INTERACTION OF STRESS, PATHOGENS

AND DEVELOPMENT

ON THE BEHAVIOR OF TELEOSTS

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EXTENDED ABSTRACT ONLY - DO NOT CITE

Fishes are frequently exposed to multiple, sequential or concurrent stressors. It appears that the physiological response to such events is adaptive in terms of resisting the stressors but could be maladaptive in terms of allostatic load (Sterling and Eyer, 1988; McEwen, 1998). For fish this consists of tradeoffs between the immediate benefits of short term survival and diminished longer-term fitness as evidenced in reduced growth, reproductive capacity, and disease resistance (Schreck, 2000).

Juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Columbia River system are exposed to multiple, sequential stressors as they migrate into lower river systems and make the transition to seawater. As judged from eight years' research on stress and health physiology based on (1) the primary stress factor cortisol, (2) energetic factors such as glucose and lactate, (3) specific and non-specific immune system responses including number of antibody producing cells and respiratory burst activity, (4) activity levels of enzymes in the circulation, (5) osmoregulatory capacity assessed by saltwater tolerance and saltwater preference tests, and (6) resistance to bacterial pathogens such as *Renebacterium salmoninarum* we predicted that stressed or pathogen-infected salmonids would have retarded or reversed smoltification and hence have impaired ability to successfully enter the ocean.

Under laboratory conditions, mildly stressed chinook salmon "smolts" in a horizontal fresh-saltwater gradient had reduced preference for salt water compared to unstressed controls that essentially all selected saltwater. More severe stress exacerbated the saltwater avoidance, as did infection with *R. salmoninarum*. Simulation of stress associated with passage through the Snake and Columbia River hydropower system (eight dams) also reduced saltwater preference relative to unstressed controls. While such a shift in behavior would be ecologically risky, the physiology of the fish suggested that they were "hardened" by the exposure to the multiple stressors since they recovered faster from the eighth than from the first stressful experience. Threat of avian predation (a simulated hazard from above) resulted in transient saltwater selection by stressed smolts that avoided salt water otherwise. However, avoidance behavior of a simulated threat from below by saltwater-preferring smolts consisted of fish swimming up to but not through the halocline.

Salmon entering the Columbia River estuary have been either stressed by passage through as many as eight dams or by a management program in which fish are transported and released upstream of the estuary in barges. Our experiments in the laboratory and assessment of fish in the field suggest that stress and pathogens affect success at seawater entry and responsiveness to threat of predation. Radiotelemetry of juvenile salmon in the Columbia River showed that that nearly 100% of the fish successfully migrate the last 200 km to the upper estuary, but that approximately 15% are taken by avian predators while traveling the last 25 km to the ocean.

We expanded a life history-based population simulation model designed to assess risk in salmon (Oosterhout, 1999) to include effects of stress, improper development (smoltification), pathogens, and predation as hazards. The model was run for 1,000 iterations per year for 100 years using present-day chinook salmon abundance as a starting point to generate population trends. Employing data and inferences from stress physiology from either our field or laboratory studies as variables, the model revealed that stress encountered upstream on mortality of salmon at ocean entry is significant in terms of recovery of stocks at risk of extinction. However, stress in juvenile salmon appears to be an important population regulating factor only when habitat conditions are poor.

References

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