**Habitat Heterogeneity and Phenotypic Diversity: The Influence of**

**Stream Attributes on Timing of Chinook Salmon Spawning**

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The population structure of Pacific salmon is an assimilation of life history forms that evolved in synchrony with diverse and complex environments across the range of salmon (Brannon et al. 2004). As a reflection of this diversity, Waples et al. (2004) described salmon as exhibiting *enormous* complexity in life-history traits. The evolution of life-history tactics is strongly influenced by patterns of variation of relevant habitats and other environmental variables in space and time (Stearns 1976). Having a variety of life history tactics serves to spread the mortality risk across habitats and thus reduces the probability of complete year class failure (Healey 1991). Chinook salmon, in particular, display a broad array of tactics including variations in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution and ocean migratory patterns; age and season of migration; and age and timing of spawning (Healey 1991).

The precision with which adult salmonids time their spawning migration (time of entry into fresh water by pre-spawning adults) can constrain gene flow between seasonally distinct spawning segments, thereby enabling local adaptation of phenology (Manhard et al. 2017). Timing of adult Pacific salmon spawning migrations has a significant genetic component (Ricker 1972), and thus early and late spawning stocks within the same river can be genetically different (Beacham and Murray 1986). Although adult run timing is the life history trait most commonly used to discriminate among and define salmon populations (Waples et al. 2004), here we focus on spawn timing as a metric to examine phenotypic diversity across populations. As with migration, spawning timing can vary widely across salmon populations, both within and across watersheds. Significant heritability of spawning date has been repeatedly found (see Wedekind 2010). However, Beacham and Murray (1986) reported that since different genotypes can respond differently to the same environment, the final phenotypic effect of a specific environment can be challenging to predict. A variety of locally adapted salmon population characteristics, habitat features, environmental conditions, and climatic factors likely interact with genotypes to influence the specific timing of salmon spawning.

In this paper, we examine how stream geomorphic attributes, water temperature profiles, habitat features, climatic factors, and spawning escapements influence wild Chinook salmon phenotypic diversity, specifically, the timing of spawning. We compare detailed salmon spawn timing data across four years (5?) in twelve stream reaches within six major watersheds, all within a relatively intact river basin in central Idaho.