



US Army Corps  
of Engineers®  
BUILDING STRONG®



#### Acknowledgments.

This work was funded by the Dredging Operations Environmental Research (DOER) program of the U.S. Army Corps of Engineers

#### References cited.

Kennedy AJ, Lotufo GR, Steevens JA. 2015. Review of Dredging Elutriate Application Factors: Relevance to Acute-to-Chronic Protection, Contaminant, and Endpoint Specificity," [ERDC/EL TR-15-10](http://el.erdc.usace.army.mil/elpubs/pdf/trel15-10.pdf), U.S. Army Engineer Research and Development Center, Vicksburg, MS. <http://el.erdc.usace.army.mil/elpubs/pdf/trel15-10.pdf>

Kennedy AJ, Lotufo GR, Laird JG, Farrar JD. 2016a. Dredged Material Evaluations: Review of Zooplankton Toxicity Test Methods for Marine Water Quality Evaluations. DOER Technical Notes Collection. ERDC TN-DOER-R24. U.S. Army Engineer R&D Center, Vicksburg, MS. [http://acwc.sdp.sirsi.net/client/en\\_US/search/asset/1051547](http://acwc.sdp.sirsi.net/client/en_US/search/asset/1051547)

Kennedy AJ, Lindsay JH, Biedenbach JM, Harmon AR. 2016b. Life stage sensitivity of the marine mussel *Mytilus edulis* to ammonia. [Environmental Toxicology and Chemistry](http://www.ncbi.nlm.nih.gov/pubmed/2710002), 10.1002/etc.3499

U.S. Environmental Protection Agency (USEPA). 1991. Methods for aquatic toxicity identification evaluations - phase I toxicity characterization procedures, 2<sup>nd</sup> edition, Duluth, MN EPA-600/6-91-003

USEPA/USACE. 1998. *Evaluation of material proposed for discharge to waters of the US - testing manual (inland testing manual)*. EPA/823/B-98/004. Washington, DC: U.S. Environmental Protection Agency.

INNOVATIVE SOLUTIONS  
for a safer, better world

\*Research supported by the US Army Corps of Engineers, Engineer Research and Development Center. The views expressed are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government

[www.erdc.usace.army.mil](http://www.erdc.usace.army.mil)

# Recent Advancements in Sediment Elutriate (Dredged Material) Water Column Evaluations

Alan J. Kennedy, Guilherme R. Lotufo, Jennifer G. Laird, James Lindsay, James M. Biedenbach, J. Daniel Farrar

[Alan.J.Kennedy@usace.army.mil](mailto:Alan.J.Kennedy@usace.army.mil), 601-634-3344

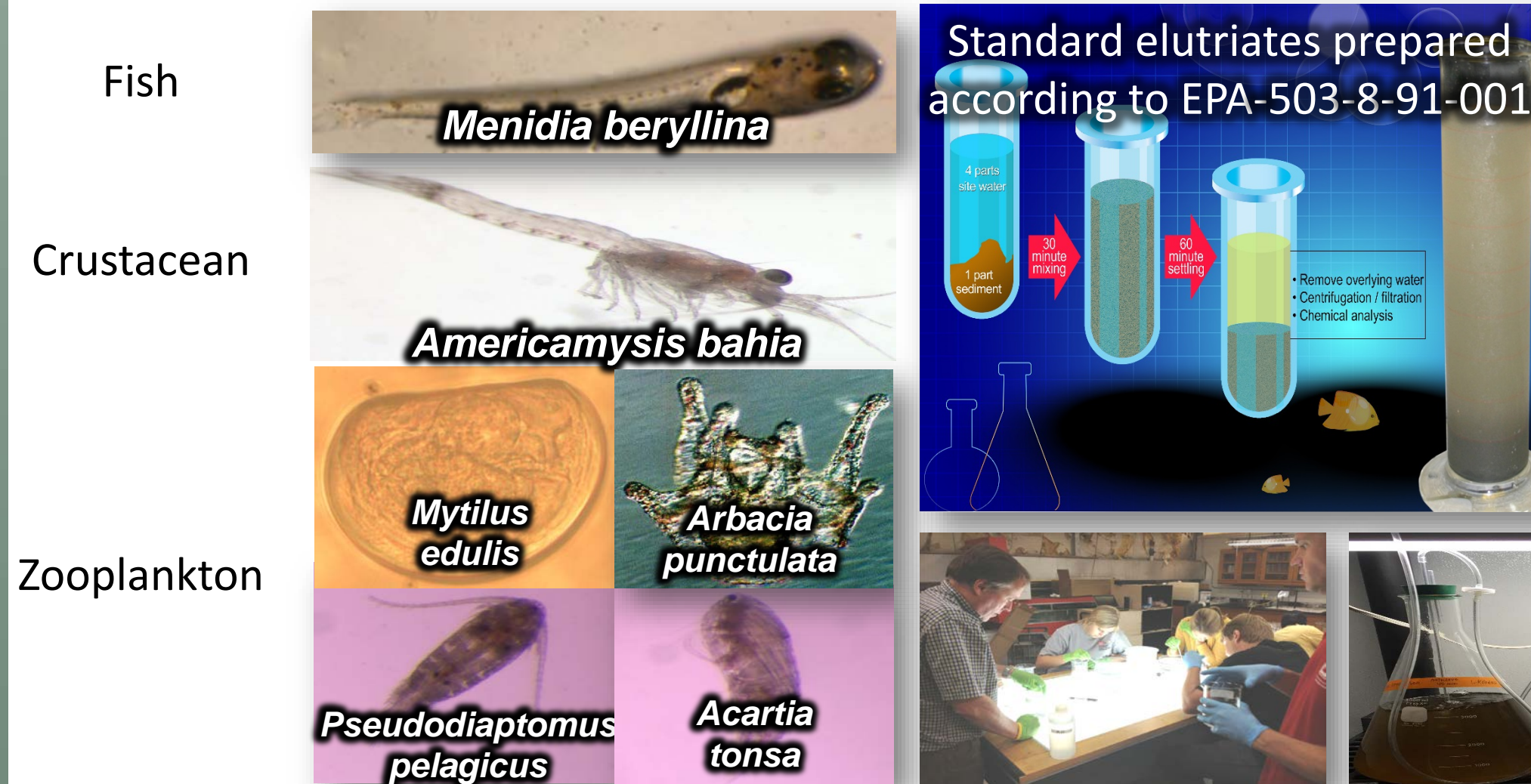
## Background

- Evaluations to determine the suitability of Dredged Material (DM) for open water placement require physical, chemical and biological evaluation.
- This work focuses on acute toxicity evaluations of suspended particulate and dissolved chemical phases released from sediment during the short settling and mixing period at the ocean placement site.
- Acute effects of persistent contaminants (e.g., metals) are of primary concern. However, ammonia frequently contributes to elutriate toxicity.
- Different methods were used for isolating the elutriate toxicity effects, including: (1) toxicity reduction evaluations; (2) alternative safety (application) factors; (3) alternative, species that are more representative of true zooplankton and less sensitive to ammonia.



## Methods

- Test organisms and elutriate preparation:



- Toxicity reduction evaluation (TRE) methods adapted from EPA-600-6-91-003 (Fig.1).
- Bioassays conducted according to EPA-823-B-98-004
- Juvenile mussel test conducted as in Kennedy *et al.* (2016a)
- Copepod testing conducted as in Kennedy *et al.* (2016b); Table 1.

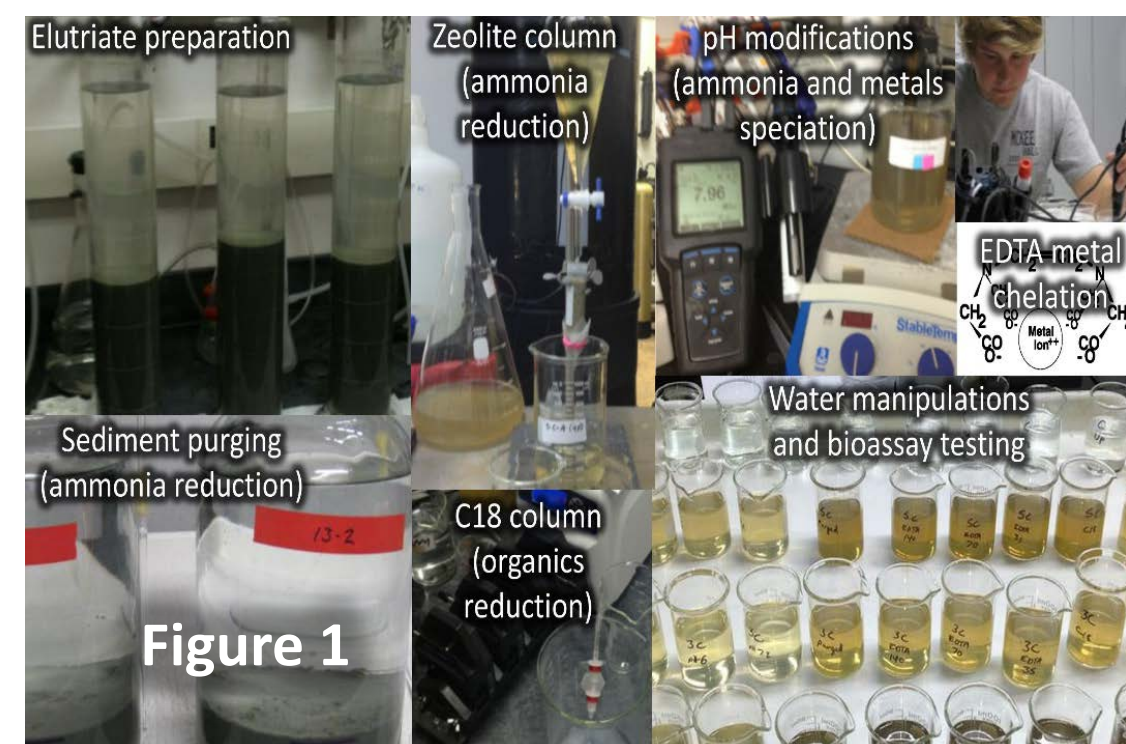
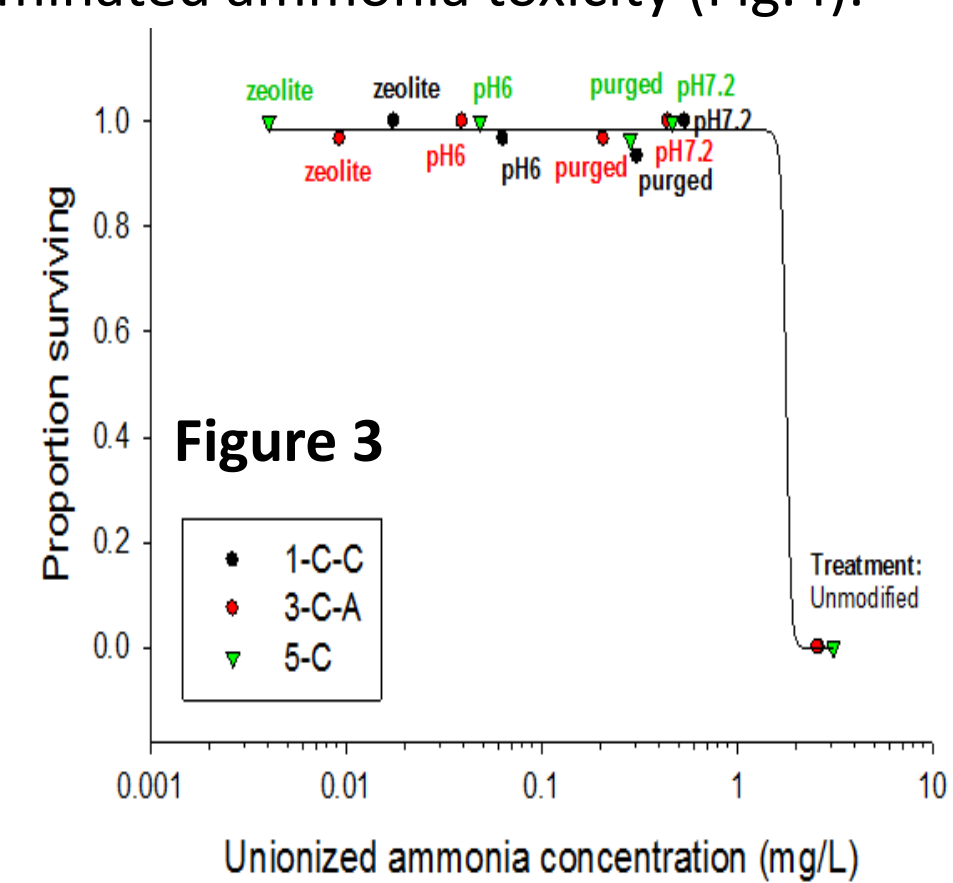
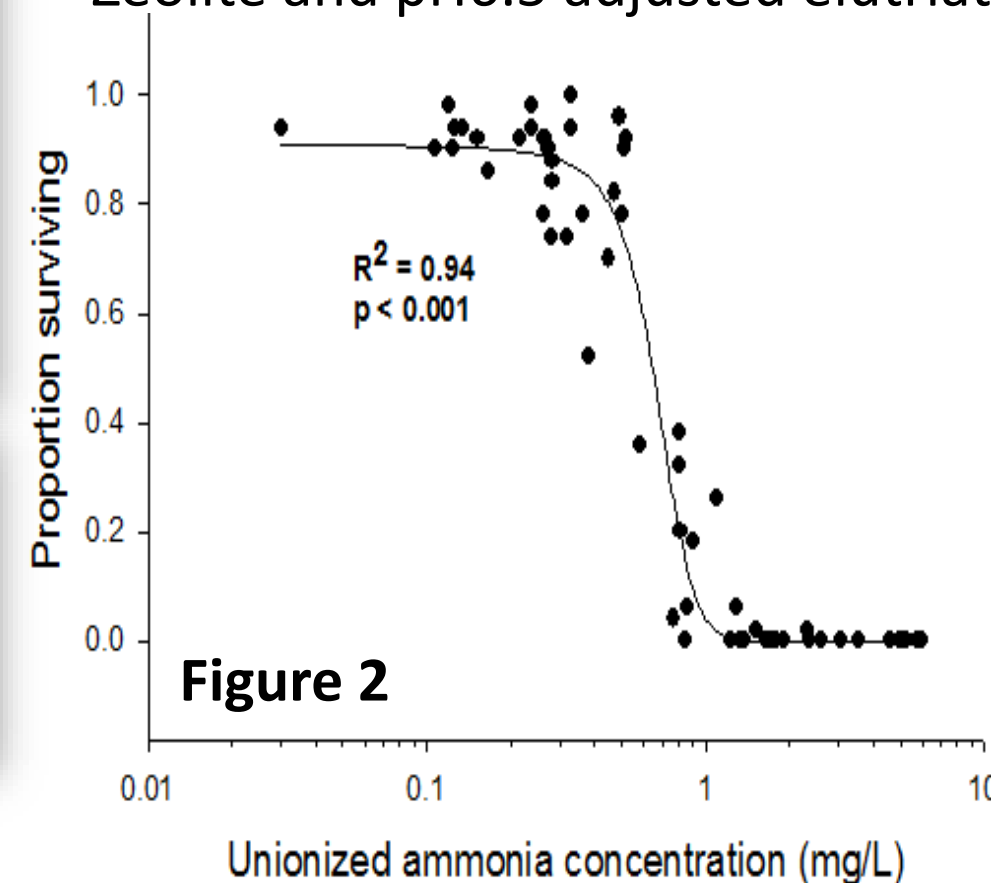


Table 1. Test species	<i>A. tonsa</i> , <i>P. pelagicus</i>
Test type	48 h, static, non-renewal
Temperature(°C)/salinity	25 ± 1; 25 to 30 ‰ (± 10%)
Test chamber/volume	40mL dish/30mL
Age of test organisms	7-11 days (±1 day range )
Replicates/organisms	N = 5; 5 copepods/rep
Feeding	None
Test concentrations	100%, 50%, 10% (1%)
Endpoint	Survival, immobilization

- Contaminants (CuSO<sub>4</sub>, NH<sub>4</sub>Cl) typically released from suspended elutriates were spiked into Crystal Sea® to determine a species sensitivity distribution.

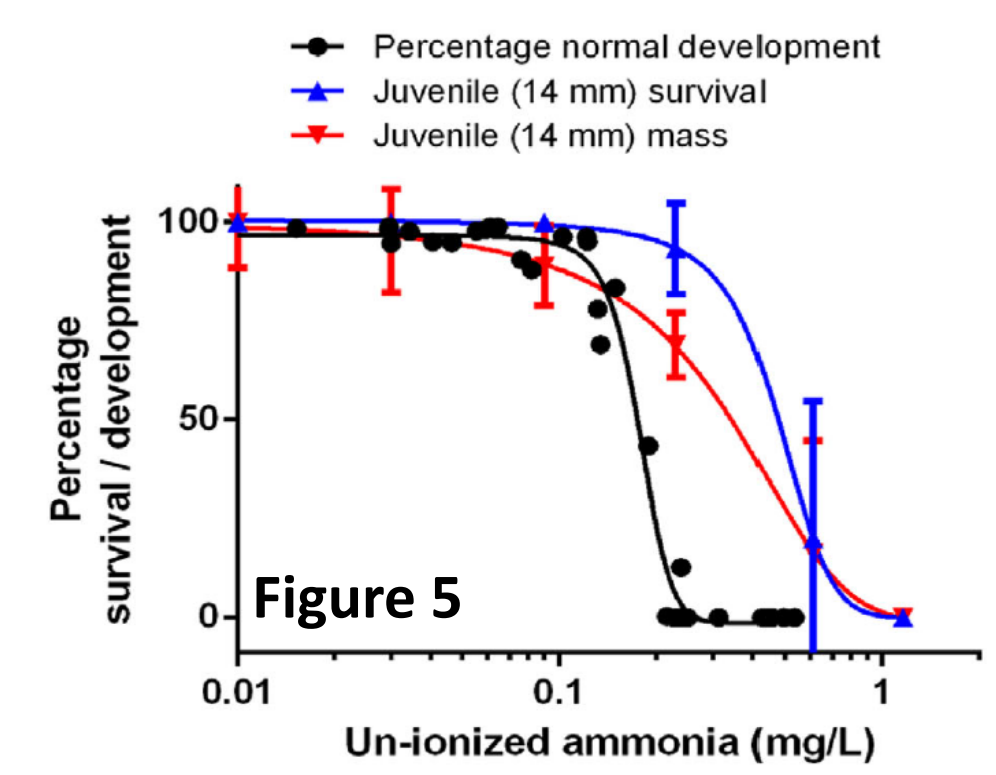
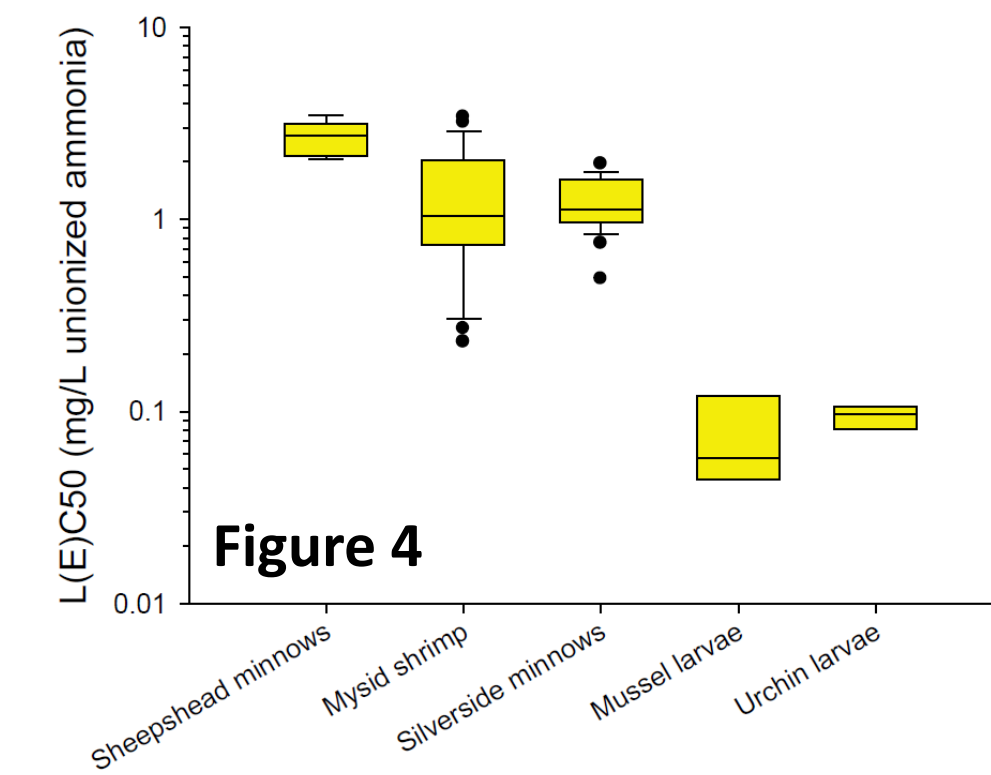
## Results

- Elutriate TREs provided robust evidence for toxicity caused by ammonia. Toxicity correlated with un-ionized ammonia (Fig.2). Sediment purging before elutriate preparation did not alter metals and removed toxicity. Zeolite and pH6.5 adjusted elutriates eliminated ammonia toxicity (Fig.4).



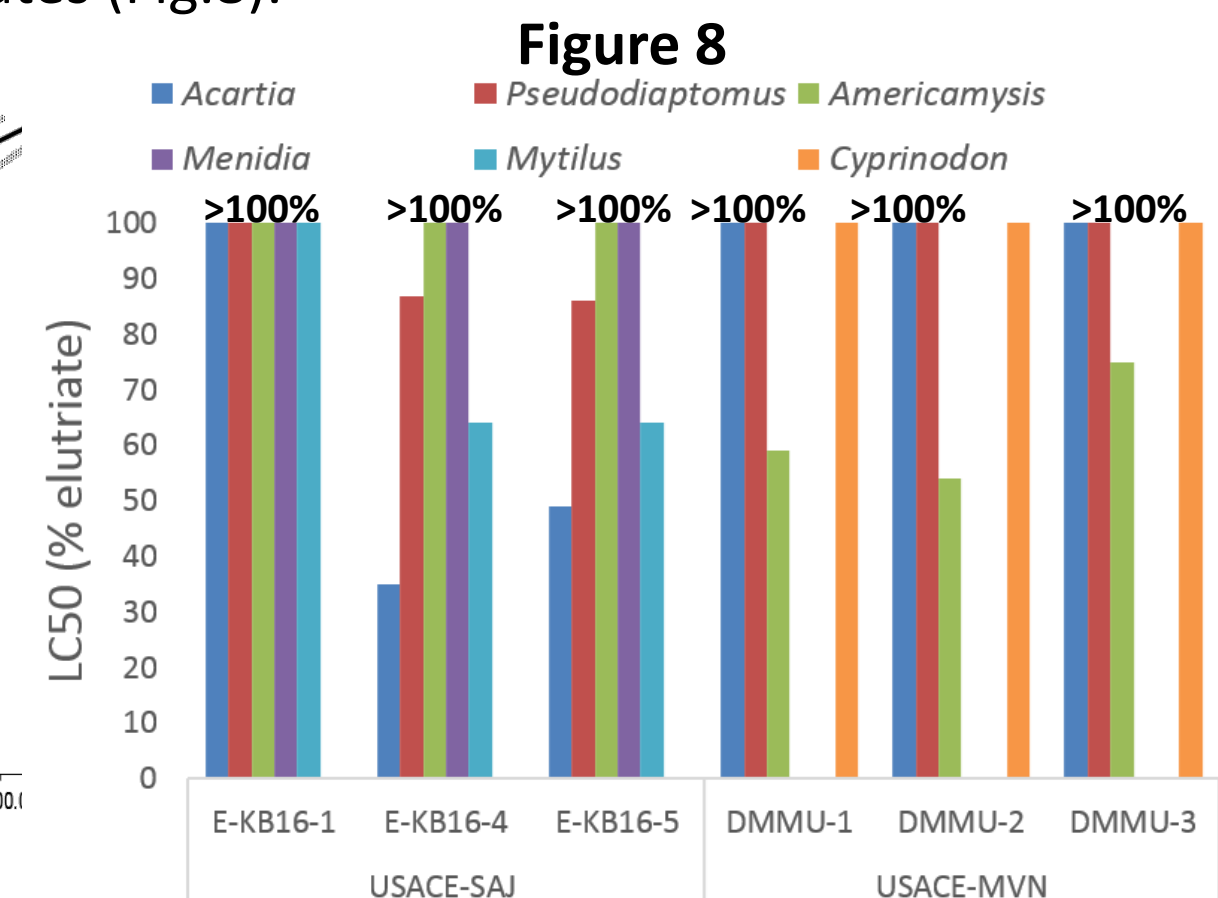
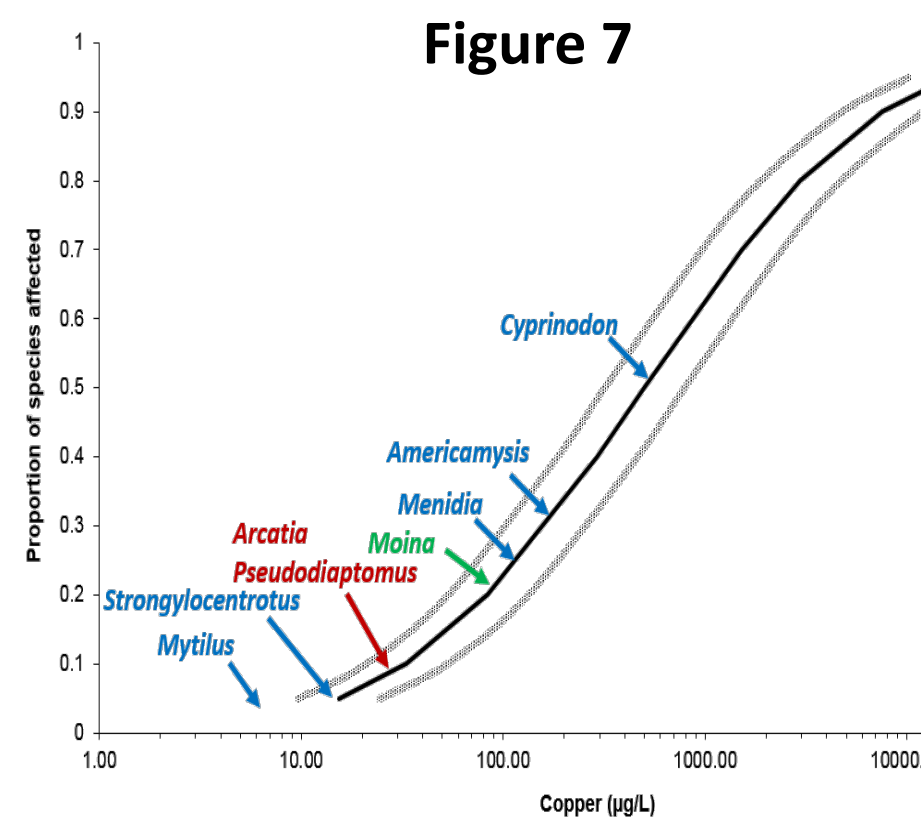
- Alternative application factors developed for ammonia

- Test organism sensitivity to ammonia varies dramatically (Fig.4)
- 48h mussel embryo development was more sensitive than 21d exposed juvenile mussels (Fig.5). Acute-to-chronic data were used to propose ammonia factors (survival: 0.05-0.1; development: 0.2; Kennedy *et al.*, 2016a)



- Copepod relative sensitivity

- Methods using holo-zooplankton copepods were successful and sensitive to Cu (Fig.6,7), sensitive to elutriates (Fig.8).



## Conclusions and path forward

- TREs provided strong evidence ammonia causes the toxicity in elutriate tests.
- Mussel/urchin embryo tests are highly sensitive to ammonia and are not holo-zooplankton. Copepods are holo-zooplankton, sensitive to Cu, less confounded by ammonia, and more relevant for risk-informed DM management decisions.
- Future work involves additional ammonia and a metal (Cd) testing and developing and standardizing an acute copepod elutriate toxicity test method