Bioretention to reduce the toxicity of urban stormwater runoff to coho salmon

RSMP effectiveness monitoring study

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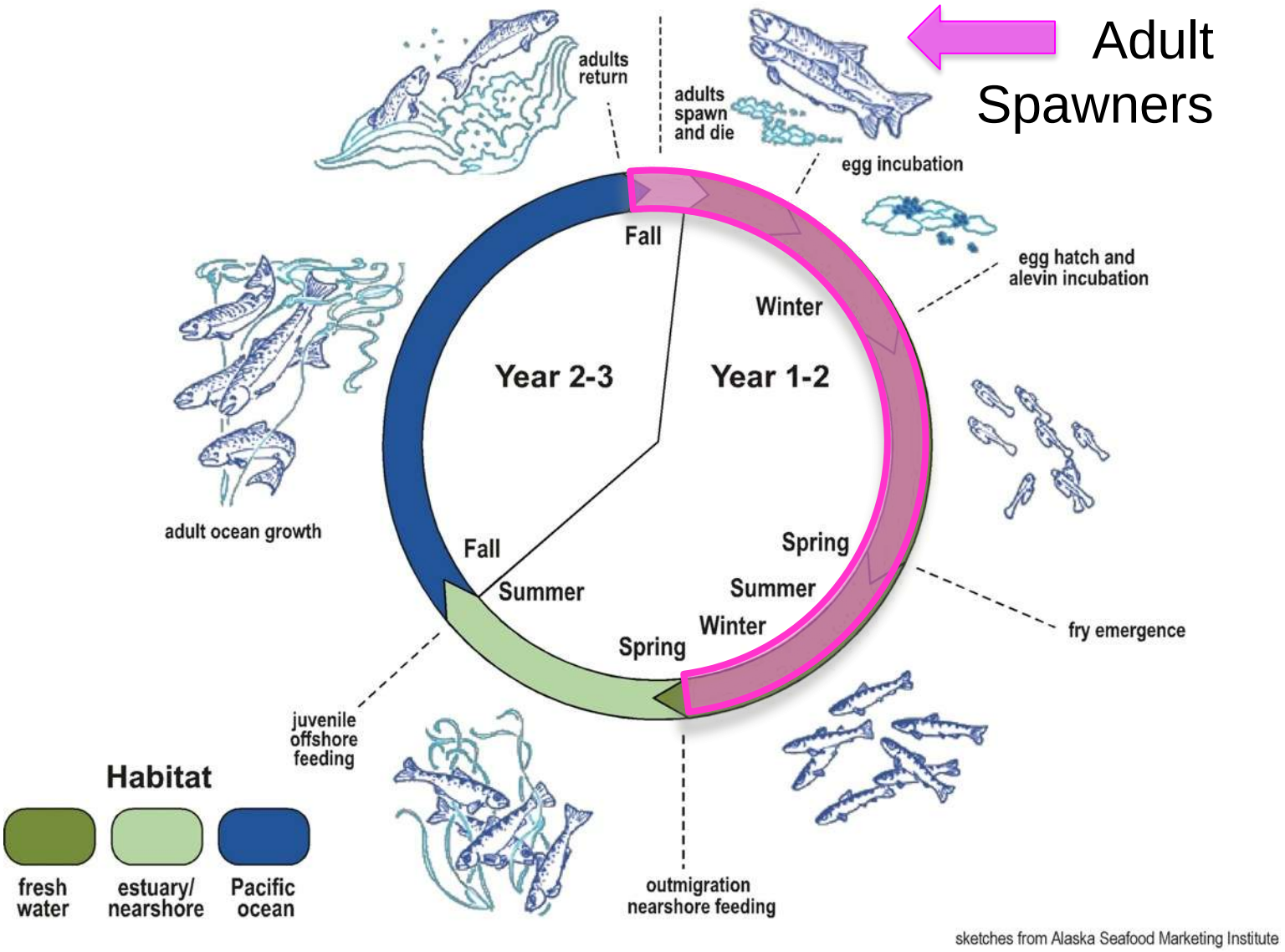
WSU – Puyallup Research & Extension Center
Suquamish Tribe

Stormwater Work Group Meeting June 3 2015 Presented by J. McIntyre WSU

Impact of Stormwater on Coho Salmon



sketches from Alaska Seafood Marketing Institute

Coho spawner mortality is widespread and recurrent in urban creeks

67%

Longfellow Creek 2003

Des Moines Creek 2004

63%

72%

Longfellow Creek 2005

Longfellow Creek 2012

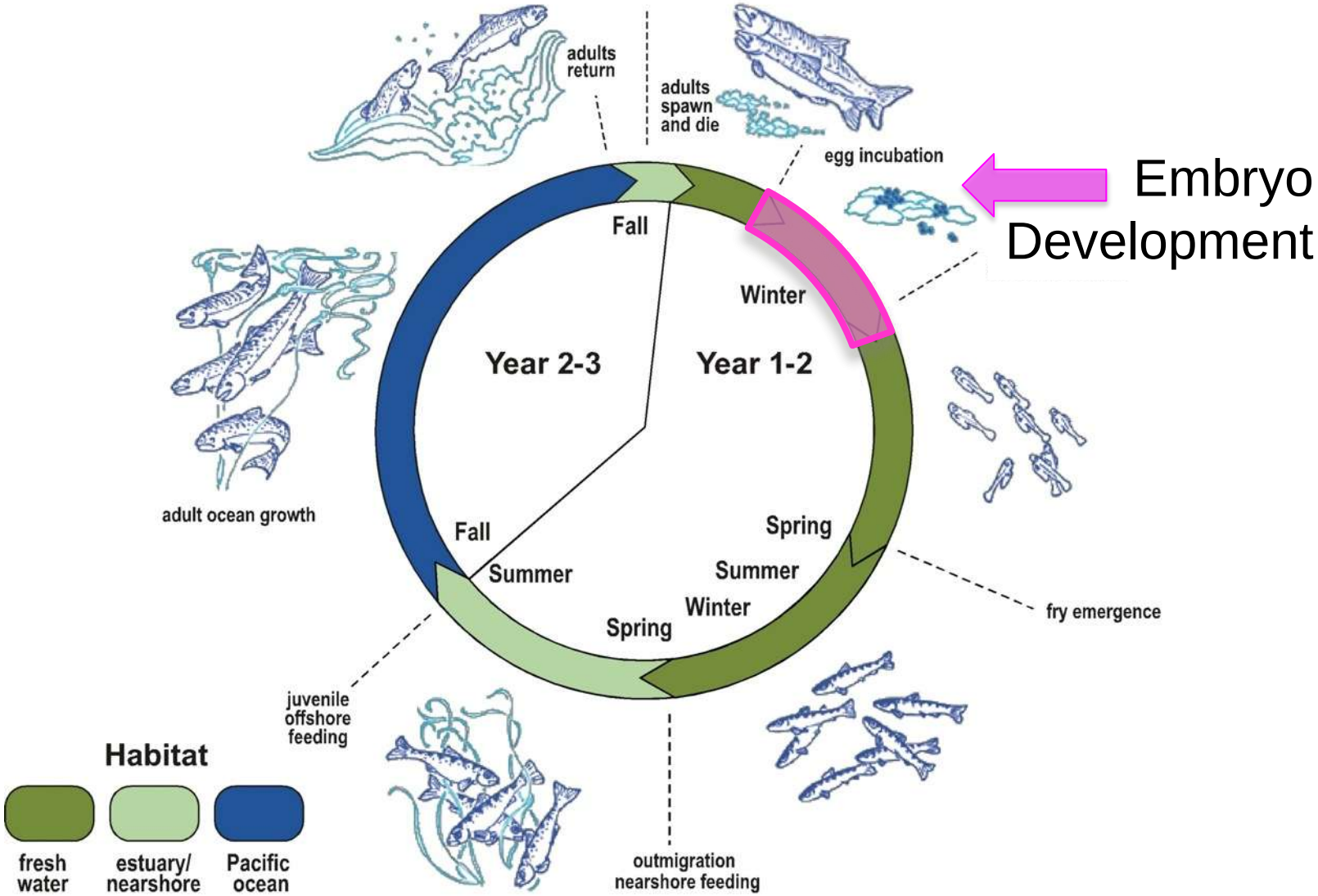
84%

A common suite of PSM symptoms

Longfellow Creek 2002

Longfellow Creek 2005

Impacts of Stormwater on Coho Salmon

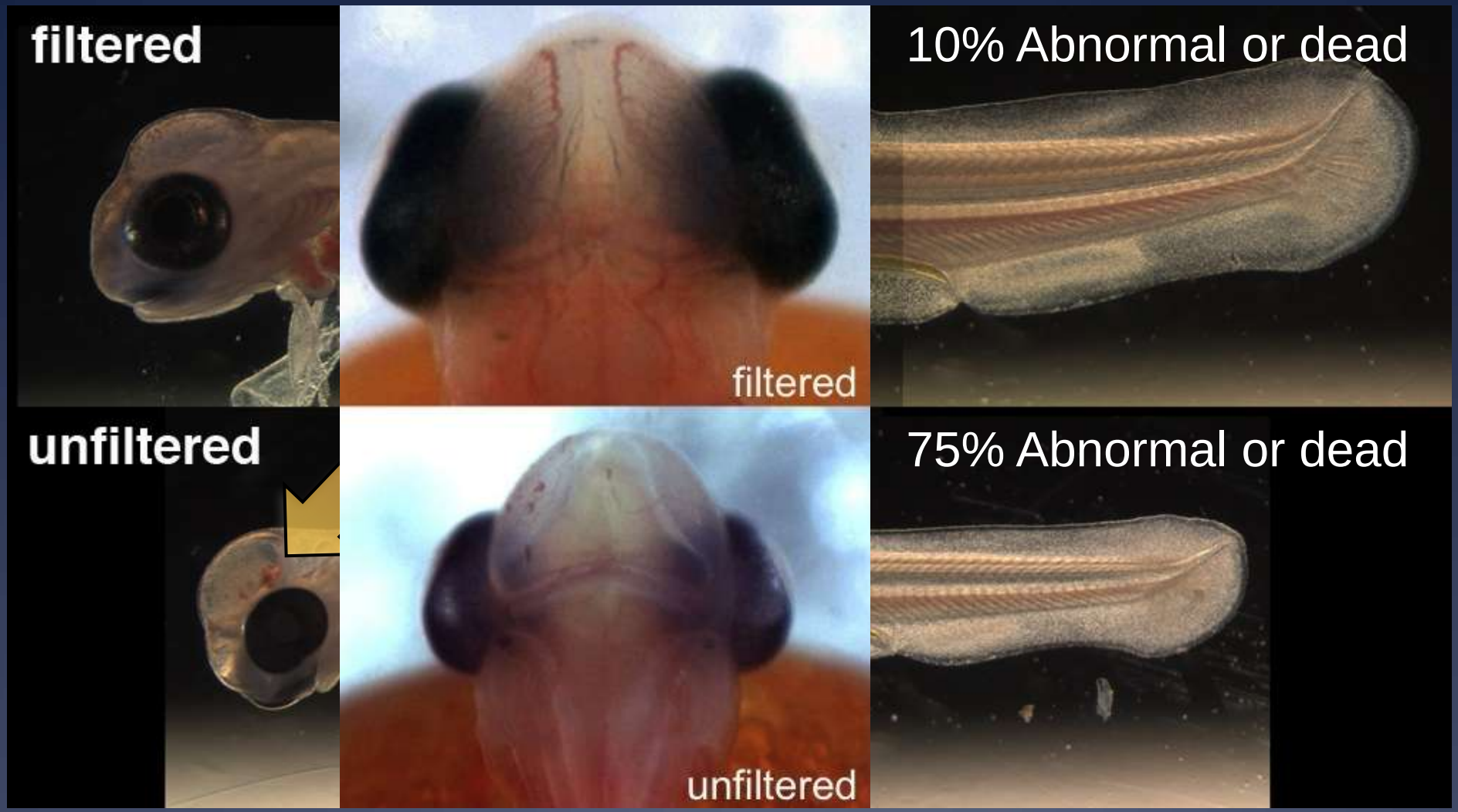


sketches from Alaska Seafood Marketing Institute

Experimental filtration of urban runoff

Stormwater research on urban Longfellow Creek, Seattle

Urban runoff is toxic to coho embryos



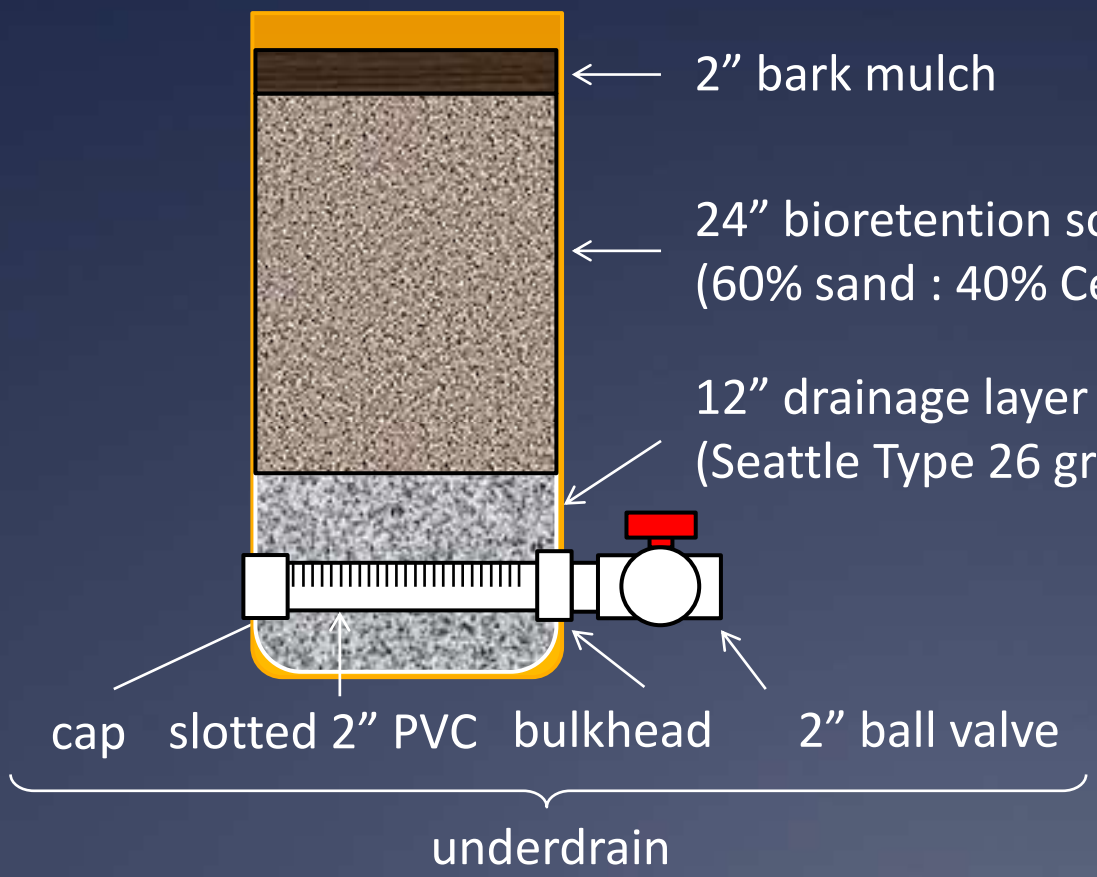
Longfellow Creek experimental facility, ~ 50 days of development

Can bioretention prevent impacts to coho?

Can bioretention prevent coho PSM?

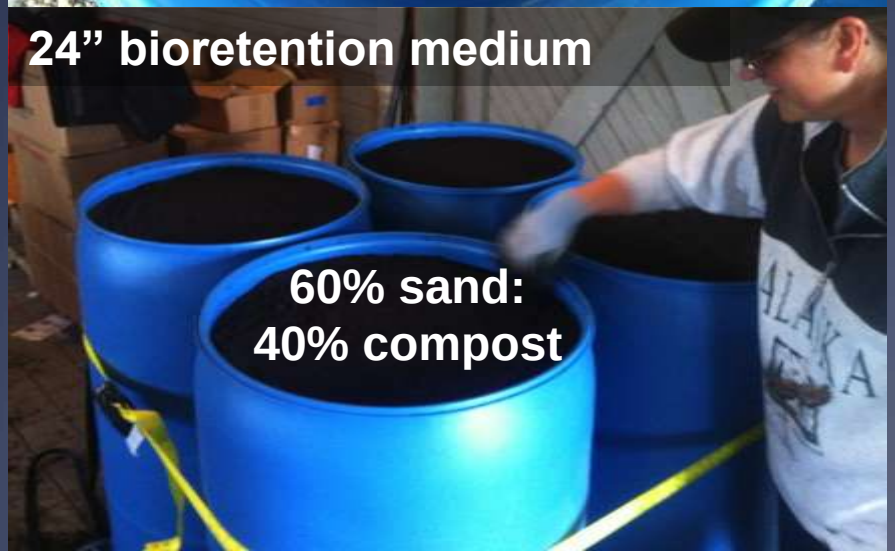
1 Bioretention cell construction (Sep 2014)

Washington State Department of Ecology
Low Impact Development Technical Guidance Manual 2012



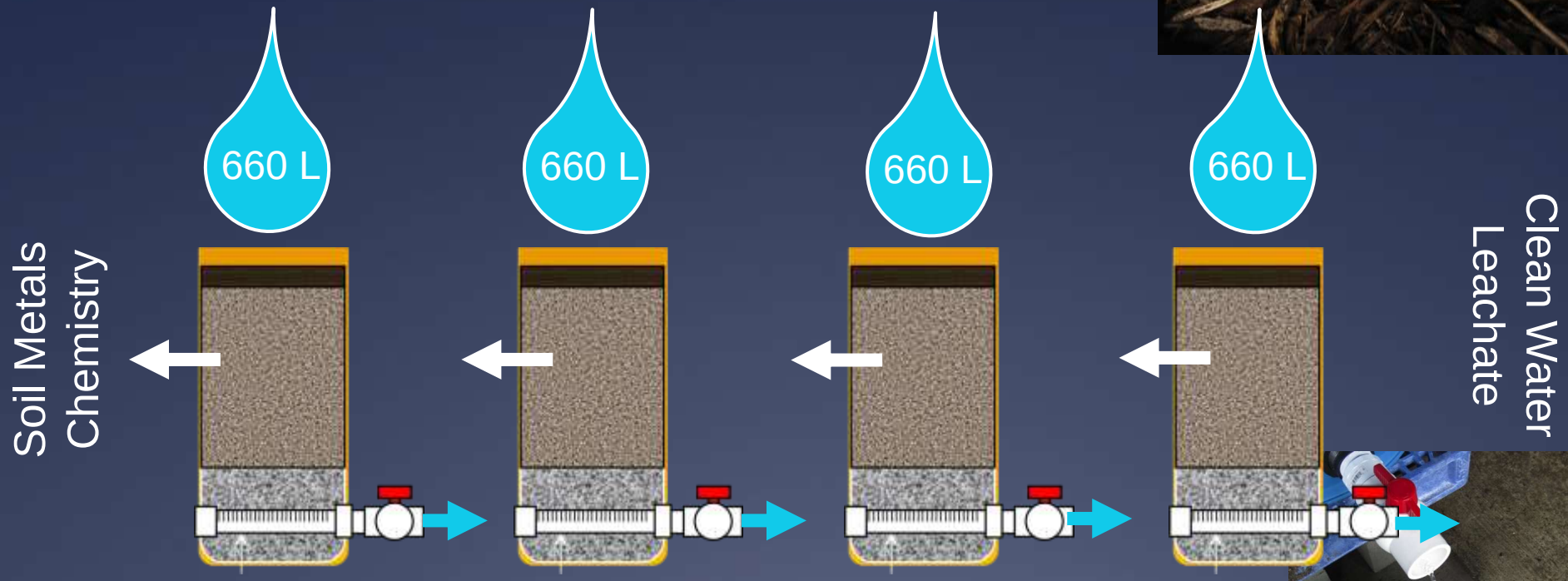
Treatment Rate = 3 mm/min

1 Bioretention cell construction (Sep 2014)



1 Bioretention cell conditioning (Oct 2014)

- Soil metal chemistry (BSM only)
- Clean water leachate (whole system)
  - Conventionals, nutrients, metals



2.1

Bioretention metals soil chemistry

mg/kg dry	LOQ[a]	Cell 1	Cell 2	Cell 3	Cell 4	Mean	SE
As	0.2	2	2	1.9	2.2	2.0	0.1
Cd	0.09	0.11	0.12	0.1	0.1	0.11	0.0
Cr	2	28	28	26	25	27	1
Cu	0.5	21.4	21.1	21.5	22.3	21.6	0.3
Pb	0.09	6.97	7.17	6.6	7.5	7.06	0.19
Ni	0.5	35.9	38.2	38	33.8	36.5	1.0
Ag	0.2	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.0
Zn	4	50	51	49	52	51	1

- Cr at average screening level
- Ni exceeds median background for western States
- Zn exceeds average screening level

2.2 Bioretention Water Chemistry - Conditioning

Category	Parameter	D.L.	Units	Well Water	Filtered Well Water
Microbiological	Fecal Coliform	5	CFU/100 mL	< D.L.	307 (63)
	E. coli	5	CFU/100 mL	< D.L.	287 (56)
Conventionals	pH	0.1	-	7.7 (0.1)	7.3 (0.0)
	TSS	1	mg/L	29 (1)	18 (6)
	SSC	0.2	mg/L	< D.L.	25.3 (0.3)
Demand	TOC	0.5	mg/L	0.5 (0)	32.7 (0.3)
	COD	10	mg/L	< D.L.	89 (6)
	DOC	0.5	mg/L	< D.L.	30.3 (1.2)

2.2 Bioretention Water Chemistry - Conditioning

Category	Parameter	D.L.	Units	Well Water	Filtered Well Water
Minerals	Alkalinity	1	mg CaCO3/L	85 (1)	110 (0)
	Hardness	0.05	mg CaCO3/L	74.00 (1.00)	56.33 (0.33)
	Ca	0.05	mg/L	18.33 (0.33)	14.00 (0.00)
	Mg	0.01	mg/L	6.83 (0.03)	5.17 (0.07)
Nutrients	Ammonia	0.01	mg/L	0.29 (0.02)	1.47 (0.00)
	Total N	0.1	mg/L	0.5 (0.0)	4.7 (0.9)
	Nitrate	0.025	mg/L	< D.L.	2.893 (0.009)
	Ortho-P	0.005	mg/L	0.223 (0.006)	0.205 (0.059)
	Total P	0.005	mg/L	0.251 (0.002)	0.571 (0.014)

2.2 Bioretention Water Chemistry - Conditioning

Category	Parameter	D.L.	Units	Well Water	Filtered Well Water
Dissolved Metals	As	0.02	ug/L	0.14 (0.01)	6.72 (0.04)
	Cd	0.025	ug/L	< D.L.	< D.L.
	Cr	0.05	ug/L	< D.L.	2.07 (0.09)
Not bioavailable at DOC (30 mg/L)	Cu	0.1	ug/L	0.8 (0.1)	12.6 (0.1)
	Pb	0.05	ug/L	0.05 (0.00)	< D.L.
	Ni	0.05	ug/L	0.11 (0.00)	4.82 (0.21)
	Ag	0.05	ug/L	< D.L.	< D.L.
	Zn	0.05	ug/L	1.55 (0.04)	23.37 (1.66)

Highway Stormwater Runoff

Urban highway, Seattle, >60,000 AADT

Grover's Creek facility, Suquamish Tribe

3 Treated effluent on adult coho salmon

3.1

Can bioretention prevent coho PSM?

Clean well water

100% Normal

Untreated runoff

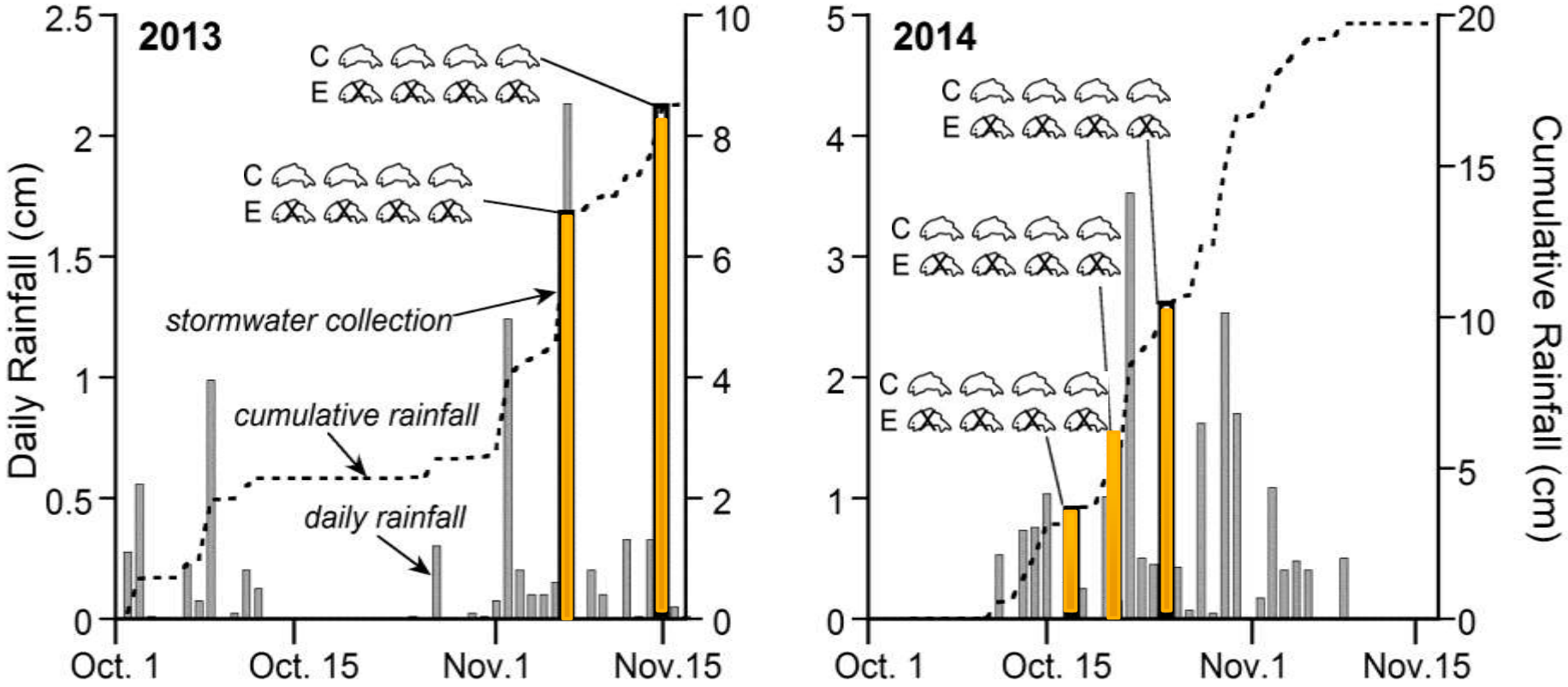
100% Symptomatic

Treated runoff

??????

3.1

Adult coho stormwater collections



Stormwater Runoff Exposure November 18th, 2013

3.1

Bioretention to prevent coho PSM

Study Year	Test Date	Exposure (hours)	Control Water	Untreated Runoff	Treated Runoff
2013	Nov 8	4	100 % Live	50% Dead; 50% Symptomatic	100% Live
2013	Nov 18	24	100% Live	100% Dead	100% Live
2014	Oct 20	24	100% Live	100% Dead	100% Live
2014	Oct 22	24	100% Live	100% Dead	100% Live
2014	Oct 27	24	100% Live	100% Dead	100% Live

- All fish exposed to Untreated Runoff were symptomatic or dead at <24 h
- All Control and Treated fish alive at 24 h

3. Episodic exposure of coho embryos

3.2 Episodic exposure of coho embryos

1 stack / treatment
7 trays / stack
9 cups / tray
130 eggs / cup

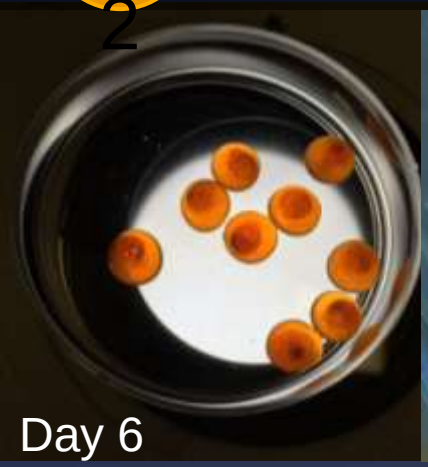
5 treatments
Background: Flowing clean water
Exposures: 24 h recirculated runoff

3.2

Episodic exposure of coho embryos

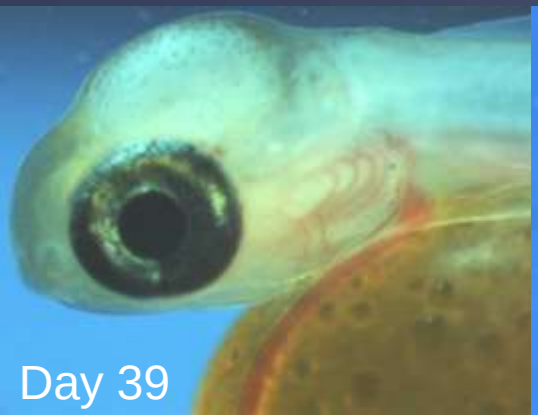
Temperature continuously monitored

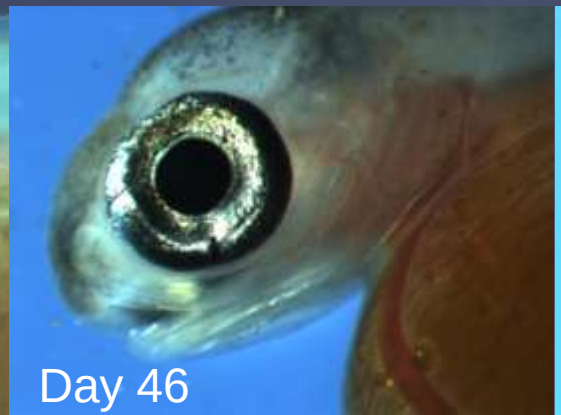
3.2 Episodic exposure of coho embryos



Individual morphometrics
- Length
- Eye Area
- Developmental stage
- Cardiovascular abnormalities

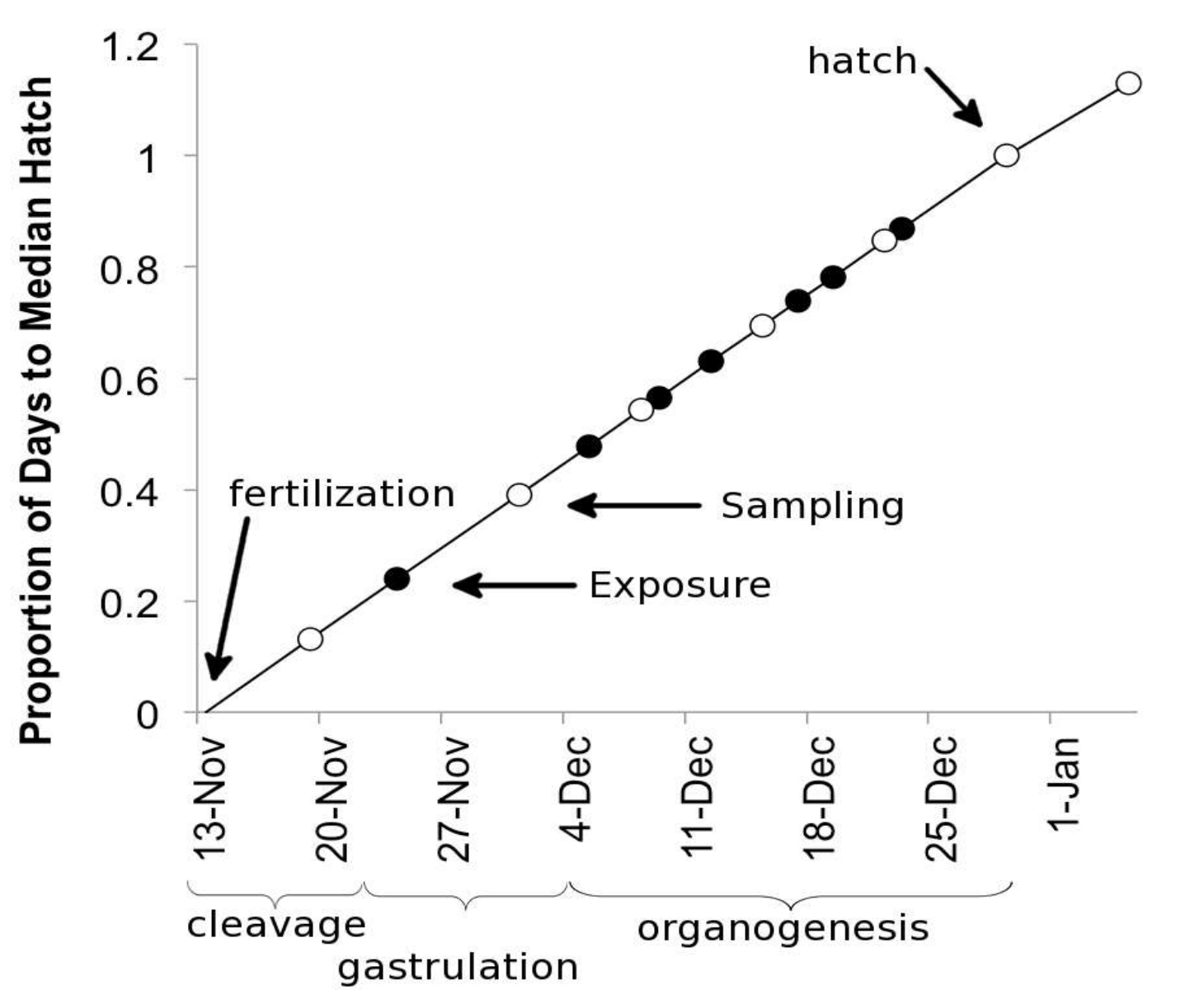
Tissue Sampling
- Molecular analyses
- PAH accumulation
- Fixed





3.2

Episodic exposure of coho embryos



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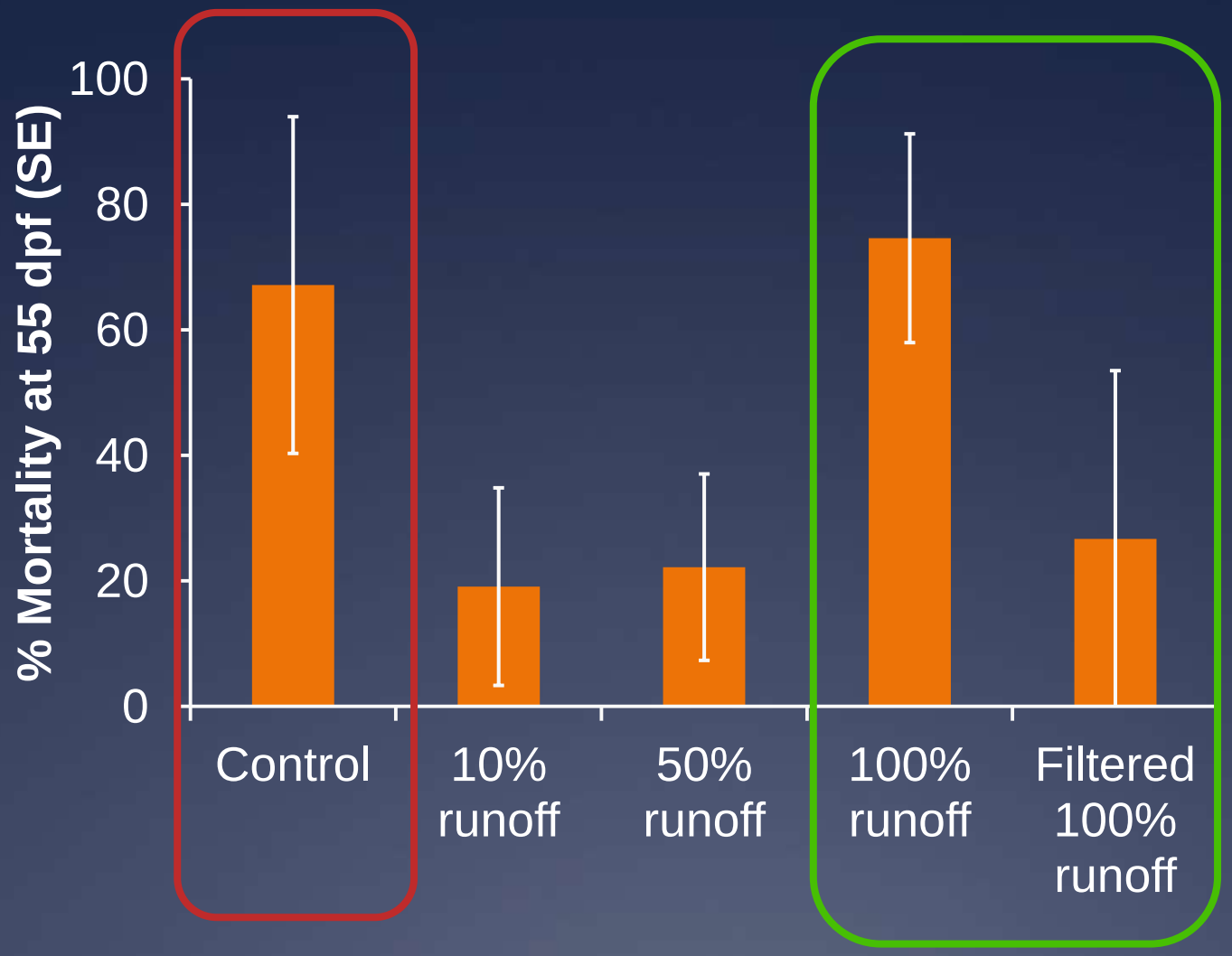
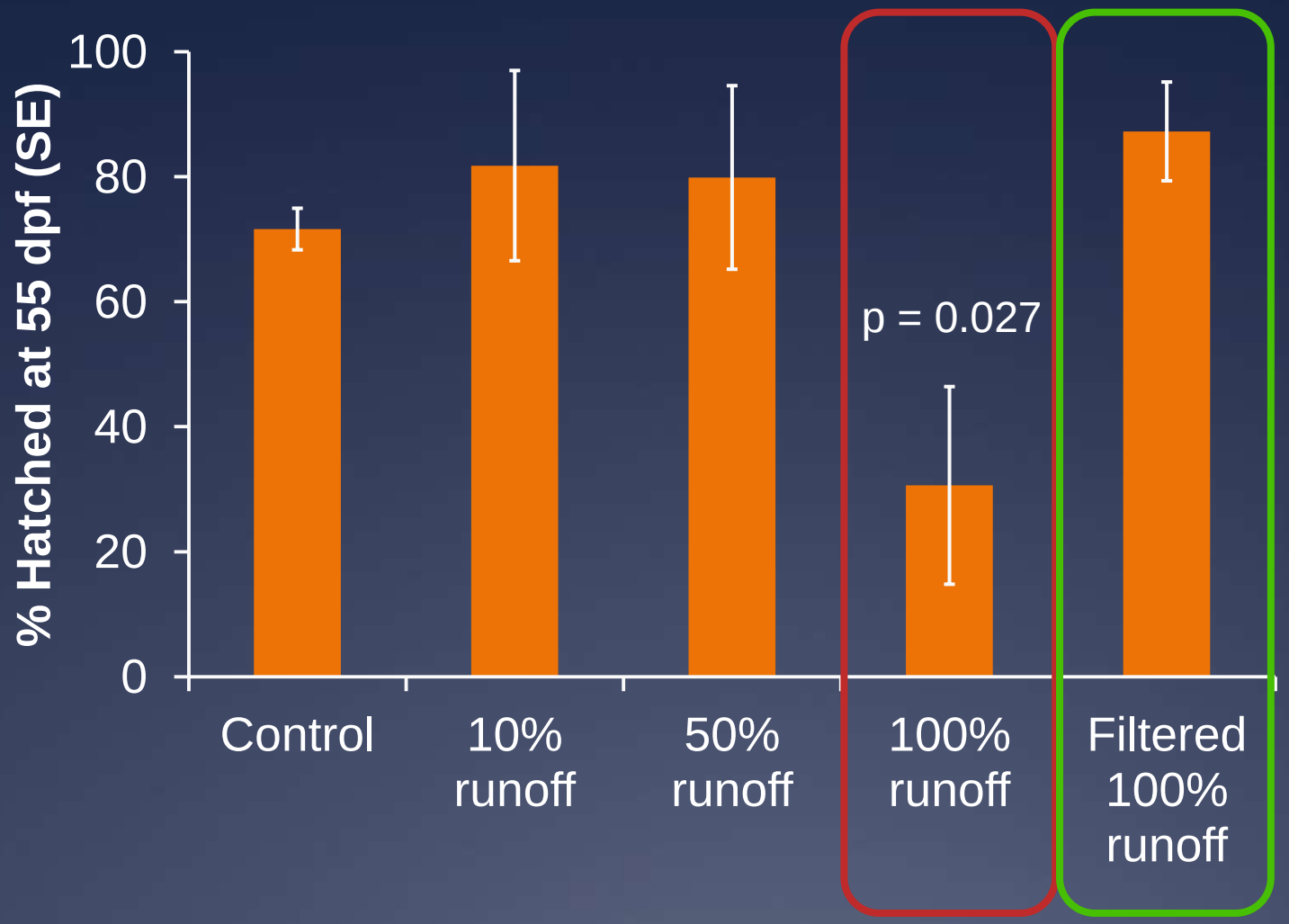
Episodic exposure of coho embryos



High mortality in controls at end of experiment

3.2

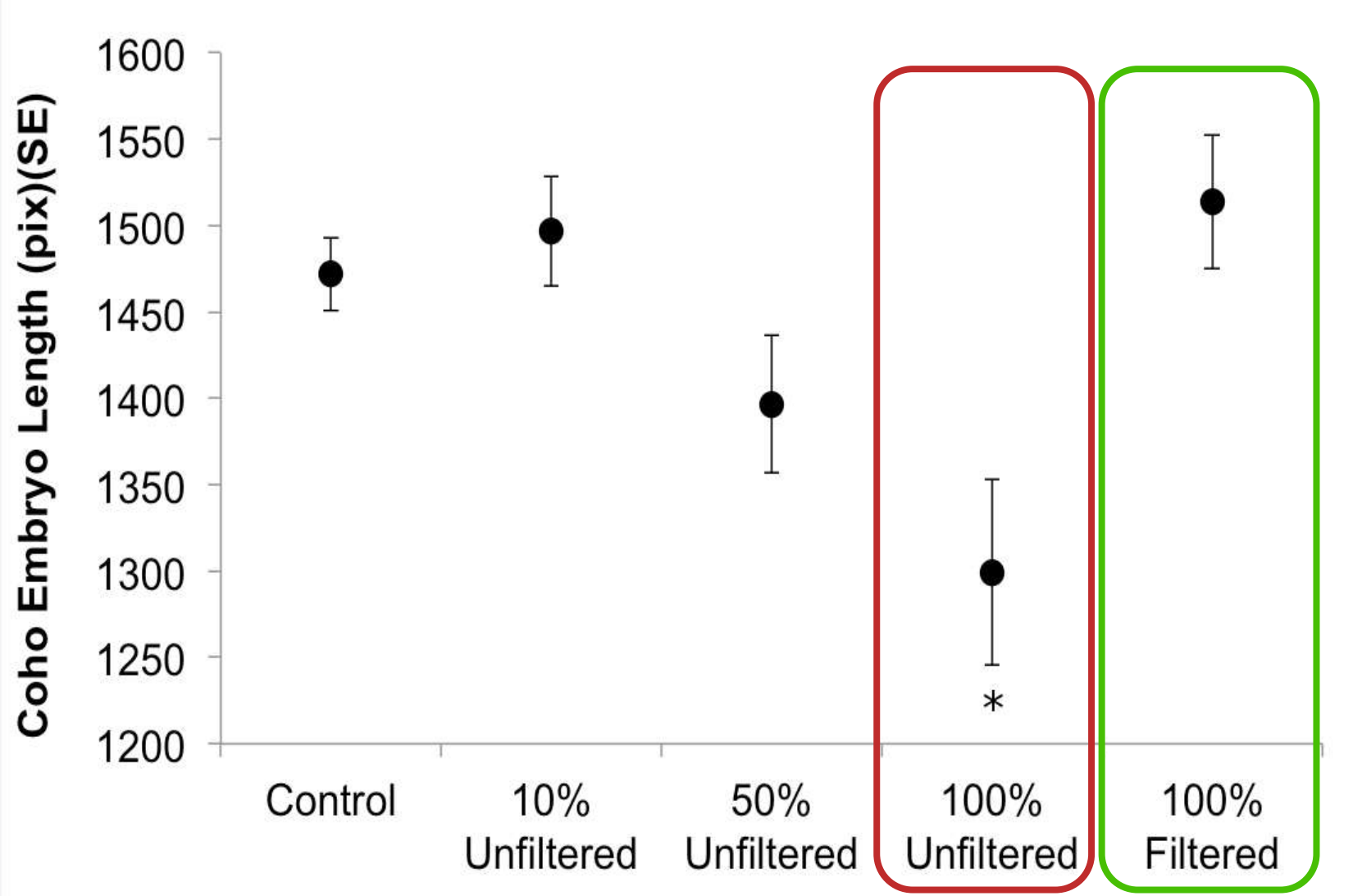
Episodic exposure of coho embryos



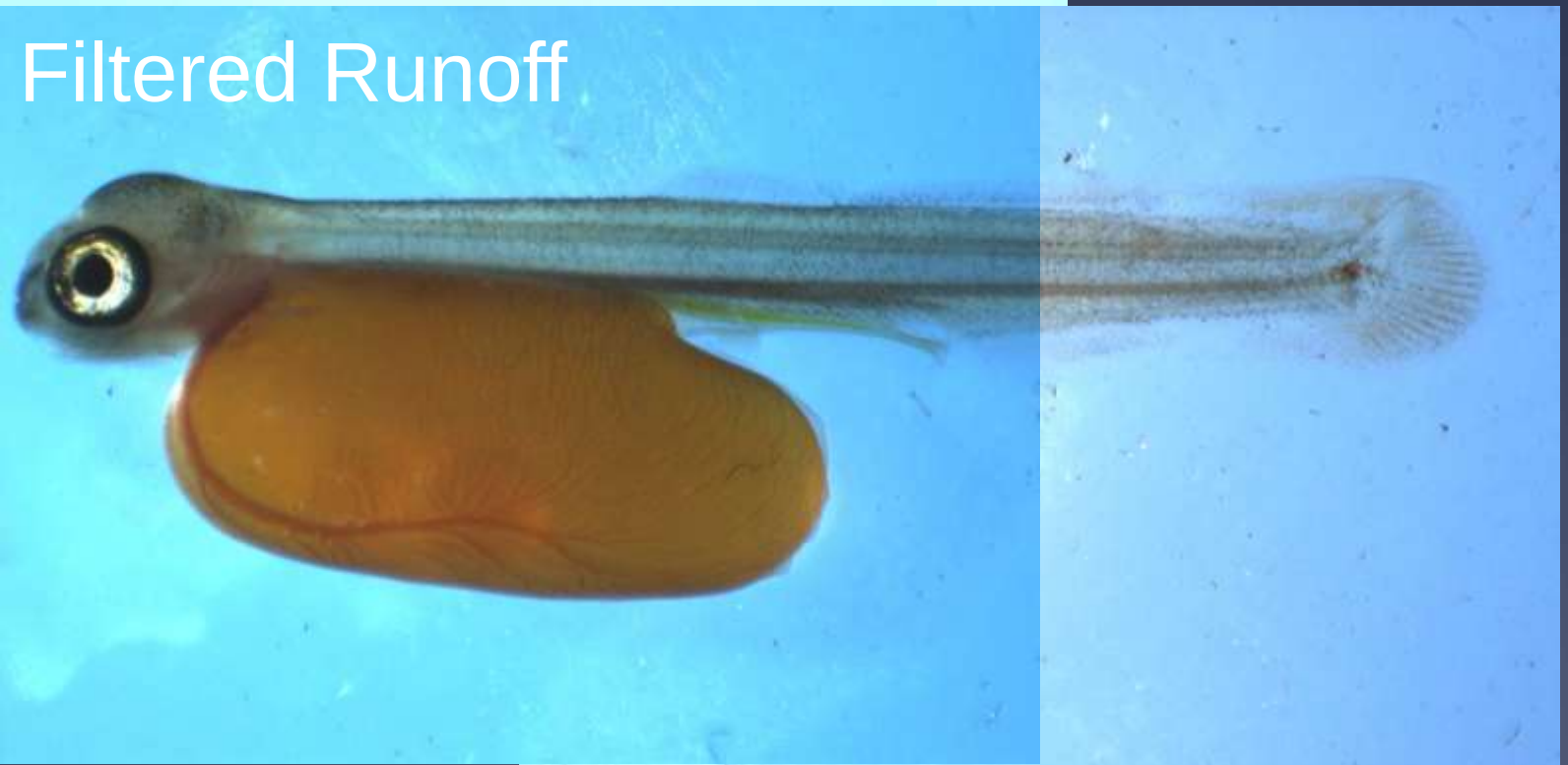
Hatching reduced by 100% runoff

3.2

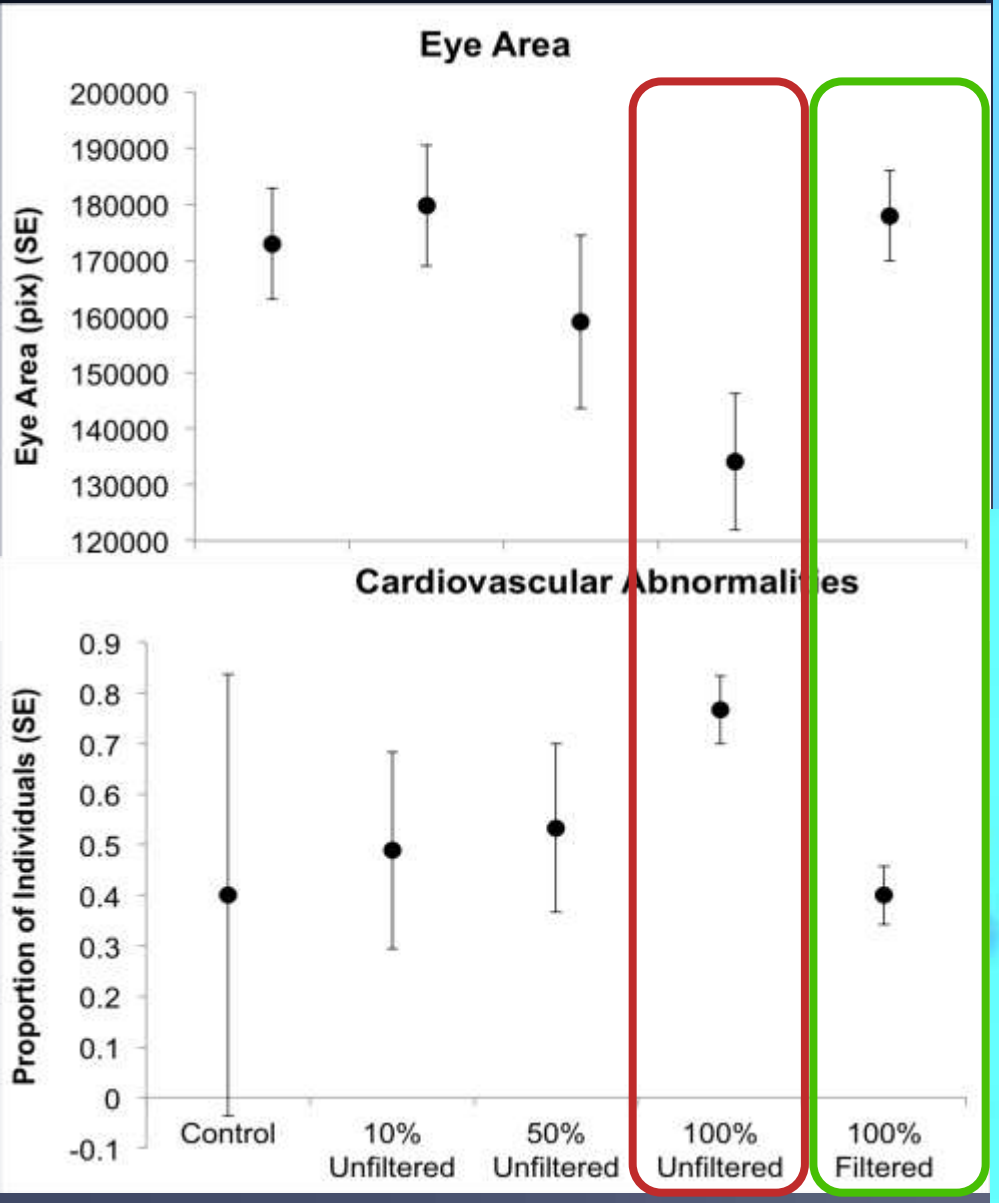
Episodic exposure of coho embryos

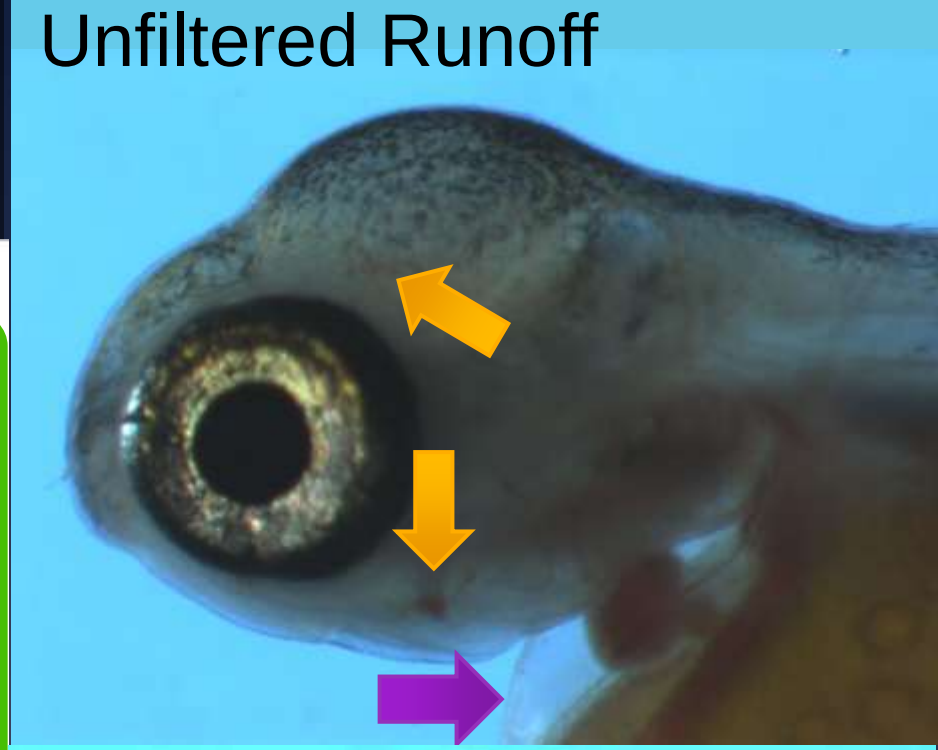


3.2 Length

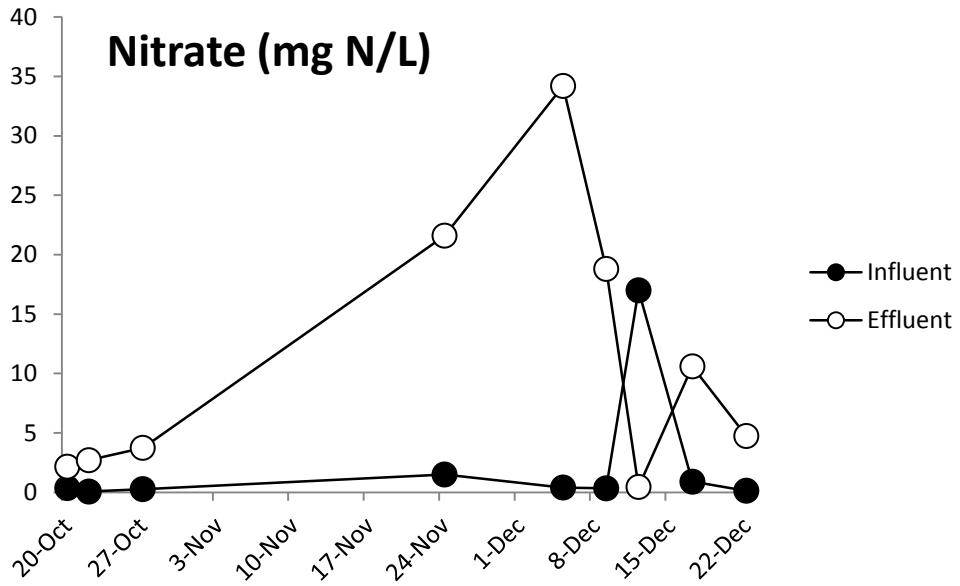


3.2 Coho Embryos

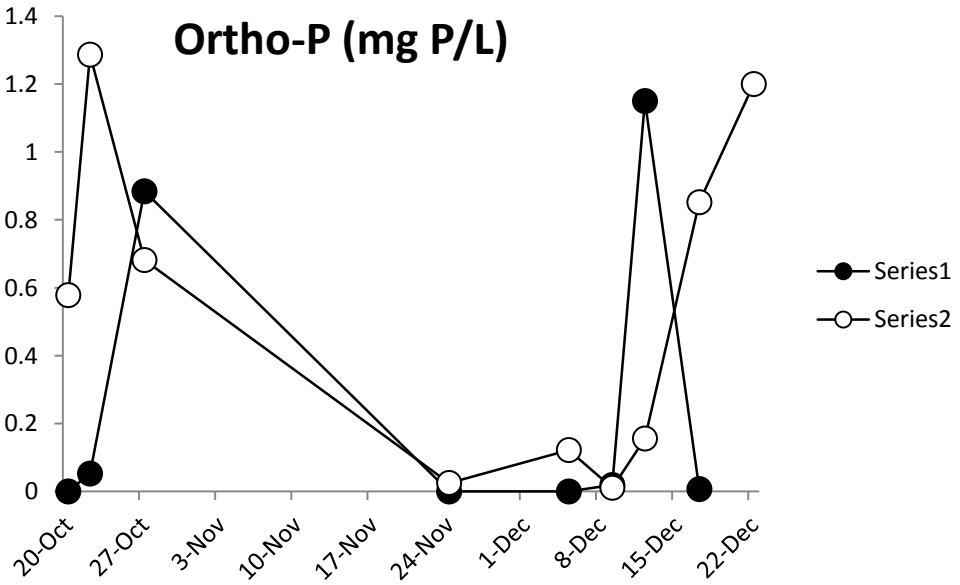




3.3 Bioretention Water Chemistry - Runoff

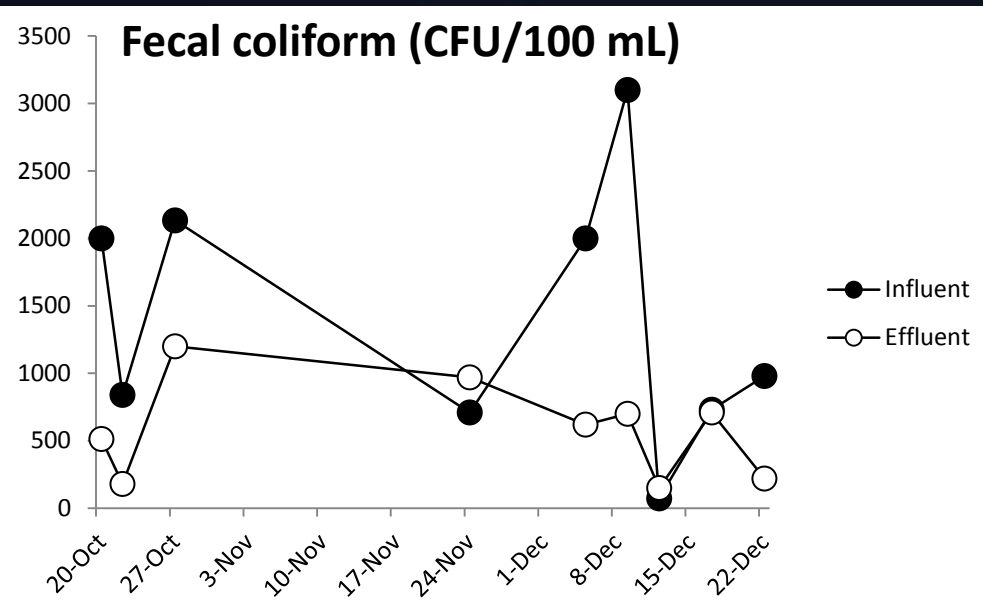


370% Net increase NO_3

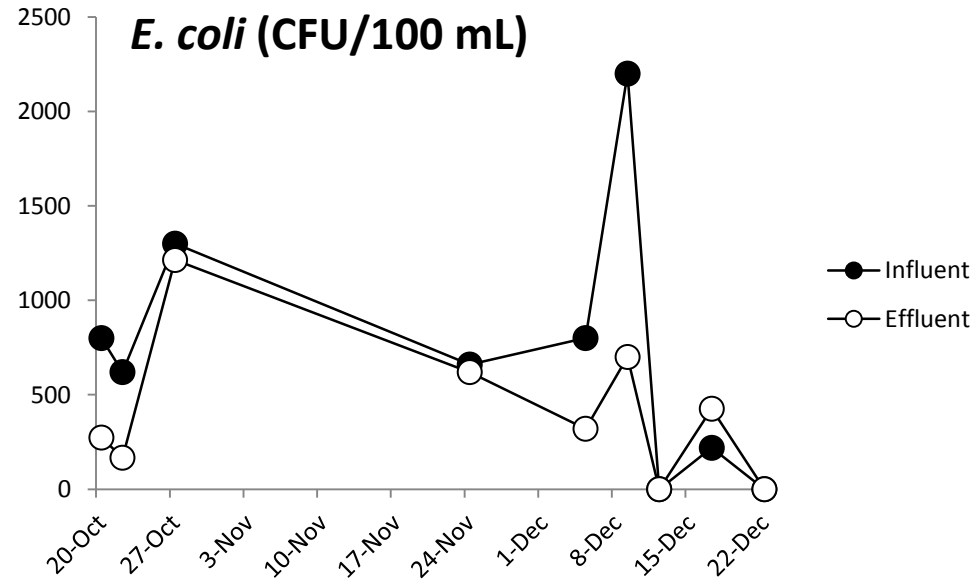


133% Net increase PO_4

3.3 Bioretention Water Chemistry - Runoff

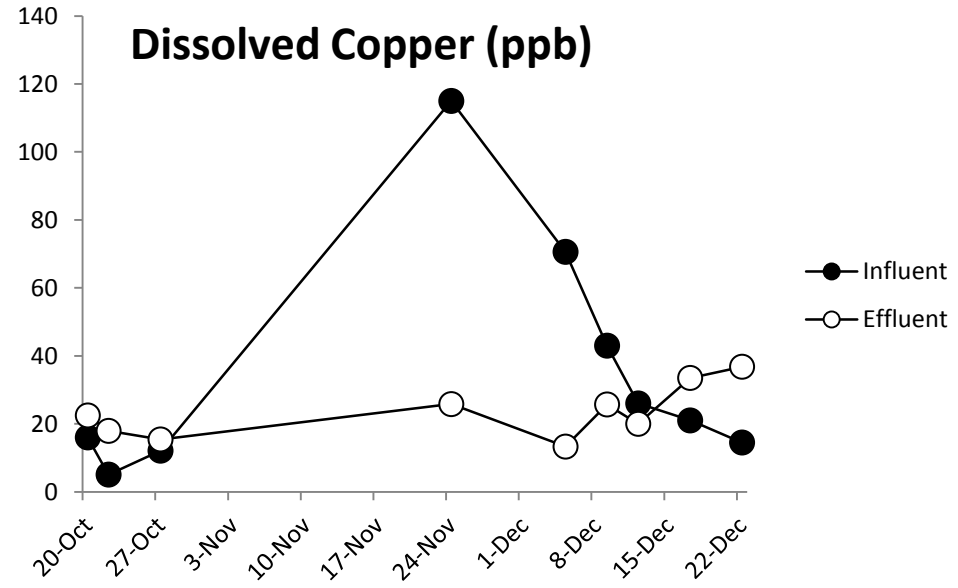


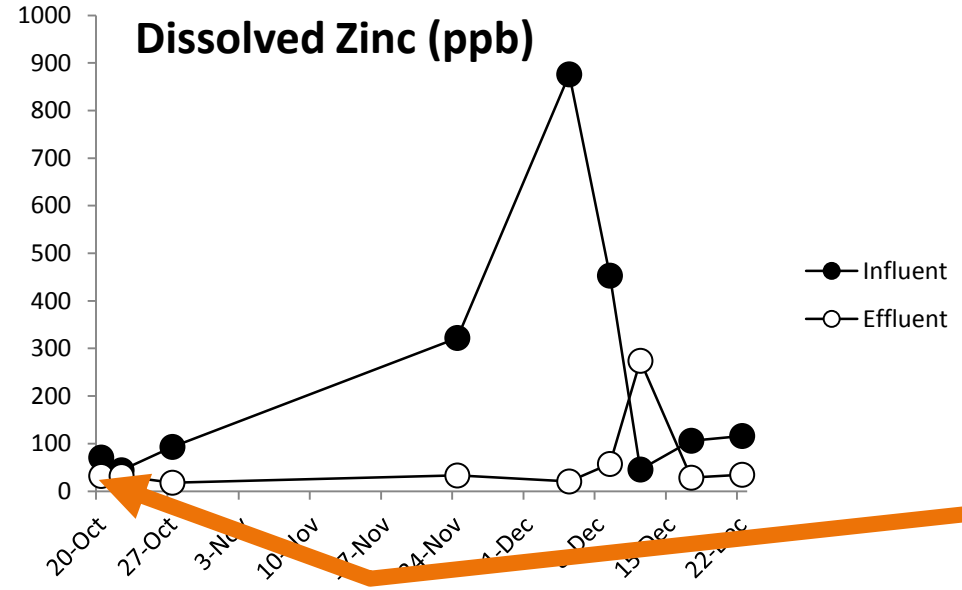
58% Net removal F.C.



44% Net removal *E. coli*

3.3 Bioretention Water Chemistry - Runoff





34% Net removal dCu

75% Net removal dZn

90% Removal PAHs

Bioretention effectiveness for coho salmon

Urban stormwater runoff causes multiple symptoms of toxicity in coho salmon

- Pre-spawn mortality in coho spawners
- Mortality and developmental toxicity in embryos

Soil bioretention can prevent acute toxicity of urban stormwater runoff

- Complete loss of mortality in coho spawners
- Able to prevent lethal and sublethal toxicity in developing coho embryos

Bioretention effectiveness for coho salmon

Final steps for RSMP

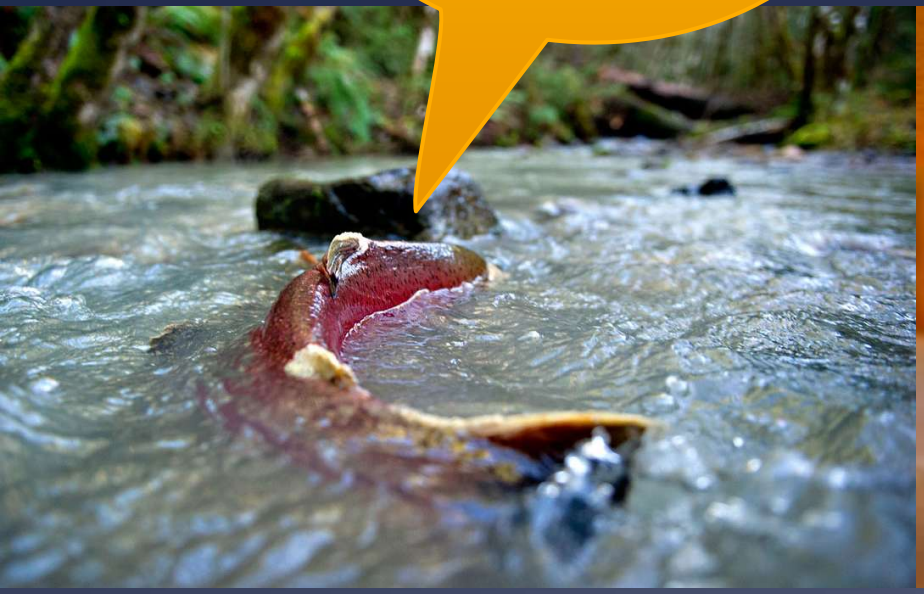
- Finish analyzing PAH chemistry
- Prepare final report

Next steps for assessing bioretention effectiveness

- PAH tissue chemistry pilot (UW-Tacoma)
- 2015 field season (EPA Region 10)

Challenges to address in 2015

- Increase control replication (randomize distribution)
- Minimize fertilization variability (spawning technique)
- Minimize control mortality (maintenance technique)
- More exposures during critical devo window


Thank You!

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