**Problem Statement and Hypothesis**

Relatively few studies have *directly* measured the contribution of hyporheic respiration (Rh) to whole stream metabolism (WSM) ([*1-3*](#_ENREF_1)). These studies have shown that the Rh ­is a major component of ecosystem respiration (ER) ([*3*](#_ENREF_3)) and that transient storage zone size and exchange rates were related to increased respiration ([*3*](#_ENREF_3)*,* [*4*](#_ENREF_4)). Recent studies in areas of continuous permafrost suggested that the hyporheic zone is hydrologically active and an important site of biogeochemical processing ([*5*](#_ENREF_5)*,* [*6*](#_ENREF_6)). Moreover, streams underlain by permafrost offer an ideal setting for hyporheic zone research because they are isolated from groundwater gains or losses ([*7*](#_ENREF_7)). Studies of arctic stream transient storage zones by Zarnetske *et al.* ([*7*](#_ENREF_7)) have shown a strong correlation between physical metrics, such as specific stream power (ω), and measures of transient storage exchange rates and reach hydraulic retention, two factors that may strongly affect Rh. This relationship is important because ω is a minimally parameterized metric defined as: ω = γ*QS / w,* where, changes in the discharge (*Q*), slope (*S*), and channel width (*w*) are considered relative to the known specific weight of water (γ). If Rh is influenced by the transient storage zone size and hydraulics, then a predictive tool using ω could be developed to evaluate Rh. *I* *hypothesize that ω can be used to predict Rh which will have a strong influence on ER and WSM in arctic streams.*

**Methods**

To test the hypothesis that ω can be used as a predictive metric of Rh, I will measure the contribution of Rh on total ER and will make the measurements necessary to calculate ω. WSM and ER will be evaluated using the two-station diel O2 difference method ([*8*](#_ENREF_8)*,* [*9*](#_ENREF_9)). Additionally, separate measures of respiration in the hyporheic zone and benthic surface will be carried out using chamber techniques ([*2*](#_ENREF_2)*,* [*3*](#_ENREF_3)*,* [*10*](#_ENREF_10)). Rh will be determined using two different approaches, where: 1) extracted hyporheic substrate will be measured in laboratory assays, and 2) the difference of ER and benthic surface respiration (Rbs) will be used to infer Rh ([*2*](#_ENREF_2)). To address the heterogeneity encountered in streams, reaches will be spatially delineated with a high-resolution Global Positioning System (GPS) into distinct habitat-patches based on substrate size and flow characteristics. The Rbs will be quantified for each reach by summing the patch chamber metabolisms relative to its hydraulic contribution. Reach-scale solute transport modeling ([*11*](#_ENREF_11)*,* [*12*](#_ENREF_12)) will be used to determine the surface processes. The surface-subsurface exchange will be measured using a network of mini hyporheic piezometers ([*6*](#_ENREF_6)) and MODFLOW ([*13*](#_ENREF_13)*,* [*14*](#_ENREF_14)), a three-dimensional solute transport model. This approach will account for the reach-scale ER across the habitat heterogeneity observed in streams as well as provide improved estimates of Rh. Biogeochemical constituents (e.g., total and dissolved nutrients) that influence metabolism will also be measured and correlated with surface-subsurface processes. Reaches will be selected across a gradient of slope, discharge, and morphologies to capture the variation of ω observed in arctic streams. The ω will be measured in the field during metabolism studies and using Geographic Information Systems (GIS) to determine the accuracy of remotely sensed estimates of ω. The relationships between ω and respiration will be validated at new sites, where predicted rates of Rh and ER (from estimated ω) will be tested against measured Rh and ER rates.

**Anticipated Results**

I anticipate there will be a positive relationship between ω and Rh, and a similar increase in ER with increasing ω. Zarnetske *et al.* ([*7*](#_ENREF_7)) found ω to positively correlate with hyporheic storage exchange rates and negatively with reach hydraulic retention. As stream power increases the surface-subsurface exchange of nutrients and dissolved oxygen are expected to increase, thus stimulating Rh. The hyporheic zone in arctic streams can act as a source of nutrients to the channel ([*5*](#_ENREF_5)*,* [*6*](#_ENREF_6)), and I expect that greater exchange rates and Rbs will lead to increased ER. If increased ω is predictive of increased ER, then it is probable that reach productivity will also scale with ω. Finally, some variation in the strength of these relationships is expected depending on the distinct biogeochemical and ecological conditions present within each stream.

**Expected Significance and Broader Impacts**

*Intellectual Merit—*Understanding the relationships between ω and Rh, ER, and WSM could provide an important link between physical stream characteristics and biogeochemical function. Using remotely sensed ω as a surrogate for ER and Rh­ will provide an innovative approach to scale stream metabolic processesacross river networks. Additionally, this research will provide new information on the metabolic implications of surface-subsurface exchange across heterogeneous habitat-patches, and the combined results of this research could be applied to non-arctic biomes. The objective of the National Science Foundation-funded Scale, Consumers and Lotic Ecosystem Rates (SCALER) project is to explore the scaling of patch and reach-scale biogeochemical experiments to river networks across biomes. Although I am a graduate student working in the Arctic on the SCALER project, the use of ω to predict Rh and ER reflect my personal research interests and are not part of the SCALER work plan. My role in the SCALER project will help leverage the resources needed to meet the high logistical demands of carrying out this research in the Arctic, while expanding the knowledge base within the field. The results of this study will benefit the diverse, multidisciplinary SCALER team, which will guide the decisions of research organizations (e.g., National Ecological Observatory Network) as they implement long-term monitoring programs in streams across the United States.

*Broader Impacts—*My proposed research will have broader impacts that extend beyond the University of Vermont’s research community and the diverse SCALER project team. I propose to work with teachers and students at my high school alma mater in Bethlehem, Pennsylvania to help promote advanced scientific discovery and understanding through experiential learning. Liberty High School has over 3,000 students and approximately a 50% non-white student body. I plan to expose teachers and students to fundamentals of stream ecology through class lectures and field laboratories that I will develop and instruct. Additionally, I will lead a publically accessible interactive web-based seminar facilitated by the Association of Polar Early Career Scientists (APECS) for those who share my interests of the Arctic environment. The societal contributions I can make through this research are as exciting as the research itself, and the dissemination of knowledge through new partnerships will remain an utmost priority.

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