Environmental R&D and Hydrologic Systems Science Activities

Dana McCoskey
WPTO Environmental Technologies Manager
July 26, 2022
Outline

• Environmental R&D and Hydrologic System Science Overview
  – Challenges the Activity Area Addresses
  – Examples of How Stakeholder Engagement Informed Strategy

• Strategy
  – Performance Goals (from MYPP)
  – Objectives (from MYPP)

• Implementation and Progress
  – Research Priorities (from MYPP)
  – Key Accomplishments
  – Future Work

• Agenda Overview
• Reviewer Introductions
R&D to Improve Environmental Performance

Improving understanding of fish movement, habitat use, and survival through the development of advanced monitoring technologies, relevant metrics, and other impact assessment tools.

Hydrologic Systems Science

Addressing fundamental questions of hydrologic variation, impacts on ecosystems, and risks for operations and engineering of hydropower systems.
Addressing Environmental Impacts and Hydrologic Uncertainties

- Knowledge gaps remain related to fish and wildlife biology, behavior, and interactions with hydropower facilities.
- Limitations in instrumentation and monitoring tools and technologies to understand the environmental impacts of hydropower.
- Uncertainties about long-term climate change and hydrologic variations or extreme events and the associated operational and ecological impacts.
How Stakeholder Engagement Informed the Strategy

• 2016 Hydropower Vision Report & Roadmap, over 200 authors from all sectors of the community
• Industry Summit (FY17), 30+ industry executives and owner/operators, and national laboratories
• Environmental Summits (FY18 and FY19); 40+ agency, NGO; with industry representatives in FY19
• Federal Hydropower Memorandum of Understanding (FY20 Action Plan, ongoing since FY15); Reclamation, Army Corps, and Power Marketing Administrations; with bi-annual progress updates for stakeholders
• Federal Inland Hydropower Working Group (ongoing since FY16); 15 federal hydropower agencies with quarterly meetings to share R&D findings, needs, and challenges
• National Hydropower Association Innovation Council Workshops (ongoing since FY16, presented on Fish Passage Portfolio in FY21); Industry CEOs, owner/operators, R&D managers
• CEATI workshops (general environmental R&D, Dissolved Oxygen working group FY18, Oil-free infrastructure FY20)
• DOE-Norway MOU FY20 with HydroCen & Norwegian Research Institutes, FY20 Hydropower Summit in Trondheim
• International Energy Agency Annex XIII - Hydropower and Fish, 20+ international experts on fish migration and hydro
• WPTO Fish Passage Strategy draft, WPTO development with experts from 4 national laboratories
• Requests for Information (Hydro Strategy FY20, Testing Capabilities FY21, Climate Change Data FY22 in process)
• Project specific outreach and webinars to gain understanding of use cases and specifications for technology, share updates, and facilitate partnerships and pairing for demonstrations
Environmental and Hydrologic Systems Science Goals

<table>
<thead>
<tr>
<th>Key Results and Performance Goals (2021–2025)</th>
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</thead>
<tbody>
<tr>
<td>✓ Complete field validations of novel and improved fish detection and tracking capabilities relevant for hydropower studies, including demonstration of environmental DNA and prototypes of acoustic telemetry tags for sensitive species and a self-powered acoustic fish tag.</td>
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<tr>
<td>✓ Demonstrate innovative tools and technologies that are benchmarked for cost and performance, including innovative fish passage technologies and sensor systems.</td>
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<tr>
<td>✓ Demonstrate real-time data collection, automation, and visualization to inform decision makers’ choices to operate hydropower resources for enhanced environmental performance in water and species management.</td>
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<tr>
<td>✓ Release a nationwide analysis and visualization platform that enables utilities and system operators to evaluate potential long-term water availability and climate change related risks to existing and new hydropower assets at meaningful local or regional scales.</td>
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<tr>
<td>✓ Validate new technologies to more accurately characterize and model methane emissions from reservoirs and other water bodies.</td>
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</table>
Environmental and Hydrologic Systems Science Objectives

Environmental and Hydrologic Systems Science Objectives (2026–2030)

• A suite of demonstrated, cutting-edge tools and technologies for hydropower-specific environmental monitoring, mitigation, and decision-making that enable accurate data collection and predictive outputs with reduced cost and time and can be utilized for community developed standardized processes and FERC relicensing.
• Quantifiable improvements in fish passage performance that can be linked to established fish population and restoration goals.
• Documented improvements in real-time data collection and accuracy for species of concern and other environmental variables that inform hydropower operations and management.
• Better understanding of the risks of long-term hydrologic variations to hydropower generation and flexibility and documented incorporation into licensing or other planning processes.
• Accurate and widely agreed-upon characterization of methane emissions from U.S. reservoirs.
Environmental R&D Research Priorities and Goals

- Monitoring
  - Develop fish tracking capabilities
  - Identify methods to modernize data collection, processing, and analysis
  - Develop advanced water quality monitoring capabilities
  - Long-term field tests of advanced fish tracking capabilities
  - Deploy artificial intelligence and machine learning enhanced technologies
  - Utilize capabilities to enhance model performance

- Mitigation
  - Develop innovative multispecies fish passage technologies
  - Field-test multi-species fish passage technologies
  - Demo models and tools that increase predictive and adaptive species and water management for hydropower
  - Improve ability to assess the full range of environmental impacts of hydro operations

- Metrics
  - Develop decision-support tools and resources
  - Develop novel approaches to monitoring and assessing flow for rapidly changing hydropower operations and to optimize environmental outcomes

FY2021
- Monitoring Technologies
- Avoid, Minimize, Mitigate Environmental Impacts
- Environmental Metrics
- Long-Term Hydrologic Variations

FY2025
Fish Tracking Capabilities:
- Commercially available Eel/Lamprey Tag (PNNL)
- Shad Tag prototype developed (PNNL)
- Self-powered Tag materials assessment complete (PNNL TCF)

Data Collection/Processing:
- Machine learning with sonar to detect/classify fish (EPRI) (FOA)

Water Quality:
- WQ Sensors ROV prototype demonstrated with real-time data transmission capabilities (Lab)
- Environmentally Acceptable Lubricants with small businesses, 3+ patents (SBIR)
### Environmental R&D Accomplishments – Mitigation

#### Multispecies Fish Passage:
- **Innovative Fish Passage (FOA):**
  - U Mass Amherst - Entrance Palisade
  - Alden Research Laboratory - Eel Bi-pass
- **HydroPASSAGE (PNNL/ORNL):**
  - Sensor Fish (1 license)
    - Sensor Fish Mini
  - HBET (6 license, 18 over project)
  - BioPA Tool (5 licenses, 9 over project)
  - 99 biological response modes for 31 species of fish (75% developed by project team)
- **Fish Protection Prize:**
  - Proof-of-concept testing for Winners
    - Alden Research Lab – Deal with the Devil Fish
    - Prometheus LLC – Inspection Materials
    - Natel Energy – Center Sender

#### MYPP Goals FY21-FY25

- **Develop multi-species fish passage:** Design and test innovative up- and down-stream fish passage technologies to support fish communities and prevent invasive species movements and investigate methods for relating technology choices to fish restoration goals.
- **Field tests of multi-species fish passage technologies:** Quantify performance of innovative technologies and applied modeling capabilities to assess population-level impacts and restoration goals.

#### R&D for Low Impact Growth: Cross-cutting Hydropower R&D

**Standard Modular Hydropower (FOA):**
- Natel Energy - Restoration Hydro Turbine
- Percheron Power – Two-way fish migration technology adapted from Archimedes Screw Turbine
- Littoral Power Systems – Prefabricated Zero Ascend Omnисpecies (ZAO) Modular Fish Passage Modules Using Advanced Manufacturing Techniques

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**U.S. DEPARTMENT OF ENERGY OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY | WATER POWER TECHNOLOGIES OFFICE**
Environmental R&D Accomplishments – Metrics

Decision Support Tools (ORNL):
- Catalogue of **Environmental Metrics for Hydropower**:
  - Biota and Biodiversity
  - Water Quality
  - Geomorphology
  - Connectivity and Fragmentation
  - Water Quantity
  - Landscape and Land Cover
- **River Function Indicator Questionnaire Tool**
  - Demonstrated with 5 external reviewers
  - Available online @HydroSource

**HydroWIRES: Cross-cutting Hydropower R&D**
Instream Flows and Hydropeaking
- Topic A: Power System and Environmental Flow Win-Wins

MYPP Goals FY21-FY25
- Develop decision support tools and resources: Provide information and science-based tools that utilize established environmental metrics and indicators.
- Access utility of tools in hydropower environmental assessments: Demonstrate toolkits with hydropower stakeholders and assess capabilities to identify key environmental impacts and relevant mitigation methods.
# Hydrologic Systems Science Research Priorities

## Climate Change and Hydrologic Science

- **Determine needs for additional modeling assessments**
- **Develop numeric models, computing, and artificial intelligence capabilities**
- **Provide relevant data and tools for the entire hydropower fleet**
- **Quantify risks at plant and basin-scales**

## Methane Emissions from Reservoirs

- **Develop capabilities to understand methane emissions from reservoirs**
- **Develop remote sensing capabilities to measure methane emissions from reservoirs**
- **Address core scientific questions about methane emissions from reservoirs**
- **Classify reservoirs and quantify measurements**

## FY2021

- **Methane Emissions from Reservoirs**
- **Climate Change and Hydrologic Science**

## FY2025
Hydrologic Systems Science Accomplishments – Climate Change

Climate Change Science:
- Third Secure Water Act Section 9505 Assessment on Climate Risks to Hydropower (ORNL/PNNL/PMAs/USACE)
- Climate-water risk assessments interactive platform tool (NREL)
- Improving large-scale hydrologic and hydrodynamic modeling (PNNL)
- Large ensemble of long-term hydrologic projections (ORNL/PNNL)
- Water risk analysis of grid assets and operations (NREL)

MYPP Goals FY21-FY25

- Climate Change and Hydrologic Science
  - Determine needs for additional modeling assessments: Assess the need to conduct additional modeling assessments or develop models with new capabilities.
  - Provide relevant data and tools for the entire hydropower fleet: Utilize modeling capabilities to clarify potential risks and uncertainties to better understand climate change and hydrologic variations.
  - Develop numeric models, computing, and artificial intelligence capabilities: Identify and apply advanced methods to increase understanding of basic hydrologic systems science and potential applications.
  - Quantify risks at plant and basin-scales: Develop tools for different user groups to investigate risks of climate change and evolving hydrology at different spatial scales.
Hydrologic Systems Science Accomplishments – Reservoir Emissions

Methane Emissions (ORNL)

- Synthesize the state of the science of GHG emissions from reservoirs
  - Data collection and analysis in coordination with EPA
- Evaluate and improve International Hydropower Association’s G-res Tool
- Improve spatial and temporal understanding of emissions from reservoirs

MYPP Goals FY21-FY25

- Methane Emissions from Reservoirs
  - Develop capabilities to understand methane emissions from reservoirs: Characterize the state of the science on methane emissions from reservoirs and other water bodies.
  - Address core scientific questions about methane emissions from reservoirs: Conduct foundational science on carbon transport and methane formation.
  - Develop remote sensing capabilities to measure methane emissions from reservoirs: Advance current and novel technologies to test and validate methane measurement capabilities for different types of reservoirs and water bodies.
  - Classify reservoirs and quantify measurements: Develop and utilize a reservoir classification scheme to assess risk and uncertainties of methane emissions.
Future Work

Outreach and Engagement:
• FY23 Environmental R&D Summit
• Federal Inland Hydropower Working Group

Reports/Publications:

New Projects/Initiatives:
• Fish Passage Lab Call for proposals under review
• Methodology from 9505 Climate Risks to Hydropower being applied and extended to an assessment to the non-federal fleet
• Basin scale monitoring and modeling for climate resilience Seedling Request for Innovation proposals under review
<table>
<thead>
<tr>
<th>Time</th>
<th>Event Details</th>
<th>Organization</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 AM</td>
<td>Environmental and Hydrologic Systems Science Activity Area Overview</td>
<td>WPTO</td>
<td>Dana McCoskey</td>
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<tr>
<td>10:30 AM</td>
<td>A Real-time and Autonomous Water Quality Monitoring System</td>
<td>PNNL</td>
<td>Daniel Deng</td>
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<tr>
<td>10:55 AM</td>
<td>Shad Tag Development</td>
<td>PNNL</td>
<td>Daniel Deng</td>
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<td>11:20 AM</td>
<td><strong>BREAK</strong></td>
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<tr>
<td>11:30 AM</td>
<td>Fish Protection Prize</td>
<td>NREL, WPTO</td>
<td>Tessa Greco, Dana McCoskey</td>
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<tr>
<td>12:00 PM</td>
<td><strong>Reviewer Debrief</strong></td>
<td>Reviewers</td>
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## Agenda Overview

### Day 3 - Wednesday, July 27, 2022

<table>
<thead>
<tr>
<th>Start (ET)</th>
<th>End (ET)</th>
<th>Presentation Topic</th>
<th>Organization</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>10:00 AM</td>
<td>10:25 AM</td>
<td>Demonstrating Value of River Data Aggregation and Visualization Capabilities</td>
<td>PNNL</td>
<td>Kyle Larson</td>
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<tr>
<td>10:25 AM</td>
<td>10:50 AM</td>
<td>GMLC Water Risk for the Bulk Power System: Asset to Grid Impacts</td>
<td>NREL, ORNL</td>
<td>Ariel Miara</td>
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<tr>
<td>10:50 AM</td>
<td>11:15 AM</td>
<td>Methane Emissions</td>
<td>ORNL</td>
<td>Natalie Griffiths</td>
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<tr>
<td>11:15 AM</td>
<td>11:25 AM</td>
<td><strong>BREAK</strong></td>
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<tr>
<td>11:25 AM</td>
<td>11:50 AM</td>
<td>FERC eLibrary</td>
<td>PNNL</td>
<td>James Bradford, Bo Saulsbury</td>
</tr>
<tr>
<td>11:50 AM</td>
<td>12:15 PM</td>
<td>Hydro Fleet Database Development and Analyses (HydroSource)</td>
<td>ORNL</td>
<td>Debjani Singh</td>
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<tr>
<td>12:15 PM</td>
<td>12:35 PM</td>
<td><strong>Reviewer Debrief</strong></td>
<td>Reviewers</td>
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Environmental and Hydrologic Systems Science
Reviewer Introductions

Shannon Ames, 
Program Chair and Panel Lead
Executive Director, Low Impact Hydropower Institute

Cheryl Laatsch
Natural Resources Program Coordinator, Wisconsin Department of Natural Resources

Twyla Cheatwood
Fish Biologist, Southeast Region Hydro Coordinator, NOAA

Wendy Bley
Senior Regulatory Advisor, Kleinschmidt Associates