RESEARCH/PD ANNUAL REPORT - PROGRESS REPORT

2015 annual report - progress John Stark The Biological Effectiveness of Bioretention for Stormwater Pollution Control R/RCE-3 Submitted On: 04/28/2016 02:05:07 PM

METRICS & MEASURES

Metric/Measure	Value	Note
Acres of coastal habitat	0	
Fishermen and seafood industry personnel	0	
Communities - economic and environmental development	0	
Stakeholders - sustainable approaches	0	
Informal education programs	0	
Stakeholders who receive information	2840	As a result of outreach activities including invited presentations, approximately 2840 stakeholders were directly reached in the current reporting period. An additional estimated 2 million were potentially reached by media reports including radio and print stories on our research. • The Seattle Times, Print and online, Oct 8, 2015 http://www.seattletimes.com/seattle- news/environment/whats-killing-coho-study-points-to-urban-road-runoff/ • Civil Engineering, academic journal, Print, March 2015, Vol 85(3): 31 Bioretention systems protect sensitive aquatic species from runoff, studies show • KUOW radio - The Record, Radio and online, Feb 12, 2015 http://kuow.org/post/chemical-cocktail-thats-killing-salmon
Volunteer hours	0	
P-12 students reached	0	We participated in an outreach effort led by the Sustainability Ambassadors who filmed a brief lecture on our research for dissemination to K-12 curricula. http://www.sustainabilityambassadors.org/apps/videos/videos/show/18820331- toxics-in-stormwater-pollution
P-12 educators	0	

REQUESTED INFORMATION

Publications

Severe coal tar sealcoat runoff toxicity to fish and reversal by bioretention filtration Publication Type: Peer-reviewed: Journals (incl. articles), Books, Proceedings, and Other Documents Publication Year: 2016 Publication Authors:

Publisher Info: Notes: **Related URLs:** Keywords: **Publication URLs:** Abstract: Citation: McIntyre JK, Edmunds RC, Anulacion BF, Davis JW, Incardona JP, Stark JD, Scholz NL. 2016. Severe coal tar sealcoat runoff toxicity to fish and reversal by bioretention filtration. Environmental Science & Technology 50(3): 1570-1578. Citation for Coverpage: SG can post PDF online?: Uploaded File: McIntyre. 2016. Coal tar bioretention.pdf Confirmation of stormwater bioretention treatment effectiveness using molecular indicators of cardiovascular toxicity in develop Publication Type: Peer-reviewed: Journals (incl. articles), Books, Proceedings, and Other **Documents** Publication Year: 2016 **Publication Authors:** Publisher Info: Notes: **Related URLs: Keywords: Publication URLs:** Abstract: Citation: McIntyre JK, Edmunds RC, Redig MG, Mudrock EM, Davis JW, Incardona JP, Stark JD, Scholz NL. 2016. Confirmation of stormwater bioretention treatment effectiveness using molecular indicators of cardiovascular toxicity in developing fish. Environmental Science & Technology 50(3): 1561-1569. **Citation for Coverpage:** SG can post PDF online?: Uploaded File: McIntyre et al. 2016. Molecular effectiveness.pdf Coho salmon spawner mortality in western U.S. urban watersheds: Bioinfiltration prevents lethal stormwater impacts Publication Type: Peer-reviewed: Journals (incl. articles), Books, Proceedings, and Other Documents Publication Year: 2015 **Publication Authors:** Publisher Info: Notes: Open Access: http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12534/epdf **Related URLs: Keywords:** Publication URLs: http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12534/epdf Abstract: Citation: Spromberg J, Baldwin D, McIntyre J, Damm S, Anulacion B, Davis J, Scholz N. 2015 Coho salmon spawner mortality in western U.S. urban watersheds: Bioinfiltration prevents letha stormwater impacts. Journal of Applied Ecology 53(2): 398-407. **Citation for Coverpage:** SG can post PDF online?: Uploaded File: Spromberg et al-2015-Journal of Applied Ecology.pdf Students Supported

Jack Domeika (New Student) jackdomeika@gmail.com No institution, No department

Field of Study:

Advisor: Degree Type: High School Degree Year:

Student Project Title: Tires as sources of toxic chemicals to juvenile coho salmon

Involvement With Sea Grant This Period (capstone, fellow, intern, etc.):

Post-Graduation Plans (employer, grad school, etc.):

Was this thesis/dissertation supported by Sea Grant?: No

Thesis / Dissertation:

New or Continuing?: New

Degree awarded this reporting period?: No

Financially supported?: No

Evelyn Davis (New Student) evelyndavis2@gmail.com No institution, No department

Field of Study: Advisor: Degree Type: High School Degree Year:

Student Project Title: Tires as sources of toxic chemicals to juvenile coho salmon

Involvement With Sea Grant This Period (capstone, fellow, intern, etc.):

Post-Graduation Plans (employer, grad school, etc.):

Was this thesis/dissertation supported by Sea Grant?: No

Thesis / Dissertation:

New or Continuing?: New

Degree awarded this reporting period?: No

Financially supported?: No

Michelle Chow (New Student) mchow01@uw.edu University of Washington, School of Aquatic and Fishery Sciences

Field of Study: Advisor: Graham Young Degree Type: MS Degree Year: 2017

Student Project Title:

Involvement With Sea Grant This Period (capstone, fellow, intern, etc.): adult/embryos studies; looking at blood chemistry of fish and get sick

Post-Graduation Plans (employer, grad school, etc.):

Was this thesis/dissertation supported by Sea Grant?: No

Thesis / Dissertation:

New or Continuing?: New

Degree awarded this reporting period?: No

Financially supported?: Yes

Narratives

Stark WSU Annual Report 2016 Uploaded File: WSG_Annual_Report_2016_WSU-Puyallup.docx

Partners This Period

US Fish and Wildlife Services (US DOI, FWS) Types: Government Scale: FEDERAL or NATIONAL Notes:

NOAA Northwest Fishery Sciences Center Types: Government Scale: FEDERAL or NATIONAL Notes:

The Suquamish Tribe Types: Other Scale: Tribal Notes: Grovers Creek Salmon Hatchery

STANDARD QUESTIONS

Impacts and Accomplishments

(1)	
Туре	impact
Title	Washington Sea Grant research inspires corporate campus to filter runoff from a nearby highway to improve salmon survival
Relevance	Juvenile salmon in urban creeks and adult salmon returning to spawn suffer devastating mortality rates —up to 90 percent of adults die before spawning. The chief culprit appears to be stormwater runoff that carries fish-killing pollution from roads and impervious surfaces into urban waterways. Bioretention systems that filter runoff through soil are often used to treat stormwater in low-impact development and can prevent hazardous materials from reaching salmon-bearing streams. But can they also protect salmon?

Response	Washington Sea Grant-funded researchers used coho salmon adults and embryos to test the effectiveness of bioretention materials — 60 percent sand and 40 percent compost, overlying gravel aggregate, topped with bark mulch — in removing toxicity from runoff. The team used blood chemistry to track injury in adult coho and developed molecular tools to identify exposure and cardiac injury in developing fish.
Results	Each type of untreated runoff killed all exposed juvenile and adult salmon within 24 hours, but all fish exposed to soil-filtered runoff survived. In addition, impacts to embryo size, development and survival were mitigated by bioretention system filtration. These exciting research results garnered significant interest from media and public officials. The research results showing effectiveness of bioretention systems has inspired an increased use of low-impact development methods in construction projects. Tableau, a Seattle software firm, redesigned their new campus to incorporate filtration of runoff from nearby Highway 99, benefiting the entire community.
Recap	Washington Sea Grant-funded researchers developed effective tools to test and prevent toxicity from urban stormwater runoff, improving water quality for coho salmon.
Comments	
Primary Focus Area	Resilient Communities and Economies
Secondary Focus Areas	Healthy Coastal Ecosystems
Goals	Ocean and coastal habitats are protected, enhanced and restored. Coastal water resources sustain human and ecosystem health.
Partners	Northwest Fisheries Science Center (US DOC, NOAA, NMFS, NWFSC) Suquamish Tribe US Fish and Wildlife Service (US DOI, FWS)
PI Draft	* Type accomplishment * Title Found that bioretention systems stop prespawn mortaltiy in Coho salmon * Relevance Stormwater is implicate in causing mortality in Coho salmon that are entering lowland urban streams to spawn. We conducted a study to determine whether we could mitigate this mortality . * Response We evaluated a means to eliminate pre-spawn mortality in Coho salmon. Our principal partners were USFW and NOAA * Results This is an important finding because pre-spawn morality in Coho salmon reduces salmon population size. The ability to reduce or stop this mortality increases salmon population size * Recap We found that we could eliminate pre-spawn mortality in Coho salmon by passing stormwater through simple soil-

	compost bioretention systems before the stormwater enters rivers and streams. Comments Primary Focus Area Healthy Coastal Ecosystems Secondary Focus Areas Goals Partners
--	--

Tools, Technologies, Information Services / Sea Grant Products

(1)	
Description	Molecular tools to detect cardiovascular toxicity in developing fish.
Developed (in the reporting period)?	Yes
Used (in the reporting period)?	Yes
Used for EBM?	Yes
ELWD product?	No
Number of managers	0
Description/Names of managers	
Reported in previous year?	

Economic Impacts

No Economic Impacts information reported

Community Hazard Resilience

No Community Hazard Resilience information reported

Meetings, Workshops, Presentations

(1)	
Type of Event	Public or professional presentation
Description	Title: Stormwater pollution & solutions International Erosion Control Association (IECA) Annual Conference, Portland, OR Feb 16, 2015
Event Date	02-16-2015
Number of Attendees	80

ſ	2	۱
l	2	J

Type of Event	Public or professional presentation
Description	Title: Stormwater runoff – Toxicity and treatment Keynote address at Northwest Environmental Business Council (NEBC) conference on Managing

	Stormwater in Washington, Tacoma, WA, Mar 11, 2015
Event Date	03-11-2015
Number of Attendees	150

(3)

Type of Event	Public or professional presentation
Description	Title: Where municipal stormwater hits the road and the salmon. Webinar. Washington Stormwater Center, Lunchtime Municipal Webinar Series. July 16, 2015 http://www.wastormwatercenter.org/lunchtime-muni- webinar-series
Event Date	07-16-2015
Number of Attendees	40

(4)

Type of Event	Public or professional presentation
Description	Title: Solutions to stormwater pollution. WRIA 8: Salmon Recovery Council meeting, WA Dept Ecology NW Regional Office, Bellevue, WA, Jul 16, 2015
Event Date	07-16-2015
Number of Attendees	50

(5)

Type of Event	Public or professional presentation
Description	Title: Mitigating effects of stormwater runoff on salmonids Cedar River Salmon Journey volunteer training, Seattle Aquarium, Sep 17, 2015
Event Date	09-17-2015
Number of Attendees	30

(6)

Type of Event	Public or professional presentation
Description	Oral presentation at Green Gardening Workshop, South Seattle Community College, Seattle, WA Oct 21, 2015 https://www.youtube.com/watch? v=qpoQTiiXcoc&list=PLO5EstoEwik1hloyLv0T8gVq DpuikN39W&index=4
Event Date	10-21-2015

Number of Attendees	200
(7)	
Type of Event	Public or professional presentation
Description	Congressional Caucus on Stormwater Impacts to Salmon Presentation to US Representatives Kilmer and Heck and regional leaders in stormwater managment and the health of Puget Sound, WSU Puyallup, WA Nov 10, 2015
Event Date	11-10-2015
Number of Attendees	40

Leveraged Funds

(1)	
Purpose	The Biological Effectiveness of Bioretention for Stormwater Pollution Control
Source	EPA
Amount	98221
Start Date	02-01-2015
End Date	01-31-2016

(2)

Purpose	The Biological Effectiveness of Bioretention for Stormwater Pollution Control - additional toxicity pilot project
Source	Washington State Department of Ecology
Amount	2520
Start Date	01-01-2016
End Date	01-31-2016

Task 1: Verifying and validating the biological effectiveness of bioretention

Bioretention effectiveness

Following the verification test (June 2014) of our initial results (Sept 2012), we abandoned repeated validations with this bioretention material because it contained an experimental mixture that was not certified by the WA Department of Ecology. For further validation of bioretention performance we tracked effectiveness over repeated tests with coho salmon.

Publications

During the reporting period, we published a research paper on the development and testing of molecular tools for identifying exposure and cardiac injury to fish exposed to urban runoff. We showed that bioretention treatment reduced molecular evidence of exposure to runoff and eliminated molecular and morphometric evidence of cardiac injury. This work was published in the journal *Environmental Science & Technology* (50(3): 1561-1569).

Performance of bioretention

Bioretention cells were constructed in 2014 for Task 2 (see below) using a drainage layer (12") of Seattle Type 26 mixed gravel aggregate topped with a bioretention soil media (BSM) that was a mixture of 60% sand and 40% Cedar Grove compost topped with 2" of bark mulch. The cells were used to filter runoff from 10 storm events during Oct-Dec 2014 plus an additional 15 events between Nov 2015 and Jan 2016, covering the current reporting period. The first three events were tested on adult coho salmon (see below). For each event, runoff filtered with bioretention prevented the pre-spawning mortality that occurred in the unfiltered runoff. The next 7 events were tested on coho embryos over the course of development. Significant impacts on embryo size were observed in the unfiltered runoff, but were prevented in the runoff filtered with bioretention (Figure 1). The cells were left open to the air between Jan 2015 and Oct 2015. In the current reporting period, an additional 15 events were filtered through the bioretention cells. Coho embryos episodically exposed to the 100% unfiltered runoff over the course of development suffered high rates of mortality by hatching (64 d), which was prevented in embryos exposed to runoff filtered through bioretention (Figure 2). In terms of chemistry, we saw no 'break-through' of metals or PAHs measured in runoff before and after bioretention treatment (Figure 3).



Figure 1. Coho embryo length at hatch following 10 runoff episodic exposures to urban runoff (10%, 50%, 100% or 100% filtered).



Figure 2. Coho embryo survival over 64 days of development including 15 exposures to urban runoff (R) or filtered urban runoff (F). Runoff was 50% or full-strength (100%). Only 100% runoff was filtered.





Figure 3. Dissolved zinc and copper in urban highway runoff before and after filtration through bioretention for 25 events across 15 months. Note: 12/15/14 storm had dissolved Zn >500 ppb.

Biological Effectiveness of Bioretention – Annual Report (Feb 2015 – Jan 2016)

Task 2: Bioretention to prevent PSM in adult coho spawners

Publications

During the reporting period, the research for this task (reported during the previous reporting period) was published in the *Journal of Applied Ecology* (53(2): 398-407). It was subsequently selected for an Editor's Choice award. The study was also reported in The Seattle Times (Oct 8, 2015).

Task 3: Exploring PAHs as drivers of toxicity

Publications

During the reporting period, the research for this task (reported during the previous reporting period) was published in the journal Environmental Science & Technology (50(3): 1570-1578).

Task 4: Ecological relevancy of episodic exposures to runoff

During June 2015, baskets of river rock were embedded in the Cedar River for colonization with native invertebrates. The baskets were to be retrieved in August 2015 for use in simulated stream channels for Task 4. Unfortunately, the record hot dry weather during June and July 2015 led to extremely low river flows (4th percentile of historic flows), which left many of the baskets out of water. The project had to be postponed until 2016.

During winter 2016, simulated stream channels were constructed from PVC rain gutters and fitted with mesh baskets for collection of insect drift at the stream channel terminus (Figure 4). Four replicates of three treatments have been constructed; control, runoff, and filtered runoff. All treatments will receive clean control water (dechlorinated municipal water from the WSU Fish Lab). Episodically, the runoff and filtered runoff treatment channels will be switched to either 100% runoff or 100% runoff that has been filtered through the bioretention cells used in Tasks 1 and 2.

The channels are filled with baskets of cleaned river rock that have been inoculated with water and rocks from the Cedar River in order to support a periphyton community. Into this system we will introduce native aquatic invertebrates collected from the Cedar River by drift net and snorkeling. We estimate that the project will be completed during spring 2016.



Figure 4. Three sets of four 'stream channels' set up for the episodic exposure of aquatic invertebrates to runoff.