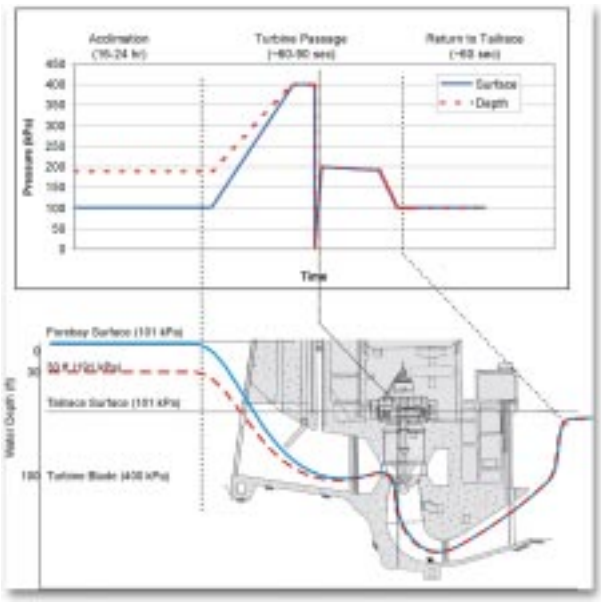
Laboratory Studies of the Effects of Pressure and Dissolved Gas Supersaturation on Turbine-Passed Fish

Migratory and resident fish in the Columbia River Basin are exposed to stresses associated with hydroelectric power production, including changes in pressure as they pass through turbines and dissolved gas supersaturation (resulting from the release of water from the spillway).

Hyperbaric chamber.

To examine pressure changes as a source of turbine-passage injury and mortality, Pacific Northwest National Laboratory scientists conducted specific tests using a hyperbaric chamber. Tests were designed to simulate Kaplan turbine passage conditions and to quantify the response of fish to rapid pressure changes, with and without the complication of fish being acclimated to gas-supersaturated water.

Rainbow trout *(Oncorhynchus mykiss),* chinook salmon *(O. tshawytscha),* and bluegill sunfish *(Lepomis macrochirus)* were exposed to gas and pressure simulations. A pressurized packed cell column generated and controlled the level of gas-supersaturated water within the turbine passage system's two acrylic exposure chambers. The chambers hold a volume of approximately 34 L. A computer program controlled pressure inside the exposure chambers.

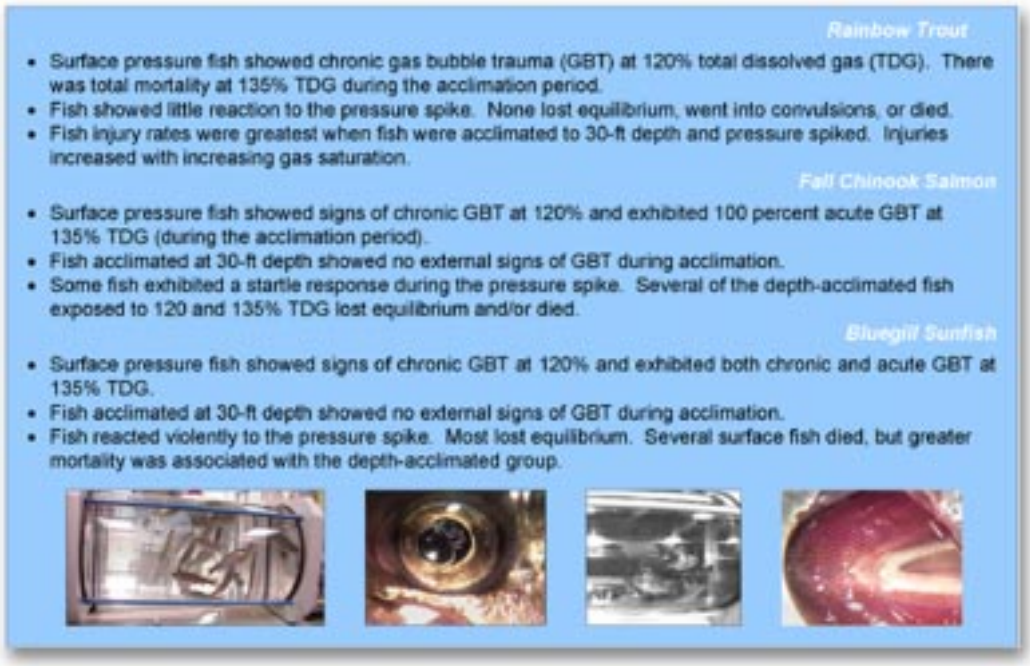


Surface and 30-ft depth pressure exposure simulation of turbine passage.

The system could drop the pressure from a maximum 400 kPa of head to near the vapor pressure of water (<2 kPa) in just 0.1 second.

Twenty fish were introduced to each exposure chamber and acclimated for 16-22 hours at either surface pressure (101 kPa) or at a pressure equivalent to a 30-ft depth (191 kPa) and at one of the three gas saturation levels (100, 120, or 135%).

After acclimation, one of the two fish groups was subjected to the simulated turbine passage pressure spike, then placed in holding troughs for observations of condition at 1, 24, and 48 hours. Necropsies were performed on fish that died during acclimation or immediately following the pressure spike to determine cause of death. Remaining fish were examined after 48 hours. Necropsies identified bubbles and hemorrhaging in the eyes, fins, gill filaments, heart and major arteries, and swim bladder rupture.



By themselves, gas saturation levels ≤120% are unlikely to cause lethal GBT in the three species tested. However, the data indicate that if fish sound to compensate for dissolved gas supersaturation near the water surface, the low-pressure spike associated with turbine passage may be more lethal. Fish entrained from greater depths experience fast expansion of the swim bladder during the low-pressure spike as they pass the turbine blade, resulting in more injuries and mortality.

In view of these findings, it would be desirable both to reduce the amount of gas supersaturation (by reducing spill or the amount of gas added during spill) and to develop advanced turbines that operate efficiently at a higher pressure downstream from the runner.

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(www.inel.gov/national/hydropower/turbine/turbine.htm)

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