AMBIENT WATER QUALITY ADVISORY

XYLENE

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER REGULATIONS AND STANDARDS
CRITERIA AND STANDARDS DIVISION
WASHINGTON, D.C.

CONTENTS

		Page
	Notices	ii
	Foreword	iii
	Acknowledgments	iv
I.	Advisories	I-1
II.	General Information	II-1
A.	Biological, Chemical and Physical Properties	II-1
B.	Occurrence	II-2
C.	Environmental Fate	II-2
III.	Aquatic Toxicity	III-1
IV.	Referances	IV-1
V.	EPA Contacts	V-1

NOTICES

This document has been reviewed by the Criteria and Standards Division, Office of Water Regulations and Standards, U.S. Environmental Protection Agency, and approved for distribution.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

This document is available to the public through the Criteria and Standards Division, Office of Water Regulations and Standards, U.S. EPA, Washington, DC.

FOREWORD

The Criteria and Standards Division of the Office of Water Regulations and Standards has instituted water quality advisories as a vehicle for transmitting the best available scientific information concerning the aquatic life and human health effects of selected chemicals in surface waters. Advisories are prepared for chemicals for which information is needed quickly, but for which sufficient data, resources, or time are not available to allow derivation of national ambient water quality criteria.

Data supporting advisories are usually not as extensive as required for derivation of national ambient water quality criteria, and the strength of an advisory will depend upon the source, type, and reliability of the data available. We feel, however, that it is in the best interest of all concerned to make the enclosed information available to those who need it.

Users of advisories should take into account the bases for their derivation and their intended uses. Anyone who has additional information that will supplement or substantially change an advisory is requested to make the information known to us. An advisory for an individual chemical will be revised if any significant and valid new data make it necessary.

We invite comments to help improve this product.

Edmund M. Notzon, Director
Criteria and Standards Division

ACKNOWLEDGMENTS

AQUATIC LIFE

Mary D. Balcer, author
University of Wisconsin-Superior, Superior, WI

AQUATIC LIFE

If the measured or estimated ambient concentration of xylene exceeds 21 µg/L in fresh or salt water, one or more of the following options must be completed within a reasonable period of time:

1. Obtain more measurements of the concentration.

2. Improve the estimate of the concentration.

3. Reduce the concentration.

4. Obtain additional laboratory and/or field data on the effect of xylene on aquatic life so that a new aquatic life advisory or a water quality criterion can be derived.

After a reasonable period of time, unless a consideration of all the available data concerning the ambient concentration and the effects of xylene on aquatic life demonstrates that the ambient concentration is low enough, it must be reduced.

SECTION II. GENERAL INFORMATION

A. Biological, Chemical, and Physical Properties

The following information on the properties of the three isomers of xylene (dimethylbenzene) and its persistence in the aquatic environment was obtained from the QSAR system on July 17, 1986. Density the exception, was obtained from the Handbook of Chemistry and Physics, 67th Ed., CRC Press, Boca Raton, Florida, 1986-87. Some of the values were calculated using structure-activity relationships.

Property	Value			Source
	Ortho-xylene	Meta-xylene	Para-xylene	
Molecular weight	106.09 g/mol	106.09 g/mol	106.09 g/mol	Calc
Density (20°C)	0.8802	0.8642	0.8611	Calc
Log P	3.44	3.44	3.44	CLogP
Melting Point	-25.00°C	-48.00°C	13.00°C	Meas
Boiling Point	144.00°C	139.00°C	138.00°C	Meas
Vapor Pressure	6.69 mm Hg	8.36 mm Hg	8.82 mm Hg	Meas
Heat of Vaporization	8720 cal/mol	8620 cal/mol	8600 cal/mol	Calc
pKa	(not applicable)	(not applicable)	(not applicable)	-
Solubility in Water	176. mg/L	185. mg/L	197 mg/L	Calc
BCF	208	208	208	Calc
Absorption Coef. [Log (Koc)]	3.21	3.21	3.21	Calc

	ortho-Xylene	meta-Xylene	para-Xylene
	1,2-dimethylbenzene	1,3-dimethylbenzene	1,4-dimethylbenzene
Log 10 (Henry's constant) =	-2.28 atm.m3/mol	-2.20 atm.m3/mol	-2.20 atm.m3/mol

It could be concluded that a chemical with these properties will vaporize rapidly from and will not persist in open water.

Neely 100-day Partitioning Pattern

	ortho-Xylene	meta-Xylene	para-Xylene
Air =	52.01%	56.37%	56.05%
Water =	29.69%	27.00%	27.20%
Ground =	9.46%	8.60%	8.67%
Hydrosoil =	8.83%	8.03%	8.09%

Information on the QSAR system, see: Hunter, R., L. Faulkner, F. Culver and J. Hill. Draft user manual for the QSAR system. Center for Data Systems and Analysis, Montana State University, November, 1985.

All the xylenes are colorless liquids with a mild sweet odor.

B. Occurrence

Xylenes occur at low levels in drinking water, food and air. Xylenes occur in both ground and surface public water supplies, with higher levels occurring in surface water supplies (Keith et al. 1976, Otson et al. 1982). The EPA's Community Water Supply Survey (U.S. EPA, 1983) found 3% of all ground- water derived public drinking water systems sampled had levels greater than 0.5 ug/L. The highest level reported in groundwater was 2.5 ug/L. The survey reported that 6% of all surface water derived drinking water systems are contaminated at levels higher than 0.5 ug/L; however none of the systems were reported to contain levels higher than 5.2 ug/L. No information on the occurrence of xylene in foods has been identified. Xylenes are found in the air of urban and suburban areas at levels of approximately 2 ug/L. Because of the low levels of xylenes reported in water, air is likely to be the major source of exposure.

While xylenes occur naturally as a component of petroleum oil, they are also produced in large amounts. For example, in 1982, 5 billion pounds of xylenes were produced (U.S. ITC, 1984). Gasoline refinement and associated operations indirectly produce large quantities of xylenes. Due to their volatile nature, the majority of releases of xylene to the environment are to the air with only smaller amounts to water and soil. Releases of the compound to water are due to spills or leaks of petroleum products and, to a lesser extent, the disposal of paints, inks and other industrial products which use xylenes as a solvent. Because of the widespread use of petroleum products, releases of xylenes occur nationwide.

C. Environmental Fate

Based on our EXAMS model (Burns et al. 1981), the dominant process for removal of xylenes in water will be volatilization. The predicted volatilization rates are as follows:

	Volatilization half-life (days)
o-xylene	2.6 - 11
m-xylene	2.8 - 11
p-xylene	2.7 - 11

Rates will vary depending on the type of environment, temperature, oxygen exchange rate and amount of organic matter in the sediments.

Oxidation of xylenes does not appear to be significant Hendey et al., 1974). Xylenes are reported not to absorb light significantly at wave lengths of ultraviolet-visible spectrum

(>300nm) that correspond to the environmentally relevant wavelengths reaching surface waters (Weast, 1972). Therefore, photolysis is unlikely to be a significant degradative pathway, if it occurs at all.

Sorption to sediments varies depending on the percent of organic matter. Green et al. (1981) found that movement of o- and p-xylene was inversely related to the octanol/water partition coefficient and that movement increased as the bulk density of the soil decreased.

Biodegradation of xylene may be significant, but varies considerably depending on the isomer the source of seed, the feed rate and whether or not it was acclimated (Dore et al., 1975, Marion and Malaney, 1964).

m-Xylene was found to be toxic to microorganisms at high feed rates (500 mg/L) (Marion and Malaney, 1964).

A poor to moderate degradation rate is indicated by results of these studies and the reports of xylenes in drinking water.

SECTION III. AQUATIC TOXICITY

Introduction

Aquatic life advisory concentrations are conceptually different from national aquatic life water quality criteria. Because aquatic life advisories are intended to be used to identify situations where there is cause for concern and where appropriate action should be taken, the advisory concentration for a chemical is derived to be equal to or lower than what the Criterion Continuous Concentration (Stephan et al. 1985) would be if a national water quality criterion for aquatic life could be derived for the chemical. If the concentration of a chemical in a variety of surface waters is found to exceed the aquatic life advisory concentration, this may indicate that the U.S. EPA should consider deriving aquatic life water quality criteria for that chemical.

The literature searching and data evaluation procedures used in the derivation of aquatic life advisories are identical to those used in the derivation of water quality criteria for aquatic life (Stephan et al. 1985). However, advisories do not contain a section on "Unused Data" as in a criteria document. This aquatic life advisory concentration for xylene was derived using the procedures described in the "Guidelines for Deriving Ambient Aquatic Life Advisory Concentrations" (Stephan et al. 1986). A knowledge of these guidelines is necessary in order to understand the following text, tables, and calculations. The latest comprehensive literature search for information for this aquatic life advisory was conducted in February, 1987.

Commercial xylene is a mixture of the three isomers of xylene and may contain traces of ethylbenzene. Although slight differences have been noted in the toxicity of the various isomers to aquatic organisms, these differences have been small (within a factor of 5) and the data have not consistently demonstrated that any one isomer is more toxic than the others. For the purpose of this advisory, it is assumed that the three isomers are equally toxic and that their toxicities are additive. Therefore, data on the toxicities of all forms of xylene were combined instead of developing advisories on each individual isomer.

In static toxicity tests, the amount of xylene in the exposure chambers declines rapidly. Benville and Korn (1977) found that concentrations decreased by 19 to 35% in 24 hr and that <1% of the initial concentration was left in 96 hr. Brooke (1987) calculated a half-life of 15.6 hr for xylene in a static exposure. Brooke also ran a set of comparison tests to determine if the 96-hr LC50 for fathead minnows exposed to xylene was dependent on the exposure method. He reported that the LC50 from a measured flow-through exposure (8,870 ug/L) was similar to that derived from a static exposure that was measured at 48 hr intervals (8,400 ug/L). However, if the static 96-hr LC50 had been calculated using only the 0-hr measurement of the xylene concentrations in the exposure, the value (i.e. 22,400 ug/L) would have been 2.525 times larger than that obtained from the flow-through exposure. In order to allow a more direct comparison of the effects of xylene on different species of aquatic organisms, the results from the various types of exposures need to be standardized. Therefore, acute toxicity data in Table 1 that were obtained from static tests that were not measured, or were only measured initially, were divided by a factor of 2.525 to equate them with flow-through test results.

Effects on Freshwater Organisms

Acceptable data on the acute toxicity of xylene to freshwater organisms are available for two species of invertebrates and six fish (Table 1). The snail, *Aplexa hyporum*, is quite tolerant of exposure to xylene with an LC50 > 22,400 ug/L (Holcombe et al., manuscript). *Daphnia magna*, the other invertebrate tested, was the most sensitive freshwater organism with a Species Mean Acute Value (SMAV) of 3,820 ug/L. The SMAVs for the six fish species were similar and ranged from 8,050 ug/L for the rainbow trout (*Salmo gairdneri*) to 16,510 ug/L for the goldfish (*Carassius auratus*) (Table 2).

No acceptable data are available on the chronic toxicity of xylene to freshwater organisms. However, Black et al. (1982) exposed the fertilized ova of rainbow trout and leopard frogs (*Rana pipiens*) to various concentrations of xylene in flow-through chambers and monitored embryo survival and development through hatching. The EC50 for rainbow trout at hatching (23 days) was, 950 ug/L while at 4 days post-hatch the EC50 declined to 3,770 ug/L (Table 3). For the leopard frog the EC50s at hatching in 5 days and at 4 days post-hatch were 4,060 and 3,530 ug/L, respectively.

Additional data are available on the lethal and sublethal effects of xylene on freshwater organisms (Table 3). Although some of these results are from static unmeasured exposures, the data were not adjusted to flow-through conditions and therefore may not be directly comparable to the values contained in Table 1. The effects of xylene on microorganisms have been determined through a variety of static tests (Table 3). Bacteria and protozoans were quite resistant to xylene with inhibition of survival and cell replication occuring at concentrations between 16,900 and 200,000 ug/L (Bringmann 1973, 1978; Bringmann and Kuhn 1977b, 1980, 1981; Bringmann et al. 1980; Rogerson et al. 1983). Algal photosynthesis and cell replication were reduced by 50%

after exposure to xylene concentrations ranging from 46,000 to 105,000 ug/L (Hutchinson et al. 1979, 1980; Kauss and Hutchinson 1975).

Maynard and Weber (1981) observed that juvenile coho salmon (Oncorhynchus kisutch) were able to detect and avoid xylene at levels as low as 680 ug/L. Concentrations of 2,000 ug/L affected the respiration rate of rainbow trout (Slooff 1979).

Effects on Saltwater Organisms

Acceptable data on the acute toxicity of xylene to saltwater organisms are available for four invertebrates and one species of fish (Table 1). The adjusted Species Mean Acute Values ranged from 1,815 ug/L for adult bay shrimp (Crangon franciscorum) to 154,300 ug/L for embryos of the Pacific oyster (Crassostrea gigas). The striped bass (Morone saxatilis), with a SMAV of 5,090 ug/L, was slightly more sensitive to xylene exposure than the freshwater fish species (Table 2).

No chronic data are available for saltwater animals exposed to xylene. Commercial xylene concentrations greater than 10,000 ug/L were found to inhibit algal growth (Dunstan et al. 1975) (Table 3), while the motility of barnacle nauplii was affected by 19,500 ug/L (Donahue et al. 1977; Winters et al. 1977).

Calculation of Advisory Concentration

Species and Genus Mean Acute Values are available for 13 organisms (Table 2) and range from 1,815 ug/L for the bay shrimp to 154,300 ug/L for the Pacific oyster. The lowest Genus Mean Acute Value (GMAV), 1,815 ug/L, is therefore divided by a factor of 3.4, in accordance with the advisory guidelines, resulting in an Advisory Acute Value (AAV) of 533.8 ug/L. Due to the lack of any acceptable data on the chronic toxicity of xylene to aquatic organisms, an empirical value of 25 is used as the Advisory Acute-Chronic Ratio (AACR). Division of the AAV (533.8 ug/L) by the AACR (25) results in an Advisory Concentration of 21 ug/L.

Table 1. Acute Toxicity of Xylene to Aquatic Animals

FRESHWATER SPECIES

Species	Method[a]	Chemical[b]	Hardness (mg/L as $CaCO_3$)	LC50 or EC50 (µg/L)	Adjusted LC50 or EC50 (µg/L)[c]	Species Mean Acute Value (µg/L)	References
Snail (adult), *Aplexa hyporum*	F, M	o	44.7	> 22,400	- -	>22,400	Holcombe et al. manuscript
Cladoceran (<48 hr), *Daphnia magna*	S, U	m	-	14,300	5,660	-	Hermens et al 1984
Cladoceran (<24 hr), *Daphnia magna*	F, M	o	44.7	3,820	-	3,820	Holcombe et al manuscript
Rainbow trout (0.9 g), *Salmo gairdneri*	S, U	Technical (100%)	40	13,500	5,350	-	Walsh et al. 1977; Mayer and Ellersieck 1986
Rainbow trout (0.6 g), *Salmo gairdneri*	S, U	Technical (100%)	44	8,200	3,250	-	Johnson and Finley 1980; Mayer and Ellersieck 1986
Rainbow trout (juvenile), *Salmo gairdneri*	F, M	o	44.7	8,050	-	8,050	Holcombe et al manuscript
Goldfish (3.8-6.4 cm), *Carassius auratus*	S, U	-	20	36,810	14,580	-	Pickering and Henderson 1966

Table 1 (continued)

Species	Method[a]	Chemical[b]	Hardness (mg/L as $CaCO_3$)	LC50 or EC50 (µg/L)	Adjusted LC50 or EC50 (µg/L)[c]	Species Mean Acute Value (µg/L)	References
Goldfish (1-1.5 yr), Carassius auratus	F, M	Analytical	80	16,940	-	-	Brenniman et al. 1976
Goldfish (juvenile), Carassius auratus	F, M	o	44.7	16,100	-	16,510	Holcombe et al. manuscript
Fathead minnow (3.8-6.4 cm), Pimephales promelas	S, U	-	360	28,770	11,390	-	Pickering and Henderson 1966
Fathead minnow (3.8-6.4 cm), Pimephales promelas	S, U	-	20	26,700	10,600	-	Pickering and Henderson 1966
Fathead minnow (juvenile), Pimephales promelas	S, U	Reagent	-	42,000	17,000	-	Mattson et al. 1976
Fathead minnow (juvenile), Pimephales promelas	S, U	p (99%)	51.1	21,200	8,400	-	Brooke 1987

Table I. (continued)

Species	Method[a]	Chemical[b]	Hardness (mg/L as $CaCO_3$)	LC50 or EC50 (µg/L)	Adjusted LC50 or EC50 (µg/L)[c]	Species Mean Acute Value (µg/L)	References
Fathead minnow (juvenile), *Pimephales promelas*	S, M_o	p (99%)	51 1	22,400	8,870	-	Brooke 1987
Fathead minnow (juvenile), *Pimephales promelas*	S, M	p (99%)	-	8,400	-	-	Brooke 1987
Fathead minnow (juvenile), *Pimephales promelas*	F, M	p	-	8,870	-	-	Geiger et al. 1986 Brooke 1987
Fathead minnow (juvenile), *Pimephales promelas*	F, M	o	44.7	16,100		11,950	Holcombe et al. manuscript
White sucker (juvenile), *Catostomus commersoni*	F, M	o	44.7	16,100	-	16,100	Holcombe et al. manuscript
Guppy (6 mo), *Poecilia reticulata*	S, U	-	20	34,730	13,750	13,750	Pickering and Henderson 1966

Table 1. (continued)

Species	Method[a]	Chemical[b]	Hardness (mg/L as $CaCO_3$)	LC50 or EC50 (µg/L)	Adjusted LC50 or EC50 (µg/L)[c]	Species Mean Acute Value (µg/L)	References
Bluegill, *Lepomis macrochirus*	S, U	-	-	19,000	7,500	-	Cope 1965
Bluegill, (3.8-6.4 cm), *Lepomis macrochirus*	S, U	-	20	20,870	8,265	-	Pickering and Henderson 1966
Bluegill (0.9 g), *Lepomis macrochirus*	S, U	Technical (100%)	44	13,500	5,350	-	Johnson and Finley 1980; Mayer and Ellersieck 1986
Bluegill (juvenile), *Lepomis macrochirus*	S, M_o	Reagent x	31.2	24,500	9,700	-	Bailey et al. 1985
Bluegill (juvenile), *Lepomis macrochirus*	F, M	Reagent x	31.2	15,700	-	-	Bailey et al. 1985
Bluegill (juvenile), *Lepomis macrochirus*	F, M	o	44.7	16,100	-	15,900	Holcombe et al manuscript

Table 1 (continued)

SALTWATER SPECIES

Species	Method[a]	Chemical[b]	Salinity (g/Kg)	LC50 or EC50 (µg/L)	Adjusted LC50 or EC50 (µg/L)[c]	Species Mean Acute Value (µg/L)	References
Pacific oyster (embryo), *Crassostrea gigas*	S, U	o	25.3-30.8	169,000	66,900	-	Legore 1974
Pacific oyster (embryo), *Crassostrea gigas*	S, U	x	25.3-30.8	602,000	238,000	-	Legore 1974
Pacific oyster (embryo), *Crassostrea gigas*	S, U	p	25.3-30.8	584,000	231,000	154,300	Legore 1974
Grass shrimp, *Palaemonetes pugio*	S, U	-	15	7,400	2,900	2,900	Tatem et al 1978
Bay shrimp (adult), *Crangon franciscorum*	S, M	o (>99%)	25	1,100	-	-	Benville and Korn 1977

Table 1. (continued)

Species	Method[a]	Chemical[b]	Salinity (g/Kg)	LC50 or EC50 (µg/L)	Adjusted LC50 or EC50 (µg/L)[c]	Species Mean Acute Value (µg/L)	References
Bay shrimp (adult), *Crangon franciscorum*	S, M	m (>99%)	25	3,200	-	-	Benville and Korn 1977
Bay shrimp (adult), *Crangon franciscorum*	S, M	p (>99%)	25	1,700	-	1,815	Benville and Korn 1977
Dungeness crab (1st zoea), *Cancer magister*	F, U	o	30	6,000	-	-	Caldwell et al. 1977
Dungeness crab (1st zoea), *Cancer magister*	F, U	m	30	12,000	-	8,500	Caldwell et al. 1977
Striped bass (juvenile), *Morone saxatilis*	S, M	o (>99%)	25	9,700	-	-	Benville and Korn 1977

Table 1. (continued)

Species	Method[a]	Chemical[b]	Salinity (g/Kg)	LC50 or EC50 (µg/L)	Adjusted LC50 or EC50 (µg/L)[c]	Species Mean Acute Value (µg/L)	References
Striped bass (juvenile), *Morone saxatilis*	S, M	m (>99%)	25	8,000	-	-	Benville and Korn 1977
Striped bass (juvenile), *Morone saxatilis*	S, M	p (>99%)	25	1,700	-	5,090	Benville and Korn 1977

[a] S = Static; F = Flow-through; M = Measured; M_o = measured only at 0-hr, U = Unmeasured.
[b] m = meta-xylene; o = ortho-xylene; p = para-xylene; x = mixed isomers; percent purity is listed in parentheses when available.
[c] Static unmeasured and static 0-hr measured data were adjusted by dividing by a factor of 2.525.

Table 2. Ranked Genus Mean Acute Values with Species Mean Acute-Chronic Ratios

Rank[a]	Genus Mean Acute Value (µg/L)	Species	Species Mean Acute Value (µg/L)[b]	Species Mean Acute-Chronic Ratio
13	154,300	Pacific oyster, *Crassostrea gigas*	154,300	-
12	> 22,400	Snail, *Aplexa hyporum*	> 22,400	-
11	16,510	Goldfish, *Carassius auratus*	16,510	-
10	16,100	White sucker, *Catostomus commersoni*	16,100	-
9	15,900	Bluegill, *Lepomis macrochirus*	15,900	-
8	13,750	Guppy, *Poecilia reticulata*	13,750	-
7	11,950	Fathead minnow, *Pimephales promelas*	11,950	-
6	8,500	Dungeness crab, *Cancer magister*	8,500	-
5	8,050	Rainbow trout, *Salmo gairdneri*	8,050	-

Table 2. (continued)

Rank[a]	Genus Mean Acute Value (µg/L)	Species	Species Mean Acute Value (µg/L)[b]	Species Mean Acute-Chronic Ratio
4	5,090	Striped bass, *Morone saxatilis*	5,090	-
3	3,820	Cladoceran, *Daphnia magna*	3,820	-
2	2,900	Grass shrimp *Palaemonetes pugio*	2,900	-
1	1,815	Bay shrimp, *Crangon franciscorum*	1,815	

[a] Ranked from most resistant to most sensitive based on Genus Mean Acute Value

[b] From Table 1.

Advisory Acute Value = (1,815 µg/L)/ 3.4 = 533.8 µg/L.

Advisory Acute-Chronic Ratio = 25

Advisory Concentration = (533.8 µg/L)/ 25 = 21 µg/L

Table 3. Other Data on Effects of Xylene on Aquatic Organisms

FRESHWATER SPECIES

Species	Chemical[a]	Hardness (mg/L as $CaCO_3$)	Duration	Effect	Concentration (µg/L)	Reference
Bacterium, *Pseudomonas putida*	-	-	16 hr	Incipient inhibition of cell replication	> 200,000	Bringmann 1973; Bringmann and Kuhn 1977b
Blue-green alga, *Anacystis aeruginosa*	-	-	8 days	Incipient inhibition of cell replication	> 200,000	Bringmann and Kuhn 1978a,b
Green alga, *Chlamydomonas angulosa*	p	-	3 hr	EC50 (photosynthesis)	46,000	Hutchinson et al 1979, 1980
Green alga, *Chlorella vulgaris*	o	-	24 hr	EC50 (cell replication)	55,000	Kauss and Hutchinson 1975
Green alga, *Chlorella vulgaris*	o	-	10 days	Reduced survival	171,000	Kauss et al. 1972, 1973
Green alga, *Chlorella vulgaris*	p	-	3 hr	EC50 (photosynthesis)	105,000	Hutchinson et al. 1979, 1980

Table 3. (continued)

Species	Chemical[a]	Hardness (mg/L as $CaCO_3$)	Duration	Effect	Concentration (µg/L)	Reference
Green alga, *Scenedesmus quadricauda*	-	-	8 days	Incipient inhibition of cell replication	> 200,000	Bringmann and Kuhn 1977b, 1978a,b
Protozoan, *Entosiphon sulcatum*	-	-	72 hr	Incipient inhibition of cell replication	> 160,000	Bringmann 1978; Bringmann and Kuhn 1981
Protozoan, *Chilomonas paramaecium*	-	-	48 hr	Incipient inhibition of cell replication	> 80,000	Bringmann and Kuhn 1981, Bringmann et al. 1980
Protozoan, *Uronema parduczi*	-	-	20 hr	Incipient inhibition of cell replication	> 160,000	Bringmann and Kuhn 1980, 1981
Protozoan, *Colpidium colpoda*	m	-	18 hr	Incipient inhibition of survival	162,000	Rogerson et al 1983
Protozoan, *Tetrahymena elliotti*	o	-	≥24 hr	Incipient inhibition of survival	18,500	Rogerson et al 1983

Table 3. (continued)

Species	Chemical[a]	Hardness (mg/L as $CaCO_3$)	Duration	Effect	Concentration (µg/L)	Reference
Protozoan, *Tetrahymena elliotti*	m	-	≥24 hr	Incipient inhibition of survival	55,700	Rogerson et al. 1983
Protozoan, *Tetrahymena elliotti*	p	-	≥24 hr	Incipient inhibition of survival	16,900	Rogerson et al. 1983
Cladoceran (24 hr), *Daphnia magna*	-	-	24 hr	EC50 (immobilization)	150,000	Bringmann and Kuhn 1977a
Cladoceran, *Daphnia magna*	-	-	24 hr	LC50	> 100,000 and < 1,000,000	Dowden and Bennett 1965
Coho salmon (juvenile), *Oncorhynchus kisutch*	o	-	1 hr	EC50 (avoidance)	680	Maynard and Weber 1981
Rainbow trout, *Salmo gairdneri*	-	180	24 hr	Increased respiration	2,000	Slooff 1979
Rainbow trout (embryo), *Salmo gairdneri*	m	96.0	23 days (to hatch)	EC50 (death and deformity)	5,950	Black et al. 1982

Table 3. (continued)

Species	Chemical[a]	Hardness (mg/L as $CaCO_3$)	Duration	Effect	Concentration (µg/L)	Reference
Rainbow trout (embryo/larva), *Salmo gairdneri*	m	96.0	27 days (4 days post-hatch)	EC50 (death and deformity)	3,770	Black et al. 1982
Goldfish (6.2 cm), *Carassius auratus*	o	-	24 hr	LC50	13,000	Bridie et al. 1979
Goldfish (6.2 cm), *Carassius auratus*	m	-	24 hr	LC50	16,000	Bridie et al. 1979
Goldfish (6.2 cm), *Carassius auratus*	p	-	24 hr	LC50	18,000	Bridie et al. 1979
Guppy (2-3 mo), *Poecilia reticulata*	o	25	7 days	LC50	35,100	Konemann 1979, 1981

Table 3. (continued)

Species	Chemical[a]	Hardness (mg/L as $CaCO_3$)	Duration	Effect	Concentration (µg/L)	Reference
Guppy (2-3 mo), *Poecilia reticulata*	m	25	14 days	LC50	37,700	Konemann 1979, 1981
Guppy (2-3 mo), *Poecilia reticulata*	p	25	7 days	LC50	35,100	Konemann 1979, 1981
Leopard frog (embryo), *Rana pipiens*	m	105.4	5 days (to hatch)	EC50 (death and deformity)	4,060	Black et al. 1982
Leopard frog (embryo/larva), *Rana pipiens*	m	105.4	9 days (4 days post-hatch)	EC50 (death and deformity)	3,530	Black et al 1982

Table 3. (continued)

SALTWATER SPECIES

Species	Chemical[a]	Salinity (g/Kg)	Duration	Effect	Concentration (µg/L)	Reference
Dino-flagellate, *Amphidinium carterae*	x	-	2-3 days	Growth inhibition	>10,000	Dunstan et al. 1975
Barnacle (nauplii), *Balanus amphitrite*	-	30	1 hr	EC50 (mobility)	19,500	Donahue et al 1977; Winters et al. 1977
Coho salmon (5-40 g), *Oncorhynchus kisutch*	-	30	24 hr	Lethality	100,000	Morrow et al 1975

[a] m = meta-xylene; o = ortho-xylene; p = para-xylene; x = mixed isomers.

SECTION IV. REFERENCES

Bailey, H.C., D.H.W. Liu and H.A. Javitz. 1985. Time/toxicity relationships in short-term static, dynamic, and plug-flow bioassays. In: Bahner, R.C. and D.J. Hansen (Eds.). Aquatic Toxicology and Hazard Assessment: Eighth Symposium ASTM STP 891. American Society for Testing and Materials, Philadelphia, PA. pp. 193-212.

Benville, P.E., Jr., and S. Korn. 1977. The acute toxicity of six monocyclic aromatic crude oil components to striped bass (Morone saxatilis)and bay shrimp (Crago franciscorum). Calif. Fish and Game 63:204-209.

Black, J.A., W.J. Birge, W.E. McDonnell, A.G. Westerman, B.A. Ramey and D.M. Bruser. 1982. The aquatic toxicity of organic compounds to embryo-larval stages of fish and amphibians. PB82-224601. National Technical Information Service, Springfield, VA.

Brenniman, G., R. Hartung and W.J. Weber, Jr. 1976. A continuous flow bioassay method to evaluate the effects of outboard motor exhausts and selected aromatic toxicants on fish. Water Res. 10:165-169.

Bridie, A.L., C.J.M. Wolff and M. Winter. 1979. The acute toxicity of some petrochemicals to goldfish. Water Res. 13:623-626.

Bringmann, G. 1973. Determination of the biological damage from water pollutants from the inhibition of glucose assimilation in the bacterium Psedomonas fluorescens. Gesund.-Ing. 94:366-369.

Bringmann, G. 1978. Studies on the biological effects of waterborne pollutants in protozoans, I. Bacteriophagus flagellates (model organisms: Entosiphon sulcatum stein). Z. Wasser Abwasser Forsch. 11:210-215.

Bringmann, G. and R. Kuhn. 1977a. Results of the damaging effect of water pollutants on Daphnia magna. Z. Wasser Abwasser Forsch. 10:161-166.

Bringmann, G. and R. Kuhn. 1977b. Limiting values for the damaging action of water pollutants to bacteria (Pseudomonas putida) and green algae (Scenedesmus quadricauda) in the cell multiplication inhibition test. Z. Wasser Abwasser Forsch. 10:87-98.

Bringmann, G. and R. Kuhn. 1978a. Limiting values for the noxious effects of water pollutant material to blue algae (Microcystis aeruginosa) and green algae (Scenedesmus quadricauda) in cell propagation inhibition tests. Vom Wasser 50:45-60.

Bringmann, G. and R. Kuhn. 1978b. Testing of substances for their toxicity threshold: Model organisms Microcystis (Diplocystis) aeruginosa and Scenedesmus quadricauda. Mitt. Int. Ver. Theor. Angew. Limnol. 21:275-284.

Bringmann, G. and R. Kuhn. 1980. Determination of the biological effect of water pollutants on protozoa. II. Bacteriovorous ciliates. Z. Wasser Abwasser Forsch. 13:26-31.

Bringmann, G. and R. Kuhn. 1981. Comparison of the effects of harmful substances on flagellates as well as ciliates and a holozoic bacteriophagus and saprozoic protozoan. Gas-Wasserfach, Wasser-Abwasser 122:308-313.

Bringmann, G., R. Kuhn and A. Winter. 1980. Determination of the biological effect of water pollutants in protozoa. III. Saprozoic flagellates. Z. Wasser Abwasser Forsch. 13:170-173.

Brooke, L.T. 1987. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI. (Memorandum to L.J. Larson, Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI. August 31).

Caldwell, R.S., E.M. Caldarone and M.H. Mallon. 1977. Effects of a seawater-soluble fraction of Cook Inlet crude oil and its major aromatic components on larval stages of the Dungeness crab (Cancer magister Dana). In: Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms. Wolfe, D.A. (Ed.). Pergamon Press, New York, NY. pp. 210-220.

Cope, O.B. 1965. Sport Fishery Investigations. U.S. Fish and Wildlife Service Circular 226:51-63.

Donahue, W.H., R.T. Wang, M. Welch and J.A.C. Nicol. 1977. Effects of water-soluble components of petroleum oils and aromatic hydrocarbons on barnacle larvae. Environ. Pollut. 13:187-202.

Dowden, B.F. and H.J. Bennett. 1965. Toxicity of selected chemicals to certain animals. J. Water Pollut. Control Fed. 37:1308-1316.

Dunstan, W.M., L.P. Atkinson and J. Natoli. 1975. Stimulation and inhibition of phytoplankton growth by low molecular weight hydrocarbons. Mar. Biol.(Berl.) 31:305-310.

Geiger, D.L., S.H. Poirier, L.T. Brooke and D.J. Call (Eds.). 1986. Acute toxicity of organic chemicals to fathead minnows (Pimephales promelas). Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, Superior, WI.

Hermens, J., H. Canton, P. Janssen and R. DeJong. 1984. Quantitative structure-activity relationships and toxicity studies of mixtures of chemicals with anaesthetic potency: Acute lethal and sublethal toxicity to Daphnia magna. Aquat. Toxicol. 5:143-154.

Holcombe, G.W., G.L. Phipps, A.H. Sulaiman and A.D. Hoffman. manuscript. Simultaneous/multiple species testing: Acute toxicity of 13 chemicals to 12 diverse freshwater families. U.S. Environmental Protection Agency, Environmental Research Laboratory-Duluth, Duluth, MN.

Hutchinson, T.C., J.A. Hellebust, D. Mackay, D. Tam and P. Kauss. 1979. Relationship of hydrocarbon solubility to toxicity in algae and cellular membrane effects. J. Am. Petrol. Inst. 4308:541-547.

Hutchinson, T.C., J.A. Hellebust, D. Tam, D. Mckay, R.A. Mascarenhas and W.Y. Shiu. 1980. The correlation of the toxicity to algae of hydrocarbons and halogenated hydrocarbons with their physical-chemical properties. Environ. Sci. Res. 16:577-586.

Johnson, W.W. and M.T. Finley. 1980. Handbook of acute toxicity of chemicals to fish and aquatic invertebrates. Resource Publication 137. U.S. Fish and Wildlife Service, Washington, DC.

Kauss, P.B. and T.C. Hutchinson. 1975. The effects of water-soluble petroleum components on the growth of Chlorella vulgaris Beijerinck. Environ. Pollut. 9:157-174.

Kauss, P.B., T.C. Hutchinson and M. Griffiths. 1972. Field and laboratory studies of the effects of crude oil spills on phytoplankton. In: Proceedings 18th annual technical meeting on environmental progress in science and education. Institute of Environmental Sciences, Mt. Prospect, IL. pp. 22-26.

Kauss, P., T.C. Hutchinson, C. Soto, J. Hellebust and M. Griffiths. 1973. The toxicity of crude oil and its components to freshwater algae. In: Proceedings of joint conference on prevention and control of oil spills. American Petroleum Institute, Washington, DC. pp. 703-714.

Konemann, W.H. 1979. Quantitative structure-activity relationships in fish toxicity studies. Part 1: A relationship for 50 industrial pollutants. In: Quantitative structure-activity relationships for kinetics and toxicity of aquatic pollutants and their mixtures in fish. Konemann, W.H. (Ed.). University of Utrecht, Utrecht, The Netherlands. pp. 33-45.

Konemann, H. 1981. Quantitative structure-activity relationships in fish toxicity studies. Part 1: Relationships for 50 industrial pollutants. Toxicology 19:209-221.

Legore, R.S. 1974. The effect of Alaskan crude oil and selected hydrocarbon compounds on embryonic development of the Pacific oyster, Crassostrea gigas. Ph.D. thesis, University of Washington, Seattle, WA. Available from: University Microfilms, Ann Arbor, MI. Order No. 74-29,447.

Mattson, V.R., J.W. Arthur and C.T. Walbridge. 1976. Acute toxicity of selected organic compounds to fathead minnows. EPA-600/3-76-097. National Technical Information Service, Springfield, VA.

Mayer, F.L., Jr. and M.R. Ellersieck. 1986. Manual of acute toxicity: Interpretation and data base for 410 chemicals and 66 species of freshwater animals. Resource Publ. No. 160. U.S. Fish and Wildlife Service, Washington, DC.

Maynard, D.J. and D.D. Weber. 1981. Avoidance reactions of juvenile coho salmon (Onchorhynchus kisutch) to monocyclic aromatics. Can. J. Fish. Aquat. Sci. 38:772-778.

Morrow, J.E., R.L. Gritz and M.P. Kirton. 1975. Effects of some components of crude oil on young coho salmon. Copeia 2:326-331.

Pickering, Q.H. and C. Henderson. 1966. Acute toxicity of some important petrochemicals to fish. J. Water Pollut. Control Fed. 38:1419-1429.

Rogerson, A., W.Y. Shiu, G.L. Huang, D. Mackay and J. Berger. 1983. Determination and interpretation of hydrocarbon toxicity to ciliate protozoa. Aquat. Toxicol. 3:215-228.

Slooff, W. 1979. Detection limits of a biological monitoring system based on fish respiration. Bull. Environ. Contam. Toxicol. 23:517-523.

Stephan, C.E., D.I. Mount, D.J. Hansen, J.H. Gentile, G.A. Chapman and W.A. Brungs. 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses. PB85-227049. National Technical Information Service, Springfield, VA.

Stephan, C.E., G.A. Chapman, D.J. Hansen and T.W. Purcell. 1986. Guidelines for deriving ambient aquatic life advisory concentrations. December 2 draft. U.S. Environmental Protection Agency, Environmental Research Laboratory, Duluth, MN.

Tatem, H.E., B.A. Cox and J.W. Anderson. 1978. The toxicity of oils and petroleum hydrocarbons to estuarine crustaceans. Estuarine Coastal Mar. Sci. 6:365-373.

Walsh, D.F., J.G. Armstrong, T.R. Bartley, H.A. Salman and P.A. Frank. 1977. Residues of emulsified xylene in aquatic weed control and their impact on rainbow trout Salmo gairdneri. PB267270 or REC-ERC-76-11. National Technical Information Service, Springfield, VA.

Winters, K., C. Van Baalen and J.A.C. Nicol. 1977. Water soluble extractives from petroleum oils: Chemical characterization and effects on microalgae and marine animals. Rapp. P.V. Reun. Cons. Int. Explor. Mer. 171:166-174.

SECTION V. EPA CONTACTS

AQUATIC LIFE ADVISORIES

For further information regarding the aquatic life and fish and water exposure advisories contact:

________________________________	FTS 382-7144	(202)382-7144
________________________________	FTS 475-7315	(202)475-7315