

Table 1. Acute Toxicity of Tributyltin to Aquatic Animals

<u>Species</u>	<u>Method^a</u>	<u>Chemical^b</u>	Hardness (mg/L as <u>CaCO₃</u>)	LC50 or EC50 (μ g/L) ^c	Species mean Acute value (μ g/L)	<u>References</u>
<u>FRESHWATER SPECIES</u>						
Hydra, <u>Hydra littoralis</u>	S,M	TBTO (97.5%)	100	1.11	-	TAI Environmental Sciences, Inc. 1989a
Hydra, <u>Hydra littoralis</u>	S,M	TBTO (97.5%)	120	1.30	1.201	TAI Environmental Sciences, Inc. 1989b
Hydra, <u>Hydra oligactis</u>	S,M	TBTO (97.5%)	100	1.14	1.14	TAI Environmental Sciences, Inc. 1989a
Hydra, <u>Chlorohydra viridissima</u>	S,M	TBTO (97.5%)	120	1.80	1.80	TAI Environmental Sciences, Inc. 1989b
Annelid (9 mg), <u>Lumbriculus variegatus</u>	F,M	TBTO (96%)	51.8	5.4	5.4	Brooke et al. 1986
Freshwater clam, (113 mm TL; 153 g) <u>Elliptio complanatus</u>	S,U	TBTO (95%)	-	24,600	24,600	Buccafusco 1976a
Cladoceran, <u>Daphnia magna</u>	S,U	TBTO	-	66.3	-	Foster 1981
Cladoceran (adult), <u>Daphnia magna</u>	S,U	TBTCl	-	5.26	-	Meador 1986
Cladoceran (<24 hr), <u>Daphnia magna</u>	S,U	TBTO (95%)	-	1.58	-	LeBlanc 1976
Cladoceran (<24 hr), <u>Daphnia magna</u>	R,M	TBTO (97.5%)	172	11.2	-	ABC Laboratories, Inc. 1990c
Cladoceran (<24 hr), <u>Daphnia magna</u>	F,M	TBTO (96%)	51.5	4.3	4.3	Brooke et al. 1986
Cladoceran (<24 hr), <u>Daphnia magna</u>	S,U	TBTCl	250	18	-	Crisinel et al. 1994
Amphipod, <u>Gammarus pseudolimnaeus</u>	F,M	TBTO (96%)	51.8	3.7	3.7	Brooke et al. 1986
Mosquito (larva), <u>Culex</u> sp.	S,M	TBTO (96%)	51.5	10.2	10.2	Brooke et al. 1986

Table 1. (continued)

<u>Species</u>	<u>Method^a</u>	<u>Chemical^b</u>	Hardness	<u>LC50 or EC50 ($\mu\text{g/L}$)^c</u>	<u>Species Mean Acute Value ($\mu\text{g/L}$)</u>	<u>References</u>
			(mg/L as CaCO_3)			
Rainbow trout, (45 mm TL; 0.68 g), <u>Oncorhynchus mykiss</u>	S,U	TBTO (95%)	-	6.5	-	Buccafusco et al. 1978
Rainbow trout (juvenile), <u>Oncorhynchus mykiss</u>	F,M	TBTO (96%)	50.6	3.9	-	Brooke et al. 1986
Rainbow trout (1.47 g), <u>Oncorhynchus mykiss</u>	F,M	TBTO (97%)	135	3.45	-	Martin et al. 1989
Rainbow trout (1.4 g), <u>Oncorhynchus mykiss</u>	F,M	TBTO (97.5%)	44	7.1	4.571	ABC Laboratories, Inc. 1990a
Lake trout (5.94 g), <u>Salvelinus naymaycush</u>	F,M	TBTO (97%)	135	12.73	12.73	Martin et al. 1989
Fathead minnow (juvenile), <u>Pimephales promelas</u>	F,M	TBTO (96%)	51.5	2.6	2.6	Brooke et al. 1986
Channel catfish, (65 mm TL; 1.9 g), <u>Ictalurus punctatus</u>	S,U	TBTO (95%)	-	11.4	-	Buccafusco 1976a
Channel catfish (juvenile), <u>Ictalurus punctatus</u>	F,M	TBTO (96%)	51.8	5.5	5.5	Brooke et al. 1986
Bluegill, <u>Lepomis macrochirus</u>	S,U	TBTO	-	227.4	-	Foster 1981
Bluegill, (36 mm TL: 0.67 g), <u>Lepomis macrochirus</u>	S,U	TBTO (95%)	-	7.2	-	Buccafusco 1976b
Bluegill (1.01 g), <u>Lepomis macrochirus</u>	F,M	TBTO (97.5%)	44	8.3	8.3	ABC Laboratories, Inc. 1990b

SALTWATER SPECIES

Lugworm (larva), <u>Arenicola cristata</u>	S,U	TBTO	28°	~2-4	-	Walsh et al. 1986b
Lugworm (larva), <u>Arenicola cristata</u>	S,U	TBTA	28	~5-10	~5.03	Walsh et al. 1986b

Table 1. (Continued)

<u>Species</u>	<u>Method^a</u>	<u>Chemical^b</u>	<u>Salinity (g/kg)</u>	<u>LC50 or EC50 (μg/L)^c</u>	<u>Species Mean Acute Value (μg/L)</u>	<u>Reference</u>
Polychaete (juvenile), <u>Neanthes</u> <u>arenaceodentata</u>	S,U	TBTO	33-34	6.812	-	Salazar and Salazar 1989
Polychaete (adult), <u>Neanthes</u> <u>arenaceodentata</u>	S,U	TBTO	33-34	21.41 ^e	6.812	Salazar and Salazar 1989
Polychaete (adult), <u>Armandia</u> <u>brevis</u>	R,M	TBTC1 (96%)	28.5	25	25	Medor 1997
Blue mussel (larva), <u>Mytilus</u> <u>edulis</u>	R,-	TATO	-	2.238	-	Thain 1983
Blue mussel (adult), <u>Mytilus</u> <u>edulis</u>	R,-	TBTO	-	36.98 ^e	-	Thain 1983
Blue mussel (adult), <u>Mytilus</u> <u>edulis</u>	S,U	TBTO	33-34	34.06 ^e	2.238	Salazar and Salazar 1989
Pacific oyster (larva), <u>Crassostrea</u> <u>gigas</u>	R,-	TBTO	-	1.557	-	Thain 1983
Pacific oyster (adult), <u>Crassostrea</u> <u>gigas</u>	R,-	TBTO	-	282.2 ^e	1.557	Thain 1983
Eastern oyster (embryo), <u>Crassostrea</u> <u>virginica</u>	S,U	TBTO	22	0.8759	-	EG&G Bionomics 1976a, 1977
Eastern oyster (embryo), <u>Crassostrea</u> <u>virginica</u>	R,U	TBTC1	18-22	1.30	-	Roberts 1987
Eastern oyster (embryo), <u>Crassostrea</u> <u>virginica</u>	R,U	TBTC1	18-22	0.71	-	Roberts 1987
Eastern oyster, <u>Crassostrea</u> <u>virginica</u>	R,U	TBTC1	18-22	3.96 ^e	0.9316	Roberts 1987
European flat oyster (adult), <u>Ostrea</u> <u>edulis</u>	R,-	TBTO	-	204.4	204.4	Thain 1983
Atlantic dogwhelk (<24 hr-old), <u>Nucella</u> <u>lapillus</u>	R,M	TBTO	34-35	72.7	72.7	Harding et al. 1996

Table 1. (Continued)

<u>Species</u>	<u>Method^a</u>	<u>Chemical^b</u>	<u>Salinity (g/kg)</u>	<u>LC50 or EC50 μg/L)^c</u>	<u>Species Mean Acute Value (μg/L)</u>	<u>References</u>
Hard clam (post larva), <u><i>Mercenaria mercenaria</i></u>	S,U	TBTCl	-	0.01466 ^f	-	Becerra-Huencho 1984
Hard clam (embryo), <u><i>Mercenaria mercenaria</i></u>	R,U	TBTCl	18-22	1.13	-	Roberts 1987
Hard clam (larva), <u><i>Mercenaria mercenaria</i></u>	R,U	TBTCl	18-22	1.65	1.365	Roberts 1987
Copepod (juvenile), <u><i>Eurytemora affinis</i></u>	F,M	TBTCl	10.6	2.2	-	Hall et al. 1988a
Copepod (subadult), <u><i>Eurytemora affinis</i></u>	F,M	TBT	10	2.5	-	Bushong et al. 1987;1988
Copepod (subadult), <u><i>Eurytemora affinis</i></u>	F,M	TBT	10	1.4	1.975	Bushong et al. 1987;1988
Copepod (adult), <u><i>Acartia tonsa</i></u>	R,U	TBTO (95%)	-	0.6326	-	U'ren 1983
Copepod (subadult), <u><i>Acartia tonsa</i></u>	F,M	TBT	10	1.1	1.1	Bushong et al. 1987;1988
Copepod (10-12-d-old), <u><i>Acartia tonsa</i></u>	S,U	TBTCl (99.3%)	18	0.47	-	Kusk and Petersen 1997
Copepod (10-12-d-old), <u><i>Acartia tonsa</i></u>	S,U	TBTCl (99.3%)	28	0.24	-	Kusk and Petersen 1997
Copepod (adult), <u><i>Nitocra spinipes</i></u>	S,U	TBTF	7	1.877	-	Linden et al. 1979
Copepod (adult), <u><i>Nitocra spinipes</i></u>	S,U	TBTO	7	1.946	1.911	Linden et al. 1979
Mysid (juvenile), <u><i>Acanthomysis sculpta</i></u>	R,M	^g	-	0.42	-	Davidson et al. 1986a,1986b
Mysid (adult), <u><i>Acanthomysis sculpta</i></u>	F,M	^g	-	1.68 ^e	-	Valkirs et al. 1985
Mysid (juvenile), <u><i>Acanthomysis sculpta</i></u>	F,M	^g	-	0.61	0.61	Valkirs et al. 1985

Mysid (juvenile),
Metamysidopsis elongata

S,U TBTO 33-34 <0.9732 - Salazar and Salazar 1989

Table 1. (Continued)

<u>Species</u>	<u>Method^a</u>	<u>Chemical^b</u>	<u>Salinity (g/kg)</u>	<u>LC50 or EC50 (μg/L)^c</u>	<u>Species Mean Acute Value (μg/L)</u>	<u>Reference</u>
Mysid (subadult), <u><i>Metamysidopsis elongata</i></u>	S,U	TBTO	33-34	1.946 ^e	-	Salazar and Salazar 1989
Mysid (adult), <u><i>Metamysidopsis elongata</i></u>	S,U	TBTO	33-34	2.433 ^e	-	Salazar and Salazar 1989
Mysid (adult), <u><i>Metamysidopsis elongata</i></u>	S,U	TBTO	33-34	6.812 ^e	<0.9732	Salazar and Salazar 1989
Mysid (<1 day), <u><i>Mysidopsis bahia</i></u>	F,M	TBTC1	19-22	1.1	-	Goodman et al. 1988
Mysid (5 day), <u><i>Mysidopsis bahia</i></u>	F,M	TBTC1	19-22	2.0	-	Goodman et al. 1988
Mysid (10 day), <u><i>Mysidopsis bahia</i></u>	F,M	TBTC1	19-22	2.2	1.692	Goodman et al. 1988
Amphipod (subadult), <u><i>Gammarus</i> sp.</u>	F,M	TBT	10	1.3	-	Bushong et al. 1988
Amphipod (adult), <u><i>Gammarus</i> sp.</u>	F,M	TBT	10	5.3 ^e	1.3	Bushong et al. 1988
Amphipod (adult), <u><i>Orchestia traskiana</i></u>	R,M	TBTO	30	>14.60 ^h	>14.60	Laughlin et al. 1982
Amphipod (adults), <u><i>Rhepoxygnus abronius</i></u>	R,M	TBTC1 (96%)	32.3	108	108	Meador 1997
Amphipod (3-5 mm; 2-5 mg), <u><i>Eohaustorius estuarinus</i></u>	R,M	TBTC1 (96%)	28.8- 29.5	10	10	Medor 1993; Meador et al. 1993; Meador 1997
Amphipod (adult), <u><i>Eohaustorius washingtonianus</i></u>	R,M	TBTC1 (96%)	32.7	9	9	Medor 1997
Grass shrimp (adult), <u><i>Palaemonetes pugio</i></u>	F,U	TBTO	-	20	20	Clark et al. 1987
Grass shrimp (subadult), <u><i>Palaemonetes</i> sp.</u>	F,M	TBT	10	>31	>31	Bushong et al. 1988
Grass shrimp (larvae), <u><i>Palaemonetes</i> sp.</u>	R,U	TBTO	20	4.07	-	Kahn et al. 1993

Grass shrimp (adult),
Palaemonetes sp.

Table 1. (Continued)

<u>Species</u>	<u>Method^a</u>	<u>Chemical^b</u>	<u>Salinity (g/kg)</u>	<u>LC50 or EC50^c (μg/L)^d</u>	<u>Species Mean Acute Value (μg/L)</u>	<u>Reference</u>
American lobster (larva), <u>Homarus americanus</u>	R,U	TBTO	32	1.745 ^h	1.745	Laughlin and French 1980
Shore crab (larva), <u>Carcinus maenas</u>	R,-	TBTO	-	9.732	9.732	Thain 1983
Mud crab (larva), <u>Rhithropanopeus harrisii</u>	R,U	TBTS	15	>24.3 ^h	-	Laughlin et al. 1983
Mud crab (larva), <u>Rhithropanopeus harrisii</u>	R,U	TBTO	15	34.90 ^h	34.90	Laughlin et al. 1983
Shore crab (larva), <u>Hemigrapsus nudus</u>	R,U	TBTO	32	83.28 ^h	83.28	Laughlin and French 1980
Amphioxus, <u>Branchiostoma caribaeum</u>	F,U	TBTO	-	<10	<10	Clark et al. 1987
Chinook salmon (juvenile), <u>Oncorhynchus tshawytscha</u>	S,M	TBTO	28	1.460	1.460	Short and Thrower 1986b;1987
Atlantic menhaden (juvenile), <u>Brevoortia tyrannus</u>	F,M	TBT	10	4.7	-	Bushong et al. 1987;1988
Atlantic menhaden (juvenile), <u>Brevoortia tyrannus</u>	F,M	TBT	10	5.2	4.944	Bushong et al. 1987;1988
Sheepshead minnow (juvenile), <u>Cyprinodon variegatus</u>	S,U	TBTO	20	16.54	-	EG&G Bionomics 1979
Sheepshead minnow (juvenile), <u>Cyprinodon variegatus</u>	S,U	TBTO	20	16.54	-	EG&G Bionomics 1979
Sheepshead minnow (juvenile), <u>Cyprinodon variegatus</u>	S,U	TBTO	20	12.65	-	EG&G Bionomics 1979

Sheepshead minnow
 (33-49 mm),
Cyprinodon variegatus

F,M TBTO 28-32 2.315^h - EG&G Bionomics

1981d

Table 1. (Continued)

<u>Species</u>	<u>Method^a</u>	<u>Chemical^b</u>	<u>Salinity (g/kg)</u>	<u>LC50 or EC50 (µg/L)^c</u>	<u>Species Mean Acute Value (µg/L)</u>	<u>Reference</u>
Sheepshead minnow (juvenile), <u><i>Cyprinodon variegatus</i></u>	F,M	TBTO	15	12.31	-	Walker 1989a
Sheepshead minnow (subadult), <u><i>Cyprinodon variegatus</i></u>	F,M	TBT	10	25.9	9.037	Bushong et al. 1988
Mummichog (adult), <u><i>Fundulus heteroclitus</i></u>	S,U	TBTO (95%)	25	23.36	-	EG&G Bionomics 1976a
Mummichog (juvenile), <u><i>Fundulus heteroclitus</i></u>	F,M	TBTO	2	17.2	-	Pinkney et al. 1989
Mummichog (larval), <u><i>Fundulus heteroclitus</i></u>	F,M	TBT	10	23.4	-	Bushong et al. 1988
Mummichog (subadult), <u><i>Fundulus heteroclitus</i></u>	F,M	TBT	10	23.8	21.34	Bushong et al. 1988
Inland silverside (larva), <u><i>Menidia beryllina</i></u>	F,M	TBT	10	3.0	3.0	Bushong et al. 1987;1988
Atlantic silverside, <u><i>Menidia menidia</i></u>	F,M	TBT	10	8.9	8.9	Bushong et al. 1987;1988
Starry flounder (<1-year-old), <u><i>Platichthys stellatus</i></u>	R,M	TBTC1 (96%)	30.2	10.1	10.1	Meador 1997

^a S = static; R = renewal; F = flow-through; M = measured; U = unmeasured.

^b TBTCl = tributyltin chloride; TBTF = tributyltin fluoride; TBTO = tributyltin oxide; TBTS = tributyltin sulfide.

Percent purity is given in parentheses when available.

^c Salinity (g/kg).

^d Concentration of the tributyltin cation, not the chemical. If the concentrations were not measured and the published results were not reported to be adjusted for purity, the published results were multiplied by the purity if it was reported to be less than 95%.

^e Value not used in determination of Species Mean Acute Value because data are available for a more sensitive life stage.

^f Value not used in determination of Species Mean Acute Value (see text).

^g The test organisms were exposed to leachate from panels coated with antifouling paint containing a tributyltin polymer and cuprous oxide. Concentrations of TBT were measured and the authors provided data to demonstrate the similar toxicity of a pure TBT compound and the TBT from the paint formulation.

^h LC50 and EC50 calculated or interpolated graphically based on the authors' data.