ACROSS YEAR VARIABILITY IN PATTERNS

OF DENSITY, SURVIVAL, SIZE, AND GROWTH

OF JUVENILE ATLANTIC SALMON

IN THE CONNECTICUT RIVER:

INSIGHTS FOR RESTORATION

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EXTENDED ABSTRACT ONLY - DO NOT CITE

The Connecticut River drainage extends over 400 miles through the states of Connecticut, Massachusetts, New Hampshire, Vermont, and into southern Canada. Historically, a self-sustaining population of Atlantic salmon, Salmo salar, flourished within the Connecticut River watershed but deforestation, pollution, and construction of the first mainstem dam caused the extirpation of the population by the early 1800's. The present Connecticut River Atlantic Salmon Restoration Program, initiated in 1967, seeks to restore a self-sustaining salmon population to the watershed. Since, 1987, the emphasis has been on the annual stocking of fry into all available juvenile rearing habitat. Currently, 27 basins and more than 125 tributaries are stocked with over 9 million fry. This fry stocking is coupled with an annual evaluation of age-specific juvenile survival, density, total length, growth at 298 index sites throughout the basin. This extensive database can provide insights into spatial patterns and temporal trends in juvenile salmon performance that may help guidance restoration strategies.

Herein we examine three questions related to across year variability:

(1) Do mean trends reflect patterns and relationships observed in individual years?

(2) Is there a consistent, predictable trend of patterns and relationships across years? If so, why?

(3) What are the management / conservation / restoration implications of these across-year patterns?

In looking at general trends and relationships, researchers and managers often examine across-year means. Although we know that ecological responses differ from year to year and that some years are "abnormal" or "exceptional," we assume that, in general, across-year means depict useful and consistent trends. For effective management, we need to know if this is a reasonable assumption. Previous results from this juvenile Atlantic salmon database using means from 1990-1996 indicate that juvenile salmon do not perform equally across index sites. Some sites showed exceptionally good performance and others showed exceptionally poor performance. In addition, mean performance within sites differed by basin, scale, and juvenile variable examined. Furthermore, based on 6-year means, some sites were better suited for high densities or large individuals but not both. To understand these patterns of good and poor performance based on mean values, we first examined the effect of density, stream order, temperature, drainage area, gradient, and elevation on survival, density, length, and growth. Based on mean trends, density adversely impacted survival and length. Stream order showed a relationship to density/survival and length/growth at both the within-basin- and watershed-scales. Drainage area was related to survival, density, length, and growth primarily at the smaller, within-basin-scale. Temperature consistently inhibited survival and density within the Farmington basin, yet affected length at the larger, watershed-scale. Similarly, gradient impacted survival and density within the Farmington basin and across the watershed, while influencing length at the larger, watershed-scale only. The relationships with survival and density were consistently opposite to those with length and growth. In fact, stream order, temperature, and drainage area all negatively influenced survival and density, yet positively influenced length and growth at both scales. Not surprisingly, when these patterns based on across year means were compared to patterns based on data from individual years, in many years, when trends were pronounced, general patterns mirrored the mean trends. For example, relative to 1st year and 2nd year survival and density, in 1993, 1994, 1995, 1996, the same sites had exceptionally high and low performance as seen using average values from 1990-1996. Yet important variations existed across years. Thus, examining the magnitude of coherence and sources of variation can provide additional insights into mechanisms for high and low survival, density, size and growth

Relative to temporal trends, performance varied across basins and across years. Years of high and low performance were not the same for all basins. For examples, numbers of 0+ salmon in the southernmost Farmington were the most variable of any basin with highest values in 1990 and 1996. Whereas in the northern West, densities at the end of the first summer were more constant with the highest numbers observed in 1992, 1993, and 1995. For 1+ density, the opposite trend was observed, with the Farmington being less variable across years than the West. Length was less variable across years although high and low values differed across years. For example, 0+ salmon were largest in 1990 in the White, 1996 in the Deerfield and Westfield, 1991 in the Farmington, and 1992 in the Salmon. Again, the southernmost Farmington and Salmon were more variable than the northern West and White. At the site level, clear patterns of increasing variation were associated with higher mean values. However, when these patterns were examined at the basin level, relationships between mean and variance were less clear.

Thus, describing patterns of responses across years may also be useful as a first step in helping us understand why fish survive and grow better under some conditions. Specifically, we may be able to identify good and bad years overall, good and bad years for certain life stages or response variables, or good and bad years for specific basins. By relating physical and biological conditions in these good or bad years to juvenile salmon performance, we could increase our understanding of which conditions favor high and low survival, density, size, and growth.