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PERSPECTIVE

Do chemically contaminated river estuaries in Puget Sound (Washington, USA) affect the survival rate of hatchery-reared Chinook salmon?

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Abstract: This study examined the rate of survival for hatchery-reared, ocean-type juvenile Chinook salmon (*Oncorhynchus tshawytscha*) to the adult life stage in relation to contamination status for estuaries where they temporarily reside. The hypothesis tested here is that juvenile Chinook from Puget Sound (Washington, USA) area hatcheries exhibit differential survival as categorized by the state of contamination in their respective natal estuaries. Data were examined from 20 hatcheries that released fish to 14 local estuaries in the Greater Puget Sound area over 37 years (1972–2008). A parallel analysis was also conducted for coho salmon (*Oncorhynchus kisutch*) outmigrating from many of the same hatcheries. For all years combined, juvenile Chinook transiting contaminated estuaries exhibited an overall rate of survival that was 45% lower than that for Chinook moving through uncontaminated estuaries, which was confirmed when tested year by year. The results for coho originating from the same hatcheries and sharing a similar marine distribution indicated no substantial differences among estuaries. These observations have important implications for wild juvenile Chinook that spend more time in the estuary compared with hatchery-reared fish.

Résumé : L'étude se penche sur le taux de survie jusqu'au stade de vie adulte de saumons quinnats (*Oncorhynchus tshawytscha*) juvéniles de type océanique élevés en écloserie par rapport à l'état de contamination des estuaires dans lesquels ils résident provisoirement. L'hypothèse testée veut que les saumons quinnats juvéniles issus d'écloseries de la région du Puget Sound (État de Washington, États-Unis) présentent des taux de survie distincts selon l'état de contamination de leurs estuaires natals respectifs. Des données ont été examinées pour 20 écloseries ayant relâché des poissons dans 14 estuaires de la grande région du Puget Sound pendant une période de 37 ans (1972–2008). Une analyse parallèle a également été réalisée pour le saumon coho (*Oncorhynchus kisutch*) migrant vers la mer à partir de bon nombre des mêmes écloseries. Pour toutes les années combinées, les quinnats juvéniles ayant transité par des estuaires contaminés présentent un taux de survie global de 45 % inférieur à celui de saumons quinnats transitant par des estuaires non contaminés, une observation également avérée à l'échelle annuelle. Les résultats pour les saumons cohos issus des mêmes écloseries et présentant une répartition marine semblable n'indiquent aucune différence notable entre estuaires. Ces observations ont d'importantes conséquences en ce qui concerne les saumons quinnats juvéniles sauvages, qui passent plus de temps en estuaire que les poissons élevés en écloserie. [Traduit par la Rédaction]

Introduction

Ocean-type Chinook salmon (*Oncorhynchus tshawtyscha*) that rear naturally or are released from a hatchery migrate in the spring and summer to the estuary as subyearlings (age 0+) and reside there for several weeks (Simenstad et al. 1982; Healey 1991; Thorpe 1994) as they adjust physiologically to seawater and increase in size and lipid content before moving offshore to marine waters. Puget Sound Chinook are of special concern because wild and some hatchery-produced populations are listed as threatened under the US Endangered Species Act (USDOC 2005). Conversely, juvenile coho salmon (*Oncorhynchus kisutch*) spend their first year in freshwater and migrate to the estuary in the spring or summer as yearlings (age 1+), generally spending only a few days in the local estuary before proceeding to more open waters (Simenstad et al. 1982; Thorpe 1994). This major difference in life history can have a large effect on the degree of toxicant exposure in contaminated estuaries, which can affect fish in several ways, including impaired growth, altered behavior, higher rates of pathogenic infections, and changes to physiological homeostasis, all of which can lead to increased rates of mortality.

Even though Puget Sound is considered one large estuary, there are many local estuaries formed by numerous rivers that empty into the Sound, and these exhibit various degrees of physical and chemical alteration. Many of these local estuaries have been highly modified over the past 100 years through dredging, channelizing, armoring, and diking for agriculture. They have been used as shipping ports, sites for industry, and as receiving water for waste treatment plants (Bortleson et al. 1980; Thom and Hallum 1990). Diking for agriculture has reduced the area of native marshlands by 25%–95% (Thom and Hallum 1990; Simenstad et al. 2011), especially in the Lummi, Samish, Skagit, Nisqually, Stillaguamish, and Snohomish river deltas. Higher percentages of loss for original habitat occurred in the Duwamish and Puyallup systems (Thom and Hallum 1990). The Bortleson et al. (1980) data show extensive reductions for subaerial and intertidal habitat for the more urban sites (e.g., Duwamish and Puyallup), but also relatively high losses for the Samish (79% of subaerial habitat) and modest losses for the Nisqually (~22%–28% of both subaerial and intertidal). Only one of the estuaries in this study, the Nooksack, is considered relatively undisturbed in terms of areal extent of subaerial and intertidal wetlands (Bortleson et al 1980; Thom and

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