Artificial Lighting Experiments in Lake Washington (2014) and Lake Sammamish (2015)

Roger Tabor and Alex Bell, U.S. Fish and Wildlife Service

Daniel Lantz, Chris Gregersen, and Hans Berge, King County

Artificial nighttime lighting has been shown to affect the behavior of various aquatic organisms, including many salmonids. Light-mediated behaviors may include changes in foraging, predator avoidance, reproduction, and migration. Often fish are attracted to artificial nighttime lighting (positive phototaxis) and their behavior may more resemble daytime behavior than nighttime behavior. In urban areas, high intensity artificial lights are common features near freshwater ecosystems. This lighting can come directly from street lights, industrial and residential buildings, bridges, and other urban structures. In shallow waters, high intensity artificial lighting at close proximity may penetrate through the entire water column. Thus, fish species that utilize shallow water in urban areas may be highly susceptible to the effects of artificial night lighting.

The objective of this study is to test the attractive quality of artificial light on juvenile salmon in nearshore areas. We hypothesized that artificial light sources will cause juvenile salmon to aggregate near artificial light sources at night and phototatic behavior will increase with light intensity. Of particular interest was the effect of nighttime lighting on juvenile Chinook salmon. Information on artificial nighttime lighting may help manage existing and future lakeshore development.

Methods.-- Experimental field trials were conducted in Lake Washington and Lake Sammamish. Within each lake, we selected one uniform 156-m long shoreline section with no direct artificial lighting. Also, we selected sites that were near the outlet of major salmon spawning streams (Cedar River in Lake Washington and Issaquah Creek in Lake Sammamish) so juvenile salmonids would be naturally abundant. The Lake Washington experimental shoreline reach was located along the south-eastern shoreline within Gene Coulon Memorial Beach Park in Renton. In Lake Sammamish, the experimental reach was located along the southern shoreline within Lake Sammamish State Park in Issaquah.

In both lakes, trials were conducted twice a month from March-May to correspond with peak nearshore rearing of subyearling salmonids. In each lake, the 156-m shoreline sections were divided into nine 4-m long experimental units with a 15-m buffer section on either side of each unit. On one night each month light treatments were used and on the other night, no lights were used. The lighted night and the non-lighted night were done within a few days of each other. On the lighted treatment nights, three light intensities were used: (1) no light (control); (2) low light (maximum, 5.0 lx); (3) bright light (maximum, 50.0 lx). Light treatments are comparable to nearshore nighttime water surface illumination values that were identified from a brief survey of artificial light sources along the shoreline of Lake Washington. Treatments were systematically arranged in each of the nine experimental units to control for effects of proximity from spawning stream. The treatment starting order of our systematic design was randomly assigned for each experimental trial.

The light source in the lighted units consisted of two incandescent light bulbs (60-watt, 780 lumens), each with a deflector to focus the light; these were held by 2-m posts over the

water. Each light was placed on either side of the experimental unit with the deflectors facing the center of the unit. Thus, there were a total of nine experimental units per sampling event, because each light intensity treatment was replicated three times. Light treatment systems were set up at dusk and lights were powered after dusk for 1-2 hours. After one hour, we began to beach seine the nine experimental units. Beach seining took approximately one hour, therefore the amount of time each experimental unit was lit varied from one to two hours. The seine was deployed offshore and parallel to shore so the lit area was fully encircled by the seine.

Results. -- For each month, the number of subyearling salmonids (Chinook, coho, and sockeye) was greater on the lighted night than they were on the control night. In Lake Washington, juvenile Chinook salmon abundance was strongly affected by light level and this effect was most apparent in the March experimental trial. Sockeye salmon fry were only collected in Lake Washington during the March trial and 94% were collected in the bright-light treatment sections. In the Lake Sammamish, subyearling salmonids (Chinook and coho) were not distributed evenly across the study area and their abundance was much higher in sections nearer to large woody debris. For experimental units near the woody debris, abundance of juvenile Chinook and coho salmon was substantially higher in the bright-light treatments than in other treatments. Other salmonids (cutthroat trout and yearling coho salmon) were collected primarily in Lake Washington and were mostly collected on control nights or in the no-light treatments.

The results of this study support our hypothesis that subyearling salmon exhibit nocturnal phototaxic behavior when exposed to elevated night light levels. We observed significant differences in the nocturnal distribution of juvenile salmon along our experimental treatment reaches, and these differences were most pronounced in the treatments with the highest light intensity.