Chemical Category: PESTICIDE (ORGANOCHLORINE)

Chemical Name (Common Synonyms): DIELDRIN **CASRN:** 60-57-1

Chemical Characteristics

Solubility in Water: 186 µg/L at 25°C [1]

Half-Life: 175 days to 3 years, based on unacclimated aerobic soil grab sample data and reported half-life in soil based on field data [2]

Log K_{ow}: 5.37 [3]

Log K_{oc}: 5.28 L/kg organic carbon

Human Health

Oral RfD: 5×10^{-5} mg/kg/day [4]

Confidence: Medium, uncertainty factor = 100

Critical Effect: Liver lesions (focal proliferation and focal hyperplasia) in rats, liver carcinomas in mice

Oral Slope Factor: $1.6 \times 10^{+1}$ per (mg/kg)/day [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Log BCFs for tadpole and juvenile frogs have been measured at 2.20 to 3.33, whereas log BCFs for adult frogs were 1.57 to 2.58. Dieldrin appears to bioconcentrate to a lesser extent in frogs than in fish. Mallard ducklings exposed to dieldrin-contaminated water for drinking and swimming had log BCFs ranging from 1.69 to 2.21 in liver, 0.98 to 1.97 in muscle, 2.25 to 2.84 in skin, and 2.85 to 3.30 in lipid. Mallard ducklings exposed for longer periods had log BCFs up to 9.30. BSAFs were calculated for red-winged blackbirds and tree swallow eggs during a study in the Great Lakes area, with values ranging from 7.5 to 448, as reported in the attached summary table. The BSAF for tree swallow nestings was 341.

Food Chain Multipliers: A biomagnification factor of 16 has been reported for dieldrin for herring gulls feeding on alewife in Lake Ontario [5]. A study of arctic marine food chains measured biomagnification factors for dieldrin that ranged from 2.2 to 2.4 for fish to seal, 4.9 to 5.5 for seal to bear, and 11.4 for fish to bear [6].

Aquatic Organisms

Partitioning Factors: In older studies, the following log BCFs have been reported for dieldrin: 4.51 in freshwater alga [7]; from 3.38 to 4.83 in fish [8]; and log 3.20 in a saltwater mussel [9]. A log BCF of 5.36 was found for rainbow trout [34]. BSAFs ranging from 1.120 to 7.134 were reported to bivalves [33].

Food Chain Multipliers: Food chain multipliers (FCMs) for trophic level 3 aquatic organisms were 8.6 (all benthic food web), 1.2 (all pelagic food web), and 5.5 (benthic and pelagic food web). FCMs for trophic level 4 aquatic organisms were 10.8 (all benthic food web), 1.9 (all pelagic food web), and 5.8 (benthic and pelagic food web) [36].

Toxicity/Bioaccumulation Assessment Profile

Dieldrin is the name of an insecticide that was used in the United States for locust and mosquito control until production and importation were banned. In addition to man-made production, dieldrin is derived from the oxidation of aldrin, which is also an insecticide. Aldrin is readily converted to dieldrin under normal environmental conditions [10]. In addition, aldrin is readily metabolized to dieldrin, so the effects seen in animals exposed to aldrin may be caused by dieldrin [11]. Dieldrin is one of the most persistent of the chlorinated hydrocarbons, and is highly resistant to biodegradation and abiotic degradation. In water, volatilization of dieldrin to the atmosphere is probably an important process, but transformation processes in soils and sediment are slow. Dieldrin sorbs tightly to soil and sediment, particularly if substantial amounts of organic carbon are present.

Dieldrin is toxic to aquatic organisms, birds, and mammals and is capable of producing carcinogenic, teratogenic, and reproductive effects [10]. Teratogenic effects include cleft palate, webbed foot, and skeletal anomalies. Reproductive effects include decreased fertility, increased fetal death, and effects on gestation [10].

In aquatic organisms, the acute toxicity of dieldrin ranges from 0.5 to 740 µg/L for freshwater and 0.7 to >100 µg/L for saltwater organisms [12]. Differences between dieldrin concentrations causing acute lethality and chronic toxicity in species acutely sensitive to this insecticide are small; acute-chronic ratios ranged from 2.4 to 12.8 for three species [12]. Dieldrin is generally an order of magnitude more toxic to fish than is aldrin [11]. LC50s for freshwater and saltwater aquatic invertebrates exposed to sediment spiked with dieldrin in the laboratory have been shown to range from 0.0041 to 386 µg/g dw [12]. Bioconcentration factors for dieldrin in various aquatic organisms range from 400 to 68,000 [8], indicating that dieldrin will show moderate to significant bioaccumulation in various aquatic species.

Mammals appear to be more sensitive to dieldrin poisoning than birds. Brain concentrations associated with lethality in mammals are 5 mg/kg and in birds are 10 mg/kg [11]. Concentrations as low as 1 mg/kg in the brain might trigger irreversible starvation in sensitive individuals of birds [13]. Major effects on reproduction in wildlife are not expected to occur at dieldrin concentrations of less than one half those causing mortality [11]. Dieldrin is commonly found in the brain, tissues, and eggs of fish-eating birds that also have residues of organochlorines such as DDE and PCBs. Based on a number of literature studies, the State of New York proposed a dietary fish flesh criterion of 0.12 mg/kg to protect piscivorous wildlife [14]. There are limited studies relating aldrin concentrations to toxicity because of the rapid conversion of aldrin into dieldrin.

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Crassostrea virginica, Eastern oyster			107 mg/kg (whole body)[4]	Cellular, NOED				[23]	L; no histological effects on structure of gill, gut or mantle
			11 mg/kg (whole body)[4]	Cellular, NOED				[23]	
			1.03 mg/kg (whole body)[4]	Cellular, NOED				[23]	
Crassostrea virginica, Eastern oyster			1.44 mg/kg (whole body)[4]	Behavior, LOED				[29]	L; erratic shell movements, extended shell closure indicated irritation
			18.6 mg/kg (whole body)[4]	Behavior, NA				[29]	
			1.44 mg/kg (whole body)[4]	Mortality, NOED				[29]	L; no effect on mortality within 168 hours
			18.6 mg/kg (whole body)[4]	Mortality, NOED				[29]	
Crassostrea virginica, Eastern oyster			13.9 mg/kg (whole body)[4]	Growth, NOED				[31]	L; estimated NOED - no statistical summary in text

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Macomona liliana, Mollusk	73.3 µg/kg OC		201.7 µg/kg lipid				2.752	[33]	F, %lipid = 2.95; %sed OC = 0.30
	52.1 µg/kg OC		371.7 µg/kg lipid				7.134	[33]	F, %lipid = 2.33; %sed OC = 0.73
	72.7 µg/kg OC		172.0 µg/kg lipid				2.366	[33]	F, %lipid = 2.57; %sed OC = 0.22
	60.0 µg/kg OC		76.0 µg/kg lipid				1.267	[33]	F, %lipid = 2.04; %sed OC = 0.25
	20.8 µg/kg OC		80.2 µg/kg lipid				3.856	[33]	F, %lipid = 3.13; %sed OC = 0.48
Austrovenus stutchburyi, Mollusk	73.3 µg/kg OC		102.7 µg/kg lipid				1.401	[33]	F, %lipid = 5.62; %sed OC = 0.30
	52.1 µg/kg OC		127.6 µg/kg lipid				2.449	[33]	F, %lipid = 5.21; %sed OC = 0.73
	72.7 µg/kg OC		105.2 µg/kg lipid				1.447	[33]	F, %lipid = 4.85; %sed OC = 0.22
	60.0 µg/kg OC		67.2 µg/kg lipid				1.120	[33]	F, %lipid = 3.87; %sed OC = 0.25
	20.8 µg/kg OC		58.6 µg/kg lipid				2.817	[33]	F, %lipid = 4.27; %sed OC = 0.48
Mercenaria mercenaria, Quahog clam			0.38 mg/kg (whole body)[4]	Behavior, NOED				[22]	L; no effect on feeding activity

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Mya arenaria, Soft shell clam			0.87 mg/kg (whole body)[4]	Behavior, NOED				[22]	L; no effect on feeding activity
Chlamydotheca arcuata, Ostracod			1 mg/kg (whole body)[4]	Mortality, LOED				[28]	L; immobility, mortality, resd_conc_wet value > 1.0
Palaemonetes pugio, Grass shrimp			2.1 mg/kg (whole body)[4]	Mortality, LOED				[31]	L; estimated loed - no statistical summary in text
			0.09 mg/kg (whole body)[4]	Mortality, NOED				[31]	L; estimated noed - no statistical summary in text
Penaeus duorarum, Pink shrimp			0.23 mg/kg (whole body)[4]	Mortality, ED50				[31]	L; ED50 via Spearman Karber 1.5 (msl)
			0.08 mg/kg (whole body)[4]	Mortality, LOED				[31]	L; estimated LOED - no statistical summary in text
			0.01 mg/kg (whole body)[4]	Mortality, NOED				[31]	L; estimated NOED - no statistical summary in text
Chironomus riparius, Midge			1.9 mg/kg (whole body)[4]	Mortality, ED10				[24]	L; all larvae moribund in 2 hours

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			1.1 mg/kg (whole body)[4]	Behavior, ED50				[24]	L; 50 - 75% mortality, lethargy within 2 hours
			1.1 mg/kg (whole body)[4]	Mortality, ED50				[24]	
			1.1 mg/kg (whole body)[4]	Behavior, ED50				[24]	L; 50 - 75% mortality, lethargy within 2 hours
			1.1 mg/kg (whole body)[4]	Mortality, ED50				[24]	
Fishes									
Squalus acanthias, Spiny dogfish			1 mg/kg (whole body)[4]	Mortality, NOED				[27]	L; no effect on mortality in 24 hours
Oncorhynchus mykiss, Rainbow trout			0.14 mg/kg (fat)[4]	Physiological, ED30				[32]	L; 30% decrease in hemoglobin content relative to control
			0.14 mg/kg (fat)[4]	Physiological, ED30				[32]	L; 30% increase in liver size relative to control
			0.05 mg/kg (fat)[4]	Physiological, ED35				[32]	L; 35% increase in kidney size relative to control
			0.14 mg/kg (fat)[4]	Growth, ED40				[32]	L; 40% decrease in growth relative to control

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Oncorhynchus mykiss, Rainbow trout (juveniles)					5.36			[34]	L
Salmonids							6.65	[35]	F
Carassius auratus, Goldfish			3.8 mg/kg (whole body)[4]	Behavior, LOED				[26]	L; hyperexcit-ability
Leuciscus idus, Golden ide			151 mg/kg (whole body)[4]	Mortality, NOED				[25]	L; no effect on survivorship in 3 days
Cyprinodon variegatus, Sheepshead minnow			52.9 mg/kg (whole body)[4]	Mortality, ED50				[31]	L; ED50 via Spearman Karber 1.5 (msl)
			34 mg/kg (whole body)[4]	Mortality, LOED				[31]	L; estimated NOED - no statistical summary in text
			12.8 mg/kg (whole body)[4]	Mortality, NOED				[31]	
Gambusia affinis, Mosquito fish			28 mg/kg (whole body)[4]	Mortality, NOED				[30]	L; no effect on survivorship after 3 days

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Poecilia reticulata, Guppy			10.7 mg/kg (whole body)[4]	Growth, NA				[21]	L; decreased biomass of guppy population in laboratory ecosystem
Lepomis macrochirus, Bluegill			3.7 mg/kg (whole body)[4]	Behavior, LOED				[26]	L; behavioral changes, loss of equilibrium, convulsions
Wildlife									
Xenopus laevis, African clawed frog (tadpole stage)		water exposure 2.3±0.2 µg/L	0.7 mg/kg[5] (whole body)		2.48			[15]	L; 28-day exposure; insufficient tissue for replicates; values are mean ± SE
		water exposure 1.1±0.1 µg/L	1.8±1.2 mg/kg[5] (whole body)		3.21±3.04			[15]	L; 28-day exposure
		(water exposure) µg/L 2.0±0.0 4.2±0.1 9.3±0.2 20.5±0.4	mg/kg[5] (whole body): 0.8 20.0±0 3.0±0.6 7.0		 2.60 2.68±0 2.51±0.07 2.53			[15]	L; 28-day exposure; insufficient tissue for replicates for all exposures; values are mean ± SE
		µg/L (water exposure): 0.9±0.1 1.8±0.2 3.8±0.3 9.7±0.4	mg/kg[5] (whole body) 0.4±0 0.8±0.2 1.5±0.5 3.0±1.0	 NOAEL LOAEL	 2.67±0 2.62±1.92 2.59±2.11 2.49±2.01			[15]	L; 24-day exposure; values are mean ± SE; effects based on mortality

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Xenopus laevis, African clawed frog (tadpole stage)		water exposure 5.5 µg/L	1.8 mg/kg[5] (whole body)	LC50				[15]	L; 24-day exposure; LC50 tissue dieldrin estimated by graphical extrapolation
Xenopus laevis, African clawed frog (juvenile stage)		water exposure 2.1±0.2 µg/L	4.5±0.3 mg/kg[5] (whole body)		3.33±2.38			[15]	L; 28-day exposure; values are mean ± SE
Rana pipiens, Leopard frog (tadpole stage)		water exposure 0.8±0.1 µg/L	0.6±0.2 mg/kg[5] (whole body)		2.84±2.28			[15]	L; 28-day exposure; values are mean ± SE
		water exposure 2.1±0.1 µg/L	0.8±0.1 mg/kg[5] (whole body)		2.59±1.60			[15]	L; 28-day exposure; values are mean ± SE
		water expo-sure (µg/L) 0.8±0.1 1.9±0.2 4.1±0.3 10.0±0.3	whole body[5] (mg/kg) 0.4±0.1 0.4±0 0.6±0.1 2.0±0.1	 NOAEL LOAEL	 2.64±1.18 2.32±0 2.20±1.08 2.30±0			[15]	L; 28-day exposure; values are mean ± SE; effects based on mortality
Rana pipiens, Leopard frog (tadpole stage)		water exposure 8.3 µg/L	1.7 mg/kg[5] (whole body)	LC50				[15]	L; 24-day exposure; LC50 tissue dieldrin estimated by graphical extrapolation

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Rana pipiens, Leopard frog (adult stage)		water exposure 10.7±1.3 µg/L	0.4±0.4 mg/kg[5] (skin) 0.9±0.1 mg/kg[5] (muscle) 1.5±0.5 mg/kg[5] (liver)		1.57±1.57 1.92±0.95 2.15±1.67			[15]	L; 28-day exposure; values are mean ± SE
		water exposure 56.2±4.1 µg/L	7.3±2.8 mg/kg[5] (skin) 17.8±7.8 mg/kg[5] (muscle) 21.5±3.3 mg/kg[5] (liver)		2.11±1.69 2.51±2.15 2.58±1.64			[15]	L; 28-day exposure; values are mean ± SE
		water exposure 53.4 µg/L	5.5 mg/kg[5] (skin) 10.0 mg/kg[5] (muscle) 13.0 mg/kg[5] (liver)	LC50 LC50 LC50				[15]	L; 28-day exposure; LC50 tissue dieldrin estimated by graphical extrapolation
Anas platyrhynchos, Mallard (ducklings)		0.014±1 mg/L	24.5 mg/kg (lipid) 2.3 mg/kg (liver) 1.3 mg/kg (muscle)	No mortality or effects on behavior or survival observed	3.24			[18]	L; 34-day exposure; 1-day-old birds had access to dieldrin-contaminated water for drinking and swimming
		0.052±4 mg/L	68.9 mg/kg (lipid) 3.4 mg/kg (liver) 1.15 mg/kg (muscle)	No mortality or effects on behavior or survival observed	3.12				

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
		0.118±11 mg/L	128 mg/kg (lipid) 7.4 mg/kg (liver) 1.1 mg/kg (muscle)	No mortality or effects on behavior or survival observed	3.04				
Anas platyrhynchos, Mallard (ducklings)		0.019±2 mg/L	37.9 mg/kg (lipid) 13 mg/kg (skin) 1.9 mg/kg (liver)	No mortality or effects on behavior or survival observed	3.30			[18]	L; 24-day exposure; 1-day old birds had access to dieldrin-contaminated water for drinking and swimming
		0.075±1 mg/L	107 mg/kg (lipid) 39.5 mg/kg (skin) 4.8 mg/kg (liver)	No mortality or effects on behavior or survival observed	3.15				
		0.193±8 mg/L	217 mg/kg (lipid) 75 mg/kg (skin) 11.3 mg/kg (liver)	No mortality or effects on behavior or survival observed	3.05				
		0.177±11 mg/L	125 mg/kg (lipid) 31.5 mg/kg (skin) 8.6 mg/kg (liver) 2.3 mg/kg (brain) 0.97 mg/kg muscle) 0.97 mg/kg (blood)		2.84 2.25 1.69 1.11 0.74 0.51			[18]	L; 8-day exposure; 14-day old birds had access to dieldrin-contaminated water for drinking and swimming

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			915 mg/kg (lipid) 305 mg/kg (skin) 52 mg/kg (liver)	96-Hour LC50	0.74 0.26 −0.52			[18]	L; 24-day exposure; birds were dosed with food spiked with dieldrin at measured concentrations of 0.3 to 165 mg/kg.
			395 mg/kg (lipid) 193 mg/kg (skin) 12 mg/kg (liver) 5 mg/kg (brain) 2 mg/kg (muscle)	24-Day LC50	1.13 0.81 −0.40 −0.70 −1.00				
			180 mg/kg (lipid) 102 mg/kg (skin) 7 mg/kg (liver) 2.5 mg/kg (brain) <1 mg/kg (muscle)	24-Day LOAEL	1.05 0.81 −0.40 −0.70				
			4 mg/kg (lipid) 2 mg/kg (skin) <1 mg/kg (liver) <1 mg/kg (brain) <1 mg/kg (muscle)	24-Day NOAEL	1.12 0.83				
Falco peregrinus, Peregrine falcon (eggs)			59 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[19]	F; Kola Peninsula, Russia; n = number of clutches sampled
Falco tinnunculus, European kestrel			6-30 mg/kg (liver)	mortality				[16]	F

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Agelaius phoeniceus, Red-winged blackbird	1.2 ng/g TOC=21.0%		16.6 ng/g				7.5	[20]	F; Great Lakes/St. Lawrence River basin; 12 wetlands sites;
(eggs)	11.0 ng/g TOC=7.5%		31.0 ng/g				21		sediment concentration reported as wet weight
	127.8 ng/g TOC=12%		84.6 ng/g				7.8		concentration which may be a typographical error.
	0.6 ng/g TOC=18.5%		8.9 ng/g				57.2		203.7 117.6 ng/g ww
	0.7 ng/g TOC=11.5%		9.1 ng/g				31.1		
	0.1 ng/g TOC=10.5%		20.0 ng/g				448		
Tachycineta bicolor, Tree swallow			(whole body minus feet, beak, wings, and feathers)					[20]	F; Great Lakes/ St. Lawrence River basin; 12 wetlands sites; sediment
(nestlings)	0.7 ng/g TOC=11.5%		211.4 ng/g				340.5		concentration reported as wet weight concentration
(eggs)	0.7 ng/g TOC=11.5%		19.3 ng/g				36.9		which may be a typographical error.

Summary of Biological Effects Tissue Concentrations for Dieldrin

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Tyto alba, Barn owl			6-44 mg/kg (liver)	mortality				[17]	F

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.
[5] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: PESTICIDE (ORGANOPHOSPHATE)

Chemical Name (Common Synonyms): DISULFOTON **CASRN:** 298-04-4

Chemical Characteristics

Solubility in Water: 25 ppm at 23°C [1]

Half-Life: 3 days - 21 days based on aerobic soil field data [2]

Log K_{ow}: 3.98 [3]

Log K_{oc}: 3.91 L/kg organic carbon

Human Health

Oral RfD: 4 X 10^{-5} mg/kg/day [4]

Confidence: Medium, uncertainty factor = 1000 [4]

Critical Effect: Cholinesterase inhibition and optic nerve degeneration in dogs

Oral Slope Factor: No data [4]

Carcinogenic Classification: D [6]

Wildlife

Partitioning Factors: Partitioning factors for disulfoton in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for disulfoton in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Partitioning factors for disulfoton in aquatic organisms were not found in the literature.

Food Chain Multipliers: Food chain multipliers for disulfoton in aquatic organisms were not found in the literature.

Toxicity/Bioaccumulation Assessment Profile

The toxicity of insecticidally active organophosphorus compounds like disulfoton to animals is attributed to their ability to inhibit acetylcholinesterase, which is a class of enzymes that catalyzes the hydrolysis of the neurotransmitting agent acetylcholine [7].

Disulfoton is relatively toxic to aquatic organisms. The acute toxicity for aquatic invertebrates ranged from 5 µg/L (96-h LC50) for *Pteronarcys californica* [8] to 52 µg/L (96-h LC50) for *Gammarus lacustris* [9], while chronic toxicity ranged from 1.4 µg/L (30-d LC50) for *Acroneuria pacifica* to 1.9 µg/L (30-d LC50) for *Pteronarcys californica* [10]. Fish are less sensitive to disulfoton. The 96-h LC50 based on the exposure with fathead minnows was 3700 µg/L [11]. The toxicity of disulfoton and its most important degradation products were measured using *Daphnia magna* [12]. The toxicity of disulfoton (24-h LC50 of 55 µg/L) was similar to two of its degradation products (disulfoton-sulfoxide and disulfoton). The remaining degradation products were much less toxic than the parent compound.

Summary of Biological Effects Tissue Concentrations for Disulfoton

Species:	Concentration, Units in:			Toxicity:	Ability to Accumulate:			Source:	
Taxa	**Sediment**	**Pore Water**	**Tissue (Sample Type)**	**Effects**	**BCF**	**BAF**	**BSAF**	**Reference**	**Comments**
Invertebrates			**[NO DATA FOUND]**						
Fishes			**[NO DATA FOUND]**						
Wildlife			**[NO DATA FOUND]**						

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Chemical Category: POLYCHLORINATED DIBENZOFURANS

Chemical Name (Common Synonyms): **CASRN:** 70648-26-9
1,2,3,4,7,8-HEXACHLORODIBENZOFURAN

Chemical Characteristics

Solubility in Water: No data [1]

Half-Life: No data [2]

Log K_{ow}: No data [3]

Log K_{oc}: —

Human Health

Oral RfD: No data [4]

Confidence: —

Critical Effect: —

Oral Slope Factor: No data [4]

Carcinogenic Classification: —

Wildlife

Partitioning Factors: Partitioning factors for 1,2,3,4,7,8-hexaCDF in wildlife were not found in the studies reviewed.

Food Chain Multipliers: Limited information was found reporting on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [5]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the biomagnification factor (BMF) can equal 3. The BMF from alewife to herring gulls in Lake Ontario was 32 for 2,3,7,8-TCDD [6]. Log BMFs of 1.70 to 1.81 were reported for mink from 1,2,3,4,7,8-hexaCDF-contaminated diet exposures.

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

Environmental Concentrations Associated With 2,3,7,8-TCDD Risk to Aquatic Life and Associated Wildlife [7]

Organism	Fish Concentration (pg/g)	Sediment Concentration (pg/g dry wt.)	Water Concentration (pg/L)	
			POC=0.2	POC=1.0
Low Risk				
Fish	50	60	0.6	3.1
Mammalian Wildlife	0.7	2.5	0.008	0.04
Avian Wildlife	6	21	0.07	0.35
High Risk to Sensitive Species				
Fish	80	100	1	5
Mammalian Wildlife	7	25	0.08	0.4
Avian Wildlife	60	210	0.7	3.5

Note: POC - Particulate organic carbon
Fish lipid of 8% and sediment organic carbon of 3% assumed where needed.
For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: Partitioning factors for 1,2,3,4,7,8-hexaCDF in aquatic organisms were not found in the studies reviewed.

Food Chain Multipliers: No specific food chain multipliers were identified for 1,2,3,7,8-hexaCDF. Food chain multiplier information was only available for 2,3,7,8-TCDD. Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotansformation by forage fish. BMFs greater than 1.0 might exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates [7]. Log BMFs of 1.70 to 1.81 were determined for mink [13].

Toxicity/Bioaccumulation Assessment Profile

The polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) each consist of 75 isomers that differ in the number and position of attached chlorine atoms. The PCDDs and PCDFs are polyhalogenated aromatic compounds and exhibit several properties common to this group of compounds. These compounds tend to be highly lipophilic and the degree of lipophilicity is increased with increasing ring chlorination [5]. In general, the PCDDs and PCDFs exhibit relative inertness to acids, bases, oxidation, reduction, and heat, increasing in environmental persistence and chemical stability with increasing chlorination [8,5]. Because of their lipophilic nature, the PCDDs and PCDFs have been detected in fish, wildlife, and human adipose tissue, milk, and serum [5].

Each isomer has its own unique chemical and toxicological properties. The most toxic of the PCDD and PCDF isomers is 2,3,7,8-TCDD, one of the 22 possible congeners of tetrachlorodibenzo-*p*-dioxin [9]. Toxicity equivalency factors (TEFs) have been developed by EPA relating the toxicities of other PCDD and PCDF isomers to that of 2,3,7,8-TCDD [9]. The biochemical mechanisms leading to the toxic response resulting from exposure to PCDDs and PCDFs are not known in detail, but experimental data suggest that an important role in the development of systemic toxicity resulting from exposure to these chemicals is played by an intracellular protein, the Ah receptor. This receptor binds halogenated polycyclic aromatic molecules, including PCDDs and PCDFs. In several mouse strains, the expression of toxicity of 2,3,7,8-TCDD-related compounds, including cleft palate formation, liver damage, effects on body weight gain, thymic involution, and chloracnegenic response, has been correlated with their binding affinity for the Ah receptor, and with their ability to induce several enzyme systems [9].

Toxicity Equivalency Factors (TEF) for PCDD and PCDF Isomers [9]

Isomer	TEF
Total TetraCDD	1
2,3,7,8-TCDD	1
Other TCDDs	0.01
Total PentaCDDs	0.5
2,3,7,8-PentaCDDs	0.5
Other PentaCDDs	0.005
Total HexaCDDs	0.04
2,3,7,8-HexaCDDs	0.04
Other HexaCDDs	0.0004
Total HeptaCDDs	0.001
2,3,7,8-HeptaCDDs	0.001
Other HeptaCDDs	0.00001
Total TetraCDFs	0.1
2,3,7,8-TetraCDF	0.1
Other TetraCDFs	0.001
Total PentaCDFs	0.1
2,3,7,8-PentaCDFs	0.1
Other PentaCDFs	0.001
Total HexaCDFs	0.01
2,3,7,8-HexaCDFs	0.01
Other HexaCDFs	0.0001
Total HeptaCDFs	0.001
2,3,7,8-HeptaCDFs	0.001
Other HeptaCDFs	0.00001

In natural systems, PCDDs and PCDFs are typically associated with sediments, biota, and the organic carbon fraction of ambient waters [7]. Congener-specific analyses have shown that the 2,3,7,8-substituted PCDDs and PCDFs were the major compounds present in most sample extracts [5]. Results from limited epidemiology studies are consistent with laboratory-derived threshold levels to 2,3,7,8-TCDD impairment of reproduction in avian wildlife. Population declines in herring gulls (*Larus argentatus*) on Lake Ontario during the early 1970s coincided with egg concentrations of 2,3,7,8-TCDD and related chemicals expected to cause reproductive failure based on laboratory experiments (2,3,7,8-TCDD concentrations in excess of 1,000 pg/g). Improvements in herring gull reproduction through the mid-1980s were correlated with declining 2,3,7,8-TCDD concentrations in eggs and lake sediments [7]. Based on limited information on isomer-specific analysis from animals at different trophic levels, it appears that at higher trophic levels, i.e., fish-eating birds and fish, there is a selection of the planar congeners with the 2,3,7,8-substituted positions [10].

PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [7]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario was examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [7]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual log BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larva appear to have the next highest log BCF values, followed by several species of fish, with the highest log BCF value of 4.79 [10].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and 2,3,7,8-TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/L resulted in significant mortality [11]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [10].

Summary of Biological Effects Tissue Concentrations for 1,2,3,4,7,8-HexaCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Fishes									
Salmonids							0.0045	[14]	F
Wildlife									
Falco peregrinus, Peregrine falcon			3.2 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[12]	F; Kola Peninsula, Russia
Mustela vison, Mink	Diet: 1 pg/g[4]		33 pg/g[4] (liver)	LOAEL; reduced kit body weights followed by reduced survival		No BMF reported		[13]	L; BMF = lipid-normalized concentration in the liver divided by the lipid-normalized dietary concentration
	2 pg/g[4]		73 pg/g[4] (liver)	Reduced kit body weights followed by reduced survival		Log BMF = 1.70			
	3 pg/g[4]		130 pg/g[4] (liver)	Significant decrease in number of live kits whelped per female		Log BMF = 1.81			

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: POLYCHLORINATED DIBENZOFURANS

Chemical Name (Common Synonyms): **CASRN:** 57117-41-6
1,2,3,7,8-PENTACHLORODIBENZOFURAN

Chemical Characteristics

Solubility in Water: No data [1]

Half-Life: No data [2]

Log K_{ow}: No data [3]

Log K_{oc}: —

Human Health

Oral RfD: No data [4]

Confidence: —

Critical Effect: —

Oral Slope Factor: No data [4]

Carcinogenic Classification: —

Wildlife

Partitioning Factors: Partitioning factors for 1,2,3,7,8-pentaCDF in wildlife were not found in the studies reviewed.

Food Chain Multipliers: Limited information was found reporting on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife; no information was available for 1,2,3,7,8-pentaCDF, specifically. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [5]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the log biomagnification factor (BMF) can equal 0.48. The log BMF from alewife to herring gulls in Lake Ontario was 1.51 for 2,3,7,8-TCDD [6].

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

Environmental Concentrations Associated With 2,3,7,8-TCDD Risk to Aquatic Life and associated Wildlife [7]

Organism	Fish Concentration (pg/g)	Sediment Concentration (pg/g dry wt.)	Water Concentration (pg/L)	
			POC=0.2	POC=1.0
Low Risk				
Fish	50	60	0.6	3.1
Mammalian Wildlife	0.7	2.5	0.008	0.04
Avian Wildlife	6	21	0.07	0.35
High Risk to Sensitive Species				
Fish	80	100	1	5
Mammalian Wildlife	7	25	0.08	0.4
Avian Wildlife	60	210	0.7	3.5

Note: POC - Particulate organic carbon
Fish lipid of 8% and sediment organic carbon of 3% assumed where needed.
For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: Partitioning factors for 1,2,3,7,8-pentaCDF in aquatic organisms were not found in the studies reviewed.

Food Chain Multipliers: No specific food chain multipliers were identified for 1,2,3,7,8-pentaCDF. Food chain multiplier information was only available for 2,3,7,8-TCDD. Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotransformation by forage fish. BMFs greater than 1.0 might exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates [7].

Toxicity/Bioaccumulation Assessment Profile

The polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) each consist of 75 isomers that differ in the number and position of attached chlorine atoms. The PCDDs and PCDFs are polyhalogenated aromatic compounds and exhibit several properties common to this group of compounds. These compounds tend to be highly lipophilic and the degree of lipophilicity is increased with increasing ring chlorination [5]. In general, the PCDDs and PCDFs exhibit relative inertness to acids, bases, oxidation, reduction, and heat, increasing in environmental persistence and chemical stability with increasing chlorination [8,5]. Because of their lipophilic nature, the PCDDs and PCDFs have been detected in fish, wildlife, and human adipose tissue, milk, and serum [5].

Each isomer has its own unique chemical and toxicological properties. The most toxic of the PCDD and PCDF isomers is 2,3,7,8-TCDD, one of the 22 possible congeners of tetrachlorodibenzo-*p*-dioxin [8]. Toxicity equivalency factors (TEFs) have been developed by the U.S. EPA relating the toxicities of other PCDD and PCDF isomers to that of 2,3,7,8-TCDD [9]. The biochemical mechanisms leading to the toxic response resulting from exposure to PCDDs and PCDFs are not known in detail, but experimental data suggest that an important role in the development of systemic toxicity resulting from exposure to these chemicals is played by an intracellular protein, the Ah receptor. This receptor binds halogenated polycyclic aromatic molecules, including PCDDs and PCDFs. In several mouse strains, the expression of toxicity of 2,3,7,8-TCDD-related compounds, including cleft palate formation, liver damage, effects on body weight gain, thymic involution, and chloracnegenic response has been correlated with their binding affinity for the Ah receptor, and with their ability to induce several enzyme systems [9].

Toxicity Equivalency Factors (TEF) for PCDD and PCDF Isomers [9]

Isomer	TEF
Total TetraCDD	1
2,3,7,8-TCDD	1
Other TCDDs	0.01
Total PentaCDDs	0.5
2,3,7,8-PentaCDDs	0.5
Other PentaCDDs	0.005
Total HexaCDDs	0.04
2,3,7,8-HexaCDDs	0.04
Other HexaCDDs	0.0004
Total HeptaCDDs	0.001
2,3,7,8-HeptaCDDs	0.001
Other HeptaCDDs	0.00001
Total TetraCDFs	0.1
2,3,7,8-TetraCDF	0.1
Other TetraCDFs	0.001
Total PentaCDFs	0.1
2,3,7,8-PentaCDFs	0.1
Other PentaCDFs	0.001
Total HexaCDFs	0.01
2,3,7,8-HexaCDFs	0.01
Other HexaCDFs	0.0001
Total HeptaCDFs	0.001
2,3,7,8-HeptaCDFs	0.001
Other HeptaCDFs	0.00001

In natural systems, PCDDs and PCDFs are typically associated with sediments, biota, and the organic carbon fraction of ambient waters [7]. Congener-specific analyses have shown that the 2,3,7,8-substituted PCDDs and PCDFs were the major compounds present in most sample extracts [5]. Results from limited epidemiology studies are consistent with laboratory-derived threshold levels to 2,3,7,8-TCDD impairment of reproduction in avian wildlife. Population declines in herring gulls (*Larus argentatus*) on Lake Ontario during the early 1970s coincided with egg concentrations of 2,3,7,8-TCDD and related chemicals expected to cause reproductive failure based on laboratory experiments (2,3,7,8-TCDD concentrations in excess of 1,000 pg/g). Improvements in herring gull reproduction through the mid-1980s were correlated with declining 2,3,7,8-TCDD concentrations in eggs and lake sediments [7]. Based on limited information on isomer-specific analysis from animals at different trophic levels, it appears that at higher trophic levels, i.e., fish-eating birds and fish, there is a selection of the planar congeners with the 2,3,7,8-substituted positions [10].

PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [7]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario was examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [7]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual log BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larva appear to have the next highest BCF values, followed by several species of fish, with the highest log BCF value of 4.78 [10].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and -TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/l resulted in significant mortality [11]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [10].

Summary of Biological Effects Tissue Concentrations for 1,2,3,7,8-PentaCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Fishes									
Salmonids							0.013	[15]	F
Wildlife									
Falco peregrinus, Peregrine falcon			4.0 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[13]	F; Kola Peninsula, Russia
Haliaeetus leucocephalus, Bald eagle chicks			Powell River site: ~160 ng/kg lipid weight basis (yolk sac) Reference site: ~30 ng/kg lipid weight basis (yolk sac)	A hepatic cytochrome P4501A crossreactive protein (CYP1A) was induced nearly six-fold in chicks from Powell River site compared to the reference ($p<0.05$). No significant concentration-related effects were found for morphological, physiological, or histological parameters.				[12]	F; southern coast of British Columbia; eggs were collected from nests and hatched in the lab; ~ indicates value was taken from a figure.

Summary of Biological Effects Tissue Concentrations for 1,2,3,7,8-PentaCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Mustela vison, Mink	Diet: 1 pg/g[4]		1 pg/g[4] (liver)	LOAEL; reduced kit body weights followed by reduced survival				[14]	L
	2 pg/g[4]		2 pg/g[4] (liver)	Reduced kit body weights followed by reduced survival					
	4 pg/g[4]		2 pg/g[4] (liver)	Significant decrease in number of live kits whelped per female					

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: POLYCHLORINATED DIBENZOFURANS

Chemical Name (Common Synonyms): **CASRN:** 57117-31-4
2,3,4,7,8-PENTACHLORODIBENZOFURAN

Chemical Characteristics

Solubility in Water: 0.24 µg/L [1]

Half-Life: No data [2,3]

Log K_{ow}: No data [4], 6.92 [2]

Log K_{oc}: 6.80 L/kg organic carbon

Human Health

Oral RfD: No data [5]

Confidence: —

Critical Effect: —

Oral Slope Factor: No data [5]

Carcinogenic Classification: —

Wildlife

Partitioning Factors: Partitioning factors for 2,3,4,7,8-pentaCDF in wildlife were not found in the studies reviewed.

Food Chain Multipliers: Limited information was found reporting on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife; no information was available for 2,3,4,7,8-pentaCDF, specifically. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [6]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the biomagnification factor (BMF) can equal 3. The BMF from alewife to herring gulls in Lake Ontario was 32 for 2,3,7,8-TCDD [7]. Log BMFs of 1.73 to 1.74 were determined for mink [18].

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

Environmental Concentrations Associated With 2,3,7,8-TCDD Risk to Aquatic Life and Associated Wildlife [8]

Organism	Fish Concentration (pg/g)	Sediment Concentration	Water Concentration (pg/L)	
			POC=0.2	POC=1.0
Low Risk				
Fish	50	60	0.6	3.1
Mammalian Wildlife	0.7	2.5	0.008	0.04
Avian Wildlife	6	21	0.07	0.35
High Risk to Sensitive Species				
Fish	80	100	1	5
Mammalian Wildlife	7	25	0.08	0.4
Avian Wildlife	60	210	0.7	3.5

Note: POC - Particulate organic carbon
Fish lipid of 8% and sediment organic carbon of 3% assumed where needed.
For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: In one study, the BSAF for carp collected from a reservoir in central Wisconsin was 0.28. The log BCF for goldfish measured during a laboratory exposure of 120 hours was 4.48

Food Chain Multipliers: No specific food chain multipliers were identified for 2,3,4,7,8-pentaCDF. Food chain multiplier information was only available for 2,3,7,8-TCDD. Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotransformation by forage fish. BMFs greater than 1.0 might exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates [8].

Toxicity/Bioaccumulation Assessment Profile

The polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) each consist of 75 isomers that differ in the number and position of attached chlorine atoms. The PCDDs and PCDFs are polyhalogenated aromatic compounds and exhibit several properties common to this group of compounds. These compounds tend to be highly lipophilic and the degree of lipophilicity is increased with increasing ring chlorination [6]. In general, the PCDDs and PCDFs exhibit relative inertness to acids, bases, oxidation, reduction, and heat, increasing in environmental persistence and chemical stability with increasing chlorination [6,9]. Because of their lipophilic nature, the PCDDs and PCDFs have been detected in fish, wildlife, and human adipose tissue, milk, and serum [6].

Each isomer has its own unique chemical and toxicological properties. The most toxic of the PCDD and PCDF isomers is 2,3,7,8-TCDD, one of the 22 possible congeners of tetrachlorodibenzo-*p*-dioxin [8]. Toxicity equivalency factors (TEFs) have been developed by the EPA relating the toxicities of other PCDD and PCDF isomers to that of 2,3,7,8-TCDD [10]. The biochemical mechanisms leading to the toxic response resulting from exposure to PCDDs and PCDFs are not known in detail, but experimental data suggest that an important role in the development of systemic toxicity resulting from exposure to these chemicals is played by an intracellular protein, the Ah receptor. This receptor binds halogenated polycyclic aromatic molecules, including PCDDs and PCDFs. In several mouse strains, the expression of toxicity of 2,3,7,8-TCDD-related compounds, including cleft palate formation, liver damage, effects on body weight gain, thymic involution, and chloracnegenic response, has been correlated with their binding affinity for the Ah receptor, and with their ability to induce several enzyme systems [10].

Toxicity Equivalency Factors (TEF) for PCDD and PCDF Isomers [10]

Isomer	TEF
Total TetraCDD	1
2,3,7,8-TCDD	1
Other TCDDs	0.01
Total PentaCDDs	0.5
2,3,7,8-PentaCDDs	0.5
Other PentaCDDs	0.005
Total HexaCDDs	0.04
2,3,7,8-HexaCDDs	0.04
Other HexaCDDs	0.0004
Total HeptaCDDs	0.001
2,3,7,8-HeptaCDDs	0.001
Other HeptaCDDs	0.00001
Total TetraCDFs	0.1
2,3,7,8-TetraCDF	0.1
Other TetraCDFs	0.001
Total PentaCDFs	0.1
2,3,7,8-PentaCDFs	0.1
Other PentaCDFs	0.001
Total HexaCDFs	0.01
2,3,7,8-HexaCDFs	0.01
Other HexaCDFs	0.0001
Total HeptaCDFs	0.001
2,3,7,8-HeptaCDFs	0.001
Other HeptaCDFs	0.00001

In natural systems, PCDDs and PCDFs are typically associated with sediments, biota, and the organic carbon fraction of ambient waters [7]. Congener-specific analyses have shown that the 2,3,7,8-substituted PCDDs and PCDFs were the major compounds present in most sample extracts [6]. Results from limited epidemiology studies are consistent with laboratory-derived threshold levels to 2,3,7,8-TCDD impairment of reproduction in avian wildlife. Population declines in herring gulls (*Larus argentatus*) on Lake Ontario during the early 1970s coincided with egg concentrations of 2,3,7,8-TCDD and related chemicals expected to cause reproductive failure based on laboratory experiments (2,3,7,8-TCDD concentrations in excess of 1,000 pg/g). Improvements in herring gull reproduction through the mid-1980s were correlated with declining 2,3,7,8-TCDD concentrations in eggs and lake sediments [8]. Based on limited information on isomer-specific analysis from animals at different trophic levels, it appears that at higher trophic levels, i.e., fish-eating birds and fish, there is a selection of the planar congeners with the 2,3,7,8-substituted positions [11].

PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [8]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario was examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [8]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual log BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larva appear to have the next highest BCF values, followed by several species of fish, with the highest log BCF value of 4.79 [11].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and -TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/L resulted in significant mortality [12]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [11].

Summary of Biological Effects Tissue Concentrations for 2,3,4,7,8-PentaCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Fishes									
Carassius auratus, Goldfish			2.69/2.5 ng/g[4] (whole body)		4.48			[14]	L; fish were exposed for 120 hr; exposure water contained fly ash extract; concentrations were measured in water, but data were not presented
Cyprinus carpio, Carp	8 pg/g[4]		4.4 pg/g[4]				0.28	[13]	F; Petenwell Reservoir, central Wisconsin; BSAF based on 8% tissue lipid content and 3.1% sediment organic carbon
Salmonids							0.095	[19]	F
Wildlife									
Falco peregrinus, Peregrine falcon			27 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[17]	F; Kola Peninsula, Russia

Summary of Biological Effects Tissue Concentrations for 2,3,4,7,8-PentaCDF

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Haliaeetus leucocephalus, Bald eagle chicks			Powell River site: ~800 ng/kg lipid weight basis (yolk sac) Reference site: ~100 ng/kg lipid weight basis (yolk sac)	A nearly 6-fold increase in hepatic cytochrome P4501A cross-reactive protein (CYP1A) was induced in chicks from Powell River site compared to the reference ($p<0.05$). No significant concentration-related effects were found for morphological, physiological, or histological parameters.				[15]	F; southern coast of British Columbia; eggs were collected from nests and hatched in the lab; ~ indicates value was taken from a figure.

Summary of Biological Effects Tissue Concentrations for 2,3,4,7,8-PentaCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Ardea herodias, Great blue heron chicks			Nicomekl site: <2 ng/kg (egg) (n = 11)					[16]	L; eggs were collected from three British Columbia colonies with different levels of contamination and incubated in the laboratory
			Vancouver site: 33±18.5 ng/kg (egg) (n = 12)	Depression of growth compared to Nicomekl site. Presence of edema.					
			Crofton site: 33±7.6 ng/kg (egg) (n = 6)	Depression of growth compared to Nicomekl site. Presence of edema.					

Summary of Biological Effects Tissue Concentrations for 2,3,4,7,8-PentaCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Mustela vison, Mink	Diet: 4 pg/g[4]		170 pg/g[4] (liver)	LOAEL; reduced kit body weights followed by reduced survival		No BMF reported		[18]	L; BMF = lipid-normalized concentration in the liver divided by the lipid-normalized dietary concentration
	6 pg/g[4]		320 pg/g[4] (liver)	Reduced kit body weights followed by reduced survival		Log BMF = 1.74			
	14 pg/g[4]		490 pg/g[4] (liver)	Significant decrease in number of live kits whelped per female		Log BMF = 1.73			

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: POLYCHLORINATED DIBENZOFURANS

Chemical Name (Common Synonyms): **CASRN:** 51207-31-9
2,3,7,8-TETRACHLORODIBENZOFURAN

Chemical Characteristics

Solubility in Water: No data [1], 0.42 µg/L [2]

Half-Life: No data [3]

Log K_{ow}: No data [4], 6.53 [2]

Log K_{oc}: —

Human Health

Oral RfD: No data [5]

Confidence: —

Critical Effect: —

Oral Slope Factor: No data [5]

Carcinogenic Classification: —

Wildlife

Partitioning Factors: Partitioning factors for 2,3,7,8-TCDF in wildlife were not found in the studies reviewed.

Food Chain Multipliers: Limited information was found reporting on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife; no information was available for 2,3,7,8-TCDF, specifically. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [6]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the biomagnification factor (BMF) can equal 3. The BMF from alewife to herring gulls in Lake Ontario was 32 for 2,3,7,8-TCDD [7]. A log BMF of -0.40 was determined for mink [2].

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

Environmental Concentrations Associated With 2,3,7,8-TCDD Risk to Aquatic Life and Associated Wildlife [8]

Organism	Fish Concentration (pg/g)	Sediment Concentration (pg/g dry wt.)	Water Concentration (pg/L)	
			POC=0.2	POC=1.0
Low Risk				
Fish	50	60	0.6	3.1
Mammalian Wildlife	0.7	2.5	0.008	0.04
Avian Wildlife	6	21	0.07	0.35
High Risk to Sensitive Species				
Fish	80	100	1	5
Mammalian Wildlife	7	25	0.08	0.4
Avian Wildlife	60	210	0.7	3.5

Note: POC - Particulate organic carbon
Fish lipid of 8% and sediment organic carbon of 3% assumed where needed.
For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: In one study, steady-state BSAFs for invertebrates exposed to 2,3,7,8-TCDF in the laboratory ranged from about 0.3 to 0.7. The BSAF for carp collected from a reservoir in central Wisconsin was 0.06.

Food Chain Multipliers: No specific food chain multipliers were identified for 2,3,7,8-TCDF. Food chain multiplier information was only available for 2,3,7,8-TCDD. Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotansformation by forage fish. BMFs greater than 1.0 might exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates [8].

Toxicity/Bioaccumulation Assessment Profile

The polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) each consist of 75 isomers that differ in the number and position of attached chlorine atoms. The PCDDs and PCDFs are polyhalogenated aromatic compounds and exhibit several properties common to this group of compounds. These compounds tend to be highly lipophilic and the degree of lipophilicity is increased with increasing ring chlorination [6]. In general, the PCDDs and PCDFs exhibit relative inertness to acids, bases, oxidation, reduction, and heat, increasing in environmental persistence and chemical stability with increasing chlorination [9,6]. Because of their lipophilic nature, the PCDDs and PCDFs have been detected in fish, wildlife, and human adipose tissue, milk, and serum [6].

Each isomer has its own unique chemical and toxicological properties. The most toxic of the PCDD and PCDF isomers is one of the 22 possible congeners of tetrachlorodibenzo-*p*-dioxin [9]. Toxicity equivalency factors (TEFs) have been developed by EPA relating the toxicities of other PCDD and PCDF isomers to that of 2,3,7,8-TCDD [10]. The biochemical mechanisms leading to the toxic response resulting from exposure to PCDDs and PCDFs are not known in detail, but experimental data suggest that an important role in the development of systemic toxicity resulting from exposure to these chemicals is played by an intracellular protein, the Ah receptor. This receptor binds halogenated polycyclic aromatic molecules, including PCDDs and PCDFs. In several mouse strains, the expression of toxicity of 2,3,7,8-TCDD-related compounds, including cleft palate formation, liver damage, effects on body weight gain, thymic involution, and chloracnegenic response, has been correlated with their binding affinity for the Ah receptor, and with their ability to induce several enzyme systems [10].

Toxicity Equivalency Factors (TEF) for PCDD and PCDF Isomers [10]

Isomer	TEF
Total TetraCDD	1
2,3,7,8-TCDD	1
Other TCDDs	0.01
Total PentaCDDs	0.5
2,3,7,8-PentaCDDs	0.5
Other PentaCDDs	0.005
Total HexaCDDs	0.04
2,3,7,8-HexaCDDs	0.04
Other HexaCDDs	0.0004
Total HeptaCDDs	0.001
2,3,7,8-HeptaCDDs	0.001
Other HeptaCDDs	0.00001
Total TetraCDFs	0.1
2,3,7,8-TetraCDF	0.1
Other TetraCDFs	0.001
Total PentaCDFs	0.1
2,3,7,8-PentaCDFs	0.1
Other PentaCDFs	0.001
Total HexaCDFs	0.01
2,3,7,8-HexaCDFs	0.01
Other HexaCDFs	0.0001
Total HeptaCDFs	0.001
2,3,7,8-HeptaCDFs	0.001
Other HeptaCDFs	0.00001

In natural systems, PCDDs and PCDFs are typically associated with sediments, biota, and the organic carbon fraction of ambient waters [7]. Congener-specific analyses have shown that the 2,3,7,8-substituted PCDDs and PCDFs were the major compounds present in most sample extracts [6]. Results from limited epidemiology studies are consistent with laboratory-derived threshold levels to 2,3,7,8-TCDD impairment of reproduction in avian wildlife. Population declines in herring gulls (*Larus argentatus*) on Lake Ontario during the early 1970s coincided with egg concentrations of 2,3,7,8-TCDD and related chemicals expected to cause reproductive failure based on laboratory experiments (2,3,7,8-TCDD concentrations in excess of 1,000 pg/g). Improvements in herring gull reproduction through the mid-1980s were correlated with declining 2,3,7,8-TCDD concentrations in eggs and lake sediments [8]. Based on limited information on isomer-specific analysis from animals at different trophic levels, it appears that at higher trophic levels, i.e., fish-eating birds and fish, there is a selection of the planar congeners with the 2,3,7,8-substituted positions [11].

PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [8]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario was examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [8]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual log BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larva appear to have the next highest BCF values, followed by several species of fish, with the highest log BCF value of 4.79 [11].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and -TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/L resulted in significant mortality [12]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [11].

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Nereis virens, Sandworm	334±6 pg/g dw n = 6		112±51 pg/g dw (whole body)				~0.25	[13,14]	L; 180-day exposure; sediment TOC was 57 mg/kg; ~ indicates approximate value, as numbers were estimated from bar graphs
Macoma nasuta, Clam	334±6 pg/g dw n = 6		51.4±6.8 pg/g dw				~0.7	[13,14]	L; 120-day exposure; sediment TOC was 57 mg/kg; ~ indicates approximate value, as numbers were estimated from bar graphs
Palaemonetes pugio, Grass shrimp	334±6 pg/g dw n = 6		58.8±7.7 pg/g dw				~0.6	[13,14]	L; 28-day exposure; sediment TOC was 57 mg/kg; ~ indicates approximate value, as numbers were estimated from bar graphs

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Fishes									
Oncorhynchus mykiss (*Salmo gairdneri*), Rainbow trout		Water exposure 0.41 ng/L	2.5 µg/kg[4]	28-Day NOEC (growth)				[15]	L
		Water exposure 1.79 ng/L	7.6 µg/kg[4]	28-Day NOEC (survival)				[15]	
Oncorhynchus mykiss, Rainbow trout			0.00009 mg/kg (whole body)[4]	Growth, NOED				[15]	L
Salmonids							0.047	[22]	F
Cyprinus carpio, Carp	182 pg/g[4]		28 pg/g[4]				0.06	[16]	F; Petenwell Reservoir, central Wisconsin; BSAF based on 8% tissue lipid content and 3.1% sediment organic carbon

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Wildlife									
Falco peregrinus, Peregrine falcon			30 ng/g (eggs) (n=6)	11.4% eggshell thinning				[19]	F; Kola Peninsula, Russia
Haliaeetus leucocephalus, Bald eagle chicks			Powell River site: 8,000 ng/kg lipid weight basis (yolk sac) Reference site: 500 ng/kg lipid weight basis (yolk sac)	A hepatic cytochrome P4501A cross-reactive protein (CYP1A) was induced nearly 6-fold in chicks from Powell River site compared to the reference ($p<0.05$). No significant concentration-related effects were found for morphological, physiological, or histological parameters.				[17]	F; southern coast of British Columbia; eggs were collected from nests and hatched in the laboratory.

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDF

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Ardea herodias, Great blue heron chicks			Nicomekl site: <1 ng/kg (egg) n = 11					[18]	L; eggs were collected from three British Columbia colonies with different levels of contamination and incubated in the laboratory
			Vancouver site: 11±4.3 ng/kg (egg) n = 12	Depression of growth compared to Nicomekl site. Presence of edema.					
			Crofton site: 8±2.3 ng/kg (egg) n = 6	Depression of growth compared to Nicomekl site. Presence of edema.					

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDF

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Aix sponsa, Wood duck			pg/g (eggs):	% eggs hatched:				[20]	F; central Arkansas; egg TEFs, hatching success, and duckling production were negatively correlated; clutch size was similar among wetland Sites 1-3, 9, 17, and 58 km downstream from point source of contamination, respectively, and Site 4, which was 111 km away on a separate drainage; duckling abnormalities were also noted; threshold range of reduced productivity was >20-50 ppt TEF
			Site 1 geometric mean: 26 (2.4-244)	47 (9.7 SE)					
			Site 2 geometric mean: 11 (1.4-60)	62 (10.1 SE)					
			Site 3 geometric mean: 5.4 (<1-22)	79 (3.8 SE)					
			Site 4 geometric mean: 0.3 (<1-3.2)	93 (3.4 SE)					

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDF

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Mustela vison, Mink	Diet: 2 pg/g[5]		2 pg/g[5] (liver)	LOAEL; reduced kit body weights followed by reduced survival		No BMF reported		[21]	L; BMF= lipid-normalized concentration in the liver divided by the lipid-normalized dietary concentration
	4 pg/g[5]		2 pg/g[5] (liver)	Reduced kit body weights followed by reduced survival		Log BMF= -0.4			
	12 pg/g[5]		3 pg/g[5] (liver)	Significant decrease in number of live kits whelped per female		Log BMF= -0.4			

[1] Concentration units based on wet weight, unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations. noted.
[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.
[5] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: POLYNUCLEAR AROMATIC HYDROCARBON (high molecular weight)

Chemical Name (Common Synonyms): FLUORANTHENE **CASRN:** 206-44-0

Chemical Characteristics

Solubility in Water: 0.20-0.26 mg/L [1]

Half-Life: 140-440 days, aerobic soil die-away test [2]

Log K_{ow}: 5.12 [3]

Log K_{oc}: 5.03 L/kg organic carbon

Human Health

Oral RfD: 4 x 10^{-2} mg/kg-day [4]

Confidence: Low, uncertainty factor = 3000

Critical Effect: Nephropathy, increased liver weights, hematological alterations, and clinical effects

Oral Slope Factor: No data [4]

Carcinogenic Classification: D [4]

Wildlife

Partitioning Factors: Partitioning factors for fluoranthene in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for fluoranthene in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: The water quality criterion tissue level (WQCTL) for fluoranthene, which is calculated by multiplying the water quality chronic value (16 µg/L) by the BCF (1741.8), is 27,869 µg/kg [5]. Salinity and particle size of the sediment had no or very little effect on survival of three amphipod species during exposure to fluoranthene [6]. Log BCFs ranged from -0.92 for *Lumbriculues variegatus* [16] to 0.63 for *Hyallela azteca* [9]. Log BAFs of 0.36 to 0.56 were calculated for the midges *Chironomus tentans* [24].

Food Chain Multipliers: Food chain multipliers for fluoranthene in aquatic organisms were not found in the literature.

Toxicity/Bioaccumulation Assessment Profile

Polynuclear aromatic hydrocarbons, (PAHs) are readily metabolized and excreted by fish and invertebrates [7], affecting bioaccumulation kinetics and equilibrium tissue residues. According to McCarty et al. [8], the toxic body residue of individual PAHs in tissues ranged from 513 to 4,248 mg/kg.

The concentration of 382 ppb produced biological effects in environmental samples (Puget Sound). The LC50 values for fluoranthene using freshwater amphipods ranged from 11.7 to 150.3 nmol/g dry weight [9].

Fluoranthene is relatively toxic to aquatic species (10-day EC50 = 2.3 to 7.4 µg/L for *H. azteca*, 10-day EC50 = 3.0 to 8.7 µg/L *C. tentans*). Its toxicity increased 6- to 17-fold under UV light [10]. *H. azteca* accumulated up to 1,131 µg/g of fluoranthene during 10 days of exposure to the LC50 concentration. Below the toxic level, the concentration of fluoranthene in amphipod tissue reached 200 to 400 µg/g within the first 48 hours and then dropped to 100 µg/g [9]. During 30-day bioaccumulation exposures, fed *H. azteca* accumulated significantly more fluoranthene than unfed organisms [11]. Furthermore, in exposures in which food was added, organisms gained weight and reproduced, even when sediment was dosed with concentrations approximately 20 to 90 times the 10-day LC50 value, with sediment containing levels of organic carbon comparable to the Suedel et al. [12] experiments. These data suggest that animals in fed exposures preferentially consumed the food, given the relatively high accumulation of compound in animal tissue. Mortality due to narcosis, the mechanism thought to be responsible for PAH toxicity, ranged from 2 to 8 µmol/g for acute responses and 0.2 to 0.8 µmol/g for chronic exposures in fish [13]. In the study by Harkey et al. [11], animals accumulated up to 1.4 µmol/g after 30 days in the highest (1,004 nmol/g) sediment concentration. Previous water-only exposures [14] predicted that a body burden of 5.6 µmol/g in *H. azteca* needs to be attained to produce 50 percent mortality. The body burden of fluoranthene associated with 50 percent mortality of *Leptocheirus plumulosus* was 0.69 µmol/g wet wt, which is lower than the predicted critical body residue for nonpolar narcotic compounds [15].

Summary of Biological Effects Tissue Concentrations for Fluoranthene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Lumbriculus variegatus, Oligochaete worm					-0.92			[16]	F
Nereis succinea, Polychaete worm	0.218 µg/g OC 0.436 µg/g OC 0.48 µg/g OC 1.4 µg/g OC 4.55 µg/g OC 10.2 µg/g OC 19.5 µg/g OC 30.1 µg/g OC		9.20 µg/g lipid – 2.55 µg/g lipid 35.6 µg/g lipid 4.80 µg/g lipid 3.79 µg/g lipid 14.1 µg/g lipid 24.0 µg/g lipid					[17]	F
Nereis virens, Sand worm					-0.096 or -0.10 -0.02 0.52			[18]	F
Modiolus demissus, Northern horse mussel					0.36			[19]	F
Mytilus edulis, Blue mussel					-0.44			[19]	F

Summary of Biological Effects Tissue Concentrations for Fluoranthene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Mytilus edulis, Mussel			627 mg/kg (whole body)[4]	Physiological, ED50				[27]	L; 50% reduction in feeding rate
			1.9 mg/kg (whole body)[4]	Physiological, ED50				[28]	L; 50% reduction in feeding, clearance rate and tolerance to aerial exposure
			0.112 mg/kg (whole body)	Physiological, LOED				[28]	L; elevated activity of superoxide dimutase (SOD)
			1.5 mg/kg (whole body)[4]	Physiological, LOED				[28]	L; inhibition of superoxide dimutase (SOD) and catalase activity
			1.5 mg/kg (whole body)[4]	Reproduction, LOED				[28]	L; reduced gametogenesis, reproductive success rate
Crassostrea virginica, Eastern oyster			62 mg/kg (whole body)[4]	Morphology, LOED				[30]	L; thickness of digestive epithelium
Crassostrea virginica, Eastern oyster					-0.15 -0.28			[19]	F

Summary of Biological Effects Tissue Concentrations for Fluoranthene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Macoma balthica, Baltic macoma	0.218 µg/g OC 0.436 µg/g OC 0.48 µg/g OC 1.4 µg/g OC 4.55 µg/g OC 10.2 µg/g OC 19.5 µg/g OC 30.1 µg/g OC		7.62 µg/g lipid 5.12 µg/g lipid – 96.2 µg/g lipid 7.48 µg/g lipid 5.73 µg/g lipid 17.2 µg/g lipid –					[17]	F
Macoma nasuta, Clam					0.58 0.39 -0.26			[18]	F
Mercenaria mercenaria, Northern quahog					-0.05			[19]	F
Mya arenaria, Softshell					-0.08			[19]	F
Daphnia magna, Cladoceran		9 µg/L	77 nM/g		0.51			[20]	L

Summary of Biological Effects Tissue Concentrations for Fluoranthene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Hyalella azteca, Amphipod		14.2 µg/L	25.6 µg/g		0.51			[9]	L
			44.0 µg/g		0.54				
			44.8 µg/g		0.54				
			65.7 µg/g		0.56				
			78.4 µg/g		0.57				
Hyalella azteca, Amphipod		56.7 µg/L	169 µg/g		0.59			[9]	L
			320 µg/g		0.55				
			458 µg/g		0.57				
			751 µg/g		0.54				
		86.2 µg/L	350 µg/g		0.60			[9]	L
			531 µg/g		0.59				
			714 µg/g		0.58				
			800 µg/g		0.62				
			1,192 µg/g		0.61				
		100.8 µg/L	644 µg/g		0.61				
			898 µg/g		0.59				
			1,074 µg/g		0.60				
			1,199 µg/g		0.56				
			1,248 µg/g		0.58				
		41.5 µg/L	307 µg/g		0.58				
			363 µg/g		0.59				
			515 µg/g		0.60				
			517 µg/g		0.63				
			763 µg/g		0.63				
			815 µg/g		0.60				
			852 µg/g		0.61				
		98.3 µg/L	566 µg/g		0.61				
			825 µg/g		0.61				
			829 µg/g		0.61				
			1,035 µg/g		0.63				
			1,171 µg/g		0.60				
			1,213 µg/g		0.61				
			1,310 µg/g		0.58				

Summary of Biological Effects Tissue Concentrations for Fluoranthene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Hyalella azteca, Amphipod		168.0 µg/L	855 µg/g		0.61				
			884 µg/g		0.59				
			971 µg/g		0.60				
			988 µg/g		0.58				
			1,265 µg/g		0.59				
			1,375 µg/g		0.60				
		184.7 µg/L	746 µg/g		0.57				
			896 µg/g		0.58				
			1,208 µg/g		0.57				
			1,302 µg/g		0.59				
			1,382 µg/g		0.59				
			1,445 µg/g		0.58				
			1,581 µg/g		0.57				
	158 nmol/g		Day 1: 160 nmol/g	no mortality				[11]	L
			Day 2: 140 nmol/g	no mortality					
			Day 3: 60 nmol/g	no mortality					
			Day 10: 90 nmol/g	no mortality					
			Day 17: 110 nmol/g	no mortality					
			Day 30: 120 nmol/g	no mortality					
	634 nmol/g		Day 1: 900 nmol/g	no mortality					
			Day 2: 1,050 nmol/g	no mortality					
			Day 3: 850 nmol/g	no mortality					
			Day 10: 700 nmol/g	no mortality					
			Day 17: 700 nmol/g	40% mortality					
			Day 30:800 nmol/g	40% mortality					
Hyalella azteca, Amphipod	1267 nmol/g		Day 1: 1,000 nmol/g	no mortality					
			Day 2: 850 nmol/g	no mortality					
			Day 3: 950 nmol/g	no mortality					
			Day 10: 700 nmol/g	no mortality					
			Day 17: 800 nmol/g	35% mortality					
			Day 30: 1,100 nmol/g	65% mortality					

Summary of Biological Effects Tissue Concentrations for Fluoranthene

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Leptocheirus plumulosus, Amphipod		38 µg/L or 187 nmol/L	0.68 µmol/g	50% mortality				[15]	L; critical body residue
		36 nmol/L							
		77 nmol/L	78 nmol/g	100% survival					
		143 nmol/L	226 nmol/g	100% survival					
		285 nmol/L	369 nmol/g	93% survival					
			721 nmol/g	46% survival					
Pontoporeia hoyi, Amphipod	60 ng/g	5 ng/mL	2,000 ng/g					[21]	L
	270 ng/g	4 ng/mL	2,000 ng/g						
	1000 ng/g	4 ng/mL	1,000 ng/g						
	21.3 nmol/g		7-12 nmol/g			1.04-1.36		[14]	L
	41.1 nmol/g		28-57 nmol/g						
	119.5 nmol/g		68-149 nmol/g						
	327.0 nmol/g		71-614 nmol/g						
Rhepoxynius abronius, Amphipod	12.09 mg/kg	14.3 µg/L		23% mortality				[22]	L
	14.50 mg/kg			52% mortality					
	25.11 mg/kg			92% mortality					
Chironomus riparius, Midge	4,040 µg/kg		181,000 µg/kg					[23]	L
Chironomus tentans Midge	377 $\mu g/g_{oc}$	4 µg/L	9,593 ng/g (larvae)			0.36		[24]	L
			22 ng/g (adult)			0.36			
	1,220 $\mu g/g_{oc}$	12 µg/L	33,455 ng/g (larvae)			0.41			
			257 ng/g (adult)			0.41			
	1,853 ug/g_{oc}	19 µg/L	72,790 ng/g (larvae)			0.56			
			9,810 ng/g (adult)			0.56			

Summary of Biological Effects Tissue Concentrations for Fluoranthene

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Fishes									
Oncorhynchus mykiss, Rainbow trout			379 µg/g, liver					[25]	F
Cyprinus carpio, Common carp			183 mg/kg (liver)	Physiological, NOED				[29]	L; no significant increase in erod enzyme and P450 1a protein content
Lepomis macrochirus, Bluegill	4,040 µg/kg		600 µg/kg					[23]	L
Pleuronectes vetulus, English sole	320-25,000 ng/g		<6.6 ng/g liver <2.6 ng/g muscle					[26]	F

1 Concentration units based on wet weight unless otherwise noted.
2 BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
3 L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
4 This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: PESTICIDE (ORGANOCHLORINE)

Chemical Name (Common Synonyms): HEPTACHLOR **CASRN:** 76-44-8

Chemical Characteristics

Solubility in Water: 0.03 mg/L [1]

Half-Life: No data [2]

Log K_{ow}: 6.26 [3]

Log K_{oc}: 6.15 L/kg organic carbon

Human Health

Oral RfD: 5×10^{-4} mg/kg/day [4]

Confidence: Low, uncertainty factor = 300 [4]

Critical Effect: Liver weight increases in rats; benign and malignant liver tumors in mice

Oral Slope Factor: $4.5 \times 10^{+0}$ per (mg/kg)/day [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Partitioning factors for heptachlor in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for heptachlor in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Log BCFs ranged from 5.30 to 11.70 for invertebrates and log BCFs for fishes ranged from 3.87 to 19.34.

Food Chain Multipliers: Food chain multipliers (FCMs) for trophic level 3 aquatic organisms were 20.8 (all benthic food web), 1.6 (all pelagic food web), and 12.7 (benthic and pelagic food web). FCMs for trophic level 4 aquatic organisms were 45.8 (all benthic food web), 3.4 (all pelagic food web), and 21.7 (benthic and pelagic food web) [18].

Toxicity/Bioaccumulation Assessment Profile

Hepatchlor is the most widely used insecticide in the organochlorine class [5]. Heptachlor is resistent to degradation and, therefore, persistent in the environment. Heptachlor acute toxic effects in animals are principally due to hyperexcitation in the nervous system and death is frequently ascribed to respiratory failure [5].

Heptachlor is relatively toxic to aquatic invertebrates. The acute toxicity of heptachlor ranged from 0.11 µg/L (96-h LC50) for *Penaeus duorarum* to 1.5 µg/L (96-h LC50) for *Crassostrea virginica* [6]. Fish are also relatively sensitive to heptachlor. The 96-h LC50 values based on the exposure of sheepshead minnows, pinfish, and spot were 3.68, 3.77, and 0.85µg/L, respectively [6].

Laboratory bioaccumulation exposures with spot showed that heptachlor was metabolized to heptachlor epoxide at all concentrations tested [7]. After 3 days of exposure, heptachlor concentrations averaged 52 percent of total residues. At the end of depuration the relative amount of heptachlor decreased to 10 percent, while heptachlor epoxide increased to 44 percent. Cooking (baking, charbroiling, canning, pan frying and deep frying) reduced the heptachlor contents by an average 40 percent in chinook salmon fillets [8].

Heptachlor was among chemicals responsible for the widespread decline of peregrine falcon populations [9]. Heptachlor concentrations above 4 mg/kg in brain is critical and could be associated with falcon mortality, while a concentration above 1.5 mg/kg in eggs was associated with lower reproductive success of falcons [9]. Birds whose life cycle depends on the aquatic environment contained higher residues of heptachlor in their tissue than the seed eaters [10]. The tissues of red-winged blackbirds and tree swallows demonstrated geographically distinct levels of chlorinated hydrocarbons including heptachlor [11]. The spatial variation of heptachlor concentration in eggs correlated significantly with those found in sediments. Higher concentrations of heptachlor in chick tissue rather than in eggs pointed to a local source of uptake through their diet [11].

Summary of Biological Effects Tissue Concentrations for Heptachlor

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Crassostrea virginica, Eastern oyster		0.08 µg/L	0.43 µg/g	30% shell reduction	7.59			[6]	L
		0.4 µg/L	3.1 µg/g	28% shell reduction				[6]	L
		0.91 µg/L	7.7 µg/g	33% shell reduction				[6]	L
		4 µg/L	18 µg/g	78% shell reduction				[6]	L
		14 µg/L	55 µg/g	98% shell reduction				[6]	L
Crassostrea virginica, Eastern oyster			0.021 mg/kg (whole body)[4]	Growth, ED18				[6]	L; exposure media 65% heptachlor (technical grade)
			0.016 mg/kg (whole body)[4]	Growth, NOED				[6]	L; exposure media 65% heptachlor (technical grade)
Mercenaria mercenaria, Quahog clam			0.11 mg/kg (whole body)[4]	Behavior, NOED				[15]	L; no effect on feeding activity
Mya arenaria, Soft shell clam			1.3 mg/kg (whole body)[4]	Behavior, NOED				[15]	L; no effect on feeding activity
Penaeus duorarum, Pink shrimp		0.04 µg/L	0.01 µg/g	5% mortality	5.30			[6]	L
		0.2 µg/L	0.033 µg/g	82% mortality				[6]	L

Summary of Biological Effects Tissue Concentrations for Heptachlor

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Palaemonetes vulgaris, Grass shrimp		0.13 µg/L	0.062 ug/g	6% mortality	11.70			[6]	L
		0.44 µg/L	0.2 µg/g	13% mortality				[6]	L
		2 µg/L	0.97 µg/g	70% mortality				[6]	L
		5 µg/L	3.6 µg/g	95% mortality				[6]	L
Fishes									
Oncorhynchus tshawytscha, Chinook salmon			27.9 µg/kg in eggs	Rearing mortality				[12]	F
Cyprinodon variegatus, Sheepshead minnow		2.7 µg/L	20 µg/g	15% mortality	3.87			[6]	L
		3.3 µg/L	33 µg/g	50% mortality				[6]	L
		3.6 µg/L	34 µg/g	50% mortality				[6]	L
		4.0 µg/L	85 µg/g	60% mortality				[6]	L
Cyprinodon variegatus, Sheepshead minnow		8.8 µg/L	133 µg/g	85% mortality	4.33			[6]	L
Cyprinodon variegatus, Sheepshead minnow			4.5 mg/kg (whole body)[4]	Behavior, LOED				[16]	L; decreased swimming activity
			4.8 mg/kg (whole body)[4]	Behavior, LOED				[16]	L; hyperkinetic behavior
			10.4 mg/kg (whole body)[4]	Behavior, NA				[16]	L; hyperkinetic behavior

Summary of Biological Effects Tissue Concentrations for Heptachlor

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			10.4 mg/kg (whole body)[4]	Mortality, NA				[16]	L; 39% decline in survivorship
			4.5 mg/kg (whole body)[4]	Cellular, NOED				[16]	L; no effect on liver, kidney, pancreas, digestive tract histopathology
			4.8 mg/kg (whole body)[4]	Cellular, NOED				[16]	L; no effect on liver, kidney, pancreas, digestive tract histopathology
			10.4 mg/kg (whole body)[4]	Cellular, NOED				[16]	L; no effect on liver, kidney, pancreas, digestive tract histopathology
			4.5 mg/kg (whole body)[4]	Mortality, NOED				[16]	L; no significant effect on mortality
			4.8 mg/kg (whole body)[4]	Mortality, NOED				[16]	L; no significant effect on mortality
			16 mg/kg (whole body)[4]	Mortality, LOED				[17]	L; increase in fry mortality
			26 mg/kg (whole body)[4]	Reproduction, LOED				[17]	L; decreased egg production of adults
			211 mg/kg (whole body)[4]	Reproduction, LOED				[17]	L; decreased fertility of eggs produced by adults
			0.022 mg/kg (whole body)[4]	Mortality, ED5				[6]	L; exposure media 65% heptachlor (technical grade)
Leiostomus xanthurus, Spot		0.14 µg/L	0.34 µg/g		19.34			[7]	L
		0.26 µg/L	0.64 µg/g	25% mortality				[7]	L
		0.58 µg/L	1.73 µg/g	35% mortality				[7]	L
		1.03 µg/L	3.70 µg/g					[7]	L
		0.5 µg/L	1.5 µg/g					[7]	L
		0.65 µg/L	2.3 µg/g					[7]	L

Summary of Biological Effects Tissue Concentrations for Heptachlor

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Leiostomus xanthurus, Spot			2.6 mg/kg (whole body)[4]	Mortality, ED40				[6]	L; exposure media 65% heptachlor (technical grade)
			0.01 mg/kg (whole body)[4]	Mortality, NOED				[6]	L; exposure media 65% heptachlor (technical grade)
			0.01 mg/kg (whole body)[4]	Mortality, NOED				[6]	L; exposure media 65% heptachlor (technical grade)
Lagodon rhomboides, Pinfish			5.7 mg/kg (whole body)[4]	Mortality, NOED				[6]	L; exposure media 65% heptachlor (technical grade)
Wildlife									
Falco peregrinus anatum, American peregrine			0.018-2.070 mg/kg in eggs (1965-1986)					[9]	F
Falco peregrinus pealei, Peale's peregrine			0.015-0.049 mg/kg in eggs (1965-1986)					[9]	F
Falco peregrinus tundrius, Arctic peregrine			0.087-2.710 mg/kg in eggs (1965-1987)					[9]	F

Summary of Biological Effects Tissue Concentrations for Heptachlor

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Martes americana, Marten			0.3 - 4.5 µg/kg in muscle; 9.1 - 12.7 µg/kg in liver					[14]	F
Martes pennanti, Fishers			1 - 5.7 µg/kg in muscle 5.8 -17µg/kg in liver					[14]	F
Quail			0.86 - 1.15 mg/kg					[13]	F
Woodcock			0.86 - 1.29 mg/kg					[13]	F
Agelaius phoeniceus, Red-winged blackbird	0.2 ng/g 0.2 ng/g 0.2 ng/g		4.1 ng/g in eggs 3.7 ng/g in eggs 4.3 ng/g in eggs		1.05 2.34 1.71			[11] [11] [11]	F F F

1 Concentration units based on wet weight unless otherwise noted.
2 BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
3 L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
4 This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: METAL

Chemical Name (Common Synonyms): LEAD **CASRN:** 7439-92-1

Chemical Characteristics

Solubility in Water: Insoluble [1] **Half-Life:** Not applicable, stable [1]

Log K_{ow}: – **Log K_{oc}:** –

Human Health

Oral RfD: Not available [2] **Confidence:** –

Critical Effect: Changes in levels of certain blood enzymes, altered neurobehavioral development of children. (These changes may occur at blood lead levels so low as to be essentially without a threshold; therefore, the RfD workgroup determined that it was inappropriate to develop an RfD for inorganic lead.)

Oral Slope Factor: Not available [2] **Carcinogenic Classification:** B2 [2]

Wildlife

Partitioning Factors: Partitioning factors for lead in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for lead in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Lead is most soluble in water and is bioavailable at low pH, low organic content, and low concentrations of calcium, iron, manganese, zinc, and cadmium. Lead is capable of forming insoluble metal sulfides and can easily complex with humic acid. The common forms of dissolved lead are lead sulfate, lead chloride, lead hydroxide, and lead carbonate, but the distribution of salts is highly dependent on the pH of the water. Most lead entering surface waters is precipitated in the sediment as carbonates or hydroxides [8]. Log BCFs of 5.15 (cladoceran) [12] and 3.56 (midge) [9] were reported in the literature.

Food Chain Multipliers: Although methylated lead is rapidly taken out from the water, e.g., by rainbow trout, there is no evidence of biomagnification in the aquatic environment [6 and 7].

Toxicity/Bioaccumulation Assessment Profile

The amount of bioavailable lead in sediment is controlled, in large part, by the concentration of acid volatile sulfides (AVS) and organic mater [3,4,5]. Lead is accumulated by aquatic organisms equally from water and through dietary exposure [6]. In the sediments, a portion of lead can be transformed to trimethyllead and tetraalkyllead compounds through chemical and microbial processes. The organolead compounds are much more toxic to aquatic organisms than are the inorganic lead compounds [7]. Bioaccumulation of organolead compounds is rapid and high; these compounds concentrate in the fatty tissues of aquatic organisms. Babukutty and Chacko [8] and others reported a strong correlation between soft tissue concentration of lead in worms and that in the exchangeable fraction of the sediment.

In vertebrates, lead is known to modify the structure and function of the kidney, bone, central nervous system, and the hematopoietic system. It produces adverse biochemical, histopathological, neuropsychological, ferotoxic, teratogenic, and reproductive effects. Inhibition of blood delta aminolevulnic acid dehydratase (ALAD), an enzyme critical in heme formation, has been observed as a result of exposure to lead in a variety of fish, invertebrates, and birds. At sufficiently high concentrations, lead effects are manifested in aquatic organisms as reduced growth, fecundity, and survivorship [9].

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Eichhornia crassipes, Water hyacinth			4.4 mg/kg (leaf)	Growth, NOED				[20]	L; no effect on growth
			4.6 mg/kg (leaf)	Growth, NOED				[20]	L; no effect on growth
			135 mg/kg (root)	Growth, NOED				[20]	L; no effect on growth
			259 mg/kg (root)	Growth, NOED				[20]	L; no effect on growth
			598 mg/kg (root)	Growth, NOED				[20]	L; no effect on growth
			1030 mg/kg (root)	Growth, NOED				[20]	L; no effect on growth
			6 mg/kg (stem)	Growth, NOED				[20]	L; no effect on growth
			16.6 mg/kg (stem)	Growth, NOED				[20]	L; no effect on growth
			48.8 mg/kg (stem)	Growth, NOED				[20]	L; no effect on growth
			70.6 mg/kg (stem)	Growth, NOED				[20]	L; no effect on growth
			4.4 mg/kg (leaf)	Morphology, NOED				[20]	L; no effect on plant appearance
			4.6 mg/kg (leaf)	Morphology, NOED				[20]	L; no effect on plant appearance
			135 mg/kg (root)	Morphology, NOED				[20]	L; no effect on plant appearance
			259 mg/kg (root)	Morphology, NOED				[20]	L; no effect on plant appearance
			598 mg/kg (root)	Morphology, NOED				[20]	L; no effect on plant appearance
			1,030 mg/kg (root)	Morphology, NOED				[20]	L; no effect on plant appearance
			6 mg/kg (stem)	Morphology, NOED				[20]	L; no effect on plant appearance
			16.6 mg/kg (stem)	Morphology, NOED				[20]	L; no effect on plant appearance
			48.8 mg/kg (stem)	Morphology, NOED				[20]	L; no effect on plant appearance
			70.6 mg/kg (stem)	Morphology, NOED				[20]	L; no effect on plant appearance

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Invertebrates									
Invertebrates, field-collected	Total µg/g / SEM µg/g	Filt µg/L / Nonfilt µg/L	Body					[15]	F
	679 / 569	<0.2 / 276	67 µg/g						
	113 / 62	1.2 / 120	11 µg/g						
	99 / 55	0.2 / 38	10 µg/g						
	86 / 50	0.3 / 35	32 µg/g						
	38 / 19	<0.2 / 9	4 µg/g						
	14 / 4	0.4 / 24	0.5 µg/g						
Tubificidae, Oligochaete worms	365 µg/g		16.5 mg/g					[14]	F
	138 µg/g		3.7 mg/g						
	375 µg/g		23.5 mg/g						
	297 µg/g		35.8 mg/g						
	283 µg/g		22.6 mg/g						
Nereis diversicolor, Polychaete worm	44 µg/g		5.9 µg/g					[10]	F
	154 µg/g		4.4 µg/g						
	35 µg/g		3.4 µg/g						
	21 µg/g		0.7 µg/g						
	299 µg/g		5.8 µg/g						
	287 µg/g		4.9 µg/g						
	359 µg/g		3.5 µg/g						
Dreissena polymorpha, Zebra mussel			200 mg/kg (whole body)[6]	Physiological, ED100				[21]	L; mussels stopped filtering
			200 mg/kg (whole body)[6]	Mortality, LOED				[21]	L; increased mortality
			30 mg/kg (whole body)[6]	Physiological, LOED				[21]	L; reduced filtration rate
			2 mg/kg (whole body)[6]	Mortality, NOED				[21]	L; no effect on mortality

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			4 mg/kg (whole body)[6]	Mortality, NOED				[21]	L; no effect on mortality
			6 mg/kg (whole body)[6]	Mortality, NOED				[21]	L; no effect on mortality
			30 mg/kg (whole body)[6]	Mortality, NOED				[21]	L; no effect on mortality
			2 mg/kg (whole body)[6]	Physiological, NOED				[21]	L; no effect on filtration rate
			4 mg/kg (whole body)[6]	Physiological, NOED				[21]	L; no effect on filtration rate
			6 mg/kg (whole body)[6]	Physiological, NOED				[21]	L; no effect on filtration rate
Elliptio complanata, Freshwater mussel	<0.9-28.8 µg/g		ND[4] (foot) ND (muscle) 5.8 µg/g (visceral) 13.0 µg/g (hepatopancreas) 18.8 µg/g (gills) 13.9 µg/g (mantle)					[16]	F
	<0.9-97.5 µg/g		5.5 µg/g (foot) 3.8 µg/g (muscle) 6.9 µg/g (visceral) 14.3 µg/g (hepatopancreas) 36.0 µg/g (gills) 33.3 µg/g (mantle)						

Summary of Biological Effects Tissue Concentrations for Lead

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
	<0.9-100.0 µg/g		ND (foot) ND (muscle) 6.0 µg/g (visceral) 15.3 µg/g (hepatopancreas) 35.4 µg/g (gills) 35.6 µg/g (mantle)						
Balanus crenatus, Barnacle			90 mg/kg (whole body)[6]	Behavior, NOED				[23]	L; regulation of metals endpoint - summer experiment
Daphnia magna, Cladoceran			1,880 mg/kg (whole body)[6]	Reproduction, ED10				[12]	L; 10% reduction in number of offspring
			5,040 mg/kg (whole body)[6]	Mortality, ED50				[12]	L; lethal body burden after 21-day exposure
Hyallela azteca, Amphipod		3.3 µg/L 2.6 µg/L 11.6 µg/L 8.8 µg/L 12.6 µg/L 24.0 µg/L	5.8 µg/g 7.1 µg/g 15.8 µg/g 19.2 µg/g 30.0 µg/g 20.9 µg/g	60% survival 65% survival 48% survival 31% survival 11% survival 4% survival				[11]	L
	Total µg/g / SEM µg/g	Filt µg/L / Nonfilt µg/L	Body					[15]	F
	679 / 569	<0.2 / 276	7 µg/g						
	113 / 62	1.2 / 120	7 µg/g						
	99 / 55	0.2 / 38	6 µg/g						
	86 / 50	0.3 / 35	2 µg/g						
	38 / 19	<0.2 / 9	6 µg/g						
	14 / 4	0.4 / 24	0.4 µg/g						

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Hyalella azteca, Freshwater amphipod			70 mg/kg (whole body)[6]	Mortality, ED50				[22]	L; lethal body burden
			160 mg/kg (whole body)[6]	Mortality, ED50				[22]	L; lethal body burden
			90 mg/kg (whole body)[6]	Mortality, ED50				[22]	L; lethal body burden
			115 mg/kg (whole body)[6]	Mortality, ED50				[22]	L; lethal body burden
Pontoporeia affiniss, Amphipod			4 mg/kg (whole body)[6]	Mortality, NOED				[24]	L; body burden estimated from graph
			4 mg/kg (whole body)[6]	Mortality, NOED				[24]	L; body burden estimated from graph
	Total SEM µg/g µg/g	Filt Nonfilt µg/L µg/L	Body					[15]	F
	679 569	<0.2 276	7 µg/g						
	113 62	1.2 120	7 µg/g						
	99 55	0.2 38	6 µg/g						
	86 50	0.3 35	2 µg/g						
	38 19	<0.2 9	6 µg/g						
	14 4	0.4 24	0.4 µg/g						
Chironomus riparius, Midge		0.728 mg/L	2650 µg/g		3.56			[9]	L
Chironomus gr. thummi, Midge	13.99 mg/kg		12.80 mg/kg 16.22 mg/kg	normal larvae deformed larvae				[13]	F

Summary of Biological Effects Tissue Concentrations for Lead

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Chironomus gr. thummi, Midge			2.56 mg/kg (whole body)[6]	Morphology, NOED				[13]	L, 4th instar larvae
Fishes									
Salvelinus fontinalis, Brook trout			24 mg/kg (gill)	Behavior, LOED				[19]	L; hyperactivity, erratic swimming, loss of equilibrium
			30 mg/kg (kidney)	Behavior, LOED				[19]	L; hyperactivity, erratic swimming, loss of equilibrium
			20 mg/kg (liver)	Behavior, LOED				[19]	L; hyperactivity, erratic swimming, loss of equilibrium
			3.2 mg/kg (red blood cells)	Behavior, LOED				[19]	L; hyperactivity, erratic swimming, loss of equilibrium
			70 mg/kg (gill)	Development, LOED				[19]	L; spinal deformities
			30 mg/kg (kidney)	Development, LOED				[19]	L; spinal deformities
			25 mg/kg (liver)	Development, LOED				[19]	L; spinal deformities
			4.02 mg/kg (whole body)[6]	Development, LOED				[19]	L; reduced embryo hatchability
			4.02 mg/kg (whole body)[6]	Growth, LOED				[19]	L; reduced weight gain
			70 mg/kg (gill)	Morphology, LOED				[19]	L; darkening of caudal peduncle
			30 mg/kg (kidney)	Morphology, LOED				[19]	L; darkening of caudal peduncle

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			25 mg/kg (liver)	Morphology, LOED				[19]	L; darkening of caudal peduncle
			4.02 mg/kg (whole body)[6]	Morphology, LOED				[19]	L; deformed vertebral column
			2.55 mg/kg (whole body)[6]	Development, NOED				[19]	L; no effect on embryo hatchability
			1.6 mg/kg (whole body)[6]	Development, NOED				[19]	L; no effect on embryo hatchability
			38 mg/kg (gill)	Growth, NOED				[19]	L; no effect on length or weight
			70 mg/kg (gill)	Growth, NOED				[19]	L; no effect on growth
			60 mg/kg (gill)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			20 mg/kg (gill)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			6 mg/kg (gill)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			3.2 mg/kg (gonad)	Growth, NOED				[19]	L; no effect on length or weight
			43 mg/kg (kidney)	Growth, NOED				[19]	L; no effect on length or weight
			30 mg/kg (kidney)	Growth, NOED				[19]	L; no effect on growth
			100 mg/kg (kidney)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			40 mg/kg (kidney)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			8 mg/kg (kidney)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			13.6 mg/kg (liver)	Growth, NOED				[19]	L; no effect on length or weight
			25 mg/kg (liver)	Growth, NOED				[19]	L; no effect on growth
			18 mg/kg (liver)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			16 mg/kg (liver)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			4 mg/kg (liver)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			0.6 mg/kg (muscle)	Growth, NOED				[19]	L; no effect on length or weight
			1.5 mg/kg (red blood cells)	Growth, NOED				[19]	L; no effect on length or weight
			4 mg/kg (red blood cells)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			0.5 mg/kg (red blood cells)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			0.2 mg/kg (red blood cells)	Growth, NOED				[19]	L; no effect on length or weight of first generation fish
			6 mg/kg (spleen)	Growth, NOED				[19]	L; no effect on length or weight
			2.55 mg/kg (whole body)[6]	Growth, NOED				[19]	L; no effect on weight gain

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			1.6 mg/kg (whole body)[6]	Growth, NOED				[19]	L; no effect on weight gain
			2.55 mg/kg (whole body)[6]	Morphology, NOED				[19]	L; no effect on skeletal deformities
			1.6 mg/kg (whole body)[6]	Morphology, NOED				[19]	L; no effect on skeletal deformities
			38 mg/kg (gill)	Mortality, NOED				[19]	L; no effect on mortality
			70 mg/kg (gill)	Mortality, NOED				[19]	L; no effect on mortality
			60 mg/kg (gill)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			20 mg/kg (gill)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			6 mg/kg (gill)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			3.2 mg/kg (gonad)	Mortality, NOED				[19]	L; no effect on mortality
			43 mg/kg (kidney)	Mortality, NOED				[19]	L; no effect on mortality
			30 mg/kg (kidney)	Mortality, NOED				[19]	L; no effect on mortality
			100 mg/kg (kidney)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			40 mg/kg (kidney)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			8 mg/kg (kidney)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			13.6 mg/kg (liver)	Mortality, NOED				[19]	L; no effect on mortality
			25 mg/kg (liver)	Mortality, NOED				[19]	L; no effect on mortality
			18 mg/kg (liver)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			16 mg/kg (liver)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			4 mg/kg (liver)	Mortality, NOED				[19]	L; no effect on survival of first generation fish

Summary of Biological Effects Tissue Concentrations for Lead

Species:	**Concentration, Units in[1]:**			**Toxicity:**	**Ability to Accumulate[2]:**			**Source:**	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
			0.6 mg/kg (muscle)	Mortality, NOED				[19]	L; no effect on mortality
			1.5 mg/kg (red blood cells)	Mortality, NOED				[19]	L; no effect on mortality
			4 mg/kg (red blood cells)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			0.5 mg/kg (red blood cells)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			0.2 mg/kg (red blood cells)	Mortality, NOED				[19]	L; no effect on survival of first generation fish
			6 mg/kg (spleen)	Mortality, NOED				[19]	L; no effect on mortality
			4.02 mg/kg (whole body)[6]	Mortality, NOED				[19]	L; no effect on mortality
			2.55 mg/kg (whole body)[6]	Mortality, NOED				[19]	L; no effect on mortality
			1.6 mg/kg (whole body)[6]	Mortality, NOED				[19]	L; no effect on mortality
			38 mg/kg (gill)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			70 mg/kg (gill)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced by second generation fish
			60 mg/kg (gill)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			20 mg/kg (gill)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			6 mg/kg (gill)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			3.2 mg/kg (gonad)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			43 mg/kg (kidney)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			30 mg/kg (kidney)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced by second generation fish
			100 mg/kg (kidney)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			40 mg/kg (kidney)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			8 mg/kg (kidney)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			13.6 mg/kg (liver)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			25 mg/kg (liver)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced by second generation fish
			18 mg/kg (liver)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			16 mg/kg (liver)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			4 mg/kg (liver)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			0.6 mg/kg (muscle)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			1.5 mg/kg (red blood cells)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			4 mg/kg (red blood cells)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			0.5 mg/kg (red blood cells)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			0.2 mg/kg (red blood cells)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced
			6 mg/kg (spleen)	Reproduction, NOED				[19]	L; no effect on number of viable eggs produced

Summary of Biological Effects Tissue Concentrations for Lead

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Pimephales promelas, Fathead minnow	107 µg/g 365 µg/g 138 µg/g 241 µg/g 375 µg/g		10.5 mg/g 5.7 mg/g 0.8 mg/g 0.9 mg/g 20.0 mg/g					[17]	F
Pimephales promelas, Fathead minnow	508 µg/g 297 µg/g 377 µg/g 283 µg/g 286 µg/g		13.6 mg/g 11.9 mg/g 19.5 mg/g 15.1 mg/g 9.3 mg/g					[17]	F
Pimephales promelas, Fathead minnow			0.816 mg/kg (brain)	Behavior, LOED				[25]	L; significant reduction in feeding rate and number of ineffective feeding behaviors with 1-day-old *Daphnia*
			0.451 mg/kg (brain)	Behavior, LOED				[25]	L; significant reduction in number of ineffective feeding behaviors in lowest test concentration with 2-day-old *Daphnia*
			0.451 mg/kg (brain)	Behavior, LOED				[25]	L; significant reduction in feeding rate and number of ineffective feeding behaviors in lowest test concentration with 7-day-old *Daphnia*
			44.2 mg/kg (whole body)[6]	Behavior, LOED				[25]	L; significant reduction in feeding rate and number of ineffective feeding behaviors with 1-day-old *Daphnia*

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			26.2 mg/kg (whole body)[6]	Behavior, LOED				[25]	L; significant reduction in number of ineffective feeding behaviors in lowest test concentration with 2-day-old *Daphnia*
			26.2 mg/kg (whole body)[6]	Behavior, LOED				[25]	L; significant reduction in feeding rate and number of ineffective feeding behaviors in lowest test concentration with 7-day-old *Daphnia*
			0.816 mg/kg (brain)	Physiological, LOED				[25]	L; significant reduction norepinephrine and serotonin levels in brain
			44.2 mg/kg (whole body)[6]	Physiological, LOED				[25]	L; significant reduction norepinephrine and serotonin levels in brain
			0.451 mg/kg (brain)	Behavior, NOED				[25]	L; no significant reduction in feeding rate and number of ineffective feeding behaviors with 1-day-old *Daphnia*
			0.816 mg/kg (brain)	Behavior, NOED				[25]	L; no significant reduction in number of ineffective feeding behaviors with 2-day-old *Daphnia*
			26.2 mg/kg (whole body)[6]	Behavior, NOED				[25]	L; no significant reduction in feeding rate and number of ineffective feeding behaviors with 1-day-old *Daphnia*

Summary of Biological Effects Tissue Concentrations for Lead

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
			44.2 mg/kg (whole body)[6]	Behavior, NOED				[25]	L; no significant reduction in number of ineffective feeding behaviors with 2-day-old *Daphnia*
			0.451 mg/kg (brain)	Physiological, NOED				[25]	L; no significant reduction norepinephrine and serotonin levels in brain
			26.2 mg/kg (whole body)[6]	Physiological, NOED				[25]	L; No significant reduction norepinephrine and serotonin levels in brain
Wildlife									
Sterna hirundo, Common tern			247-389 ng/g (eggs) 912-1559 ng/g (feathers)					[18]	F
Sterna forsteri, Forster tern			174 ng/g (eggs) 1527 ng/g (feathers)					[18]	F
Sterna dougallii, Roseate tern			318 ng/g (eggs) 2213 ng/g (feathers)					[18]	F
Rynchops niger, Black skimmer			402-664 ng/g (eggs) 832-4091 ng/g (feathers)					[18]	F
Larus argentatus, Herring gull			1720-6743 ng/g (eggs) 1818-2101 ng/g (feathers)					[18]	F

Summary of Biological Effects Tissue Concentrations for Lead

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Zenaida macroura, Mourning dove			58.35-214.7 mg/kg dry wt (liver alive) 267.3 mg/kg dry wt (liver dead) 346-1,297.6 mg/kg dry wt (kidney alive) 1,901 mg/kg dry wt (kidney dead)	Cellular abnormalities increased with increasing tissue concentrations				[26]	L; dosage was ingested lead shot pellets

1 Concentration units based on wet weight unless otherwise noted.
2 BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
3 L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
4 ND = not detected.
5 CBR = critical body residue.
6 This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: METAL

Chemical Name: METHYLMERCURY **CASRN:** 22967-92-6

Chemical Characteristics

Solubility in Water: No data [1]

Half-Life: No data [2]

Log K_{ow}: –

Log K_{oc}: –

Human Health

Oral RfD: 1×10^{-4} mg/kg-day [3]

Confidence: Medium, uncertainty factor = 10

Critical Effect: Developmental neurologic abnormalities in infants

On May 1, 1995, IRIS was updated to include an oral RfD of 1×10^{-4} mg/kg/d based on developmental neurological effects in human infants. An oral RfD of 3×10^{-4} mg/kg/d for chronic systemic effects of methylmercury among the general adult population was available in IRIS until May 1, 1995; however, it was not listed in the IRIS update on that date. For the purposes of calculating an SV for methylmercury that is protective of developing fetuses and nursing infants, EPA's Office of Water has chosen to continue to use the general adult population RfD of 3×10^{-4} mg/kg/d for chronic systemic effects of methylmercury until a value is relisted in IRIS, and to reduce this value by a factor of 5 to derive an RfD of 6×10^{-5} mg/kg/d for developmental effects among fetuses and nursing infants. The protective factor of 5 is based on experimental results that suggest a possible 5-fold increase in fetal sensitivity to methylmercury exposure. This more protective approach recommended by the Office of Water was deemed to be most prudent at this time. This approach should be considered interim until such time as the Agency has reviewed new studies on the chronic and developmental effects of methylmercury.

Oral Slope Factor: –

Carcinogenic Classification: C [3]

Wildlife

Partitioning Factors: Over 90 percent of methylmercury is absorbed from the gastrointestinal tract in animals, and following such absorption most accumulates in erythrocytes, giving red cell to plasma ratios of up to 300 to 1 [4]. This allows for efficient transport through the body and results in a generally uniform pattern of distribution in tissues and organs—blood, kidney, and brain concentrations are within a range of one to three by ratio [5]. There is an exceptional ability of methylmercury to pass the blood-brain barrier, and injury to the central nervous system then arises by strong binding of methylmercury to sulfhydryl residues and subsequent release of mercuric ions to binding sites in the central nervous system. The slow elimination of methylmercury from the body is a result of the high erythrocyte-plasma ratio [4]. Mercury will accumulate in both cerebellum and also cerebral cortex, where it will be tightly bound by sulfhydryl groups. Inside the cell, methylmercury will inhibit protein synthesis and RNA synthesis [6,7]. The effects are particularly important in the developing fetal and young brain of most animals. The ability of methylmercury to penetrate the placental barrier leads to accumulation in the fetus. The rate of transport across the placental barrier is 10-fold higher than for inorganic mercury. It appears that fetal tissue has a greater binding ability for methylmercury than does the pregnant mother. Exposure via milk is also important for feeding babies. It does appear that pregnant animals may detoxify themselves by transferences to their fetuses [8].

Food Chain Multipliers: In birds, there is a tendency for mercury concentrations to be highest in species feeding on fish (or on other seabirds) [9]. However, when one compares mercury levels among predominantly fish-eating species, levels apparently do not show clear patterns or any evident association with diet composition [10]. Particularly high concentrations have been found in some species of procellariiforms [11]. There is an inverse relationship between total mercury and percent methylmercury in tissues of various avian species [12,13]. Overall, the form of mercury in seabirds is predominantly inorganic, suggesting that biotransformation of ingested methylmercury is an important mechanism by which long-lived and slow-moulting seabirds avoid the toxic effects of accumulating large quantities of methylmercury [14,15]. Among furbearers, mecury burdens are higher in fish-eating species than in herbivorous ones [16]. Mink and river otter accumulate about 10 times more mercury than predatory fishes from the same areas [17]. Nonmarine mammals with mercury concentrations in the liver and kidney in excess of approximately 30 mg/kg of wet weight were likely to suffer mercury intoxification. The results of laboratory studies support this value and indicate that a dietary methylmercury concentration of aproximately 2 to 6 mg/kg of wet weight produced mercury poisoning in feeding experiments using a range of mammalian species [18].

Aquatic Organisms

Partitioning Factors: Concentrations of total mercury in water are usually low, typically on the order of a few nanograms per liter. Elemental mercury adsorbs to sediments, where methylmercury can be produced and destroyed by microbial processes. This complex process is affected by environmental factors [1]. A significant fraction of the total mercury in water is found in the form of methylmercury, the species predominantly accumulated by aquatic organisms [19]. In the Onondaga Lake food web, the percent of total mercury occurring as methylmercury was determined as follows [20]:

Lake water 5%
Interstitial water 37%
Phytoplankton 24%
Zooplankton 40%
Benthic macroinvertebrates 26%
Fishes 96%

Bioconcentration factors (BCFs) for methylmercury are highly variable. Log BCFs for methylmercury in brook trout range from 4.84 to 5.80, depending on the tissue analyzed. Methylmercury concentrations and bioaccumulation factors (BAFs) increased with higher trophic levels in both the pelagic and benthic components of aquatic food webs [20].

Food Chain Multipliers: Fish bioconcentrate methylmercury directly from water by uptake across the gills [21,22,23] and piscivores, such as walleye, readily accumulate mercury from dietary sources [24,25]. Methylmercury accumulation from either source may be substantial, but the relative contribution of each pathway may vary with fish species [26,27,28,29]. In addition, invertebrates generally have a lower percentage of methylmercury in their tissues than fish or marine mammals [30]. The percentage of methylmercury increases with age in both fish and invertebrates [30].

Mercury is accumulated by all trophic levels with biomagnification occurring up the food web. While sediment is usually the primary source of methylmercury in most aquatic systems, the food web is the main pathway for accumulation [24,25]. High concentrations of organic substances and reduced sulfur can complex free mercury ions in the sediment and reduce the availability to organisms [31,32]. Methylmercury can be accumulated directly from the water by uptake across the gills [21,22,23]. High-trophic-level species tend to accumulate the most methylmercury, with concentrations highest in fish-eating predators. Methylmercury concentrations in higher trophic species often do not correlate with concentrations in environmental media. Correlations have been made between sediment and lower trophic species that typically have a high percentage of inorganic mercury, and between mercury concentrations in higher trophic species and their prey items. The best measure of bioavailability of mercury in any system can be obtained through analysis of mercury concentrations in the biota at the specific site.

The transfer efficiency of mercury through the food web is affected by the form of mercury. Although inorganic mercury is the dominant form in the environment and easily accumulated, it is also depurated quickly. Methylmercury accumulates quickly, depurates very slowly, and therefore has a greater potential to biomagnify in higher-trophic-level species. Pharmacologic half-lives of total mercury in tissues of aquatic organisms have been estimated at approximately 2 months to 1 year in saltwater mussels, 1 to more than 3 years in fishes, and 1.4 to 2.7 years in pinnipeds and dolphins [33]. As the concentration of methylmercury increases in prey items, the transfer efficiency also increases [34]. Methylmercury accumulation from either the water column or food sources might be substantial, but the relative contribution of each pathway varies from species to species [26,27,28,29]. Invertebrates generally have a lower percentage of methylmercury in their tissues than fish or marine mammals, but the percentage can vary greatly, from 1 percent in deposit-feeding polychaetes to almost 100 percent in crabs.

The amount of methylmercury in animal tissues increases proportionately with the age of the organism, with the exception of marine mammals. Because marine mammals feed primarily on fish, they have the greatest potential for the highest tissue concentrations of methylmercury compared to other marine organisms. Contrary to other species or groups of animals, the tissue concentrations of methylmercury are higher in juvenile marine mammals than in adults because the adults can mineralize methylmercury into inorganic mercury [33].

Toxicity/Bioaccumulation Assessment Profile

Methylmercury is the most hazardous mercury species due to its high stability, its lipid solubility, and its ionic properties that lead to a high ability to penetrate the membranes of living organisms [35]. Because methylmercury is lipid-soluble, it can rapidly penetrate the blood-brain barrier [36,37,38,39,40]. Injury to the central nervous system arises by accumulation in the cerebellum and cerebral cortex, where methylmercury binds tightly to sulfhydryl groups, resulting in pathological changes [41]. Inside the cell, methylmercury inhibits protein synthesis and RNA synthesis [6,7].

The early developmental stages of organisms are the most sensitive to the toxic effects of mercury, with methylmercury being more toxic than inorganic mercury. Mercury adversely affects reproduction, growth, behavior, osmoregulation, and oxygen exchange in aquatic organisms. In birds and mammals, comparatively low concentrations of mercury have adverse effects on growth and development, behavior, motor coordination, vision, hearing, histology, and metabolism [33].

Toxicity of methylmercury is dependent on temperature [42], oxygen conditions [43], salinity [44], and the presence of other metals such as zinc and lead [45]. The complex behavior of methylmercury in sediments makes it difficult to predict toxicity from bulk sediment chemistry. Toxicity of mercury has been linked with bioaccumulation, but the situation is complicated by the fact that some animals exposed to low concentrations of mercury can build up a tolerance to this contaminant, as well as detoxify the free metal within their cells via the production of metallothioneins and other metal-binding proteins. Brown et al. [46] propose that toxic effects occur as the binding capacity of these metal-binding proteins becomes saturated.

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Phytoplankton		Interstitial water: 0.003 µg/L Lake water: 0.0003 µg/L	32 µg/kg			5.00		[20]	F; estimated from chart; chart reported log BAF values
Crepidula fornicata, Slipper limpet			9.00045013427734 mg/kg (whole body)[5]	Growth, ED25				[62]	L; approximate 25% reduction in growth at lowest test concentration; algal food contained mercury at approximatley 2.9 µg/L in addition to water concentration
			15.0007495880126 mg/kg (whole body)[5]	Reproduction, LOED				[62]	L; significant effect on fecundity (number of gametes); exposure includes mercury in food at approximately 9.5 µg/L

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			30.0014991760253 mg/kg (whole body)[5]	Development, NOED				[62]	L; no significant effect on number of live spat at peak settlement; exposure includes mercury in food at approximately 31 µg/L
			30.0014991760253 mg/kg (whole body)[5]	Reproduction, NOED				[62]	L; no significant effect on ability to produce gametes; exposure includes mercury in food at approximately 31 µg/L
			9.00045013427734 mg/kg (whole body)[5]	Reproduction, NOED				[62]	L; no significant effect on fecundity (number of gametes); exposure includes mercury in food at approximately 2.9 µg/L

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Elliptio complanata, Freshwater mussel			43 µg/kg	Relative to least contaminated station (17.9 mg/kg, dry total Hg in sediment vs. 0.07 mg/kg, dry), whole animal ww was reduced by 97 percent				[48]	F; 42 and 84 days exposure; probable effects at tissue concentrations >34 µg/kg, ww
Rangia cuneata, Marsh clam			12 mg/kg (whole body)[5]	Mortality, ED50				[54]	L; lethal to 50% of clams in 7 days
			28 mg/kg (whole body)[5]	Mortality, ED50				[54]	L; lethal to 50% of clams in 7 days
			73.1399993896484 mg/kg (whole body)[5]	Mortality, LOED				[54]	L; lethal body burden
			6 mg/kg (whole body)[5]	Mortality, NOED				[54]	L; no effect on mortality
Zooplankton, Cladocerans		Interstitial water: 0.003 µg/L Lake water: 0.0003 µg/L	260 µg/kg			5.94		[20]	F; estimated from chart; chart reported log BAF values

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Diaptomus oregonensis		Unfiltered water: total Hg = 0.43-4.79 ng/L MeHg = 0.04-2.20 ng/L	22-66 µg/kg (dw)		7.10			[47]	F; results were summarized for zooplankton and water samples taken from 12 lakes - ranges are given
Diaptomus minutus, Zooplankton		Filtered water: total Hg = 0.27-4.50 ng/L MeHg = 0.03-1.95 ng/L			4.04			[47]	F; results were summarized for zooplankton and water samples taken from 12 lakes - ranges are given
Holopedium gibberum, Zooplankton		Unfiltered water: total Hg = 0.43-4.79 ng/L MeHg = 0.04-2.20 ng/L Filtered water: total Hg = 0.27-4.50 ng/L MeHg = 0.03-1.95 ng/L	40-419 µg/kg (dw)					[47]	F; results were summarized for biota and water samples taken from 12 lakes - ranges are given

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Bosmina longirostris, Cladoceran		Unfiltered water: total Hg = 0.43-4.79 ng/L MeHg = 0.04-2.20 ng/L Filtered water: total Hg = 0.27-4.50 ng/L MeHg = 0.03-1.95 ng/L	479 µg/kg (dw)					[47]	F; results were summarized for biota and water samples taken from 12 lakes - ranges are given
Daphnia pulex *Daphnia galeatra mendotae* *Daphnia ambigua*, Cladocerans		Unfiltered water: total Hg = 0.43-4.79 ng/L MeHg[4] = 0.04-2.20 ng/L Filtered water: total Hg = 0.27-4.50 ng/L MeHg = 0.03-1.95 ng/L	1-211 µg/kg (dw)					[47]	F; results were summarized for biota and water samples taken from 12 lakes - ranges are given
Daphnia magna, Cladoceran			18.3999996185302 mg/kg (whole body)[5]	Mortality, ED25				[51]	L; 25% reduction in survival compared to controls in 21 days

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			2.32800006866455 mg/kg (whole body)[5]	Reproduction, NA				[51]	L; 32% reduction in number of neonates produced in 21 days
			1.63999998569488 mg/kg (whole body)[5]	Reproduction, NA				[51]	L; 35% reduction in number of neonates produced in 21 days
			4.67000007629394 mg/kg (whole body)[5]	Reproduction, NA				[51]	L; 62% reduction in number of neonates produced in 21 days
			7.57000017166137 mg/kg (whole body)[5]	Reproduction, NA				[51]	L; 63% reduction in number of neonates produced in 21 days
			18.3999996185302 mg/kg (whole body)[5]	Reproduction, NA				[51]	L; 99% reduction in number of neonates produced in 21 days
			0.859000027179718 mg/kg (whole body)[5]	Mortality, NOED				[51]	L; no effect on mortality
			1.52600002288818 mg/kg (whole body)[5]	Mortality, NOED				[51]	L; no effect on mortality
			2.32800006866455 mg/kg (whole body)[5]	Mortality, NOED				[51]	L; no effect on mortality
			1.63999998569488 mg/kg (whole body)[5]	Mortality, NOED				[51]	L; no effect on mortality
			4.67000007629394 mg/kg (whole body)[5]	Mortality, NOED				[51]	L; no effect on mortality

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			7.57000017166137 mg/kg (whole body)[5]	Mortality, NOED				[51]	L; no effect on mortality
			0.859000027179718 mg/kg (whole body)[5]	Reproduction, NOED				[51]	L; no significant reproductive impairment
			1.52600002288818 mg/kg (whole body)[5]	Reproduction, NOED				[51]	L; no significant reproductive impairment
Daphnia magna, Cladoceran			0.790000021457672 mg/kg (whole body)[5]	Reproduction, ED10				[55]	L; 10% reduction in number of offspring
			91.3000030517578 mg/kg (whole body)[5]	Mortality, ED50				[55]	L; lethal body burden after 21 day exposure
Benthic invertebrates *Scientific names not given* (amphipods and chironomids)		Interstitial water: 0.003 µg/L Lake water: 0.0003 µg/L	25 µg/kg			8.3×10^4		[20]	F
Palaemonetes pugio, Grass shrimp			1.09399998188018 mg/kg (whole body)[5]	Behavior, LOED				[50]	L; decreased sensitivity to physical disturbance

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			2.12299990653991 mg/kg (whole body)[5]	Mortality, NOED				[50]	L; no statistically significant increase in mortality
Uca pugnax, Fiddler crab			12.329999923706 mg/kg (whole body)[5]	Development, LOED				[53]	L; inhibition of limb regeneration and molting in male crabs
			19.4200000762939 mg/kg (whole body)[5]	Development, LOED				[53]	L; inhibition of limb regeneration and molting in female crabs
Fishes									
Squalus acanthias, Spiny dogfish			0.0930000022053719 mg/kg (whole body)[5]	Mortality, NOED				[57]	L; no effect on mortality in 24 hours

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Oncorhynchus mykiss, Rainbow trout		Exposure concentrations (CH_3HgCl): 4 µg/L	kidney = 74±30 (16-116 mg/kg) liver = 76±19 (32-114 mg/kg) spleen = 89±38 (32-118 mg/kg) brain = 19±8 (7-32 mg/kg) muscle = 31±12 (9-52 mg/kg) gill = 66±15 (42-93 mg/kg)	58.2 d±21.4				[49]	L; d = mean days to death ± SD; n = 20 fish per treatment.
		Exposure concentrations (CH_3HgCl): 9 µg/L	whole fish =11.2±6.1 (4.0-27.3 mg/kg)	24.2 d±5.6				[49]	
		Exposure concentrations (CH_3HgCl): 10 µg/L	kidney = 64±20 (40-116 mg/kg) liver = 47±10 (27-65 mg/kg) spleen = 72±22 (37-112 mg/kg) brain = 13±3 (7-19 mg/kg) muscle = 18±5 (9-27 mg/kg) gill = 51±12 (34-85 mg/kg)	21.7 d±6.0				[49]	L; n = 20 per treatment; d = days to death; n = 20 per treatment.

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
		Exposure concentrations (CH_3HgCl): 13 µg/L	kidney = 39±21 (19-91 mg/kg) liver = 42±27 (16-129 mg/kg) spleen = 51±38 (19-194 mg/kg) brain = 7.7±5.6 (2.3-22 mg/kg) muscle = 6.2±7.7 (1.2-26 mg/kg) gill = 64±15 (36-98 mg/kg)	7.6 d±5.1				[49]	L; n = 20 per treatment; d = days to death; n = 20 per treatment.
		Exposure concentrations (CH_3HgCl): 34 µg/L	kidney = 6.2±2.7 (2.3-10 mg/kg) liver = 7.2±2.8 (3.0-12 mg/kg) spleen = 6.4±3.2 (2.7-14 mg/kg) brain = 1.1±0.3 (0.6-1.5 mg/kg) muscle = 0.7±0.3 (2.7-14 mg/kg) gill = 56±12 (29-73 mg/kg)	1.0 d				[49]	L; d = mean days to death (no SD reported)
Oncorhynchus mykiss, Rainbow trout			1.60000002384185 mg/kg (blood)[5]	Growth, NOED				[52]	L; no effect on growth
			0.100000001490116 mg/kg (blood)[5]	Growth, NOED				[52]	L; no effect on growth

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.5 mg/kg (brain)[5]	Growth, NOED				[52]	L; no effect on growth
			0.100000001490116 mg/kg (brain)[5]	Growth, NOED				[52]	L; no effect on growth
			0.400000005960464 mg/kg (gill)[5]	Growth, NOED				[52]	L; no effect on growth
			0.100000001490116 mg/kg (gill)[5]	Growth, NOED				[52]	L; no effect on growth
			1.60000002384185 mg/kg (kidney)[5]	Growth, NOED				[52]	L; no effect on growth
			0.200000002980232 mg/kg (kidney)[5]	Growth, NOED				[52]	L; no effect on growth
			1 mg/kg (liver)[5]	Growth, NOED				[52]	L; no effect on growth
			0.100000001490116 mg/kg (liver)[5]	Growth, NOED				[52]	L; no effect on growth
			0.5 mg/kg (muscle)[5]	Growth, NOED				[52]	L; no effect on growth
			0.100000001490116 mg/kg (muscle)[5]	Growth, NOED				[52]	L; no effect on growth
			1.60000002384185 mg/kg (posterior intestine)[5]	Growth, NOED				[52]	L; no effect on growth

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			6 mg/kg (posterior intestine)[5]	Growth, NOED				[52]	L; no effect on growth
			1.29999995231628 mg/kg (spleen)[5]	Growth, NOED				[52]	L; no effect on growth
			0.300000011920929 mg/kg (spleen)[5]	Growth, NOED				[52]	L; no effect on growth
			0.140000000596046 mg/kg (whole body)[5]	Growth, NOED				[52]	L; no effect on growth
			0.469999998807907 mg/kg (whole body)[5]	Growth, NOED				[52]	L; no effect on growth
			1.60000002384185 mg/kg (blood)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.100000001490116 mg/kg (blood)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.5 mg/kg (brain)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.100000001490116 mg/kg (brain)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.400000005960464 mg/kg (gill)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.100000001490116 mg/kg (gill)[5]	Mortality, NOED				[52]	L; no effect on mortality
			1.60000002384185 mg/kg (kidney)[5]	Mortality, NOED				[52]	L; no effect on mortality

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.200000002980232 mg/kg (kidney)[5]	Mortality, NOED				[52]	L; no effect on mortality
			1 mg/kg (liver)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.100000001490116 mg/kg (liver)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.5 mg/kg (muscle)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.100000001490116 mg/kg (muscle)[5]	Mortality, NOED				[52]	L; no effect on mortality
			1.60000002384185 mg/kg (posterior intestine)[5]	Mortality, NOED				[52]	L; no effect on mortality
			6 mg/kg (posterior intestine)[5]	Mortality, NOED				[52]	L; no effect on mortality
			1.29999995231628 mg/kg (spleen)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.300000011920929 mg/kg (spleen)[5]	Mortality, NOED				[52]	L; no effect on mortality
			0.140000000596046 mg/kg (whole body)[5]	Mortality, NOED				[52]	L; no effect on survival
			0.469999998807907 mg/kg (whole body)[5]	Mortality, NOED				[52]	L; no effect on survival

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Oncorhynchus mykiss, Rainbow trout			15 mg/kg (whole body)[5]	Mortality, ED100				[58]	L; 100% mortality in 15 days
			20 mg/kg (whole body)[5]	Mortality, ED100				[58]	L; 100% mortality in 15 days
			6 mg/kg (whole body)[5]	Mortality, ED50				[58]	L; 50% mortality in 15 days
			4.76000022888183 mg/kg (whole body)[5]	Mortality, ED50				[58]	L; 30 day ED50 for brain
			5.69999980926513 mg/kg (whole body)[5]	Mortality, ED50				[58]	L; 15 day ED50 for single intraperitoneal injection
			3.91000008583068 mg/kg (whole body)[5]	Mortality, ED50				[58]	L; 30 day ED50 for muscle
			2.02999997138977 mg/kg (whole body)[5]	Mortality, ED50				[58]	L; 30 day ED50 for eye
			10 mg/kg (whole body)[5]	Mortality, LOED				[58]	L; 83% mortality in 15 days
			2 mg/kg (whole body)[5]	Mortality, LOED				[58]	L; 33% mortality in 15 days
			5 mg/kg (whole body)[5]	Mortality, LOED				[58]	L; 83% mortality in 15 days
			8 mg/kg (whole body)[5]	Mortality, LOED				[58]	L; 67% mortality in 15 days

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			4 mg/kg (whole body)[5]	Mortality, LOED				[58]	L; 13% mortality in 15 days
			2 mg/kg (whole body)[5]	Mortality, NOED				[58]	L; no mortality in 15 days
Salvelinus fontinalis, Brook trout			46.2000007629394 mg/kg (blood cells)[5]	Development, LOED				[38]	L; affected embryo development
			16.8999996185302 mg/kg (brain)[5]	Development, LOED				[38]	L; affected embryo development
			4.40000009536743 mg/kg (carcass)[5]	Development, LOED				[38]	L; affected embryo development
			22.2000007629394 mg/kg (gill)[5]	Development, LOED				[38]	L; affected embryo development
Salvelinus fontinalis, Brook trout			12.3000001907348 mg/kg (gonad)[5]	Development, LOED				[38]	L; affected embryo development
			26.8999996185302 mg/kg (kidney)[5]	Development, LOED				[38]	L; affected embryo development
			24.3999996185302 mg/kg (liver)[5]	Development, LOED				[38]	L; affected embryo development
			10.1999998092651 mg/kg (muscle)[5]	Development, LOED				[38]	L; affected embryo development
			38.7000007629394 mg/kg (spleen)[5]	Development, LOED				[38]	L; affected embryo development
			46.2000007629394 mg/kg (blood cells)[5]	Growth, LOED				[38]	L; decreased weight

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			16.8999996185302 mg/kg (brain)[5]	Growth, LOED				[38]	L; decreased weight
			4.40000009536743 mg/kg (carcass)[5]	Growth, LOED				[38]	L; decreased weight
			22.2000007629394 mg/kg (gill)[5]	Growth, LOED				[38]	L; decreased weight
			12.3000001907348 mg/kg (gonad)[5]	Growth, LOED				[38]	L; decreased weight
			26.8999996185302 mg/kg (kidney)[5]	Growth, LOED				[38]	L; decreased weight
			24.3999996185302 mg/kg (liver)[5]	Growth, LOED				[38]	L; decreased weight
Salvelinus fontinalis, Brook trout			10.1999998092651 mg/kg (muscle)[5]	Growth, LOED				[38]	L; decreased weight
			38.7000007629394 mg/kg (spleen)[5]	Growth, LOED				[38]	L; decreased weight
			9.39999961853027 mg/kg (whole body)[5]	Mortality, LOED				[38]	L; mortality of offspring
			46.2000007629394 mg/kg (blood cells)[5]	Reproduction, LOED				[38]	L; reduced reproduction
			16.8999996185302 mg/kg (brain)[5]	Reproduction, LOED				[38]	L; reduced reproduction
			4.40000009536743 mg/kg (carcass)[5]	Reproduction, LOED				[38]	L; reduced reproduction

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			22.2000007629394 mg/kg (gill)[5]	Reproduction, LOED				[38]	L; reduced reproduction
			12.3000001907348 mg/kg (gonad)[5]	Reproduction, LOED				[38]	L; reduced reproduction
			26.8999996185302 mg/kg (kidney)[5]	Reproduction, LOED				[38]	L; reduced reproduction
			24.3999996185302 mg/kg (liver)[5]	Reproduction, LOED				[38]	L; reduced reproduction
			10.1999998092651 mg/kg (muscle)[5]	Reproduction, LOED				[38]	L; reduced reproduction
			38.7000007629394 mg/kg (spleen)[5]	Reproduction, LOED				[38]	L; reduced reproduction
			3.40000009536743 mg/kg (whole body)[5]	Reproduction, LOED				[38]	L; reduction in reproduction
			2.70000004768371 mg/kg (whole body)[5]	Development, NOED				[38]	L; no physical abnormalities
Salvelinus fontinalis, Brook trout			21.3999996185302 mg/kg (blood cells)[5]	Growth, NOED				[38]	L; decreased weight
			5.19999980926513 mg/kg (blood cells)[5]	Growth, NOED				[38]	L; decreased weight
			2.29999995231628 mg/kg (blood cells)[5]	Growth, NOED				[38]	L; decreased weight
			5.30000019073486 mg/kg (brain)[5]	Growth, NOED				[38]	L; decreased weight

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			1.70000004768371 mg/kg (brain)[5]	Growth, NOED				[38]	L; decreased weight
			0.800000011920928 mg/kg (brain)[5]	Growth, NOED				[38]	L; decreased weight
			1.60000002384185 mg/kg (carcass)[5]	Growth, NOED				[38]	L; decreased weight
			0.589999973773956 mg/kg (carcass)[5]	Growth, NOED				[38]	L; decreased weight
			0.400000005960464 mg/kg (carcass)[5]	Growth, NOED				[38]	L; decreased weight
			6.19999980926513 mg/kg (gill)[5]	Growth, NOED				[38]	L; decreased weight
			1.60000002384185 mg/kg (gill)[5]	Growth, NOED				[38]	L; decreased weight
			0.699999988079071 mg/kg (gill)[5]	Growth, NOED				[38]	L; decreased weight
			2.90000009536743 mg/kg (gonad)[5]	Growth, NOED				[38]	L; decreased weight
			0.899999976158142 mg/kg (gonad)[5]	Growth, NOED				[38]	L; decreased weight
Salvelinus fontinalis, Brook trout			0.200000002980232 mg/kg (gonad)[5]	Growth, NOED				[38]	L; decreased weight
			8.89999961853027 mg/kg (kidney)[5]	Growth, NOED				[38]	L; decreased weight

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			2.5 mg/kg (kidney)[5]	Growth, NOED				[38]	L; decreased weight
			1.20000004768371 mg/kg (kidney)[5]	Growth, NOED				[38]	L; decreased weight
			8.30000019073486 mg/kg (liver)[5]	Growth, NOED				[38]	L; decreased weight
			2.20000004768371 mg/kg (liver)[5]	Growth, NOED				[38]	L; decreased weight
			0.699999988079071 mg/kg (liver)[5]	Growth, NOED				[38]	L; decreased weight
			4.90000009536743 mg/kg (muscle)[5]	Growth, NOED				[38]	L; decreased weight
			1.89999997615814 mg/kg (muscle)[5]	Growth, NOED				[38]	L; decreased weight
			1 mg/kg (muscle)[5]	Growth, NOED				[38]	L; decreased weight
			11.8000001907348 mg/kg (spleen)[5]	Growth, NOED				[38]	L; decreased weight
			3.20000004768371 mg/kg (spleen)[5]	Growth, NOED				[38]	L; decreased weight
			1.20000004768371 mg/kg (spleen)[5]	Growth, NOED				[38]	L; decreased weight
			2.70000004768371 mg/kg (whole body)[5]	Mortality, NOED				[38]	L; no effect on mortality
Salvelinus fontinalis, Brook trout			21.3999996185302 mg/kg (blood cells)[5]	Reproduction, NOED				[38]	L; reduced reproduction

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			5.19999980926513 mg/kg (blood cells)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			2.29999995231628 mg/kg (blood cells)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			5.30000019073486 mg/kg (brain)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			1.70000004768371 mg/kg (brain)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			0.800000011920928 mg/kg (brain)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			1.60000002384185 mg/kg (carcass)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			0.589999973773956 mg/kg (carcass)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			0.400000005960464 mg/kg (carcass)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			6.19999980926513 mg/kg (gill)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			1.60000002384185 mg/kg (gill)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			0.699999988079071 mg/kg (gill)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			2.90000009536743 mg/kg (gonad)[5]	Reproduction, NOED				[38]	L; reduced reproduction

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.899999976158142 mg/kg (gonad)[5]	Reproduction, NOED				[38]	L; reduced reproduction
Salvelinus fontinalis, Brook trout			0.200000002980232 mg/kg (gonad)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			8.89999961853027 mg/kg (kidney)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			2.5 mg/kg (kidney)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			1.20000004768371 mg/kg (kidney)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			8.30000019073486 mg/kg (liver)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			2.20000004768371 mg/kg (liver)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			0.699999988079071 mg/kg (liver)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			4.90000009536743 mg/kg (muscle)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			1.89999997615814 mg/kg (muscle)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			1 mg/kg (muscle)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			11.8000001907348 mg/kg (spleen)[5]	Reproduction, NOED				[38]	L; reduced reproduction

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			3.20000004768371 mg/kg (spleen)[5]	Reproduction, NOED				[38]	L; reduced reproduction
			1.20000004768371 mg/kg (spleen)[5]	Reproduction, NOED				[38]	L; reduced reproduction
Esox lucius, Northern pike			7 mg/kg (whole body)[5]	Physiological, LOED				[60]	F; lowered blood alkaline phosphatase, serum cortisol, emaciation
Planktivores: *Dorosoma cepedianum*, Gizzard shad		Interstitial water: 0.003 µg/L Lake water: 0.0003µg/L	680 µg/kg			6.40		[20]	F; mean methylmercury concentrations in whole bodies of fish were slightly lower than concentrations in fillets for 4 species evaluated (white perch, smallmouth bass, bluegill, and gizzard shad); differences were significant ($P \leq 0.05$, t-test) for bluegill only; BAF value estimated from chart as log BAF

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Benthivores: *Cyprinus carpio*; Carp; *Ictalurus punctatus*, Channel catfish; and *Lepomis macrochirus*, Bluegill		Interstitial water: 0.003 µg/L Lake water: 0.0003 µg/L	480 µg/kg			6.20		[20]	F; mean methylmercury concentrations in whole bodies of fish were slightly lower than concentrations in fillets for 4 species evaluated (white perch, smallmouth bass, bluegill, and gizzard shad); differences were significant (P≤0.05, t-test) for bluegill only; BAF value estimated from chart as log BAF
Oryzias latipes, Japanese medaka			54 mg/kg (whole body)[5]	Development, ED100				[59]	L; complete failure of eggs to hatch
			56 mg/kg (whole body)[5]	Development, ED100				[59]	L; complete failure of eggs to hatch
			54 mg/kg (whole body)[5]	Morphology, ED100				[59]	L; subcutaneous hemorrhage, deformed vertebrae
			56 mg/kg (whole body)[5]	Morphology, ED100				[59]	

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			29 mg/kg (whole body)[5]	Behavior, LOED				[59]	L; hatchlings unable to control fin movement, loss of equilibrium
			29 mg/kg (whole body)[5]	Development, LOED				[59]	L; over 50% reduction in number of eggs which hatched
			29 mg/kg (whole body)[5]	Morphology, LOED				[59]	L; subcutaneous hemorrhage, deformed vertebrae
			16 mg/kg (whole body)[5]	Development, NOED				[59]	L; no effect on hatchability of eggs compared to controls
			16 mg/kg (whole body)[5]	Morphology, NOED				[59]	L; no observations of subcutaneous hemorrhage or deformed vertebrae

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Morone americana, White perch		Interstitial water: 0.003 µg/L Lake water: 0.0003 µg/L	680 µg/kg			6.40		[20]	F; mean methylmercury concentrations in whole bodies of fish were slightly lower than concentrations in fillets for 4 species evaluated (white perch, smallmouth bass, bluegill, and gizzard shad); differences were significant ($P \leq 0.05$, t-test) for bluegill only; BAF value estimated from chart as log BAF
Perca flavescens, Yellow perch			0.135000005364418 mg/kg (whole body)[5]	Growth, NOED				[63]	F, controlled field study; two years but only 1-year-old fish analyzed; basin treated by reducing pH from about 6 to 5.6

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species: Taxa	Concentration, Units in[1]: Sediment	Water	Tissue (Sample Type)	Toxicity: Effects	Ability to Accumulate[2]: Log BCF	Log BAF	BSAF	Source: Reference	Comments[3]
Piscivores: *Microplerus dolomieui*, Smallmouth bass; and *Stizostedion vitreum*, Walleye		Interstitial water: 0.003 µg/L Lake water: 0.0003 µg/L	1,100 µg/kg			3.7×10^6		[20]	F; mean methylmercury concentrations in whole bodies of fish were slightly lower than concentrations in fillets for 4 species evaluated (white perch, smallmouth bass, bluegill, and gizzard shad); differences were significant ($P \leq 0.05$, t-test) for bluegill only; BAF value estimated from chart as log BAF
Stizostedion vitreum, Walleye			0.25 mg/kg (whole body)[5]	Cellular, LOED				[56]	L; multifocal cell atrophy, testicular atrophy
			2.36999988555908 mg/kg (whole body)[5]	Cellular, LOED				[56]	
			0.25 mg/kg (whole body)[5]	Development, LOED				[56]	L; decreased testicular development, lowered gonadosomatic index
			2.36999988555908 mg/kg (whole body)[5]	Development, LOED				[56]	

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			2.36999988555908 mg/kg (whole body)[5]	Growth, LOED				[56]	L; significant reduction in length and weight of males, but not females
			0.25 mg/kg (whole body)[5]	Physiological, LOED				[56]	L; reduced cortisol levels
			0.25 mg/kg (whole body)[5]	Growth, NOED				[56]	L; no effect on length or weight
			0.25 mg/kg (whole body)[5]	Mortality, NOED				[56]	L; no statistically significant increase in mortality
			2.36999988555908 mg/kg (whole body)[5]	Mortality, NOED				[56]	
			2.36999988555908 mg/kg (whole body)[5]	Physiological, NOED				[56]	L; no effect on cortisol levels
Pseudopleuronectes americanus, Winter flounder			5 mg/kg (whole body)[5]	Mortality, LOED				[61]	L; increased mortality
			2 mg/kg (whole body)[5]	Physiological, LOED				[61]	L; increased ornithine decarboxylase activity

Summary of Biological Effects Tissue Concentrations for Methylmercury

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Wildlife									
Larus californicus, California gull			0.404000014066696 mg/kg (brain)[5]	Mortality, NA				[64]	L
			0.828999996185302 mg/kg (breast)[5]	Mortality, NA				[64]	L
			1.08000004291534 mg/kg (liver)[5]	Mortality, NA				[64]	L
Pelecanus occidentalis, Brown pelican			0.202999994158745 mg/kg (brain)[5]	Mortality, NA				[64]	L
			0.347499996423721 mg/kg (breast)[5]	Mortality, NA				[64]	L
			0.806500017642974 mg/kg (liver)[5]	Mortality, NA				[64]	L
Phalacrocorax penicillatus, Brandts cormorant			0.648999989032745 mg/kg (brain)[5]	Mortality, NA				[64]	L
			0.986000001430511 mg/kg (breast)[5]	Mortality, NA				[64]	L
			2.94000005722045 mg/kg (liver)[5]	Mortality, NA				[64]	L
			3.06999993324279 mg/kg (liver)[5]	Mortality, NA				[64]	L

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] MeHg = methylmercury.
[5] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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