Section 6

EFFECTS OF PREDATOR AVOIDANCE TRAINING ON THE POSTRELEASE SURVIVAL OF FALL CHINOOK SALMON

by

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Introduction

Predator avoidance training may be useful for improving the postrelease survival of hatchery-reared salmonids (Maynard et al. 1995). Laboratory studies have indicated salmon rapidly learn to recognize and avoid predators after observing attacks on conspecifics (Patten 1977, Thompson 1966, Olla and Davis 1989). Such experiences could increase their chances of survival during subsequent encounters with predators.

Thompson (1966) and Kanayama (1968) demonstrated that survival of young chinook and chum salmon in natural and artificial streams was increased by conditioning them to avoid models of predacious rainbow trout. This study attempts to demonstrate that postrelease survival of young fall chinook salmon is increased by conditioning them to avoid live predators.

Methods

Ninety-six thousand swim-up fry of fall chinook salmon, donated by the WDFW Minter Creek Hatchery, were transported to the NMFS Manchester Research Station. They were then systematically divided into six equal lots and placed in one of six outdoor pilot-scale raceways (6.4 × 1.5 × 1 m, with 0.6-m water depth) in the Station's freshwater facility. Fish in three raceways received experimental predator avoidance training. Fish in the three other raceways acted as controls and were tightly covered with nets to ensure no outside interference by predators. Except for the predator avoidance training, fish in both treatments received identical husbandry and standard rearing protocols for salmon.

The predator avoidance training employed a diverse array of predators to ensure the fish were exposed to at least one species they would encounter after release. It was also an opportunity to compare the suitability of each predator for conditioning avoidance behavior in hatchery-reared salmon.

In March 1997, predator training was initiated by uncovering the three experimental raceways to allow local fish-eating birds access to the fish. Although a young great blue heron occasionally fished the raceways, it disappeared within a few weeks and was not observed again. Belted kingfishers occasionally flew overhead during the study, but were never observed to fish in the raceways. The potential for any in situ training exposure to natural predators was therefore deemed impractical.

More routine predator training sessions began in April by placing caged hooded mergansers, largemouth bass, and brown catfish in the raceways. The cages (1.6 × 1.1 × 1.1 m) were frame constructed with PVC-pipe (1" diameter) and fittings, and covered with net. The mesh size (3.8 cm^2) allowed fry to swim freely in and out of the cage, while confining the predators. The top half of each cage was out of the water so that the birds would not drown. Empty cages were also placed in the raceways to train the fish to associate predation events with predators, and not the cage itself.

Two phases of cage training were carried out. In the first phase, a pair of hooded mergansers was used for seven training periods of 50 minutes duration in late April. In nearly every session, the mergansers were removed before they ceased fishing. This ensured the fry experienced nearly continuous negative reinforcement from these predators. In the second series, two largemouth bass and one brown catfish were used for a week. Before being used, the appetite of each predator for chinook salmon fry was demonstrated by their consuming fry in pre-training evaluations. Both phases were completed by mid-May.

The effects of predator avoidance training on postrelease survival were evaluated in Curley Creek, a tributary of Puget Sound. The releases were made with representative samples of fish from each of the six raceways. The samples were removed from the raceways, transferred to six circular tanks (1.5-m diameter), and held until they were released in July. About three weeks before the first release, each fish was measured for fork length (to the nearest 1 mm), weight (to the nearest 0.1 g), and tagged with a passive integrated transponder (PIT tag). On 25 and 30 June one unconstrained largemouth bass was placed in each of the tanks containing the conditioned fish and allowed to prey for eight hours.

Releases began on 3 July 1997. A total of 51 fish were transported and released into each of two tributaries of Curley Creek. Each release site was about 1.3 Km upstream of the Curley Creek smolt collection weir. The release program attempted to minimize any effects of contagious behavior by releasing fish from only one rearing treatment in each tributary on a given release day. Contagious behavior is a form of social learning, where naive animals mimic the behavioral displays of their more experienced peers to predators, food sources, and new stimuli. The possibility of fish from different rearing treatments meeting each other at the release sites was further reduced by making releases every 48 hours. Any effects of the tributary choice were further reduced by alternating each tributary from one release to the next. A total of 511 control and 510 predator-trained fish were released in 10 equal releases. The difference in recovery between the two treatments was compared with contingency table analysis.

Results

The fry rapidly learned to avoid mergansers in the predator conditioning trials. Before the introduction of the birds into the cage in a raceway, the fry readily swam in and out of the cage. However, after three training sessions with mergansers few fry continued to enter the cage. By the fifth session almost no fry entered the cage at all, and nearly all the fish remained at least 15 cm from the cage. Initially, mergansers consumed an average of more than nine prey per training session. This declined rapidly to less than six prey per training session as the fry became conditioned to avoid the birds.

The predator avoidance behavior of the fry to largemouth bass and brown catfish differed from that for mergansers. Few fry entered the cage when bass and catfish were first introduced, but they began to enter within a day. After a week living with these piscivores there were as many fry residing in the cage as out. This difference in distribution over time may be related to the different hunting tactics. The mergansers continuously pursued their prey. The bass and catfish, on the other hand, passed their time either holding in place or slowly cruising around the cage perimeter. Furthermore, although proven predators, their appetites seemed not as great as the mergansers. The largemouth bass used in the final conditioning before release, for example, consumed on average only five fish during the overnight training period.

Predator avoidance training did not appear to affect fish growth. The average fork lengths of fish in the two treatments (Fig. 1), measured when the fish were tagged, did not significantly (P = 0.702) differ. Neither did the weights (Fig. 2) of fish (P = 0.110).

In this experiment, predator avoidance training increased postrelease survival. The post-release recovery of predator-conditioned fish was significantly higher (P = 0.046) than that of control fish (Fig. 3). The relative survival [(% recovery experimental treatment - % recovery control treatment) / (% recovery control treatment)][100%] of predator conditioned fish was 26% higher than that of control fish. Within a week of the last release, the recovery rate of fish from both treatments had drastically dropped. Although the weir was operated into September, only 18.6% of all the fish released were recovered.

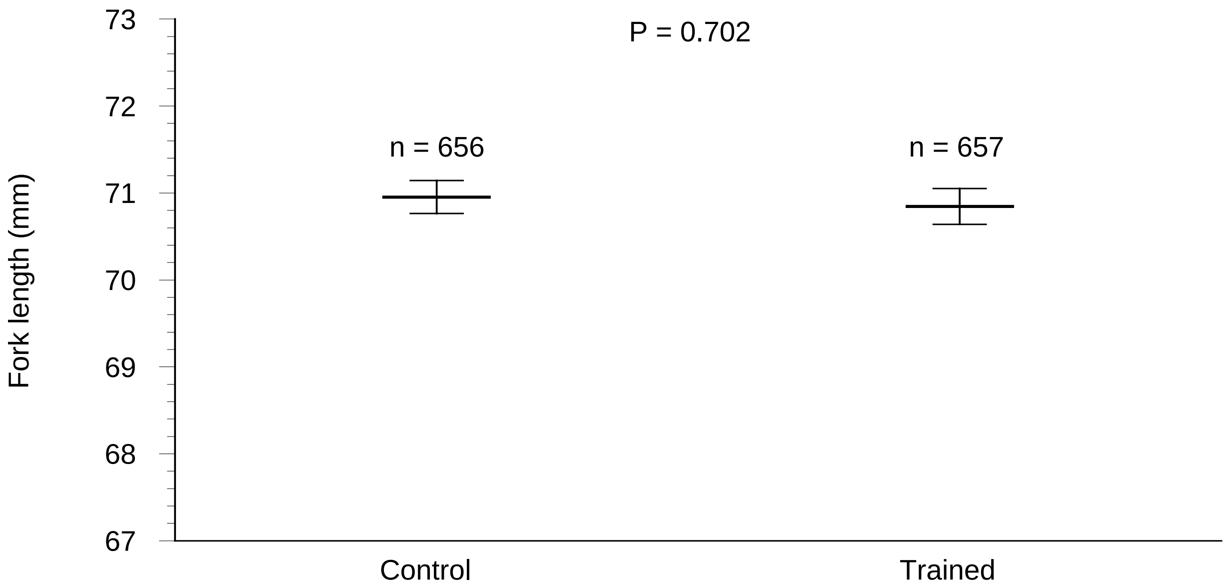

Figure 1. Mean fork length (with standard error bars) of control and predator trained fall chinook salmon at tagging. Probability values (P) are based on *t*-tests.

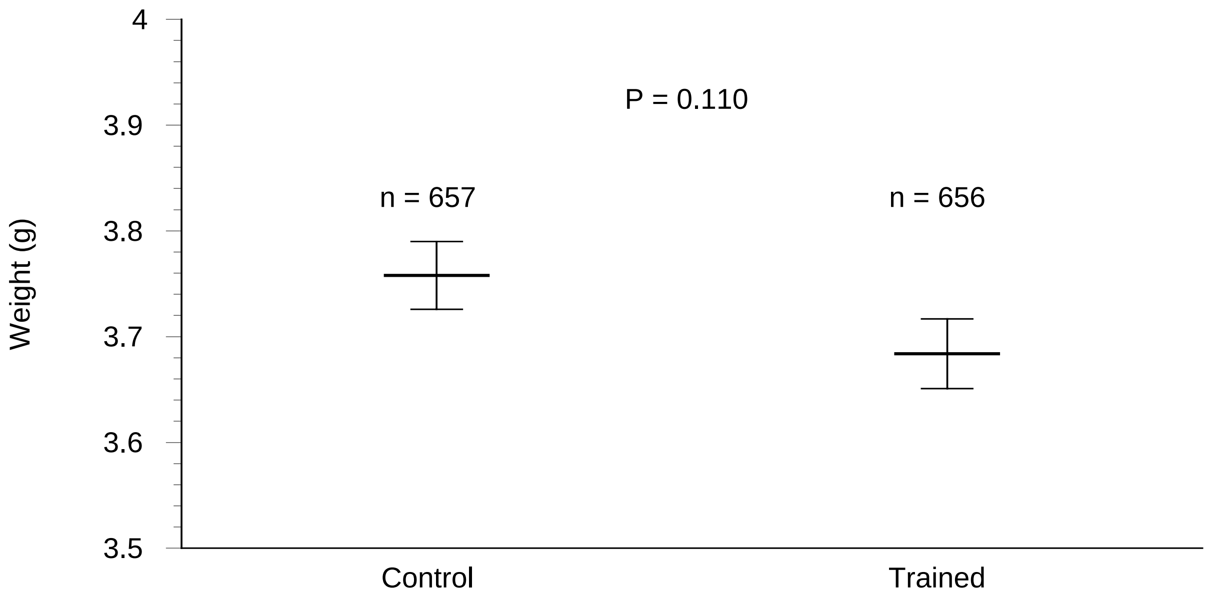

Figure 2. Mean weight (with standard error bars) of control and predator trained fall chinook salmon at tagging. Probability values (P) are based on *t*-tests.

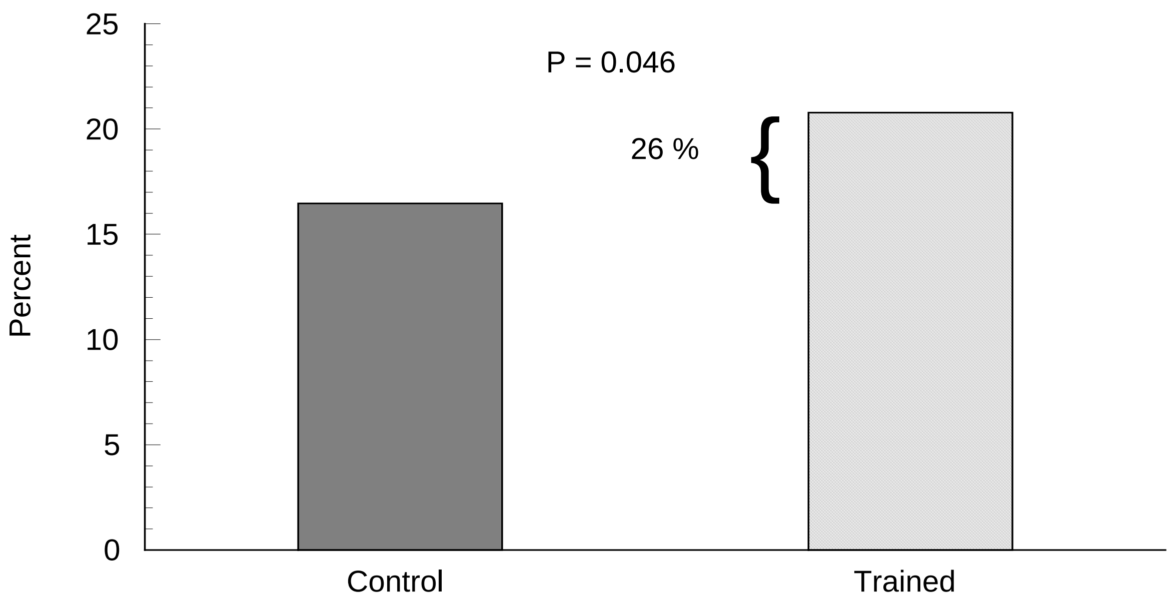

Figure 3. Percent postrelease recovery of control and predator trained fall chinook salmon at the Curley Creek weir. Probability values (P) are based on chi-square analysis.

Discussion

The study indicated that predator avoidance training with live predators can increase the postrelease survival of hatchery-reared salmonids. The benefits of training can be considerable, with postrelease survival of predator-trained fish in the current study being about 26% higher than untrained fish.

The predator avoidance training protocol used in this study required only a slight increase in operational costs. During training less than 2 hours of personnel time were expended per day in handling mergansers. The birds rapidly learned to enter the training cage, which was easily transported to and from the raceways. Once the cage was placed in the raceway it did not interfere with routine fish culture operations. A pair of hooded mergansers can be purchased for about $125, and it took less than 10 minutes of attention each day to maintain them in captivity. The bass and catfish have similarly low acquisition, handling, and maintenance costs. Therefore, the increased survival of predator-trained fish far outweighed the small increase in operational costs.

Although predator avoidance training is a useful tool for increasing postrelease survival, it need only be used at facilities which produce predator-naive fish. Hatcheries which allow predators to enter their ponds, with no bird nets or electric fences to provide protection, are probably already providing uncontrolled predation training.

Programs using production hatcheries to enhance a fishery or mitigate for habitat loss could derive several benefits by adopting predator avoidance training protocols. The most obvious is simply to use increased postrelease survival following training to increase the number of fish available for harvest. Secondly, the increased survival might also be used to reduce the number of fish which must be reared and released to produce an equivalent number of fish for harvest or to meet mitigation goals. Thirdly, greater survival could be used to lower operational costs (with fewer fish needing to be fed, marked, etc.) to produce an equivalent number of recruits to the fishery. Finally, the increased survival offered by antipredator training would permit facilities to meet their enhancement and mitigation goals while reducing the number of wild fish needed for broodstock and releasing fewer smolts to interact negatively with wild fish in the migratory corridor. These are two important considerations for enhancement practices in areas where they may impact endangered and threatened stocks.

The development of predator training protocols is in its infancy. Research is necessary to compare the conditioning stimuli of live predators with electrified models, similar to those used by Thompson (1966) and Kanayama (1968). Work is also required to identify which cues (visual, acoustic, chemical, or a combination) provide the information necessary for effective predator avoidance training. This research will not only refine techniques but will also provide non-lethal training protocols for the reintroduction of endangered and threatened stocks of salmon.

References

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