Interactive ecology of Atlantic salmon and smallmouth Bass

Research proposal submitted to the Technical Advisory Committee

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Statement of the problem

Recently, Maine Atlantic Salmon Commission issued a 10-year strategic plan whose long-term goal is to restore a viable population of Atlantic salmon with access to historical habitat, with a short-term objective of improving population trends for the DPS river-specific stocks. Immediate conservation measures enacted by MASC include protecting and restoring critical in-stream habitat, and stocking suitable habitat with juveniles. Maintaining a biotic community free from invasive competitors and predators is a critical component of habitat protection. However, many streams containing otherwise suitable habitat for juvenile Atlantic salmon have been colonized by exotic smallmouth bass (Warner 2005). Known as “one of the world’s most disastrous invasive species” (Kei’ichiro et al., 2004), adult and sub-adult smallmouth bass can be highly predacious on salmonine fry, parr, and sometimes smolts (Moring et al., 1999; Fritts and Pearsons 2004). However, the potential for direct competitive interactions between lotic smallmouth bass and Atlantic salmon juveniles is not yet clear. Studies of habitat use and foraging behavior of juvenile smallmouth bass in streams (e.g., Sabo et al., 1996) suggest functional similarities and potential habitat overlap with Atlantic salmon that could result in competitive interactions. One may expect the relatively large-gaped, aggressive, and thermally-tolerant smallmouth bass to possess an inherent competitive advantage over Atlantic salmon, although this has not been tested (hence another rationale for this proposed study). However, suggestive data from the Maine Atlantic Salmon Commission and the US Fish and Wildlife Service (Sweka and Mackey, unpublished) show an inverse relation between the abundances of Atlantic salmon and smallmouth bass juveniles in several Downeast Maine streams. Most likely, negative effects on Atlantic salmon resultant from competition with smallmouth bass would be most pronounced during energetically-stressful summer periods of high water temperatures, reduced stream flows, and decreased prey availability; under such conditions, smallmouth bass should be the energetically-favored species and thus emerge as the competitive superior. Changes in landscape- or climate-related variables that cascade to alter in-stream habitat may exacerbate the invasion, establishment, and ultimately competitive

impact of smallmouth bass Atlantic salmon streams. Both the Atlantic Salmon Conservation Plan issued by the Maine Atlantic Salmon Task Force and the DPS Recovery Plan issued by NOAA / USFWS (2006) identify invasive fish species (including smallmouth bass) as a potential threat to restoring and sustaining Atlantic salmon, but virtually no data exist to evaluate that risk. Our proposed project is wholly consistent with research needs, goals, and objectives associated with protecting DPS Atlantic salmon, and is a rigorous, empirical evaluation of a the effects of an invasive species.

We view the issues addressed in our study as urgently needing attention for several reasons. First, smallmouth bass have spread rapidly throughout most Maine watersheds, and their abundance is beginning to increase in streams that are the last strongholds of wild Atlantic salmon in the US. Second, although the negative effects of invasive smallmouth bass on other native fishes (e.g., cyprininds, Pacific salmonines) are well-documented, virtually no studies exist on interactions with Atlantic salmon. These data are vital to managers in developing conservation and management plans for both species. Third, smallmouth bass provide valuable sport fisheries and are extremely popular with a select group of anglers, so we need to increase public awareness of potential problems associated with promoting smallmouth bass populations, especially when empirical data on ecological consequences are lacking. Fourth, as Maine streams warm due to climate change, we might expect environmental conditions to favor smallmouth bass at the expense of Atlantic salmon, and thus any competitive or predative interactions should only intensify over time. Therefore, our proposed study is especially timely. Finally, there is a strong level of support for our project within state and federal agencies responsible for managing native and invasive species, and we expect our results to influence future conservation actions.

Objectives

The objectives of our research are to:

1) Quantify habitat use of Atlantic salmon in allopatry and in sympatry in laboratory tanks and natural streams
2) Test the efficacy of smallmouth bass removal from natural streams as a conservation tool for wild Atlantic salmon

Methods - Field Component

We will combine electrofishing surveys with archived data review to select study sites in several streams known to contain DPS Atlantic salon, and may include non-DPS streams to increase sample size. We will select sites that are similar in habitat, but differ primarily in species composition. Because most Atlantic salmon streams rely on planting juveniles, we have flexibility in choosing sites containing salmon. Ultimately we will obtain six replicates each of sites containing salmon in alloptatry, bass in allopatry, and both species in sympatry, for a total of 18 sites. Nine sites will be reserved for a small-scale removal and monitoring study, and the other nine will be reserved for a larger scale removal study. Potential candidate streams include mainstem and tributaries of the Dennys, Narraguagus, and West Branch Penobscot Rivers; selection of suitable study sites will proceed with the technical advice of state and federal biologists, and may depend on the availability of long-term data sets on relative abundances of species of interest. Standard, periodic electrofishing surveys will yield basic demographic information such as abundance, density, size and age distributions, growth rate, and diet of target species. Standard, periodic habitat surveys will yield data on important abiotic variables, including depth, width, velocity, substrate, channel morphology (e.g., Froude number), cover, and temperature.

For the small-scale portion of the study, we will conduct several snorkeling surveys throughout the summer and early fall and quantify habitat use of individual fish. Variables measured will include focal point height, velocity, and substrate, fish body size, feeding frequency, and distance from cover. Habitat availability will be quantified at each site to facilitate comparisons with habitat selected by individual fish. We will use

snorkeling and drawstring-capture-nets (e.g., Steingrimsson and Grant 2001) to remove individual bass from sites in which both species are present. Several days and several weeks after bass removal, we will revisit each site and re-quantify habitat use of individual fish, and also monitor for bass re-invasion. If salmon occupy different habitats in the presence and absence of bass, we will interpret this as a result of competition. If salmon that previously cohabitated with bass shifted habitats after bass removal, we will interpret this as a positive effect of bass removal. By testing for differences between salmon in sympatry and allopatry in addition to quantifying habitat shifts after bass removal, we control for natural variation in habitat use in response to environmental variation and fish growth, thus increasing our ability to detect negative effects of competition and positive effects of removal.

For the large-scale portion of the study, we will conduct electrofishing surveys of the remaining study sites and quantify density, biomass, and growth rates of both species. Salmon will be returned to the study sites, whereas bass will be sacrificed for stomach contents analysis (to assess potential diet overlap with salmon, as determined from previous studies and literature review, but also to document direct predation). Sites will be electrofished periodically to track changes in density, biomass, and growth rates, and also to monitor re-invasion rates of bass. Significant differences in salmon demography among sites with and without bass removal will indicate the efficacy of bass removal as a conservation tool. As stated above, monitoring allopatric and sympatric sites for both species will allow us to control for natural environmentally-induced variation. Compared with snorkeling removal, electrofishing removal of bass is probably more feasible and cost-effective, but more stressful to cohabitating salmon; therefore, comparing results from both methods is a critical component of this study.

Methods - Laboratory Component

The laboratory component will take place in Dr. Zydlewski's experimental stream channel housed in the Aquaculture Research Center. This channel contains alternating riffle-pool sequences and natural cobble substrate, and depths and velocities can be manipulated relatively easily to provide a variety of microhabitat regimes. Experimental smallmouth bass will be collected from natural streams, experimental Atlantic salmon will be obtained from hatcheries, and both species will be acclimated in holdingtanks before beginning the experiment. To test for the relative effects and importance of intraspecific vs. interspecific competition, we will assign each species to competitive treatments according to protocol proposed by Fausch (1988, 1998). Behavioral attributes such as foraging frequency, foraging mode, frequency of agonistic interactions, and dominance status will be assessed by observation. Habitat use and residence patterns will be quantified via behavioral observation, but also by establishing an antenna array grid on the channel bottom and recording locations of PIT-tagged individuals. Energetic attributes such as net energy profit will be quantified by combining information on habitat use, growth rate, and foraging behavior and incorporating these data into readily-available bioenergetics models (e.g., Sabo and Orth 1996; Nislow et al., 1998; Murphy 2003; Sweka and Mackey, in preparation). Generally, we will interpret competition to be significant for a particular species under a particular thermal and habitat regime if we observe any or all of the following in the presence of a putative competitor: significant differences between preferred and occupied microhabitats; declining energy profitability of occupied habitats; declining growth or survival rates; decreased ability or willingness to defend a particular habitat; decreased foraging rate (e.g., Fausch and White 1981, 1986; Cunjak and Green 1984; Glova 1986; Gatz et al., 1987; DeWald and Wilzbach 1992; Kocik and Taylor 1994; Nakano 1995; Nakano et al., 1998; Volpe et al., 2001; Young 2001; Miyasaka et al., 2003; Baxter et al., 2004).