Characterizing Nutrient TRENDS, Loads, and Transformations in Suisun Bay and the Delta

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Introduction

The conceptual model for the Pelagic Organism Decline recognizes that multiple factors may act in concert to degrade habitat in Suisun Bay and the Delta (Baxter et al., 2010).

Anthropogenic nutrient loads are considered to be one potential factor: recent studies hypothesize that anthropogenically-altered nutrient concentrations or ratios exert bottom-up pressures on Delta and Suisun food webs (e.g., Dugdale et al., 2007; Parker et al., 2012; Glibert et al., 2011). Understanding the underlying causes of habitat degradation and the POD requires a broad and integrated analysis of all potential drivers. In addition, a better understanding of nutrient concentrations, sources, and fate in Suisun Bay and the Delta is necessary in order to inform near-term nutrient management decisions.

The goals of this project are to use existing data resources to:

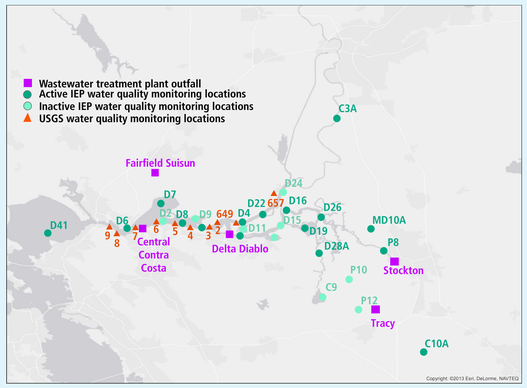
1. Explore seasonal, spatial, and temporal variability in nutrient concentrations, particularly forms of nitrogen, in Suisun Bay and the Delta.
2. Estimate nutrients loads into and out of these systems.
3. Assess the importance of nutrient transformations.

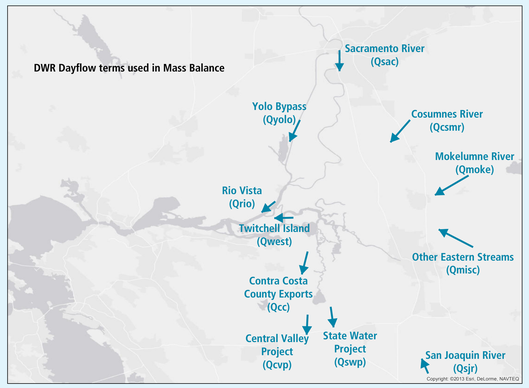
Methods

DATA SOURCES

Monthly monitoring data from the U.S. Geological Survey (USGS) and the CA Department of Water Resources Interagency Ecological Program (DWR/IEP) were used to assess long-term trends in nutrient concentrations. While data is available for a number of physical and chemical properties, the data analysis here focuses on forms of dissolved inorganic nitrogen (DIN). Long-term trends in advective nutrient loads into and out of the Delta and Suisun Bay were assessed using this water quality data in combination with flow data from DWR's Dayflow Program, following the approach used by Jassby and Cloern (2000) for organic matter. Due to limited availability of POTW effluent data, a full-scale mass balance, including estimates of DIN loss, was only performed for the period of 2006-2011.

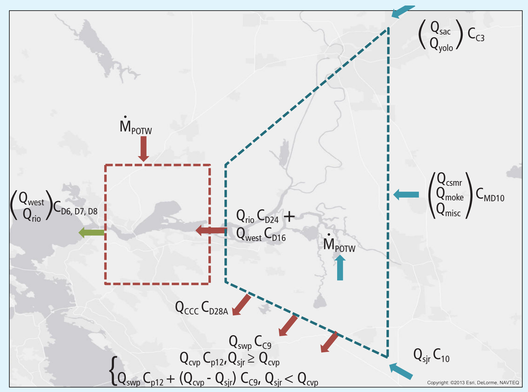
Source	*Period of Record used*	*Parameters used*
Water Quality Data		
USGS	1975-2011	NH4+, NO3-
DWR/IEP	1975-2011	NH4+, NO3-
Flow		
DWR - Dayflow	1975-2011	Flow
Publicly Owned Treatment Works (POTW) loads*		
Central Contra Costa	2006-2011	Flow, NH4+, NO3-
Delta Diablo	2007-2011	Flow, NH4+, NO3-
Fairfield-Suisun	2004-2011	Flow, NH4+, NO3-
Tracy	2007-2011	Flow, NH4+, NO3-
Stockton	2007-2009	Flow, NH4+, NO3-





LOADS ESTIMATION

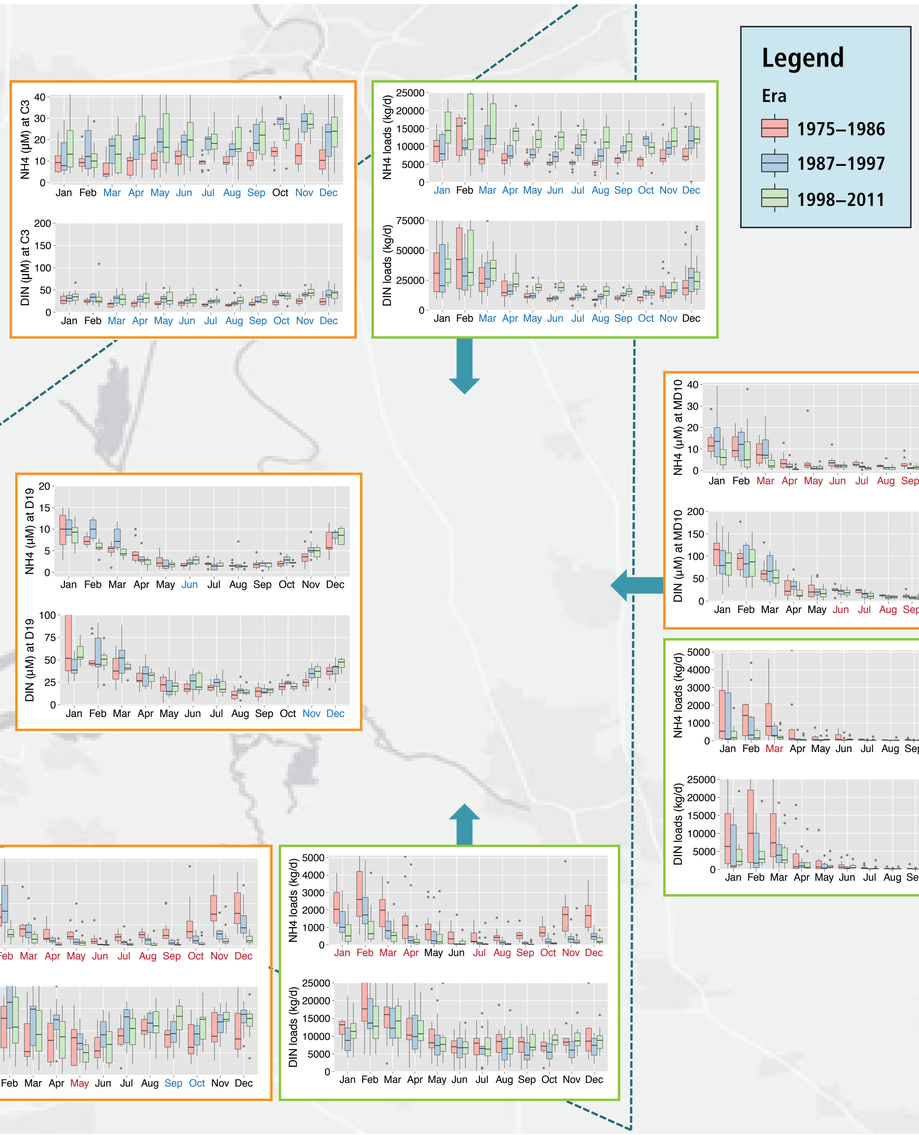
Loads were estimated in a method similar to Jassby and Cloern (2000). After 1995, some stations were discontinued and were replaced with the best linear combination of nearby stations. Internal loads from agricultural return were not considered.



Trends

Concentrations (μM) and loads (kg d-1) of both NH4+ and DIN at select locations within Suisun Bay and the Delta were divided into three eras and averaged by month in order to assess both seasonal and temporal trends. Months in which trends were statistically significant are highlighted blue (positive) and red (negative).

- The Sacramento River is the major source of water at D19 (M. Guerin, pers comm), but the seasonal trends in NH4+ seen at D19 are absent at C3, suggesting significant transformation along this path during summer months
- Both NH4+ and DIN Loads into the Delta along the Sacramento River have increased from 1975-2011, most notably between the first and second era. This corresponds with a similar increase in [NH4+] and [DIN] at station C3
- Loads into the Delta along other advective pathways have not increased similarly
- Both loads into and concentrations within Suisun Bay, of both NH4+ and DIN, have increased significantly during summer months



Current Conditions: 2006-2011

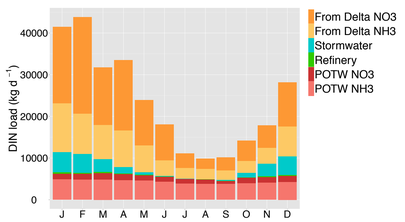
LOADS

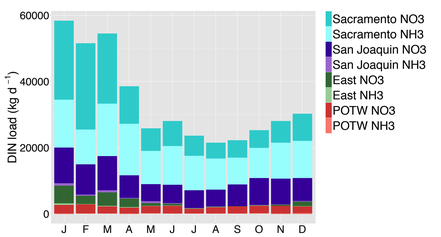
Into Suisun Bay

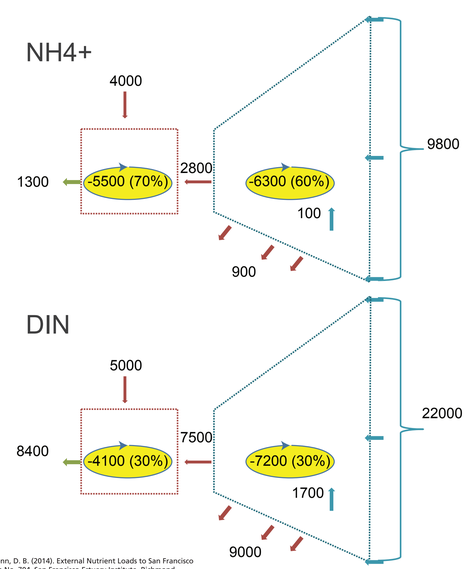
- Delta efflux loads show strong seasonal variability, likely due to changes in flow
- Delta efflux loads are the dominant source of both NH4+ and NO3- during high flow months
- POTWs contribute comparable loads of NH4+ during summer months

Into the Delta

- During all months,NH4+ and NO3- loads from direct POTW discharge to the Delta are small compared to advective river loads
- Loads along the Sacramento River are the dominant source of advective river loads
- All advective river loads show strong seasonal variability, particularly of NO3-







Mass Balance: June - October (kg d^{-1})

A rough mass-balance was performed for both Suisun Bay and the Delta for June-October, when conditions could be approximated as steady state.

NH4+ and DIN losses in Suisun Bay are on the order of roughly 0.1/d and 0.02/d (respectively).

Overall loss of DIN suggests both nitrification and denitrification may be occurring during these warm, low-flow summer months.

Next Steps

Refine delta load estimates and transformations, including uncertainty analysis and use of water quality models (DSM2-HYDRO and DSM2-QUAL).

Estimate internal agricultural nutrient loads within the Delta, and extend mass balance to TN and TP.

Using water quality models and isotope data in the Delta, better constrain nutrient transformation estimates and internal loads, and identify conditions (where, when) that most strongly influence transformations.

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References

Baxter, R., Breuer, R., Brown, L., Conrad, L., Feyrer, F., Fong, S., Gehrts, K., Grimaldo, L., Herbold, B., Hrodey, P., Mueller-Solger, A., Sommer, T., Souza, K. (2010). Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and synthesis of results. University of California, Davis, California: http://www.water.ca.gov/iep/docs/FinaPOD- 2010Workplan12610.pdf

Dugdale, R.C., F.P. Wilkerson, V.E. Hogue and A. Marchi, (2007). The role of ammonium and nitrate in spring bloom development in San Francisco Bay. 2007. Estuarine, Coastal and Shelf Science 73: 17-29

Glibert, P. M., D. Fullerton, J. M. Burkholder, J. C. Cornwell, and T. M. Kana. (2011). Ecological stoichiometry, biogeochemical cycling, invasive species, and aquatic food webs: San Francisco Estuary and Comparative Systems. Reviews in Fisheries Science 19:358-417.

Jassby, A.D., and Cloern, J.E. (2000) Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems 10: 323–352.

Novick, E. and Senn, D. B. (2014). External Nutrient Loads to San Francisco Bay. Contribution No. 704. San Francisco Estuary Institute, Richmond, California.

Parker, A.E., Dugdale, R.C., F.P. Wilkerson (2012) Elevated ammonium concentrations from wastewater discharge depress primary productivity in the Sacramento River and the Northern San Francisco Estuary. Mar. Pollut. Bull. 64(3):574-86.

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