Attachment 5 All Acceptable Decapod Studies for Chemicals of Interest for Crab

Analyte	Test Species	Marine or Fresh-water	Tissue Type	NOAEL	LOAEL	Unit	Exposure Duration	Exposure Route	Endpoint	Source	Notes
Metals and Trace Elements											
Arsenic	grass shrimp	marine	whole body	1.28	na	mg/kg ww	28 days	water	growth	Lindsay and Sanders (1990)	accumulation test where no mortality observed (not a toxicity test)
Arsenic	grass shrimp	marine	whole body	1.15	na	mg/kg ww	28 days	water	growth	Lindsay and Sanders (1990)	accumulation test where no mortality observed (not a toxicity test)
Cadmium	red swamp crayfish	fresh-water	not measured–injection study	0.5	na	mg/kg ww	21 days	single injection	reproduction	Reddy et al. (1997)	no significant effect on ovarian maturation was observed; NOAEL is injected dose (whole body tissues were not measured)
Cadmium	grass shrimp	marine	whole body	0.6	na	mg/kg ww	14 days	exposed sediment	mortality	Rule and Alden (1996)	NOAEL estimated assuming 80% moisture in organism; no significant mortalities observed in accumulation study where shrimp were exposed to cadmium only (up to 5 mg/kg in sediment); estimated from figure
Cadmium	grass shrimp	marine	whole body	na	2.6	mg/kg ww	21 days	water	mortality	Vernberg et al. (1977)	at LOAEL – approximately 20% increase in mortality after 7 days at 5 ppt salinity; no statistics; little increase in mortality after day 7; only one cadmium exposure dose at varying salinities.
Cadmium	shore crab	marine	muscle	4.9	9.5	mg/kg ww	40 days	1 and 10 ppm in water for 40 days	survival	Jennings and Rainbow (1979)	measured in muscle; NOAEL based on 1 ppm exposure; LOAEL based on 10 ppm exposure. Concentrations lowest in five tissue types (midgut gland, gills, muscle tissue, remaining tissue
Cadmium	adult Norway lobster	marine	hepato-pancreas	5.7	na	mg/kg ww	50 days	13 mg/kg ww in diet	survival	Canli and Furness (1995)	measured in hepatopancreas; no mortality
Cadmium	adult Norway lobster	marine	gills	2.7	na	mg/kg ww	50 days	13 mg/kg ww in diet	survival	Canli and Furness (1995)	measured in gills; no mortality

Analyte	Test Species	Marine or Fresh-water	Tissue Type	NOAEL	LOAEL	Unit	Exposure Duration	Exposure Route	Endpoint	Source	Notes
Cadmium	adult Norway lobster	marine	tail muscle	0.13	na	mg/kg ww	50 days	13 mg/kg ww in diet	survival	Canli and Furness (1995)	measured in tail muscle; no mortality
Cadmium	adult Norway lobster	marine	hepato-pancreas	46	na	mg/kg ww	30 days	100 µg/L in water	survival	Canli and Furness (1995)	measured in hepatopancreas; no mortality
Cadmium	adult Norway lobster	marine	gills	32	na	mg/kg ww	30 days	100 µg/L in water	survival	Canli and Furness (1995)	measured in gills; no mortality
Cadmium	adult Norway lobster	marine	tail muscle	0.58	na	mg/kg ww	30 days	100 µg/L in water	survival	Canli and Furness (1995)	measured in tail muscle; no mortality
Cadmium	crustaceans	fresh-water	whole body	na	3.5-10.3	mg/kg ww	22 days	water	prenatal mortality	Marshall (1978) in Dillon (1984)	reduced longevity and increased prenatal mortality
Cadmium	crayfish		whole body	14.9	22	mg/kg ww	5 months	water	mortality	Thorp et al. (1979)	significant increase in mortality at LOAEL; water contaminated with 10 µg/L cadmium; no effect on growth at LOAEL; NOAEL is whole-body concentration where no significant mortality was observed where crayfish were exposed to 5 µg/L cadmium in water
Cadmium	crayfish	fresh-water	whole body	na	28.4	mg/kg ww	2 weeks	water	mortality	Mirenda (1986b)	at LOAEL – 25% mortality after 2 weeks in lowest dose group
Cadmium	crayfish	fresh-water	whole body	534	na	mg/kg ww	approx. 8 days	water	mortality	Gillespie et al. (1977)	no significant difference in mortality (1/15 died) in crayfish exposed to 1 ppm cadmium in water; NOAEL is average tissue concentration
Chromium	juvenile (2nd instar) sand crab	marine	whole body	1	3.2	mg/kg ww	30 days	0.1 and 0.3 mg/L in water	growth	Mortimer and Miller (1994)	NOAEL and LOAEL values read of Figure 2. Paper provide equations that would slightly lower LOAEL (2.67) and increase NOAEL (1.2)

Analyte	Test Species	Marine or Fresh-water	Tissue Type	NOAEL	LOAEL	Unit	Exposure Duration	Exposure Route	Endpoint	Source	Notes
Copper	grass shrimp	marine	whole body	40	na	mg/kg ww	14 days	exposed sediment	mortality	Rule et al. (1996)	NOAEL estimated assuming 80% moisture in organism; no significant mortalities observed in accumulation study where shrimp were exposed to copper only (up to 25 mg/kg in sediment); estimated from figure (a little less than 200 mg/kg); relationship of copper uptake to body burden was weak
Copper	crayfish	fresh-water	whole body	50	na	mg/kg ww	48 hours	water	mortality	Evans (1980)	accumulation test where no mortality was observed (not a toxicity test); NOAEL estimated from study assuming 80% moisture in organism
Copper	crayfish	fresh-water	thorax and abdomen	34	na	mg/kg ww	48 hours	water	mortality	Evans (1980)	accumulation test where no mortality was observed (not a toxicity test); NOAEL estimated from study assuming 80% moisture in organism
Mercury	red swamp crayfish	fresh-water	not measured - injection study	na	0.5	mg/kg ww	21 days	single injection	reproduction	Reddy et al. (1997)	ovarian maturation was significantly reduced at LOAEL; LOAEL is injected dose (whole body tissues were not measured); reduced ovarian maturation may cause a reduction in egg laying
Mercury	adult male shore crab	fresh and salt water	hepato-pancreas	na	1	mg/kg ww	32 hours	1 mg/L in water	survival	Bianchini and Gilles (1996)	concentration is lowest of three crab species tested (*Carcinus maenas, Eriocheir sinensis*, and *Cancer pagurus*)
Mercury	adult Norway lobster	marine	hepato-pancreas	0.99	na	mg/kg ww	50 days	164 mg/kg ww in diet	survival	Canli and Furness (1995)	measured in hepatopancreas; no mortality
Mercury	Adult Norway lobster	marine	gills	0.77	na	mg/kg ww	50 days	164 mg/kg ww in diet	survival	Canli and Furness (1995)	measured in gills; no mortality
Mercury	adult Norway lobster	marine	tail muscle	0.23	na	mg/kg ww	50 days	164 mg/kg ww in diet	survival	Canli and Furness (1995)	measured in tail muscle; no mortality

Analyte	Test Species	Marine or Fresh-water	Tissue Type	NOAEL	LOAEL	Unit	Exposure Duration	Exposure Route	Endpoint	Source	Notes
Mercury	adult Norway lobster	marine	hepato-pancreas	1.43	na	mg/kg ww	30 days	10 µg/L in water	survival	Canli and Furness (1995)	measured in hepatopancreas; no mortality
Mercury	adult Norway lobster	marine	gills	46.5	na	mg/kg ww	30 days	10 µg/L in water	survival	Canli and Furness (1995)	measured in gills; no mortality
Mercury	adult Norway lobster	marine	tail muscle	0.34	na	mg/kg ww	30 days	10 µg/L in water	survival	Canli and Furness (1995)	measured in tail muscle; no mortality
Vanadium	shrimp	marine	whole body	0.6	na	mg/kg ww	21 days	100 µg/L in water	mortality	Miramand et al. (1981)	no mortality observed
Zinc	crayfish	fresh-water	whole body	12.7	35.2	mg/kg ww	2 weeks	water	mortality	Mirenda (1986a)	at LOAEL = 23% mortality; at NOAEL = 6% mortality; NOAEL and LOAEL estimated from study assuming 80% moisture in organism. Other tissue types analyzed in the study: gills, abdominal muscle, carapace, and intestine.
Zinc	crayfish	fresh-water	hepato-pancreas	42.5	85.6	mg/kg ww	2 weeks	water	mortality	Mirenda (1986a)	at LOAEL = 23% mortality; at NOAEL = 6% mortality; NOAEL and LOAEL estimated from study assuming 80% moisture in organism. Other tissue types analyzed in the study: gills, abdominal muscle, carapace, and intestine.

Analyte	Test Species	Marine or Fresh-water	Tissue Type	NOAEL	LOAEL	Unit	Exposure Duration	Exposure Route	Endpoint	Source	Notes
SVOCs											
1,4-dichloro-benzene	sand crab	marine	whole body	na	1,600	µg/kg ww	90 hours	concentration range 0.1-10 ppm in water	mortality	Mortimer and Connell (1994)	values derived from Fig.3. Read tissue conc. as 1/16 of 100, 4/16 of 100, and 14/16 of 100 = 6.3, 25, and 87.5 mmol/kg lipid. 1,4-dichlorobenzene = 147 g/mol, which then gives 926, 3675, and 12,863 mg/kg lipid. Assume 0.9% lipid and 80% moisture, which gives: 1.6 mg/kg ww, 6.6 mg/kg ww, and 23 mg/kg ww. ERED from the same paper comes up with four values: 5.88, 14.7, 33.8, and 85.27 mg/kg for LC100 – does not state ww or dw.
1,4-dichloro-benzene	sand crab	marine	whole body	na	6,600	µg/kg ww	60 hours	concentration range 0.1-10 ppm in water	mortality	Mortimer and Connell (1994)	
1,4-dichloro-benzene	sand crab	marine	whole body	na	23,000	µg/kg ww	40 hours	concentration range 0.1-10 ppm in water	mortality	Mortimer and Connell (1994)	
Naphthalene	spot shrimp	marine	whole body	na	50	µg/kg ww	24 hours	concentration range 8-12 ppb in water	mortality	Sanborn and Malins (1977)	LOAEL read of Fig. 1. Bovine serum albumin was added to the seawater without telling why
Phthalates											
1,2-di-2-ethylhexyl phthalate	penaied shrimp	marine	whole body	18,300	na	µg/kg ww	14 days	diet	mortality	Hobson et al (1984)	no mortality at the highest exposure concentration
Phthalates	crustaceans	fresh-water	whole body	320-26,800	na	µg/kg ww	21 days	water	reproduction	Brown and Thompson (1982) s cited in Dillon (1984)	no effects on reproduction after one-generation exposure
PCBs											
PCBs (Aroclor 1254)	crayfish	fresh-water	whole body	1,220	na	µg/kg ww	21 days	water	mortality	Sanders and Chandler (1972)	NOAEL based on dose given for 21 days in biomagnification study; based on magnification factor and water concentration with no effects data; NOAEL concentration reported in study = 6.1 mg/kg dw
PCBs (Aroclor 1254)	pink shrimp	marine	whole body	1,300	3,900	µg/kg ww	48 hours	water	mortality	Duke et al. (1970)	100% mortality at LOAEL; 0% mortality at NOAEL; no control was reported

Analyte	Test Species	Marine or Fresh-water	Tissue Type	NOAEL	LOAEL	Unit	Exposure Duration	Exposure Route	Endpoint	Source	Notes
PCBs (Aroclor 1254)	pink shrimp	marine	whole body	na	16,000	µg/kg ww	20 days	water	mortality	Duke et al. (1970)	72% mortality at LOAEL (0% mortality in control); LOAEL is average concentration in dead shrimp, average concentration is higher in surviving shrimp subject to same dose-33 ppm
PCBs (Aroclor 1254)	blue crab	marine	whole body	23,000	na	µg/kg ww	20 days	water	mortality	Duke et al. (1970)	equal mortality in control and dose group (5 µg/L) – 1/20 crabs died; NOAEL is average of 5 crabs (range of 18 to 27 ppm)
PCBs (Aroclor 1254)	grass shrimp	marine	whole body	18,000	27,000	µg/kg ww	16 days	water	mortality	Nimmo et al. (1974)	45% mortality at LOAEL – significantly higher than control group (25% mortality); NOAEL is 40% mortality, which paper states is not significantly higher than control ($p < 0.05$)
PCBs (Aroclor 1016)	grass shrimp	marine	whole body	na	1,100	µg/kg ww	96 hours	water	mortality	Hansen et al. (1974)	33% mortality at LOAEL; control is next lowest dose with 8% mortality; no statistics; shrimp collected at Gulf Breeze lab
PCBs (Aroclor 1016)	brown shrimp	marine	whole body	3,800	42,000	µg/kg ww	96 hours	water	mortality	Hansen et al. (1974)	43% mortality at LOAEL; 8% mortality at NOAEL; 0% mortality in control; no statistics
Organochlorine Pesticides											
Chlordane	pink shrimp	marine	whole body	710	1,700	µg/kg ww	96 hours	water	mortality	Parrish et al (1976)	10% mortality at NOAEL 55% mortality at LOAEL (two replicates no statistics on mortality)
Chlordane	grass shrimp	marine	whole body	4,500	9,100	µg/kg ww	96 hours	water	mortality	Parrish et al (1976)	15% mortality at NOAEL 45% mortality at LOAEL (two reps no stats on mortality). Tissue concentration lower at NOAEL than at a lower concentration with 0 mortality (tissue concentration 4.8 µg/g ww)
DDTs	crayfish (adult)	fresh-water	whole body	46	na	µg/kg ww	3 days	water	mortality	Johnson et al. (1971)	not a toxicity test; accumulation test with 0% mortality

Analyte	Test Species	Marine or Fresh-water	Tissue Type	NOAEL	LOAEL	Unit	Exposure Duration	Exposure Route	Endpoint	Source	Notes
DDTs	pink shrimp	marine	whole body	na	60	µg/kg ww	56 days	water	mortality	Nimmo et al. (1970)	30% mortality (control: 17%), includes DDE, DDD, and DDT; shrimp collected from Escambia and Bay counties, Florida; uncertainty with high mortality in control and field collected shrimp
DDTs	blue crab (juvenile)	marine	whole body	26	200	µg/kg ww	5 weeks	treated food	metabolic rate	Leffler (1975)	dosed with 4,4'-DDT, but total DDT metabolites measured in residues; mortality reported as "chlorinated hydrocarbon poisoning;" crabs collected from estuarine Cedar Key, Florida; metabolic rate measured – not relevant endpoint
Heptachlor	pink shrimp	marine	whole body	10	30	µg/kg ww	96 hours	water	mortality	Schimmel et al. (1976)	5% mortality at NOAEL, 80% at LOAEL
Heptachlor	grass shrimp	marine	whole body	200	970	µg/kg ww	96 hours	water	mortality	Schimmel et al. (1976)	13% mortality at NOAEL, 70% at LOAEL
Heptachlor epoxide	pink shrimp	marine	whole body	54	180	µg/kg ww	96 hours	water	mortality	Schimmel et al. (1976)	5% mortality at NOAEL, 80% at LOAEL
Heptachlor epoxide	grass shrimp	marine	whole body	550	2500	µg/kg ww	96 hours	water	mortality	Schimmel et al. (1976)	13% mortality at NOAEL, 70% at LOAEL
Methoxychlor	blue crab	marine	whole body	na	340	µg/kg ww	mean duration 63 days		mortality	Bookhout et al (1976)	states that concentrations > 1.0 ppb larval mortality was nearly complete after third stage. 1.3 ppb first concentration above 1.0 ppb. Tissue concentration at LOAEL is lowest measured value out of 3.
Methoxychlor	mud-crab	marine	whole body	na	230	µg/kg ww	mean duration 20 days	water	mortality	Bookhout et al (1976)	states that all concentrations > 1.0 ppb gave significant first stage larval mortality. 2.5 ppb first concentration above 1.0 ppb and had 72 to 86% survival. Tissue concentration at LOAEL is lowest measured value out of 4.

Analyte	Test Species	Marine or Fresh-water	Tissue Type	NOAEL	LOAEL	Unit	Exposure Duration	Exposure Route	Endpoint	Source	Notes
Methoxychlor	Dungeness crab (adults)	marine	whole body	na	570	µg/kg ww	up to 15 days	water	mortality	Armstrong et al. (1976)	LOAEL concentration 4.0 ug/L measured body concentration exposed to a water concentration of 7.5 µg/L. No tissue measurement at LOAEL of 4.0 µg/L
Methoxychlor	Dungeness crab (juveniles)	marine	whole body	na	150	µg/kg ww	18 days	water	mortality	Armstrong et al. (1976)	LOAEL concentration 0.04 µg/L. Figure 8 measured tissue concentration after 18 days at LOAEL concentration.

COI – chemical of interest

ERED – environmental residue effects database

LOAEL – lowest-observed-adverse-effect level

na – not available

NOAEL – no-observed-adverse-effect level

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

ppb – parts per billion

ppm – parts per million

ppt – parts per thousand

SVOC – semivolatile organic compound

ww – wet weight

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