

Estuarine and Marine Aquatic Bioassays for Use in Sediment Investigations

Test Species, Test Duration, and Medium	Endpoints	Advantages	Disadvantages	Other Remarks	Protocol Reference
Amphipod <i>Ampelisca abdita</i> 10 Day Acute Sediment Test 28 Day Chronic Sediment Test	10 Day Survival, Reburial. 28 Day Growth, Reproduction	Highly reliable test; laboratory exposure analogous to field conditions; very useful in defining gradients of sediment toxicity; readily available and widely distributed species; test salinities from 10 to 35 ppt; tolerant of fine sediments; high regulatory relevance; mortality endpoint has high ecological relevance; moderately cost-effective	Tube dweller, not in direct contact with sediment; sensitive to coarse-grained sediments; species is field-collected	Less sensitive than <i>E. estuarius</i> and <i>R abronius</i> ; LC50 value for un-ionized ammonia is 0.83 mg/L (Kohn et al., 1994)	Test Method 100.4 (EPA 1994); ASTM E1367-99 EPA 1998
Amphipod <i>Eohaustorius estuarius</i> 10 Days Sediment	Survival, Reburial	Highly reliable test; laboratory exposure analogous to field conditions; very useful in defining gradients of sediment toxicity; readily available species; test salinities from 2 to 28 ppt; tolerant of fine sediments; directly exposed to sediments; high regulatory relevance; mortality endpoint has high ecological relevance; moderately cost-effective	Less sensitive than <i>R. abronius</i> ; potential sediment interferences; not as well distributed as <i>L. plummulosus</i> or <i>A. abdita</i> ; species is field collected	Remove potential predators from sediment before testing; less sensitive to sulfide than <i>R. abronius</i> (LC50 = 104 µM total sulfides/L [Knezovich et al., 1995]); <i>E. estuarius</i> mortality is as sensitive as <i>R. abronius</i> mortality; <i>R. abronius</i> nonreburial is more sensitive than <i>E. estuarius</i> nonreburial; <i>E. estuarius</i> mortality more sensitive than <i>N. areanaceodentata</i> biomass, which is more sensitive than <i>N. areanaceodentata</i> mortality; mortality endpoint more sensitive than reburial; LC50 value for total ammonia is 125.5 mg/L and un-ionized ammonia is 2.49 mg/L (Kohn et al., 1994)	Test Method 100.4 (EPA 1994); ASTM E1367-99 EPA 1998

Estuarine and Marine Aquatic Bioassays for Use in Sediment Investigations (page 2 of 5)

Test Species, Test Duration, and Medium	Endpoints	Advantages	Disadvantages	Other Remarks	Protocol Reference
Amphipod <i>Leptocheirus plumulosus</i> 10 Days Sediment	Survival, Growth, Reproduction	Species is cultured; salinity range of 1.5 to 32 ppt (pore water salinities of less than 1 to 35 ppt [Niewolny et al., 1997]); tolerates full range of grain sizes (except sandy sediments with less than 5% silt/clay [Niewolny et al., 1997]); tolerant of fine sediments; highly reliable test; high ecological relevance; laboratory exposure analogous to field conditions; widely distributed and cultured	Tube dweller – not in direct contact with sediment		Test Method EPA 600/R-01/020 (2001)
Amphipod <i>Leptocheirus plumulosus</i> 10 Days Sediment	Survival, Reburial	As above.	Tube dweller – not in direct contact with sediment		Test Method 100.4 (EPA 1994); ASTM E1367-99
Amphipod <i>Rhepoxynius abronius</i> 10 Days Sediment	Survival, Reburial	Highly reliable test; most sensitive of amphipods usually tested; laboratory exposure analogous to field conditions; very useful in defining gradients of contamination; readily available species; test salinities from 25 to 32 ppt; directly exposed to sediment; high regulatory relevance; mortality endpoint has high ecological relevance; moderately cost-effective	Sensitive to high total organic content; sensitive to fine grained sediments; not as well distributed as <i>Leptocheirus plumulosus</i> and <i>Ampelisca abdita</i> ; species is field-collected	<i>R. abronius</i> mortality as sensitive as <i>E. estuarius</i> mortality; <i>R. abronius</i> nonreburial is more sensitive than <i>E. estuarius</i> nonreburial; LC50 value for un-ionized ammonia is 1.59 mg/L (Kohn et al., 1994); more sensitive to sulfides than <i>E. estuarius</i> (LC50 for total sulfides is 50 µM total sulfides/L [Knezovich et al., 1995]); 10-day survival protocol using <i>R. abronius</i> was a more sensitive indicator of toxicity than 20-day test with <i>N. arenaceodentata</i> based on statistical power of the test and not greater sensitivity of the organisms or endpoints (Anderson et al., 1998)	Test Method 100.4 (EPA 1994); ASTM E1367-99 EPA 1998

Estuarine and Marine Aquatic Bioassays for Use in Sediment Investigations (page 3 of 5)

Test Species, Test Duration, and Medium	Endpoints	Advantages	Disadvantages	Other Remarks	Protocol Reference
Diatom <i>Thalassiosira pseudomona</i> <i>Skeletonema costatum</i> <i>Dunaliella tertiolecta</i> <i>Phaeodactylum tricornutum</i> 4 Days Water	Growth, Biomass, Cell Counts	Represents aquatic primary producers; Can be used with filtered porewater	Primarily a water test; not relevant to sediment	Not recommended unless there is clear evidence that Navy activities are currently impacting the water body.	ASTM E 1218-97a
Mollusc <i>Macoma balthica</i> 28 Days Sediment	Bioaccumulation	Species is wild-harvested	Ecological relevance; available year-round, surface deposit-feeder; tolerates salinity down to 10 ppt		ASTM 1668-00 EPA 1998
Mollusc <i>Macoma nasuta</i> 28 Days Sediment	Bioaccumulation	Species is wild-harvested	Ecological relevance; available year-round, common test species; tolerates salinity down to 10 ppt		ASTM 1668-00 EPA 1998
Mollusc <i>Yoldia imatula</i> 28 Days Sediment	Bioaccumulation	Species is wild-harvested	Ecological relevance; available year-round, subsurface deposit-feeder	Seawater must be >25 ppt	ASTM 1668-00 EPA 1998
Mollusc Blue mussel <i>Mytilus edulis</i> 2 Days Water column	Development	Species is cultured; high dose responsiveness	Moderate ecological relevance; does not spawn year-round	Less sensitive than <i>Strongylocentrotus purpuratus</i> to sulfides (complete inhibition at 8- μ M total sulfide/L [Knezovich et al., 1995])	Test Method 1005.0 (Chapman, 1995)
Polychaete <i>Capetella</i> sp. 20-28 Days Sediment	Bioaccumulation	Species can be cultured	Low sensitivity; mortality has moderate dose responsiveness		ASTM 1668-00

Estuarine and Marine Aquatic Bioassays for Use in Sediment Investigations (page 4 of 5)

Test Species, Test Duration, and Medium	Endpoints	Advantages	Disadvantages	Other Remarks	Protocol Reference
Polychaete <i>Nereis</i> (<i>Neanthes</i>) <i>arenaceo-</i> <i>dentata</i> 20 Days Sediment	Growth Survival	Species is cultured; species can be tested at salinities less than 20 ppt; growth test is cost-effective; low cost; mortality has high dose response; mortality has high ecological relevance	Low to medium sensitivity; mortality has moderate dose responsiveness; growth has moderate ecological relevance	Test animal age, duration of exposure, food ration, and choice of endpoint affects the magnitude of the toxic response (Bridges and Farrar, 1997; Bridges et al., 1997); <i>N. arenaceodentata</i> biomass is more sensitive than <i>N. arenaceodentata</i> mortality	(EPA 1990) ASTM 1611-99
Polychaete <i>Nereis virens</i> 28 Days Sediment	Bioaccumulation	Species is cultured, or wild harvest, can tolerate salinities as low as 10 ppt	Cannot be tested with other test species (predator).	Surface deposit-feeder and omnivore. Good provider of biomass.	Test Method 1005.0; (Chapman et al., 1995); ASTM 1688-00
Possum mysid <i>Americamysis bahia</i> 7 Days Water column	Fecundity Survival Growth	Species is cultured	Very sensitive to changes in ionic balance in test solution	Laboratory success with the fecundity endpoint is rare (WSDE, 1997)	EPA Test Method 1007.0
Purple sea urchin <i>Strongylocentrotus purpuratus</i> 72 Hours Water column	Development Survival	Highly sensitive; early-life stage toxicity test; can be performed using filtered porewater	Species is field-collected; not recommended for sediments with a porewater salinity less than 10 ppt; does not spawn year-round; does not directly live in sediments; moderate ecological relevance	Highly susceptible to unionized ammonia toxicity when testing sediment pore water (EC50 for un-ionized ammonia was 0.057 mg/L [Greenstein et al., 1996]); total inhibition from sulfides at 20- μ M total sulfide/L [Knezovich et al., 1995])	Test Method 1008.0 (Chapman, 1995)
Sand dollar <i>Dendraster excentricus</i> 72 Hours Water column	Development Survival	Highly sensitive; early-life stage toxicity test; gravid adults can be obtained year-round (U.S. EPA 1993b); can be performed using filtered porewater	Species is field collected; medium dose responsiveness; moderately cost-effective; moderate ecological relevance	Can be induced to spawn but with reduced gamete viability; proposed echinoderm effect threshold for unionized ammonia is 0.04 mg/L (U.S. EPA, 1993b)	Test Method 1008.0 (Chapman, 1995)

Estuarine and Marine Aquatic Bioassays for Use in Sediment Investigations (page 5 of 5)

Test Species, Test Duration, and Medium	Endpoints	Advantages	Disadvantages	Other Remarks	Protocol Reference
Topsmelt <i>Atherinops affinis</i> 12 Days Sediment-water interface	Percent hatched	Most appropriate for testing early life stage fishes; can tolerate salinities from 2 to 60 ppt; can tolerate wide range in temperature with a preference of 19 to 23°C; reproductive season from early March to July or August depending upon latitude		Suggested test instead of using sediment pore water where fish are receptors of concern; numerically abundant in California estuaries	(Protocol based on Anderson, 1996)
Inland silverside <i>Menidia beryllina</i> 7 Days Water column	Survival	Species is cultured; occurs along both coasts of the United States; can tolerate freshwater to salinities of 35 ppt; can tolerate temperatures from 9.8 to 30°C; sexually mature from March or April through July or August			EPA Test Method 1006.0

ASTM = American Society for Testing and Materials.

EC50 = Concentration that causes an effect in 50% of the test organisms.

LC50 = Concentration that is lethal to 50% of the test organisms.

WSDE = Washington State Department of Ecology.

Freshwater Bioassays for Use in Sediment Investigations

Test Species	Test Duration and Medium	Endpoints	Advantages	Disadvantages	Other Remarks	Protocol Reference
Algae, <i>Selenastrum capricornutum</i> , <i>Scenedesmus subspicatus</i> , <i>Chlorella vulgaris</i>	4 Days; water	Growth, Biomass, Cell Counts	Represents aquatic primary producers	Primarily a water test. Can be used with filtered pore water extracts		ASTM E 1218-97a
African Clawed Frog (FETAX) <i>Xenopus laevis</i>	96 Hours; sediment	Development Teratogenesis	Time and cost-effective; technical ease in conducting test; versatile for testing various media; sensitive to low levels of developmental toxicants; extensive literature available; most predictive when compared to lettuce germination, earthworm survival, <i>Daphnia</i> survival, and fathead minnow survival (Fort et al. 1995)		Can be used to test complex industrial mixtures; has been used to test surface water and aqueous extracts of soil; reference toxicant is 6-aminonicotinamide	ASTM E1439-98
Amphipod <i>Diporeia</i> sp.	10 Days; sediment	Bioaccumulation	Species can be cultured; pollution tolerant; important component in freshwater food chain	Small size requires massive numbers of individuals for chemical analysis	Subsurface deposit-feeder	ASTM 1688-00 EPA 1998
Amphipod <i>Hyalella azteca</i>	10 Days; sediment	Survival, Growth	Species is cultured; most highly sensitive of the freshwater test organisms; tolerates wide range of sediment grain sizes	Alkalinity commonly encountered in sediment porewater is toxic (Lasier et al., 1997; Duh and Myers, 1997)	Tolerates salinities up to 15 ppt	Test Method 100.1 (EPA 2000); ASTM E-1706-95b
Amphipod <i>Hyalella azteca</i>	42 Days; sediment	Survival, Growth, Reproduction	Species is cultured; most highly sensitive of the freshwater test organisms; tolerates wide range of sediment grain sizes	Alkalinity commonly encountered in sediment porewater is toxic (Lasier et al., 1997; Duh and Myers, 1997)	Can be used to evaluate the bioavailability of sediment associated contaminants; tolerates salinities up to 15 ppt	EPA/600/R-99/064, ASTM E-1706-95b

Freshwater Bioassays for Use in Sediment Investigations (page 2 of 3)

Test Species	Test Duration and Medium	Endpoints	Advantages	Disadvantages	Other Remarks	Protocol Reference
Daphnid <i>Ceriodaphnia dubia</i>	8 Days or until 60% of survivors have three broods; water	Survival, Reproduction	Species is cultured; important link in many food chains; species is as sensitive as fathead minnow; wide hardness tolerance; found throughout the United States	Test was originally developed to support water testing. Sediment elutriates containing massive amounts of fine material can mechanically induce mortality and /or create difficulty observing the very small offspring.	Applicable to testing effluents, leachates, liquid phases of sediments with minimal quantities of "permanently" suspended material, and pore-water	Test Method 1002.0
Fathead Minnow <i>Pimephales promelas,</i>	7 Days; water column	Survival, Growth	Species is cultured; occurs throughout the United States; eggs and early larvae commercially available; large effects data base	Not typically used in sediment suspended particulate testing	Applicable to testing effluents, leachates, and liquid phases of sediments with minimal quantities of "permanently" suspended material, and porewater	EPA/600/4-91/002
Mayfly - Burrowing, <i>Hexagenia</i> sp.	Life Stage Dependent; sediment	Survival, Growth, Bioaccumulation	Species is cultured; sensitive freshwater test organism; tolerates wide range of sediment grain sizes	Can mature into flying form if test duration extended	Important food chain item for freshwater fish	ASTM 1688-00
Midge Larvae, <i>Chironomus tentans</i>	10 Days; sediment	Survival, Growth	Species is cultured; sensitive freshwater test organism; tolerates wide range of sediment grain sizes	Can mature into flying form if test duration extended	Important food chain item for freshwater fish	ASTM 1706-95b; EPA Test Method #0100.2
Midge Larvae, <i>Chironomus tentans</i>	14 Days; sediment	Bioaccumulation	Species is cultured; sensitive freshwater test organism; tolerates wide range of sediment grain sizes	Can mature into flying form if test duration extended, requires many individuals to provide sufficient biomass	Important food chain item for freshwater fish	ASTM 1688-00 EPA 1998; Lifecycle Test Method #0100.5

Freshwater Bioassays for Use in Sediment Investigations (page 3 of 3)

Test Species	Test Duration and Medium	Endpoints	Advantages	Disadvantages	Other Remarks	Protocol Reference
Oligochaete <i>Lumbriculus variegatus</i>	28 Days; sediment	Bioaccumulation	Species is easy to culture, know chemical exposure history, tolerant to wide range of sediment types, low acute sensitivity to wide range of chemicals, tolerates long exposures without feeding	Individuals are small and often difficult to remove from sediment and detritus matrix		ASTM E1688-00, EPA/600/R-99/064 (2000[2])

ASTM = American Society for Testing and Materials.

EC50 = Concentration that causes an effect in 50% of the test organisms.

LC50 = Concentration that is lethal to 50% of the test organisms.

WSDE = Washington State Department of Ecology.

REFERENCES

Anderson, B.S., J.W. Hunt, M. Hester, and B.M. Phillips. 1996. Assessment of sediment toxicity at the sediment –water interface. In: Techniques in Aquatic Toxicology. CRC Press, Inc. Boca Raton, FL pp. 609-624.

ASTM. 1998. Standard Guide for Conducting Toxicity Tests with Bioluminescent Dinoflagellates, E 1924-97. 1999 Annual Book of ASTM Standards, Section 11.05, Biological Effects and Environmental Fate; Biotechnology; Pesticides, June.

ASTM. 1999. “Standard Guide for Selection of Resident Species as test Organisms for Aquatic and Sediment Toxicity Tests.” E 1850 - 97 American Society of Testing and Materials.

ASTM. 1999. “Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Fresh Water Invertebrates.” E 1706-95b American Society of Testing and Materials.

United States Environmental Protection Agency. 1994. Methods for Assessing the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods. USEPA Office of Research and Development, Washington, D.C. EPA/600/R-94/025.

United States Environmental Protection Agency. 2000. Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Fresh Water Invertebrates- Second Edition. USEPA Office of Science and Technology, Washington, D.C. EPA/600/R-99/064.