Summarizing population status: Metrics for spatial structure

Note: this brief handout is meant to stimulate discussion between technical staff and the TRT liaisons for each watershed. We hope that the ideas presented here are helpful in illustrating possible ways to represent the outcomes of different habitat conditions on spatial structure in each population. We assume that discussions between watershed technical staff and TRT liaisons can illuminate similar possibilities in each watershed, given locally available information and results. Ultimately, the outcomes of combined habitat, hatchery and harvest conditions on VSP will need to be evaluated for each population—the examples we include here focus on alternative habitat conditions as a starting point.

Background

Spatial structure is the distribution of individuals in habitats they use throughout their life cycle, and it is one of the 4 key population parameters NOAA Fisheries uses to describe a Viable Salmonid Population (i.e., a VSP). A population that has a greater spatial distribution of individuals is more likely to persist than a population whose individuals are concentrated in a few locations. The contribution of spatial structure to population persistence results from 3 main processes: (1) reduced chance of catastrophic losses of the population (i.e., when groups of individuals are spread out in space), (2) greater chance that locally extirpated or dwindling groups will be rescued by re-colonization (i.e., when individual groups are close enough together), and (3) a greater opportunity for long-term demographic processes to buffer a population from future environmental changes. Collectively, these phenomena commonly are referred to as metapopulation processes. Because of the contrasting benefits of groups of individuals being close enough together for re-colonization to occur and yet spread out enough so that all groups do not fall victim to the same catastrophe, spatial structure for a viable population should include multiple clusters of groups that are closely aggregated, with the clusters themselves being spread out throughout the geographic area occupied by the population.

Overview

The examples we present here are aimed at providing simple metrics we can use to summarize spatial structure for populations of listed salmon in the Puget Sound Chinook and Hood Canal Summer Chum ESUs. Contrasting alternative population spatial structures under different habitat conditions is a useful way to evaluate the relative value of alternative habitat actions to salmon population status. Thus far, we have summarized three spatial structure metrics in freshwater and some estuarine areas at the population level: (1) the number and spatial distribution of occupied subwatersheds under alternative conditions, (2) differences in the distribution of distances separating occupied subwatersheds between current and historical habitat conditions, and (3) a summary of the proportion of the historically available spawning area that is occupied by salmon under different habitat conditions. These metrics can be used to compare alternative land use and habitat condition scenarios in their effects on this key component of VSP.

Example products for the Snohomish populations (Skykomish and Snoqualmie):

- Maps depicting the percent reduction in current spawning and rearing habitats relative to historical (potential) (Figure 1a)
- Maps depicting the spatial locations of subwatersheds supporting adults, as predicted by modeling the effects of current habitat conditions, a test case alternative, and historical habitat conditions (Figure 1b).
- Proportion of historically accessible adult subwatersheds that are occupied under different habitat conditions (in Figure 1b).
- Current, test case and historical distributions of network distances separating subwatersheds supporting adults (Figure 2).

Approach and methods for Snohomish populations

Spatial locations of current adult and juvenile rearing for each population were provided by the Snohomish Basin Technical Committee (EASC 2004). Maps of the percent reduction in current adult and juvenile rearing habitats relative to those historically available were estimated from an analysis of intrinsic potential capacity (EASC 2004, Sanderson et al. 2004; Fig. 1a). The maps showing spatial locations of subwatersheds supporting adult spawning under current, test case and historical habitat conditions were produced as output from the SHIRAZ modeling being conducted in the Snohomish River Basin (Scheuerell et al., unpublished data; Fig. 1b). The "current path" alternative describes the changes in land use and habitat conditions expected into the future under current land use, human population and regulatory conditions in the Snohomish Basin. The "test case" alternative represents a set of land use and habitat conditions identified by the Snohomish Technical Committee as those improving recovery prospects for salmon in the Basin.

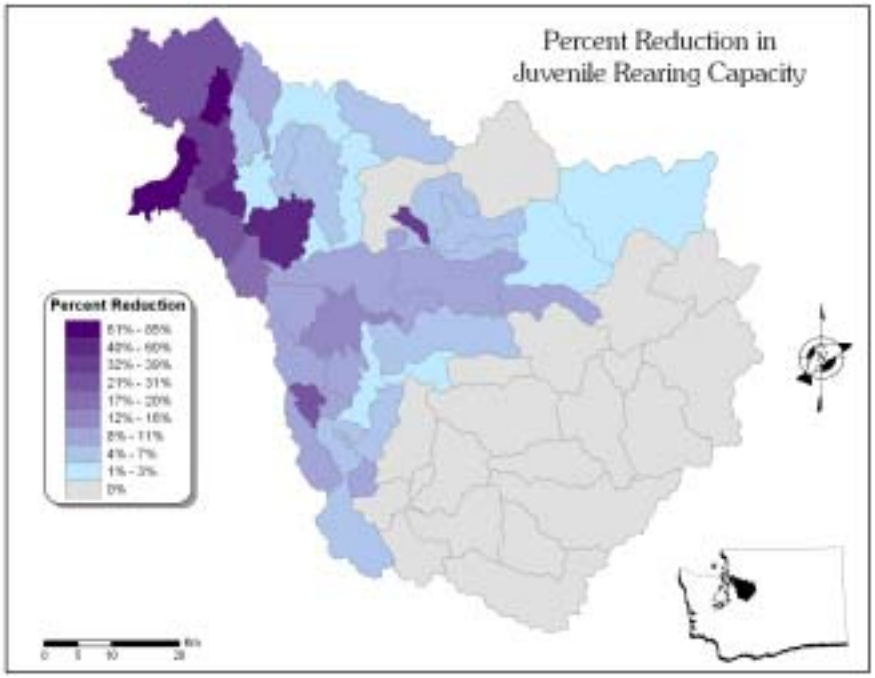
We summarized the distribution of stream network distances separating adult and juvenile rearing habitats by first generating a pairwise distance matrix that tallied the number of subwatersheds along the stream network separating each pair of occupied subwatersheds as modeled in SHIRAZ. Three distance matrices were generated for each population, which represent distances separating subwatersheds predicted by SHIRAZ to contain spawners under current path, test case and historical habitat conditions (Fig. 2).

We estimated the proportion of historically occupied subwatersheds that were occupied under current path and test case alternatives by comparing the number of subwatersheds occupied by >500 spawners under each of the alternatives modeled in SHIRAZ. These percentages are depicted in Figure 1b.

References cited

EASC 2004. Snohomish River Basin Ecological Analysis for Salmonid Conservation. Ecological Analysis/TRT Case Study Subcommittee. External Review Draft.

Sanderson, B., J. Davies, K. Lagueux, T. Beechie, L. Holsinger and M. Ruckelshaus. 2004. Potential capacity of Puget Sound watersheds to support spawning Chinook salmon. Manuscript in preparation.



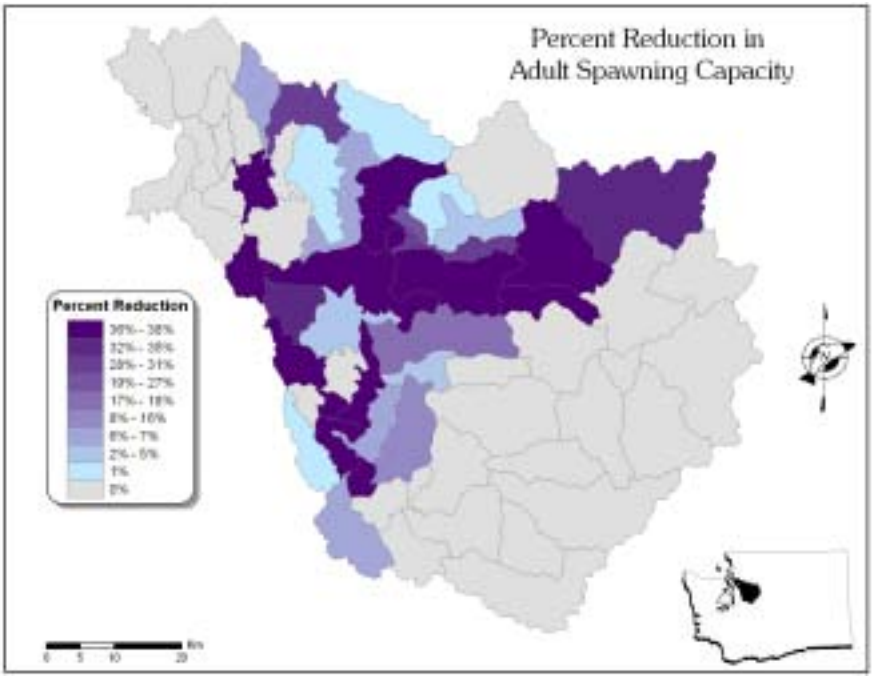


Figure 1a. Maps depicting the percent reduction in current Chinook spawning and rearing habitats relative to historical (potential) in the Snoqualmie and Skykomish populations in the Snohomish River Basin (Sanderson et al. 2004, Lagueux et al. unpubl. data.)

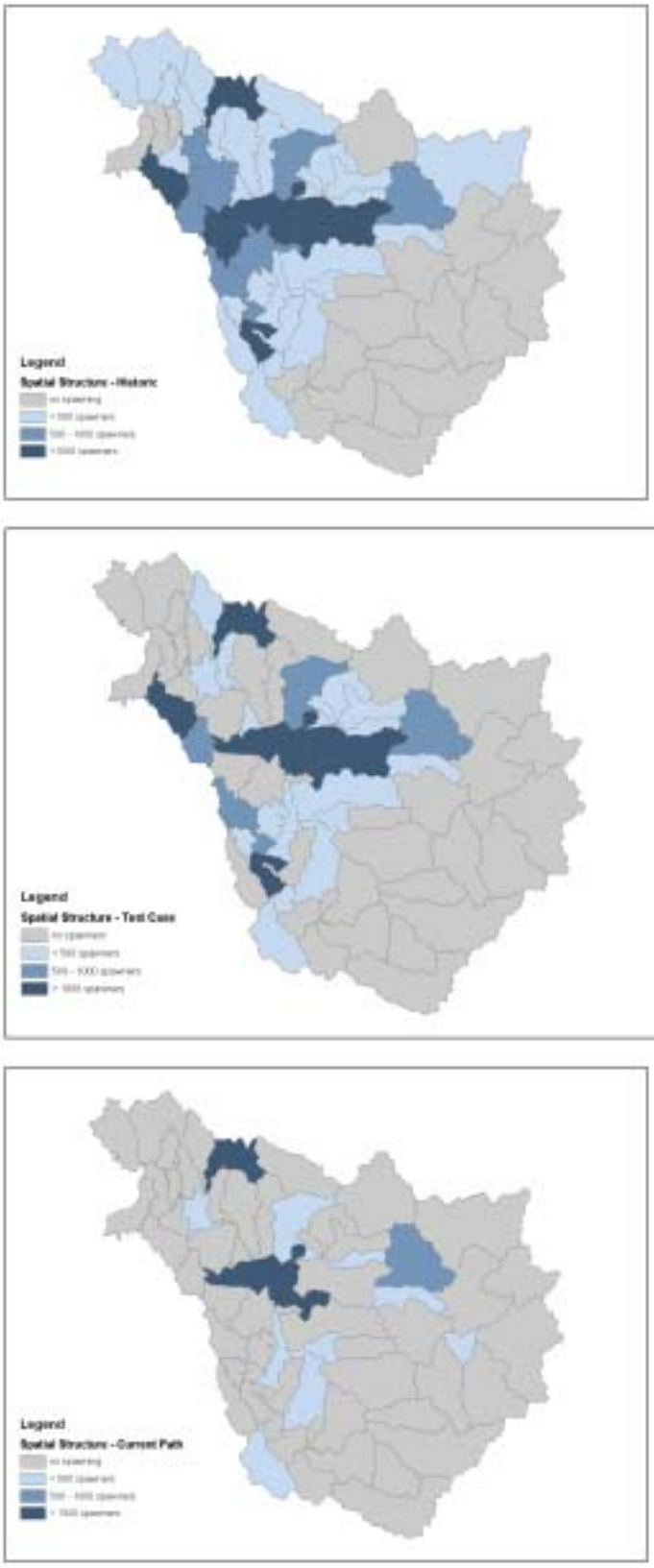


Table 1. Proportion of historical subbasins that are occupied by > 500 spawners under alternative watershed habitat conditions

	Current Path	Test Case	Historical
# occupied subbasins	3	9	13
Proportion of historical	0.23	0.69	1

Figure 1b. Maps depicting the spatial locations of subwatersheds in the Snohomish River Basin supporting adults, as predicted by modeling the effects of historical habitat conditions, a test case alternative, and habitat conditions under a current path alternative (unpublished results from SHIRAZ modeling for the EASC).

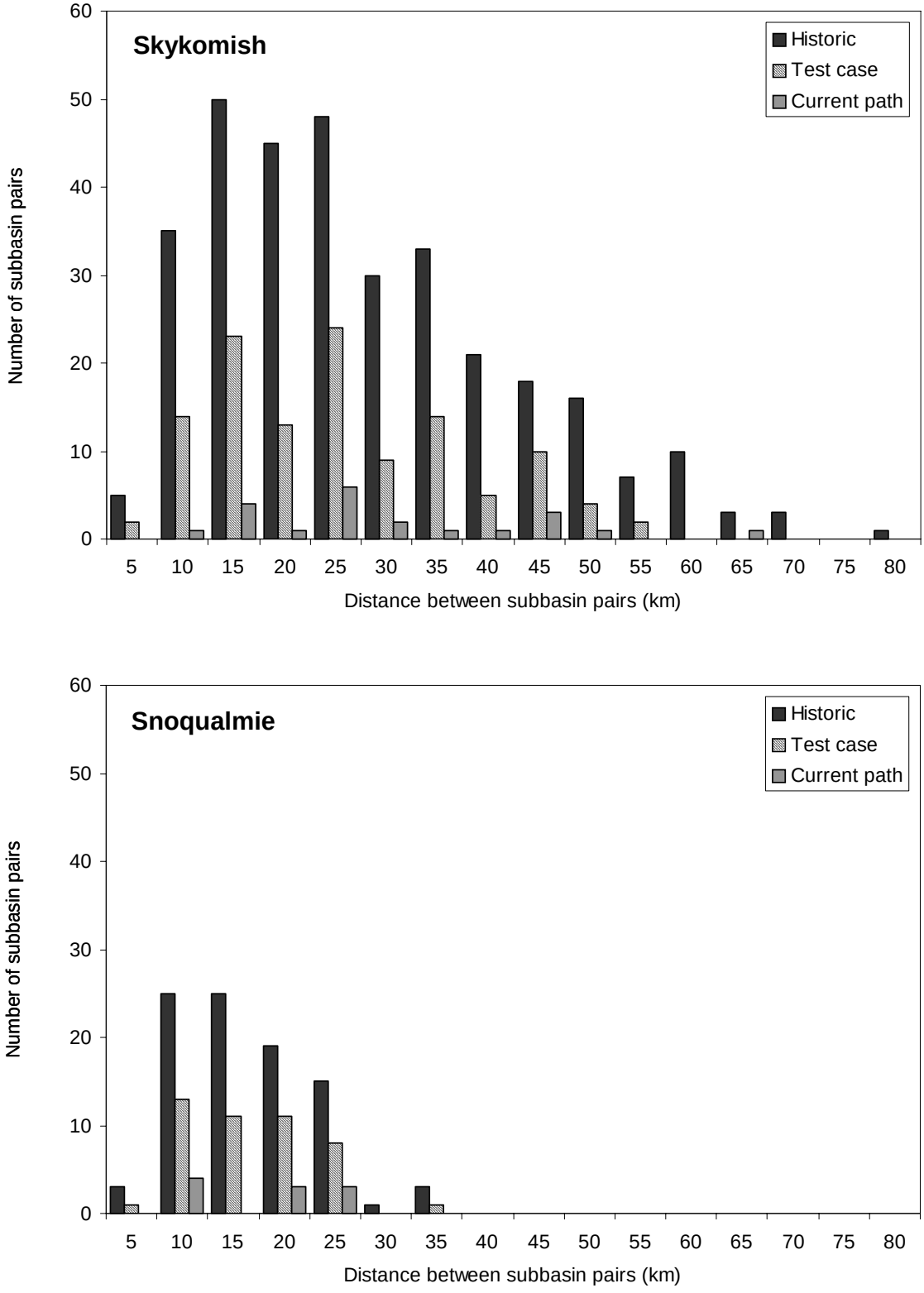


Figure 2. Distributions of network distances separating subwatersheds supporting adults under current path, test case and historical habitat conditions in the Skykomish and Snoqualmie populations (unpublished results from SHIRAZ modeling for the EASC).