Out of Subbasin Survival Effects in EDT Analyses

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Ecosystem Diagnosis and Treatment (EDT) evaluates habitat across the life history of a focal fish species. For anadromous species, this evaluation addresses conditions within a subbasin as well as conditions outside the subbasin in, for example, the mainstem Columbia River, estuary and ocean. Conditions outside the subbasin are often referred to as “Out-of-subbasin effects” or OOSE. While EDT includes out of subbasin effects, the focus of an EDT evaluation is on the potential of a habitat condition within a subbasin. However, it is of interest to understand how survival conditions outside the subbasin might affect protection and restoration priorities within the subbasin.

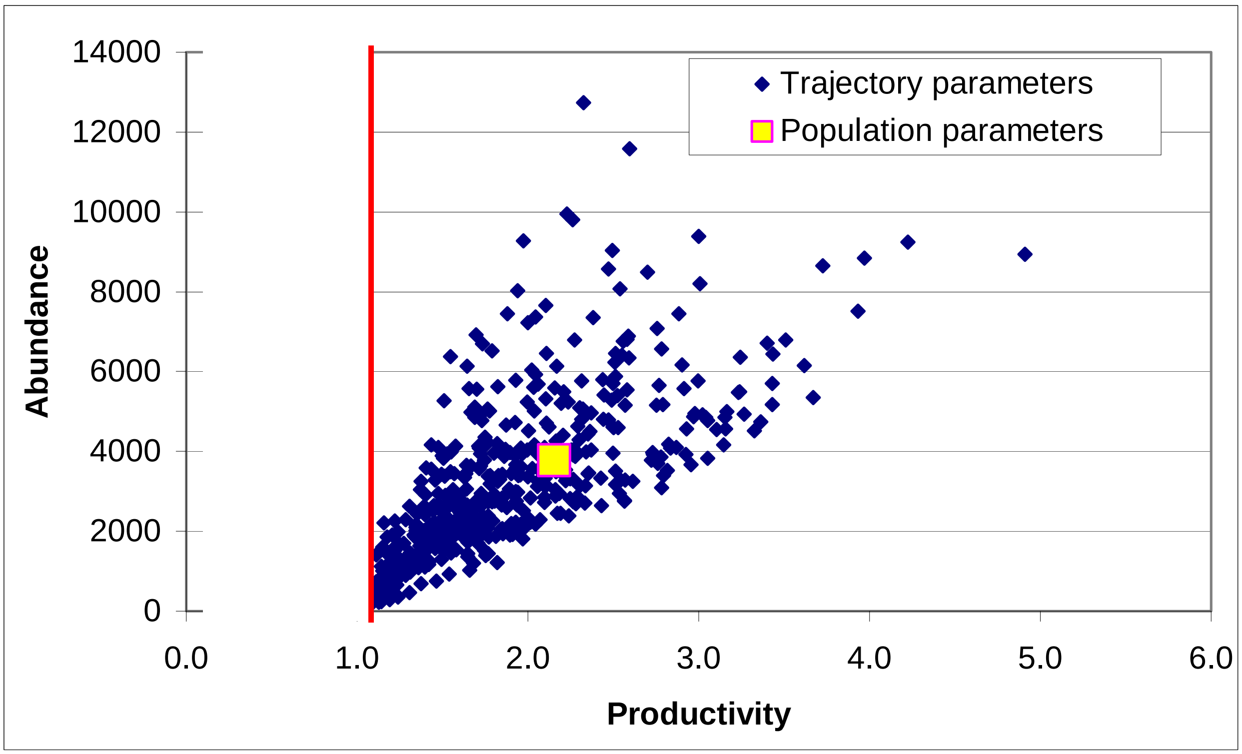
In contrast to the situation within a subbasin, in EDT, OOSE survival is not calculated from habitat information, instead a set of survival multipliers are used to achieve reported smolt to adult survival rates (SAR). These multipliers result in an SAR value for the focal population, which is reported in the standard EDT output summary.

The SAR, as reported in the EDT output, represents the survival from a juvenile leaving the subbasin to an adult returning. Since EDT accounts for age at emigration and at maturation, the survival value will vary depending on the age composition of a population. However, since age-composition for a given population is stable, a single SAR value can be used for each population. For some populations in some watersheds, significant numbers of juveniles that emigrate from the subbasin are not smolts. I these cases the SAR reported by EDT may be an underestimate.

SAR has been estimated from empirical data for some species in a limited number of subbasins (see NOAA 2004). Form these estimates it is clear that the SAR is highly variable from year to year and from subbasin to subbasin, and spatial or temporal trends in SAR are difficult to discern. The variability in SAR indicates that the survival rate of smolts leaving a subbasin is highly dependent on conditions both inside and outside the subbasins.

Life History Trajectories in Ecosystem Diagnosis and Treatment. To understand how the SAR affects results in EDT it is necessary to explain the concept of life history trajectories. A life history trajectory is the unbroken sequence of life stages and habitat segments that a fish moves through in completing its full life cycle. Trajectories start and end with spawning at a particular spot (i.e. a stream reach) and at a particular time within a year (Figure 1). At each trajectory segment (defined by a life stage, a location, and a time), the survival conditions are computed from habitat characteristics as they affect the life stage. Trajectory segments outside the subbasin are greatly simplified by applying constant, population specific survival factors. EDT then computes the cumulative survival of all segments along each trajectory[1]. EDT samples the environment by starting trajectories in a regular pattern along the stream course and at regular time intervals during the spawning season (Figure 1). In a typical stream, EDT generates hundreds of life history trajectories to sample and characterize the habitat conditions within a stream. EDT finally estimates survival parameters for the focal population from this collection of trajectories (Figure 2). Thus the SAR computation is embedded in the trajectory calculations.

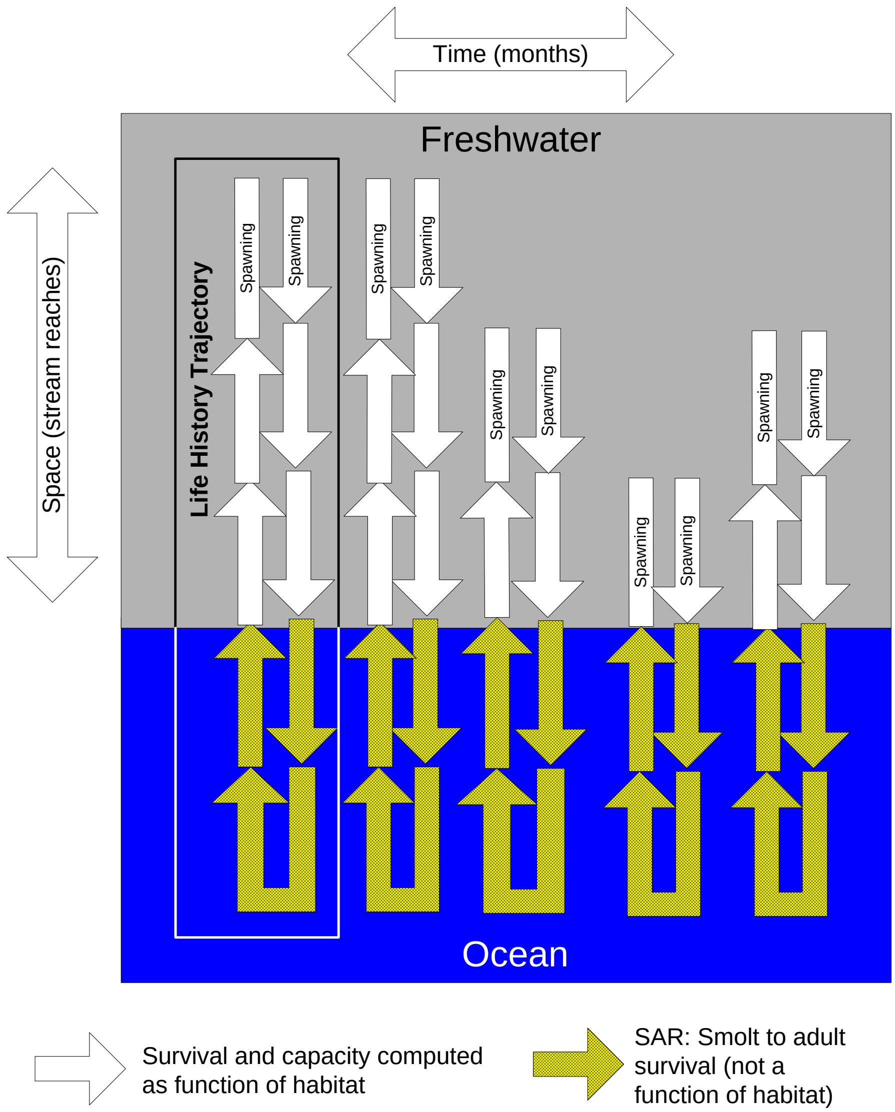
Figure 2. Hypothetical population depicting individual trajectories and the population abundance and productivity parameters EDT derives from the trajectories.



[1] A return/spawner of 1 means that two adult fish return for each pair of adult fish that spawned in the previous generation. In other words, the abundance remains constant at a productivity of 1, but declines if the productivity is less than 1. In reality, because of environmental variability and density dependent effects, a healthy population has a productivity considerably in excess of 1.

To capture the seasonal variations of hydroelectric operations and conditions in the estuary and ocean, survival conditions outside the subbasin are shaped by month within a year. This shaping of the OOSE, conditions coupled with the timing of entry of fish into the mainstem and population specific age structure will affect the actual survival applied

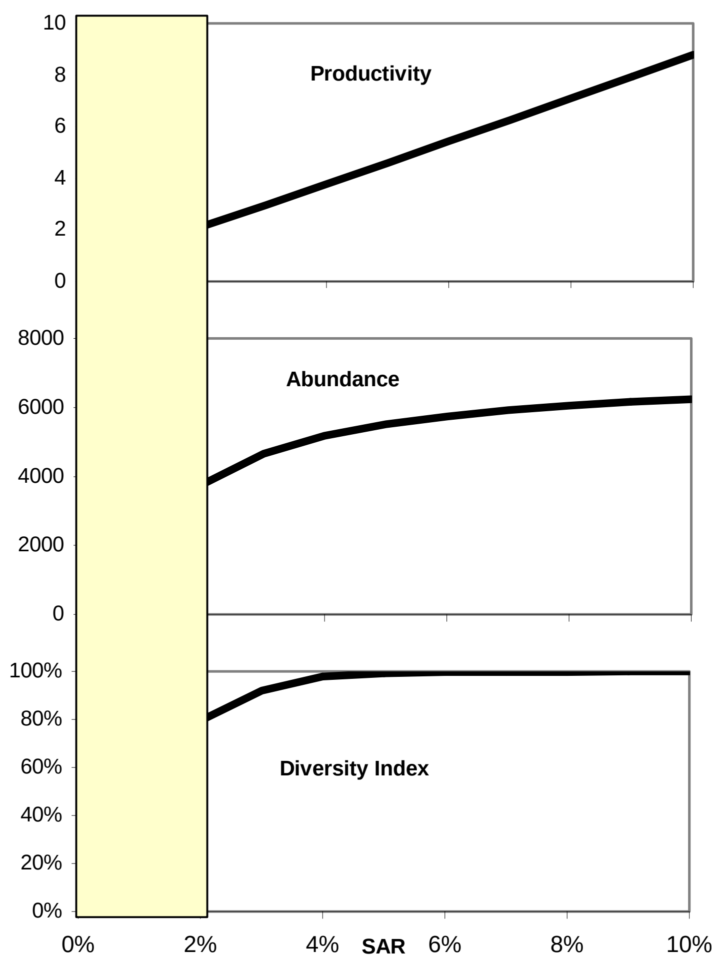
Figure 1. Illustration of life history trajectory concept in Ecosystem Diagnosis and Treatment. Habitat within a freshwater study area is sampled along the string of life stages forming a life history. Outside the study area conditions are characterized by an overall smolt to adult survival rate (SAR).



to the population. However, the overall effect of this shaped OOSE still reduces down to a single SAR value for each population in each subbasin. As noted above, EDT provides a calculation of that SAR for each population in a subbasin as a standard output. The EDT calculation of SAR is the number of returning adults at the mouth of the subbasin divided by the number of juvenile fish leaving the mouth of the subbasin.

Effects of OOSE on population parameters. A hypothetical example might help illustrate how the survival outside the subbasin, the SAR, affects the EDT estimates of the population parameters of the focal population. There is a near linear relationship between productivity and the SAR as might be expected (Figure 3). The deviation from linearity are due to the fact that the SAR affects the population productivity parameter through the individual trajectories described above. For small SAR's (< 2% in the example) both equilibrium abundance and the diversity index[2] are very sensitive to changes in SAR (Figure 3). Among the consequences of this are that errors in the estimate of SAR in this range will have a significant effect on the abundance and diversity estimates. It also implies that overall improvements in productivity (e.g. through habitat restoration) will stabilize the population, making it less vulnerable to changes in SAR.

Figure 3. Effects of SAR on EDT estimates of population productivity, abundance and diversity.



[2] The diversity index used in EDT is defined as the probability that a trajectory will have a productivity greater than one.