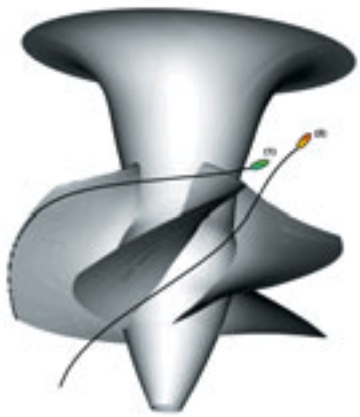
Digital fish helps make hydropower more "fish-friendly"

ORNL and its research partners are developing a "digital fish" and other computer models to study the environmental impacts of hydropower projects. These new modeling tools will ultimately help balance the competing needs of fish and power generation in the Pacific Northwest and other regions of the United States.

The digital fish is one of several ORNL projects to help hydropower systems generate electricity with less harm to salmon, sturgeon, and steelhead that pass through turbines. The DOE Advanced Hydropower Systems Program is sponsoring this research. ORNL is working with Georgia Tech and turbine maker Voith Siemens to build digital fish models that will take advantage of ORNL's teraflop (1 trillion calculations per second) supercomputers for simulation and data analysis. TVA is also supporting the research by collecting detailed measurements of the flow fields inside turbines.

The hydraulic environment inside a hydropower turbine is extremely complex and difficult to observe, so computational fluid dynamics models are used to simulate what happens to fish traveling through turbines. The models provide data to define a zone within which water pressure, shear forces, turbulence, and the likelihood of collision with turbine blades are reduced. The digital fish moves within the simulated flow field and measures physical stresses that would occur over different passage trajectories. The results of this work will be used to design turbines that are safer for fish.



Computed fish trajectories through a Kaplan turbine.

DOE's goal for the research is to reduce the mortality of fish passing through turbines to 2% from the current levels of 5 to 30%. Another goal is to develop aerating turbines to increase the level of dissolved oxygen in tail waters.

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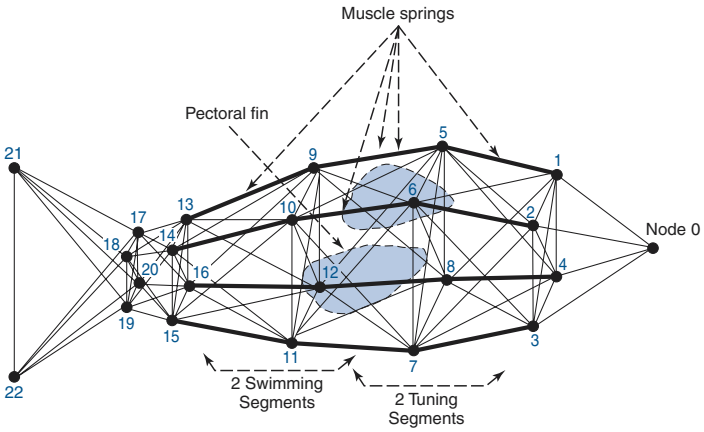

A "digital fish" model being used to design turbines that are safer for fish.

The ORNL team also is studying the viability of the white sturgeon in the Snake River. The white sturgeon, which can live more than 100 years, is the largest freshwater fish in North America. Fragmentation of rivers by dams threatens the sturgeon population by separating male and female spawning fish and by converting free-flowing rivers to reservoir habitats unsuitable for spawning. ORNL has developed a white sturgeon model that quantifies the effects of fragmentation, and a similar model to track individual Chinook salmon as adults migrate upstream to spawn.

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Sponsor: DOE Office of Biopower and Hydropower Technologies and the Idaho Power Company

continued from page10

NRECA is purchasing the microturbines with funds from its Central Research Network and from EPRI. DOE and EPRI are funding the data collection and analysis.

Microturbines from several manufacturers will be tested. Five sites have microturbines installed and operating: Alaska Village Electric Cooperative Association (AVEC), Arkansas Electric, Cass County, Chugach, and the Tennessee Valley Authority. Four of those have 30-kW Capstone microturbines and one a 75-kW Honeywell microturbine. The AVEC unit is operating on No. 1 fuel oil and the Chugach unit on low-pressure natural gas. The Associated Electric microturbine will use high-pressure propane and the Kotezebue unit will use No. 2 fuel oil.

NRECA has developed a data collection protocol and identified monitoring technologies for the cooperatives. The cooperatives will collect the data, which will be made available to ORNL and EPRI for analysis.

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