Advanced Sensor Fish Device for Improved Turbine Design

Juvenile salmon (smolts) passing through hydroelectric turbines are subjected to environmental conditions that can potentially kill or injure them. Many turbines are reaching the end of their operational life expectancies and will be replaced with new turbines that incorporate advanced "fish friendly" designs devised to prevent injury and death to fish. To design a fish friendly turbine, it is first necessary to define the current conditions fish encounter.

Scientists at Pacific Northwest National Laboratory have developed a sensor fish device to collect data that measures the forces fish experience during passage through hydroelectric projects. The sensor fish device is a 7.5-inch long data collection package designed to withstand and measure the severe hydraulic environment in dams and spillways.

Sensor fish prototype device.

This device is providing us with the first-ever data on actual conditions experienced by juvenile salmon passing through an operating dam. While we knew fish were injured or killed during turbine passage, we couldn't correlate conditions to specific injuries. With the sensor fish device, we know what conditions—hydraulic or structural mechanical features—may be responsible for injuries and where these conditions occur. The data are helping us identify the most vulnerable locations for fish during passage and enabling engineers to design safer turbines for fish.

The sensor fish device contains accelerometers, a microprocessor, a pressure sensor, an analog-to-digital converter amplifier, digital memory, and computer communication capability, all encased in a clear polycarbonate plastic cylinder. It runs on standard AAAA batteries. It is neutrally buoyant (like a live fish, it doesn't float or sink), so its path mimics that of migrating smolts, which in the high-velocity turbine flows (10 to >30 ft/sec) move downstream with little control over their movements.

The sensor fish device is sent through a pipe directly into the turbine chamber, sluiceway, spillway, or other area to be studied. Before deployment, specially designed balloons inflate, bringing the device to the surface. An attached micro-radio transmitter helps scientists in boats find and recover the sensor fish device in the dam tailrace, downstream of the

Field biologists releasing sensor fish device.

turbine exit. Passage time from insertion to recovery is typically <5 minutes. Each device is then connected to a desktop computer to transfer the data. After data recovery, the fish's memory is cleared, the battery recharged, new balloons attached, and the fish is ready for another deployment.

The sensors' analog outputs are sampled at a rate of 200 points/sec. Acquired digital samples (12 bit) are stored in nonvolatile memory (4096K). The pressure and tri-axial acceleration data provide detailed time histories at 0.005-sec increments of the sensor fish device's motion resulting from forces acting on it during passage. From the data, we can tell when the sensor fish device is moving forward and backward, if it's been spun around, if it's been caught in a backroll, or if it's hit a structure in the turbine. The data we collect using the sensor fish device are helping us visualize a fish's path through the turbine environment in a way we've never been able to before.

Data collected from the sensor fish device will help power producers, regulators, and fish management agencies make decisions about the configuration and operation of the Columbia River system.

This project has benefited from support by the U.S. Department of Energy Advanced Hydropower Turbine System Program.

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

For more information, contact
Thomas J. Carlson
Pacific Northwest National Laboratory
(503) 417-7567
or
Peggy Brookshier
U.S. Department of Energy
(208) 526-1403