluent containing 60 µM NH_4^+. The water was incubated at ambient water temperature in 10-L cubitainers at two light levels: 50% and 5% of surface irradiance. Over two days, chlorophyll *a* (Chl *a*) concentrations increased seven-fold in response to both the $+NH_4^+$ and effluent additions at the upstream stations in the 50% light treatment, suggesting strong phytoplankton growth in response to added NH_4^+. At all stations, Chl *a* accumulation was strongly affected by light limitation in the 5% light treatment. We also report changes in phytoplankton community structure, based on microscopy enumeration, HPLC pigment analysis, and analysis on a FlowCam, among treatments over the 48 hours. Additionally, we assessed variations in NO_3^- and NH_4^+ uptake and CO_2 fixation across treatments over the course of the incubation. Taken as a whole, our results suggest that NH_4^+ from wastewater effluent does not inhibit phytoplankton growth in the Bay Delta, contrary to what has been previously suggested, and that light limitation plays a major role in controlling the productivity of the lower Sacramento River.

Keywords: ammonium, phytoplankton, nutrients, nitrogen, nitrate, wastewater, light uptake

Poster Topic: Primary Productivity