APPLICATIONS OF PHYSIOLOGICAL KNOWLEDGE TO WILD FISH MANAGEMENT

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Abstract

Knowledge of physiological systems could be of value in making management decisions regarding performance of fish in the wild. Studies on salmonids of the genus *Oncorhynchus* demonstrate that taxonomically recognizable groups within a species may have different performance capabilities, tolerance limits, and habitat requirements. Physiological assessments are useful in discerning habitat quality. In addition, such assessments are useful in optimizing management conditions such as regulating water discharge, passage at dams, and transportation protocols as well as release strategies for fish at hatcheries. We illustrate these contentions with examples based on our research with anadromous salmonids.

Introduction

The literature is replete with studies concerning physiological assessments of fish under laboratory conditions. There are also many physiological investigations of fish in hatcheries. The fact remains, however, that there are relatively few studies directed at understanding physiological systems of fish in the wild. This is true despite the objective of many laboratory and hatchery studies being the making of inferences about either naturally reared fish or fish released into the wild. It is operationally more difficult and expensive to conduct research on fish in the wild than in the laboratory or hatchery. Information obtained from recent physiological studies by our laboratory on wild stocks or freely migrating hatchery salmonids liberated into rivers is extremely powerful in terms of relevance to management decisions.

Gene Conservation Groups

Our genetic, taxonomic characterization of Western North American trouts and salmon of the genus *Oncorhynchus* using allozyme, mtDNA, and morphological traits suggests the presence of vast numbers of distinguishable groups. Relationships based on phenologies, however, do not uniformly allow clustering of like genotypes correlating to geographic distribution. For example, while genetic analysis of coho salmon, *O. kisutch*, and rainbow trout, *O. mykiss*, indicates that geographically proximate populations are genetically similar, this is not the case with cutthroat trout, *O. clarki*, and results with chinook salmon, *O. tshawytscha*, depend on the types of characters analyzed. We thus suggest that performance traits could be of great value in determining constituency to gene conservation groups.

While it is known that populations of salmon and trout may differ with regard to their ability to resist various pathogens, we know little about other inter-populational differences in performance traits. We have shown based on dynamics of plasma cortisol that there are genetically determined differences in response to handling types of stress in hatchery rainbow (steelhead) trout. In addition, we now have comparative studies using wild stocks of rainbow trout, which similarly suggest genetically controlled differences in response to stress based on estimates of time to fatigue, oxygen consumption, and the ability to move to cover when frightened.

Management of endangered or threatened species frequently necessitates capture of adults for rearing of progeny in hatcheries for subsequent release back into the wild. Because of the extremely limited number of brood fish available, this practice presents special difficulties for broodstock management. Our laboratory has developed a method to sex and also determine state of reproductive maturity of Pacific salmon based on analysis of sex steroids in a small blood sample. We have used this approach successfully for several seasons for the Sacramento River, California, winter-run chinook salmon that are classified as "threatened" under the U.S.A. Endangered Species Act. Hatchery staff drew a blood sample from the broodfish and overnight mailed them to us. We then assayed for steroids and within 36 hours informed the hatchery as to the sex of each individual and the approximate spawning time. Where necessary, we then also recommended when therapy to induce spawning needed to be initiated.

Habitat and Water Quality

Juvenile anadromous salmonids are exposed to a variety of habitat and water quality conditions on their migration to the sea. Because physiological systems are integrators of habitat quality factors, assessment of physiological status of fish is useful in characterizing general habitat quality and pin-pointing bottlenecks. For example, in a multiagency study of the Chehalis River system, Washington, we assayed a variety of indices of stress in freely migrating coho salmon smolts collected from various areas in the basin to help establish the root cause of poor return rates. These data, particularly those concerning immunocompetence, in concert with behavioral tests, identified locations in the watershed where industrial effluents could be causing problems.

Adult spring chinook salmon are in fresh water six to nine months and must remain over summer in streams prior to spawning. During this time they are exposed to great variations in water quality. Using radiotelemetry we were able to demonstrate that among chinook salmon migrating up the Willamette River, Oregon, early to mid-run fish generally survived to reach upstream spawning areas. However, late-run fish tended to migrate much more slowly through the middle section of the river and a significant portion of them (up to 40%) died in this reach of the river during the course of the summer. We attribute this mortality to high water temperatures. Physiological analysis of the fish over the course of the run revealed that they were stressed, but that androgens were also increasing during the maturational process. We determined that stress hormones in concert with elevated androgens greatly compromise the immune defenses of chinook salmon. The salmon migrating in the river are thus most likely succumbing directly to

pathogenic insults that are favored by elevated temperatures.

Water Management and Fish Passage

Water is frequently spilled from hydroelectric projects to assist smolt passage down-river. We have shown that there is a direct relationship between flow (and river velocity) and chinook salmon out-migration velocity using radiotelemetry in the Columbia River. However, imposition of additional stress on the fish causes them to hold for substantial periods of time, placing them at risk to predation. Physiological evaluation of general health and smoltification status revealed that different segments of the run are comprised of fish of greatly differing physiological status relative to stress as well as developmental stage. It is thus possible to make decisions relative to water spill at hydroelectric projects relative to fish condition. In addition, it is also possible to use knowledge of the physiological condition of salmon as a way of comparing different scenarios for up-river collection of smolts for transportation around dams for liberation in the lower reaches of the river.