Effects of California's Drought on San Francisco Bay Specific Conductance and Temperature

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The current drought in California is poised to be the most significant in recent history. As the drought persists, reduced freshwater flows and increased demand on surface- and ground water reservoirs will allow coastal ocean waters to intrude further inland in the San Francisco Bay-Delta Estuary. For this study we analyzed up to 24 years of continuous records of specific conductance and temperature collected in San Francisco Bay (Bay). Salinity can be calculated from specific conductance and they covary. Instruments equipped with specific conductance and temperature sensors recording every 15 minutes were deployed at seven fixed locations throughout the Bay—Benicia Bridge, Carquinez Bridge, Richmond-San Rafael Bridge, Alcatraz Island, San Mateo Bridge, Dumbarton Bridge, and Alviso Slough (listed geographically from north to south). Five of the locations were deep enough to deploy instruments at two depths in the water column to assess vertical variations, for a total of 12 instruments and 145 sensor-years of data. During water year (WY) 2014 (1 Oct 2013 through 30 Sep 2014), record-high values were observed for nine specific conductance and seven temperature sensors. For specific conductance, the maximum values were lowest in the northeastern region (nearest the major source of freshwater inflow) and highest in the southern extent of the Bay (far from ocean boundary). For temperature, the maximum values generally increased moving landward from the ocean boundary in both north and south directions. The quantity of record high values we observed during WY2014 is unprecedented and demonstrates both the effect of the drought on the Bay and the value of long-term monitoring. Better understanding of the effects of reduced flows from the Delta and their impact on the natural and human environment in the Bay will provide insight on potential effects from future droughts or other reductions in Delta flow.

Keywords: water quality, monitoring, drought

Poster Topic: Regional Monitoring Program for Water Quality in San Francisco Bay

Evaluation of Mercury and PCB Trends in San Francisco Bay Region Stormwater

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San Francisco Bay is listed as a water body impaired due to chemical pollution, including mercury and polychlorinated biphenyls (PCBs) bioaccumulating in fish consumed by wildlife and humans. This has led to development of Total Maximum Daily Load (TMDL) control plans for these legacy contaminants, which call for significant reductions in stormwater loads. Some challenges of evaluating the efficacy of these plans include: (1) the heterogeneous distribution of these contaminants in urban areas (particularly PCBs), (2) the difficulty of representatively sampling episodic and individually unique storm events, (3) the mixing of loads from managed and unmanaged areas, and (4) climatic variation leading to highly variable interannual loads. All these factors confound the differentiation of impacts of management action from those arising from other drivers of environmental spatial and temporal variability. Work is ongoing to develop a set of trends indicators to allow local stakeholders to measure the benefits of implemented and planned management actions. We examined data for samples from various watersheds collected since 2010. Parameters such as contaminant concentrations directly measured on solids collected from stormwater, or surrogate measures such as whole water contaminant concentrations normalized to suspended sediment concentration (SSC), show promise for reducing the uncertainty from climatic variation in characterizing loads from some watersheds. However, there remain unknown or poorly characterized factors affecting contaminant delivery for other watersheds. Power analyses using currently available data suggest that for the least variable watersheds, modest changes arising from management action may be detectable within a decadal time frame. However, for the most variable watersheds, much larger reductions over a longer multi-decadal scale may be needed to distinguish benefits of management action with any reasonable or usable degree of certainty.

Keywords: stormwater, trends, PCB, mercury

Poster Topic: Regional Monitoring Program for Water Quality in San Francisco Bay

Fipronil Water Pollution and Its Sources

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Both professional and non-professional urban pesticide users are shifting to new pest control chemicals, partly in response to California state regulatory actions addressing widespread aquatic toxicity from pyrethroid insecticides. The first alternative to pyrethroids to gain significant urban market share in California is fipronil. Fipronil is a phenylpyrazole insecticide with multiple stable degradates, some of which are more toxic to aquatic organisms than the parent chemical. California fipronil sales nearly tripled from 2003 to 2011. In California, fipronil is used for structural pest control and pet treatments; it is not approved for agricultural use. Except in the Coachella Valley (Palm Springs region), fipronil may not be used on landscaping in California. Recent monitoring has revealed the presence of fipronil and its degradates in urban runoff, municipal wastewater treatment plant effluent, and in both water and sediment in rivers, streams, and estuaries. Measured fipronil and degradate concentrations are reaching—and in some cases exceeding—concentrations known to cause toxicity to sensitive aquatic organisms. Based on fipronil use patterns, urban drainage designs, monitoring data, and environmental fate data, the most likely source (outdoor structural pest control) and pathways for fipronil to move into urban runoff are relatively clear. Further exploration is needed to determine the major source for fipronil flowing into municipal wastewater treatment plants, which may relate to pet treatments and/or structural pest control applications, uses not typically considered likely to entail discharges to the sewer system. Additional urban monitoring data, particularly data characterizing the presence of fipronil and its degradates in wastewater influent, effluent, biosolids, estuaries and sediments, would strengthen understanding of the types of urban areas with fipronil water pollution. Toxicity testing (particularly with *Chironomus dilutes* and *Americamysis bahia*) paired with chemical analysis of environmental samples is recommended. Degradates warrant further characterization (toxicity, chemical properties, environmental fate).

Keywords: Pesticides, Fipronil, Surface water, Wastewater, Stormwater, Sources

Poster Topic: Regional Monitoring Program for Water Quality in San Francisco Bay

Microplastic Contamination in San Francisco Bay

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Microplastic is a term used to describe fragments of plastic 5 mm or smaller. Sources of aquatic microplastic pollution include microbeads used in personal care products such as facial scrubs and toothpastes, pellets used as precursors for industrial products, plastic fibers derived from washing clothes made with synthetic materials, and fragments of larger plastic items. Motivated by recent state and federal efforts to ban microbeads in personal care products, the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) characterized Bay surface waters and wastewater treatment plant (WWTP) effluents for microplastic contaminants. Nine Central and South Bay surface water samples were collected using a manta trawl. Two-hour sieved samples of effluent were collected from eight WWTPs discharging to the Bay. Microplastics in samples were characterized by size, type, and abundance. Preliminary results from this survey for plastic pollution in the San Francisco Bay are presented.

Keywords: Microplastic, microbeads, RMP, wastewater, effluents, San Francisco Bay

Poster Topic: Regional Monitoring Program for Water Quality in San Francisco Bay

Poly- and Perfluoroalkyl Substances in Wastewater Effluent Discharged to SF Bay

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Perfluorooctane sulfonate (PFOS) has been measured at persistently high concentrations in San Francisco Bay wildlife. To assess potential sources of PFOS and other poly- and perfluoroalkyl substances (PFASs) to the region, wastewater effluent samples from eight local treatment plants were collected for PFAS analysis. Wastewater samples were analyzed directly for a suite of PFASs and were also subjected to an oxidation assay to indirectly estimate the total concentration of polyfluorinated compounds.

Effluent collected from the San Francisco Airport industrial treatment plant and Fairfield Suisun contained the highest total concentrations of individually measured PFASs, 2900 ng/L and 450 ng/L, respectively. Both these treatment plants receive runoff from areas that are likely impacted by aqueous film forming foam, a major source of PFASs. In the other six effluent samples, between 75 and 150 ng/L of individual PFASs were measured. Short chain perfluorinated acids (i.e., C6 and shorter perfluorinated carboxylates) predominated in most samples, followed by the C8 forms, PFOS and PFOA. Polyfluorinated species that were indirectly measured accounted for 30% to 60% of total molar PFASs, and also indicated a predominance of short chain species in all the effluent samples. These results overall indicate that C8 PFASs are waning relative to their shorter chain counterparts in SF Bay effluent.

The views expressed herein are those of the authors and do not necessarily reflect those of the California Department of Toxic Substances Control.

Keywords: perfluorinated, PFC, PFAS, PFOS, wastewater effluent, AFFF

Poster Topic: Regional Monitoring Program for Water Quality in San Francisco Bay

Biogeochemical Effects of Shifts in Ammonia-Oxidizing Microbial Community Structure and Gene Expression in the Waters of Suisun Bay and the Sacramento River

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Ammonia oxidation is the link between reduced and oxidized forms of inorganic nitrogen, and is therefore a crucial step in the aquatic nitrogen cycle. Yet, the microbial ecology and biogeochemistry of this process is largely unknown in estuary and river waters. Few studies have measured nitrification rates in tandem with functional gene (*amoA*) expression, abundance, and diversity, yet these organisms and this process are a critical link in the nitrogen cycle of nutrient-rich estuaries. We sampled diverse regions throughout northern San Francisco Bay and the lower Sacramento River to determine the community structure and biogeochemical impact of ammonia-oxidizing microbes, using functional gene-based PCR assays and stable isotope tracer experiments to quantify the microbial ecology and biogeochemistry of nitrification, respectively. Ammonia-oxidizing archaea (AOA) generally outnumbered ammonia-oxidizing bacteria (AOB) throughout the sampled gradient, though the relative abundance of AOB increased in brackish regions. AOA were always numerically dominant in the Sacramento River. Based on gene diversity, distinct AOA communities were present in fresh, brackish, and marine waters, whereas AOB were split into freshwater and non-freshwater communities. mRNA expression of *amoA* appeared to largely track DNA abundance, but suggested only a fraction of the ammonia-oxidizing community was typically active. While the pulse of ammonium delivered via wastewater discharge had little effect on microbial abundance, nitrification rates and gene expression increased downstream of the discharge site. Profiles of nitrification rates also suggested high biogeochemical activity near the sediment-water interface. This work increases our knowledge of the ecology and dynamics of ammonia oxidizers in the San Francisco Bay-Delta, and provides an initial attempt to link nitrification rates to microbial gene expression in this river and estuary.

Keywords: nitrogen, biogeochemistry, ammonium, microbiology, salinity, ecology, archaea, bacteria, isotopes

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