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Predator Removal Efficiency

Northern squawfish are believed to be a major source of mortality for juvenile salmonids in the Columbia River (Rieman et al. 1991; Ward et al. 1995). During April to June when spring/summer chinook are migrating through the mainstem rivers, the predation-related rate of mortality for salmonids is approximately 7-11% (mean ±1 SD) of all juvenile salmon entering John Day Reservoir (Rieman et al. 1991; their Table 6). Modeling studies suggested that removal of 10-20% of the northern squawfish population in John Day Reservoir (fish > 250 mm) would reduce predation-related mortality by as much as 50% (Rieman and Beamesderfer 1990). Beginning in 1990, the Bonneville Power Administration has funded various programs designed to remove lrge northern squawfish from the lower Snake and Columbia rivers. In this section, we discuss estimates of the potential effects of predator removal on spring/summer chinook survival in the system.

Through a bounty fishery, directed gill netting, and angling at dams, over 1.3 million northern squawfish have been collected and removed between the mouth of the Columbia River upriver to about the Idaho border (Beamesderfer et al. 1996; Oregon Department of Fish & Wildlife). The average annual exploitation rate of the northern squawfish population by removal fisheries has ranged from 9-16% during 1991-1996 (Beamesderfer et al. 1996; Friesen and Ward 1997). At this level of exploitation, Friesen and Ward (1997) estimated that predation on juvenile salmonids due to northern squawfish has decreased by 25% to 55% of pre-removal levels; the median estimate of decrease was 38%. Continued removal at the current rate of exploitation is not expected to decrease predation further (Friesen and Ward 1997). These estimates of changes in predation were made with a "Loss Spreadsheet Model" that includes population dynamics and predation rates per individual in the population. Friesen and Ward (1997) did not partition loss for spring/summer chinook, but predation indices for the spring period have shown a decline in some areas since removals began (Zimmerman and Ward 1997).

The efficiency of the predator removal program depends not only on the total number of fish removed from the system, but also on the potential compensatory responses by northern squawfish and other predators that remain in the system (Rieman and Beamesderfer 1990; Beamesderfer et al. 1996). Changes in growth rate of individuals, reproductive success, rate of predation, or other processes, could reduce the overall effectiveness of the removal program. The Oregon Department of Fish and Wildlife has been monitoring populations of northern squawfish, smallmouth bass, and walleye for potential changes since implementation of the predator removal program.

Growth varies considerably from year-to-year, but no significant increase in age-specific growth rate or relative weight has been detected since removals of northern squawfish began (Knutsen and Ward 1997). Relative fecundity (number of developed eggs per gram of northern squawfish) and year-class strength (ages 3 and older) have also changed little since 1990 (Knutsen and Ward 1997).

Increased feeding on juvenile salmonids by northern squawfish or other predator species would be a rapid behavioral response that could reduce the effectiveness of predator removal. Such behavior could occur as a result of local changes in predator density (e.g. reduced competition), or as a result of increases in prey density that stimulate a higher feeding rate (Petersen and DeAngelis 1992). Consumption indices and diets of northern squawfish, smallmouth bass, and walleye have shown little change during the removal period when data were pooled within a reservoir or across large sections of the river (Friesen and Ward 1997; Zimmerman 1997). Compensatory feeding could, however, be occurring at a more "local" scale, and such changes in predation rates would not be detected when data are pooled over such large spatial scales.

Before removals began (1983-86), juvenile salmonids were 4-9% (mean = 6%) of the diet of northern squawfish in mid-reservoir areas of John Day Reservoir during April-June (Petersen and Ward, in press), so even an increase of salmon in the diet to 12% would effectively double the loss in the large mid-reservoir. For data collected during June-July (comparable spring data were not available), the salmonid portion of northern squawfish diet in John Day mid-reservoir appears to have more than doubled between 1983-86 (pre-removal) and 1993-96 after significant predator removals (J.H. Petersen, unpublished analyses). The sample sizes available to make such before-after removal comparisons on a local scale are small so the power of statistical tests is low. Detecting and demonstrating compensation, or no compensation, will thus be difficult, but it may be occurring in these mid-reservoir areas thus reducing the effectiveness of predator removal. A strong compensatory feeding response seems less likely in dam tailrace areas where juvenile salmon are often >90% of the total diet of northern squawfish (Poe et al. 1991), leaving little scope for increased feeding. The diet of northern squawfish in dam forebays is generally intermediate between the high consumption of salmonids in tailraces and the low consumption in mid-reservoirs (Poe et al. 1991; Petersen and Ward, in press).

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