Lake Washington/Cedar/Sammamish (WRIA 8) Watershed
201 S. Jackson Street, Suite 600
Seattle, WA 98104-3855

Artificial Lighting Impacts to Salmon in WRIA 8 Briefing Memo

March 10, 2020

Introduction

The *Lake Washington/Cedar/Sammamish Watershed Chinook Salmon Conservation Plan* (WRIA 8 Plan) identifies artificial light pollution as a priority limiting factor and critical research and data need to advance salmon recovery. Reductions in artificial lighting at night is a priority strategy to increase survival of juvenile Chinook and other salmon species during their journey from natal streams to the Puget Sound. Over the next year, WRIA 8 staff and the Technical and Implementation Committees are completing a synthesis of information on urban light pollution to inform commonsense lighting recommendations for our watershed. In the interim, this memo provides an overview of best available science and existing standards to reduce adverse consequences of artificial lighting at night.

Key Takeaways

- Improved juvenile survival is critical to recover self-sustaining populations of Chinook and other at-risk salmon species in our watershed.
- Both direct lighting on adjacent waterways and more indirect, chronic increases in lighting (aka "skyglow") have adverse consequences for survival of juvenile salmon, especially as they migrate through Lakes Sammamish and Washington, and the Lake Washington Ship Canal.
- Artificial nighttime lighting alters juvenile salmon behavior in ways that make them more susceptible to predation and increases the length of time their predators actively feed.
- Commonsense lighting standards can reduce non-target, unintentional, and often unnecessary impacts of artificial light pollution on salmon recovery, human health, and other biological resources.

Summary of the Problem

Migration through Lakes Sammamish and Washington and the Lake Washington Ship Canal presents a survival bottleneck for juvenile salmon in WRIA 8. From 2014 to 2019 an average of just 9% and 11% of tagged juvenile Chinook migrating from the Cedar River and Bear Creek, respectively, reached the Puget Sound (Lisi 2019). Emerging research suggests artificial nighttime lighting alters the behavior of these juvenile migrants in ways that make them more susceptible to predation and increases the length of time their predators actively feed. Reductions in predation rates and improved survival of juveniles is critical for boosting our odds of recovering self-sustaining Chinook populations.

Studies conducted in WRIA 8 suggest both direct lighting on adjacent waterways and more indirect, chronic increases in lighting (aka "skyglow") have adverse consequences for salmon recovery. *Direct lighting* attracts juvenile salmon, slowing or stopping migration and making

them more vulnerable to predators. Tabor et al. (2004) found that direct lighting delays or stops juvenile sockeye outmigrants in the Cedar River, and the number of sockeye delayed increases with light intensity. Predation by sculpins increases substantially (45% as compared to 5% consumed without lights) on juvenile sockeye congregated beneath lights. Celedonia et al. (2008) found that juvenile Chinook salmon are attracted to roadway lighting along the SR 520 Bridge and the Lake Washington Ship Canal, slowing or stopping their migration and potentially increasing loss to predation. Tabor et al. (2017) also found that juvenile Chinook, coho, and sockeye salmon aggregate beneath artificial lights in nearshore areas of Lake Washington and Lake Sammamish, and this effect increases with light intensity.

Indirect lighting, or skyglow, is diffuse light reflected on surfaces or scattered in the atmosphere. Skyglow can increase night brightness by orders of magnitude (Kyba et al. 2015) resulting in increased predation risk for juvenile salmon (Mazur & Beauchamp 2006). Long-term studies in Lake Washington show a shift in the extent and timing of predation on juvenile fish. Thirty years ago, most predation occurred during twilight. Now predators feed throughout the night (Beauchamp 2019). Analyses of light pollution in the Lake Washington Ship Canal suggest skyglow effects have resulted in a seven-fold increase in nighttime predation risk for juvenile salmon compared to historical, pre-lightbulb conditions (Beauchamp 2019). Fortunately, studies also suggest even marginal reductions in artificial lighting at night can substantially reduce predation risk (Beauchamp et al. 1992; Hansen et al. 2013; Mazur & Beauchamp 2003; Vogel & Beauchamp 1999).

In recent decades, popularity of cool-blue, high intensity light-emitting diode ("LED") technology has unintentionally exacerbated the level and extent of light pollution effects in our watershed and urban areas worldwide. These lights are energy efficient but particularly problematic due to their blue-rich light spectrum and increased brightness. Light pollution is spectrally dependent –shorter blue wavelengths are more prone to scattering and radiating back down, contributing to increased skyglow. In aquatic environments, blue wavelengths penetrate deep into the water whereas warm-red light is absorbed at shallower depths of a few feet. Additionally, use of higher efficiency of LED's can lead to inadvertent over-lighting. A growing body of evidence demonstrates adverse consequences of high color intensity (cool-blue) LED lighting for a range of biological resources and human health (Zielinska-Dabkowska 2018). The American Medical Association (2016) recommends warm-red (3000K color temperature or below) LEDs for outdoor street lighting, use of shielding to minimize glare, and dimming lights during off-peak hours (Kraus 2016). It's also important to note, since all spectrums of light can penetrate shallow nearshore habitats used by juvenile salmon, minimizing the amount and intensity of any overwater lighting is critical to reduce light pollution impacts in these areas (Tabor et al. 2019).

Interim Lighting Recommendations

Fortunately, practices and design technologies to meaningfully reduce effects of artificial light pollution at night are known, and there are examples of successful implementation at large scales. Manufacturers produce LEDs with "warm" color qualities and high energy efficiency. Appropriate use of LED lighting with shields, dimmers, and adaptive controls can reduce light pollution and save energy costs.

WRIA 8 is working to synthesize technical information on light pollution and develop a set of commonsense recommendations for our watershed. In the interim, the International Dark Skies

Association (IDA) and the Illuminating Engineering Society of North America (IESNA) have established guidelines to reduce adverse consequences of artificial lighting at night. IDA lighting recommendations focus on five principles to reduce light pollution and its ecological and human health impacts. These include:

1) Use light only if it is needed;
2) Use shielding and shaping to direct light only where it is needed;
3) Use active controls (e.g. timers, motion detectors) to use light only when it is needed;
4) Minimize brightness to the amount of light needed; and
5) Minimize blue-rich lighting and use "warm" color temperature or filtered LEDs (3000K or less).

The IDA and IESNA developed a joint *Model Lighting Ordinance* (2011) to help municipalities design science-based and consistent outdoor lighting standards. This template uses five lighting zones and specific numerical requirements to curtail light pollution, reduce skyglow, and conserve energy resources. However, these standards do not specifically address lighting adjacent to aquatic areas. Washington State's lighting guidance requires the use of low-intensity lights located and shielded to prevent attracting fish or disrupting fish migration behavior, in the absence of safety concerns (WAC 220-660-140; WAC 220-660-400). Until WRIA 8 develops a watershed-specific set of recommendations, these resources provide guidance to reduce impacts of nighttime artificial light.

Conclusion

WRIA 8 staff and committees recognize multiple factors inform artificial lighting decisions and standards. This memo provides a preliminary summary of artificial lighting impacts to salmon and an overview of existing recommendations to consider in updates to municipal codes and other relevant ordinances. We encourage increased actions to reduce non-target, unintentional, and often unnecessary impacts of light pollution on Endangered Species Act listed Chinook, steelhead and other at-risk-salmon populations.

If you have questions about this memo or the WRIA 8 Plan, please contact Jason Mulvihill-Kuntz, WRIA 8 Salmon Recovery Manager, at 206-477-4780 or jason.mulvihill-kuntz@kingcounty.gov.

References

American Medical Association. 2016. "AMA adopts guidance to reduce harm from high intensity street lights". *Press Release*, June 14, 2016.

Beauchamp, D.A., Vecht, S.A. and Thomas, G.L., 1992. Temporal, spatial, and size-related foraging of wild cutthroat trout in Lake Washington. *Northwest Science*, *66*(3).

Beauchamp, D. 2019. "Visual foraging capabilities of predators and impacts of artificial light at night (ALAN)." Presentation the WRIA 8 Technical Committee, October 9, 2019, Seattle Washington.

Celedonia, M.T., Tabor, R.A., Sanders, S., Damm, S., Lantz, D.W., Lee, T.M., Li, Z., Pratt, J.M., Price, B.E., and Seyda, L. 2008. Movement and habitat use of Chinook salmon smolts, northern pikeminnow, and smallmouth bass near the SR 520 bridge, 2007 acoustic

tracking study, annual report (No. WA-RD 694.1). Washington State Dept. of Transportation.

Hansen, A.G., Beauchamp, D.A. and Schoen, E.R., 2013. Visual prey detection responses of piscivorous trout and salmon: effects of light, turbidity, and prey size. *Transactions of the American Fisheries Society*, *142*(3), pp.854-867.

Kraus, L. 2016. Human and environmental effects of light emitting diode (LED) community lighting (Report No. 2). https://www.darksky.org/wp-content/uploads/bsk-pdf-manager/AMA_Report_2016_60.pdf

Kyba, C.C., Tong, K.P., Bennie, J., Birriel, I., Birriel, J.J., Cool, A., Danielsen, A., Davies, T.W., Peter, N., Edwards, W. and Ehlert, R., 2015. Worldwide variations in artificial skyglow. *Scientific reports*, *5*, p.8409.

Lisi, P. 2019. "Lake Washington basin juvenile salmon 20-year PIT tagging synthesis." Presentation the WRIA 8 Technical Committee, November 13, 2019, Seattle Washington.

Mazur, M.M. and Beauchamp, D.A., 2003. A comparison of visual prey detection among species of piscivorous salmonids: effects of light and low turbidities. *Environmental Biology of Fishes*, *67*(4), pp.397-405.

Mazur, M.M. and Beauchamp, D.A., 2006. Linking piscivory to spatial–temporal distributions of pelagic prey fishes with a visual foraging model. *Journal of Fish Biology*, *69*(1), pp.151-175.

Tabor, R.A., Brown, G.S. and Luiting, V.T., 2004. The effect of light intensity on sockeye salmon fry migratory behavior and predation by cottids in the Cedar River, Washington. *North American Journal of Fisheries Management*, 24(1), pp.128-145.

Tabor, R.A., Bell, A.T., Lantz, D.W., Gregersen, C.N., Berge, H.B. and Hawkins, D.K., 2017. Phototaxic behavior of subyearling salmonids in the nearshore area of two urban lakes in western Washington state. *Transactions of the American Fisheries Society*, *146*(4), pp.753-761.

Tabor, R.A., E. K. Perkin, D. A. Beauchamp, L. L. Britt, R. Haehn, J. Green, T. Robinson, S. Stolnack, D. W. Lantz, Z. J. Moore. 2019. Effect of six types of artificial nighttime lights on the attraction of subyearling salmonids in the nearshore area of south Lake Washington. Final report to King County Flood Control District, Seattle.

Vogel, J.L. and Beauchamp, D.A., 1999. Effects of light, prey size, and turbidity on reaction distances of lake trout (*Salvelinus namaycush*) to salmonid prey. *Canadian Journal of Fisheries and Aquatic Sciences*, *56*(7), pp.1293-1297.

Zielinska-Dabkowska, K. M. 2018. Make lighting healthier. *Nature*, 553, 274–276.