Appendix E

Summary of Literature-Derived Fish Tissue Toxicity Data for the Baseline Ecological Risk Assessment

Halaco Superfund Site, Oxnard, California

Remedial Investigation

Prepared for

U.S. Environmental Protection Agency Region 9

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Acronyms and Abbreviations

BERA	baseline ecological risk assessment
ERED	Environmental Residue Effects Database
LOEC	lowest observed effect concentration
NOEC	no observed effect concentration
TRV	toxicity reference value

APPENDIX E

Summary of Literature-Derived Fish Tissue Toxicity Data

E.1 Objectives

Whole-body fish tissue benchmarks were developed for metals and dioxins and furans, as available data supported. Studies that reported tissue levels in whole fish associated with no and lowest adverse effects to survival, reproduction, or growth were identified from a search of electronic databases and reference sources, including the following:

- Environmental Residue-Effects Database (ERED) (U.S. Army Corps of Engineers, 2003)
- ECOTOX Database (U.S. Environmental Protection Agency, 2003)
- Jarvinen and Ankley (1999), a compilation of tissue residue no observed effects concentrations (NOECs) and lowest observed effects concentrations (LOECs)
- Scientific literature searches through search engines such as BIOSIS and Science Direct

Tissue effects data were available for aluminum, antimony, arsenic, cadmium, copper, lead, mercury, selenium, silver, vanadium, zinc, and dioxin and furans. These data are presented in Tables E-1 through E-12.

For each analyte with toxicity data, the study reporting the lowest of the LOECs was first evaluated to determine if the study was acceptable. If that study was considered to be acceptable, the LOEC was selected as the baseline ecological risk assessment (BERA) LOEC. If that study was not considered to be acceptable, the study reporting the next lowest LOEC was evaluated and so forth, until the lowest LOEC reported from an acceptable study was selected. The acceptability of fish toxicity studies was determined through best professional judgment, taking into account the following:

- What is the ecological relevance of the exposure duration? Chronic studies measuring exposure for 30 days or longer were preferred. Application of an acute-to-chronic uncertainty factor of 10 was not required for the metals and dioxin and furan data.
- Did the measured endpoint in the study directly measure the growth, survival, or reproductive success of the test organism? Behavioral studies were considered in the toxicity reference value (TRV) selection process; however, behaviors that did not result in an adverse effect on growth, survival, or reproductive success were not preferred.

Following the selection of the lowest acceptable LOEC, a NOEC was selected. The NOEC was selected either from (1) the same study in which the selected LOEC was reported, or (2) another study evaluating the same endpoint as the selected LOEC (growth, survival, reproduction, or behavior).

A NOEC was selected from a different study if no NOEC was reported in the study reporting the selected provisional LOEC or if a higher NOEC that was less than the selected LOEC was reported in a similar study that measured the same endpoint as the selected LOEC. For example, if two NOECs were reported based on rainbow trout growth over similar test durations, the higher of the two NOECs was selected. The acceptability of a study was evaluated if the NOEC was selected from another study.

If no LOEC was reported in the reviewed studies (only NOECs were reported), the highest NOEC was selected as the BERA NOEC and no LOEC was selected. This is the case for silver. The highlighted studies in Tables E-1 through E-12 were selected as representative NOEC and LOEC values for use in the BERA. A summary of the selected studies is shown in Table E-13.

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Tables

TABLE E-1

Whole-body Fish Tissue Toxicity Data for Aluminum

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	Chemical	Test Species	Scientific Name	Lifestage	Test Conditions	Exposure Route	Exposure Concentration	Units	Duration	Units	Tissue	Tissue Concentration (wet weight)	Units	Effect	Effect2	Reference	Comments
Al	Aluminum chloride	Atlantic Salmon	*Salmo salar*	Alevin, newly hatched	Lab; renewal, 1d	Water	181-1809	mg/l	43	days	Whole Body	36.8	mg/g	survival	reduced	Peterson et al. 1989	Residues in dead fish
Al	Aluminum chloride	Atlantic Salmon	*Salmo salar*	Alevin, newly hatched	Lab; renewal, 1d	Water	181-1809	mg/l	43	days	Whole Body	1	mg/g	survival	none	Peterson et al. 1989	Residues in surviving fish
Al	Aluminum chloride	Atlantic Salmon	*Salmo salar*	Alevin, newly hatched	Lab; renewal, 1d	Water	67.5-240.3	mg/l	30	days	Whole Body	20	mg/g	survival	reduced	Peterson et al. 1989	Residues in dead fish
Al	Aluminum chloride	Atlantic Salmon	*Salmo salar*	Alevin, newly hatched	Lab; renewal, 1d	Water	67.5-240.3	mg/l	30	days	Whole Body	<8	mg/g	survival	reduced <20%	Peterson et al. 1989	Residues in surviving fish
Al	Aluminum chloride	Atlantic Salmon	*Salmo salar*	Alevin, newly hatched	Lab; renewal, 1d	Water	67.5-240.3	mg/l	30	days	Whole Body	<8	mg/g	growth	none	Peterson et al. 1989	

Notes:

Shaded rows represent the benchmarks selected for use in the risk assessment.

All information presented in this table was extracted from Jarvinen and Ankley, 1999.

µg/L = micrograms per liter

µg/g = micrograms per gram

TABLE E-2

Whole-body Fish Tissue Toxicity Data for Antimony

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	Chemical	Test Species	Scientific Name	Lifestage	Organism Weight (g)	Test Conditions	Exposure Route	Exposure Concentration	Units	Duration	Units	Tissue	Tissue Concentration (wet weight)	Units	Effect	Effect2	Reference	Comments
Sb	Antimony potassium tartrate	Rainbow Trout	*Oncorhynchus mykiss*	Fingerling	1.2	Lab; renewal, 3-4d	Water	16	mg/l	30	d	Whole Body	9	mg/g	survival	reduced 50%	Doe et al. 1987	Residues in surviving fish
Sb	Antimony potassium tartrate	Rainbow Trout	*Oncorhynchus mykiss*	Fingerling	1.2	Lab; renewal, 3-4d	Water	8	mg/l	30	d	Whole Body	5	mg/g	survival	none	Doe et al. 1987	

Notes:

Shaded rows represent the benchmarks selected for use in the risk assessment.

All information presented in this table was extracted from Jarvinen and Ankley, 1999.

mg/L = milligrams per liter

µg/g = micrograms per gram

TABLE E-3

Whole-body Fish Tissue Toxicity Data for Arsenic

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Arsenic		0.62[a]	mg/kg	Cockell and Hilton 1988	growth	rainbow trout	fry	food	8 wks	body weight	arsenic trioxide	significant effect on growth at LOEC in fish fed 180 ug/g As; feed refusal accompanied effects; study also looked at organic As (arsenic acid and dimethylarsenic acid) there were no significant effects on growth from either compound at test concentrations; organic arsenics are less toxic and more easily excreted.
Arsenic		1.38[a]	mg/kg	Cockell and Hilton 1988	growth	rainbow trout	fry	food	8 wks	body weight	disodium arsenate	significant effect on growth at LOEC in fish fed 137 ug/g As; feed refusal accompanied effects. Study also looked at organic As (arsenic acid and dimethylarsenic acid) there were no significant effects on growth from either compound at test concentrations. Organic arsenics are less toxic and more easily excreted.
Arsenic	1.5	2.0	mg/kg	McGeachy and Dixon 1990	growth	rainbow trout	fingerling	aqueous	11 wks	body weight (ww and dw)	arsenate	at 15 degrees C, reduced growth significant after 28 days; tissue-residue LOEC at 28 days in fish exposed to 18 mg/L; NOEC is highest tissue residue in fish exposed to 9 mg/L (at 63 days); NOECs and LOECs estimated from figure
Arsenic		2.32[a]	mg/kg	Gilderhus 1966	mortality & growth	bluegills	adult	aqueous	16 wks	% survival, length and body weight	herbicide containing 40% sodium arsenite by weight	poor controls- high mortality in controls; 31% survival at LOEC; 60% survival at control- low survival in controls; growth controls was less than all treated groups (poor controls); no stats; survival in other test groups >50%
Arsenic		2.34[a]	mg/kg	Gilderhus 1966	mortality & growth	bluegills	immature	aqueous	16 wks	% survival, length and body weight	herbicide containing 40% sodium arsenite by weight	no clear dose-response in tissue; 18% survival at LOEC; 90% survival at control; next highest dose with high survival- lower doses with lower survival- no clear dose response
Arsenic	3.0		mg/kg	Dixon and Sprague 1981	growth	rainbow trout	juvenile	aqueous	21 days (+ pre-exposure)	growth	arsenic	aqueous concentrations were 0, 6.2, 8.6, 12, 16.6, and 23.1 mg/L. Resulting tissue conc of pre-exposed fish ranged from 0.4 - 4.7 ug/g ww an average of fish exposed at all concentrations; NOEC is at 21 days arsenic concentration was higher at 7 days (4.7 ug/g ww); looks like there is a tolerance from pre-exposure to As
Arsenic	2.03	5.36	mg/kg	McGeachy and Dixon 1990	mortality	rainbow trout	fingerling	aqueous	11 wks		arsenate	at 5 degrees C, mortality significant "by 2 weeks"; overall mortality after 11 weeks was 25-31%; LOEC is mean tissue residue of fish that died during the experiment; NOEC is the tissue residues in surviving fish;
Arsenic	1.5	2.5	mg/kg	McGeachy and Dixon 1990	growth	rainbow trout	fingerling	aqueous	11 wks	body weight (ww and dw)	arsenate	at 5 degrees C, reduced growth significant after 28 days; tissue-residue LOEC at 28 days in fish exposed to 36 mg/L; NOEC is highest tissue residue in fish exposed to 18 mg/L; NOECs and LOECs estimated from figure
Arsenic		8.1	mg/kg	McGeachy and Dixon 1992	behavior	rainbow trout		aqueous	up to 34 hours	loss of equilibrium	arsenate	LOEC is lowest residue reported where equilibrium loss was reported. NOTE: discussion states that toxicants can act at different sites during acute vs chronic exposure, thus the "threshold" conc can be expected to differ depending on the exposure mode (and the exposure time).
Arsenic		33.4	mg/kg	Sorensen 1976	mortality	green sunfish		aqueous	up to 380 hours (16 days)		sodium arsenate	poorly reported results; 100% mortality was reported; no mortality reported in control and no discussion on when mortality becomes significant in treated groups with tissues ranging from 33.4 - 581.6 ug/g; 100% mortality at all treatment levels at the end of experiment (16 day exposure)

Notes:

[a] Whole body tissue concentrations were converted to wet weight assuming 80% moisture in the organism.

Shaded rows represent the benchmarks selected for use in the risk assessment.

mg/kg = milligram per kilogram

WB = whole body

ww = wet weight

TABLE E-4

Whole-body Fish Tissue Toxicity Data for Cadmium

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Cadmium	0.06	0.25	mg/kg	Handy 1992	mortality	rainbow trout		aqueous	8 hours, with 72 hrs recovery	mortality		at NOEC- 0/7 fish died; no discussion of stats; tissue residues back calculated from data reported in paper; short term exposure. WB conc from 6 hrs into the 8 hr exposure; toxicant conc changes throughout the exposure (2 hrs of increasing conc, 4 hrs of plateau, and 2 hours of decreasing conc)
Cadmium	0.25		mg/kg	Kumada et al. 1980	mortality, growth	Rainbow trout	fingerling, 7.8 g	aqueous	10 wks		cadmium stearate, cadmium acetate, cadmium chloride	no effect on growth or survival; NOEC is highest tissue concentration measured in fish exposed to various forms of aqueous Cd (over 20 wks), WATER EXPOSURE: conc in organs = highest in Kidney, then liver then gills, then GI tract
Cadmium	0.13[a]	0.252[a]	mg/kg	Benoit et al. 1976	growth	brook trout	F3, 12 wk old juvenile	aqueous	multigenerational	mean juvenile bw	cadmium	tissue residues reported only in F3 generation; LOEC at 3.4 ug/L; NOEC at fish exposed to 1.7 ug/L; only effects reported in F3 generation was considered because tissue residues were only measured in this generation
Cadmium		0.51	mg/kg	Pascoe and Mattey 1977	mortality	3-spined stickleback	adult	aqueous	79 days	>/= 80% mortality	cadmium chloride	at least 80% mortality was observed in fish exposed to 0.001 ug/L cadmium chloride; lowest dose tested
Cadmium	0.52		mg/kg	Cope et al. 1994	growth, mortality	bluegills	juvenile	aqueous	28 days		cadmium chloride	no treatment related mortality and no significant (p<0.15) effect on growth
Cadmium	0.59		mg/kg	Kumada et al. 1980	mortality, growth	Rainbow trout	fingerling, 11.7 g	food	12 wks		cadmium stearate, cadmium acetate, cadmium chloride	no effect on growth or survival; NOEC is highest tissue concentration measured in fish fed various forms of Cd (over 20 wks). DIET EXPOSURE: conc in organs = highest in GI tract, then Kidney, then liver, then gills (ONLY 0.5 to 5.45% OF THE CADMIUM IN THE FOOD WAS ACCUMULATED IN THE FISH BODIES)
Cadmium		0.7[a]	mg/kg	Pascoe et al. 1986	mortality	rainbow trout	fingerling	aqueous	29 days	mortality	cadmium chloride	30% mort after 140 hrs (Hard water, 280 mg CaCO3/L) unbounded LOEC as significant morts at all treatment concs
Cadmium		0.8[a]	mg/kg	Hatakeyama and Yasuno 1987	growth	guppy	2 months	aqueous	12 months	body weight	cadmium chloride	female growth was impaired at 10 ug/L after 360 days; in males bw loss was recovered; LOEC is male WB conc at 10 ug/L; female and male WB-conc "did not differ significantly"; LOEC is estimated from figure; no stats; sample size low for this study & no replication methods unclear
Cadmium		0.92[a]	mg/kg	Rehwoldt 1976	reproduction	Zebrafish	adult males	diet	6 months (effects observed at 2 months)	reduced number of offspring		significantly reduced number offspring after 6 months of fish food diet with 10 ppm Cd; (# offspring was down by 60% by month 2, LOEC conc is from month 2) males with lower tissue residues; female residues @ 12.9 ug/g dw by month 6; not clear if reduced no. of offspring was result of reduced no. of eggs or reduced viability of eggs; no replicates, only one concentration that induced effects, thus unbounded LOEC
Cadmium	1[a]		mg/kg	Hatakeyama and Yasuno 1982	growth	guppy		food	10 days	growth	cadmium	fed exposed *Monia macrocopa,* significant growth effect at day 10 (in fish exposed to 10 ug/L) effect disappeared at day 20; tissue residues estimated from figure; poor dose-response results- bw was recovered;
Cadmium	1.33		mg/kg	Cope et al. 1994	growth, mortality	bluegills	juvenile	aqueous	28 days		cadmium chloride	no treatment related mortality and no significant (p<0.15) effect on growth
Cadmium	1.366[a]		mg/kg	Mount et al. 1994	mortality, growth	Rainbow trout	fry	combined food and aqueous	60 days	100% survival, body weight, length	cadmium	1.1 ppb Cd and some other metals in water in addition to dietary exposure; only no-effect reported; fish exposed to live prey; lower residue concentration (6.83 ug/g dw) reported after 60d of exposure
Cadmium	1.484[a]		mg/kg	Mount et al. 1994	mortality, growth	Rainbow trout	fry	combined food and aqueous	60 days	100% survival, body weight, length	cadmium	1.1 ppb Cd and some other metals in water in addition to dietary exposure; only no-effect reported; fish exposed to live prey; lower residue concentration (6.83 ug/g dw) reported after 60d of exposure, see below
Cadmium	2.5[a]	4.24[a]	mg/kg	Shazili 1995	mortality	seabass	20d old (transition from larvae to juvenile)	aqueous (saltwater, 20 ppm)	16 days	mortality	cadmium	no stats- @ LOEC-10% mortality; @ NOEC- 0% mortality; @ higher exposure with residues of 41.4 ug/g dw- 50% mortality. At lower salinities (5ppm, for seabass 4 months old) there were significant mortalities at all treatment levels NOEC = 0.1 (no WB conc given); relatively short-term exposure (16 days) unknown how fish would acclimatize
Cadmium	5.6[a]	8.3[a]	mg/kg	Middaugh et al. 1975	mortality	spot	larval	aqueous	200 hrs (8 days)	mortality	cadmium	(SEAWATER) 50% mortality at LOEC (LC50); 0% mortality at NOEC; no stats, field collected fish (with controls); unknown background concentrations in field collected fish
Cadmium		0.96[a]	mg/kg	Pascoe et al. 1986	mortality	rainbow trout	fingerling	aqueous	29 days	mortality	cadmium chloride	90% mort after 140 hrs (Soft water, 70 mg CaCO3/L) unbounded LOEC as significant mortality at all treatment concs

TABLE E-4

Whole-body Fish Tissue Toxicity Data for Cadmium

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Cadmium		1.92[a]	mg/kg	Rehwoldt 1976	reproduction	Zebrafish	adult females	diet	6 months	reduced number of offspring		significantly reduced number offspring after 6 months of fish food diet with 10 ppm Cd; (# offspring was down by 60% by month 2, LOEC conc is from month 2) males with lower tissue residues; female residues @ 12.9 ug/g dw by month 6; not clear if reduced no. of offspring was result of reduced no. of eggs or reduced viability of eggs; no replicates, only one concentration that induced effects, thus unbounded LOEC
Cadmium		2[a]	mg/kg	Hatakeyama and Yasuno 1987	reproduction	guppy	2 months	aqueous	12 months	# fry produced	cadmium chloride	fed exposed Chironomus yoshimatsui (midge larvae); cumulative number of fry decreased to 70-80% of the control in fish exposed to 10 to 20 ug/L at 7 months; no discussion of stats; LOEC is estimated using figure of MALE tissue which is uncertain for evaluating reproductive effects; however, female and male WB-conc "did not differ significantly"; study is not replicable
Cadmium		5.4[a]	mg/kg	Hatakeyama and Yasuno 1987	reproduction	guppy	2 months	diet	200 days	# fry produced	cadmium chloride	fed exposed Chironomus yoshimatsui (midge larvae); cumulative number of fry decreased to around 60% of the control in fish exposed to 80 and 160 ug/L after 200 days; no discussion of stats; unclear of the reproductive effects at lower levels; LOEC is estimated using figure of MALE tissue. Unbounded LOEC, effects at all treatment levels; LOEC is estimated using figure of MALE tissue which is uncertain for evaluating reproductive effects; however, female and male WB-conc "did not differ significantly"; study is not replicable
Cadmium		9.4[a]	mg/kg	Hatakeyama and Yasuno 1987	growth	guppy	2 months	diet	200 days	body weight	cadmium chloride	assumed that growth was significantly impaired at all doses (not specified in reference) after 70 days; in males bw gain was recovered; LOEC is male WB conc at lowest dose (2.5 ug/L); female and male WB-conc "did not differ significantly"; LOEC is estimated from figure; sample size low for this study & no replication methods unclear
Cadmium		28.8[a]	mg/kg	Hamilton et al. 1987	mortality	brook trout	2-3 mos old; 5g	aqueous	30 days	20% mortality	cadmium chloride	significant mortality (20%) at LOEC (fish exposure to 3.6 ug/L) compared to control (2%); NOEC is the residue for the control = 35 ug/g; high background concentrations

Notes:

[a] Whole body tissue concentrations were converted to wet weight assuming 80% moisture in the organism.

Shaded rows represent the benchmarks selected for use in the risk assessment.

mg/kg = milligram per kilogram

WB = whole body

ww = wet weight

TABLE E-5

Whole-body Fish Tissue Toxicity Data for Copper

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Copper		1.04	mg/kg	Handy 1992	mortality	rainbow trout	adult	aqueous	8 hrs with 72 hours recovery			at LOEC- 4/7 fish died; no discussion of stats; 40% of fish died at higher dose- unbounded LOEC; tissue residues back calculated from data reported in paper; short term exposure. 1 of 4 morts was during exposure, the other 3 where 2,6, and 24 hrs post-exposure. NO morts in control
Copper	1.17[b]	1.71[b]	mg/kg	Marr et al. 1996	growth	Rainbow trout	fry	aqueous	60 days	body weight, length	copper	significant depressed bw and body length @ 20 days in fish exposed to 4.6 ug/L (LOEC is lowest tissue concentration associated with sig growth effect); LOEC and NOEC are based on WB tissue conc after 60 days, not when effects were first noticed (this is more representative of a chronic field exposure); no effect on growth until 4.6 ug/L exp conc (2nd highest exposure concentration), then next conc did have greater effect on growth. Cu accumulation in tissue was positively correlated with exp conc and time of exposure
Copper	3.92[b]	4.48[b]	mg/kg	Mount et al. 1994	mortality	Rainbow trout	fry	combined food and aqueous	60 days	69% and 95% surv @ LOEC & NOEC	copper	12 ppb Cu and some other metals in water in addition to dietary exposure; fish fed live Artemia; mortality was likely due to elevated copper concentrations in the water
Copper	11.5[b]		mg/kg	Mount et al. 1994	growth	Rainbow trout	fry	combined food and aqueous	60 days	body weight, length	copper	12 ppb Cu and some other metals in water in addition to dietary exposure; only no-effect level concentration reported; fish fed live Artemia; lower residue concentration (27.7 ug/g dw) reported after 60d of exposure; NOEC at 30d exposure

Notes:

[a] Whole body tissue concentrations were converted to wet weight assuming 80% moisture in the organism.

Shaded rows represent the benchmarks selected for use in the risk assessment.

mg/kg = milligram per kilogram

WB = whole body

ww = wet weight

TABLE E-6

Whole-body Fish Tissue Toxicity Data for Lead

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Lead	2.0[b]		mg/kg	Mount et al. 1994	mortality, growth	Rainbow trout	fry	combined food and aqueous	60 days	100% survival, body weight, length	lead	3.2 ppb Pb and some other metals in water in addition to dietary exposure; only no-effect reported; fish exposed to live prey; lower residue concentration (10 ug/g dw) reported after 60d of exposure; NOEC at 30d exposure
Lead	2.58[b]		mg/kg	Mount et al. 1994	mortality, growth	Rainbow trout	fry	combined food and aqueous	60 days	100% survival, body weight, length	lead	3.2 ppb Pb and some other metals in water in addition to dietary exposure; only no-effect reported; fish exposed to live prey; lower residue concentration (10 ug/g dw) reported after 60d of exposure; NOEC at 30d exposure
Lead	4.02[b]		mg/kg	Holcombe et al. 1976	mortality	brook trout	egg - 12 wks (3rd gen)	aqueous	3 generations / 3 years		lead	significant decreases in alevin-juvenile survival for F-2 at 474 ug Pb/L - exposure. No fish survived from F-2 to spawn at 474 or 235 ug Pb/L - exposure, thus 3rd generation was only exposed to 3 treatment concentrations (119, 58, 34 ug Pb/L). No WB residues measured in F1 or F2; no mortality in F3 fish
Lead	2.54[b]	4.02[b]	mg/kg	Holcombe et al. 1976	growth	brook trout	egg - 12 wks (3rd gen)	aqueous	3 generations / 3 years	body weight	lead	LOEC- bw signif decreased in 12-wk old fish (F3) @ 119 ug/L; There were birth defects (scoliosis of the spine) at 119 ug Pb/L for F-2 (same concentration as caused growth effects in F-3). no WB residues measured in F1 or F2.

Notes:

[a] Whole body tissue concentrations were converted to wet weight assuming 80% moisture in the organism.

Shaded rows represent the benchmarks selected for use in the risk assessment.

mg/kg = milligram per kilogram

WB = whole body

ww = wet weight

TABLE E-7

Whole-body Fish Tissue Toxicity Data for Mercury

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Mercury	0.2		mg/kg	Kudo and Mortimer 1979	mortality	Guppy	male adult	sediment and water	20 days		mercuric chloride	only no-effect level reported
Mercury		0.254	mg/kg	Friedmann et al. 1996	growth	Walleye	juvenile	food	6 months	male growth	methylmercury	fish fed 1.0 mg/kg mercury in diet consisting of catfish fillets injected with methylmercury 3X per week; LOEC is WB concentration minus viscera; no significant effect on mortality observed; no replication, elevated control mortality (28%), growth effect not dose responsive (increased growth and body weight in fish fed 0.1 mg/kg mercury in diet
Mercury	0.2	0.47	mg/kg	Matta et al. 2001	mortality	Mummichog		water	42 days		methyl-mercuric chloride	wild male fish
Mercury	0.8	1.31	mg/kg	Snarski and Olson 1982	growth	Fathead minnow	3 mos	food	60 days		mercuric chloride	
Mercury	2.28		mg/kg	Phillips and Buhler 1978	growth	Rainbow trout	fingerling	water	24 days		methyl-mercuric chloride	only no-effect level reported
Mercury		2.83	mg/kg	Hammerschmidt et al. 2002	reproduction	Fathead minnow	juvenile and adult	food	multi-generation	spawning success	methylmercury	spawning success at LOEC - 46%; 75% in control; no stats; LOEC is average male residue; ave female residue = 3.4 mg/kg dw; converted to ww assuming 80% moisture in whole fish
Mercury	2.75	4.18	mg/kg	Snarski and Olson 1982	mortality	Fathead minnow	3 month old	water	60 days		mercuric chloride	
Mercury	2.84	4.47	mg/kg	Snarski and Olson 1982	reproduction	Fathead minnow	larvae-adult	water	287 days		mercuric chloride	
Mercury		5.6	mg/kg	Heisinger et al. 1979	mortality	Goldfish	4.5-6.5 cm	water	2 days		mercuric chloride	Concentration converted from dry weight to wet weight assuming 80% moisture in whole fish
Mercury	5		mg/kg	Lock 1975	growth, mortality	Rainbow trout	juvenile	water	84 days		methyl-mercury	only no-effect level reported
Mercury	5.67		mg/kg	Phillips and Buhler 1978	growth	Rainbow trout	fingerling	water	24 days		methyl-mercuric chloride	only no-effect level reported
Mercury		6.5	mg/kg	Cember et al. 1978	mortality	Bluegill	juvenile	water	12.5 days		methyl-mercuric chloride	
Mercury	8.63		mg/kg	Phillips and Buhler 1978	growth	Rainbow trout	fingerling	water	24 days		methyl-mercuric chloride	brook trout= 9.4 (NOEC); rainbow trout more closely related to Chinook; only no-effect level reported
Mercury	3.4	9.4	mg/kg	McKim et al. 1976	reproduction	Brook trout	embryo – adult	water	756 days	reduced egg hatch and juvenile weight	methyl-mercury	Residue measured in parental fish at 39 weeks.
Mercury	9.4		mg/kg	McKim et al. 1976	growth, mortality	Brook trout	39 wks old	water	756 days	reduced juvenile weight		residues measured in parental fish at 39 wks; only no-effect level reported
Mercury		10	mg/kg	Rodgers and Beamish 1982	growth	Rainbow trout	fingerling		84 days	reduced growth	methyl-mercury	hatchling fish; reduced growth assoc with feeding; approximated from graph
Mercury	10.9		mg/kg	Olson et al. 1975	growth, mortality, behavior	Fathead minnow	larvae-adult	water	336 days		methyl-mercury	only no-effect level reported
Mercury	1.1	11	mg/kg	Matta et al. 2001	reproduction	Mummichog		food	42 days	F1 fertilization success	methyl-mercuric chloride	Residue measured in parental fish
Mercury	12		mg/kg	Niimi and Lowe-Jinde 1984	growth, mortality	Rainbow trout	sub-adult	water	75 days	body weight	methyl-mercuric chloride	only no-effect level reported
Mercury	12		mg/kg	Matta et al. 2001	reproduction	Mummichog		food	42 days	F1 hatchability, survival, fecundity, F2 larval survival	methyl-mercuric chloride	Residue measured in female parental fish; only no-effect level reported
Mercury	12		mg/kg	Matta et al. 2001	reproduction	Mummichog		food	42 days	fecundity, fertilization success, offspring weight, female survival	methyl-mercuric chloride	Offspring of medium and high doses were larger than offspring of control fish; only no-effect level reported; Residue measured in female parental fish;
Mercury	29		mg/kg	Rodgers and Beamish 1982	mortality	Rainbow trout	fingerling		84 days			only no-effect level reported

Notes:

Shaded rows represent the benchmarks selected for use in the risk assessment.

mg/kg = milligram per kilogram

WB = whole body

ww = wet weight

TABLE E-8

Whole-body Fish Tissue Toxicity Data for Selenium

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Selenium	0.6[a]	0.68[a]	mg/kg	Cleveland et al. 1993	mortality	bluegill	juvenile, 5 mos, 0.3 g	aqueous	60 days	20% mortality at LOEC (signif)	Sodium selenate and Sodium selenite	LOEC- mortality significant at 30d in fish exposed to 0.34 ug/L (mortality not significant at 60d); NOEC- no sig mort at 30d in fish exposed to 0.17 ug/L; tissue concentration estimated from figure
Selenium	0.54[a]	0.8[a]	mg/kg	Hamilton et al. 1990	growth	chinook salmon (FW)	swim up	food	90 days	body weight	SLD (high [Se] mosquitofish)	LOEC- growth affects @ 5.3 ppm; NOEC- no effect @ 3.2 ppm; residue at 90 days; FW fish. Length effects too but weight more so.
Selenium	0.64[a]	0.84[a]	mg/kg	Cleveland et al. 1993	mortality	bluegill	juvenile, 3 mos, 0.2 g	food	60 and 90 days	23% mortality at LOEC (signif)	Sodium selenate and Sodium selenite	LOEC-significant mort at 60d in fish fed 6.5 ppm; NOEC- no sig mort at 60d in fish fed 3.3 ppm; tissue concentration estimated from figure
Selenium	0.52[a]	1.08[a]	mg/kg	Hamilton et al. 1990	mortality	chinook salmon (FW)	swim up	food	90 days		SeMet (low [Se] mosquitofish and fortified seleno-DL-methiomine diet)	LOEC- growth affects @ 9.6 ppm; NOEC- no effect @ 5.3 ppm; residue at 90 days; FW fish
Selenium	1.0[a]	1.09[a]	mg/kg	Ogle and Knight 1989	growth	Fathead minnow	adult	food	98 days + spawnings	body weight	selenium	no clear dose-response in tissue- @ 15 ppm tissue residues up to 5.7 ug/g; decreased palatability observed, food aversion likely played a role in depressed growth; LOEC tissue conc at 56 day (@ 20 ppm) where signif depressed growth was observed; NOEC- @ 56 days (15 ppm) where no sig effect on growth
Selenium	0.8[a]	1.3[a]	mg/kg	Hamilton et al. 1990	mortality	chinook salmon (FW)	swim up	food	90 days		SLD (high [Se] mosquitofish)	LOEC- growth affects @ 9.6 ppm; NOEC- no effect @ 5.3 ppm; residue at 90 days; FW fish
Selenium	0.94[a]	1.52[a]	mg/kg	Cleveland et al. 1993	growth	bluegill	juvenile, 3 mos, 0.2 g	food	90 days	condition factor (body weight, length)	Sodium selenate and Sodium selenite	LOEC-significant change in body condition factor at 90d in fish fed 13 ppm; NOEC- no sig change in condition at 90d in fish exposed to 6.5 ppm; tissue concentration estimated from figure
Selenium	0.72[a]	1.6[a]	mg/kg	Hamilton et al. 1990	growth	chinook salmon	fingerlings	food	120 days	body weight	SLD (high [Se] mosquitofish)	LOEC- growth affects @ 9.6 ppm; NOEC- no effect @ 5.3 ppm; residue at 120 days; brackish water fish
Selenium	1.2[a]	1.6[a]	mg/kg	Lemly 1993	mortality, growth	bluegill	juvenile	combined food and aqueous	180 days	30% mortality at 120 days, 33.8% mort at 180 days; body condition factor (bw/length)	Sodium selenate	5.16 ug/g dw in diet and 4.83 ug/L in water; both cold water and warm water test; significant effects observed only in cold water group (compared with cold water control); LOEC is tissue-residue estimated based on graph (same residue at 120 and 180 days). Looked at effects of lower temp and lower photoperiod (winter) on SE sensitivity
Selenium	1.61[a]		mg/kg	Ogle and Knight 1989	reproduction	Fathead minnow	adult	food	98 days + spawnings	# spawns, # eggs, % hatch, % offspring survival after 14d	selenium	lack of effect on reproduction may involve reduced selenium bioaccumulation relative to other fish groups (i.e. fathead minnows may be less sensitive); LOEC is highest tissue conc measured over 98 days (pre-spawning)
Selenium	1.08[a]	2.16[a]	mg/kg	Hamilton et al. 1990	growth	chinook salmon (FW)	swim up	food	90 days	body weight	SeMet (low [Se] mosquitofish and fortified seleno-DL-methiomine diet)	LOEC- growth affects @ 18.2 ppm; NOEC- no effect @ 9.6 ppm; residue at 90 days; FW fish. Length effects too but weight more so.
Selenium	1.94[a]	2.94[a]	mg/kg	Cleveland et al. 1993	growth	bluegill	juvenile, 5 mos, 0.3 g	aqueous	90 days	condition factor (body weight, length)	Sodium selenate and Sodium selenite	LOEC-significant change in body condition factor at 30d in fish exposed to 2.7 ug/L; NOEC- no sig change in condition at 60d in fish exposed to 1.4 ug/L; tissue concentration estimated from figure
Selenium	3.1		mg/kg	Lemly 1982	mortality	largemouth bass	juvenile	aqueous	120 days		selenium	no effect on fish exposed to 10 ug/L; max tissue residue over 120 days (@ 120d)
Selenium	2[a]	3.76[a]	mg/kg	Coyle et al. 1993	reproduction	bluegill	adult, 2 yrs old	aqueous and food	140 days + spawning	decreased larval survival	selenium	LOEC- fry survival= 7%; fry survival at NOEC and control 75-90%. I think this is DW based on the values.. But the methods make it sound like WW?
Selenium	3.76[a]		mg/kg	Coyle et al. 1993	mortality, growth	bluegill	adult, 2 yrs old	aqueous and food	140 days + spawning	body weight & length	selenium	growth and mortality not significantly diff from control. I think this is DW based on the values.. But the methods make it sound like WW?
Selenium		4.6	mg/kg	Hermanutz et al. 1992	mortality, growth, and reproduction	bluegills	adult	aqueous and food	365 days	depressed growth, mortality, progeny survival	Sodium Selenite	LOEC- sig mort and depressed growth in fish exposed to 10 ug/L; residues after 365 days. At 10 and 30 ug/L (4.6 mg/kg ww) there were significant effects on reproduction (embryo hatch, larval survival, lordosis, edema, internal hemorrhage)
Selenium	2.52[a]	4.64[a]	mg/kg	Hamilton et al. 1990	growth	chinook salmon	fingerlings	food	120 days	body weight	SeMet (low [Se] mosquitofish and fortified seleno-DL-methiomine diet)	LOEC- growth affects @ 35.4 ppm; NOEC- no effect @ 18.2 ppm; residue at 120 days; brackish water fish
Selenium	4.64[a]		mg/kg	Hamilton et al. 1990	mortality	chinook salmon	fingerlings	food	120 days		SeMet (low [Se] mosquitofish and fortified seleno-DL-methiomine diet)	no effect on mortality @ 35.4 ppm; residue at 120 days; brackish water fish

TABLE E-8

Whole-body Fish Tissue Toxicity Data for Selenium

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Selenium	4.8		mg/kg	Lemly 1982	mortality	bluegill	juvenile	aqueous	120 days		selenium	no effect on fish exposed to 10 ug/L; max tissue residue over 120 days (@ 90d) (4.7 at 120 days)
Selenium	5.76[a]		mg/kg	Hamilton et al. 1990	mortality	chinook salmon	fingerlings	food	120 days		SLD (high [Se] mosquitofish)	no effect on mortality @ 35.4 ppm; residue at 120 days; brackish water fish
Selenium		12.2[a]	mg/kg	Dobbs et al. 1996	growth	fathead minnow	larval, 24 hrs	aqueous	25 days	depressed growth	selenium	significantly depressed growth at 106.8 ug/L, and unbounded LOEC = 100 ug/L (resulting in 61 ug/g dw) was the lowest exposure; not recommended- possible food chain effects--prey items (rotifers) experienced high mortality- affected diet of fish

Notes:

[a] Whole body tissue concentrations were converted to wet weight assuming 80% moisture in the organism.

Shaded rows represent the benchmarks selected for use in the risk assessment.

mg/kg = milligram per kilogram

WB = whole body

ww = wet weight

TABLE E-9

Whole-body Fish Tissue Toxicity Data for Silver

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Silver	0.06[a]		mg/kg	Coleman and Cearley 1974	mortality, growth	bluegill	young of the year	aqueous	6 months	body weight	silver	no effect on mortality or growth. Bass were also tested and experienced significant mortality at highest conc, but no WB residues measured (only organs). Reached equilibrium at 2 months.

Notes:

[a] Whole body tissue concentrations were converted to wet weight assuming 80% moisture in the organism.

Shaded rows represent the benchmarks selected for use in the risk assessment.

mg/kg = milligram per kilogram

WB = whole body

ww = wet weight

TABLE E-10

Whole-body Fish Tissue Toxicity Data for Vanadium

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	Chemical	Test Species	Scientific Name	Lifestage	Test Conditions	Exposure Route	Exposure Concentration	Units	Duration	Units	Tissue	Tissue Concentration (wet weight)	Units	Effect	Effect2	Reference*	Comments
V	Vanadium pentoxide	Flagfish	*Jordanella floridae*	Larvae-1st generation	Lab; flow-through	Water	1.5	mg/l	28	days	Whole Body	3.12	µg/g	survival	reduced 73%	208, 209	
V	Vanadium pentoxide	Flagfish	*Jordanella floridae*	Larvae-1st generation	Lab; flow-through	Water	0.48	mg/l	28	days	Whole Body	2.4	µg/g	survival	none	208, 209	
V	Vanadium pentoxide	Flagfish	*Jordanella floridae*	Adult	Lab; flow-through	Water	1.5	mg/l	96	days	Whole Body	5.74	µg/g	survival	none	208, 209	
V	Vanadium pentoxide	Flagfish	*Jordanella floridae*	Adult	Lab; flow-through	Water	1.5	mg/l	96	days	Whole Body	5.74	µg/g	growth	none	208, 209	
V	Vanadium pentoxide	Flagfish	*Jordanella floridae*	Adult	Lab; flow-through	Water	1.5	mg/l	96	days	Whole Body	5.74	µg/g	reproduction	none	208, 209	
V	Vanadium pentoxide	Flagfish	*Jordanella floridae*	Larvae	Lab; flow-through	Adult fish + water	1.5	mg/l	30	days	Whole Body	3.12	µg/g	survival	reduced 60%	208, 209	Second generation fish
V	Vanadium pentoxide	Flagfish	*Jordanella floridae*	Larvae	Lab; flow-through	Adult fish + water	0.17	mg/l	30	days	Whole Body	2.22	µg/g	growth	reduced	208, 209	Second generation fish
V	Vanadium pentoxide	Flagfish	*Jordanella floridae*	Larvae	Lab; flow-through	Adult fish + water	0.04	mg/l	30	days	Whole Body	0.57	µg/g	reproduction	none	208, 209	Second generation fish

Notes:

Shaded rows represent the benchmarks selected for use in the risk assessment.

All information presented in this table was extracted from Jarvinen and Ankley, 1999.

*For reference, see Jarvinen and Ankley, 1999.

mg/L = milligrams per liter

µg/g = micrograms per gram

TABLE E-11

Whole-body Fish Tissue Toxicity Data for Zinc

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
Zinc	59		mg/kg	Farmer et al. 1979	mortality, growth	Atlantic salmon	juvenile	aqueous	80 days		zinc	fish offered two percentages of rations (2 and 3.5% dry bw; NOEC higher in 2% ration group, in 3.5% ration group residues were 57 ug/g ww; tissue residues are estimated from figure
Zinc	78.4[a]		mg/kg	Mount et al. 1994	mortality, growth	Rainbow trout	fry	combined food and aqueous	30 and 60 days	100% survival, body weight, length	zinc	50 ppb Zn and some other metals in water in addition to dietary exposure; only no-effect reported; fish exposed to live prey; lower residue concentration (303 ug/g dw) reported after 60d of exposure; NOEC at 30d exposure
Zinc	41.4[a]	88.8[a]	mg/kg	Pierson 1981	reproduction	guppies	fry, 5 day old	aqueous	134 days	onset of sexual maturity	zinc	NOEC (207) is the control value effect on sexual maturity was significant at LOEC at fish exposed to 0.166 mg/L after 134 d; no effect on in fish exposed to <0.050 mg/L (NOEC); endpoint is not a direct measure of reproductive success; no effect on percentage of females to reproduce at LOEC exp conc
Zinc		297[a]	mg/kg	Pierson 1981	growth	guppies	fry, 5 day old	aqueous	135 days	female body weight	zinc	values not significantly diff from control according to paper stats, however they were 60% of the control value; LOEC is an average female WB conc for fish exposed to 0.605 + 0.609 mg/L zinc in water

Notes:

[a] Whole body tissue concentrations were converted to wet weight assuming 80% moisture in the organism.

Shaded rows represent the benchmarks selected for use in the risk assessment.

mg/kg = milligram per kilogram

WB = whole body

ww = wet weight

TABLE E-12

Whole-body Fish Tissue Toxicity Data for Dioxin/Furans

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

Analyte	NOEC (WB)	LOEC (WB)	Units (ww)	Source	Endpoint	Test Species	Lifestage	Exposure Mode	Exposure Duration	Endpoint Effect	Chemical Form	Notes
2,3,7,8-TCDD	46	85	pg/g	Fisk et al. 1997	growth	Lake Whitefish	juvenile	food	30 days	body weight		exposed for 30 days and effect measured for 180 days post-exposure; unclear when residues measured; assumed WB residues (with liver conc); 29% mortality in control
2,3,7,8-TCDD	72	150	pg/g	Fisk et al. 1997	growth	Rainbow trout	juvenile	food	30 days	body weight		exposed for 30 days and effect measured for 180 days post-exposure; unclear when residues measured; assumed WB residues (with liver conc)
2,3,7,8-TCDD		780	pg/g	Branson et al. 1985	growth	Rainbow trout	10-15cm	water	2 & 6 hr	body weight		no stats; LOEC presented is based on tissue resides measured 28d after end of exp- LOEC is misleading; higher LOEC should be used (max WB for dose, WB at end of exp, etc); tissue burdens assoc with same dose but measured earlier in exp were higher
2,3,7,8-TCDD		980	pg/g	Mehrle et al. 1988	mortality	Rainbow trout	fry	water	~28 days			LOEC is based on tissue residue measured at the end of the exposure period
2,3,7,8-TCDD		990	pg/g	Mehrle et al. 1988	growth	Rainbow trout	fry	water	~28 days			
2,3,7,8-TCDD	1,486		pg/g	Tietge et al. 1998	survival, growth, gonadal development, egg production	Brook trout	adult	food	182 days			NOEC is initial concentration in female fish exposed to 1,200 pg TCDD/g-food; Giesy et al. (2002) report adverse effects in rainbow trout at similar exposure levels after 250 days of exposure
2,3,7,8-TCDD	125	2,170	pg/g	Miller et al. 1979	growth	Coho salmon	juvenile	water	96 hr			body burdens measured after 114 days in clean water following exposure, thus not conservative
2,3,7,8-TCDD	125	2,170	pg/g	Miller et al. 1979	mortality	Coho salmon	juvenile	water	96 hr			body burdens measured after 114 days in clean water following exposure
2,3,7,8-TCDD		2,410	pg/g	Schmieder et al. 1995	growth	Medaka	juvenile	water	12 days	body weight		no stats; growth increased 74% vs 94% in control
2,3,7,8-TCDD		69,000	pg/g	Adams et al. 1986	mortality	Fathead minnow	juvenile	water	28 day			no stats- 100% mort; LOEC is ave concentration in dead fish
2,3,7,8-TCDD	1,570	1,380,000	pg/g	Hawkes and Norris 1977	mortality	Rainbow trout	young	food	105 days			
2,3,7,8-TCDD	1,570	1,380,000	pg/g	Hawkes and Norris 1977	growth	Rainbow trout	young	food	105 days	body weight		

Notes:

Shaded rows represent the benchmarks selected for use in the risk assessment.

pg/g = picogram per gram

WB = whole body

ww = wet weight

TABLE E-13

Literature-based Fish Tissue Benchmarks (wet weight)

Baseline Ecological Risk Assessment, Halaco Site, Oxnard, California

			NOEC			LOEC			
Analyte	**Form**	**Units**	**NOEC**	**Test Species**	**Test Endpoint**	**LOEC**	**Test Species**	**Effect**	**Source**
Aluminum	Aluminum chloride	mg/kg	1	Atlantic salmon	Survival	8	Atlantic salmon	20% reduction in survival	Peterson et al. 1989
Antimony	Antimony potassium tartrate	mg/kg	5	Rainbow trout	Survival	9	Rainbow trout	50% reduction in survival	Doe et al. 1987
Arsenic	Sodium arsenate	mg/kg	1.5	Rainbow trout	Growth	2	Rainbow trout	significantly lowered body weight	McGeachy and Dixon 1990
Cadmium		mg/kg	0.13[a]	Brook trout	Growth	0.252[a]	Brook trout	significantly lowered mean body weight in juveniles	Benoit et al. 1976
Copper		mg/kg	1.17[a]	Rainbow trout	Growth	1.71[a]	Rainbow trout	significant decrease in body weight and length	Marr et al. 1996
Lead		mg/kg	2.54[a]	Brook trout	Growth	4.02[a]	Brook trout	significantly lowered body weight	Holcombe et al. 1976
Mercury	Methyl-mercuric chloride	mg/kg	0.2	Mummichog	Survival	0.47	Mummichog	Survival	Matta et al. 2001
Selenium	Sodium selenate and Sodium selenite	mg/kg	0.6[a]	Bluegill	Survival	0.68[a]	Bluegill	20% reduction in survival	Cleveland et al. 1993
Silver		mg/kg	0.06[a]	Bluegill	Survival, growth	--	--	--	Coleman and Clearley 1974
Vanadium	Vanadium pentoxide	mg/kg	0.57	Flagfish	Reproduction	2.22	Flagfish	Reduced growth	Jarvinen and Ankley 1999*
Zinc		mg/kg	41.4[a]	Guppies	Reproduction	88.8[a]	Guppies	Delayed onset of sexual maturity	Pierson 1981
2,3,7,8-TCDD		ng/kg	72	Rainbow trout	Growth	150	Rainbow trout	significantly lowered body weight	Fisk et al. 1997

Notes:

*For reference, please see Jarvinen and Ankley (1999) paper.

-- = no data available

LOEC = lowest observed effect concentration

NOEC = no observed effect concentration