INVESTIGATING AVIAN PREDATION ON JUVENILE SALMONIDS USING DIETARY ANALYSIS

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Introduction:
Pacific salmon populations along the west coast of North America are diminishing due to predation, stream alterations, pollution, and salmon hatcheries (Brown et al. 1994, Busby et al. 1996, Weitkamp et al. 1995). The Endangered Species Act (ESA) has listed many populations along California’s central coast (Kostow 2009). In Scott Creek (Santa Cruz County), coho salmon (Oncorhynchus kisutch) and steelhead (O. mykiss) are listed as endangered and threatened, respectively (Brown et al. 1994, Busby et al. 1996). How and to what extent predators are contributing to declines or impeding recovery of coho and steelhead in the Scott Creek watershed is poorly understood. In particular, although piscivorous birds have been shown to cause substantial mortality on salmonid populations elsewhere, the extent to which these predators feed on salmonids in Scott Creek has not been explored.

Methods:

Study System
Scott Creek is a perennial water system on the coast of central California with a hatchery located on one of the tributaries, Big Creek (Bond, 2006, Fig. 1). Previous studies have shown that the most common piscivorous birds in Scott Creek are Common Mergansers (Mergus merganser), and Belted Kingfishers (Ceryle alcyon). In particular, although piscivorous birds have been shown to cause substantial mortality on salmonid populations elsewhere (Steinmetz et al. 2003), we focused on consumption of juvenile salmonids by Common Mergansers and Belted Kingfishers because both predators are known to impact salmon populations elsewhere (Steinmetz et al. 2003, Wood 1987).

Results:

Belted Kingfisher
We used the regression equation generated by Bond (2006) to back-calculate fish fork length from scale radius (Eqn 1) to determine the fork length of fish eaten by the kingfishers. The regression equation was:

\[
\text{Fork Length} (\text{mm}) = 115.11 \times \text{Otolith Width} (\text{mm}) - 56.656 \ (R^2=0.847)
\]

Using otoliths, the minimum number of salmonids found in kingfisher stomach contents varied from 0 to 9 (Fig. 3). We could not differentiate between coho and steelhead salmonid otoliths or scales, but all complete PIT tags were from wild (i.e. non-hatchery) fish. We detected a significant relationship between the fork length and the otolith width of salmonids consumed by the kingfisher (\(R^2 = 0.847\), \(p < 0.001\)). A significant relationship also existed between otolith width and fork length (\(p < 0.001\)). However, otolith width was a better predictor of fork length than was otolith length (\(R^2 = 0.733\)). We applied the otolith regression model to otoliths collected from stomach contents to back-calculate fork lengths of fish eaten by the kingfishers.

\[
\text{Fork Length} (\text{mm}) = 115.11 \times \text{Otolith Width} (\text{mm}) - 56.656
\]

Common Merganser
Juvenile salmonids (including PIT tags, otoliths, scales, and bones) were found in most merganser diets. We found parts of other fish species (sculpin and stickleback), and invertebrate parts (crayfish, beetles, nematodes, crickets and caddisflies). Sculpin and stickleback were most frequent in diets (Fig. 2). Adult 5 had the most varied diet and chick 2 had the least varied diets.

Discussion:

We found that mergansers and kingfishers consume juvenile salmonids in Scott Creek. According to other studies, mergansers can consume from four to 444 juvenile salmon daily (Wood 1987) and 58.4% of kingfisher diet can be comprised of salmonids when present (Cornell, 1963).

Lengths of salmonids eaten by kingsfishers and mergansers match lengths of fish eaten by these species in other published studies. However, the sizes of fish consumed based on scales may have been inaccurate in our study because we do not know where on the body of the fish that scales originated. Scales grow at different rates depending on where on the body the scales are located. The size of fish consumed based on otoliths may also be biased because otoliths erode in stomach acid. Many of the otoliths exhibited some level of erosion, so fork lengths of fish determined using otoliths likely were underestimated.

Combined with previous estimates of predation rates of piscivorous birds on young salmonids, our results suggest that predation on juvenile salmonids by mergansers and kingfishers may be a substantial source of mortality to young coho and steelhead in Scott Creek. These results indicate the need for greater consideration of the role of piscivorous birds in Scott Creek and other coastal watersheds, including the incorporation of these sources of mortality in population models.

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