Potential Effects of Alkaline pH on Passage of Juvenile Anadromous Fish through Lake Billy Chinook

Robert Casey[1], Matthew Orr[1], Greg McMillan [2]
[1]OSU-Cascades Dept. of Biology, [2]Deschutes River Alliance

ABSTRACT

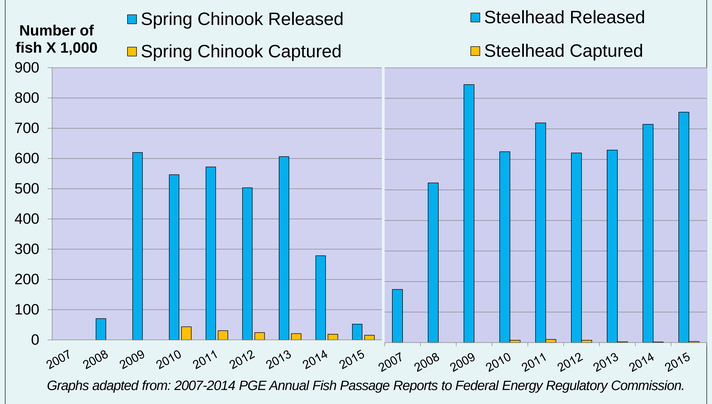
In 2009, Portland General Electric constructed a $90 million selective water withdrawal tower in Central Oregon's Round Butte Dam complex on the reservoir known as Lake Billy Chinook (LBC). The tower was designed to create an artificial current in the epilimnion of the reservoir to help guide downstream migration of juvenile chinook salmon (Oncorhynchus tshawytscha) and steelhead (Oncorhynchus mykiss). However, total migration of juvenile salmon and steelhead from their planted headwaters (the Crooked, Deschutes, and Metolius Rivers) through the reservoir since their reintroduction in 2011 has been unexpectedly low. When accompanied by available literature, data collected by the Deschutes River Alliance and Portland General Electric suggests that the alkalinity of the reservoir's epilimnion may influence juveniles to avoid the surface current by spending time in a water zone with a more neutral pH. As a result, juvenile fish may be exposed to negative stressors including ammonia autointoxication, more time spent in the reservoir, increased parasitic load, and a higher amount of predation by other fish. This poster illustrates the potential effects of high pH on juvenile salmonid migration, and how pH may be a key to discovering why juvenile salmon and steelhead have low passage rates through Lake Billy Chinook.

Image taken from LakeBillyChinook.com/lake.html

Lake Billy Chinook

RESERVOIR PASSAGE RATES

Tributary releases far exceed tower arrivals at Lake Billy Chinook



Graphs adapted from: 2007-2014 PGE Annual Fish Passage Reports to Federal Energy Regulatory Commission.

Juvenile salmon & steelhead passage rates are over 65x higher in other Oregon reservoirs

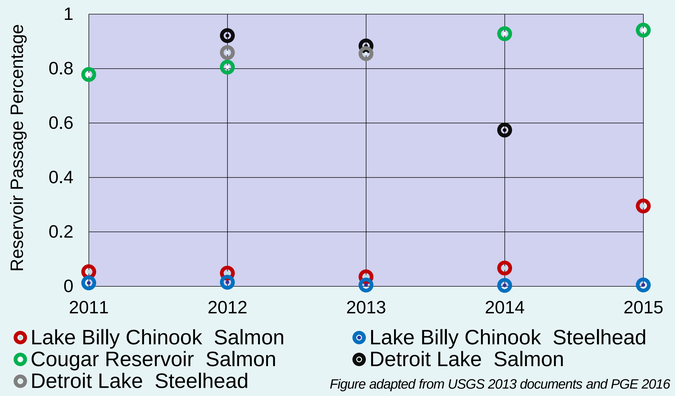
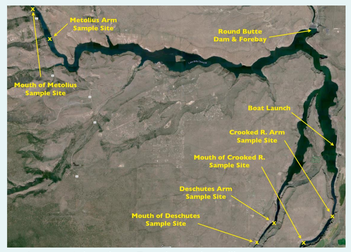
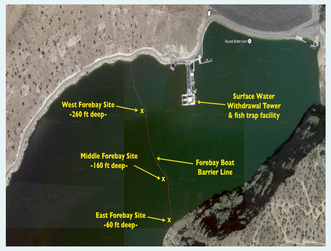


Figure adapted from USGS 2013 documents and PGE 2016

Lake Billy Chinook **Forebay**





Images taken from Deschutesriveralliance.org

- Oregon Department of Environmental Quality standard for pH is 6.5-8.5. pH > 9.0 is common in Lake Billy Chinook's epilimnion
- Cost to produce a juvenile salmonid ~ $1
- Avg. time spent in LBC during down stream migration: >30 days
- Median time spent in Lower Deschutes below reservoir: <4 days*

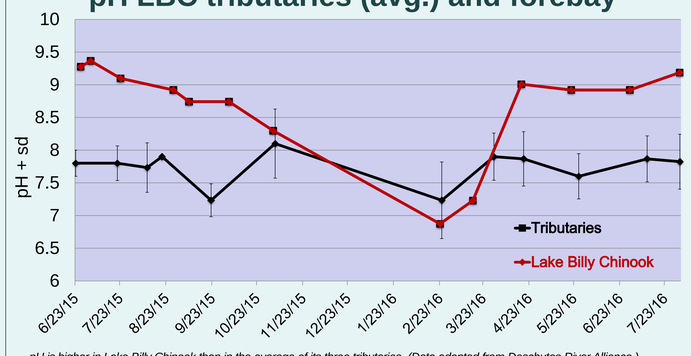
**Hill & Quesada, 2016*

ALKALINE pH

Why are passage rates so low?

Among factors that influence juvenile salmonids' ability to migrate (e.g. temperature, flows, dissolved oxygen, and predation), pH is often overlooked. Water quality problems such as high nutrient loads and increased photosynthesis in phytoplankton can cause pH to vary. Effects of low pH on juvenile salmon and steelhead are widely documented. However, effects of alkaline (high) pH are less studied. Wagner et al. (1997) found that pH > 9.4 caused death of rainbow trout juveniles in the field after <12 hr exposure, especially at temperatures from 19-22 C, which compares with the epilimnion temperatures at Lake Billy Chinook. At 24 hrs, mortality rates increased from 30 to 50%. pH values of 9.0 or greater cause stress responses in rainbow trout including sluggish movement, reduced feeding, and ammonia intoxication. High pH also influences the ability of rainbow trout to chemosense in predator/prey interactions (Smith et al. 2008).

pH LBC tributaries (avg.) and forebay



pH is higher in Lake Billy Chinook than in the average of its three tributaries. (Data adapted from Deschutes River Alliance.)

Alkaline pH inhibits a fish's ability to excrete ammonia, leading to ammonia-auto-intoxication

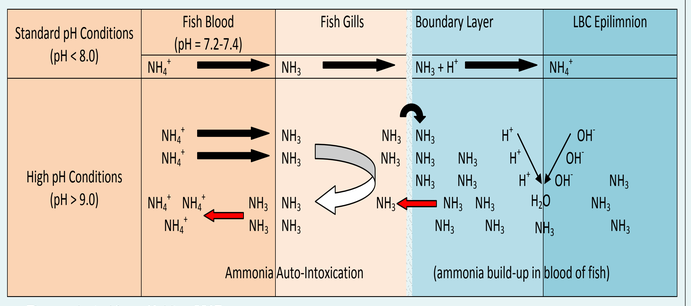
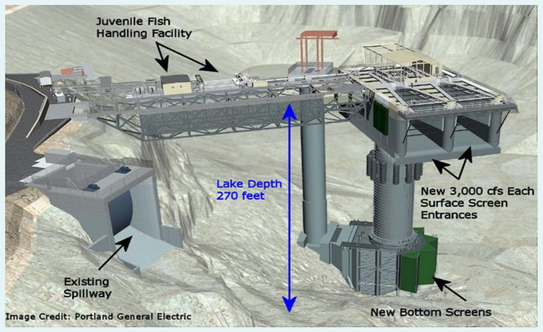


Figure adapted from Kubitza 2017.

CONCLUSIONS

What can be done?

Avoidance of high pH (Hara 1992, Serafy 1993) may force juveniles outside of the artificial current designed to help migration through the reservoir. This may cause juveniles to spend more time in LBC, exposing them to greater parasitic loads, increased predation, and poorer water quality. Since high nutrient loads affect pH, more data is needed about water quality in the three tributaries entering Lake Billy Chinook and the possible formation of a chemocline. Comparing pH valuethes of Lake Billy Chinook (12 miles at longest) with Detroit (8.5 miles) and Cougar (5.5 miles) Reservoirs would be very useful but that data are not yet available. Releasing juveniles below the reservoir instead of in its tributaries, or collecting them before they enter the reservoir should be examined as possible approaches to mitigating low passage rates because survival through the remaining lower Deschutes is relatively high.



Selective Water Withdrawal Tower

Beeman, et al. "Behavior and dam passage of juvenile Chinook salmon at Cougar Reservoir and Dam, Oregon, March 2011 - February 2012." USGS Publications Warehouse RSS. USGS, 4 Apr. 2013. Web. 22 Feb. 2017.

DRA. "What Happened to All the Fish?" Deschutesriveralliance. N.p., 15 Feb. 2016. Web. 22 Jan. 2017.

Hill, Megan, and Cory Quesada. "History of Salmon in the Deschutes - portlandgeneral.com." Portland General Electric. PGE, June 2016. Web. 27 Feb. 2017.

Hara, Toshiaki J. Fish Chemoreception. Dordrecht: Springer Netherlands, 1992. Internet resource.

Kubitza, Fernando. "The oft-overlooked water quality parameter: pH." *The Advocate*. Global Aquaculture Advocate, 03 Jan. 2017. Web. 16 Feb. 2017.

Portland General Electric, and The Confederated Tribes of the Warm Springs Reservation of Oregon. "Pelton Round Butte Project (FERC No. 2030) 2015 Fish Passage Annual Report." Federal Energy Regulatory Comission. PGE, May 2016. Web. Feb. 2017.

Serafy, J.E. and Harrell, R.M. (1993), Behavioural response of fishes to increasing pH and dissolved oxygen: field and laboratory observations. Freshwater Biology, 30: 53–61. doi:10.1111/j.1365-2427.1993.tb00788.x

Smith, J. J., Leduc, A. O. H. C. and Brown, G. E. (2008), Chemically mediated learning in juvenile rainbow trout. Does predator odour pH influence intensity and retention of acquired predator recognition?. Journal of Fish Biology, 72: 1750–1760. doi:10.1111/j.1095-8649.2008.01849.x

Wagner, E.J., T. Bosakowski, and S. Intelmann. 1997. Combined Effects of Temperature and High pH on Mortality and the Stress Response of Rainbow Trout after Stocking. Transactions of the American Fisheries Society. 126:985-998.