

The effects of gas supersaturation on fish and benthic invertebrates

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ABSTRACT: Freshwaters are rarely saturated with more than 100% air. Gas supersaturation can still occur in natural settings, and especially downstream from waterfalls. In hydropower plants, supersaturation can occur when air is entrained in the tunnel system and saturated in water under high pressure. Exposure to supersaturation negatively affects aquatic biota through the formation of bubbles in the tissue, analogous to the bends in humans. We have performed lab experiments with up to 120% saturation to find the tolerance towards supersaturation in Atlantic salmon parr-, fry- and alevins, brown trout, minnow, rainbow trout, and nine species of common benthic invertebrates. We have also tested in-situ effects on Atlantic salmon and brown trout in the River Otra.

Clinical signs of gas bubble disease in fish start to develop at 105% saturation, subacute mortality occurs from 110% saturation, and acute mortality occurs from 115% saturation. Parr of Atlantic salmon and brown trout are most sensitive towards supersaturation, while minnow is least sensitive. The clinical symptoms of gas bubble disease in Atlantic salmon parr, such as subcutaneous emphysema, disappears within one week in 100% saturated water. Field studies indicate reduced fish density downstream of hydropower plants emitting supersaturated water and that tagged brown trout has limited ability to sense supersaturation. However, high levels of supersaturation cause lower mortality than expected from laboratory studies because mortality depends not only on dose but also on duration, frequency, dilution, aeration, and water depth. Unlike the fish studied in the lab, macroinvertebrates had a lower mortality caused by supersaturation. However, most invertebrates experienced buoyancy problems and floated on the water surface when the water was supersaturated.

Hydropower is predicted to increase by 73% worldwide in the next 10-20 years, and more data on the prevalence and impact of supersaturation on biota are needed to design more efficient mitigation measures in new and revised constructions.