Off the Chart! Measuring Hydro's Value…

Session Moderator

Patrick March

Principal Consultant, Hydro Performance Processes Inc.

Panelists

John Pizzimenti, PhD

Vice President, GEI Consultants, Inc.

Jeff Opperman, PhD

Senior Advisor for Sustainable Hydropower, The Nature Conservancy

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Program Manager, Wind and Water Power Programs, Oak Ridge National Laboratory

National Hydropower Association Annual Meeting

Session 5B

Tuesday, April 27, 2010 - 3:45 PM – 5:00 PM

Complexities, Constraints, and Challenges

Market

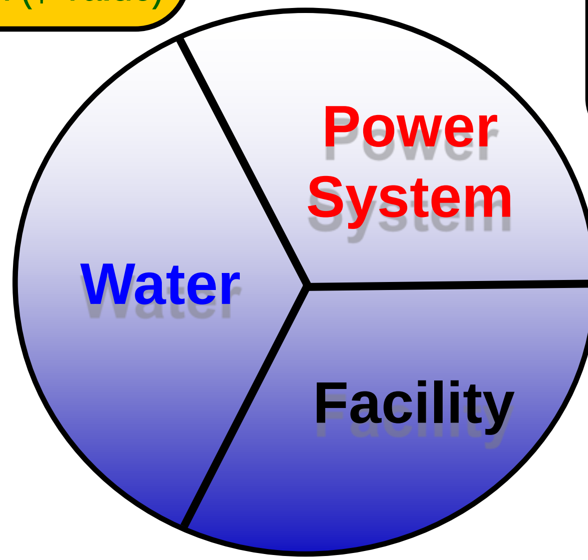
Supply/Demand
Multiple Markets
(Energy, A/S,
Reserves, etc.)
Monetization ($ Value)

Electrical

Transmission restrictions
Nearby load levels
Over-voltage and Under-voltage
System frequency

Environmental

Weather
Fish & Wildlife
Flood Control
Water Temperature
Water Quality
Water Supply
Quality of Shore



Equipment

Min/Max Generation
Generator ramp rates
Turbine Shaft Torque
Turbine Speed
Reactive Load

Regulatory

Hydraulic Coupling
Navigation
Recreation
Land Rights
Federal, State, Local
Policies

O & M

Mechanical Vibrations
Efficiency Criteria
Avoidance Zones
Env. Restrictions

John J. Pizzimenti, Ph.D.
Darryll Olsen, Ph.D.
Rick K. Suttle, M.L.A

April 27, 2010

Quantifying the Non-Energy Benefits of Hydro Power

Prepared for:
CEATI International Inc.
Montreal Canada

REVIEW OF HPLIG GOALS I

Assess Methods to Value :

Ancillary Benefits of Hydropower

- ✓ Energy-Capacity
- ✓ Load Following
- ✓ Load and Voltage Regulation
- ✓Reserve Capacity

REVIEW OF HPLIG GOALS II

Assess Methods to Value :

Non-Energy Economic Benefits

- ✓Irrigation-Water Supply
- ✓Recreation
- ✓Flood Control
- ✓Environmental
- ✓Navigation

METHODS AND DATA

- Market and Non-Market Values
- Consistent Hydro Economic Values
- National-Regional Literature/Analyses
- IMPLAN (Economic Impact Multipliers)
- Regional Power Markets
- Marginal Supply Costs
- Market Exchange Value Estimates

RESULTS

Summary of National Values:

Data include four regions: NW; NE; Mid Atlantic; and SE

✓Energy Benefits
✓Ancillary Benefits
✓Non-Energy Benefits

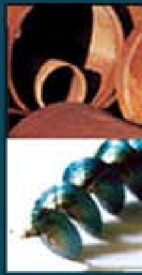
The Economic Benefits of Hydro Projects (Example)

"Econ-Green No.1" Hydro Project

FERC Annual Costs, Power Benefits and Net Benefits – Priest Rapids

ANNUAL VALUES	NO ACTION	APPLICANT PROPOSAL	FERC LICENSE CONDITION
PROJECT CAPACITY MW	1,893	1,994	1,994
GENERATION MWh	9.4	9.8	9.8
POWER VALUE (millions)	$329	$377	$377
$ / MEGAWATT-HOUR	38.28	38.69	38.69
COST (millions)	$69	$146	$146
$ / MEGAWATT-HOUR	8.06	15.04	14.93
NET BENEFIT (millions)	$260	$231	$232
$ / MEGAWATT-HOUR	30.22	23.64	23.75

CONCLUSIONS



All Benefits of Hydro:

- ✓Are valuable but not equal
- ✓Benefits can be monetized $
- ✓Are being traded without accounting for “net” societal benefits
- ✓Net benefits appear to be declining and portend trouble

RECOMMENDATIONS

GEI Consultants

Increased awareness of:

- ✓ Cost: Benefits from Hydropower is different than other sources of energy
- ✓Regulations: now ignore cost : benefits in traditional economic terms
- ✓ Risks: greater potential for major outages and large unrecognized costs

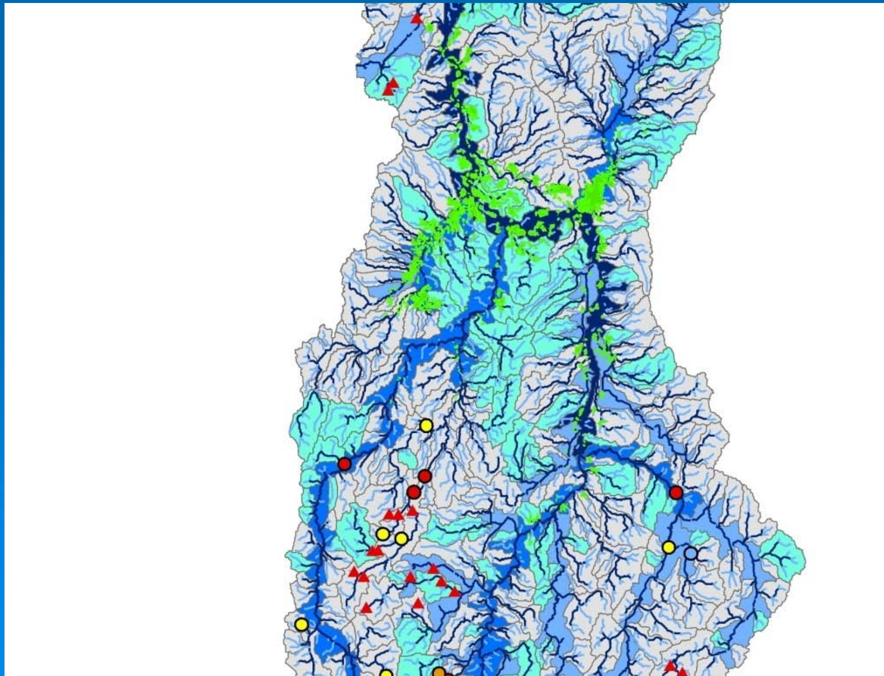
Thank you,

CEATI International Inc.

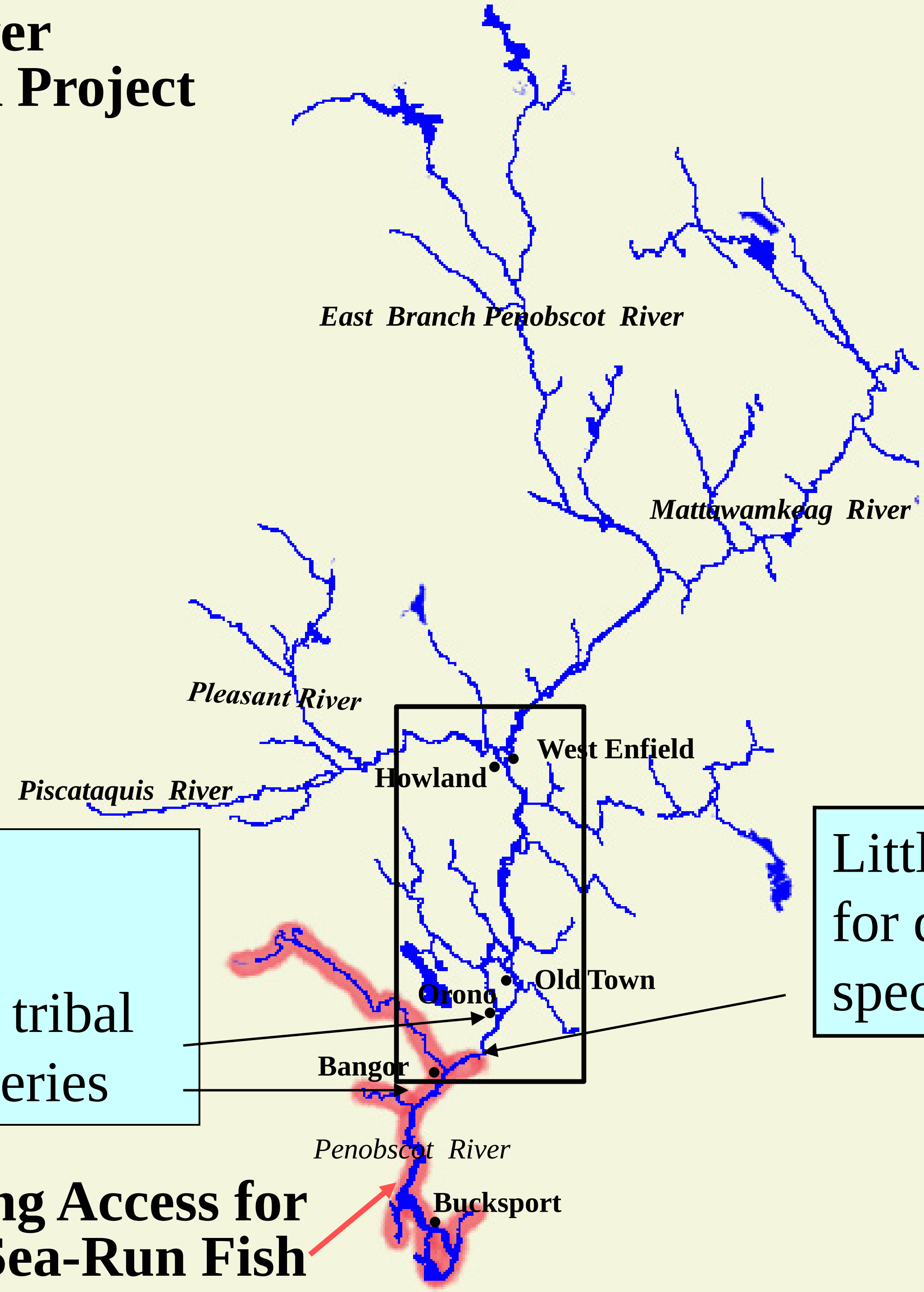
and the entire HPLIG Committee

Maximizing values of river basins: moving from the project to the basin scale

Jeff Opperman
The Nature Conservancy
NHA Conference; April 2010



Penobscot River Restoration Project

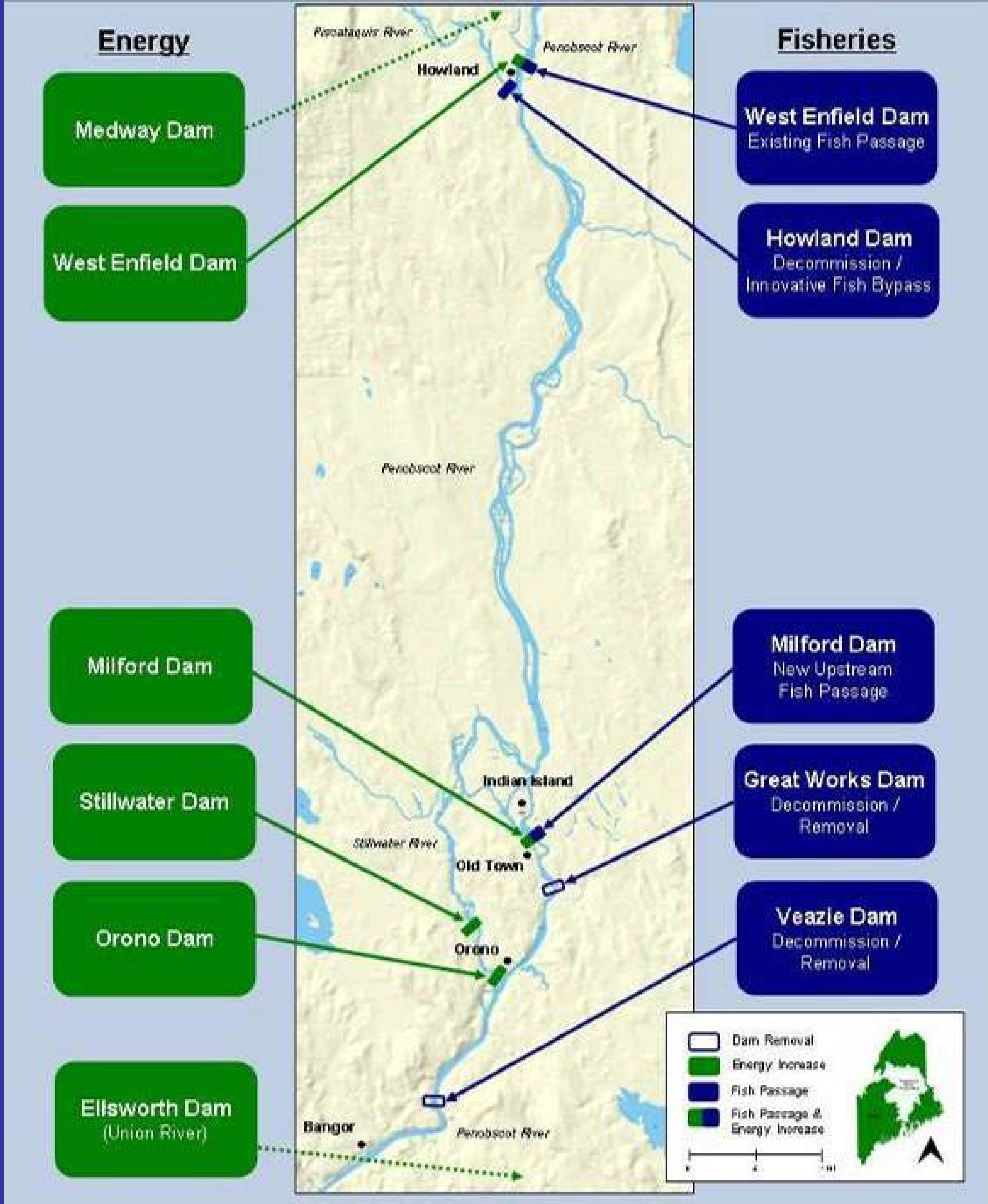


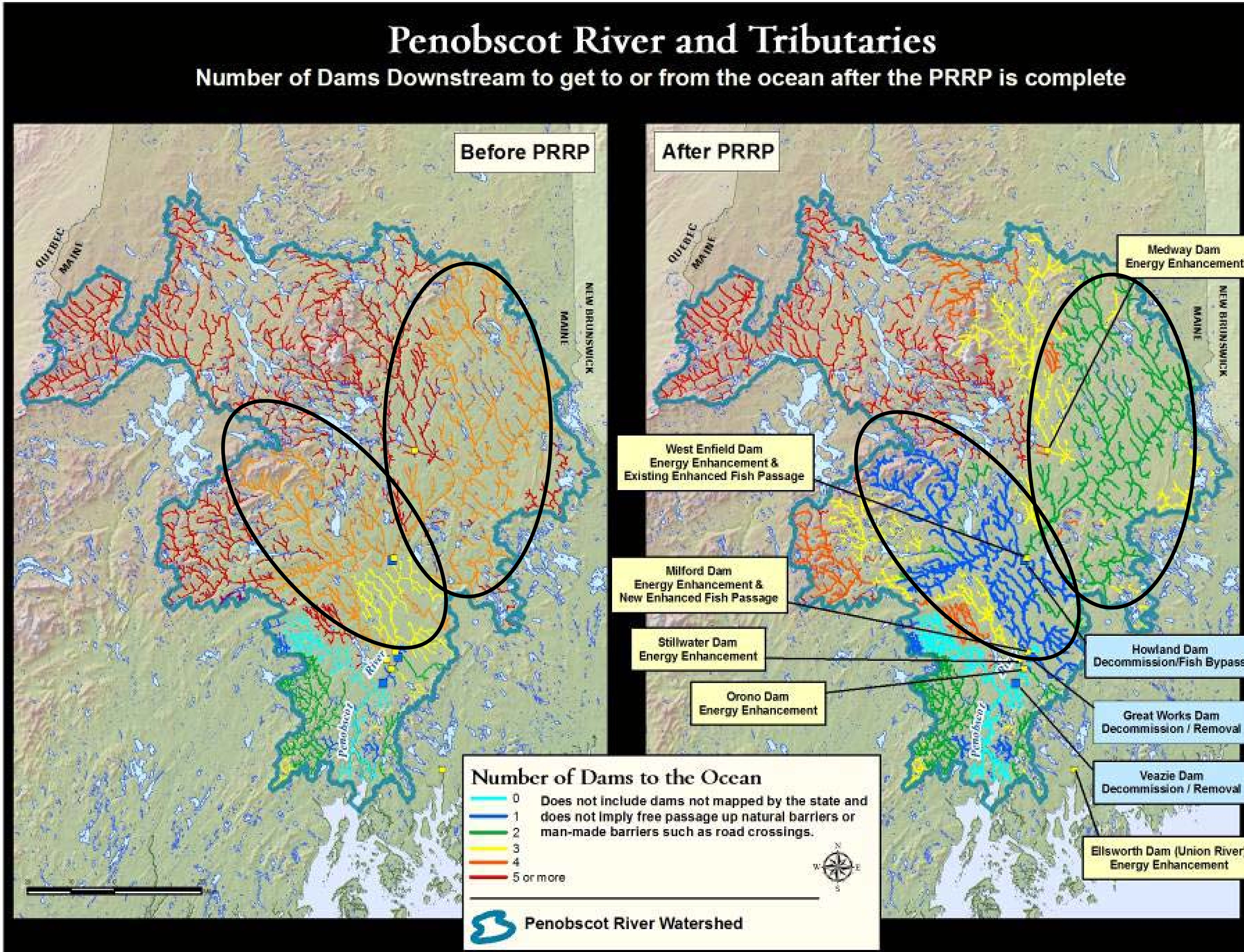
Little or no commercial, recreational, or tribal sustenance fisheries

Little, if any, passage for diadromous fish species

Existing Access for Sea-Run Fish

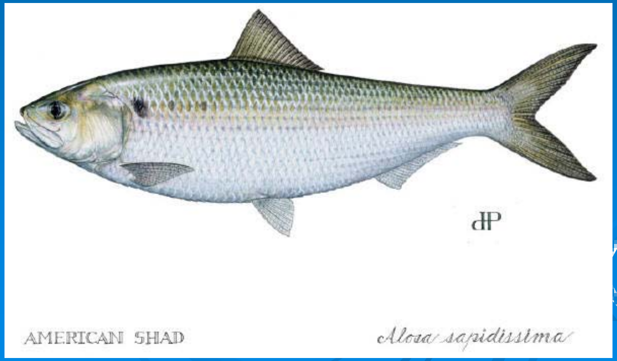
Penobscot River Restoration Project




Penobscot River and Tributaries
Number of Dams Downstream to get to or from the ocean after the PRRP is complete
Before PRRP
After PRRP
QUEBEC
MAINE
NEW BRUNSWICK
MAINE
Penobscot
River
Medway Dam
Energy Enhancement
West Enfield Dam
Energy Enhancement &
Existing Enhanced Fish Passage
Milford Dam
Energy Enhancement &
New Enhanced Fish Passage
Stillwater Dam
Energy Enhancement
Orono Dam
Energy Enhancement
Howland Dam
Decommission/Fish Bypass
Great Works Dam
Decommission / Removal
Veazie Dam
Decommission / Removal
Ellsworth Dam (Union River)
Energy Enhancement
Number of Dams to the Ocean
0
1
2
3
4
5 or more
Does not include dams not mapped by the state and does not imply free passage up natural barriers or man-made barriers such as road crossings.
N
W
E
S
Penobscot River Watershed

Penobscot example: basin-scale approach

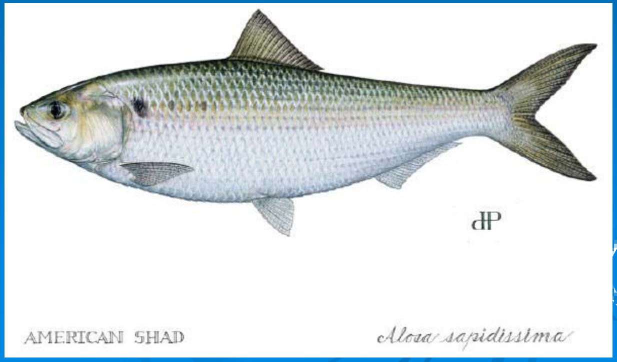
	Scenario A (the past)	Scenario B (the future)
Annual energy generation	~ 300,000 MWh	
Proportion of basin accessible to migratory fish	Minimal	
Annual shad run	Near zero	



The Nature Conservancy
Protecting nature. Preserving life.™

Penobscot example: basin-scale approach

	Scenario A (the past)	Scenario B (the future)
Annual energy generation	~ 300,000 MWh	~ 300,000 MWh
Proportion of basin accessible to migratory fish	Minimal	Majority of basin
Annual shad run	Near zero	1.5 million



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Maximizing total values from river basins

•In addition to quantifying the non-energy benefits of hydro, we can quantify the non-hydro benefits of rivers. Understanding both concepts can contribute to maximizing total values from river systems.

•Penobscot Case study: for a given energy target, future Penobscot comes much closer to maximizing total values of river basin.

•Are there more "Penobscots" out there? What are the necessary ingredients for achieving similar outcomes?

•Large spatial approach essential for maximizing total values from river systems.

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“Holistic Hydropower Optimization”

Brennan T. Smith
Program Manager, Wind & Water Power Technologies
Oak Ridge National Laboratory

NHA Annual Meeting
April 27, 2010
Washington, D.C.

Oak Ridge National Laboratory

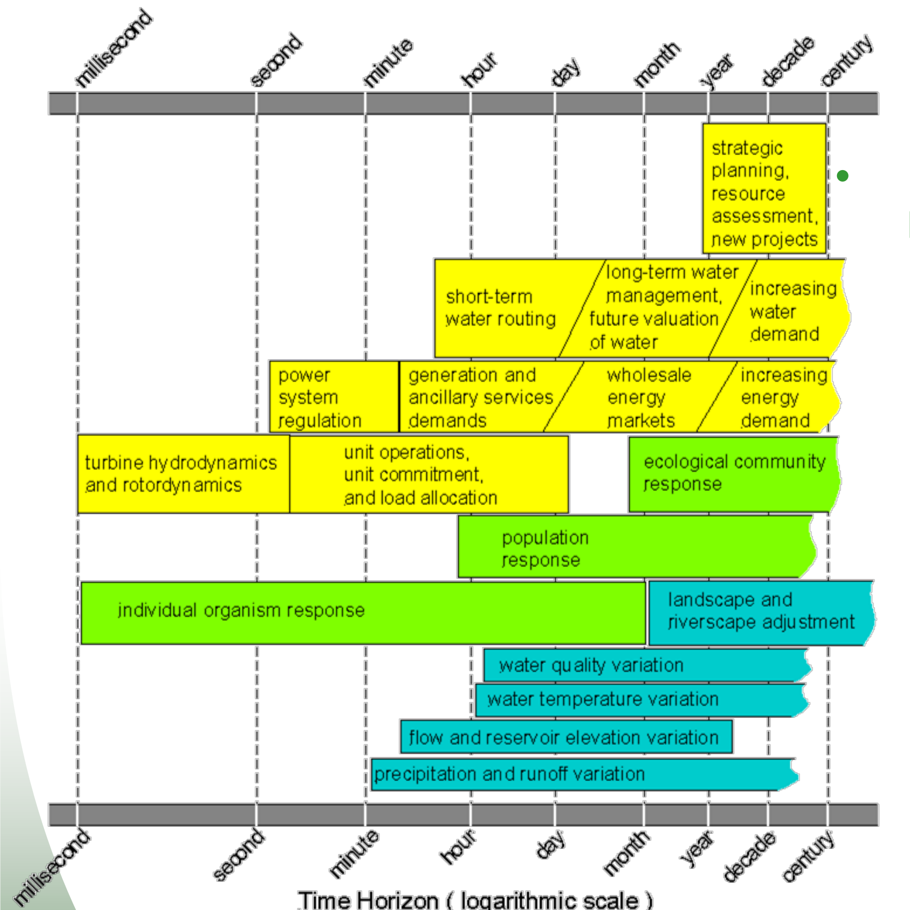
Hydropower Context

- An important component of water resources development and management:
  - Flood damage reduction
  - Municipal, industrial, and agricultural water supply
  - Clean, renewable energy production
  - Energy reliability and security
  - Ecological provision and management
  - Commercial navigation
  - Recreation and aesthetics

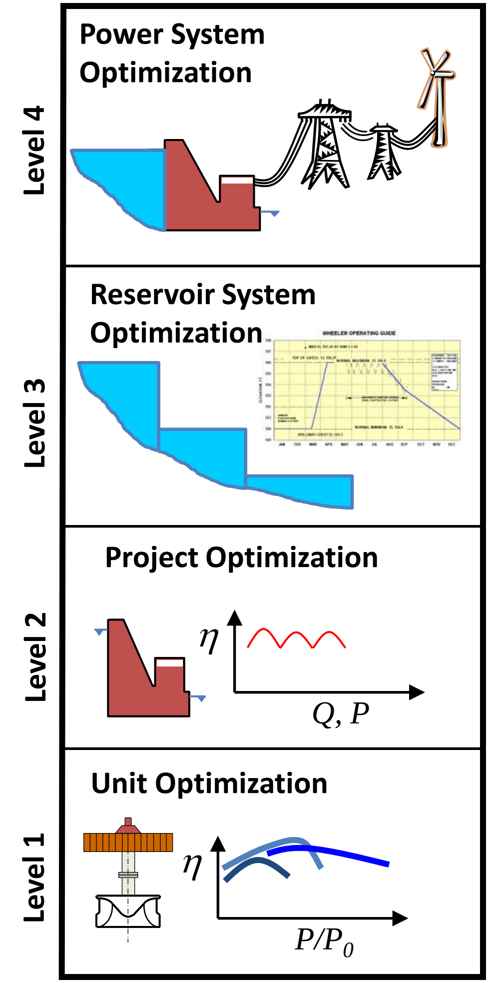
All are under stress and increasing demands!

Oak Ridge National Laboratory

Spatial / Temporal Scale and Horizon



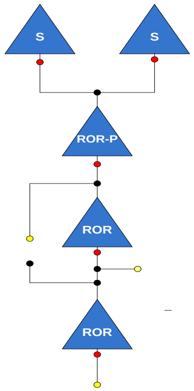
- **Resolving events and processes—examples:**
  - Reproduction, mortality, growth
  - Drought, floods, climate change
  - Reservoir stratification and turnover
  - Peak energy and ancillary services valuation



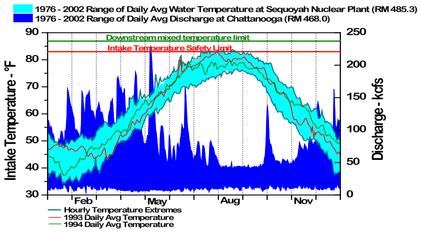
- **Modeling across time scales**
  - **Aligning energy, water, and ecological model timing**
  - **Transferring energy, mass balance, and other constraints between nested models**

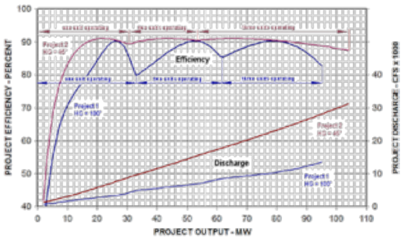
Complex Hydropower Decisions

- Questions
  - Can we value and compare multiple objectives?
  - Can we measure and allocate benefits?
  - Can we influence outcomes amidst uncertainty?
  - Can we improve knowledge and controls?

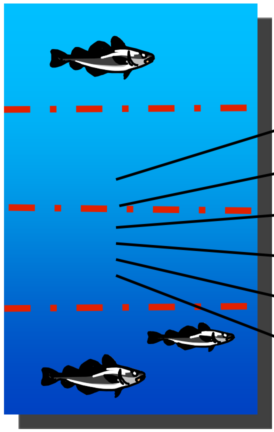


- Dimensions
  - Multiple time-horizons for decisions and outcomes
  - System boundaries and spatial scales for decisions and outcomes

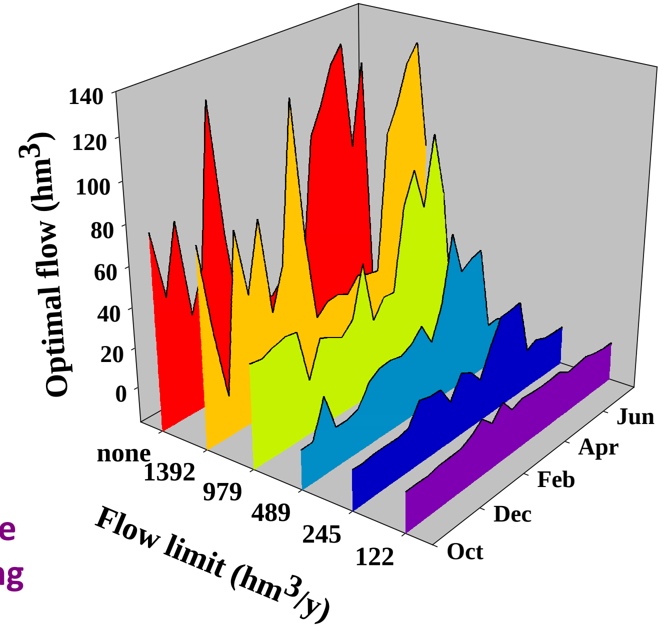


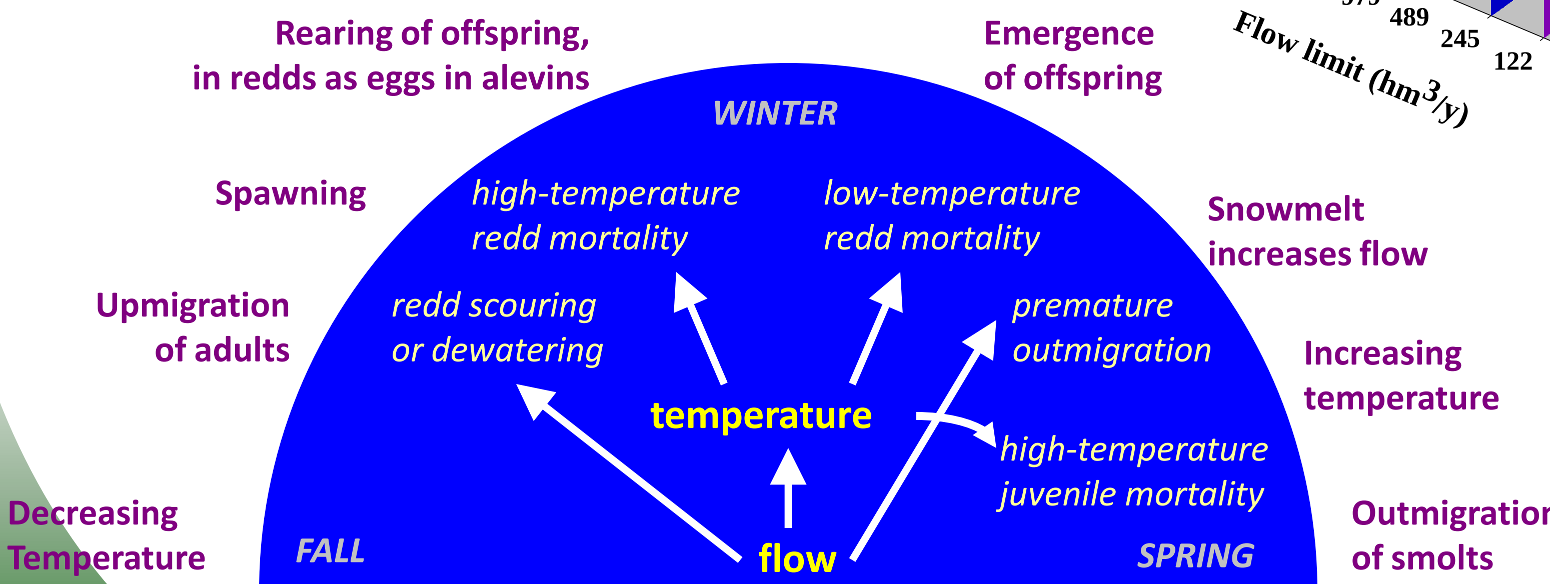


Example: Optimizing Ecological Value with the Oak Ridge Chinook Model



Water volume attributes:
- % pool vs. riffle
- number of predators
- number of overlapping spawners
- number of larger Chinook competitors
- weighted usable area
- temperature and flow





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Towards New Solutions

- **Decision support convergence**
  - Water ops, power sys ops, eco-monitoring from minutes to months – We manage, but are we near-optimal? What about wind/solar?
  - Integrated models for development and environmental assessment – Challenging and expensive for industry alone. Are we missing the sweet spots for ecology and energy?
- **Markets and more markets – ancillary services, RECs, carbon**
  - Can and should we "monetize" ecology?
- **Workforce development**
  - Hydropower professionals must define and address "grand challenges" to engage graduates
  - Scientists, engineers, regulators, economists, attorneys, educators …

DOE and others are working on it. Stay tuned!

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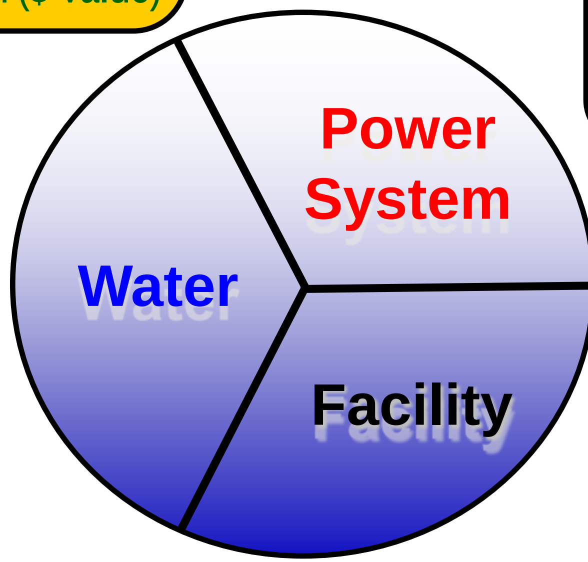

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