ENVIRONMENTAL FLOWS DETERMINATION FOR HYDROPOWER DAMS

Dr. Ryan A. McManamay, Dr. Mark S. Bevelhimer

Oak Ridge National Laboratory

Background

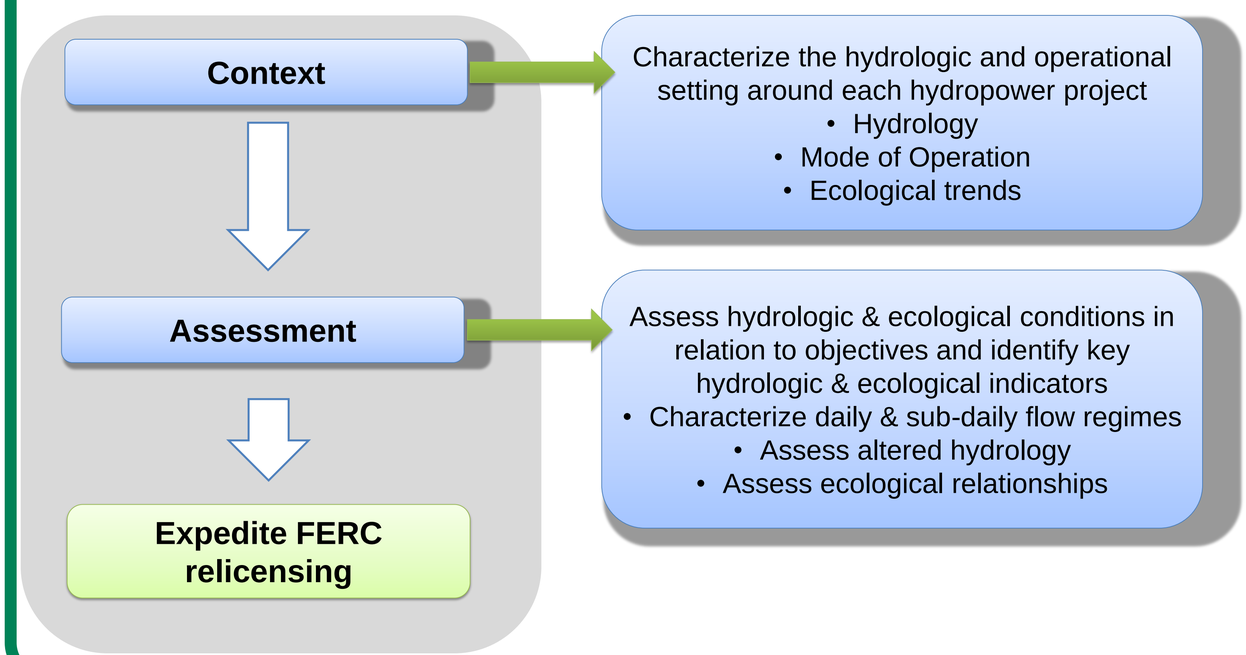
- The natural flow regime (NFR) sustains the ecological integrity of river systems
- Increased pressure on hydropower dam owners to change plant operations to benefit aquatic biological communities
- Identifying the necessary environmental flows to meet ecological needs is challenging because the ecological responses to changes in flows may not be fully known, there are usually a multitude of competing users of flow, and implementing environmental flows usually comes at a price to energy production.
- A framework is needed to create and organize environmental flow tools into a staged process to fill information gaps and expedite FERC relicensing procedures

Objectives

- Develop a framework to create and organize tools aimed at defining environmental flow needs for hydropower operations
- Create a hydrologic classification to characterize Natural Flow Regimes
- Classify dams by their mode of operation
- Characterize daily and sub-daily flow regimes influenced by dam operations
- Assess ecological relationships with streamflows

Methods

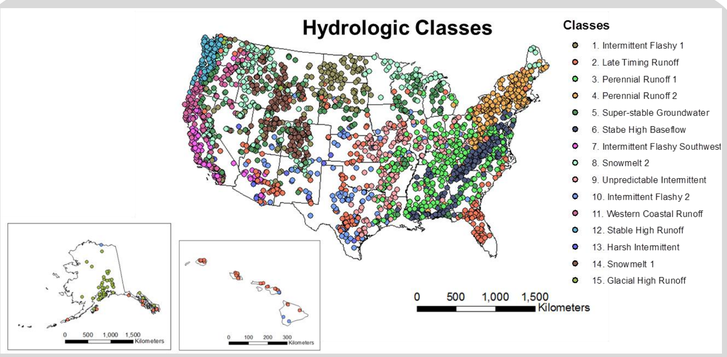
Construct Environmental Flow Determination Framework



Results

Context

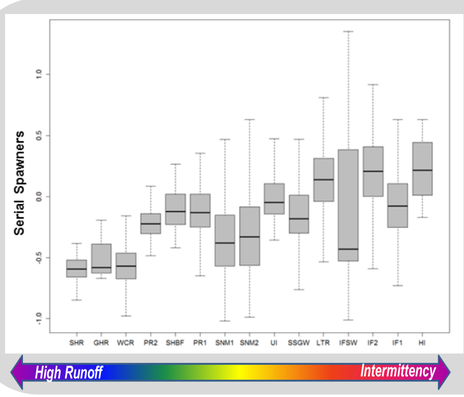
- Hydrologic classification identified 15 natural flow regime (NFR) types
- Fish assemblages varied predictably with hydrology
- Developed hydropower dam operational regimes



15 Natural Flow Regime Types across the US

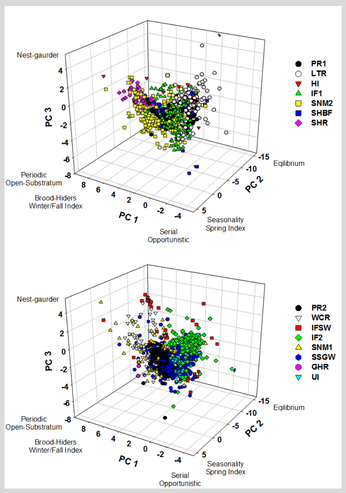
Hydropower Dam Mode of Operation
Mode-of-operation classes created from sample of 432 power plants, the range in generation capacity in megawatts (MW).

Mode-of-Operation Class	% of Power Plants	MW Capacity Range
Run-of-river	36	0.01 - 436
Reregulating	2.5	0.70 - 49.0
Run-of-river/Peaking	5.3	0.08 – 28.8
Reregulating/Peaking	0.2	9.6
Intermediate Peaking	9.7	0.10 - 6809
Run-of-river/Upstream Peaking	11	0.68 - 162
Peaking	35	0.46 - 912



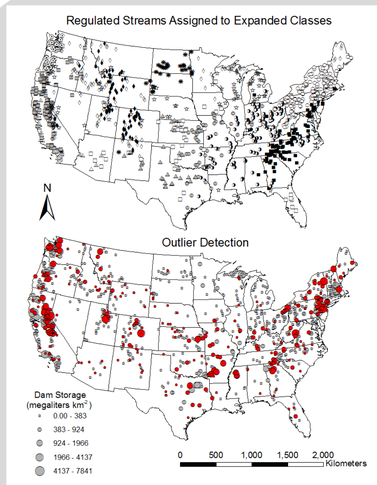
Predictable trends in fish traits across hydrologic gradients, e.g. from high runoff to highly intermittent NFR types

Serial spawners, i.e. species that spawn multiple times per season, show positive associations with intermittent NFR types.



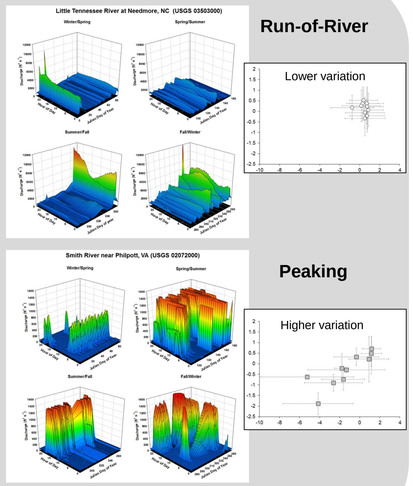
Variation in Fish Traits across Natural Flow Regime Types

Assessment



Daily streamflow responses specific to NFR Types

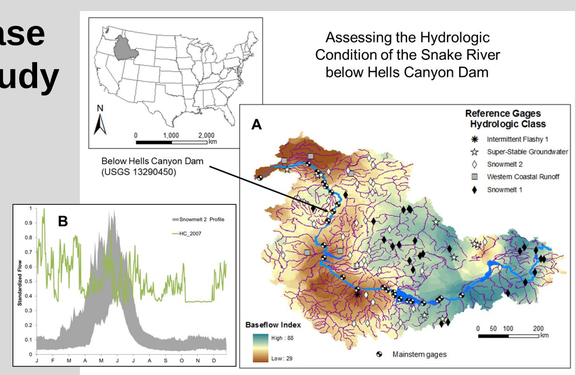
- Daily streamflow responses to dam operations were variable, but may be specific to NFR types
- Dams operating outside realm of NFR can be identified
- Sub-daily patterns in streamflows show more general patterns



Examples of sub-daily streamflow responses

- Hydrologic classes can be used to assess hydrologic alterations
- Current hydrologic regimes below hydropower dams can be compared to the "typical" range found within NFR types

Case Study



Conclusions

- Environmental flow framework is provided that can expedite the FERC relicensing process .
- Quickly characterize hydropower project hydrologic and ecological condition
- Framework is applicable to multiple spatial and temporal scales
  - Context provides information on hydrologic and operational regimes
  - Ecological indicators can be determined from NFR-fish trait relations
  - Assessment provides degree of alteration relative to ecological objectives

Future Directions

- More context is needed
  - Geomorphology
  - Temperature regimes
- Hydrologic alteration-ecological responses are needed to fill information gaps
- Build higher resolution datasets to increase specificity of results and alleviate burden of 'on-the-ground' analyses

U.S. DEPARTMENT OF ENERGY

For more information contact: Dr. Ryan McManamay, mcmanamayra@ornl.gov
Dr. Mark Bevelhimer, bevelhimerms@ornl.gov

FY2010-FY2013
Budget: $600,000

Acknowledgements: This research was funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, Water Power Program

OAK RIDGE National Laboratory