Northeast Gulf Science

Volume 6
Number 2 *Number 2*

Article 6

10-1983

Impact on and Recovery of Experimental Macrobenthic Communities Exposed to Pentachlorophenol

M.E. Tagatz
U.S. Environmental Protection Agency

C.H. Deans
U.S. Environmental Protection Agency

G.R. Plaia
U.S. Environmental Protection Agency

J.D. Pool
U.S. Environmental Protection Agency

DOI: 10.18785/negs.0602.06

Northeast Gulf Science Vol. 6, No. 2, p. 131-136 October 1983

IMPACT ON AND RECOVERY OF EXPERIMENTAL MACROBENTHIC COMMUNITIES EXPOSED TO PENTACHLOROPHENOL[1]

M.E. Tagatz, C.H. Deans, G.R. Plaia, and J.D. Pool
U.S. Environmental Protection Agency
Environmental Research Laboratory
Gulf Breeze, FL 32561

Abstract: Recovery of macrobenthic animal communities in sand-filled aquaria was determined 7 weeks after a 5-week exposure to 55 $\mu g/\ell$ pentachlorophenol. The communities developed from planktonic larvae in flowing estuarine water continuously supplied during treatment and recovery. Significantly fewer ($\alpha = 0.05$) individuals and species occurred in contaminated aquaria than in control aquaria immediately after exposure to pentachlorophenol. Numbers of arthropods, chordates, echinoderms, and mollusks were decreased; annelids and coelenterates were not affected. Seven weeks after exposure was discontinued, total numbers of individuals and species in previously contaminated and control aquaria no longer differed. The dominant echinoderm, *Leptosynapta inhaerens*, reduced numerically in contaminated aquaria at 5 weeks, increased in number not significantly different from the control at 12 weeks. However, there were some differences among species in previously contaminated aquaria and the control that could be attributed to the toxicant. Numbers of *Galathowenia* sp., the dominant annelid at 12 weeks and not collected at 5 weeks, were lower in previously contaminated aquaria than in control aquaria. The dominant mollusk, *Laevicardium mortoni*, did not recover after it was reduced in abundance by exposure to PCP. Major differences in community structure between 5 and 12 weeks were not toxicant related, however, and possibly represent natural succession. These consisted of reduced numbers of amphipods, *Corophium acherusicum*, and tunicates, *Molgula manhattensis*, at 12 weeks in both control and previously contaminated aquaria.

The structure of experimental estuarine macrobenthic communities is often changed when they are exposed to pesticides and industrial chemicals (Hansen and Tagatz, 1980). Aquatic ecosystems damaged by pollutants can remain significantly altered after pollution has abated or they can undergo various degrees of recovery. The recovery period may consist of conditions which include some original and some new characteristics. A comprehensive discussion of impacted ecosystems and the natural processes and rates applicable to recovery can be found in Cairns (1980), and a review of response to stress in marine benthic communities is presented by Boesch and Rosenberg (1981).

Our objective was to obtain information on the extent of recovery of such impacted communities under our experimental conditions following exposure to pentachlorophenol, a toxic compound used in previous studies (Tagatz *et al.,* 1977; 1981). Structural comparisons of contaminated and non-contaminated communities were made 7 weeks after exposure ceased (an interval sufficient to enumerate readily newly settled animals interacting as additions to the already established communities).

METHODS AND MATERIALS

We determined the degree of recovery of communities exposed to pentachlorophenol (PCP) by comparing the numbers of individuals and species of animals that grew from planktonic larvae in contaminated and non-contaminated aquaria, several days and seven weeks after exposure. The treatment period was

[1]Gulf Breeze Contribution No. 443.

5 weeks (June 8 to July 13, 1981) and the recovery period was 7 weeks (July 13 to August 31, 1981). Planktonic larvae entered the aquaria in continuously supplied unfiltered seawater during treatment and recovery. We used eight acrylic plastic apparatuses (Fig. 1), each consisting of a central constant-head box atop six aquaria (40 cm long, 10 cm wide, and 12 cm high). Aquaria were filled to a depth of 5 cm with clean silica sand (particle size 0.2 to 0.8 mm) collected more than a year previously from Santa Rosa Sound, Florida. Water level in aquaria was maintained at 3 cm above the sand.

Seawater with its plankton was pumped from Santa Rosa Sound to a splitter box where eight adjacent glass tubes supplied water at a rate of 1.4 ℓ/min to the eight constant-head boxes that routed water to the aquaria (Fig. 1). Flow to each aquarium was maintained at 200 ml/min by adjusting the height of a glass standpipe (2.2-mm ID) in the constant-head box. Water flowed from each aquarium through a notched end-opening; large predators, such as crabs, escaped through these openings before they could affect community structure. Salinity and temperature of incoming seawater, recorded continuously, averaged 27 ppt (24 to 31 ppt) and 30°C (28 to 33°C). Photoperiod was 12L:12D; light was supplied by four 48-inch fluorescent lamps (34 watt).

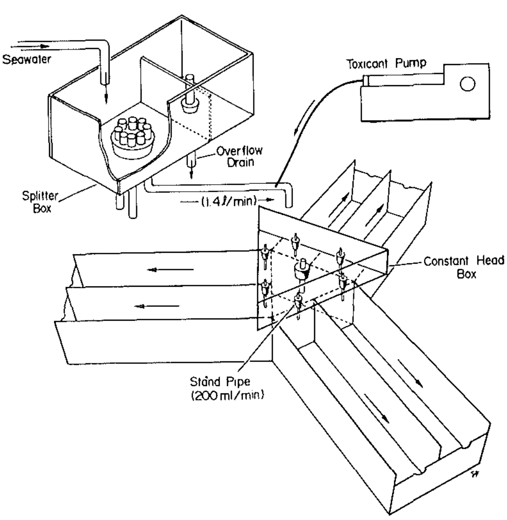

Figure 1. One of eight identical apparatuses of six aquaria used in the recovery study. The splitter box supplied seawater to the eight apparatuses.

Four apparatuses were maintained as a control, and four were exposed for 5 weeks to 50 μg PCP/ℓ, nominal concentration. Desired dilution of stock (5.7 g technical grade PCP converted to the soluble potassium salt by addition of 1.2 g KOH per liter of distilled water) was metered by syringe pump into seawater entering the center of the constant-head box of each apparatus that received PCP. Samples of water were taken from constant-head boxes once a week for analyses for PCP concentrations by gas chromatography (Tagatz *et al.,* 1977). The average and range of twenty PCP concentrations measured in water from the four apparatuses treated with the toxicant were 55 μg/ℓ (27 to 78 μg/ℓ). After 5 weeks of exposure, only uncontaminated water was supplied to the aquaria for 7 weeks to determine if communities in contaminated aquaria would recover.

Animals were collected from two contaminated (12 aquaria) and two control (12 aquaria) apparatuses after 5 and 12 weeks. Communities were harvested by siphoning the contents of the aquaria into a 1-mm mesh sieve; animals retained were preserved and identified.

Results are presented as pooled data from each PCP concentration and the control. Two-sample t-tests were used to compare average numbers of animals or species of treatment with the control (Brownlee, 1965; SAS, 1979). Differences were considered significant at the 5% level.

RESULTS AND DISCUSSION

Impact of PCP Exposure

A total of 5,963 animals representing 33 species of 6 phyla was collected at the 5-week harvest (Table 1). *Corophium acherusicum* (amphipod) was most abundant; other dominant species were *Molgula manhattensis* (tunicate), *Letosynapta inhaerens* (holothurian), and *Laevicardium mortoni* (mollusk).

Community structure was significantly affected by 55 μg PCP/ℓ (Table 2). Fewer arthropods (primarily *C. acherusicum*), chordates (all *M. manhattensis*), echinoderms (primarily *L. inhaerens*), and mollusks (primarily L. mortoni) occurred in contaminated aquaria than in the control. Numbers of annelids and coelenterates collected from exposed and non-exposed communities were not significantly different. Finally, average number of species per aquarium was significantly less in aquaria containing 55 μg PCP/ℓ than in control aquaria, primarily due to fewer species of mollusks. The data support the molluscacide effect of PCP referred to in earlier community studies (Tagatz *et al.*, 1977).

Recovery after PCP Exposure

A total of 1,627 animals representing 54 species of 9 phyla was collected at the 12-week harvest (Tables 1 and 2).

Except for numbers of annelids, average density of animals and number of species per phylum in aquaria that had been treated did not differ significantly from those in control aquaria at 12 weeks. Numbers of echinoderms and mollusks in previously contaminated aquaria increased to near those of the control. *Leptosynapta inhaerens,* the dominant echinoderm which showed reduced numbers in contaminated aquaria at 5 weeks, recovered by 12 weeks. However, the dominant mollusk, *Laevicardium mortoni,* maintained numerical difference between control and treated aquaria after both periods of time. Failure of *L. mortoni* to re-establish may have been due to a cessation of its settling larvae. Its abundance did not change during the recovery period, and it was replaced in dominance by another mollusk, *Musculus lateralis,* in the control as well as in previously contaminated aquaria. There appeared to be species specificity among mollusks. *Diastoma varium* also maintained a numerical difference between control and treated aquaria at 5 and 12 weeks, whereas *Acteocina canaliculata* and *M. lateralis* showed no effects of the treatment after either period of time. Although about equal numbers of annelids were collected from exposed and non-exposed communities at 5 weeks, they were significantly fewer in previously contaminated aquaria than in the control at 12 weeks. The dominant annelid at 12 weeks, *Galathowenia* sp., was not collected at 5 weeks, but may have occurred during exposure at sizes too small to be retained by our sieve and may be among species particularly sensitive to PCP. In earlier community studies, annelids decreased significantly when exposed to a higher concentration, 76 μg PCP/ℓ (Tagatz *et al.*, 1977). Coelenterates did not appear to be affected by PCP in the present study.

Although not toxicant-related, certain reductions represented major differences in community structure between the two periods. Arthropods (primarily *Corophium acherusicum*) and chordates (*Molgula manhattensis*), significantly affected by PCP at 5 weeks, were much less abundant at 12 weeks in both control and previously contaminated aquaria. Both phyla were

Table 1. Animals collected from control aquaria and from aquaria that received 55 μg PCP/ℓ for 5 weeks, followed by 7 weeks of uncontaminated water. Replicates were pooled.

	5 weeks		12 weeks	
Taxon	Control	55 μg/ℓ	Control	55 μg/ℓ
Arthropoda				
Corophium acherusicum	4,500	555	24	30
Balanus amphitrite	6	5	8	10
Anoplodactylus sp.	3	0	-	-
Pinnixa sayana	1	0	0	1
Neopanope texana	0	3	-	-
Unident. Xanthidae	-	-	1	0
Total Arthropods	4,510	563	33	41
Chordata				
Molgula manhattensis	259	20	6	5
Echinodermata				
Leptosynapta inhaerens	178	109	194	171
Unident. Holothuroidea	1	0	-	-
Hemipholis elongata	1	0	-	-
Ophiophragmus filograneus	1	0	15	4
Ophiophragmus wurdemani	-	-	0	1
Unident. Scutillidae	-	-	1	0
Total Echinoderms	181	109	210	176
Mollusca				
Laevicardium mortoni	62	32	63	27
Acteocina canaliculata	29	23	48	58
Musculus lateralis	20	18	206	208
Diastoma varium	13	6	52	23
Mactra fragilis	4	1	16	13
Abra sp.	2	0	7	3
Tagelus divisus	2	0	10	11
Anadara ovalis	1	0	-	-
Ancula evelinae	1	0	-	-
Crassostrea virginica	1	0	0	1
Anadara transversa	0	1	1	2
Brachidontes exustus	-	-	9	16
Lyonsia hyalina	-	-	4	2
Anadara notablis	-	-	3	0
Cyrenoida floridana	-	-	3	5
Chione latilirata	-	-	1	0
Mitrella lunata	-	-	1	0
Dinocardium robustum	-	-	0	1
Total Mollusks	135	81	424	370
Annelida				
Neanthes succinea	8	10	8	9
Capitella capitata	6	5	25	16
Cistenides gouldii	5	2	2	3
Armandia agilis	4	4	3	4
Polydora sp.	3	2	7	7
Hydroides dianthus	2	3	11	6
Mediomastus californiensis	2	1	13	17
Amphictene sp.	1	2	4	2
Unident. Cirratulidae	1	0	2	1
Gyptis vittata	0	3	7	3
Sthenelais articulata	0	1	1	2
Galathowenia sp.	-	-	38	21
Travisia sp.	-	-	12	7
Dasybranchus lunulatus	-	-	5	1

Table 1. Continued.

Taxon	5 weeks Control	5 weeks 55 µg/ℓ	12 weeks Control	12 weeks 55 µg/ℓ
Prionospio heterobranchia	-	-	3	4
Dorvillea sociabilis	-	-	2	1
Chone sp.	-	-	1	4
Diopatra cuprea	-	-	1	2
Lumbrineris tenuis	-	-	1	2
Marphysa sanguinea	-	-	1	0
Owenia fusiformis	-	-	1	1
Piromis sp.	-	-	1	1
Phylo ornatus	-	-	1	0
Phyllodoce sp.	-	-	1	0
Thelepus setosus	-	-	1	0
Total Annelids	32	33	152	114
Coelenterata				
Unident. Actiniaria	25	15	48	41
Sipuncula				
Phascolion strombi	-	-	3	2
Phoronida				
Phoronis architecta	-	-	0	1
Rhynchocoela	-	-	0	1
All Phyla				
Individuals	5,142	821	876	751
Species	29	22	48	45

dominant at 5 weeks, but 5th and 6th in dominance at 12 weeks. Although these reductions may only be inherent to our laboratory study, they could be characteristic of temporal changes in natural communities.

Because of decreased density of the early dominant, *C. acherusicum,* fewer individuals were collected in control and previously contaminated aquaria at 12 weeks than at 5 weeks, but the number of species approximately doubled. Some of these species probably were present at the earlier harvest but at sizes too small to be retained by our sieve.

This study provided some insight on structural changes during community development in our experimental system and on the extent of recovery after toxicant exposure. Communities showed various degrees of recovery, carry-over effects from toxicant exposure, and changes unrelated to exposure. On the basis of early recolonization of numbers of individuals and species, PCP appeared to have no lasting impact in our experiment. However, species composition and relative abundance differed from that during exposure, factors that would affect community functions and trophic patterns. Our study was too limited to comprehensively identify those shifts in species and dominance due to the toxicant, directly or as affecting species interaction, and those resulting from normal estuarine succession. Boesch and Rosenberg (1981) review some of the many aspects involved in the response to stress in marine benthic communities including spatial and temporal succession. They conclude that estuarine benthic communities are more resistant and resilient to toxic pollutants than are communities in constant environments. The rapid numerical recolonization of a variety of species

Table 2. Average density of animals and number of species (S.E.M.) per aquarium collected from control aquaria and aquaria receiving 55 μg PCP/ℓ for 5 weeks, followed by 7 weeks of uncontaminated water.

	5 weeks		12 weeks	
Phylum	Control	55 μg/ℓ	Control	55 μg/ℓ
Arthropoda	375.8(21.8)	46.9*(8.7)	2.8(0.8)	3.4(0.8)
	1.6(0.2)	1.5(0.2)	1.2(0.1)	1.3(0.3)
Chordata	21.6(10.2)	1.7*(0.6)	0.5(0.4)	0.4(0.3)
	1.0(0.0)	0.6(0.2)	0.2(0.1)	0.2(0.1)
Echinodermata	15.1(1.9)	9.1*(1.5)	17.5(1.4)	14.7(1.7)
	1.2(0.1)	0.9(0.1)	1.6(0.2)	1.4(0.2)
Mollusca	11.2(0.8)	6.8*(1.0)	35.3(2.7)	30.8(3.3)
	4.2(0.2)	2.9*(0.3)	7.2(0.5)	6.6(0.6)
Annelida	2.7(0.5)	2.8(0.4)	12.7(1.2)	9.5*(0.9)
	2.2(0.3)	2.5(0.3)	7.6(0.4)	6.3(0.5)
Coelenterata	2.1(0.4)	1.2(0.4)	4.0(0.7)	3.4(0.7)
	0.9(0.1)	0.7(0.1)	1.0(0.0)	0.9(0.1)
Other Phyla	0	0	0.2(0.1)	0.3(0.2)
	0	0	0.2(0.1)	0.3(0.2)
All Phyla	428.5(26.1)	68.4*(7.6)	73.0(4.4)	62.6(5.3)
	11.2(0.6)	9.1*(0.6)	19.1(0.6)	17.2(1.0)

*Significantly different from control at the 5% level.

after our experimental exposure to PCP seems to indicate such an advantage.

ACKNOWLEDGMENTS

We thank James Moore and Johnnie Knight for chemical analyses and Steven Foss for his schematic illustration.

LITERATURE CITED

Boesch, D.F. and R. Rosenberg. 1981. Response to stress in marine benthic communities. In: G.W. Barrett and R. Rosenberg (eds.), Stress Effects on Natural Ecosystems. John Wiley and Sons Ltd., New York. p. 179-200.

Brownlee, K.A. 1965. Statistical Theory of Methodology in Science and Engineering. 2nd ed., John Wiley and Sons, Inc., New York. 590 p.

Cairns, J., Jr. (ed.). 1980. The Recovery Process in Damaged Ecosystems. Ann Arbor Science Publishers Inc., The Butterworth Group. 167 p.

Hansen, D.J., and M.E. Tagatz. 1980. A laboratory test for assessing impacts of substances on developing communities of benthic estuarine organisms. In: J.G. Eaton, P.R. Parrish, and A.C. Hendricks (eds.), ASTM Spec. Tech. Publ. 707, Am. Soc. for Test. and Materials, Philadelphia, PA. p. 40-57.

SAS User's Guide. 1979 Edition. SAS Institute, Inc., Cary, N.C.

Tagatz, M.E., J.M. Ivey, J.C. Moore, and M. Tobia. 1977. Effects of pentachlorophenol on the development of estuarine communities. J. Toxicol. Environ. Health 3:501-506.

__________, N.R. Gregory, and J.L. Oglesby. 1981. Effects of pentachlorophenol on field- and laboratory-developed estuarine benthic communities. Bull. Environ. Contam. Toxicol. 26:137-143.