2015 Bainbridge Basin Marine Sediment Monitoring

Sediment Toxicity Data Summary

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Results and Statistical Summaries

Amphipod Survival

Results of amphipod survival tests for the 33 sediment samples for the 2015 Urban Bays survey of the Bainbridge Basin.

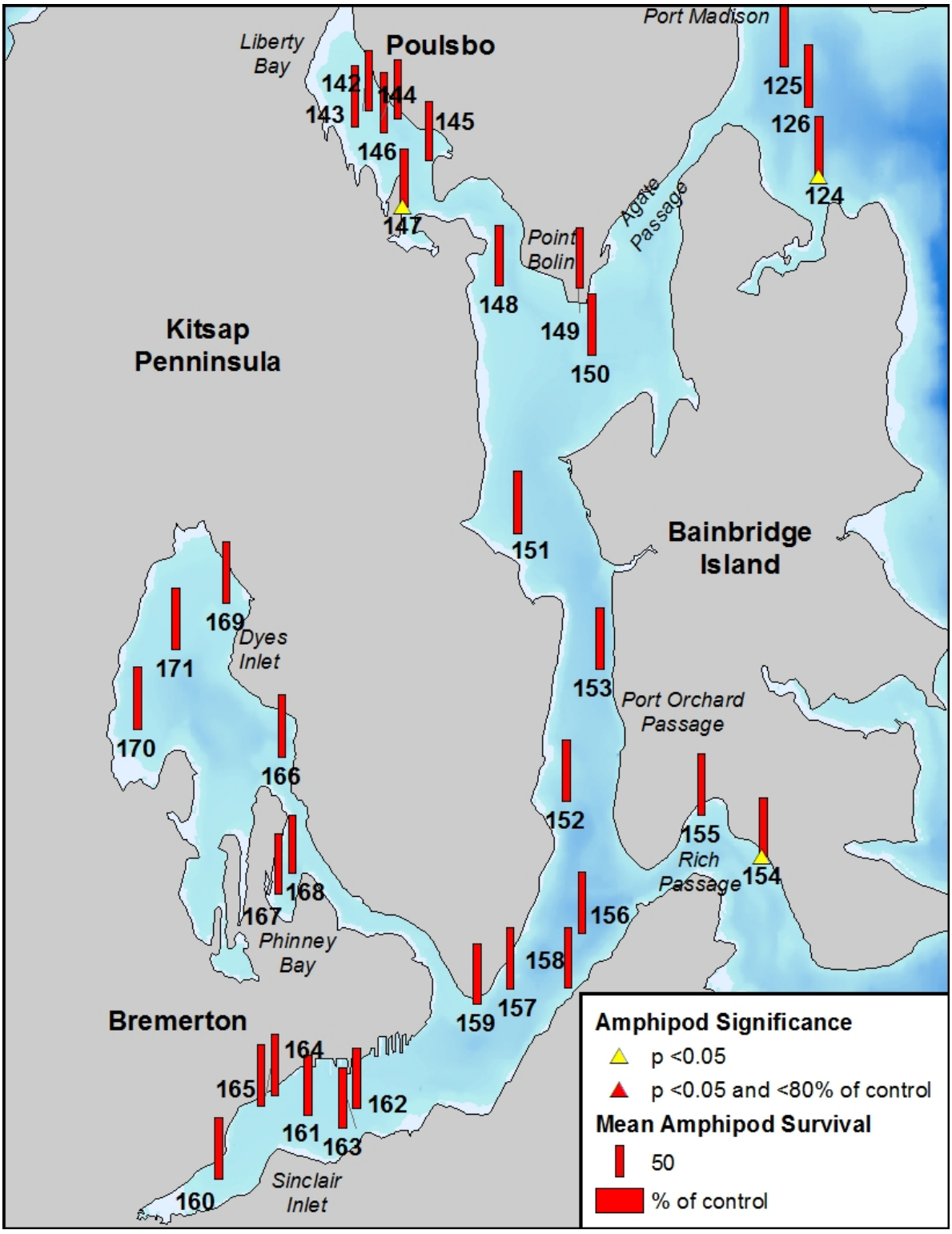
Tests were performed with *Eohaustorius estuarius*.

Data are expressed as mean percent survival and as percentage of control.

* = Results statistically significant (t-test, α = 0.05).
** = Results statistically significant and mean survival <80% of control.

Sample	Location	Mean amphipod survival (%)	Mean amphipod survival as % of control	Statistical significance
124	Port Madison	96.0	96.0	*
125	Port Madison	97.0	97.0	
126	Port Madison	100.0	100.0	
142	Liberty Bay	99.0	99.0	
143	Liberty Bay	100.0	100.0	
144	Liberty Bay	97.0	97.0	
145	Liberty Bay	97.0	97.0	
146	Liberty Bay	98.0	98.0	
147	Liberty Bay	94.0	94.0	*
148	Southeast of Keyport	99.0	99.0	
149	North Port Orchard, Pt. Bolin	98.0	98.0	
150	North Port Orchard	99.0	99.0	
151	North Port Orchard, E. of Brownsville	100.0	100.0	
152	Port Orchard, Illahee	100.0	100.0	
153	Port Orchard	100.0	100.0	
154	Rich Pass, Pleasant Beach	97.0	97.0	*
155	Rich Pass, Lynwood Center	100.0	100.0	
156	South Port Orchard	100.0	100.0	
157	South Port Orchard, East Bremerton	99.0	99.0	
158	South Port Orchard	98.0	98.0	
159	South Port Orchard, Pt. Herron	98.0	98.0	
160	Sinclair Inlet	98.0	98.0	

Sample	Location	Mean amphipod survival (%)	Mean amphipod survival as % of control	Statistical significance
161	Sinclair Inlet	99.0	99.0	
162	Sinclair Inlet	98.0	98.0	
163	Sinclair Inlet	99.0	99.0	
164	Sinclair Inlet	100.0	100.0	
165	Sinclair Inlet	99.0	99.0	
166	Dyes Inlet, Tracyton	100.0	100.0	
167	Phinney Bay	98.0	98.0	
168	Phinney Bay	94.0	94.0	
169	Dyes Inlet, SE of Silverdale	100.0	100.0	
170	Dyes Inlet, North Chico Bay	100.0	100.0	
171	Dyes Inlet	99.0	99.0	



Spatial patterns in toxicity determined with the amphipod *Eohaustorius estuarius* (control-corrected % survival) for the 2015 Urban Bays Monitoring Program.

The numbers on the map are the station identifications.

Urchin Fertilization

Results of sea urchin fertilization tests in undiluted porewaters from the 33 sediment samples for the 2015 Urban Bays Monitoring Program.

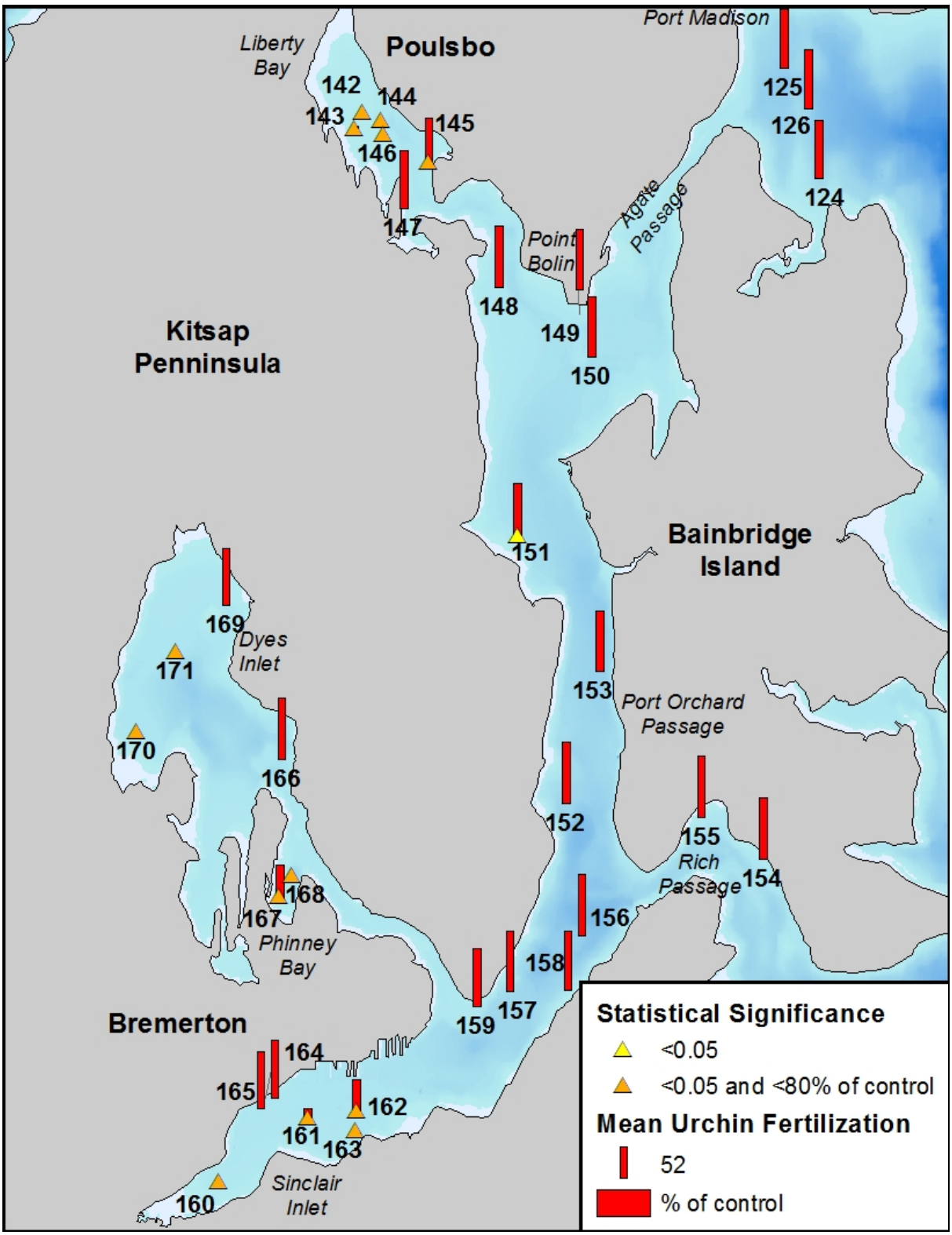
Tests were performed with *Strongylocentrotus purpuratus*.

Data are expressed as mean percent fertilization and as percentage of control response.

* = Results statistically significant (t-test, α = 0.05).
** = Results statistically significant and mean survival <80% of control.

Station	Location	100% porewater		
		Mean fertilization (%)	Mean fertilization as % of control	Statistical significance
124	Port Madison	96.0	98.2	
125	Port Madison	97.8	100.0	
126	Port Madison	97.8	100.0	
142	Liberty Bay	0.0	0.0	**
143	Liberty Bay	3.0	3.1	**
144	Liberty Bay	0.0	0.0	**
145	Liberty Bay	74.4	76.1	**
146	Liberty Bay	0.0	0.0	**
147	Liberty Bay	96.2	98.4	
148	Southeast of Keyport	99.4	104.9	
149	North Port Orchard, Pt. Bolin	98.0	103.4	
150	North Port Orchard	96.2	101.5	
151	North Port Orchard, E. of Brownsville	84.4	89.0	*
152	Port Orchard, Illahee	99.0	104.4	
153	Port Orchard	96.8	102.1	
154	Rich Pass, Pleasant Beach	98.8	104.2	
155	Rich Pass, Lynwood Center	98.8	104.2	
156	South Port Orchard	99.4	104.9	
157	South Port Orchard, East Bremerton	99.4	101.6	

Station	Location	100% porewater		
		Mean fertilization (%)	Mean fertilization as % of control	Statistical significance
158	South Port Orchard	98.6	100.8	
159	South Port Orchard, Pt. Herron	97.2	99.4	
160	Sinclair Inlet	0.0	0.0	**
161	Sinclair Inlet	0.2	0.2	**
162	Sinclair Inlet	53.0	54.2	**
163	Sinclair Inlet	16.4	17.3	**
164	Sinclair Inlet	93.2	98.3	
165	Sinclair Inlet	93.6	95.7	
166	Dyes Inlet, Tracyton	97.8	103.2	
167	Phinney Bay	53.4	56.3	**
168	Phinney Bay	0.0	0.0	**
169	Dyes Inlet, SE of Silverdale	94.6	96.7	
170	Dyes Inlet, North Chico Bay	0.0	0.0	**
171	Dyes Inlet	0.0	0.0	**



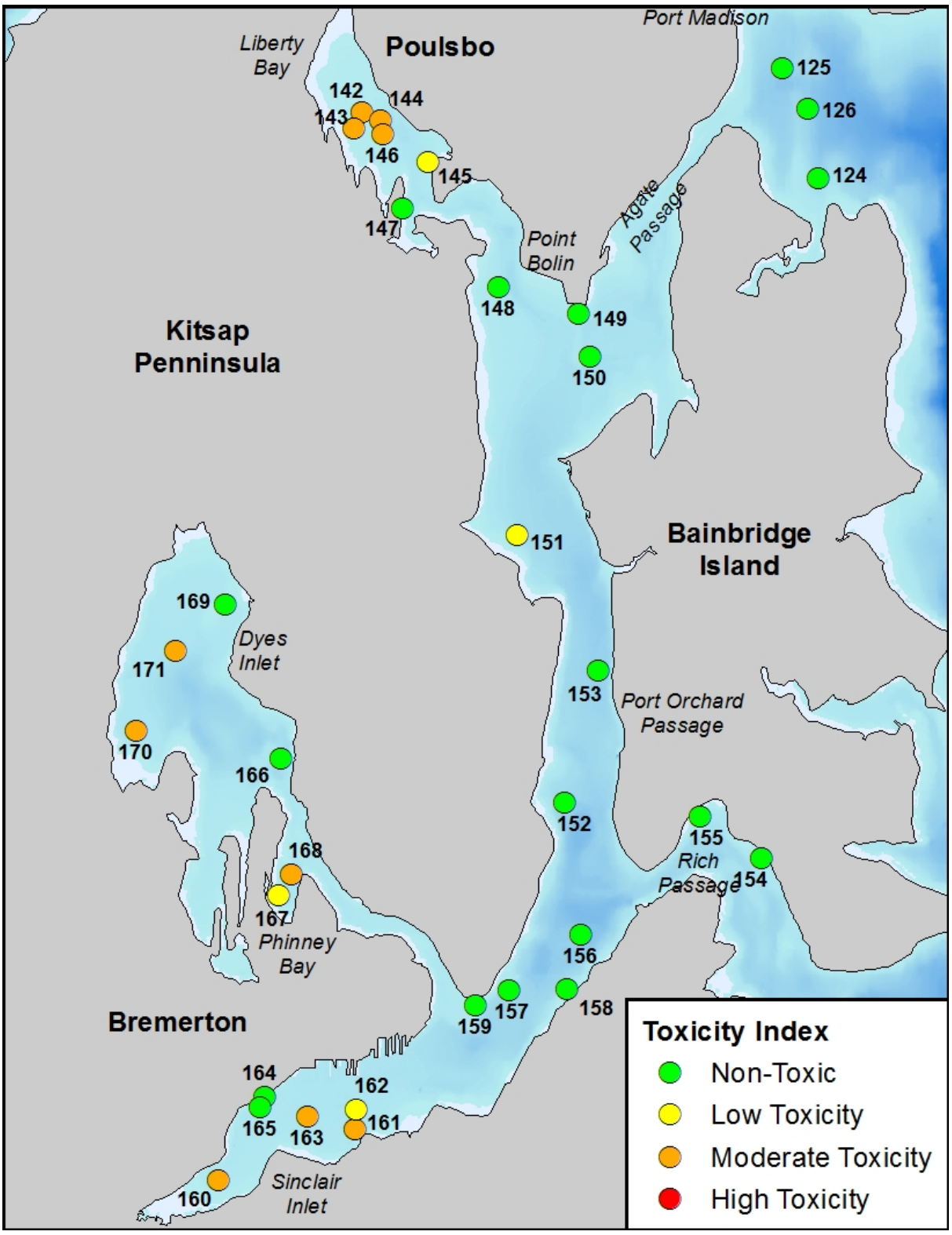
Spatial patterns in toxicity determined with the sea urchin *Strongylocentrotus purpuratus* (control-corrected % fertilization) for the 2015 Urban Bays Monitoring Program.

The numbers on the map are the station identifications.

Toxicity

Incidence and spatial extent of toxicity in the 2015 Urban Bays Monitoring Program, as measured with the Sediment Toxicity Index.

Sediment Toxicity Index Category	Stations		Area	
	No.	(%)	km^2	(%)
Bainbridge Basin	33	(100.0)	81.9	(100.0)
Non-Toxic	19	(57.6)	60.6	(74.0)
Low Toxicity	4	(12.1)	6.5	(7.9)
Moderate Toxicity	10	(30.3)	14.8	(18.1)
High Toxicity	0	(0.0)	0.0	(0.0)



Spatial patterns in Sediment Toxicity Index in the 2015 Urban Bays Monitoring Program. *The numbers on the map are the station identifications.*

Comparisons over Time

Changes in sediment toxicity from 1998 to 2015 in the Bainbridge Basin surveys.

Year sampled	Numbers of samples	Sea Urchin Fertilization Test		Amphipod Survival Test		
		Incidence (# of stations)	Spatial extent (% of area)	Test Species	Incidence (# of stations)	Spatial extent (% of area)
1998	33	6.06	2.53	*Ampelisca abdita*	3.03	1.30
2009	33	33.33	19.68	*Eohaustorius estuarius*	3.03	2.42
2015	33	39.39	21.86	*Eohaustorius estuarius*	0	0.0

Summary of pairwise statistical comparisons[1,2] of toxicity measured for the 1998 PSAMP/NOAA, 2009 Urban Waters, and 2015 Urban Bays Monitoring Programs.

↓ = decrease; ↑ = increase; -- = no change

Parameter	Change from 1998 to 2009	Change from 1998 to 2015	Change from 2009 to 2015
Toxicity Tests			
Amphipod Survival	--	--	--
Sea Urchin Fertilization	↓	↓	↓
Sediment Toxicity Index			
Toxicity Index	↓	↓	--

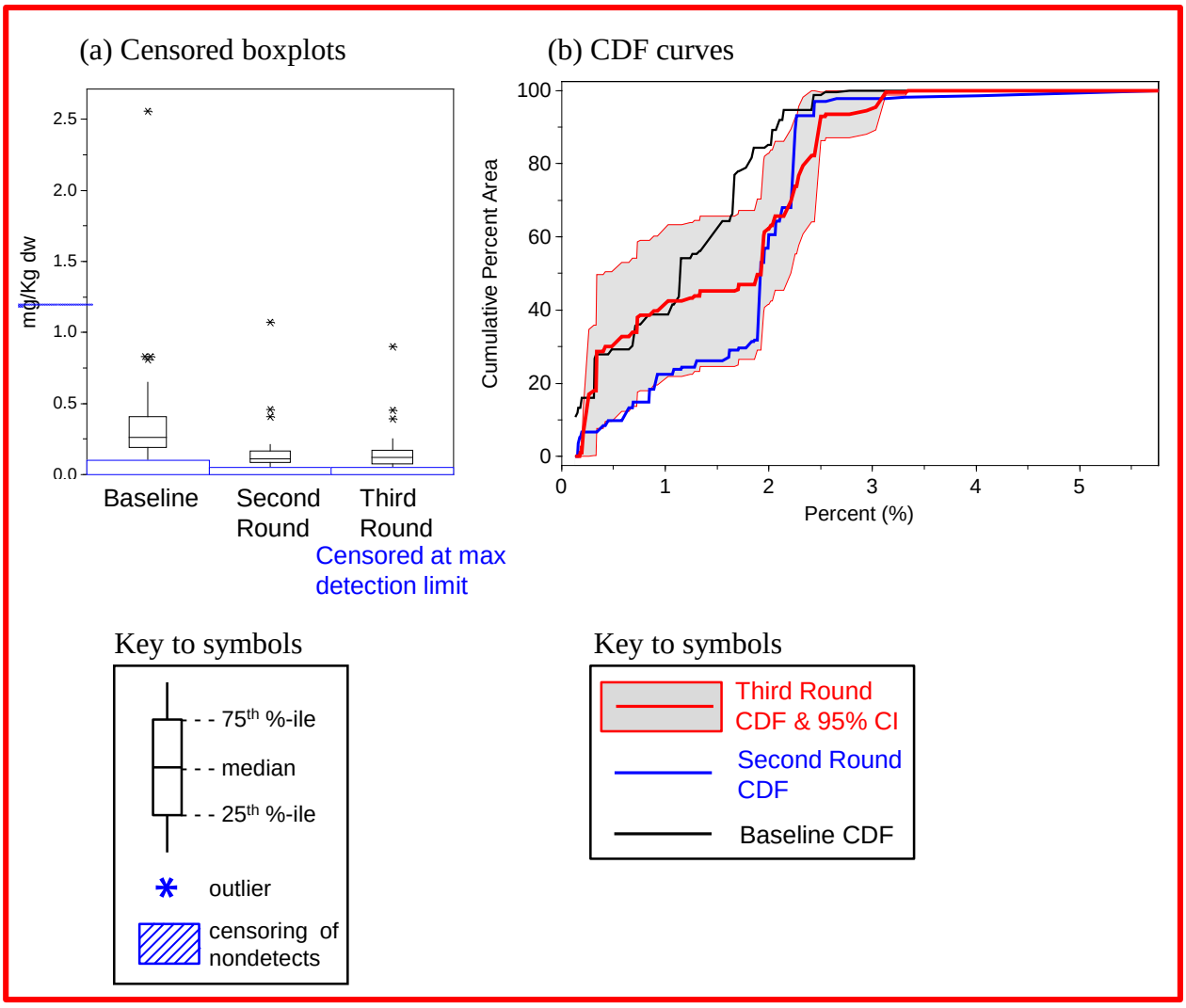
[1] Medians (unweighted) compared by Kruskal-Wallis test (α = 0.05).

[2] CDFs (weighted) compared by Wald F test (α = 0.05).

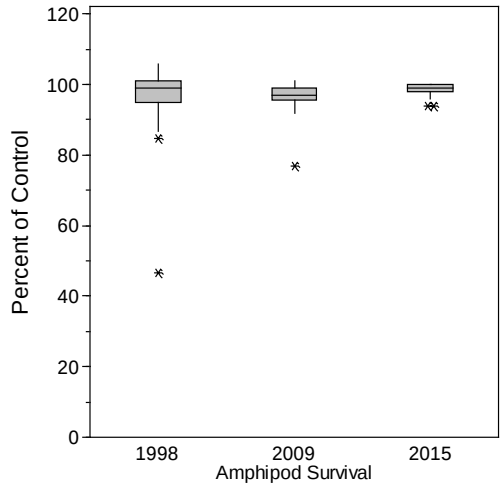
Comparison of amphipod survival test results, sea urchin fertilization test results, and Sediment Toxicity Index values calculated for the in the 1998, 2009, and 2015 surveys of Bainbridge Basin.

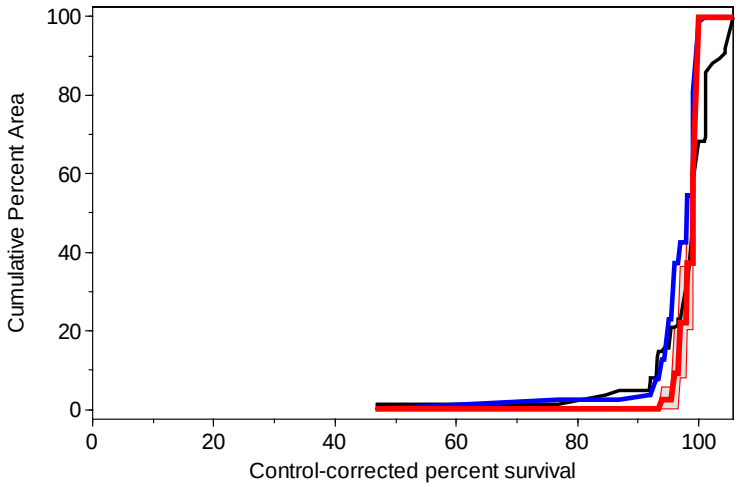
The graphical displays include two types of graphs:

(a) Censored boxplots display the distributions of the data unweighted by sample area.
(b) Cumulative distribution function (CDF) curves display the cumulative distributions of the data weighted by sample area. Confidence intervals are shown for 2015 CDF curves only.

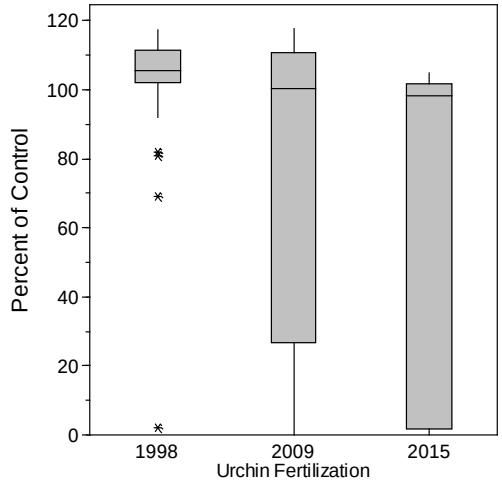


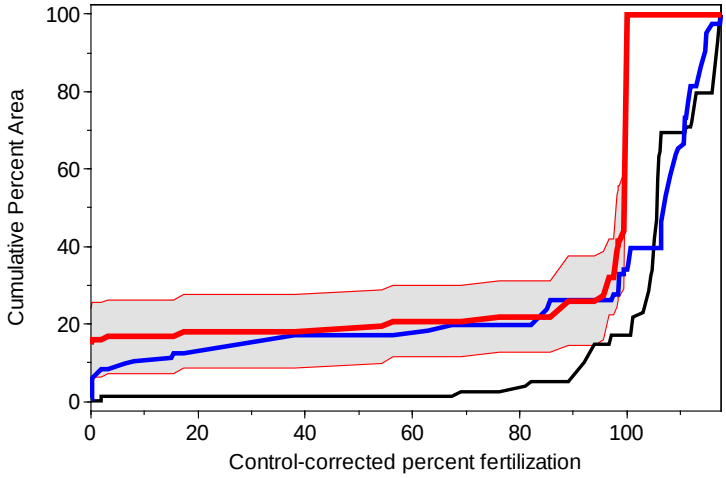
Amphipod Survival (%)



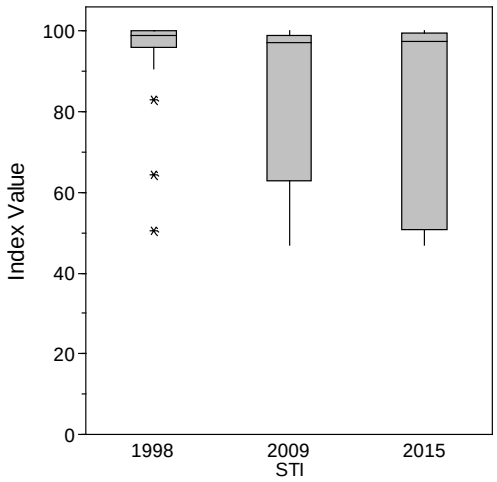


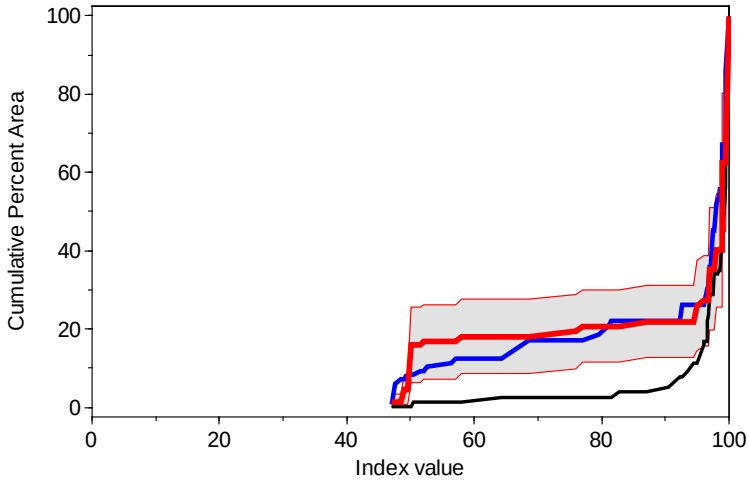
Urchin Fertilization (%)





Sediment Toxicity Index (STI)





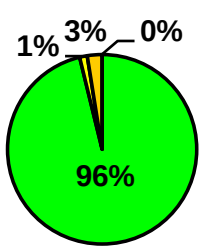
Comparison of Sediment Toxicity Index Categories by Year

Estimated spatial extent (percent of area) and 95% confidence intervals for each of the STI categories for the Bainbridge Basin in 2015, compared to 1998 and 2009.

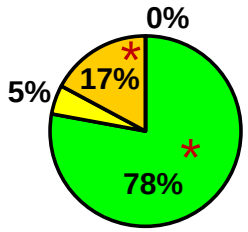
None of the changes were statistically significant (Kincaid, 2005, α = 0.05).

NA = not applicable (cannot be computed)

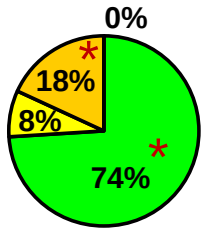
Sediment Toxicity Index Category	1998			2009			2015		
	Estimate	Confidence Limit		Estimate	Confidence Limit		Estimate	Confidence Limit	
		Lower	Upper		Lower	Upper		Lower	Upper
Non-Toxic	96.19	70.64	86.86	77.92	53.06	74.52	74.02	49.94	71.26
Low Toxicity	1.29	0.00	2.82	4.93	0.03	8.05	7.88	0.21	12.69
Moderate Toxicity	2.52	0.00	4.39	17.15	4.39	23.69	18.10	6.58	23.06
High Toxicity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



1998



2009*



2015*

Spatial and temporal patterns in spatial extent (percent of area, shown in pie charts) for the Toxicity Index categories in the Bainbridge Basin.

*Statistically significant from 1998 (Kincaid, 2005, α = 0.05).

Comparisons with the Region

Incidence and spatial extent of sediment toxicity in sea urchin fertilization test and amphipod survival test in Bainbridge Basin, Central Puget Sound, and all of Puget Sound.

Region	Year(s) sampled	Numbers of samples	Sea Urchin Fertilization Test		Amphipod Survival Test		
			Incidence (% of stations)	Spatial extent (% of area)	Test Species	Incidence (% of stations)	Spatial extent (% of area)
Bainbridge Basin	1998	33	6.06	2.53	*Ampelisca abdita*	3.03	1.30
	2009	33	33.33	19.68	*Eohaustorius estuarius*	3.03	2.42
	2015	33	39.39	21.86	*Eohaustorius estuarius*	0	0.0
Central Puget Sound	1998-1999	128	7.8	0.6	*Ampelisca abdita*	0.8	0.2
	2008-2009	80	10	4.6	*Eohaustorius estuarius*	5.0	3.0
All of Puget Sound	1997-2003	381	10.2	4.5	*Ampelisca abdita, Eohaustorius estuarius*	0.3	0.05
	2004-2014	368	8.7	6.7	*Eohaustorius estuarius*	2.7	2.3

Incidence and spatial extent of sediment toxicity in Bainbridge Basin, Central Puget Sound, and all of Puget Sound, as measured with the Sediment Toxicity Index.

Sediment Toxicity Index Category	Baseline				Second Round				Third Round			
	Stations		Area		Stations		Area		Stations		Area	
	No.	(%)	km^2	(%)	No.	(%)	km^2	(%)	No.	(%)	km^2	(%)
Bainbridge Basin	33	(100.0)	81.9	(100.0)	33	(100.0)	81.9	(100.0)	33	(100.0)	81.9	(100.0)
Non-Toxic	30	(90.9)	78.7	(96.2)	21	(63.6)	63.8	(77.9)	19	(57.6)	60.6	(74.0)
Low Toxicity	1	(3.0)	1.1	(1.3)	3	(9.1)	4.1	(4.9)	4	(12.1)	6.5	(7.9)
Moderate Toxicity	2	(6.1)	2.1	(2.5)	9	(27.3)	14.0	(17.2)	10	(30.3)	14.8	(18.1)
High Toxicity	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
Central Sound	128	(100.0)	683.9	(100.0)	80	(100.0)	667.4	(100.0)				
Non-Toxic	113	(88.3)	677.8	(99.1)	54	(67.5)	504.7	(75.6)				
Low Toxicity	9	(7.0)	3.1	(0.5)	19	(23.8)	135.9	(20.4)				
Moderate Toxicity	6	(4.7)	3.0	(0.4)	3	(3.8)	21.1	(3.2)				
High Toxicity	0	(0.0)	0.0	(0.0)	4	(5.0)	5.7	(0.9)				
Total Study Area	381	(100.0)	2294.1	(100.0)	368	(100.0)	2207.5	(100.0)				
Non-Toxic	335	(87.9)	2182.3	(95.1)	291	(79.1)	1774.9	(80.4)				
Low Toxicity	23	(6.0)	49.84	(2.2)	54	(14.7)	324.7	(14.7)				
Moderate Toxicity	23	(6.0)	61.93	(2.7)	16	(4.3)	69.9	(3.2)				
High Toxicity	0	(0.0)	0	(0.0)	7	(1.9)	38.0	(1.7)				

Laboratory Reports

Amphipod survival toxicity test lab report

Urchin fertilization toxicity test lab report