

Laboratory Studies on the Accumulation of Polychlorinated Dibenzo-*p*-dioxins and Dibenzofurans from Sediment and Food by the American Lobster (*Homarus americanus*)

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OBJECTIVES

A laboratory study was designed to investigate the transfer of organic contaminants from sediments to two marine organisms. This experiment involved a simple two-step food chain that consisted of an infaunal polychaete worm, *Nereis virens*, and a crustacean, the American lobster, *Homarus americanus*. *Nereis virens* was used in this study because it readily accumulates sediment-associated contaminants¹ and is a natural component of the diet of the American lobster. American lobster were selected as the top level organism for this study because they have been shown to accumulate high contaminant concentrations² and are of commercial importance.

APPROACH AND METHODS

Sediments from the Passaic River, NJ were selected for this experiment because of their high concentrations of polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)^{2,3}. Polychaete worms (*Nereis virens*) were exposed to Passaic River sediment, which was designated as Contaminated sediment (CS), or an uncontaminated Reference sediment (RS) for 70 days to allow steady-state concentrations to be achieved. Polychaetes exposed to CS were then fed to American lobster (*Homarus americanus*) as Contaminated food (CF) and worms held in RS were used as Reference food (RF).

The lobsters used for this experiment were all about 18 months old and had been laboratory reared from the eggs obtained from 3 females. These animals

were placed in glass aquaria which were divided into six chambers (one lobster per chamber) and contained a 4.5 cm layer of bedded sediment. Lobsters were exposed to four treatments (RS/RF, RS/CF, CS/RF and CS/CF) and samples were collected on Days 7, 28 and 56. The CS/CF exposure was continued until day 112 when the final lobster samples were taken. Data from the Reference treatment (RS/RF) are not included in this report because concentrations in these samples were consistently near or below the analytical detection limits.

Lobster samples from each sampling day and treatment were composited (tissues from 6 lobsters per composite) into three samples with muscle and hepatopancreas samples combined separately. Replicate sediment and polychaete samples were also analyzed. Samples were prepared for chemical analysis using methods similar to those described previously⁴. This included Soxhlet extraction followed by a column containing acid, base and silver nitrate treated silica, a second column of neutral alumina and an activated carbon column to purify the extract. Concentrations of all the 2,3,7,8-substituted "biosignificant" PCDDs and PCDFs as well as several chlorinated pesticides and chlorobiphenyl congeners, including the coplanar congeners were measured; however, only data for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) and 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF) are reported here. These compounds were measured using a Hewlett Packard 5890 gas chromatograph (GC) - mass selected detector (Hewlett Packard 5971A) system. The GC was equipped with a 60 m DB-5 fused silica capillary column (J & W Scientific, Inc.).

RESULTS AND DISCUSSION

The Passaic River sediment used for this experiment contained high concentrations of PCDD and PCDF congeners that were similar to those previously reported^{3,5}. Sediments (CS) collected from the exposure chambers during the experiment contained 219 ± 37 pg/g of 2,3,7,8-TCDD and 145 ± 29 pg/g of 2,3,7,8-TCDF dry weight.

Polychaetes exposed to CS for 70 days before being fed to the lobsters accumulated 168 ± 7 pg/g of 2,3,7,8-TCDD and 72.0 ± 9.7 pg/g of 2,3,7,8-TCDF dry weight. The ratios of contaminant concentrations between sediment and polychaetes observed after this exposure period are similar to those found in a previous experiment where polychaetes were exposed to Passaic River sediment for 180 days⁴. These similarities indicate that the 70 day exposure used in the present experiment was sufficient time for the concentrations of these compounds to reach steady-state levels in the polychaetes.

Contaminant concentrations were considerably higher in lobster hepatopancreas

samples compared to levels in muscle tissue (Figure 1). In the hepatopancreas samples, concentrations were similar on Days 56 and 112 for both compounds indicating that steady-state levels had been reached (Figures 1b&d). Concentrations of both compounds in the muscle tissue were highest on Day 112 (Figures 1a&c) which indicates that steady-state levels may not have been attained in this tissue.

Differences were noted in the accumulation of 2,3,7,8-TCDD and 2,3,7,8-TCDF by the lobsters. On Day 56 the concentrations of 2,3,7,8-TCDD were similar for the RS/CF and CS/CF treatments (both muscle and hepatopancreas samples) and considerably lower for the CS/RF treatment (Figures 1a&b), indicating that food was the major exposure route for this compound. However, 2,3,7,8-TCDF concentrations were similar in the RS/CF and CS/RF treatments and these values were each about one-half of the concentrations found in lobsters exposed to CS/CF (Figure 1c&d). This indicates that both sediment and food were important sources of 2,3,7,8-TCDF to the lobsters and that their contributions appeared to be roughly equivalent.

REFERENCES

- 1 Rubinstein NI, Pruell RJ, Taplin BK, LiVolsi JA, Norwood CB. Bioavailability of 2,3,7,8-TCDD, 2,3,7,8-TCDF and PCBs to marine benthos from Passaic River sediments. *Chemosphere* 1990;20:1097-102.
- 2 Belton TJ, Hazen R, Ruppel BE, Lockwood K, Mueller R, Stevenson E, Post JJ. A study of dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) contamination in select finfish, crustaceans and sediments of New Jersey waterways. Trenton NJ: Office of Science and Research, New Jersey Department of Environmental Protection, 1985.
- 3 Bopp RF, Gross ML, Tong H, Simpson HJ, Monson SJ, Deck BL, Moser FC. A major incident of dioxin contamination: Sediments of New Jersey estuaries. *Environ Sci Technol* 1991;25:951-6.
- 4 Pruell RJ, Rubinstein NI, Taplin BK, LiVolsi JA, Bowen RD. Accumulation of polychlorinated organic contaminants from sediment by three benthic marine species. *Arch Environ Contam Toxicol* 1993;24:290-7.
- 5 Wenning RJ, Harris MA, Finley B, Paustenbach DJ, Bedbury H. Application of pattern recognition techniques to evaluate polychlorinated dibenzo-*p*-dioxin and dibenzofuran distributions in surficial sediments from the Lower Passaic River and Newark Bay. *Ecotox Environ Saf* 1993;25:103-25.

Figure 1. Concentrations of 2,3,7,8-TCDD and 2,3,7,8-TCDF in lobster samples.

