Toxcity of Dry Weather Flow in Ballona Creek

Ballona Creek is one of the few flood control channels that flows throughout the year into Santa Monica Bay. In addition to receiving surface runoff from streets and commercial and industrial properties during storms, Ballona Creek receives discharges from a variety of sources throughout the year (e.g., groundwater pumping and decontamination, swimming pool drainage, and dehumidifier condensate).

Previous studies by SCCWRP measured the chemical composition and toxicity of samples collected from Ballona Creek during storms. The concentrations of oil and grease, cadmium, chromium, copper, and nickel in stormwater samples from Ballona Creek are higher than concentrations in stormwater samples from several other channels in southern California (Schafer and Gossett 1988), and are comparable to concentrations in sewage effluents discharged into Santa Monica Bay. The concentrations of lead, zinc, total DDT, and total PCB in stormwater samples from Ballona Creek are greater than concentrations in sewage effluents discharged into the bay. The toxicity of Ballona Creek stormwater samples is similar to the toxicity of stormwater samples from the Los Angeles River, the largest source of gauged runoff in Southern California (SCCWRP 1989).

Storm drain warning

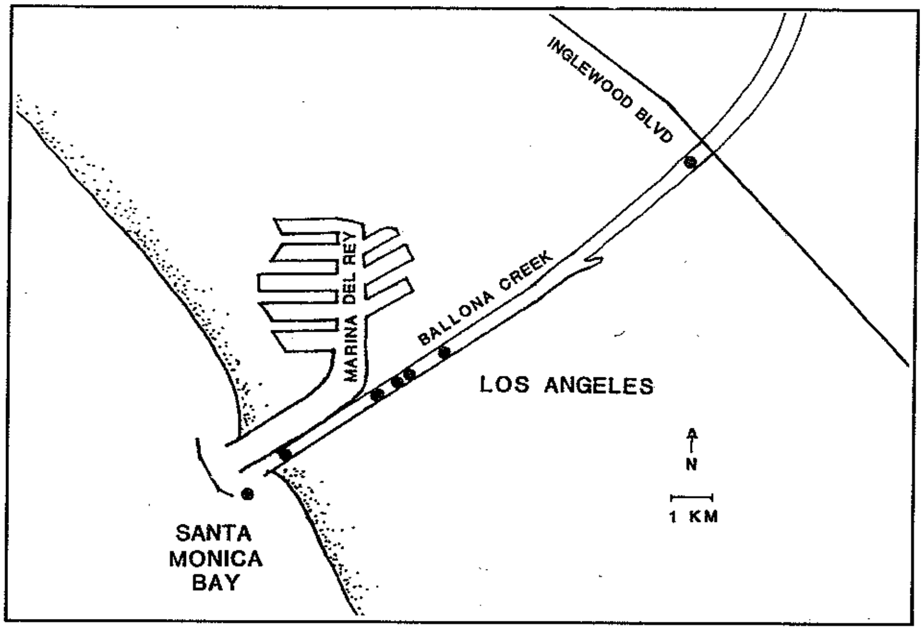
Elevated levels of contaminants are also present in Ballona Creek dry weather flow (SCCWRP, unpublished data), but we have not measured the toxicity of dry weather discharge to marine animals. The object of this study was to determine the toxicity of dry weather flow in Ballona Creek to sea urchin gametes and embryos. We compared the sensitivity of the two toxicity tests and examined the variability in toxicity over different temporal scales (hours and months). Sea urchin toxicity tests provide data useful for assessing impacts in the environment because sea urchins inhabit rocky intertidal areas of Santa Monica Bay and their larvae are found in the water column.

Materials and Methods Sampling

Three water samples were collected at hourly intervals on the afternoon of December 10, 1990 below the Inglewood Street overpass of Ballona Creek (Figure 1). Samples were collected from the center of the channel with a glass bottle. The collection site was above the tidal prism and contained undiluted dry weather flow; samples from this site had a salinity of 0 mg/g. Two additional water samples were collected from this location on February 25, 1991. Sampling in December was preceded by 21 days of dry weather, while sampling in February was preceded by 47 days of dry weather.

Surface water samples from six areas near the mouth of Ballona Creek were also collected on February 25 (Figure 1). These stations were within the mixing zone of Ballona Creek discharge with ocean water. Conductivity measurements indicated that the water samples contained 0-22% creek water.

Figure 1
Location of water sampling sites in Ballona Creek.



Sample preparation

The water samples were stored at 5°C and tested for toxicity within 24 h. Each of the Inglewood Street samples was diluted with filtered natural seawater (34 ppt salinity) to produce concentrations of 2-32% dry weather flow. Dilutions of distilled water with natural seawater were used to test the effects of variable salinities. Receiving water samples from the mouth of Ballona Creek were tested at full strength.

Seawater controls were used to document the health of the test organisms and to provide a reference for identifying toxic effects. We also used a series of reference toxicant dilutions ($CuCl_2 \cdot 2H_2O$ in seawater) in each toxicity test to document relative sensitivity between test dates. The pH of some Ballona Creek samples was adjusted by adding either 0.1 N HCl or 0.1 N NaOH.

Test procedures

Purple sea urchins *(Strongylocentrotus purpuratus)* were collected from the intertidal near Point Dume in northern Santa Monica Bay. The urchins were held in recirculating seawater aquaria at 13-15°C until the tests were performed.

Three or four replicates of each sample were tested for toxicity at 15°C. All samples were tested with the sea urchin fertilization test; one sample from December was also tested with the embryo development test. The fertilization test followed the procedures of Dinnel *et al.* (1987) and consisted of a 60 min exposure of sperm to the test samples. Eggs were then added to the samples and allowed 20 min for fertilization to occur. Preserved samples were examined under a microscope and the percent of eggs fertilized was determined. Reduced fertilization is an indicator of toxic effects.

The embryo development test consisted of a 48 h exposure and followed the procedures described in Long *et al.* (1990). Preserved embryo samples were examined under a microscope to detect developmental abnormalities, indicators of toxic effects. Normal embryos have a pyramid shape, differentiated gut, and well-developed skeletal rods. Abnormal embryos exhibit either a delayed rate of development, or pathological conditions such as aberrant cleavage and cell death.

Statistical significance was determined by analysis of variance and Dunnett's multiple comparison test of the toxicity data (relative to controls). Raw proportion data were transformed by the arcsine for the analyses. The concentration of sample producing the median toxic response (EC50) was estimated using probit analysis.

Results

Relative sensitivity

Dilutions of the December 1990 Ballona Creek sample were toxic to both sea urchin sperm and embryos (Figure 2). The fertilization test was more strongly affected than the development test by sample concentrations of 10% and greater.

Control percent fertilization was high in the December and February sea urchin sperm tests (95-98%; Table 1). There was little variability in toxicity among the Inglewood Street samples, or among samples collected on the same day (Table 1). The February Ballona Creek samples were slightly more toxic (EC50 = 6%) than the December samples (EC50 = 10%).

Results of the copper reference toxicant were similar between experiments (Table 1). The fertilization test in February was slightly more sensitive to copper (EC50 = 13 µg/L) than the fertilization test in December (EC50 = 19 µg/L).

The fertilization test results were unaffected by salinity changes over the range of 28-34 mg/g (Table 1). Large reductions in fertilization were produced by Ballona Creek dry weather flow dilutions with salinities of 30-32 mg/g, well within the range tolerated by the sperm.

The pH of undiluted dry weather flow was unexpectedly high in both sets of samples (pH 10.1). Consequently, the pH of test samples containing more than 5% Ballona Creek effluent was greater than the control (pH = 8.1; Table 1). The effect of pH on fertilization was tested on dilutions of a dry weather flow sample collected in February. The sample pH was adjusted to 8.1, the pH of the dilution seawater. Both the pH-adjusted and non-adjusted samples were toxic (Figure 3). However, the non-adjusted sample produced stronger effects on the sperm. At a concentration of 5.6%, fertilization in the non-adjusted sample was 53%. Fertilization in the adjusted sample was 89%, which was not significantly different from the control (Dunnett's test, $p>0.05$).

Figure 2

Response of sea urchin sperm (fertilization test) and embryos (development test) to various concentrations of Ballona Creek dry weather flow collected in December 1990. Data are mean ±1 standard error.

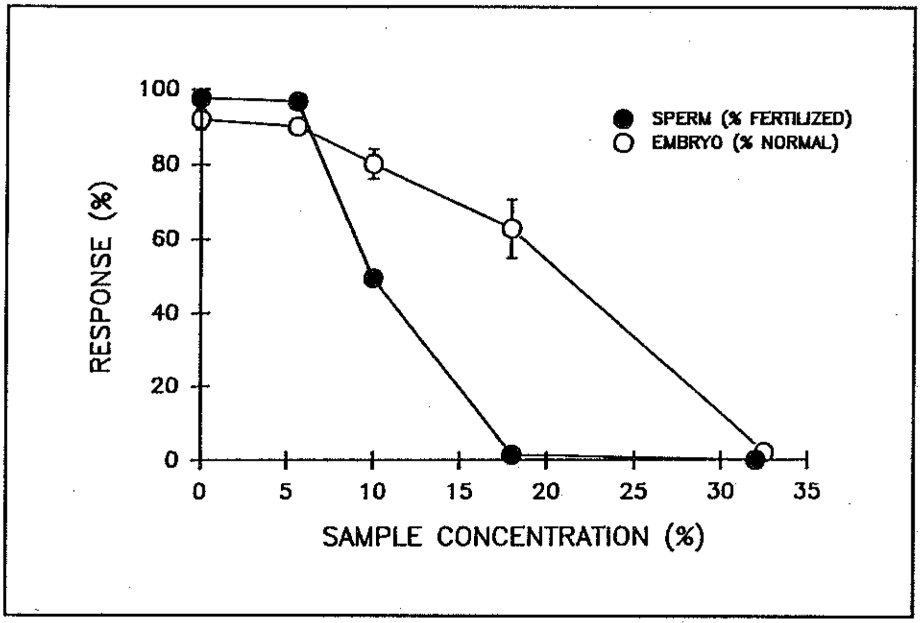
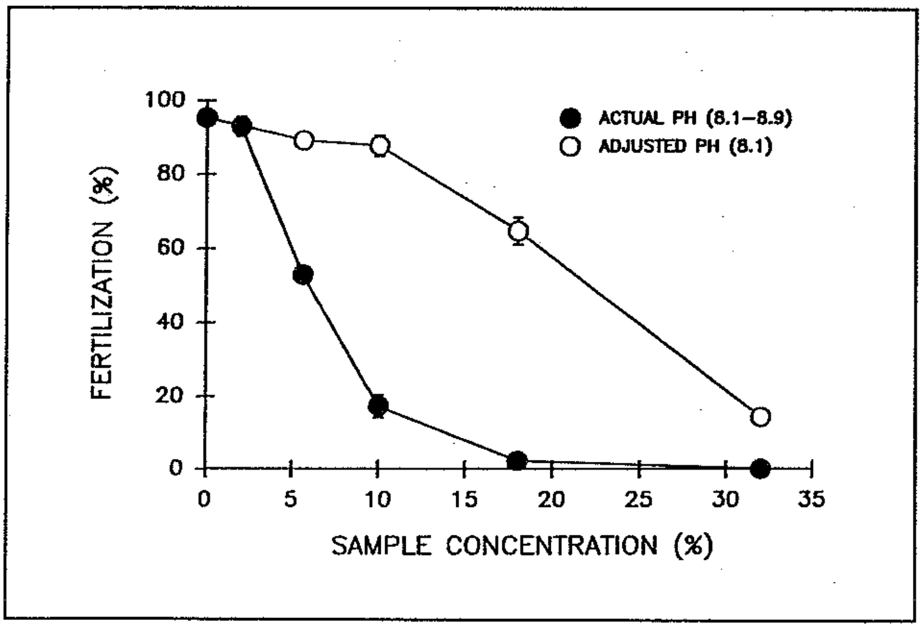


Figure 3

Influence of pH on fertilization test results of a February 1991 dry weather flow sample. Data are mean ±1 standard error.



Most of the receiving water samples from the mouth of Ballona Creek were toxic to sea urchin sperm (Table 2). High toxicity was present in samples from the upstream and downstream ends of the mixing zone. Samples from the middle of the mixing zone were the least toxic. The pattern of toxicity in Ballona Creek did not correspond to the amount of creek water in the sample; the greatest effects were produced by water samples containing no dry weather flow.

Discussion

Ballona Creek dry weather flow was toxic to sea urchin sperm and embryos at low concentrations. The level of toxicity was similar among samples taken the same day and among samples taken several months apart. The greater toxic effects of the February samples may have been the result of variations in test sensitivity, rather than changes in dry weather flow toxicity. This conclusion is supported by the reference toxicant and salinity control data; tests conducted in February were more sensitive than tests conducted in December.

Variation in sensitivity among tests is an inherent characteristic of most biological test methods. The acceptability of test results is based on the magnitude of sensitivity changes measured by reference toxicants. Results of reference toxicant tests should be interpreted cautiously, however. Variations in sensitivity to one reference toxicant may not be an accurate indicator of overall test performance, unless the reference material possesses the same mode of toxic action and chemical characteristics (e.g., changes in speciation with pH) as the unknown material(s) exerting toxicity in the samples. The differences in sperm sensitivity to copper in this study were relatively small in comparison to other data (SCCWRP 1990) and unlikely to have had a large influence on the results for the Ballona Creek water samples.

Sea urchin fertilization was more sensitive to Ballona Creek water samples than embryo development. The relative sensitivity of these toxicity tests depends on the toxicant(s) present. In this study, elevated pH was responsible for much of the toxicity. Sea urchin sperm are sensitive to pH; fluctuations as small as 0.2 units (e.g., pH 8.2 to 8.4) produce declines in percent fertilization (Bay *et al.* 1992). The embryo development test is similar in sensitivity to the fertilization test for other toxicants (e.g., copper) and is more sensitive in some cases (e.g., ammonia; Bay *et al.* 1992).

Table 1

Water quality characteristics and results of sea urchin fertilization tests of dry weather flow from Ballona Creek at Inglewood Street. Results are also presented for diluted seawater (salinity control) and dissolved copper (reference toxicant) tests. Fertilization (Fert) is mean ± 1SE (N = 3-4). Conc = percent of dry weather flow or distilled water in test sample; Sal = salinity; Rep = replicate sample.

	Ballona Creek						Salinity control			Reference toxicant	
	Conc (%)	Sal (mg/g)	pH	Fertilization (%) Rep1	Rep2	Rep3	Conc (%)	Sal (mg/g)	Fert (%)	Copper (µg/l)	Fert (%)
Dec 1990											
										3.2	99±1
	5.6	32	8.2	97±1	97±1	97±1	5.6	32	97±1	5.6	98±1
	10	30	8.3	50±2			10	30	97±1	10	97±1
	18	28	8.6	1±1			18	28	95±1	18	56±2
	32	24	9.0	0±0	0±0	0±0	32	23	73±1	32	2±1
Feb 1991											
	2	32	8.1	93±3						3.2	95±3
	5.6	32	8.2	53±1	61±7					5.6	88±4
	10	30	8.4	17±3	22±5		10	30	88±2	10	70±5
	18	28	8.5	2±1	14±2		18	28	84±3	18	20±11
	32	24	8.9	0±0			32	23	27±5	32	0±0

The toxicity detected in Ballona Creek dry weather flow is the result of toxic constituents in addition to altered pH. Salinity variations of 28-34 mg/g did not exert a major influence on test results.

The cause of high pH in Ballona Creek is unknown. None of the NPDES-permitted discharges to the creek has a high pH (S. Birosik, Los Angeles Regional Water Quality Control Board, personal communication). Altered pH may be the result of the normal metabolic activity of algae (uptake of dissolved CO_2 during photosynthesis) lining the concrete channels of the Ballona Creek drainage system. Algal metabolism raises pH in other waterbodies (Lee and Jones-Lee 1991).

The results of the receiving water tests indicated that water quality was reduced near the mouth of Ballona Creek. The spatial pattern of toxicity results suggested that there were upstream (dry weather flow) and downstream (Santa Monica Bay) sources of toxicity. Sources contributing to the toxicity of the receiving water may be contamination from nearby Marina del Rey or the release of toxicants from Ballona Creek sediments into the water.

This is the first of our efforts to understand the biological effects of nonpoint source pollutants on the marine environment. The toxicity of Ballona Creek dry weather flow and the receiving water was comparable to the toxicity of Southern California sewage effluents (SCCWRP 1990), yet much less effort has been expended to study the composition and toxicity of this and other urban drainages. In the future, more intensive studies of the potential effects of discharge from channels like Ballona Creek will be conducted by agencies such as the Santa Monica Bay Restoration Project. ■

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Table 2

Toxicity test results for samples of Ballona Creek dry weather flow and Santa Monica Bay receiving water (bay) in the sea urchin fertilization test. The amount of dry weather flow in each sample was based on conductivity measurements.

		Distance from Santa Monica Bay (km)				
	Bay	0.5	3.3	3.8	4.3	5.3
Fertilization (%)	16	16	54	90	62	21
Dry weather flow (%)	0	0	4	6	9	22

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