**Density dependence, hatchery releases and environmental conditions explain annual variation in productivity of Skagit River wild steelhead**

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**Abstract**

Successful recovery of threatened populations of Puget Sound steelhead (*Oncorhynchus mykiss*) will undoubtedly require knowledge of the predominant processes affecting population productivity. Here we utilize a 24 year data set of spawners and total resulting recruitment of adult wild winter run steelhead in the Skagit River basin to build a Ricker stock-recruit model with life-stage specific predictors. The analysis examines management actions (release of hatchery steelhead) and environmental variables (freshwater and marine conditions) hypothesized to impact wild steelhead productivity. Our study provides two important results relevant to management. First, results provide evidence for density dependent regulation of wild steelhead productivity. Specifically, the number of wild spawners significantly improved model fits relative to models without this predictor. Second, we found a statistically significant negative relationship between the number of hatchery fish released and wild steelhead productivity. Additional predictors associated with wild productivity include an index of sea surface temperature in the North Pacific and the smolt to adult return rate of the Skagit River hatchery population, which we use as a surrogate for conditions encountered in habitats shared by hatchery and wild fish (e.g., marine waters). Freshwater conditions such as winter peak flow and summer low flow generally explained much less of the variability in wild productivity than the hatchery release number and marine predictors. Our results are consistent with, but cannot discriminate between, a variety of ecological mechanisms by which hatchery smolts might impact wild productivity including competition, direct predation, and predator attraction. We found no relationship between wild productivity and an index of the spatial dispersal of hatchery releases, suggesting that any negative impacts of the hatchery program are primarily due to the sheer number of fish released. Our model was not designed, nor has the ability, to evaluate genetic mechanisms of hatchery impacts on wild productivity. Although our analysis was correlative rather than experimental or causative, these results quantify ecological risks posed to threatened steelhead and urge careful consideration of the impacts on the wild population when setting hatchery program policy. Model predictions, specifically the productivity of the wild population under alternative hatchery, harvest, and habitat restoration scenarios provide co-managers a scientific tool for making informed management decisions.