NOAA Technical Memorandum ERL GLERL-87

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NOTICE

CONTENTS

TABLES

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Peter F. Landrum

ABSTRACT. This report contains a summary of the toxicokinetics data for the amphipod *Diporeia* spp. from the last 13 years. Data are from both aqueous and sediment exposures and are focused primarily on selected polycyclic aromatic hydrocarbons and polychlorinated biphenyls.

1. INTRODUCTION

The toxicokinetics of contaminants in the amphipod *Diporeia* spp. and the factors that affect those kinetics have been under investigation (1) to understand the importance of benthic organisms as pathways for reintroducing sediment-associated contaminants to the food chain, and (2) to develop methods for assessing the hazards of sediment-associated contaminants. *Diporeia* spp., formerly *Pontoporeia hoyi* (Bousfield, 1989), was chosen for study because it is the predominant macrobenthic organism in the Great Lakes (Mozley and Howmiller, 1977; Nalepa *et al*., 1985). *Diporeia* spp. is also recognized as a major prey item for Great Lakes fish (Mozley and Howmiller, 1977), for some diving ducks (Peterson and Ellarson, 1978), and for *Mysis relicta* (Parker, 1980). In addition to its ecological importance, *Diporeia* is thought to be sensitive to toxic environmental contamination (Nalepa and Landrum, 1988).

The accumulation of selected contaminants has been measured for *Diporeia* from both aqueous and sediment exposures. This accumulation is described as an uptake clearance. The uptake clearance is the amount of contaminant cleared from the source compartment per mass of organism per time. The elimination is defined in terms of the elimination rate constant, which is the fractional change in organism concentration per time. These coefficients are presumed to be constant over the time course of the experiments from which they were determined. However, the coefficients are recognized as conditional for the conditions of exposure and testing. The uptake clearances from aqueous exposure vary with organism size and temperature (Landrum, 1988). The uptake clearance also depends on the extent of binding to dissolved organism matter for aqueous exposures (Landrum *et al*., 1985) and the strength of binding to sediment for sediment exposures (Landrum, 1989; Landrum and Faust, 1994). The elimination is also subject to factors such as organism size and lipid content that influence the physiology of the *Diporeia* (Landrum, 1988).

This report provides a referable review of data that is in the published literature and of data that has yet to be published. Analysis of this data will be useful to understand the role of *Diporeia* in its interactions with important Great Lakes contaminants.

GLERL Contribution No. 960

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Temperature °C	Mass mg	Error sd	k_u ml $g^{-1}h^{-1}$	Error se	k_e h^{-1}	Error se	Reference
4	6.9	2.4	97.9	7.1			Landrum 1986
4	5.0	2.0	122.8	12.3			Landrum 1986
4	5.0	2.0	155.8	8.5			Landrum 1986
4	7.2	1.7	81.8	9.6	0.0044	0.001	Landrum 1986
4	5.9	1.8	85.1	5.7			Landrum 1986
4	5.6	0.6	117.1	15.5	0.0041	0.0009	Landrum 1986
4	6.9	3.1	141.4	19.9	0.0015	0.0011	Landrum 1986
4	6.2	2.2	201.2	18.3	0.0036	0.001	Landrum 1986
4	7.7	2.3	82.8	13.7	0.0011	0.0005	Landrum 1986
4	8.6	1.6	128.6	12.6	0.0014	0.0005	Landrum 1986
4	7.6	3.3	141.3	8.3	0.0034	0.0009	Landrum 1986
4	8.1	2.6	100.3	15.3	0.0024	0.0007	Landrum 1986
4	9.2	1.9	171.8	10.7	0.0037	0.0004	Landrum 1986
4	6.8	2.0	131.2	14.6	0.0028	0.0009	Landrum 1986
4	3.6	2.3	207.3	12.4	0.008	0.001	Landrum 1986
7	5.0	0.9	148.1	9.5	0.0076	0.0013	Landrum 1986
7	6.2	2.2	205.4	21.5	0.0038	0.0015	Landrum 1986
10	6.2	1.5	176.9	11.5	0.009	0.0009	Landrum 1986
10	6.2	2.2	205.2	22.1	0.0086	0.0007	Landrum 1986
15	6.0	1.7	235.1	14.6	0.02	0.002	Landrum 1986

Table 1.--Anthracene Uptake Clearance From Aqueous Exposures and Elimination Constant.

Temperature °C	Mass mg	Error sd	k_u ml g^{-1} h^{-1}	Error sd	k_e h^{-1}	Error sd	Reference
4	5.3	2.3	123.9	26.5	0.001	0.0005	Landrum 1986
4	6.6	2.8	97.5	24.5			Landrum 1986
4	6.3	2.4	140.8	18.1	0.0033	0.00012	Landrum 1986
4	6.3	1.7	162.6	32.1			Landrum 1986
4	7.5	3.0	137.6	25.4			Landrum 1986
4	7.5	1.7	169.3	23.7			Landrum 1986

Table 2.--Benz(a)anthracene Uptake Clearance from Aqueous Exposures and Elimination Rate Constant.

Temperature	Mass	Error	k_u	Error	k_e	Error	Reference
^oC	mg	sd	ml g^{-1} h^{-1}	sd	h^{-1}		
3.3	4.2	2.7	183.4	38.2	0.0002	0.0006	Landrum, 1986
4	5.8	1.4	200	13	0.0035	0.001	Landrum, 1986
4	6.2	2.2	259.5	33.4			Landrum, 1986
4	6.2	2.2	164.4	64.2			Landrum, 1986
4	8.0	2.6	72.2	10.6	0.0021	0.0009	Landrum, 1986
4	8.3	1.8	101.3	9.7	0.0006	0.0004	Landrum, 1986
4	9.0	2.7	111.6	21.7			Landrum, 1986
4	9.2	2.7	104.8	11.7	0.0009	0.0004	Landrum, 1986
4	9.2	1.9	114.4	18.4	0.0006	0.0003	Landrum, 1986
4	7.5	2.5	119.7	21.4			Landrum, 1986
4	3.3	2.3	173	17	0.0014	0.0004	Landrum, 1986
4	5.3	2.2	181.8	26.6	0.0021	0.0006	Landrum, 1986
4	6.7	2.4	200.9	55.8	0.0011	0.0002	Landrum, 1986
4	6.5	2.2	108	19.4	0.0013	0.0007	Landrum, 1986
4	6.8	2.4	164.4	19.1	0.0019	0.0008	Landrum, 1986
4	7.5	1.7	134.7	11			Landrum, 1986
4	6.3	4.3	107	18.3	0.0009	0.0006	Landrum, 1986
4	6.5	2.5	165	26.4	0.0019	0.0007	Landrum, 1986
4	6.4	2.5	215.1	20.3	0.0024	0.0005	Landrum, 1986
4	4.2	2.7	86.2	11.3	0.0015	0.0006	Landrum, 1986
4	6.7	2.0	106.8	11.7	0.0008	0.0005	Landrum, 1986
4	5.8	1.8	146.4	16.3	0.0007	0.0007	Landrum, 1986
4	6.6	1.2	131.4	17.9	0.0016	0.001	Landrum, 1986
4	5.9	1.3	90.6	5.3	0.0007	0.0005	Landrum, 1986
4	7.2	1.6	77.5	10.2	0.0009	0.0006	Landrum, 1986
4	8.0	3.2	59.4	6.7	0.0005	0.0005	Landrum, 1986
4	6.9	2.3	92.2	6.8	0.0014	0.0005	Landrum, 1986
4	5.3	3.5	71.4	12.6	0.0043	0.00085	Landrum, 1986
4	5.3	3.4	68.6	11.7	0.0043	0.00085	Landrum, 1986
4	5.6	1.8	85.2	15.7	0.0032	0.0006	Landrum, 1986
4	4.1	1.4	143.8	20.2	0.0027	0.0004	Landrum, 1986
4	4.1	1.4	176.2	25.9			Landrum, 1986
4	4.1	1.4	171.4	17.2			Landrum, 1986
4	9.2	1.4	75.2	15.4	0.0013	0.0004	Landrum, 1986
4	6.5	2.7	112.3	24.8	0.0023	0.0006	Landrum, 1986
4	8.8	1.8	84.1	8.9	0.0013	0.0005	Landrum, 1986
4	6.8	2.0	103.8	9.6	0.0009	0.00033	Landrum, 1986
4	7.1	1.0			0.0022	0.0003	Landrum and Faust 1991
4	7.3	1.4			0.0031	0.0009	Landrum and Faust 1991
4	7.4	1.8			0.0018	0.0003	Landrum and Faust 1991
4	7.5	1.4			0.0025	0.0006	Landrum and Faust 1991
4	5.4		122.64				Landrum and Stubblefield 1991
4	5.2		162.91				Landrum and Stubblefield 1991
4	4.4		57				Landrum and Stubblefield 1991
4	8.1		105.5				Landrum and Stubblefield 1991
4	2.4		161.6				Landrum and Stubblefield 1991
4	11.2		78.8				Landrum and Stubblefield 1991
4	10.8		94.6				Landrum and Stubblefield 1991
4	10.6		89.5				Landrum and Stubblefield 1991
4	10.2		61.6				Landrum and Stubblefield 1991
4	11.3		66.9				Landrum and Stubblefield 1991
4	14.0		39.8				Landrum and Stubblefield 1991
4	8.9		197.2				Landrum and Stubblefield 1991
4	9.0		208.2				Landrum and Stubblefield 1991
4	3.0		266				Landrum and Stubblefield 1991
4	3.7		243				Landrum and Stubblefield 1991
4	3.7		213.6				Landrum and Stubblefield 1991
4	11.5		86.1				Landrum and Stubblefield 1991

Table 3.--Benz(a)pyrene Uptake Clearance from Aqueous Exposures and Elimination Rate Constant.

Temperature	Mass	Error	k_u	Error	k_e	Error	Reference
°C	mg	sd	ml g^{-1} h^{-1}	sd	h^{-1}		
3.3	4.2	2.7	87.7	12.3	0.003	0.0009	Landrum 1986
4	5.7	3.1	65.4	19.6	0.0026	0.0012	Landrum 1986
4	5.6	1.9	122.5	39	0.0027	0.002	Landrum 1986
4	6.7	2.4	119	11.9	0.0016	0.0028	Landrum 1986
4	5.8	1.5	172.8	12.4	0.0062	0.0009	Landrum 1986
4	6.8	2.4	126.3	15.8	0.0026	0.0006	Landrum 1986
4	7.9	1.7	157.9	17.6	0.00021	0.0003	Landrum 1986
4	6.5	2.5	167.6	20	0.007	0.001	Landrum 1986
4	6.4	2.5	78.1	11.4	0.0038	0.0006	Landrum 1986
4	4.2	2.7	137.2	14.6	0.0058	0.0007	Landrum 1986
4	6.5	2.5	174.3	21.7			Landrum 1986
4	6.7	2.0	181.1	30.1	0.0029	0.0006	Landrum 1986
4	5.8	1.8	137.2	19.2	0.0026	0.0006	Landrum 1986
4	6.6	1.2	72.6	15.2	0.0008	0.0007	Landrum 1986
4	5.9	1.3	170.9	12.4	0.0036	0.0005	Landrum 1986
4	7.2	1.6	142.1	7.3	0.002	0.0005	Landrum 1986
4	8.0	3.2	127.7	21.2	0.0081	0.0023	Landrum 1986
4	6.9	2.3	122.7	11	0.0026	0.0004	Landrum 1986
4	8.0	3.2	126.5	17.4	0.0031	0.0008	Landrum 1986
4	5.3	3.5	92.5	19.5	0.0078	0.0007	Landrum 1986
4	5.3	3.5	140.8	12.9	0.0078	0.0007	Landrum 1986
4	5.6	1.8	94	13.1	0.0085	0.0004	Landrum 1986
4	4.1	1.4	129.1	11.1	0.0086	0.0006	Landrum 1986
4	4.1	1.4	150.1	10.9			Landrum 1986
4	4.1	1.4	139.5	16.9			Landrum 1986
4	9.2	1.4	124.2	16.8	0.005	0.0007	Landrum 1986
4	6.5	2.7	167.5	28.6	0.0044	0.0005	Landrum 1986
4	8.8	1.8	89	7.6	0.009	0.0005	Landrum 1986
4	6.8	2.0	120.3	27.8	0.0055	0.0007	Landrum 1986
4	6.1	0.5			0.008	0.004	Landrum 1986
4	6.1	0.5			0.018	0.007	Landrum 1986
4	6.1	0.5			0.008	0.002	Landrum 1986
4	6.1	0.5			0.008	0.002	Landrum 1986
4	5.6		157.5				Landrum and Stubblefield 1991
4	5.3		149.9				Landrum and Stubblefield 1991
4	2.3		102.1				Landrum and Stubblefield 1991
4	3.2		64.6				Landrum and Stubblefield 1991
4	2.2		146.3				Landrum and Stubblefield 1991
4	4.2		177.7				Landrum and Stubblefield 1991
4	3.5		84.4				Landrum and Stubblefield 1991
4	2.9		124.8				Landrum and Stubblefield 1991
4	2.0		74.4				Landrum and Stubblefield 1991
4	1.7		68				Landrum and Stubblefield 1991
4	3.1		157.6				Landrum and Stubblefield 1991
6	5.0	2.3	125.9	15	0.0066	0.0016	Landrum 1986
7	7.2	1.5	158.5	10.3	0.0034	0.0005	Landrum 1986
8	7.2	2.0	143.4	19.9	0.011	0.002	Landrum 1986
8	6.1	1.4	152.3	22.7	0.0027	0.0006	Landrum 1986
10	4.5	1.1	124.9	11.1	0.019	0.002	Landrum 1986
10	6.0	1.2	164.7	13.95	0.0047	0.0005	Landrum 1986
10	8.0	3.2	181.3	17.1	0.0045	0.0006	Landrum 1986

Table 4.--Phenanthrene Uptake Clearance from Aqueous Exposures and Elimination Rate Constant.

Temperature	Mass	Error	k_u	Error	k_e	Error	Reference
°C	mg	sd	ml g^{-1} h^{-1}	sd	h^{-1}		
4	6.7	2.4	208	32.8	0.0012	0.0005	Landrum 1986
4	5.8	1.5	205.1	31.4	0.0018	0.0009	Landrum 1986
4	6.8	2.4	148.4	24.9			Landrum 1986
4	7.5	1.7	235.3	14.6	0.0006	0.0001	Landrum 1986
4	7.1	1.3			0.0028	0.0001	Landrum and Faust 1991
4	7.8	1.6			0.0025	0.0006	Landrum and Faust 1991
4	7.2	1.7			0.0026	0.0003	Landrum and Faust 1991
4	7.3	1.9			0.0025	0.0004	Landrum and Faust 1991
4	6.1	0.7			0.002	0.0007	Landrum *et al.* 1994
4	6.1	0.7			0.0023	0.0009	Landrum *et al.* 1994
4	6.1	0.7			0.0031	0.0006	Landrum *et al.* 1994
4	6.1	0.7			0.002	0.0008	Landrum *et al.* 1994
4	7.2	1.0			0.0016	0.002	Landrum *et al.* 1994
4	6.9	1.2			0.0012	0.0003	Landrum *et al.* 1994
4	6.9	0.8			0.0022	0.0002	Landrum *et al.* 1994
10	7.7	2.1	49.51	8.3			Harkey *et al.* 1994
10	8.6	2.1	63.8	4.82			Harkey *et al.* 1994

Table 5.--Pyrene Uptake Clearance from Aqueous Exposures and Elimination Rate Constant.

Temperature	Mass	Error	k_u	Error	k_e	Error	Reference
°C	mg	sd	ml g^{-1} h^{-1}	sd	h^{-1}	sd	
4	7.8	2.2	83.8	5.6	0.019	0.0015	Landrum 1986
4	9.2	1.9	83	8.4	0.013	0.001	Landrum 1986
4	9.2	1.9	82.8	7	0.013	0.001	Landrum 1986
4	9.0	3.0	120	13.7	0.008	0.001	Landrum 1986
4	8.3	1.8	147	22.5	0.0091	0.0011	Landrum 1986
4	7.1	2.4	108.7	6.5	0.009	0.0016	Landrum 1986
4	6.9	3.0	107	6.3	0.01	0.002	Landrum 1986
4	5.7	1.0	52.4	14	0.01	0.002	Landrum 1986
4	3.3	2.3	73.5	10	0.021	0.002	Landrum 1986
							Landrum 1986
7	6.2	2.2	93.9	7.7	0.017	0.0014	Landrum 1986
10	6.2	2.2	106	7.7	0.019	0.002	Landrum 1986

Table 6.--Biphenyl Uptake Clearance from Aqueous Exposures and Elimination Rate Constant.

Temperature	Mass	Error	k_u	Error	k_e	Error	Reference
^oC	mg	sd	ml $g^{-1}h^{-1}$	sd	h^{-1}	sd	
4	5.7	1.0	153	44.2			Landrum 1986
4	6.9	3.0	124.3	12.7			Landrum 1986
4	9.0	2.5	109.7	12.7			Landrum 1986
4	8.3	1.8	145.2	11.1			Landrum 1986
4	9.0	3.0	134.7	10.7			Landrum 1986
4	9.2	1.9	123.9	18.3			Landrum 1986
4	9.2	1.9	132.6	13.1			Landrum 1986
4	7.8	2.2	140.8	24.6			Landrum 1986
4	3.3	2.3	149.5	15.9			Landrum 1986
4	7.1	1.3			0.0013	0.0002	Landrum and Faust 1991
4	7.8	1.6			0.0009	0.0003	Landrum and Faust 1991
4	7.2	1.7			0.0011	0.0002	Landrum and Faust 1991
4	7.3	1.9			0.0006	0.0002	Landrum and Faust 1991
7	6.2	2.2	163.8	15.7			Landrum 1986
10	6.2	2.2	198	15.6			Landrum 1986

Table 7.--2,2',5,5'-Tetrachlorobiphenyl Uptake Clearance from Aqueous Exposures and Elimination Rate Constant.

Temperature	Mass	Error	Ku	Error	Ke	Error	Reference
°C	mg	sd	ml g^{-1} h^{-1}	sd	h^{-1}	sd	
4	7.1	1.0			0.0007	0.0003	Landrum and Faust 1991
4	7.3	1.4			0.0018	0.0008	Landrum and Faust 1991
4	7.4	1.8			0.0006	0.0005	Landrum and Faust 1991
4	7.5	1.4			0.0005	0.0003	Landrum and Faust 1991
4	8.7		88.53				Landrum and Stubblefield 1991
4	5.2		152.7				Landrum and Stubblefield 1991
4	3.9		136.1				Landrum and Stubblefield 1991
4	8.1		70.3				Landrum and Stubblefield 1991
4	3.6		147.6				Landrum and Stubblefield 1991
4	9.8		51.5				Landrum and Stubblefield 1991
4	10.8		64.5				Landrum and Stubblefield 1991
4	10.7		83.7				Landrum and Stubblefield 1991
4	10.2		62.4				Landrum and Stubblefield 1991
4	11.5		56.4				Landrum and Stubblefield 1991
4	14		36.1				Landrum and Stubblefield 1991
4	8.7		112.6				Landrum and Stubblefield 1991
4	9.0		95.8				Landrum and Stubblefield 1991
4	6.3		102.6				Landrum and Stubblefield 1991
4	3.7		184.7				Landrum and Stubblefield 1991
4	3.8		149.2				Landrum and Stubblefield 1991
4	14.9		50.2				Landrum and Stubblefield 1991
4	13.5		49.8				Landrum and Stubblefield 1991
4	12		85.8				Landrum and Stubblefield 1991
4	11.5		99.2				Landrum and Stubblefield 1991
4	15		82.3				Landrum and Stubblefield 1991
4	7.0		82.4				Landrum and Stubblefield 1991
4	6.6		167.5				Landrum and Stubblefield 1991
4	3.6		183.3				Landrum and Stubblefield 1991
4	3.7		62.5				Landrum and Stubblefield 1991
4	3.3		179				Landrum and Stubblefield 1991
4	2.1		92.8				Landrum and Stubblefield 1991
4	10.9		29				Landrum and Stubblefield 1991
4	10.4		33.4				Landrum and Stubblefield 1991
4	8.1		50.3				Landrum and Stubblefield 1991
4	10.5		30.1				Landrum and Stubblefield 1991
4	7.9		119.6				Landrum and Stubblefield 1991
4	15.5		14.4				Landrum and Stubblefield 1991
4	6.8		113				Landrum and Stubblefield 1991
4	5.2		199				Landrum and Stubblefield 1991
4	3.2		250				Landrum and Stubblefield 1991
4	6.4		127.8				Landrum and Stubblefield 1991
4	3.1		190.9				Landrum and Stubblefield 1991
4	3.0		278.4				Landrum and Stubblefield 1991
4	3.3		405.6				Landrum and Stubblefield 1991
4	3.1		172				Landrum and Stubblefield 1991
4	2.5		122.5				Landrum and Stubblefield 1991
4	2.4		89.5				Landrum and Stubblefield 1991
4	1.6		305.1				Landrum and Stubblefield 1991
4	2.4		111.9				Landrum and Stubblefield 1991

Table 8.--2,2',4,4',5,5'-Hexachlorobiphenyl Uptake Clearance from Aqueous Exposures and Elimination Rate Constant.

Compound	Temperature	Mass	Error	Ku	Error	Ke	Error	Reference
	^{o}C	mg	sd	ml g^{-1} h^{-1}	sd	h^{-1}	sd	
Trans-Chlordane	10	6.7	3.6	70.24	0.8			Harkey *et al.* 1994
	10	5.2	1.6	66.67	4.43			Harkey *et al.* 1994
Carbaryl	4			3.74	0.63	0.0002	0.00016	Landrum and Dupuis 1990
Pentachlorophenol	4			3.1	0.9	0.0033	0.0014	Landrum and Dupuis 1990

Table 9.--Uptake Clearance from Aqueous Exposures and Elimination Rate Constants for other Compounds.

Compound	Sediment source	Organic Carbon	Temperature	Concentration	Uptake Clearance (Mass)	Error	Uptake Clearance (OC)	Error	Reference
		g-OC g^{-1} Dry Sediment	°C	nmol g^{-1} dry sediment	g-dry sediment g^{-1}-organism h^{-1}	sd	µg organic carbon g^{-1} organism h^{-1}	sd	
Pyrene	Lk MI GH-45 7d	0.00434	10	0.004	0.074	0.006	319.1	28	Harkey *et al.* 1994
	Lk MI GH-45 7d	0.0053	10	0.004	0.033	0.002	176	11.7	Harkey *et al.* 1994
	Lk Michigan S-45	0.0313	4	0.0007	0.0029	0.0004	90.77	12.52	Landrum and Faust 1994
	Lk Michigan S-16	0.0111	4	0.0007	0.0143	0.0009	158.7	10	Landrum and Faust 1994
	Lk Michigan GH-45	0.0048	4	0.0007	0.0155	0.0009	71.3	4.14	Landrum and Faust 1994
	Lk Michigan S-22	0.0047	4	0.0007	0.0306	0.0024	143.8	11.3	Landrum and Faust 1994
	Lk Michigan S-10	0.0023	4	0.0007	0.0505	0.0063	116.2	14.5	Landrum and Faust 1994
	Lk Michigan GH-45	0.0046	4	0.0006	0.0139	0.0002	63.9	1	Landrum and Faust 1991
	Lk Michigan GH-45	0.004	4	0.0006	0.0147	0.0016	58.8	6.4	Landrum and Faust 1991
	Lk MI GH-45 Mod	0.008	4	0.0006	0.0076	0.0005	60.8	4	Landrum and Faust 1991
	Lk MI GH-45 Mod	0.0103	4	0.0006	0.0048	0.0004	48	4	Landrum and Faust 1991
	Lk Superior	0.0042	4	0.0025	0.034	0.00085	140	3.5	Landrum Unpublished
	Lk Michigan GH-45	0.0045	4	0.002	0.0288	0.00082	130	3.7	Landrum Unpublished
	Georgian Bay 1211	0.0389	4	0.0003	0.0026	0.00125	100	48.1	Landrum Unpublished
	Georgian Bay 1611	0.0562	4	0.0003	0.0037	0.0015	210	85.1	Landrum Unpublished
	Lk Erie	0.1062	4	0.0008	0.052	0.0009	5520	95.5	Landrum Unpublished
	Savannah River	0.0045	4	0.0085	0.0506	0.00038	230	1.72	Landrum Unpublished
	Pond 5	0.0142	4	0.0051	0.0285	0.00071	410	10.2	Landrum Unpublished
	Lk Saimaa	0.0549	4	0.0018	0.0064	0.00045	350	24.6	Landrum Unpublished
	Hollow Creek	0.0909	4	0.0047	0.0098	0.00036	890	32.7	Landrum Unpublished
	Lower Three Runs	0.2123	4	0.0012	0.004	0.00058	850	123.3	Landrum Unpublished
	Soil B-2	0.4504	4	0.0001	0.0007	0.0001	320	45.7	Landrum Unpublished
	Florissant	0.0125	4	0.0006	0.0183	0.0008	203	8.9	Landrum and Faust 1994
	Lk Michigan GH-45	@	4	0.002	0.019	0.001	87.4	4.6	Landrum 1989
	Lk Michigan GH-45	@	4	0.0004	0.023	0.001	106	4.6	Landrum *et al.* 1992
Py High Conc.	Lk Michigan GH-45	@	4	140	0.03	0.005	138	23	Landrum *et al.* 1994
		@		160	0.049	0.009	225	41.3	Landrum *et al.* 1994
		@		300	0.044	0.005	202	23	Landrum *et al.* 1994
		@		800	0.019	0.004	87.4	18.4	Landrum *et al.* 1994
		0.0046		260	0.048	0.003	221	13.8	Landrum *et al.* 1994
		0.0046		580	0.018	0.001	82.8	4.6	Landrum *et al.* 1994
		0.0046		910	0.018	0.002	82.8	9.2	Landrum *et al.* 1994
		0.0046		1230	0.017	0.001	78.2	4.6	Landrum *et al.* 1994
Pyrene Mixture	Lk Michigan GH-45	@	4	0.89	0.019	0.002	87.4	9.2	Landrum et al .1991
	Lk Michigan GH-45	@	4	21.4	0.045	0.006	207	27.6	Landrum et al .1991
	Lk Michigan GH-45	@	4	41	0.048	0.006	221	27.6	Landrum et al .1991
	Lk Michigan GH-45	@	4	119.6	0.098	0.014	451	64.4	Landrum et al .1991
	Lk Michigan GH-45	@	4	327	0.079	0.014	363	64.3	Landrum et al .1991
	Lk MI GH-45 3d	@	4	248.5	0.124	0.013	5700	591	Landrum *et al.* 1992
	Lk MI GH-45 60d	@	4	246.5	0.034	0.003	156	13.8	Landrum *et al.* 1992
	Lk MI GH-45 150d	@	4	270.1	0.064	0.012	294	55.1	Landrum *et al.* 1992

Table 10.--Uptake Clearance of Sediment-Associated Pyrene.

Compound	Sediment source	Organic Carbon	Temperature	Concentration	Uptake Clearance (Mass)	Error	Uptake Clearance (OC)	Error	Reference
		g-OC g $^{-1}$ Dry Sediment	^{o}C	nmol g^{-1} Dry Sediment	g-dry sediment g^{-1}-organism h^{-1}	sd	ug organic carbon g^{-1} organism h^{-1}	sd	
Benzo(a)pyrene	Lk. Michigan GH-45	0.00473	10	0.0014	0.00333	0.0013	15.3	4.3	Harkey *et al.* 1994
	Lk. Michigan S-45	0.0313	4	0.0006	0.0001	0.00003	3.19	0.95	Landrum and Faust 1994
	Lk Michigan S-16	0.011	4	0.0005	0.00036	0.00004	3.96	0.44	Landrum and Faust 1994
	Lk Michigan GH-45	0.0048	4	0.0006	0.00094	0.00007	4.51	0.34	Landrum and Faust 1994
	Lk Michigan S-22	0.0047	4	0.0006	0.00123	0.00014	5.78	0.66	Landrum and Faust 1994
	Lk Michigan S-10	0.0023	4	0.0006	0.0019	0.0002	4.37	0.46	Landrum and Faust 1994
	Lk Michigan GH-45	0.0046	4	0.0006	0.0046	0.0003	21.2	1.4	Landrum and Faust 1991
	Lk Michigan GH-45	0.004	4	0.0006	0.0046	0.0008	18.4	3.2	Landrum and Faust 1991
	Lk MI GH-45 Mod	0.008	4	0.0006	0.0022	0.0002	17.6	1.6	Landrum and Faust 1991
	Lk MI GH-45 Mod	0.01	4	0.0006	0.0015	0.0002	15	2	Landrum and Faust 1991
	Lk Michigan GH-45	0.0045	4	0.0035	0.0029	0.0002	13	0.9	Landrum unpublished
	Lk Michigan GH-45	0.0045	4	0.0001	0.0051	0.007	23	31.6	Landrum Unpublished
	LK Superior	0.0042	4	0.0001	0.0006	0.0001	2.5	0.42	Landrum Unpublished
	Georgian Bay 1211	0.0389	4	0.00014	0.0002	0.00002	7.8	0.78	Landrum Unpublished
	Georgian Bay 1600	0.0562	4	0.00009	0.0005	0.0001	28	5.6	Landrum Unpublished
	Lk Erie	0.1062	4	0.00005	0.0024	N/A	255	N/A	Landrum Unpublished
	Savannah river	0.0045	4	0.0003	0.002	0.0002	9.1	0.91	Landrum Unpublished
	Pond 5	0.0142	4	0.0002	0.0008	0.0001	11	1.4	Landrum Unpublished
	Lk Saimaa	0.0549	4	0.00031	0.0001	0.00003	6.3	1.9	Landrum Unpublished
	Hollow Creek	0.0909	4	0.0004	0.0001	0.00004	10	4	Landrum Unpublished
	Lower 3 runs	0.2123	4	0.00059	0.0003	0.0001	63	20.8	Landrum Unpublished
	Soil 217g	0.3221	4	0.0002	0.0006	N/A	190	N/A	Landrum Unpublished
	Florissant Soil	0.0125	4	0.0006	0.00079	0.00005	98.8	6.3	Landrum and Faust 1994
	Florissant Soil	0.0135	4	1.377	0.0018	0.0006	24.3	8.1	Lydy and Landrum 1993
	Florissant Soil	0.0132	4	41.2	0.0029	0.0009	38.3	12	Lydy and Landrum 1993
	Lk. Michigan GH-45	@	4	0.0011	0.0029	0.001	13.34	4.6	Landrum 1989
	Lk Michigan GH-45	@	4	0.00075	0.0018	0.0002	8.28	0.92	Landrum *et al.* 1989
BaP in Mixture	Lk Michigan GH-45	@	4	21.4	ND				
	Lk Michigan GH-45	@	4	41	0.0051	0.002	23.5	9.2	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	119.6	0.0093	0.002	42.8	9.2	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	327	0.0094	0.001	43.2	4.6	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	248.5	0.053	0.02	244	92	Landrum *et al.* 1992
	Lk MI GH-45 60d	@	4	246.5	0.022	0.002	101	9.2	Landrum *et al.* 1992
	Lk MI GH-45 150d	@	4	270.1	0.054	0.02	248	92	Landrum *et al.* 1992
BaP with Cl Hydro	Lk Michigan GH-45	@	4	0.00075	0.0024	0.0005	11	2.3	Landrum *et al.* 1989

Table 11.--Uptake Clearance of Sediment-Associated Benzo(a)pyrene.

	Sediment source	Organic Carbon	Temperature	Concentration	Uptake Clearance (Mass)	Error	Uptake Clearance (OC)	Error	Reference
		g-OC g^{-1} dry sediment	^{o}C	nmol g^{-1} dry sediment	g-dry sediment g^{-1}-organism h^{-1}	sd	ug organic carbon g^{-1}organism h^{-1}	sd	
Phenanthrene	Lk Michigan GH-45	@	4	1.05	0.041	0.009	188.6	41.4	Landrum 1989
	Lk Michigan GH-45	@	4	1.05	0.08	0.0006	368	2.8	Landrum 1989
	Lk Michigan GH-45	@	4	1.05	0.08	0.0009	368	4.1	Landrum 1989
	Lk Michigan GH-45	@	4	1.05	0.075	0.011	345	50.6	Landrum 1989
	Lk Michigan GH-45	@	4	1.05	0.075	0.011	345	50.6	Landrum 1989
	Lk Michigan GH-45	@	4	1.05	0.058	0.006	266.8	27.6	Landrum 1989
	Lk Michigan GH-45	@	4	1.05	0.047	0.023	216.2	105	Landrum 1989
	Lk Michigan GH-45	@	4	0.7	0.038	0.009	174.8	41.4	Landrum *et al.* 1991
	Lk Michigan GH-45	0.0046	4	80	0.25	0.07	1150	322	Landrum *et al.* 1994
	Lk Michigan GH-45	0.0046	4	180	0.18	0.03	828	138	Landrum *et al.* 1994
	Lk Michigan GH-45	0.0046	4	450	0.55	0.09	2530	414	Landrum *et al.* 1994
	Lk Michigan GH-45	0.0046	4	620	0.27	0.05	1240	230	Landrum *et al.* 1994
Anthracene	Lk Michigan GH-45	@	4	0.7	0.024	0.002	110	9.2	Landrum 1989
Chrysene	Lk Michigan GH-45	0.0052	10	0.00015	0.028	0.002	128.5	7	Harkey *et al.* 1994
Benz(a)anthracene	Lk Michigan GH-45	@	4	0.21	0.005	0.001	23	4.6	Landrum 1989
PAH In Mixture									
Fluorene	Lk MI GH-45 3d	@	4	248.5	0.464	0.13	2130	597	Landrum *et al.* 1991
	Lk MI GH-45 60 d	@	4	246.5	0.079	0.046	363	211	Landrum *et al.* 1991
	Lk MI GH-45 150d	@	4	270.1	0.083	0.015	382	69	Landrum *et al.* 1991
Phenanthrene	Lk MI GH-45 3d	@	4	248.5	0.213	0.039	980	179	Landrum *et al.* 1991
	Lk MI GH-45 60 d	@	4	246.5	0.092	0.033	423	152	Landrum *et al.* 1991
	Lk MI GH-45 150d	@	4	270.1	0.094	0.013	432	59.7	Landrum *et al.* 1991
Anthracene	Lk MI GH-45 3d	@	4	248.5	0.21	0.034	966	156	Landrum *et al.* 1991
	Lk MI GH-45 60 d	@	4	246.5	0.145	0.037	667	170	Landrum *et al.* 1991
	Lk MI GH-45 150d	@	4	270.1	0.239	0.046	1100	212	Landrum *et al.* 1991
Fluoranthene	Lk MI GH-45 3d	@	4	248.5	0.082	0.021	377	97	Landrum *et al.* 1991
	Lk MI GH-45 60 d	@	4	246.5	0.11	0.025	506	115	Landrum *et al.* 1991
	Lk MI GH-45 150d	@	4	270.1	0.086	0.024	396	111	Landrum *et al.* 1991
Chrysene	Lk MI GH-45 3d	@	4	248.5	0.18	0.036	828	166	Landrum *et al.* 1991
	Lk MI GH-45 60 d	@	4	246.5	0.051	0.004	235	18	Landrum *et al.* 1991
	Lk MI GH-45 150d	@	4	270.1	0.126	0.012	580	55	Landrum *et al.* 1991
Benzo(b)Fluoranthene	Lk MI GH-45 3d	@	4	248.5	0.095	0.02	437	92	Landrum *et al.* 1991
	Lk MI GH-45 60 d	@	4	246.5	0.052	0.02	239	92	Landrum *et al.* 1991
	Lk MI GH-45 150d	@	4	270.1	0.059	0.004	271	18	Landrum *et al.* 1991
Benzo(e)pyrene	Lk MI GH-45 3d	@	4	248.5	0.043	0.013	198	60	Landrum *et al.* 1991
	Lk MI GH-45 60 d	@	4	246.5	0.019	0.003	87.4	13.8	Landrum *et al.* 1991
	Lk MI GH-45 150d	@	4	270.1	0.047	0.01	216	46	Landrum *et al.* 1991

Table 12.--Uptake Clearance of Other Sediment-Associated Polycyclic Aromatic Hydrocarbons.

Fluorene	Lk Michigan GH-45	@	4	21.4	0.077	0.014	354	197	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	41	0.152	0.028	699	129	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	119.6	0.137	0.017	630	78.2	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	327	0.27	0.06	1240	276	Landrum *et al.* 1991
Phenanthrene	Lk Michigan GH-45	@	4	21.4	0.139	0.011	639	50.6	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	41	0.137	0.017	630	78.2	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	119.6	0.233	0.023	1070	106	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	327	0.189	0.029	869	133	Landrum *et al.* 1991
Anthracene	Lk Michigan GH-45	@	4	21.4	0.057	0.009	262	41.4	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	41	0.139	0.019	639	87.3	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	119.6	0.112	0.013	515	59.8	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	327	0.12	0.023	552	106	Landrum *et al.* 1991
Fluoranthene	Lk Michigan GH-45	@	4	21.4	0.036	0.012	166	55.3	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	41	0.165	0.01	759	46	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	119.6	0.112	0.03	515	138	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	327	0.205	0.07	943	322	Landrum *et al.* 1991
Chrysene	Lk Michigan GH-45	@	4	21.4	0.023	0.007	106	32.3	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	41	0.037	0.001	170	4.6	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	119.6	0.023	0.0005	106	2.3	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	327	0.03	0.005	138	23	Landrum *et al.* 1991
Benzo(b)fluoranthene	Lk Michigan GH-45	@	4	21.4	0.011	0.002	50.6	9.2	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	41	0.117	0.089	538	409	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	119.6	0.0322	0.003	148	13.8	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	327	0.042	0.011	193	50.5	Landrum *et al.* 1991
Benzo(e)pyrene	Lk Michigan GH-45	@	4	21.4	0.0021	0.0018	9.66	8.28	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	41	0.0069	0.002	31.7	9.2	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	119.6	0.0094	0.002	43.2	9.2	Landrum *et al.* 1991
	Lk Michigan GH-45	@	4	327	0.0093	0.002	42.8	9.2	Landrum *et al.* 1991

Table 12 (cont).--Uptake Clearance of Other Sediment-Associated Polycyclic Aromatic Hydrocarbons.

Compound	Sediment source	Organic Carbon	Temperature	Concentration	Uptake Clearance (Mass)	Error	Uptake Clearance (OC)	Error	Reference
		g-OC g^{-1} dry sediment	^{o}C	nmol g^{-1} dry sediment	g-dry sediment g^{-1} organism h^{-1}	sd	ug organic carbon g^{-1} organism h^{-1}	sd	
2,5,2',5' Tetra	Lk MI GH-45	0.0046	4	0.315	0.019	0.0007	87.4	3.22	Landrum and Faust 1991
	Lk MI GH-45*	0.004	4	0.282	0.0212	0.0017	84.8	6.8	Landrum and Faust 1991
	Lk MIGH-45**	0.008	4	0.322	0.0108	0.0004	86.4	3.2	Landrum and Faust 1991
	Lk MIGH-45**	1.03	4	0.334	0.006	0.0004	61.8	4.1	Landrum and Faust 1991
	Lk MI GH-45	0.0048	4	0.31	0.0223	0.0008	107	3.8	Landrum and Faust 1994
	Lk MI S-45	0.0313	4	0.32	0.00396	0.0009	123.9	2.8	Landrum and Faust 1994
	Lk MI S-16	0.011	4	0.38	0.0249	0.0024	273.9	26.4	Landrum and Faust 1994
	Lk MI S-22	0.0047	4	0.41	0.0516	0.0031	242.5	14.6	Landrum and Faust 1994
	Lk MI S-10	0.0023	4	0.32	0.0929	0.0047	213.7	10.8	Landrum and Faust 1994
	Florissant	0.0125	4	0.33	0.0585	0.0071	731	88.7	Landrum and Faust 1994
2,4,2',4' Tetra	Lk Superior	0.0042	4	0.066	0.0238	0.002	100	0.84	Unpublished Data
	Lk MI GH-45	0.0045	4	0.057	0.002	0.0005	9	2.3	Unpublished Data
	Lk MI GH-45	0.0045	4	0.051	0.0059	0.00065	26.6	2.9	Unpublished Data
	Lk Huron GB-1211	0.0389	4	0.092	0.0008	0.00011	31.1	4.3	Unpublished Data
	Lk Huron GB-1600	0.0562	4	0.126	0.0009	0.00014	50.6	7.9	Unpublished Data
	Lk Erie	0.1062	4	0.076	0.0007	0.00013	74.3	13.8	Unpublished Data
	Savannah River	0.0045	4	0.055	0.0028	0.00052	12.6	2.34	Unpublished Data
	Pond 5	0.0142	4	0.123	0.0123	0.0017	175	24.2	Unpublished Data
	Lk Saimaa	0.0549	4	0.067	0.0006	0.00006	32.9	3.3	Unpublished Data
	Hollow Creek	0.091	4	0.059	0.0006	0.00007	54.5	6.4	Unpublished Data
	Lower 3 Runs	0.2123	4	0.108	0.0003	0.00005	63.7	10.7	Unpublished Data
	Soil B-2	0.4504	4	0.078	0.0003	0.00009	135	40.5	Unpublished Data
	Lk MI GH-45	@	4	0.94	0.018	0.001	82.8	4.6	Landrum *et al.* 1989
In Mixture									
2,2',4,4' Tetra	Lk MI GH-45	@	4	2.4	0.029	0.003	133	13.8	Landrum *et al.* 1989
2,2',3,4 Tetra	Lk MI GH-45	@	4	2.4	0.06	0.004	276	18.4	Landrum *et al.* 1989
2,2',6,6' Tetra	Lk MI GH-45	@	4	2.4	0.057	0.014	262	64.4	Landrum *et al.* 1989
3,3',4,4' Tetra	Lk MI GH-45	@	4	2.4	0.15	0.07	690	322	Landrum *et al.* 1989

@ = organic carbon not measured and 0.46% used to calculate carbon normalized uptake clearance

Table 13.--Uptake Clearance of Sediment-Associated Tetrachlorobiphenyl.

Compound	Sediment source	Organic Carbon	Temperature	Concentration	Uptake Clearance (Mass)	Error	Uptake Clearance (OC)	Error	Reference
		g-OC g^{-1} dry sediment	^{o}C	nmol g^{-1} dry sediment	g-dry sediment g^{-1} organism h^{-1}	sd	ug organic carbon g^{-1} organism h^{-1}	sd	
Hexachlorobiphenyl	Lk MI GH-45	0.0046	4	0.37	0.012	0.0008	55.2	3.7	Landrum and Faust 1991
	Lk MI GH45	0.004	4	0.29	0.0146	0.0024	58.4	10	Landrum and Faust 1991
	Lk MI GH-45 (Fine Fraction)	0.008	4	0.39	0.0064	0.0008	51.2	6.4	Landrum and Faust 1991
	Lk MI GH-45 (very Fine Fraction)	0.0103	4	0.39	0.0036	0.0003	37.1	3.1	Landrum and Faust 1991
	Lk MI GH-45	0.0048	4	0.23	0.0066	0.0002	31.7	0.96	Landrum and Faust 1994
	Lk MI S-45	0.0313	4	0.24	0.00138	0.00004	43.8	1.3	Landrum and Faust 1994
	Lk MI S-16	0.011	4	0.22	0.00387	0.0006	42.6	6.6	Landrum and Faust 1994
	Lk MI S-22	0.0047	4	0.24	0.0111	0.0011	52.2	5.2	Landrum and Faust 1994
	Lk MI S-10	0.0023	4	0.26	0.0195	0.0008	44.9	1.84	Landrum and Faust 1994
	Florissant	0.0125	4	0.21	0.0192	0.0009	240	17.3	Landrum and Faust 1994
	Lk MI GH-45	0.0046	4	0.05	0.0057	0.0033	26.2	15.1	Landrum 1989
	Lk Superior	0.0042	4	0.259	0.0097	0.0001	40.7	0.42	Unpublished Data
	Lk MI GH-45	0.0045	4	0.291	0.0043	0.0003	19.4	1.4	Unpublished Data
	Lk MI GH-45	0.0045	4	0.258	0.0052	0.00045	23.4	2	Unpublished Data
	Lk Huron GB-1211	0.0389	4	0.312	0.0008	0.0001	31.2	3.9	Unpublished Data
	Lk Huron GB-1600	0.0562	4	0.262	0.0011	0.0001	61.8	5.6	Unpublished Data
	Lk Erie	0.1062	4	0.147	0.0019	0.0005	202	53.2	Unpublished Data
	Savannah River	0.0045	4	0.184	0.005	0.0008	22.5	3.6	Unpublished Data
	Pond 5	0.0142	4	0.147	0.0097	0.0017	138	24.2	Unpublished Data
	Lk Saimaa	0.0549	4	0.227	0.0006	0.00005	32.9	2.7	Unpublished Data
	Hollow Creek	0.091	4	0.354	0.0014	0.0001	127	9.1	Unpublished Data
	Lower 3 Runs	0.2123	4	0.429	0.0003		63.7		Unpublished Data
	Soil 217g	0.3221	4	0.436	0.0005		161		Unpublished Data
In Mixture									
2,2',4,4',5,5'	Lk MI GH-45	@	4	2.4	0.006	0.004	27.6	18.4	Landrum *et al.* 1989
2,2',4,4',6,6'	Lk MI GH-45	@	4	2.4	0.012	0.006	55.2	27.6	Landrum *et al.* 1989

@ = organic carbon not measured and 0.46% used to calculate organic carbon normalized uptake clearance

Table 14.--Uptake Clearance of Sediment-Associated Hexachlorobiphenyl

Compound	Sediment source	Organic Carbon	Temperature	Concentration	Uptake Clearance (Mass)	Error	Uptake Clearance (OC)	Error	Reference
		g-OC g^{-1} dry sediment	^{o}C	nmol g^{-1} dry sediment	g-dry sediment g^{-1} organism h^{-1}	sd	ug organic carbon g^{-1} organism h^{-1}	sd	
Trans-Chlordane	Lk MI GH-45	0.005	10	1.5	0.05	0.004	246.7	18	Harkey et al 1994
	Lk MI GH-45	0.004		1.28	0.054	0.003	216.8	12.6	Harkey et al 1994
	Lk MI GH-45	0.0052		0.95	0.048	0.003	252.7	16	Harkey et al 1994
DDT	Lk MI GH-45	0.005	10	1.04	0.018	0.001	91	5	Harkey et al 1994
Endrin	Lk MI GH-45	0.0068	10	3.69	0.254	0.045	1726.9	308	Harkey et al 1994
Endrin - Dilution	Lk MI GH-45	0.0044	10	1.32	0.043	0.0048	189.2	21	Harkey et al 1994
In Mixture									
Lindane	Lk MI GH-45	@	4	2.4	0.085	0.017	391	78.2	Landrum *et al.* 1989
Dieldrin	Lk MI GH-45	@	4	2.4	0.032	0.015	147	68.9	Landrum *et al.* 1989
2,2',5 Trichloro	Lk MI GH-45	@	4	2.4	0.012	0.005	55.2	23	Landrum *et al.* 1989
HCB	Lk MI GH-45	@	4	2.4	0.043	0.004	198	18.4	Landrum *et al.* 1989
2,4,4' Trichloro	Lk MI GH-45	@	4	2.4	0.008	0.004	36.8	18.4	Landrum *et al.* 1989
p,p'-DDE	Lk MI GH-45	@	4	2.4	0.022	0.013	101	59.7	Landrum *et al.* 1989
p,p'-DDT	Lk MI GH-45	@	4	2.4	0.014	0.008	64.4	36.8	Landrum *et al.* 1989

@=organic carbon not measured and 0.46% used to calculate carbon normalized uptake clearance

Table 15.--Uptake Clearance of Other Sediment-Associated Chlorinated Hydrocarbons