EVALUATION OF PCDD/Fs IN COMMERCIAL OYSTERS FROM ARCATA BAY, CALIFORNIA

Richard J. Wenning[1], Linda Mackey[2], Jill Kurtz[1], Scott Braithwaite[1], and William Luksemburg[3]

[1] ENVIRON International, 6001 Shellmound Street, Emeryville, CA 94608 USA
[2] Pacific Northwest EnviroNet Group, 3645 Westwind Boulevard, Santa Rosa, CA 94503 USA
[3] Alta Analytical Laboratory, 1104 Windfield Way, El Dorado Hills, CA 95762 USA

Introduction

Humboldt Bay is located along the western coast of the United States and is one of the State of California's largest coastal estuaries. The wetlands, intertidal mudflats and marshes in the northern portion of the bay, called Arcata Bay, provide habitat for a great diversity of wildlife and support both commercial shellfish and recreational fishing industries. The Port of Humboldt Bay is the only deep-water port between San Francisco and Coos Bay, Oregon, and one of the largest forest product ports in western North America.

Problems from over a century of dredging, industrial discharges, storm water runoff, urban development, and oil spills have prompted studies aimed at evaluating the environmental quality of the bay for wildlife and humans [1, 2]. During the past few years, the contamination of the bay by polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), metals, petroleum hydrocarbons, and other persistent environmental pollutants has received much attention because these compounds may be accumulated through the food chain to aquatic organisms, fish and humans. This has led to concerns raised by the shellfish industry about possible contamination of commercial oyster beds in Arcata Bay. The purposes of this study were to determine the levels of PCDD/Fs in commercial shellfish in Arcata Bay and to assess the health risks to consumers potentially associated with the consumption of shellfish from the bay.

Methods and Materials

Oysters were collected from nine different commercial oyster beds in Arcata Bay and one in the Mad River Slough, a main tributary that empties into Arcata Bay, during June and October 2002. At each oyster bed, approximately 24 oysters of comparable shell size and age class were collected from oyster flats located on the sediment bottom or from longlines suspended in the water column. In addition, mussels grown in suspended net bags were collected from a storage platform in the Mad River Slough. Composite samples of either whole oyster tissue or mussel tissue were assayed for total PCDD/Fs and individual 2,3,7,8-substituted congeners using USEPA Method 8290 by Alta Analytical Laboratory (El Dorado Hills, CA). Dioxin test results were evaluated using the 1997 World Health Organization (WHO) toxic equivalency (TEQ) scheme[3]. Health risks to shellfish consumers were calculated in accordance with U.S. EPA risk assessment guidance [4, 5] using the mean and 95th percentile of the dioxin TEQ_{WHO97} data set for each sampling event.

Results and Discussion

Analytical results are summarized in Table 1. There were no significant differences in PCDD/F levels in Pacific diploid or triploid, Kumamoto, or Olympia oysters collected either in June or October 2002. In composite whole oyster tissue samples collected in June 2002, total PCDD/F concentrations ranged between 36 and 174 picograms per gram wet weight (pg/g ww; mean concentration of 85 pg/g ww) and the dioxin TEQ_{WHO97} concentration ranged between 0.8 and

4.3 pg/g ww (mean concentration of 1.8 pg/g ww). In oysters collected in October 2002, total PCDD/F concentrations ranged between 3.5 and 10.7 pg/g ww (mean concentration of 8.2 pg/g ww) and the dioxin TEQ_{WHO97} concentration ranged between 0.12 and 0.25 pg/g ww (mean concentration of 0.21 pg/g ww). Results in composite whole mussel tissue were comparable to the levels in oysters; total PCDD/F and dioxin TEQ_{WHO97} concentrations were 91 pg/g ww and 1.0 pg/g ww, respectively, in June 2002, and 6.6 pg/g ww and 0.1 pg/g ww, respectively, in October 2002. Seasonal differences in the lipid content of oysters collected in June 2002 (mean of 41%) and oysters collected in October 2002 (mean of 2%) may contribute to the differences in PCDD/F levels. Temporal variations in contaminant and lipid levels and enzyme activities have been reported in oysters and other bivalves [6, 7].

Table 1. Dioxin TEQ_{WHO97} testing (pg/g ww) of oysters and mussels collected from commercial shellfish beds in Arcata Bay, California.

	June 2002			October 2002		
	N	Range	Mean	N	Range	Mean
Mussel	1	--	1.0	1	--	0.10
Pacific Triploid	2	0.9, 1.4	1.15	0	--	--
Pacific Diploid	6	0.8 – 4.3	2.12	9	0.16 – 0.25	0.22
Kumamoto	2	1.2, 1.3	1.25	3	0.20 – 0.24	0.22
Olympia	0	--	--	1	--	0.12

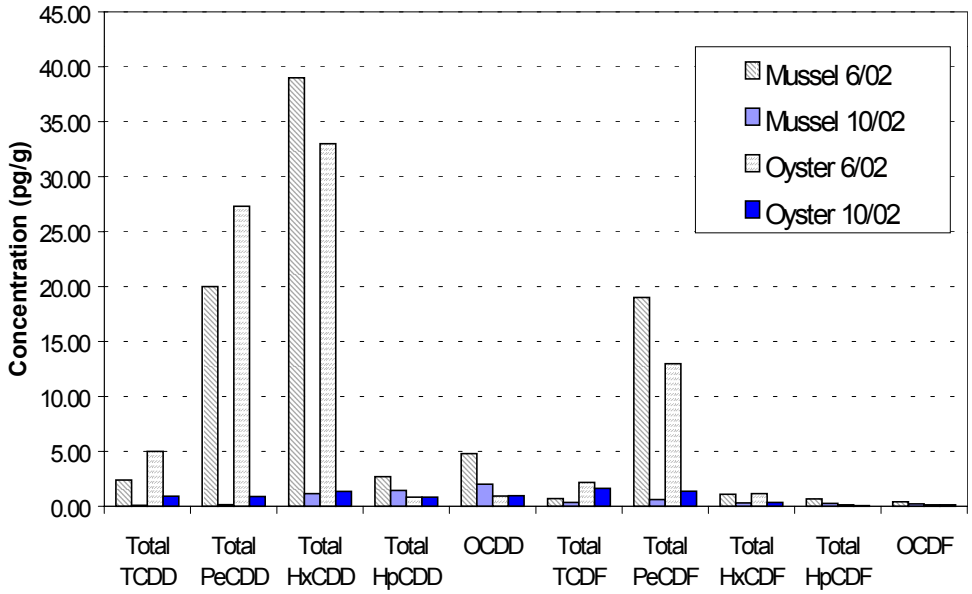

Figure 1. Average profile of total PCDD/Fs in oyster and mussel tissues from Arcata Bay, California.

The few data available in the scientific literature report dioxin TEQ_{WHO97} concentrations ranging between 0.25 and 0.45 pg/g in the eastern and Gulf coasts of the United States [2, 8, 9, 10]. In California, the mean dioxin TEQ_{WHO97} concentration in San Joaquin River clams collected adjacent to a wood treatment facility was 1.9 pg/g [11]. For comparison, dioxin TEQ_{WHO97} concentrations in fish from San Francisco Bay and two California freshwater lakes ranged between 0.08 pg/g and 1.5 pg/g [12, 13].

The distribution of total PCDD/Fs in whole oyster and mussel tissues is shown in Figure 1. The occurrence of several 2,3,7,8-substituted and non-2,3,7,8-substituted congeners suggests more than one source of PCDD/Fs in oysters and mussels. The pattern of PCDD/Fs is unlike the profile typically associated with wood treatment products containing pentachlorophenol [5]. Possible environmental sources that warrant further investigation include storm water and surface water runoff, effluents from municipal sewage treatment plants, and releases from combustion sources reaching the Bay either directly through effluent or indirectly through deposition of particulates.

PCDD/F levels in oysters and mussels were well below the 25 pg/g benchmark for dioxins in fish and shellfish tissues that the U.S. FDA has identified as a level associated with no serious health effects, and well below the 50 pg/g action level at which U.S. FDA recommends against consumption [14]. However, the results in several oyster samples collected in June 2002 were above the 1 pg/g level for further investigation identified by the U.S. FDA [15].

A summary of the screening-level exposure model used to evaluate intake and health risks to shellfish consumers is presented in Table 2. Assuming the typical shellfish consumer enjoys a daily diet of oysters and mussels obtained exclusively from Arcata Bay, the theoretical cancer risk and non-cancer hazard to a shellfish consumer associated with exposure to dioxins is below 1 in 1,000,000 (1×10^{-6}) and well below a hazard index value of one, respectively.

Table 2. Theoretical daily intake and health risks posed by exposure to dioxin TEQ_{WHO97} from consumption of oysters and mussels exclusively from Arcata Bay, California.

	Risk Assessment Results		
	Based on 95th percentile dioxin TEQ_{WHO97} concentration in oysters	**Based on mean dioxin TEQ_{WHO97} concentration in oysters**	**Based on mean dioxin TEQ_{WHO97} concentration in mussels**
July 2002 data			
Theoretical daily intake (mg TEQ/kg BW-day)	4×10^{-12}	2×10^{-12}	5×10^{-13}
Theoretical cancer risk	5×10^{-7}	3×10^{-7}	7×10^{-8}
Theoretical non-cancer hazard index	0.0004	0.0002	0.00005
October 2002 Data			
Theoretical daily intake (mg TEQ/kg BW-day)	3×10^{-13}	2×10^{-13}	5×10^{-14}
Theoretical cancer risk	4×10^{-8}	3×10^{-8}	7×10^{-9}
Theoretical non-cancer hazard index	0.00003	0.00002	0.0000005

The predicted theoretical cancer risk to shellfish consumers was approximately 5 in 10,000,000 (5×10^{-7} risk) using the June 2002 data and approximately 4 in 100,000,000 (4×10^{-8} risk) using the October 2002 data. These results are below the range of 1×10^{-4} to 1×10^{-6} risk considered acceptable by U.S. EPA and below the 1×10^{-5} risk level often used in the State of California's consumer protection statute. The hazard quotient representing the theoretical non-cancer risk posed by exposure to dioxins was three to four orders of magnitude below a value of one.

Based on the results of environmental testing and the shellfish consumption risk assessment, the occurrence of trace levels of PCDD/Fs in commercial shellfish from Arcata Bay does not pose a threat to consumers. The results suggest that studies are warranted to determine contaminant inputs from other sources to Arcata Bay. Additional environmental studies are planned to further evaluate PCDD/Fs, as well the significance of other environmental contaminants in Arcata Bay.

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