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Population diversity in Kuskokwim Chinook:

New findings on trade-offs for different harvest strategies

A research team funded by the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative used estimates of Chinook population diversity to build computer simulations that evaluated how well alternative harvest policies meet Chinook population diversity and fishery objectives in the Kuskokwim.

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Variation among salmon populations in their productivity, carrying capacity and life history characteristics (population diversity) contributes to stable fisheries as a result of portfolio effects, whereby fisheries that harvest multiple populations benefit from the averaging effects of their variable dynamics (**Figure 1**). This diversity also supports fishery resilience because typically at least some populations will do well when others do not and populations that are less productive today might be more productive under future conditions.

As a result population diversity is increasingly viewed as a foundation of sustainable and resilient resource management and the importance of protecting population diversity is recognized in fisheries management policies such as [Alaska's Sustainable Salmon Policy].

When mixed-stock fisheries for multiple populations overlap in space and time there can be an inherent conflict between harvest rates and population diversity: high harvest rates, which can be sustained by the most productive populations, can come at the cost of increased risk of overfishing less productive ones (**Figure 2**).

Despite the potential importance of these harvest-population diversity tradeoffs, Chinook salmon management, including in the large river basins of

Figure 1. Illustration of how population diversity contributes to harvest stability. When diversity is high, individual populations doing very well can compensate for those that are doing poorly, leading to a more stable harvest over time. When diversity is low, harvests are more variable because there are fewer populations to buffer the effects of a variable environment.

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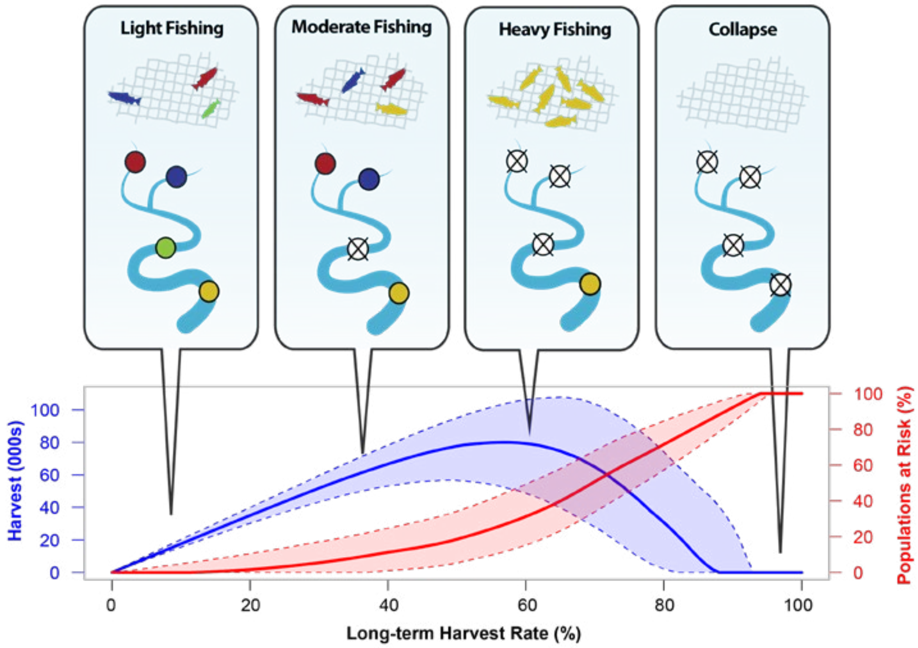

Figure 2. Relationship between long-term mixed-population harvest and risks to individual populations across a range of long-term average harvest rates. Overall harvest from the system is predicted to increase as the average harvest rate increases up to a point, after which it rapidly declines because most populations are overfished and then driven to extinction. This figure illustrates that you have to be willing to accept some risk to the weakest (least productive) populations if you want to maximize total harvest from the system.

Western Alaska and the Yukon, does not often explicitly consider them. To help address this knowledge gap we characterized the degree of Chinook population diversity within the Kuskokwim River basin by fitting spawner-recruitment models to all available tributary level data on Chinook escapement along with estimates of age composition and total harvest (13 populations accounting for approximately half of the total production from the Kuskokwim). We found clear evidence of population diversity in the system where population productivity and size were estimated to vary by as much as 3-fold and 18-fold among populations, respectively (**Figure 3**).

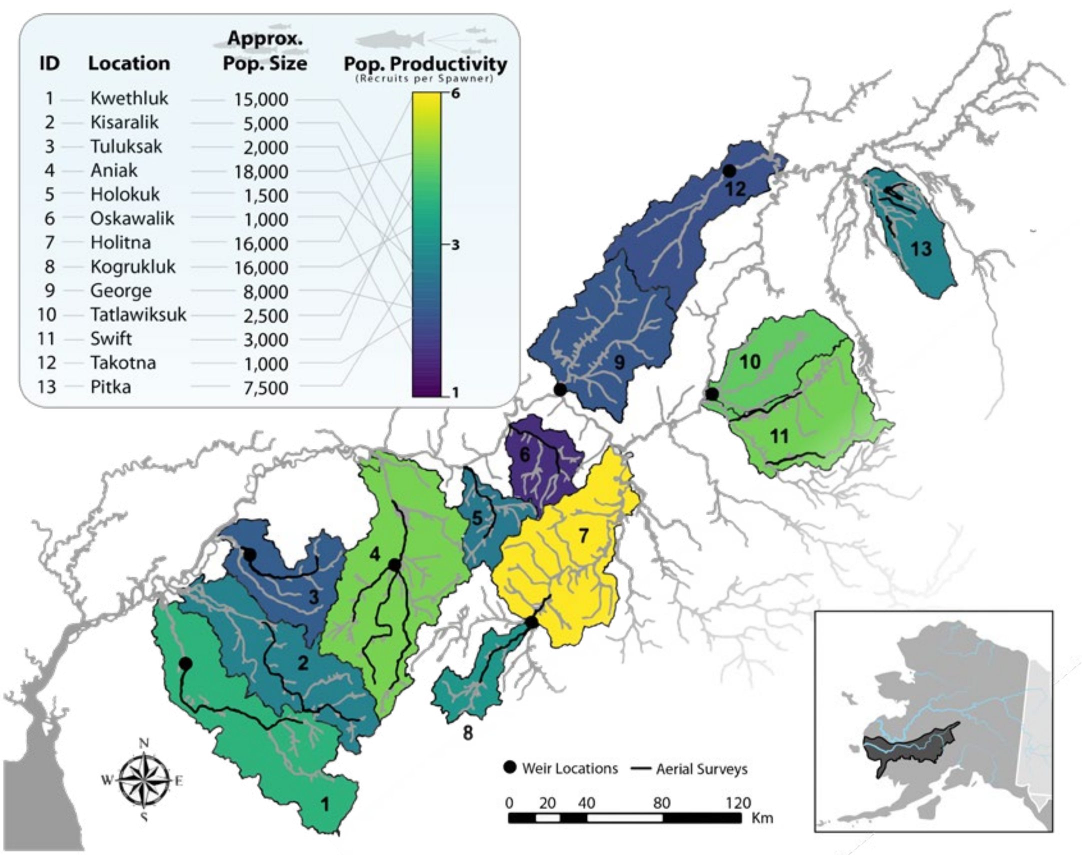

Figure 3. Chinook population diversity in the Kuskokwim River basin. Each polygon depicts the general spawning distribution of the 13 Chinook populations for which there are estimates of spawner abundance based on either weir (points) or aerial (thick line) surveys. Populations are color coded by their productivity (recruits produced per spawner at small population size) and estimated average population size (predicted in absence of fishing) is listed next to each system's name. This biodiversity emphasizes that large populations are not necessarily the most productivity, and vice-versa.

We used estimates of Chinook population diversity to build computer simulations that evaluated how well alternative harvest policies (defined by basin wide escapement and harvest goals) meet Chinook population diversity and fishery objectives in the Kuskokwim. We found that harvest policies focused on meeting minimum subsistence needs were unlikely to jeopardize long-term prospects for basin-wide sustainable use. However, Chinook population diversity gives rise to asymmetric trade-offs among fishery and conservation objectives in the Kuskokwim. For example, relative to a harvest policy that seeks to maximize mixed-stock harvests, foregoing relatively small amounts of mixed-stock harvest is predicted to yield relatively large increases in the chances of ensuring equitable access to Chinook (i.e., meeting tributary goals) and to nearly eliminate biological risks to weak populations (**Figure 4**).

The approach we developed for the Kuskokwim provides a general framework for characterizing salmon population diversity in large river basins and evaluating harvest-population diversity trade-offs among alternative harvest policies within them. With support from AYK-SSI we are now exploring Chinook salmon population diversity in the Yukon River basin. Ongoing research analyzing Chinook salmon ear stones (otoliths) in the Kuskokwim and Yukon suggests that different parts of these large watersheds are hot spots for salmon production and growth, and that favorable locations change year to year. Together with our efforts to characterize Chinook population diversity, this research emphasizes the importance of protecting and monitoring salmon habitats and populations (both large and small) throughout these large free flowing river basins to maximize their resilience to environmental change and the benefits communities derive from them.

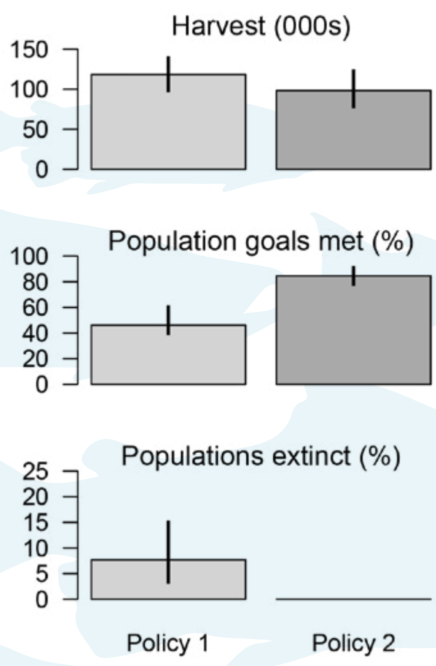

Figure 4. Illustration of the predicted performance of two alternative harvest policies for Kuskokwim Chinook. Policy 1 seeks to maximize total mixed-population harvest while Policy 2 seeks to maximize harvests only once the risk of driving the weakest populations extinct is minimized. Shown for each policy is (1 – top panel) the predicted average harvest, (2 – middle panel) proportion of individual populations whose average spawner abundance is above a population (or tributary) level goal which is also a proxy for equitable access to Chinook, and (3 – lower panel) the proportion of populations predicted to be driven to extinction.

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