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ARTICLE

Sea-to-sea survival of late-run adult steelhead (*Oncorhynchus mykiss*) from the Columbia and Snake rivers

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Abstract: We used biotelemetry and genetic stock identification to assess sea-to-sea survival and run composition of 1212 late-migrating adult steelhead (anadromous *Oncorhynchus mykiss*) through the Columbia River and Snake River migratory corridors. The late run was predominated by steelhead from Idaho's Clearwater and Salmon rivers that must pass eight large hydroelectric dams during both prespawn and postspawn migrations. In 2 years (2013 and 2014), prespawn survival to Snake River tributaries (>500 km) was 0.48–0.67 for the most abundant populations and was higher for females and 1-sea fish (i.e., fish that spend one winter at sea). Annual survival from Snake River tributary entry to postspawn kelt status was 0.14–0.17, with higher survival for females and those without hatchery fin clips. Kelt outmigration survival was 0.31–0.39 past four Snake River dams and 0.13–0.20 past all eight dams and was highest for smaller kelts. Full-cycle adult freshwater survival (sea-to-sea) including 16 dam passage events was 0.01–0.02. Younger steelhead and those without fin clips survived at the highest rates. This study uniquely partitioned mortality across prespawn, reproductive, and kelt life history stages and informs management strategies for this conservation-priority metapopulation.

Résumé : Nous avons utilisé la biotélémétrie et l'identification génétique du stock pour évaluer la survie de l'océan à l'océan et la composition de la montaison de 1212 truites arc-en-ciel anadromes (*Oncorhynchus mykiss*) à migration tardive dans les corridors de migration du fleuve Columbia et de la rivière Snake. Des truites arc-en-ciel anadromes provenant des rivières Clearwater et Salmon en Idaho étaient prédominantes dans la migration tardive, ces truites devant franchir huit grands barrages hydroélectriques durant leurs migrations avant et après le frai. En 2 ans (2013 et 2014), le taux de survie avant le frai jusqu'à des affluents de la Snake (>500 km) était de 0,48–0,67 pour les populations les plus abondantes et était plus élevé pour les femelles et les individus ayant été dans l'océan une fois. La survie annuelle de l'entrée dans les affluents de la rivière Snake jusqu'à l'état de charognard était de 0,14–0,17, les taux les plus élevés étant observés pour les femelles et les individus sans marque d'ablation de nageoire en alevinière. Les taux de survie des charognards durant la dévalaison étaient de 0,31–0,39 après quatre barrages sur la rivière Snake et de 0,13–0,20 après tous les huit barrages, et ce taux était le plus élevé pour les charognards plus petits. Le taux de survie en eau douce des adultes après un cycle complet (océan à océan) comptant 16 franchissements de barrage était de 0,01–0,02. Les truites arc-en-ciel anadromes plus jeunes et celles sans marque d'ablation de nageoire en alevinière présentaient les taux de survie les plus élevés. L'étude distingue nettement la mortalité des stades prégénésique, reproducteur et de charognard du cycle biologique et fournit de l'information utile pour l'élaboration de stratégies de gestion pour cette métapopulation dont la conservation est prioritaire. [Traduit par la Rédaction]

Introduction

Preservation of genetic and life history diversity are becoming increasingly important objectives in fish conservation and management programs. In the United States, the Endangered Species Act has essentially codified tenets like reproductive isolation, degree of genetic divergence, and adaptive distinctiveness into species conservation planning (Moritz 1994; Waples 1995; Crandall et al. 2000). Application of these criteria is commonly used in the management of Pacific salmonids (*Oncorhynchus* spp.), a genus with exceptional conspecific and intraspecific diversity (Groot and Margolis 1991; Waples 1991; Quinn 2005). *Oncorhynchus mykiss* is often considered the most phenotypically diverse species in the genus, with a continuum of life history types ranging from freshwater resident (i.e., rainbow trout) to fully anadromous (i.e., steelhead) (Behnke 1992; Courter et al. 2013; Kendall et al. 2015). There are dozens of genetic and life history variants at the anadromous end of the *O. mykiss* spectrum, with differences in freshwater and ocean rearing duration, age at maturity, timing of migrations, and the timing and frequency of reproduction (Busby et al. 1996; Moore et al. 2014; Hodge et al. 2016). This variation is thought to ultimately reflect life history trade-offs in the allocation of reproductive effort among populations and functions to buffer populations against environmental variability (Moore et al. 2014).

The conservation of life history variation is an integral component of many management frameworks, and this study was motivated by a mandate to protect and restore steelhead that inhabit the large (~278 500 km^2) Snake River basin in Idaho, Oregon, and Washington (USA). The river historically sustained many genetically and phenotypically distinct steelhead populations, but overharvest, construction of impassable dams, hatchery practices,

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