Supporting Information

Benthic Organisms

Algae (Figure 1)

Entomoneis cf *punctulata* is a unicellular benthic marine alga (strain no. CS-426, obtained from CSIRO Marine Research, Hobart, Tasmania, Australia). *E.* cf *punctulata* has been shown to be tolerant to a wide range of physico-chemical parameters including salinity (15-35 ‰), pH (6.5-8.5) and particle size (0-100% fines <63 µm). Toxicity tests with this species determine enzyme (esterase) activity, rather than growth rate as the test endpoint as nutrient release from sediments has previously been shown to stimulate algal growth, potentially masking contaminant toxicity. This test is relatively sensitive to copper (EC50 <100 µg/L), but was not sensitive to other metals such as cadmium, lead, manganese or zinc (Adams and Stauber, 2004).

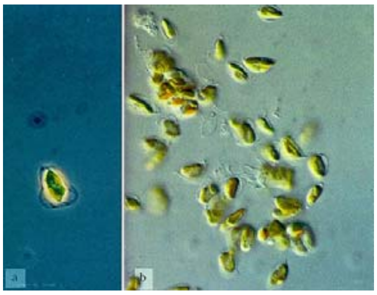

Figure 1 ***Entomoneis cf punctulata***

Amphipods (Figure 2)

Melita plumulosa (family Melitidae) is commonly found in estuarine tidal mudflat areas ranging from silty to sandy sediments in freshwater, estuarine and marine environments throughout south-eastern Australia (Simpson et al., 2005). *M. plumulosa* is an epibenthic deposit-feeding amphipod, living in close association with sediments, using the sediment as both a home and a food source. They are an important source of food for higher tropic levels. They inhabit a wide variety of surroundings from intertidal seagrass beds to muddy sand, up to a water depth of 25 m. *M. plumulosa* resides mostly on the sediment surface, rather than burrowing deeply into sediments. Male species grow to an approximate length of 7 mm, and females to a length of 5 mm (Lowry et al., 2000; Simpson et al., 2005).

Corophium colo (Fam. Corophidae) is an infaunal sediment dwelling corophiid amphipod (Lowry, 2004; Lowry et al., 2000) and is abundant in fresh and estuarine tidal sections of the Hawkesbury River catchment in New South Wales (Hyne and Everett, 1998). The amphipod is typically found 1-5 cm below the sediment surface in the intertidal zone of river banks which are vertical, of solid structure, low sand content, with abundant macrophyte growth and water in the range 0.1-24‰.

These amphipods build U-shaped burrows in sediment consisting of fine sand mixed with clays. Females of *C. colo* with body lengths greater than 8 mm were considered sexually mature as no gravid individuals were observed below this size. The average maximum body length of females was 13.1 mm and that of males was 11.6 mm (Surtikanti et al., 1998, 2000). *C. colo* normally only feed in their burrows, obtaining food by moving their appendages to create a water current from the sediment surface.

Corophium insidiosum (Fam. Corophidae) was discovered in 1931, assumed to be introduced to Australia through aquaculture practices or ship hull ballast waters, and has a widespread distribution in Victoria, Australia (Adams et al., 2001). *C. insidiosum* build U-shaped burrows in sediment consisting of fine sand mixed with clays. Male species grow to an approximate length of 10 mm, and females to a length of 7 mm. *C. insidiosum* feed mostly in their burrows, obtaining food by moving their appendages to create a water-current from the sediment surface.

Figure 3 ***Melita plumulosa*** ***Corophium* colo** ***Corophium insidiosum***

Bivalve Clams (Figure 3)

Tellina deltoidalis (Fam. Tellinidae) is endemic to Australia and ranges from southern Queensland to Tasmania and south Western Australia. It has a smooth, broadly triangular shell that is laterally compressed and grows to approximately 20 mm in length. Tissue weights (no shell) were 10-150 mg (wet) and 2-30 mg (dry). This species is found in estuarine and coastal lagoons and burrows into sand or mud, often amongst seagrass. Like other tellinids, *T. deltoidalis* is a deposit feeder, collecting organic material and particles from surface sediments [Willan, 1998; Ponder et al., 2000].

Soletellina alba (Fam. Psammobiidae) is endemic to Australia, ranging from mid Queensland to South Australia in estuaries and coastal areas (King et al., 2004). The shell of *S. alba* is oblong to rectangular in shape and grows to a length of 50 mm. Tissue weights (no shell) were 100-1500 mg (wet) and 10-400 mg (dry). This species burrow deeply (to 30 cm) in sands or muds and filter feeds on particulate matter, collected from the overlying water by using their long inhalent siphon which can protude well above the surface of the sediment (Willan, 1998; Ponder et al., 2000).

Mysella anomala (Fam. Galeommatidae) is a common bivalve found in estuaries and coastal areas in NSW (Ponder, 1998; Ponder et al., 2000; King et al., 2004). It has a very small (<5 mm) broadly triangular shell, and burrows shallow in muddy to sandy areas. Tissue weights (no shell) were 5-25 mg (wet) and 1-15 mg (dry). It feeds by filtering suspended particles from overlying waters (Ponder, 1998; Ponder et al., 2000).

Figure 3 ***Tellina deltoidalis*** ***Soletellina alba*** ***Mysella anomala***

Polychaete worms (Figure 4)

Australonereis ehlersi (Fam. Nereididae) is very common in estuarine and coastal areas throughout the southern region of Australia from Western Australia to Queensland (King et al., 2004). It inhibits in a wide range of sediment types, from coarse sand to fine mud, and grows to be a length of 20 cm. Worms were generally 6-10 cm in length and had body weights of 100-800 mg (wet) and 10-150 mg (dry). While this species is reportedly a deposit feeder, it also has carnivorous attributes, with an eversible pharynx and a pair of jaws (Glasby et al., 2000). It forms a series of mucus-lined burrows of up to 40 cm long, which protect the worms from predators including fish and birds.

Nephtys australiensis (Fam. Nephtyidae) is endemic to Australia and is most commonly found in muddy intertidal and sub-tidal sediments in the estuaries of south-eastern Australia (King et al., 2004). The body of *N. australiensis* is muscular, enabling this species to swim powerfully and to burrow to depths of up to 20 cm. Worms were generally 5-9 cm in length and had body weights of 20-200 mg (wet) and 4-40 mg (dry). This species is free-living within the sediment and does not form permanent tubes. Nephtyids are thought to be predators on other small invertebrates, although some studies have suggested that they may be opportunistic feeders, switching between carnivory and sub-surface deposit feeding when prey items are scarce (Glasby et al., 2000).

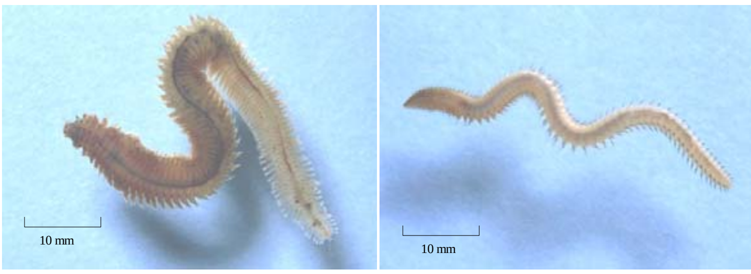

Figure 4 ***Australonereis ehlersi*** ***Nephtys australiensis***

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Table S1. Effect concentrations for sediments with a range of copper-partitioning properties (K_d) calculated using exposure-effects model with both water and sediment exposure-effects pathways (4-d exposure) [a]

Sediment Type: K_d, L/kg:	Silt High Fe/TOC 1×10^5	Silt Med Fe/TOC 5×10^4	Silt-Sand Med Fe/TOC 1×10^4	Silt-Sand Low Fe/TOC 5×10^3	Sandy Low Fe/TOC 1×10^3	Sand V.low Fe/TOC 5×10^2
Organism	**LC50, mg/kg copper (4-d exposure period)**					
Melita plumulosa	3500	3250	2060	1430	408	213
Corophium colo	10300	10300	8750	7500	3500	2100
Corophium insidiosum	3930	3750	2600	1900	595	325
Tellina deltoidalis	2680	2550	1580	1080	305	163
Soletellina alba	3170	2500	950	530	118	60
Mysella anomala	9800	9250	6180	4380	1310	700
Australoneris ehlersi	3530	2875	1180	675	153	78
Nephtys australiensis	6550	5000	1730	960	205	103

[a] Exposure-effect model (equation 4) used the parameters in Table 2 and $K_d = 5\times10^4$ L/kg.

Table S2. PC 95 (50) values calculated using species sensitivity distributions for nine Australian benthic organisms [a]

Sediment Type: K_d, L/kg:	Silt High Fe/TOC 1×10^5	Silt Med Fe/TOC 5×10^4	Silt-Sand Med Fe/TOC 1×10^4	Silt-Sand Low Fe/TOC 5×10^3	Sandy Low Fe/TOC 1×10^3	Sand V.low Fe/TOC 5×10^2
Exposure	**PC 95 (50), mg/kg**					
4-d Water-only LOEC	7250	3620	725	362	72.3	36.2
4-d Water-only LC50	4690	2350	469	234	46.9	23.5
4-d Whole-sediment LC50	2480	2230	945	515	106	53.0
10-d Whole-sediment LC50	993	893	378	206	42.5	21.2

[a] PC 95 (50) values (95% protection concentrations, 50% confidence) calculated using (i) 4-d water-only LC50 and LOEC values (Table 1) and equilibrium partitioning model (equation 3), and (ii) 4-d (Table S1) and 10-d (Table 4) whole-sediment LC50 values from exposure-effect model (equation 4)

Table S3. Effect copper assimilation efficiency on exposure-effects for sediments with a range of copper-partitioning properties (K_d) [a]

Sediment K_d, L/kg:	$1{\times}10^5$	$5{\times}10^4$	$1{\times}10^4$	$5{\times}10^3$	$1{\times}10^3$	$5{\times}10^2$
			AE not adjusted			
Organism			**LC50, mg/kg copper**			
M. plumulosa	1400	1300	825	570	163	85
C. colo	4120	4100	3500	3000	1400	840
C. insidiosum	1570	1500	1040	760	238	130
T. deltoidalis	1070	1020	630	430	122	65
S. alba	1269	1000	380	212	47	24
M. anomala	3920	3700	2470	1750	525	280
A. ehlersi	1410	1150	470	270	61	31
N. australiensis	2620	2000	690	385	82	41
			AE increased by 50%			
Organism			**LC50, mg/kg copper**			
M. plumulosa	950	900	650	480	155	83.7
C. colo	2760	2730	2470	2210	1200	764
C. insidiosum	1110	1030	825	617	231	123
T. deltoidalis	733	695	494	363	116	63.0
S. alba	925	780	337	198	46.0	23.0
M. anomala	2680	2560	1910	1440	494	271
A. ehlersi	1010	873	415	251	61	31.7
N. australiensis	1950	1580	634	362	82	41.5
			AE decreased by 50%			
Organism			**LC50, mg/kg copper**			
M. plumulosa	2580	2260	1130	700	172	88.6
C. colo	2980	2690	1510	980	256	133
C. insidiosum	8080	7770	6000	4670	1680	934
T. deltoidalis	1980	1730	860	528	129	66
S. alba	2000	1410	420	223	47	23.7
M. anomala	7370	6560	3500	2210	560	290
A. ehlersi	2300	1690	539	291	62.3	31.4
N. australiensis	4000	2710	760	400	83.5	42.0

[a] Exposure-effect model (equation 4) used the parameters in Table 3, except the AE was adjusted up or down by 50% for two sets of calculations. A 10-d exposure model was used and Kd = $5{\times}10^4$ L/kg.

Table S4. Effect of copper assimilation efficiency (AE) on calculated PC 95 (50) values

Sediment Type:	Silt	Silt	Silt-Sand	Silt-Sand	Sandy	Sand
	High Fe/TOC	Med Fe/TOC	Med Fe/TOC	Low Fe/TOC	Low Fe/TOC	V.low Fe/TOC
K_d, L/kg:	$1{\times}10^5$	$5{\times}10^4$	$1{\times}10^4$	$5{\times}10^3$	$1{\times}10^3$	$5{\times}10^2$
Exposure			**PC 95 (50), mg/kg**			
AE increased by 50%	681	639	337	197	42.5	21.2
AE not adjusted	993	893	378	206	42.5	21.2
AE decreased by 50%	1770	1370	410	211	42.5	21.2

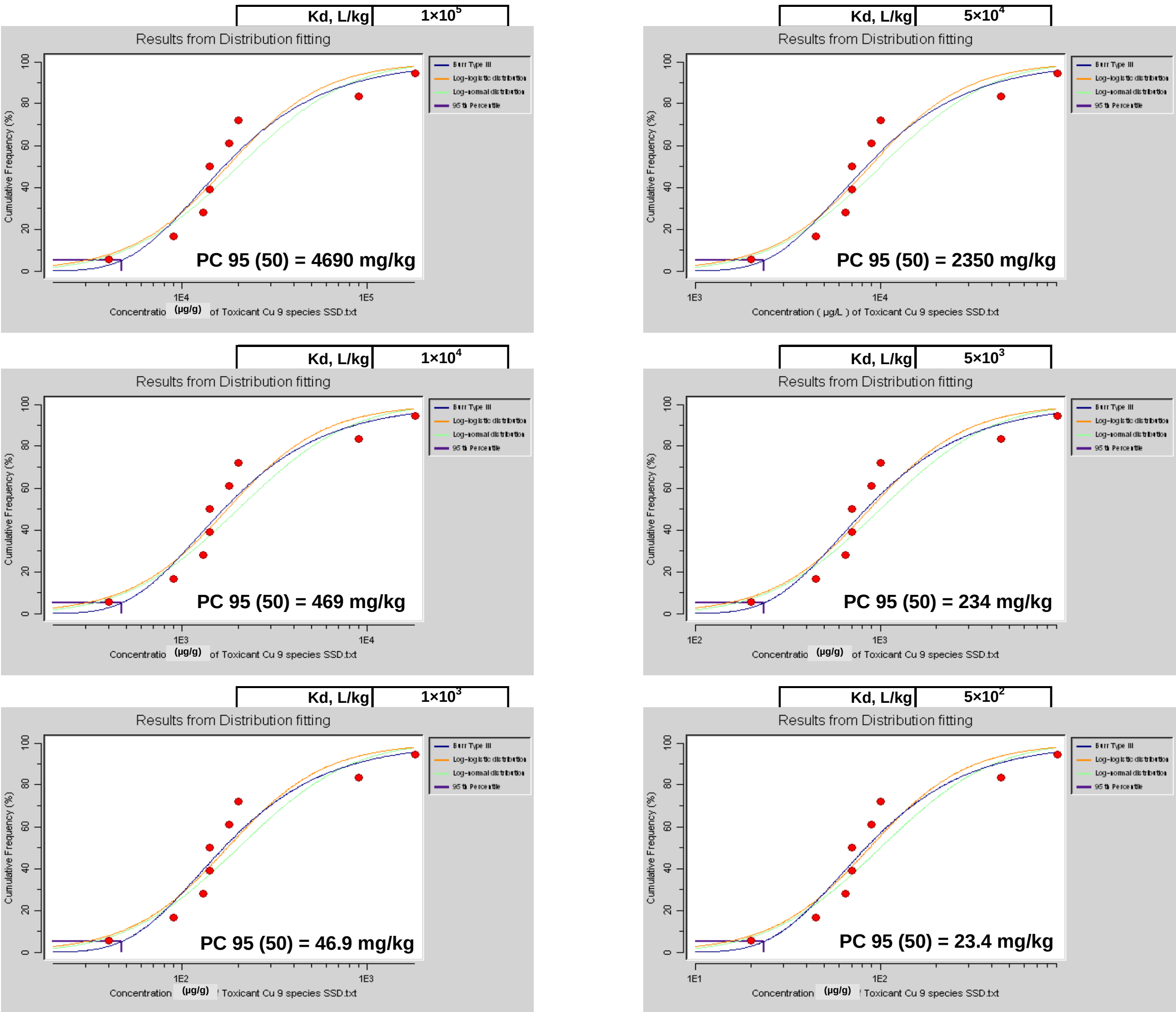

Figure S1 Species sensitivity distributions (SSD) for copper in sediments with a range of copper-partitioning properties (K_d). Effect concentrations calculated using using equilibrium-partitioning and water-only effects concentrations (4-d LOEC water-only exposure)

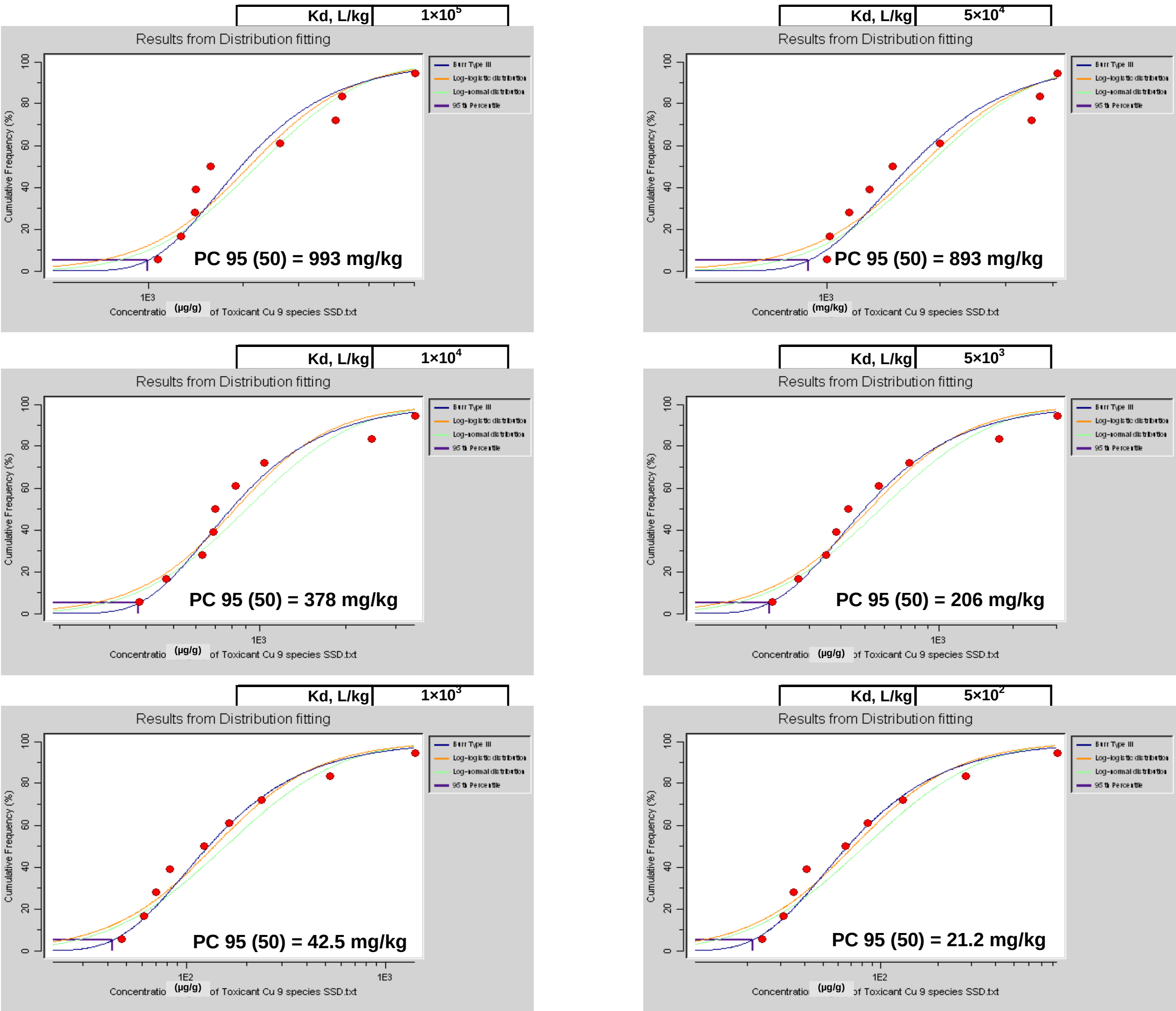

Figure S2 Species sensitivity distributions (SSD) for copper in sediments with a range of copper-partitioning properties (K_d). Effect concentrations calculated using exposure-effects model with both water and sediment exposure-effects pathways (10-d exposure)