SOURCES OF GROWTH RATE VARIATION

IN INDIVIDUAL ATLANTIC SALMON PARR

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EXTENDED ABSTRACT ONLY – DO NOT CITE

Growth rate is a highly plastic trait in Atlantic salmon (*Salmo salar*). Smolt ages can range from one to six among rivers (Metcalfe and Thorpe, 1990) and depending on dominance interactions, life history tactic and possibly genetics, growth rate can also vary substantially within a river. Because interactions among fish are often size dependent (Miller et al. 1988), and smolt age in salmonids is related to growth rate (Thorpe, 1986; Duston and Saunders, 1997) understanding the relative importance of factors governing growth rates should lead to increased understanding of individual survival and ultimately population dynamics. Our aim is to describe sources of variation in juvenile Atlantic salmon growth rates based on three years of data on individually-tagged fish from a stream in Massachusetts, USA. We describe variation in growth due to the year, season, life history tactic and present preliminary data on growth rate variation of fish from different families (single mother-father pair).

Our study site was a 1-km stretch of the West Brook, in Whately, MA, a second order stream with an average width of 4.8 m. The study site was divided into 47 contiguous 20-m sections that we sampled in a downstream to upstream direction 22 times from May 1997 to March 2000. In total, we have tagged 3629 fish from three stocking years. Fish greater than 60-mm were tagged intraperitoneally with a 12-mm PIT tag. In a little over one-half of these samples, we sampled fish using electroshocking (500 V unpulsed DC) and we used night-seining in the remaining samples. In the spring of each year, we constructed a smolt-sampling weir approximately 4-km downstream of our study site. There is no natural reproduction in the West Brook and fry are stocked ($50 \cdot 100\ m^{-2}$) each spring.

Upon capture, we recorded the location of each fish (±2.5 m). Untagged fish were tagged with PIT tags and sampled for scales after anesthetizing with MS-222; all fish were measured for length, wet mass, maturity status (milt expression), a digital photograph was taken and anal fin clips for fish from the 1999 stocking year were taken for family identification. Upon recovery, each fish was returned to its approximate sampling location. A fish's family was identified by comparing its multilocus genotype (microsatellites) to those of the candidate parents at the hatchery (standard allele matching parentage assignment). All fish stocked into the study section in 1999 were from one of six families.

Seasonal growth variation was substantial. Growth rates were highest during the spring and lowest in the summer. This growth pattern was consistent across years, although growth was slightly slower in 1999 than in 1998. For age-1 and age-2 fish, growth was low to negative in the summer, increased somewhat through the fall and winter and was very rapid in the spring. Among years, average spring growth (log10 instantaneous growth · 100) of individual fish caught on consecutive samples ranged from 0.7 to 0.9 for age-1 fish and ranged from 0.3 to 0.6 for age-2 fish. Spring growth was rapid for both age-2 smolts and age-2 residents. Over two years of life in the stream, age-2 smolts amassed 72% of their total 2-year weight gain during just 13% of year (two springs).

Most age-based growth rate variation appeared allometric, with larger fish growing proportionately more slowly, but age-0 fish in 1998 had positive growth rates (~0.2), while the age-1 and age-2 fish in the stream were losing mass.

Male parr maturation rates were very high (~100%) for age-1 fish and appeared to significantly influence growth rate variation. For the 1996 and 1997 stocking years, masses of age-1 fish that matured began to diverge from immature fish in the late summer. By the subsequent spring, mature fish (age-2) were about 10-g lighter than immature fish (1996, 33 v. 22 g; 1997 27 v. 18 g). This difference disappeared during the rapid growth spring period; previously mature smolts (40% of the smolts) were only several grams lighter than immature smolts and resident fish (virtually all previously mature) were approximately the same size as smolts two weeks following smolting. These results did not depend on a size-selective sampling artifact; we obtained similar results comparing individual growth rates of mature and immature fish. A large part of the 10-g difference between mature and immature fish in the spring could be explained by differences in mass between mature fish that would become smolts and immature fish that would become smolts. In March, mature pre-smolts weighed 25 g and immature pre-smolts weighed 27 g. In contrast, mature future resident fish weighed only 18 g. Based on captures of fish caught in the smolt trap, mature smolts were slightly lighter (33 g) than immature smolts (36 g). Mature smolts were heavier than mature residents (31 g).

Patterns of mass difference among fish with different life histories were not limited to smolts, pre-smolts and residents. As early as their first fall, fish that would eventually mature and smolt were significantly heavier (logistic regression, $P<0.05$) than eventual mature residents. This pattern was continued through to smolting, although mass differences among life histories were not significant during early summer. Eventual immature smolts displayed an intermediate pattern. Masses of immature smolts were similar to mature residents until the middle of their second summer (age-1), when they switched trajectories to match and then surpass masses of mature smolts during late fall and their second winter. These results suggest significant size structuring relating to life history tactic.

Based on data from the 1999 stocking year class, masses also appear to vary among fish from different families. Of the fish sampled from the study section, 81% were assigned to one of the six stocked families. The remaining 19% represented fish with unknown parents stocked outside the section. Over the course of four samples (August 1999 to March 2000), masses of fish from one family (number 5) were consistently 33% greater than masses of fish from the other five families. Masses of fish from family five were also consistently heavier for fish raised in the hatchery, suggesting a genetic component to the greater masses of family five fish. Length at stocking was greatest for family five, but they were not the heaviest. Numbers of fish from the heaviest family were consistently 1.5 to two-fold more dominant during the four samples than numbers of the other families.

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