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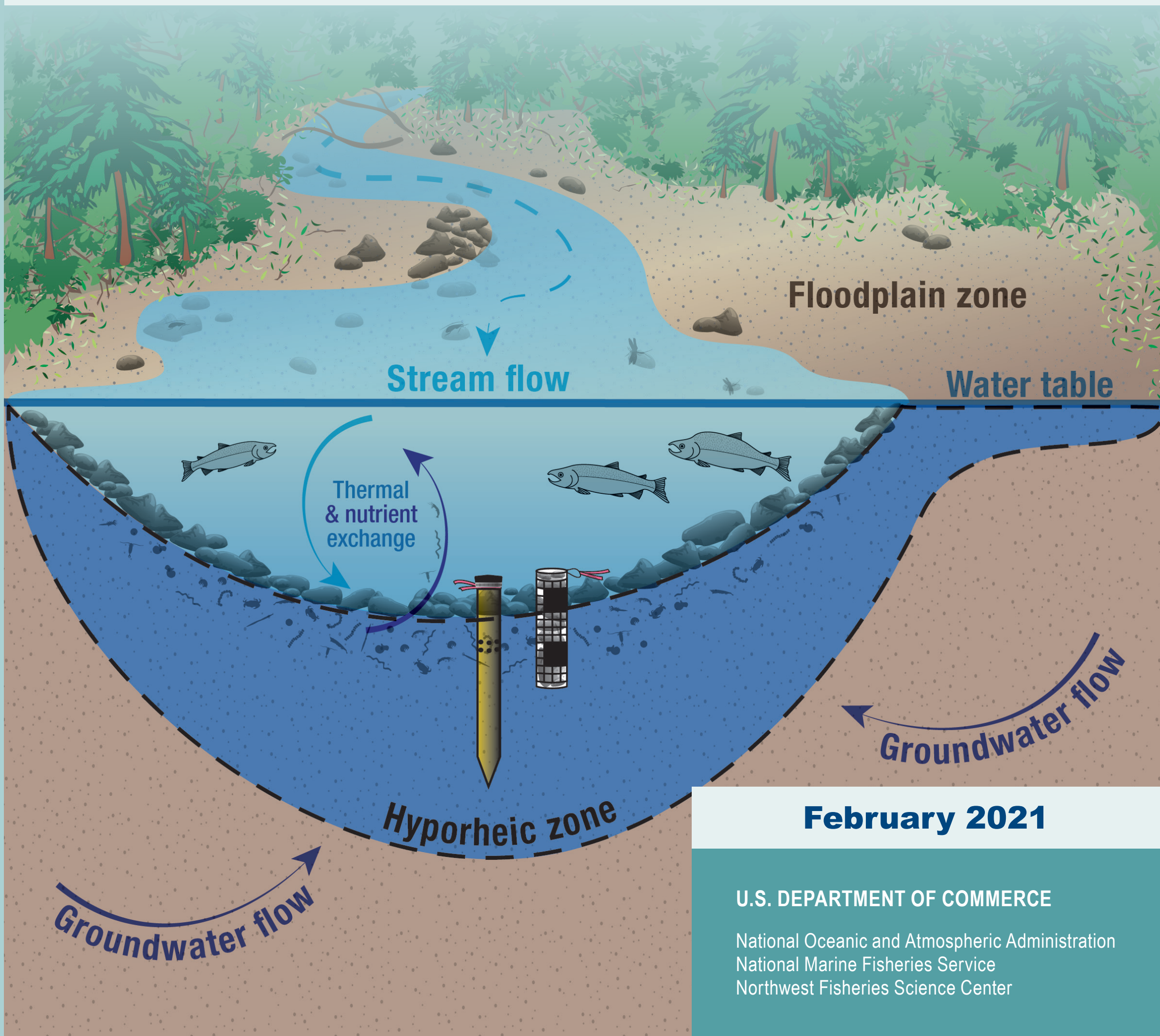

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Cover image: Location of piezometer and colonization basket installation within the hyporheic zone, relative to the stream's active channel and floodplain. Drawing by S. Kim, NMFS/NWFSC.

Recommended citation:

(Morley et al. 2021)[1]

[1] Morley, S. A., L. D. Rhodes, A. E. Baxter, G. W. Goetz, A. H. Wells, and K. D. Lynch. 2021. Invertebrate, Microbial, and Environmental Data from Surface and Hyporheic Waters of Urban and Forested Streams of the Cedar River–Lake Washington Watershed. U.S. Department of Commerce, NOAA Data Report NMFS-NWFSC-DR-2021-01.

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Invertebrate, Microbial, and Environmental Data from Surface and Hyporheic Waters of Urban and Forested Streams of the Cedar River–Lake Washington Watershed

Sarah A. Morley,[1] Linda D. Rhodes,[2] Anne E. Baxter,[2] Giles W. Goetz,[3] Abigail H. Wells,[3] and Katherine D. Lynch[4]

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[1]Fish Ecology Division
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112

[2]Environmental and Fisheries Sciences Division
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112

[3]Conservation Biology Division
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112

[4]Seattle Public Utilities
700 5th Avenue, Suite 4900
Seattle, Washington 98124

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Northwest Fisheries Science Center

Description

In October 2014, Seattle Public Utilities (SPU) completed construction of two large-scale floodplain reconnection projects in the Thornton Creek Watershed of northeast Seattle: Thornton Confluence and Kingfisher (Figure 1). These projects were designed to reconnect the stream laterally within its floodplain and also vertically with the hyporheic zone—the layer of saturated substrate beneath and adjacent to the active stream channel. Within this area of surface and subsurface/groundwater mixing, microbial and invertebrate assemblages carry out organic matter decomposition, nutrient cycling, and contaminant detoxification. With these projects, SPU seeks to: a) maximize onsite water, sediment, and wood storage with expanded floodplain and hyporheic capacity, b) slow erosive peak flows, c) modulate stream temperature, d) filter stormwater contaminants, e) increase in-stream hydraulic diversity, and ultimately f) improve the biological health of Thornton Creek.

The inclusion of hyporheic design elements is an innovative, but largely untested, approach in urban stream restoration. As such, there is much to be learned from the Confluence and Kingfisher projects—most immediately, whether further investment in this approach by SPU is warranted in other local watersheds. Beyond Seattle, Thornton Creek offers a novel case study for restoration practitioners grappling with stormwater management in other rapidly urbanizing landscapes. For the broader scientific community, information on hyporheic zone structure and function in urban streams will help increase our understanding of this understudied environment. Therefore, SPU has engaged science partners from various disciplines to evaluate the effectiveness of the Confluence and Kingfisher projects.

NOAA led the biological monitoring component of this effort, research which focused on hyporheic invertebrate and microbial community structure and function. Microbes are the interface between the physical and chemical attributes of water and the larger food web. Microscopic organisms play an important role, decomposing organic matter and transferring nutrients to higher trophic levels, such as invertebrates. While some species of invertebrates are adapted to spend their entire life in the subterranean hyporheic environment, many more move back and forth between hyporheic and surface waters. In this way, the hyporheic zone helps support prey production for fish and other members of the stream food web.

NOAA's monitoring design consisted of three components:

1. To evaluate overall biological response to hyporheic restoration, we used piezometers to conduct annual monitoring at restored treated reaches and at unrestored control reaches over 2014–17.
2. To test whether assisted recolonization could speed biological recovery in newly restored habitat, we used gravel colonization baskets to seed a portion of the Kingfisher treated reach with invertebrates and microbes from forested reference reaches.
3. The third component of the study was a methodological comparison of hyporheic sample techniques.

This report summarizes environmental, invertebrate, and microbial data collected for all components of this study over 2014–17.

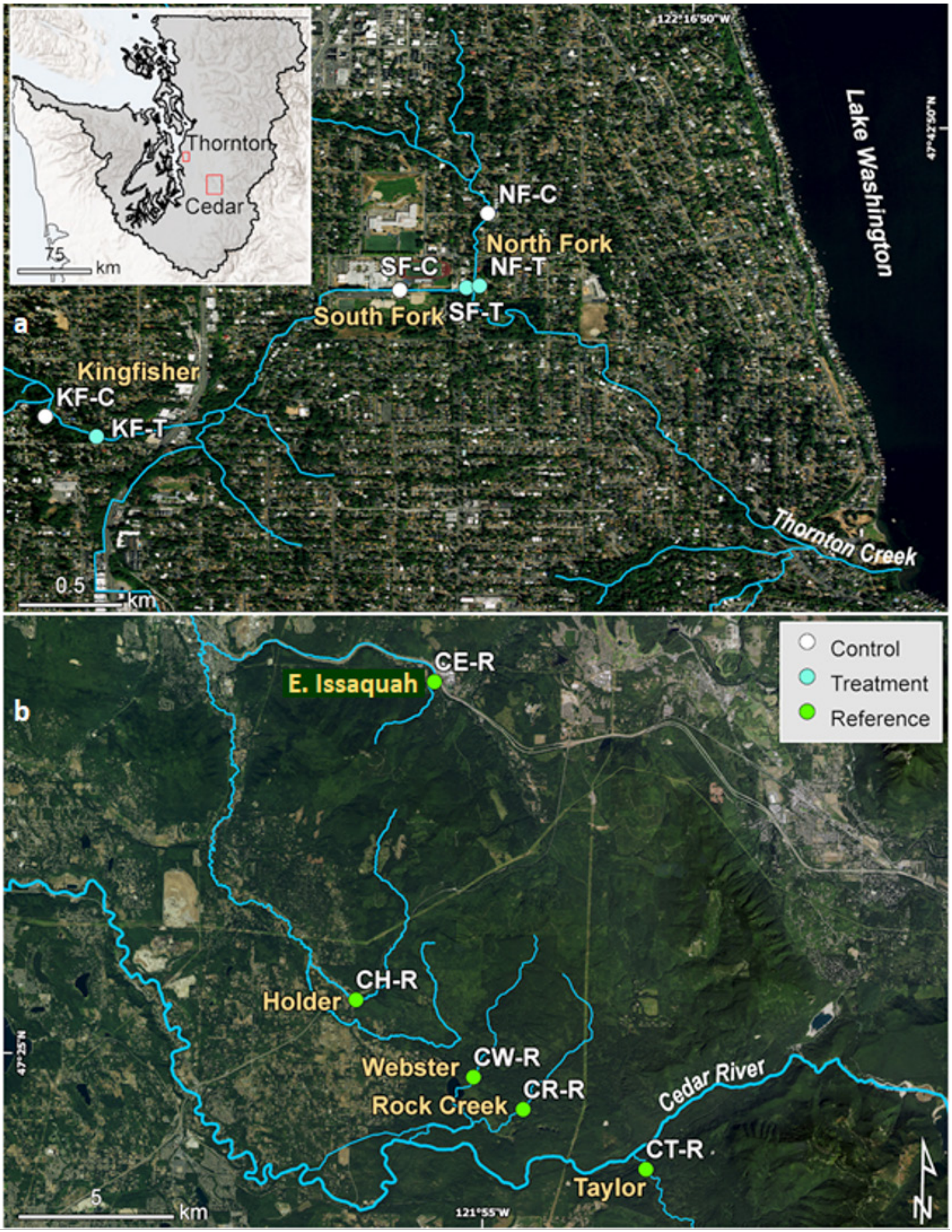

Figure 1. (a) Locations of treatment and control study reaches associated with the Kingfisher and Confluence floodplain restoration projects on Thornton Creek. (b) Forested reference reaches on tributaries of the Cedar River. Inset map shows locations of the two subwatersheds within the greater Puget Sound area.

Results

The majority of environmental data we collected varied more by sample year than by restoration status—likely reflecting different climatic conditions across years. A few variables showed a similar reach difference at two of the three projects, but none were consistent across all three. Piezometer water temperatures were significantly lower in treated than in control reaches for Kingfisher and the North Fork portion of Confluence, but not different at the South Fork. Dissolved organic carbon concentrations were also significantly different at Kingfisher and North Fork (treated > control), but again not at South Fork. Nitrite concentrations were significantly lower at the treated reaches of both North Fork and South Fork, but not different at Kingfisher. Particulate organic matter concentration also differed only at North Fork and South Fork (treated > control), and was similar to concentrations at reference reaches. Mean nitrate, ammonium, and phosphate were elevated across Thornton compared to reference reaches.

Restoration had measurable effects on hyporheic microbial metabolism (i.e., heterotrophic production) and community structure (i.e., taxonomy). We did not detect a strong effect of restoration on total bacterial abundance or taxa richness (number of unique taxa per sample). Microbial heterotrophic production in hyporheic water was significantly greater in treated than in control reaches at Kingfisher and North Fork. Higher production indicates that a metabolically active microbial community flourishes in the interstitial portions of the hyporheic zone, allowing for greater recycling of nutrients. Based on similarity of percentages, bacterial community structure was more homogeneous in the hyporheic zone of treated reaches. The overall taxonomic structure of microbial communities was significantly different between treated and control reaches at all project sites.

Hyporheic invertebrate density, taxa richness, and community structure were significantly different between control and treated reaches across all three projects. Both density and taxa richness were significantly higher at the restored treated reaches relative to the unrestored control reaches. Average invertebrate density at treated reaches was similar to or higher than reference reaches, and an order of magnitude greater than control reaches. Taxa richness at treated reaches was lower than reference reaches, but double that of control reaches. Thornton hyporheic samples were dominated by crustaceans such as amphipods and copepods, while reference reaches included a greater diversity of aquatic insects. In terms of benthic invertebrates (which reside on the surface of the stream benthos, as opposed to beneath it), there was no improvement in the Benthic Index of Biological Integrity at any of the treated reaches.[1]

We observed limited effects of experimental seeding on microbes or invertebrates at the Kingfisher treated reach. Surface heterotrophic production from the seeded portion of Kingfisher was intermediate to production from the unseeded reach and the source reaches. However, there was no change in the taxonomic structure of surface microbes as a result of seeding, and only small transient changes on hyporheic biofilms. Nor did we

[1] https://pugetsoundstreambenthos.org/About-BIBI.aspx

detect a significant increase in overall hyporheic invertebrate density or taxa richness as a result of seeding. We identified four invertebrate taxa that may have established themselves in the seeded reach as a result of assisted recolonization. Of these, the most likely to have originated from our reference reaches are the mayfly genus *Ephemerella* and the chironomid genus *Rheocricotopus.* Neither of these taxa had been observed in Thornton Creek for at least a decade prior to the seeding experiment.

Sampling methodology had significant effects on both microbial and invertebrate parameters. For microbes, fractionating hyporheic samples into particle-associated (≥5 µm) and planktonic (0.02–5 µm) portions resulted in distinct differences in bacterial and archaeal taxa. Enteric commensals, biofilm-forming bacteria, and degradative microbes (including those with bioremediation potential) occurred in the particle-associated fraction. Taxa in the planktonic fraction represented endosymbionts (bacteria that live inside of larger organisms), intracellular bacteria, and predatory bacteria. For invertebrates, colonization baskets yielded double the taxa richness and 10–100 times the densities of piezometer samples. While a similar number of noninsect taxa were captured using both techniques, far fewer of the larger-bodied aquatic insects were found in piezometer samples.

As Thornton Creek moves around more freely in its expanded floodplain and as its riparian vegetation matures, the Kingfisher and Confluence restoration projects will continue to evolve. Long-term monitoring of these projects will help account for natural interannual variation, enabling managers to better evaluate the role of hyporheic design in restoring the health of urban streams. A number of factors likely contributed to the absence of a major response to recolonization, chief among them the low seeding densities we employed and the continued presence of anthropogenic stressors not fully addressed by reach-scale restoration actions.

Further analyses and results on the first component of this study (overall biological response to hyporheic restoration) are described in Morley et al. (2021). Future publications are planned on study components two and three. Tables of data can be downloaded from this report's NOAA Institutional Repository record by clicking on the "Supporting Files" tab.[2] Microbial DNA sequencing data and associated metadata are available in the Sequence Read Archive (SRA) publicly-available database of the National Center for Biotechnology Information (NCBI), under BioProject PRJNA692741.[3]

[2] https://repository.library.noaa.gov/
[3] https://www.ncbi.nlm.nih.gov/bioproject

References

Morley, S. A., L. D. Rhodes, A. E. Baxter, G. W. Goetz, A. H. Wells, and K. D. Lynch. 2021. Invertebrate and microbial response to hyporheic restoration of an urban stream. Water, in press.

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National Marine
Fisheries Service
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112