

# Ecological, socio-cultural, and economic implications of changes in the distribution and abundance of sockeye salmon

S. Ellison, E. Nichols, S. Pyare, D. Montieth, R. Kovach, D. Tallmon



## II. Site-Specific Changes

- Auke Creek in central Southeast Alaska has a permanent weir that has provided over 40 years of census data on all salmonids that use Auke Creek and Auke Lake
- Stream temperatures have significantly increased in the last 40 years
- Sockeye adults are returning later, though pink and coho salmon are returning earlier. The juveniles of all species are emigrating to sea earlier
- The range of dates over which salmon are available for harvest has narrowed over the last 40 years

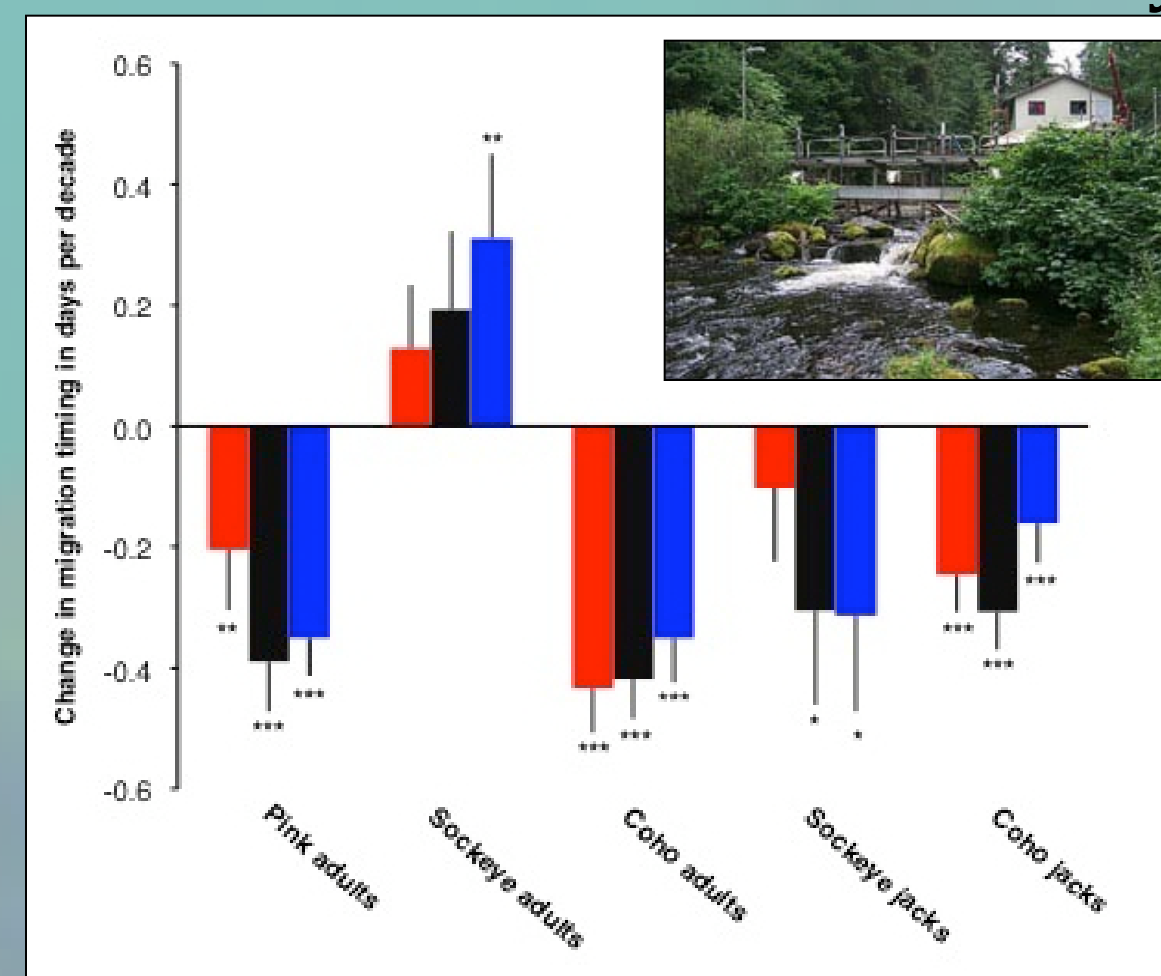


Fig. 2. Changes in migration timing for salmonids at Auke Creek

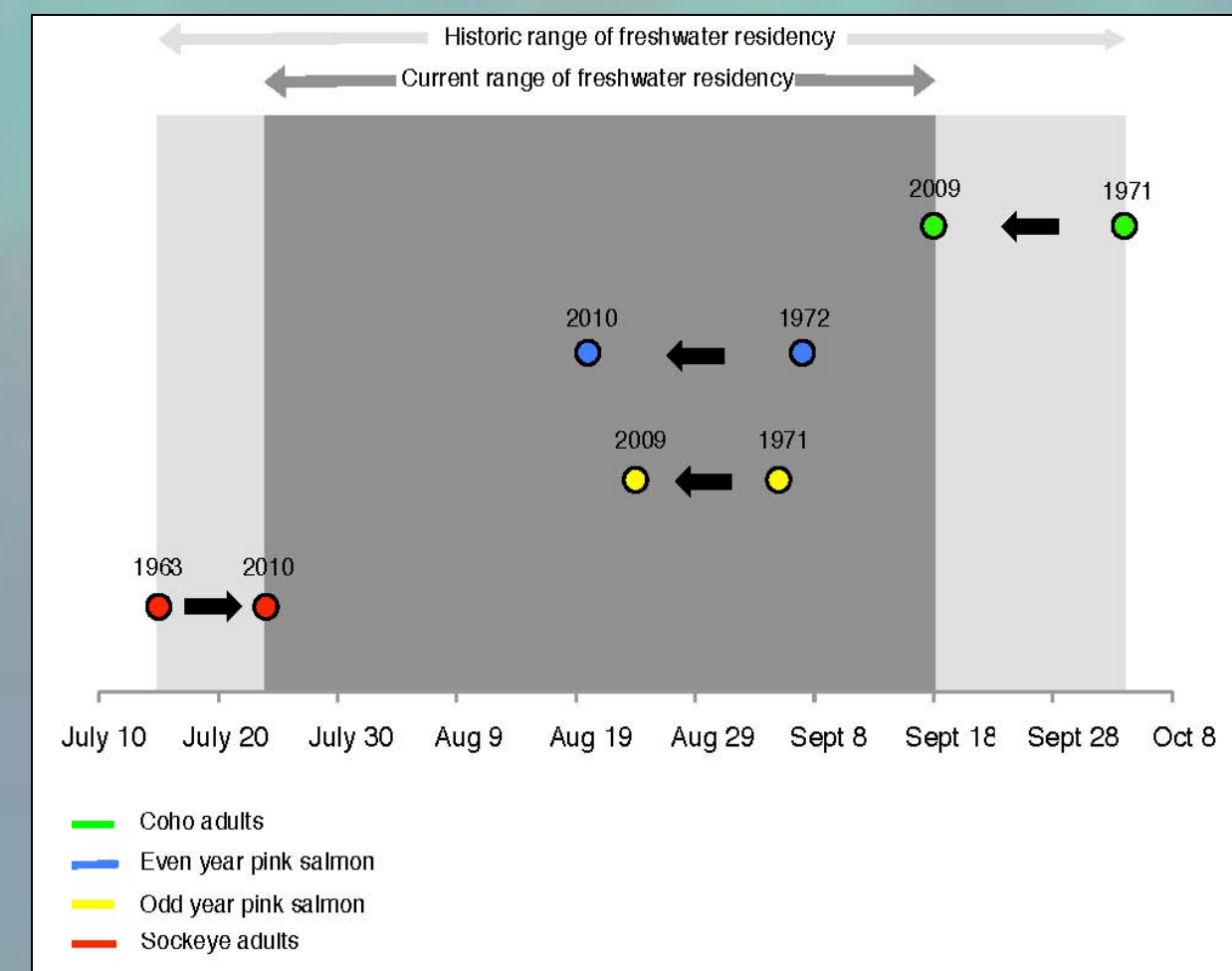


Fig. 3. Historic vs. current range of freshwater residency for salmonids at Auke Creek

## Overall Scope of Study

Sockeye salmon (*Oncorhynchus nerka*) is among the most economically, socially, culturally, and ecologically important species in Alaska. An important, recent paper in the journal *Nature* suggests that the large population diversity and life history diversity of sockeye salmon in Bristol Bay collectively ameliorate underlying variation in different individual sockeye runs, by providing a stabilizing “portfolio effect” (Schindler et al. 2010). This portfolio effect results in this species serving as an especially dependable and sustainable ecosystem service for the Bristol Bay region. However, data from southeast Alaska suggest that there are changes in the run timing of some salmon stocks in response to a warming environment (Taylor 2008, Kovach, *pers. comm.*). There may also be associated changes in their abundance and distribution, which would have major social, cultural, economic, and ecological implications in southeast Alaska. Here, we present preliminary findings on these 4 integrated aspects of sockeye ecology, including salmon distribution, run timing, and abundance over the last century in southeast Alaska using historic and modern data, as well as an exploration of the cultural and ecological implications of any changes on southeast Native Alaskan culture and economies.

## III. Ecosystem Services

- Sockeye salmon is a flagship ecosystem service because it is traditionally highly valued by humans, has significant economic value and may be one of the most highly prized of the salmon species to both subsistence harvesters and commercial fishers, and, unlike other salmon, does not do as well under hatchery conditions.
- Through the use of (a) archaeological fish weir data (Fig 1 inset), some > 3,000 years old; (b) historical production and harvest data as far back as the 1880s; and (c) over thirty to forty years of more contemporary fish weir information, we are investigating how human factors and climate change may be changing the timing of salmon runs in Southeast Alaska.
- Southeast Alaska has variable climates and ecologies. This provides a diversity of salmon runs that may help human harvesters sustain salmon productivity by diversifying their fishing portfolio temporally and spatially across the region.



## II. Regional Shifts

- Approximately 30 years of ADF&G count data on 11 weirs (Fig 1) across Southeast was analyzed in terms of changes in run timing of returning adult sockeye salmon
- As with Auke Creek, the majority of streams analyzed across Southeast seem to suggest later run timing for returning sockeye
- The original weir data are somewhat inconsistently collected and spawn different time frames, but provide an initial description of temporal patterns

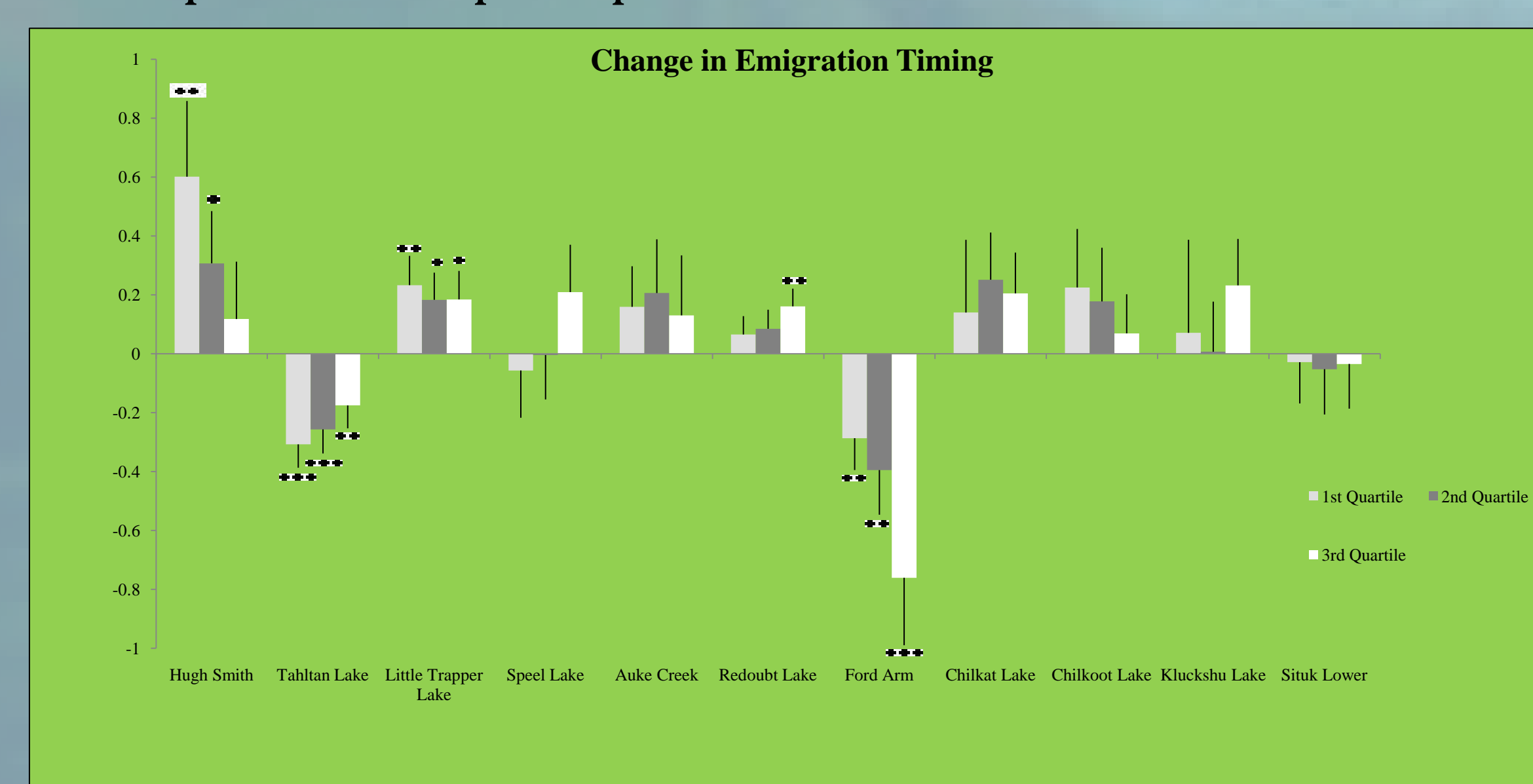
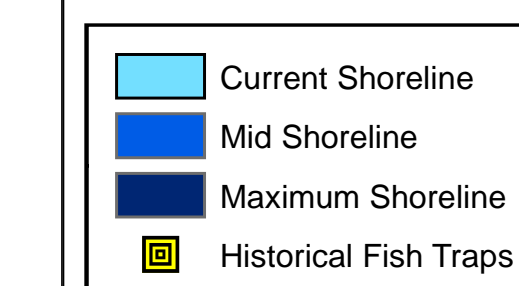


Fig. 4. Changes in emigration timing for sockeye salmon at 11 streams across Southeast Alaska over approximately 30 years

Fig. 1. Locations of sockeye streams/lakes with 20+ years of continuous count data and locations of archaeological fish traps (inset)



## Synthesis

- Sockeye salmon phenology appears to be changing across Southeast Alaska, which potentially compromises the “portfolio” service of sockeye to humans
- Individual streams with intensive and consistent sampling regimes, like Auke Creek, are ideal and mechanistic opportunities for studying phenological change
- Even streams with cruder observational datasets show utility for evaluating effects of climate change, and are consistent with a shifting phenology
- Regional climatic variability and local site differences may interplay to explain historical and potential future patterns in sockeye phenology

## IV. Forecasting Regional Vulnerability

We are investigating the potential for future shifts and resulting vulnerabilities in the regional portfolio diversity of sockeye, through:

- Conducting a multi-scale analysis of geographic-environmental correlates of historical trends in phenology, including climatic, oceanographic, and geophysical covariates
- Extrapolating these patterns to spatially-explicitly model the “phenological niche” (e.g., a novel derivative of bioclimatic envelope models) of sockeye, historically
- Use future climate scenarios to model geographic patterns in salmon phenology; and identifying clusters of streams that represent areas particularly vulnerable to phenological change.

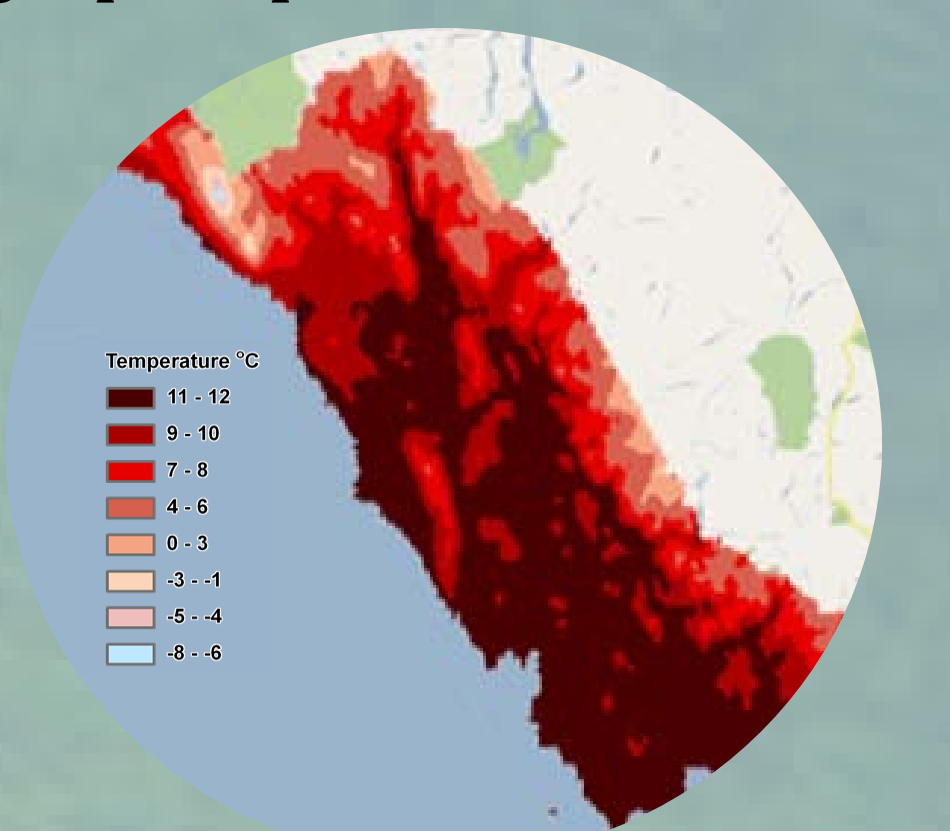


Fig. 5. Forecasted surface-temperature changes in Southeast Alaska to the Year 2099, resulting from a CO2 high-emissions scenario. Courtesy SNAP Alaska.