# Environmental R&D and Hydrologic Systems Science Activities

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# 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

# Environmental and Hydrologic Systems Science Overview

## 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.

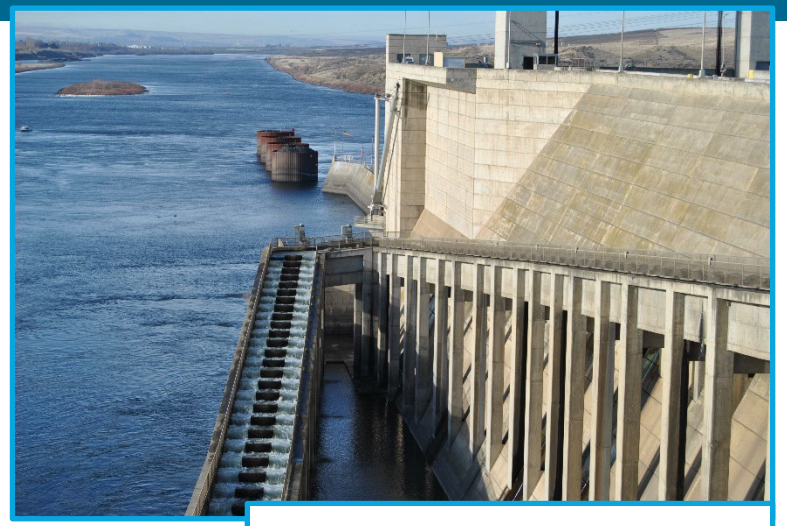

# How Stakeholder Engagement Informed the Strategy

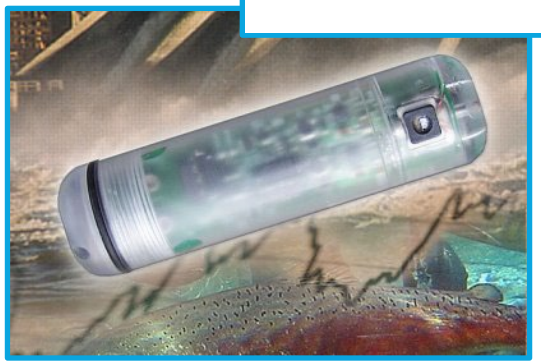
- **2016 Hydropower Vision Report & Roadmap**, over 200 authors from all sectors of the community
- **Industry Summit** (FY17), 30+ industry executives and owner/operators, and national laboratories
- **Environmental Summits** (FY18 and FY19); 40+ agency, NGO; with industry representatives in FY19
- **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

## Key Results and Performance Goals (2021–2025)

- ✓ 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.
- ✓ Demonstrate innovative tools and technologies that are benchmarked for cost and performance, including innovative fish passage technologies and sensor systems.
- ✓ 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.
- ✓ 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.
- ✓ Validate new technologies to more accurately characterize and model methane emissions from reservoirs and other water bodies.



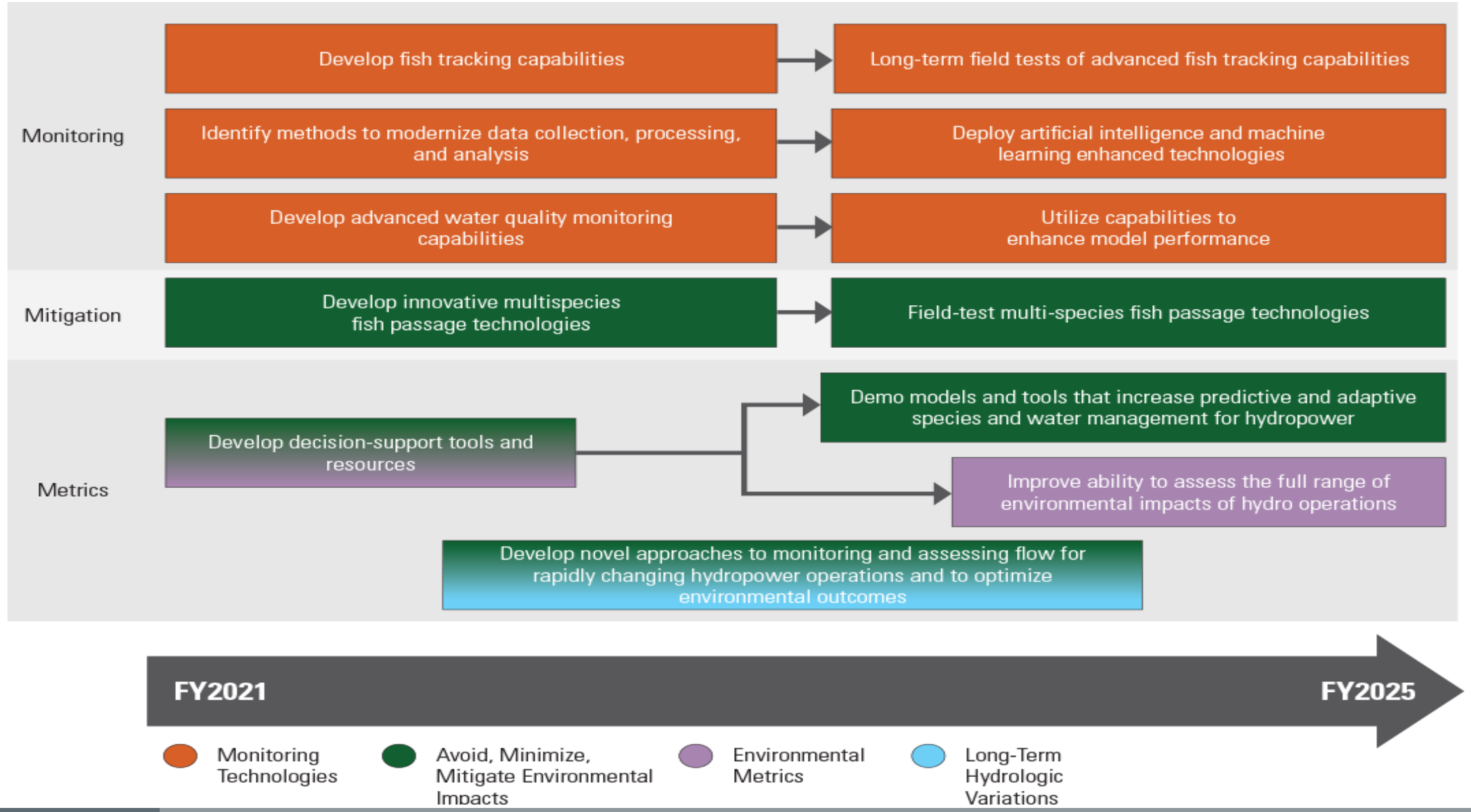


# Environmental and Hydrologic Systems Science Objectives

## 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



# Environmental R&D Accomplishments – Monitoring

## 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)

MYPP Goals FY21-FY25

- **Monitoring**
  - **Develop fish tracking capabilities**: Provide more accurate and greater data for sensitive species over greater spatial and temporal scales.
  - **Long-term field tests of advanced fish tracking capabilities**: Conduct field tests to demonstrate advances in fish tracking capabilities.
  - **Identify methods to modernize data collection, processing, and analysis**: Identify and develop tools for data automation and investigate methods to apply artificial intelligence and machine learning for processing and analysis for rapid and real-time environmental assessments.
  - **Deploy artificial intelligence and machine learning enhanced technologies**: Demonstrate tools that utilize artificial intelligence and machine learning for environmental monitoring and quantify improvements in the data pipeline and cost reductions.
  - **Develop advanced water quality monitoring capabilities**: Research and prototype tools and technologies for more accurate and representative water quality measurements.
  - **Utilize capabilities to enhance model performance**: Develop more robust models and methods to inform real-time operations for improved water quality.

# 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

**Mitigation**

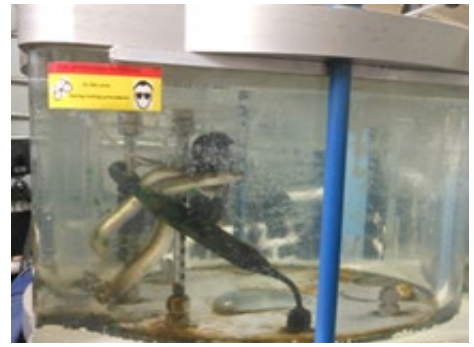
MYPP Goals FY21-FY25

- **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)

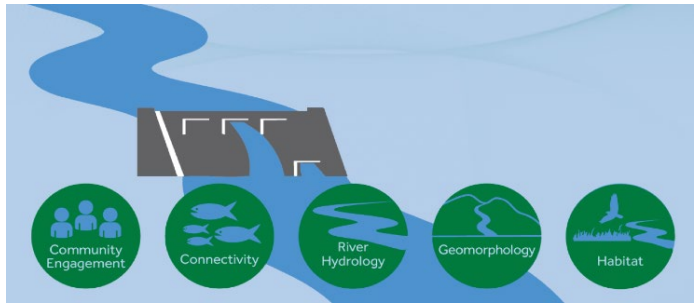
- Natel Energy - **Restoration Hydro Turbine**
- Percheron Power – **Two-way fish migration technology** adapted from Archimedes Screw Turbine
- Littoral Power Systems – Prefabricated **Zero Ascend Omnispecies (ZAO) Modular Fish Passage** Modules Using Advanced Manufacturing Techniques



# 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




- **Metrics**

MYPP Goals FY21-FY25

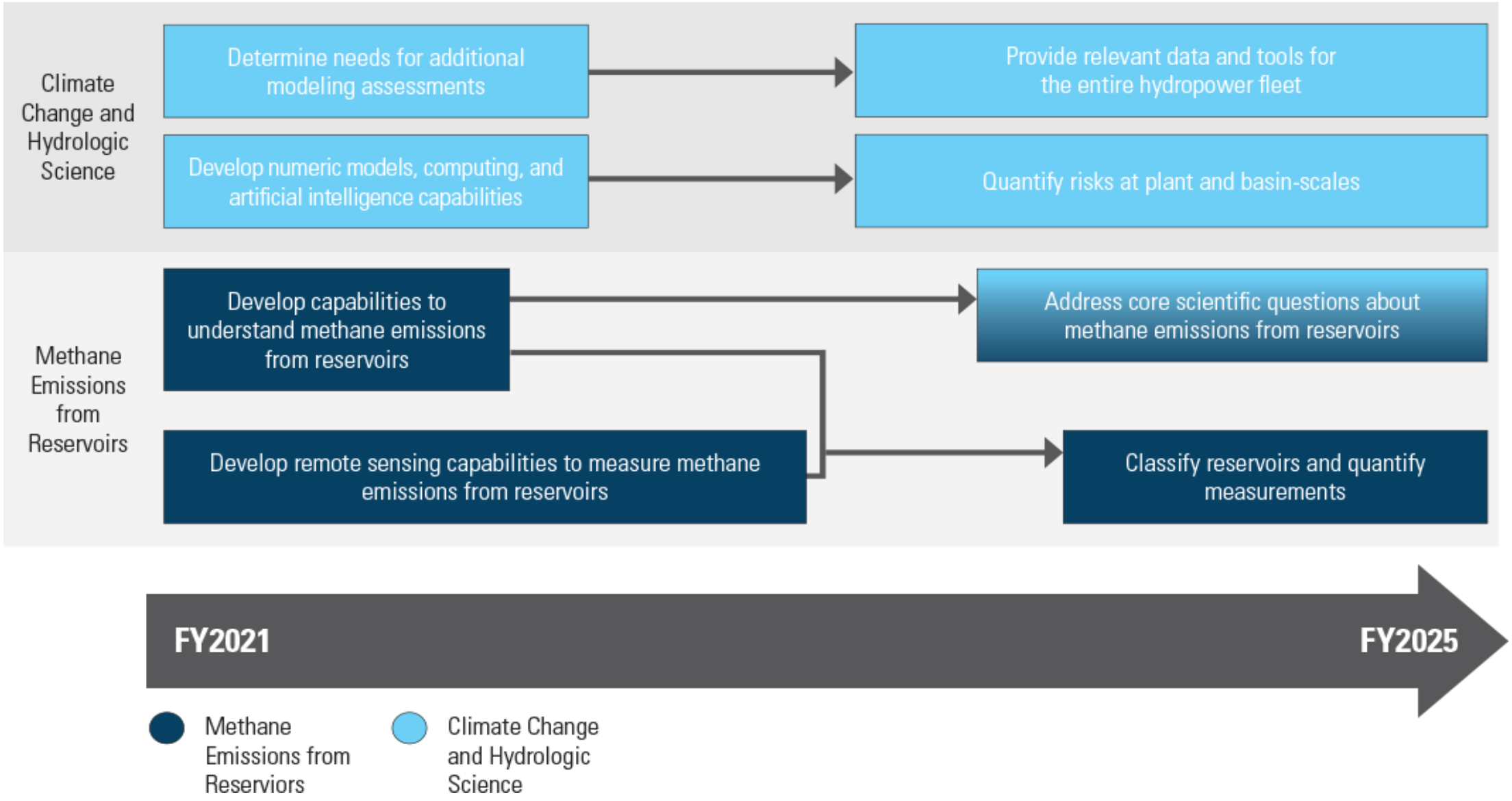
- **Develop decision support tools and resources**: Provide information and science-based tools that utilize established environmental metrics and indicators.
- **Access utility of tools in hydropower environmental assessments**: Demonstrate toolkits with hydropower stakeholders and assess capabilities to identify key environmental impacts and relevant mitigation methods.

HydroWIRES: *Cross-cutting Hydropower R&D*

**Instream Flows and Hydropeaking**

- Topic A: Power System and Environmental Flow Win-Wins

# Hydrologic Systems Science Research Priorities



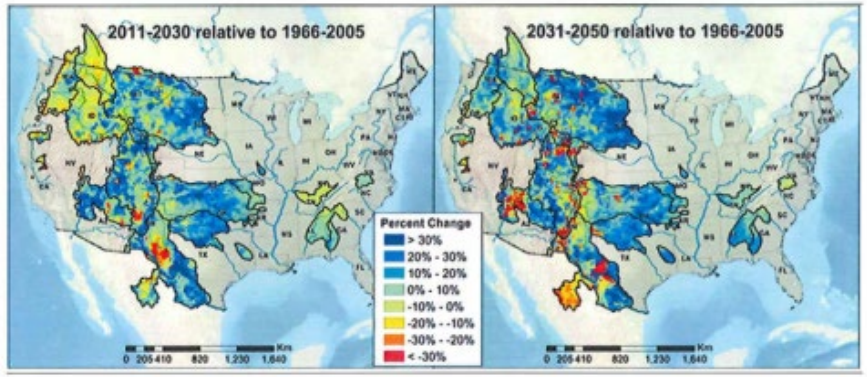
# Hydrologic Systems Science Accomplishments – Climate Change

**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

- **Methane Emissions from Reservoirs**

MYPP Goals FY21-FY25

- **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:

- International Energy Agency's Annex/Task XIII Hydropower & Fish Roadmap Report – catalogue of impacts and known solutions in preparation

## 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

# Agenda Overview

| DAY 2 – TUESDAY, JULY 26, 2022 | | | | |
|---|---|---|---|---|
| **Start (ET)** | **End (ET)** | **Presentation Topic** | **Organization** | **Speaker** |
| 10:00 AM | 10:30 AM | Environmental and Hydrologic Systems Science Activity Area Overview | WPTO | Dana McCoskey |
| 10:30 AM | 10:55 AM | A Real-time and Autonomous Water Quality Monitoring System | PNNL | Daniel Deng |
| 10:55 AM | 11:20 AM | Shad Tag Development | PNNL | Daniel Deng |
| 11:20 AM | 11:30 AM | **BREAK** | | |
| 11:30 AM | 12:00 PM | Fish Protection Prize | NREL, WPTO | Tessa Greco, Dana McCoskey |
| 12:00 PM | 12:25 PM | **Reviewer Debrief** | **Reviewers** | |

# Agenda Overview

| DAY 3 – WEDNESDAY, JULY 27, 2022 | | | | |
|---|---|---|---|---|
| **Start (ET)** | **End (ET)** | **Presentation Topic** | **Organization** | **Speaker** |
| 10:00 AM | 10:25 AM | Demonstrating Value of River Data Aggregation and Visualization Capabilities | PNNL | Kyle Larson |
| 10:25 AM | 10:50 AM | GMLC Water Risk for the Bulk Power System: Asset to Grid Impacts | NREL, ORNL | Ariel Miara |
| 10:50 AM | 11:15 AM | Methane Emissions | ORNL | Natalie Griffiths |
| 11:15 AM | 11:25 AM | **BREAK** | | |
| 11:25 AM | 11:50 AM | FERC eLibrary | PNNL | James Bradford, Bo Saulsbury |
| 11:50 AM | 12:15 PM | Hydro Fleet Database Development and Analyses (HydroSource) | ORNL | Debjani Singh |
| 12:15 PM | 12:35 PM | **Reviewer Debrief** | **Reviewers** | |

# 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

# Q&A