Take a Hike: Using Stream Surveys to Assess Avian Predation of Juvenile Salmonids

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Introduction

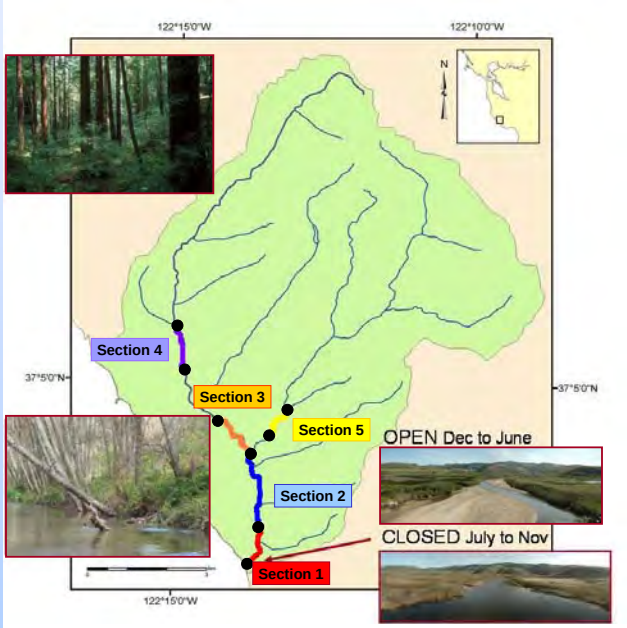
In central California, coho salmon (*Oncorhynchus kisutch*) are listed as endangered and steelhead (*O. mykiss*) as threatened, under the U.S. Endangered Species Act. Continued declines of central California salmonids are attributed to degradation/loss of habitat and diversion of water for human use. Other factors, however, may limit recovery of depressed populations, including variation in ocean primary productivity and predation (Anderson et al. 2004, Good et al. 2007). Salmonids are eaten by a variety of piscivorous birds, fish, and mammals, and are vulnerable to predation during all life history stages (e.g. Collis et al. 2001, Weise & Harvey 2005, Wright et al. 2007). Mortality of juvenile salmonids during freshwater rearing has a disproportionate effect on numbers of returning adults, compared with mortality during other life stages (Kareiva et al. 2000). In systems where piscivorous birds and salmonids co-occur, predation of juveniles can be substantial (Cairns, 1998). Recent studies in Scott Creek (Santa Cruz County) indicate that predation of coho and steelhead by piscivorous birds may be limiting recovery of these species. The extent to which juvenile salmonids are susceptible to predation depends on abundance of predators, overlap in space and time between predators and prey, and consumption of alternative prey. The objective of our study was to use stream surveys to determine species identity, abundance, and annual trends in distribution of piscivorous birds in Scott Creek to assess susceptibility of juvenile salmonids to predation by avian species.

Juvenile steelhead

Juvenile coho

Methods

Between 2008 and 2010 we conducted surveys (N = 55) 7-14 days apart ($\bar{x} = 13$ days) in 10 stream reaches randomly selected using a General Randomized Tessellation Stratified (GRTS) sampling program. Surveyed reaches were representative of all habitat types within Scott Creek and encompassed 40% of habitat available to anadromous salmonids.



Scott Creek watershed, with survey sections color coded. The upper watershed is dominated by a coastal redwood forest; willow and alder dominate the canopy of the lower mainstem. The watershed terminates in a small estuary which is connected to the ocean during winter months; during summer months sandbar formation blocks the creek mouth from the ocean forming a freshwater lagoon.

Stream reaches were grouped into 5 fixed-width strip transects (referred to as stream sections), with the stream corridor selected as the transect width because we were concerned with the number of birds available for eating salmonids. During surveys, two observers walked stream sections and recorded species identity, location, and time of observation. We assumed all birds present in stream sections were seen. The order in which sections were surveyed was randomized and all surveys began 2 hours after sunrise to minimize effects of daily patterns of bird activity on observations.

Diversity indices (species richness, Simpson's Index) were calculated for each stream section. Simpson's Index was chosen as a measure of diversity because it weights common species more heavily than rare species, and common species are more likely to have a greater impact on salmonid populations. Using a Generalized Linear Model with a quasi-poisson distribution and a log link function, we examined whether bird counts related to river mile (station), day of the year, and seasonal cycle (sin transformed day of year). We also examined the interaction between seasonal cycle and station to determine whether there were seasonal patterns in bird distribution within the watershed. All statistical analyses were run using R version 2.12.0

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Sources: Anderson et al. 2007. Est. Coast Shelf Sci 73:44-456; Cairns. 1998. Canadian Techl Report of Aquatic and Fisheries Sciences No 2225; Collis et al. 2001. Trans Am Fish Sco 130:385-396; Feltham. 1995. J Fish Biol 46:273-281; Good et al. 2007. Endang Spec Res 3:11-21; Kareiva et al. 2000. Science 290:977-979; Weise & Harvey 2005. Fish Bull 103:685-696; Wright et al. 2007. Ecol Appl 17:338-351

Results

Ten species of piscivorous birds were observed in Scott Creek during the course of this study. The most common species were Common Mergansers and Belted Kingfishers. Rare species (represented by < 3 sightings) included the Pied-Billed Grebe, Snowy Egret, and Double-Crested Cormorant.

Belted Kingfisher (BEKI)

Common Merganser (COME)

Black-crowned Night Heron (BCNH)

Hooded Merganser (HOME)

Pied-billed Grebe (PBGR)

Great Egret (GBEG)

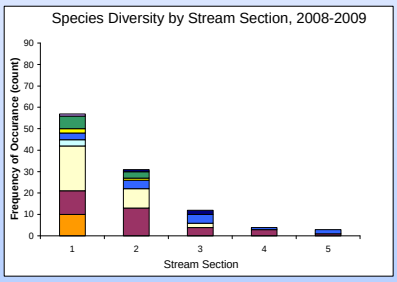
Great Blue Heron (GBHE)

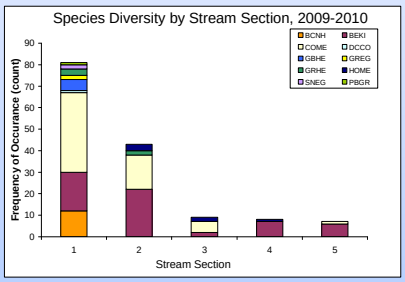
Green Heron (GRHE)

Snowy Egret (SNEG)

Double-crested Cormorant (DCCO)

Based on both measures (species richness and Simpson's Index), species diversity was greatest in Section 1 (estuarine/lagoon) habitat. For all stream sections, diversity was slightly greater during Year 1 (Dec 2008- Nov 2009) than during Year 2 (Dec 2009- Nov 2010). Diversity decreased with increasing distance from the lagoon.





Measures of Species Diversity in Surveyed Sections of Scott Creek, 2008 - 2010

Species Richness (S)	Stream Section 1	2	3	4	5	*Simpson's (1/D)*	Stream Section 1	2	3	4	5
Years combined	10	6	5	3	3	Years combined	4.50	2.84	4.37	1.41	1.85
Year 1	9	6	4	2	2	Year 1	5.43	3.47	3.60	1.60	1.80
Year 2	10	4	4	2	2	Year 2	3.65	2.46	3.27	1.28	1.32

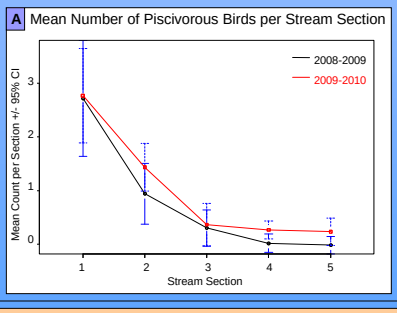
Year 1: Dec 2008 to Nov 2009; Year 2: Dec 2009 to Nov 2010

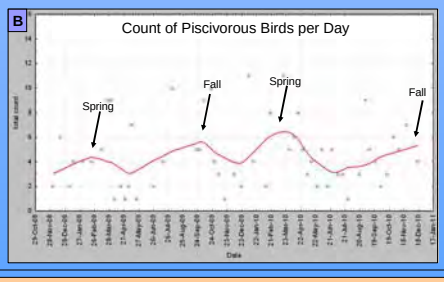
GLM Results: Stream section and sin transformed day of year (sinDay) led to significant reductions in model deviance. Counts of birds differed significantly among stream sections, with the greatest number of birds in the lagoon/estuarine habitat (Section 1, A). Mean number of birds decreased with increasing distance from the estuary. However, there was no seasonal variability in bird distribution. For all sections, counts of birds were greater during Year 2 than Year 1. The significant effect of sinDay means that counts of birds varied in a seasonal manner (B).

Analysis of deviance in models of piscivorous birds in Scott Creek. Factors were Stream Section (section), Day of Year (Day), and sin transformed day of year (sinDay)

Model	Deviance Reduction	Residual df	Residual Deviance	F	p
Null		274	635.91		
Station	267.83	273	368.09	144.80	<0.01
Day	0.59	272	367.49	0.32	0.57
sinDay	10.50	271	356.98	5.68	0.01
Station*sinDay	0.04	270	356.95	0.02	0.89

y = Count + Station + Day +sin(Day) + Station*sin(Day)





Conclusions

We found that stream surveys were an effective method of assessing predation pressure faced by salmonids in a small, coastal watershed. Predation pressure was greatest in the estuary, where species abundance and diversity were greatest. Predation pressure also varied seasonally, with peaks in predator abundance occurring in the spring (Feb-Mar) and Autumn (Sept-Oct). These periods correspond with migration of juvenile salmonids to the ocean (Spring) and the lagoon rearing period for juvenile steelhead (Autumn). Predators may be responding to increased availability of fish in the lagoon during these periods, however, other explanations must be ruled out (e.g. changes in bird abundance because of breeding or migration). Fish densities and growth rates are lower in the oligotrophic upper watershed than in the nutrient rich estuary, which may explain the greater bird abundance/diversity in the estuary. Based on published estimates of energetic requirements, a kingfisher can eat ~ 6 juvenile salmonids (100 mm fork length) and a merganser can eat ~ 47 juvenile salmonids per day (Feltham 1995). Mean annual smolt production in Scott Creek (wild and hatchery) was ~ 3,000 coho and 13,500 steelhead (2003-2009). On a diet of salmonids only, one merganser and one kingfisher could consume 9.5% of the mean annual smolt production in one month. Stickleback, sculpin and invertebrates represent alternative prey for birds in Scott Creek (Langford unpub. data). Inclusion of these species in predator diets will reduce overall impact of predation on juvenile salmonids, however, the data presented here indicate that predation by birds likely represents a significant source of mortality and may limit recovery of federally listed salmonids in Scott Creek, and should be accounted for in management and recovery strategies.