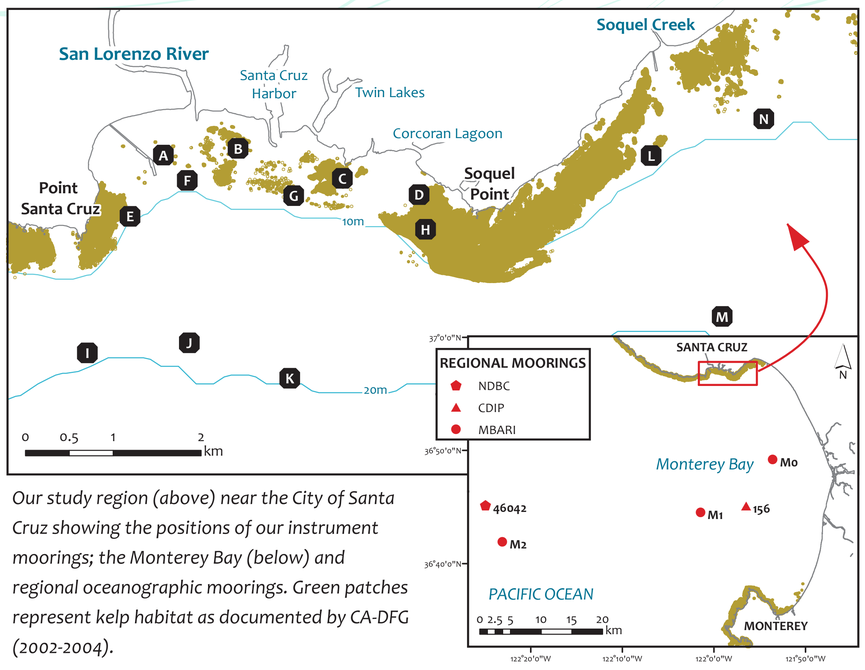
An Interdisciplinary Approach to Understanding Runoff & Nearshore 'Zones of Impact': Example of the San Lorenzo River (Santa Cruz, CA)

Lauren E. Garske[1], John L. Largier[1], Peter G. Green[2]

[1] Bodega Marine Laboratory and Department of Environmental Science & Policy, University of California at Davis, USA

[2] Department of Civil & Environmental Engineering, University of California at Davis, USA



Our study region (above) near the City of Santa Cruz showing the positions of our instrument moorings; the Monterey Bay (below) and regional oceanographic moorings. Green patches represent kelp habitat as documented by CA-DFG (2002-2004).

Objectives

Using the San Lorenzo River (SLR) and nearby kelp forest habitats in the northern Monterey Bay, we are developing a portable statistical model with the ZOI framework to:

- identify the nearshore areas and periods that may be physically susceptible to runoff pollution impacts;
- investigate nearshore exposure to dissolved metals during runoff events.

Background

A 'zone of impact' (ZOI) is the area/period where/when one expects runoff pollution to impact humans and/or ecosystems due to inadequate dilution. Assuming $\infty > t_{\text{biogeochem rxns}} >> t_{\text{physical transport \& mixing}}$, a ZOI should be approximately common for physical systems although its boundaries will vary among constituent species.

As ZOIs relate to the nearshore ocean environment (< 30m depth and < 2km from shore) and the small-scale freshwater inflows (daily mean < 100 m^3s^{-1}) commonly occuring along the California coast, they are poorly understood but arguably important for investigating the potential impacts of freshwater runoff in both intertidal and subtidal habitats.

Methods

The material presented here was collected during field efforts in April 2008 - June 2009. Data from regional sensors (see map inset) is available as reference for Bay waters but for high-resolution information from the nearshore, we deployed:

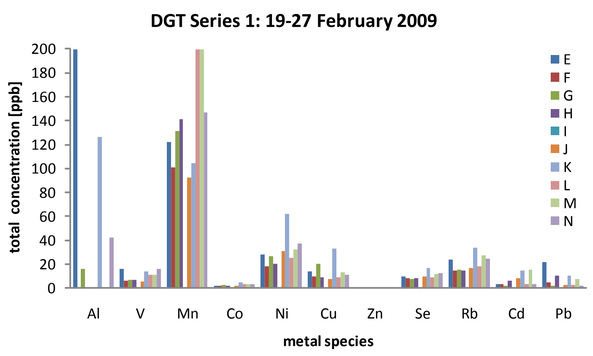
- moored arrays of temperature-salinity sensors (SeaBird Electronics 37SMs) 1 m below the ocean surface @ 7, 10 & 20 m isobaths, logging at 2-minute intervals
- diffusive gradient thin-films (DGT Research Ltd) for integrated measures of dissolved metals in surface waters, 3 sequential 1-week deployments as part of a preliminary study; analyzed with ICP-MS

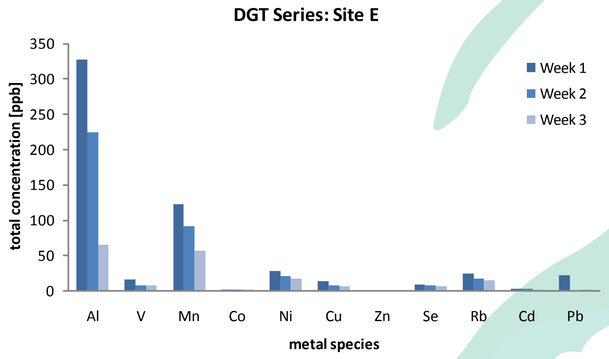
Results

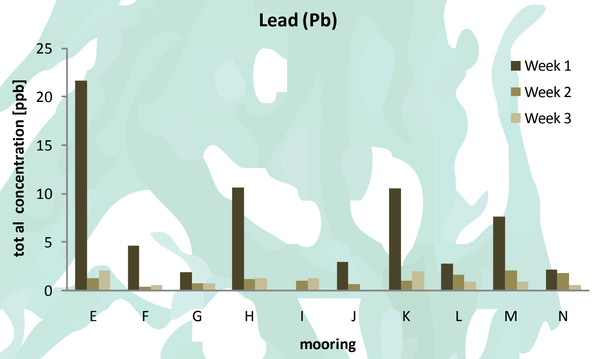
In the table below, we present the probabilities of a given dilution factor (DF) at each of the moorings for the seasons deployed. DFs were calculated as $100/(100 \times (S_{ref} - S_{obs})/S_{ref}) - 1$ where S_{ref} is the concurrent salinity at the Mo mooring. Note that a drop of 33.4 $^o/_{oo}$ to 33.1 $^o/_{oo}$ corresponds to DF ~ 100.

	SPRING 2008			FALL 2008			WINTER 2009			SPRING 2009			DGT-1			DGT-2			DGT-3		
dates	17 Apr-23 May 2008			13 Oct-10 Dec 2008			12 Dec-20 Mar 2009			1 Apr-4 Jun 2009			19-27 Feb 2009			27 Feb-6 Mar 2009			6-12 Mar 2009		
precipitation	12 mm			70 mm			450 mm			57 mm			63.3 mm			37.1 mm			0.5 mm		
mean discharge	0.64 (1.1) m^3s^{-1}			0.47 (6.6) m^3s^{-1}			4.8 (69.0) m^3s^{-1}			1.0 (1.8) m^3s^{-1}			12.7 (41.6) m^3s^{-1}			12.6 (25.2) m^3s^{-1}			7.0 (11.7) m^3s^{-1}		
MOORING	DF<10	DF<100	DF<1000	DF<10	DF<100	DF<1000	DF<10	DF<100	DF<1000	DF<10	DF<100	DF<1000	DF<10	DF<100	DF<1000	DF<10	DF<100	DF<1000	DF<10	DF<100	DF<1000
A	0.0000	0.0638	0.7657																		
B	0.0000	0.0383	0.7865																		
C	0.0000	0.0267	0.5377																		
D	0.0000	0.0012	0.4809																		
E	0.0000	0.0139	0.5597				0.0529	0.8112	0.9978				0.1186	0.9742	1.0000	0.1479	1.0000	1.0000	0.0000	0.9580	0.9930
F	0.0000	0.0440	0.9873	0.0031	0.1883	0.6926	0.0344	0.3521	0.9845	0.0000	0.0630	0.7500	0.0670	0.9433	0.9897	0.1598	1.0000	1.0000	0.0000	0.6503	0.9930
G	0.0000	0.1217	0.9977	0.0039	0.4459	0.7370	0.0297	0.3194	0.9780	0.0000	0.0688	0.8396	0.0923	0.9282	0.9795	0.1310	1.0000	1.0000	0.0000	0.6224	0.9930
H	0.0000	0.0012	0.8876				0.0499	0.3866	0.8291				0.0863	0.7056	0.9492	0.1012	0.9821	1.0000	0.0000	0.2639	0.9444
I							0.0017	0.4275	0.9087				0.0000	0.8418	0.9745	0.0000	0.9405	1.0000	0.0070	0.5035	0.9930
J							0.0013	0.2300	0.8160	0.0000	0.0312	0.8480	0.0051	0.8359	0.9692	0.0000	0.9286	1.0000	0.0000	0.4056	0.9720
K							0.0017	0.2020	0.8070	0.0000	0.0052	0.5189	0.0103	0.8410	0.9692	0.0000	0.8698	1.0000	0.0000	0.4225	0.9648
L				0.0000	0.2903	0.4941	0.0034	0.4689	0.9566				0.0051	0.7563	0.9695	0.0000	0.9527	0.9941	0.0070	0.4126	0.9930
M							0.0000	0.3305	0.7223				0.0000	0.6616	0.9192	0.0000	0.8988	0.9940	0.0070	0.1259	0.7832

Selected results for dissolved metals: (left) first week of DGT deployments, including the largest precipitation/runoff event of the series; (center) the 3-week series at Mooring E for 11 species, where the probability of DF<100 is greatest among the array of sites; (right) the 3-week series for lead (Pb) as an example of trends occurring across several species.







Discussion Points

- As a foundation for our ongoing investigations, this work provides seasonal estimates for local exposure to SLR runoff. The data suggests that Site E, in the kelp forest southwest of the river mouth, is often at greatest risk for pollutant exposure.
- Preliminary results for measured metal loads offers clues as to which pollutant species may be important to consider - for example, Al and Pb appear to spike during runoff events; Zn is non-detectable; Cu peaks near the Santa Cruz Harbor sites.
- Winter 2009-2010 Season Repeat deployment of Moorings E-H (at the outer edges of kelp beds) with additional T-S sensors near the seafloor; biweekly rotation of DGTs at the moorings (2 depths); water samples and kelp tissue from throughout the area (for metals analysis with ICP-MS).

Acknowlegments Many thanks to those who have supported this work; in particular, C. Storlazzi and C. Conway at the USGS; D. Dann, M. Robart, and M. Sheridan at Bodega Marine Lab; J. Douglas at Moss Landing Marine Labs; the PISCO Subtidal Team, M. Carr, and S. Clabeusch at UC Santa Cruz; and J. Ryan at MBARI. This work was conducted under MBNMS permit # 2007-0017 to L.E.G and J.L.L. Financial support was provided by NSF Grant # 0525765 to J.L.L. and a 2009 Dr. Nancy Foster Scholarship (NOAA) to L.E.G.

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