During the past several years, SCCWRP has been developing and evaluating methods useful for studying the toxicity of sediments in southern California. Reports elsewhere in this volume describe results obtained by using sea urchins (embryos and adults), shrimp, and fish larvae (see pp. 50, 58, and 70). In addition to these test systems, SCCWRP scientists Steven M. Bay and Darrin J. Greenstein have also been developing test methods with a local species of amphipod.

Short-term tests with marine amphipods have been widely used to assess sediment toxicity. This group of crustaceans contains species that burrow or build tubes in the sediment. Previous studies have demonstrated the sensitivity of amphipods to environmentally realistic levels of pollutants (Swartz et al. 1982). The most commonly used species, *Rhepoxynius abronius*, does not occur in high enough densities in southern California to be used in tests. This species is also stressed by the silty sediments characteristic of sewage outfall sites and other contaminated areas.

Initial toxicity studies with amphipods at SCCWRP have focused upon the species *Grandidierella japonica*. This is a tube-dwelling species common in intertidal and shallow estuarine areas of central and southern California. *G. japonica* has several characteristics that indicate its potential value in sediment toxicity studies. This species has a short generation time in laboratory culture (30 days at 19°C) and is tolerant of wide fluctuations in temperature, salinity, and sediment grain size.

Preliminary studies by Dr. Donald J. Reish of California State University, Long Beach (CSULB), demonstrated the utility of this species for sediment toxicity testing. With the assistance of Dr. Marion Nipper, a visiting environmental scientist from Brazil, Bay and Greenstein refined the acute test methods developed at CSULB and also developed a chronic test.

Toxicity of Contaminated Sediments to the Amphipod Grandidierella japonica

G. japonica was one of three test species used in a survey of sediment toxicity, contamination, and infauna funded by the California State Water Resources Control Board. All of the results from this project will be reported later, when the chemical and statistical analyses are complete. The effects of sediment from several highly contaminated sites in southern California on amphipod survival, reburial, and growth are reported here. To discriminate between pollutant effects and other environmental factors, the sediments were also analyzed for chemical composition, grain size, and organic carbon content.

Sediments were collected from a total of 11 southern California coastal areas (Figure 1). These sites included a relatively uncontaminated reference area, industrialized harbors, and areas adjacent to three large municipal wastewater outfalls. Sediment from the amphipod collection site in Newport Bay was collected for use as a control. A wide range of sediment texture and contamination levels was represented by these locations (Table 1).

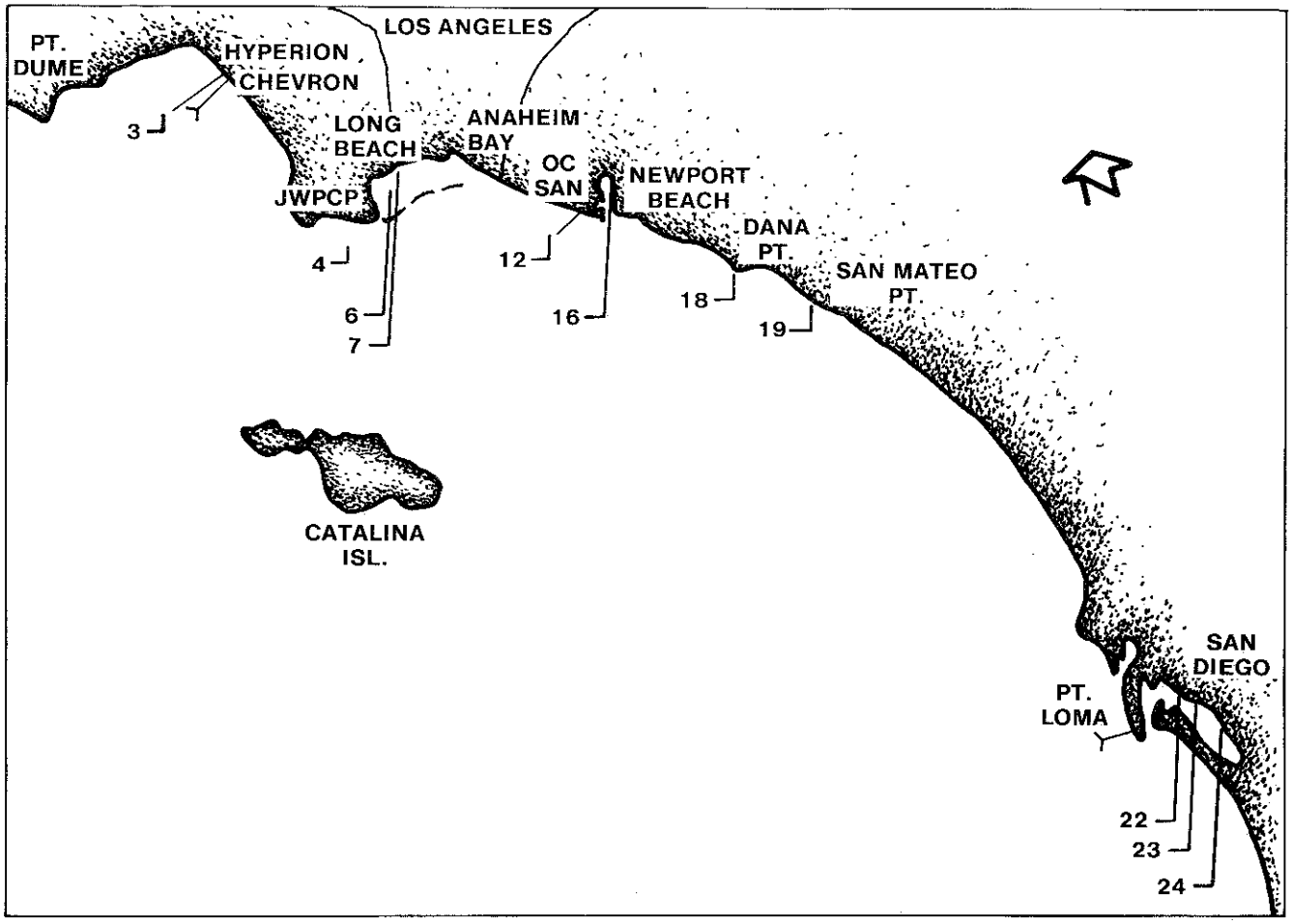

Figure 1. Location of sites examined in this study.

All bioassays were conducted by using flow-through conditions to minimize the effects of contaminants leaching into the water column. The exposure system consisted of 1-L polypropylene beakers containing a 2-cm layer of the test sediment.

G. japonica specimens were collected from Newport Bay. Acute (10-day exposure) bioassays were conducted with young amphipods which had not yet reached sexual maturity. This test was conducted at 15°C according to the procedure described by Swartz et al. (1985) for *R. abronius* and modified for a flow- through system. Animals were not fed during the test.

Bioassays were terminated after 10 days by passing the test sediments through a screen and counting the surviving amphipods. The number of surviving amphipods able to rebury within a 1-h period was also determined. The reburial test was intended to evaluate the organisms' condition, by observing if they responded normally to a favorable environment.

Chronic (28-day) toxicity tests with recently hatched amphipods were also conducted during this study. These tests were conducted on selected sediment types representing contamination from both sewage disposal and harbor activities.

Chronic tests were conducted at 19°C in a manner similar to the acute tests, except that newly released juveniles were used and food was given to the animals throughout the 28-day exposure period. Juvenile amphipods were obtained by

Table 1. Physical and chemical characteristics of sediments from study areas. All measurements were made at the start of each experiment.

Station	Location	Depth (m)	%TOC[a]	%Sand	Hydrocarbons (ng/g dry)			Metals (μg/g dry)			
					PAH	DDT	PCB	Cr	Cu	Pb	Zn
16	Newport Bay (control)	0	0.11	96.5	ND[b]	4	ND	2.5	1.9	4.1	13
3	Santa Monica Bay sludge outfall	157	10.5	53.4	20386	196	654	258	511	133	675
4	Palos Verdes Outfall	62	4.2	28.5	3209	5966	1548	326	213	112	630
6	L.A. Harbor E. Turning Basin	14	1.1	42.5	5310	88	217	50	82	64	211
7	L.A. Harbor L.A. River Mouth	5	4.3	40.7	9914	91	310	32	83	130	389
12	Orange Co. Outfall	60	0.55	77.4	90	7	55	19	24	12	62
18	Dana Pt. Marina	5	0.82	16.2	96	4	8	18	26	8.1	71
19	San Mateo Pt.	60	1.0	4.4	44	20	7	21	14	5.5	61
22	San Diego Bay NASSCO[c]	9	1.7	16.1	4711	10	208	64	214	60	321
23	San Diego Bay Chollas Creek	12	1.5	39.6	7625	30	188	37	132	70	235
24	San Diego Bay Seventh St.	8	1.7	37.6	12106	79	353	62	122	104	581

[a]TOC, Total organic carbon.
[b]Sample below detection limit for analysis.
[c]NASSCO, National Steel and Shipbuilding Company.

placing egg-laden females in petri dishes containing only seawater. Offspring released from the females 1 to 2 days before the test were used in the bioassays.

Amphipods were retrieved at the end of each experiment by passing the test sediment through a screen. The number and total body length of surviving animals were determined. Growth during the experiment was calculated by subtracting the animals' initial size (determined on a subset of the test population) from their final size.

The 10-day acute exposure produced reduced amphipod survival at most of the highly contaminated stations (Table 2). The lowest survival values were for animals exposed to sediment from the San Diego Bay and sludge outfall stations. The data from the sludge outfall site were highly variable, with survival ranging from 0 to 70% within the three replicates.

A statistically significant decline in acute survival was not found in sediment from Palos Verdes, even though high levels

Table 2. Amphipod survival, growth, and reburial following acute or chronic exposure to contaminated sediments. Values are mean ± standard error.

Station	Acute exposure		Chronic exposure	
	%Survival	%Reburial	%Survival	Growth (mm)
Newport Bay	88 ± 4	98 ± 2	62 ± 4	4.0 ± 0.6
Santa Monica Bay	34 ± 20	100 ± 0		
Palos Verdes Outfall	67 ± 5	93 ± 3	17 ± 4	0.6 ± 0.4
L.A. Harbor	48 ± 7	91 ± 3	40 ± 4	2.0 ± 0.8
L.A. River Mouth	88 ± 4	100 ± 0		
Orange Co. Outfall	77 ± 3	98 ± 2	60 ± 3	2.7 ± 0.6
Dana Pt. Marina	61 ± 5	94 ± 1		
San Mateo Pt.	84 ± 3	96 ± 4	49 ± 7	1.9 ± 0.7
NASSCO[a]	35 ± 5	89 ± 6		
Chollas Creek	68 ± 2	100 ± 0	45 ± 2	1.8 ± 0.3
Seventh St.	42 ± 6	97 ± 3		

[a]NASSCO, National Steel and Shipbuilding Company.

of chlorinated hydrocarbons were present. Reduced survival was found at stations having total polynuclear aromatic hydrocarbon (PAH) levels above 4,000 ng/g (ppb, dry weight), except for the Los Angeles River mouth and Dana Point Marina stations. Although the Los Angeles River site had substantial levels of hydrocarbon and metal contaminants, amphipod survival was unaffected. An unexpected result was the observation of moderate toxicity at the Dana Point Marina site. Sediment from this location had contamination levels similar to that from San Mateo Point and the Orange County outfall, where survival was greater.

No significant differences were found in the reburial activity of amphipods from the acute test. The lowest reburial percentage (88%) was at the Los Angeles Harbor site. These data indicate that the surviving *G. japonica* did not have reduced activity as the result of exposure to contaminated sediment.

Results from the chronic test of sediment from six locations are shown in Table 2. A different pattern of amphipod survival was observed compared with the acute test results. Survival at the Palos Verdes site was the only value significantly lower than the Newport Bay control value. Significant differences in amphipod growth were found for all of the sites tested, however. The greatest inhibition of growth was found at Palos Verdes, where the change in length during the test was only 16% that of the controls. These chronic test results contrast with the relatively small, acute effects seen for the Palos Verdes site. These data suggest that the high concentrations of chlorinated hydrocarbons or metals at this site may require chronic exposure before toxic effects are expressed or that the process of growth by molting in these crustaceans is very sensitive to the contaminants present at this site.

Significant differences in growth were found for amphipods in the remaining test sediments; these values were 46 to 69% of the control growth. An unexpected result that we found was the reduced growth of amphipods in the San Mateo Point sediment. Amphipod growth in the Orange County outfall sediment was greater than that at San Mateo Point, suggesting that the finer grain size or higher organic carbon content of the sediment may have had an important effect on the chronic test results.

This study has proven the usefulness of *G. japonica* as a sediment toxicity test organism. Both the acute and chronic test results have demonstrated the sensitivity of this species to environmentally realistic levels of sediment contamination. Results from these tests have also corresponded well to results obtained with chronic exposure of the white urchin, *Lytechinus pictus*, to the same sediments.

G. japonica is a suitable alternative to *R. abronius* for use in amphipod tests in southern California. The short life history of *G. japonica* also permits chronic tests with the measurement of sublethal responses such

as growth and reproductive success, information necessary for determining the effects of contaminants on population size.

SCCWRP researchers are presently using chronic tests with this species in laboratory studies of the toxicity of individual PAH compounds. This work, also funded by the California State Water Resources Control Board, will further refine these amphipod test methods and produce a greater understanding of how factors such as PAH structure and sediment organic carbon content affect the toxicity of marine sediments.

Acknowledgment

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References

Swartz, R. C., W. A. Deben, J. K. P. Jones, J. O. Lamberson, and F. A. Cole. 1985. Phoxocephalid amphipod bioassay for marine sediment toxicity, pp. 284-307. *In* Aquatic Toxicology and Hazard Assessment: Seventh Symposium, ASTM STP 854 (R. D. Cardwell, R. Purdy, and R. C. Bahner, Eds.). American Society for Testing and Materials, Philadelphia.

Swartz, R. C., W. A. Deben, K. A. Sercu, and J. O. Lamberson. 1982. Sediment toxicity and the distribution of amphipods in Commencement Bay, Washington, USA. *Mar. Pollut. Bull.* 13:359-364.