Steve Dearden, Vice President, Whooshh Innovations, LLC

Carol Wasserman, Regulatory and Environmental Affairs,
New England Hydropower Company, LLC

Patrick Wendt, Aquatic Specialist
New England Hydropower Company, LLC

Presentation to:

Environmental Business Council of New England: Innovations in Fish Passage: Concepts, Costs & Conflicts

April 19, 2018

Restoring North America's original renewable energy resource ™

Presentation Agenda: Why Are We Talking About Fish Passage Now?

History of Northeast Fish Passage Requirements

What is Fish Passage?

Conventional Fish Passage...But does it work?...What does it Cost?

Nature-Like Fish Passage

Innovations in Fish Passage

Why are We Talking About Fish Passage Now?

Over the next five years, the Federal Energy Regulatory Commission estimates that 183 hydropower licenses will require re-licensing:

2018:	11 Nationally; 5 in New England and NY
2019:	24 Nationally; 14 in New England and NY
2020:	30 Nationally; 17 in New England and NY
2021:	37 Nationally; 27 in New England and NY
2022:	59 Nationally; 25 in New England and NY
2023:	22 Nationally; 8 in New England and NY
Total:	183 Nationally; 96 in New England and NY

Of those, 2/3 will need to construct new upstream/downstream passage or update existing passage to conform to statutory and regulatory changes.

History of U.S. Fish Passage Requirements

Historic Framework for U.S. Fish Passage

August 1735 - LAWS Made and past by the General Assembly of His Majesty's Colony of Rhode Island and Providence Plantations:

> An ACT to prevent the fish from being hindered in their course, going up several fresh rivers within this Colony...
>
> Be it enacted...that no person... within this colony shall
>
> erect, or make any dam or weir, across any fresh river, brook, or course of water where any fish usually pass; nor keep up any dam or weir already made across any such river at any time between the 10th day of April and the 20th day of May, annually, except such person shall leave and keep open during all said time, a good and sufficient way through his dam or weir.

Historic Framework for U.S. Fish Passage

1791 – (Bill of Rights Ratified) Nine states had laws compelling mill owners to modify their dams to allow fish to pass upstream.

1837 – (New York, Virginia, North Carolina, Connecticut) Dam owners to receive just compensation when fish-conservation laws require them to lower their dams so salmon, shad, or other fish could swim upstream to smelt.

1906 – General Dam Act Enacted (dams for water power or other purposes):
Persons owning or operating any... Dam [across navigable waters of the U.S.] shall maintain, at their own expense,... Such fishways as the Secretary of Commerce and Labor shall prescribe.

Historic Framework for U.S. Fish Passage

1920 – Federal Water Power Act Enacted: Section 18 provides, "... The [Federal Power] Commission shall require the construction, maintenance, and operation by a licensee at its own expense... Such fishways as may be prescribed by the Secretary of the Interior..."

1986 – Electric Consumers Protection Act enacted, amending the Federal Power Act: "In deciding whether to issue any license under this Part for any project, the Commission... shall give equal consideration to the purposes of energy conservation, protection, mitigation of damage to, and enhancement of, fish and wildlife (including related spawning grounds and habitat), protection of recreational opportunities, and preservation of other aspects of environmental quality...[T]hat in order to adequately and equitably protect, mitigate damages to, and enhance, fish and wildlife (including related spawning grounds and habitat) affected by the development, operation, and management of the project, each license ... shall include conditions for such protection, mitigation, and enhancement...such conditions shall be based on recommendations received pursuant to the Fish and Wildlife Coordination Act, from the National Marine Fisheries Service, the United States Fish and Wildlife Service, and State fish and wildlife agencies."

1986 – to the Present

2005 – Energy Power Act enacted, amending the FPA to authorize the applicant or any party to the licensing proceeding to propose an alternative to any condition or fishway prescription that the federal resource management agencies have imposed on the license...

The agency that proposed the condition or prescription must accept the alternative if it:

provides for the adequate protection and utilization of the reservation, or

is no less protective than the fishway initially prescribed, and

the alternative will cost significantly less to implement or result in improved operation of the project works for electricity production.

How is Fish Passage Defined?

What Constitutes a Fish Passage

National Energy Policy Act, Section 1701(b) defines a fish passage (fishway) as follows:

> **...items which may constitute a fishway... for the safe and timely upstream and downstream passage of fish shall be limited to physical structures, facilities, or devices necessary to maintain all life stages of such fish, and project operations and measures related to such structures, facilities, or devices which are necessary to ensure the effectiveness of such structures, facilities, or devices for such fish.**

Fish Passage Objectives

The U.S. Fish and Wildlife Service requires fish passage structures to:

(courtesy of Gary Larson, The Far Side)

Enable movement of fish past a stream barrier; and

Provide safe, timely, and effective access to and from habitat for purposes such as spawning, rearing, feeding, growth to maturity, and dispersion.

Fish Passage Designs:

Conventional Fish Passage Structures

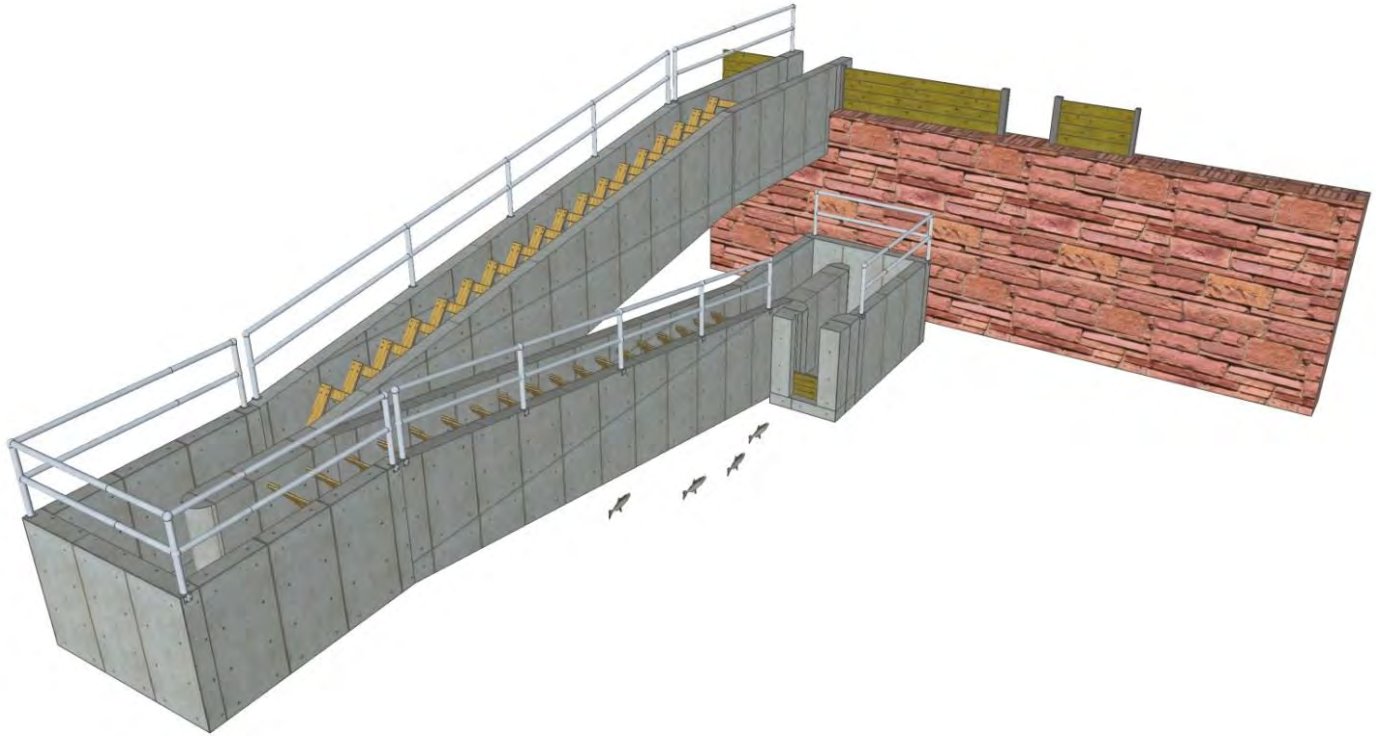
Nature-Like Fish Passage Designs

Innovative Fish Passage

Conventional Fish Passage Structures

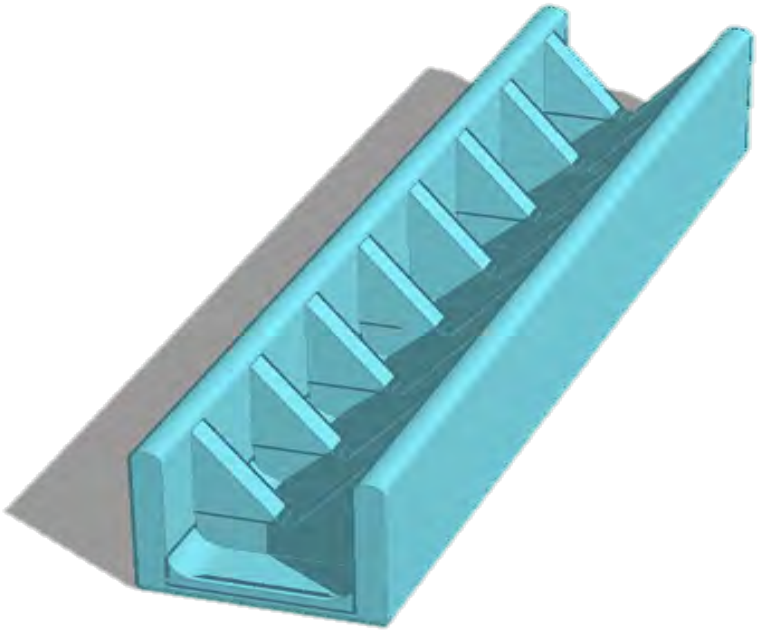
Denil Ladders

Denils are a family of baffled-chute ladders that utilize roughness elements (i.e., baffles) to dissipate the kinetic energy of water to create a low velocity zone of passage. The baffles turn a portion of the flow to oppose the main current, which results in a decrease in velocity but also generates considerable turbulence that can reduce passage efficiency. Denils have demonstrated an efficacy in the passage of salmonids, alosines, and other species at relatively steep slopes



Steeppass

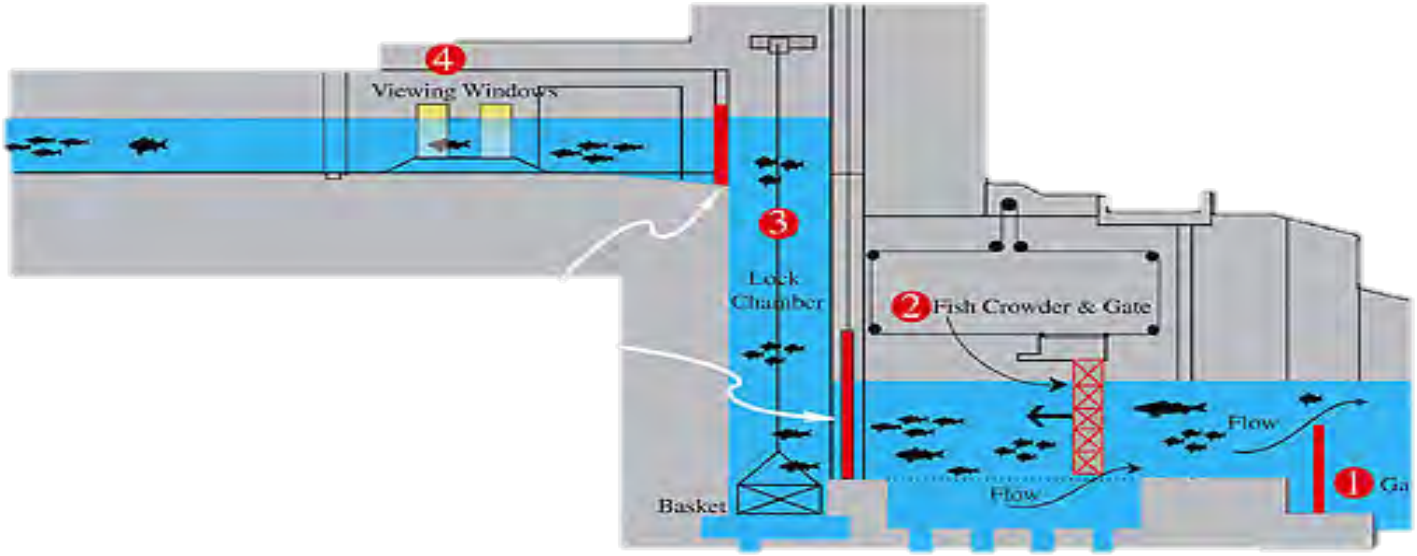
A Denil variant, the steeppass is a baffled-chute type fishway designed to be portable and applicable to low head dams. Typically, this fishway is prefabricated in 10-foot sections made of sheet aluminum or steel and bolted together on site. Compared to a Standard Denil, a steeppass has a lower flow capacity and greater form roughness. It is commonly used on the East Coast for salmonids and river herring.



Fish Lifts (Elevators):non-volitional upstream passage comprised of mechanical, hydraulic, and electrical components

Five-Step Cycle:

1. **Fishing:** Fish attracted to the fishway entrance, enter the entrance structure. Fish swim upstream to holding pool through a retaining V-gate.
2. **Crowding:** Retaining V-gate mechanically crowds the fish above the hopper.
3. **Lifting:** Fish are lifted within the hopper to the exit channel or impoundment.
4. **Releasing**: Fish are released from the hopper to the exit channel.
5. **Returning:** The hopper, empty of fish, is returned to the fishing position



Target Species and Passage Designs (February 2014, Atlantic States Marine Fisheries Commission)

Structure	Species
Denil, Nature-Like (rock ramp)	Atlantic salmon (*Salmo salar*) Alewife (*Alosa pseudoharangus)* American shad (*Alosa sapidissima*)[1] Brown trout (*Salmo trutta*)
Denil Steeppass Nature-Like (rock ramp, Bypass channel)	Atlantic salmon (*Salmo salar*) Brown trout (*Salmo trutta*) Alewife (*Alosa pseudoharangus)*
Fish Lift	American shad (*Alosa sapidissima*) Atlantic sturgeon (*Acipenser oxyrinchus* Shortnose sturgeon (*Acipenser brevirostrum*)

1 Downstream end of Denil submerged to 7.5 ft (0.7 m)

Conventional Fish Passage Structures: Do They Work?

Conventional Fish Passage Expectations – Triumph of Hope Over Experience

Relatively few conventional fish passages structures consistently provide safe, timely and effective passage greater than 3% - 16% when passing the first dam *(Castro-Santos, Fish Manage. Ecol., 2010, 2014)*. **Why ?**

Degraded habitats

- Inaccurate assumptions re: existing populations
- Extirpation of certain target species over the past 200years

Insufficient understanding of fish behavior

- Approach velocities, passage delays, energy dissipation
- Designs are often based on the “Olympians” of commercially important species

Design Issues

- Attraction flows
- Poor physical configuration, poor hydraulics

Externalities; i.e. Climate Change impacts

Conventional Fish Passage Designs: Costs

Disconnect between projects driven by fish passage objectives and projects driven by other factors; power production, location, etc.

Cost of Conventional Fish Passage Designs (2015 NOAA/USACE estimates):

- National Average: $ 50,000/vertical foot
  - 2 - 5 feet: $11,460 median cost/vertical foot
  - 6 – 10 feet: $ 9,120 median cost/vertical foot
  - 11 – 15 feet: $ 10,780 median cost/vertical foot
  - 16 – 25 feet: $ 16,450 median cost/vertical foot
  - 26 + feet: $23,870 median cost/vertical foot

Nature-Like Fish Passage Designs

Nature-Like Fish Passage Designs

Nature-like Fish Passages encompass structural styles constructed of natural materials (i.e. rock). The goal of nature-like fish passage designs is the simulation of natural river channels:

- Fish react to flow and bathymetric cues. Channels similar to natural channels tend to limit migratory disorientation
- Natural channels may simulate spawning, as well as passage habitat
- Use of natural substrates provides roughness and interstitial spaces that allow small fish and benthos to pass and colonize

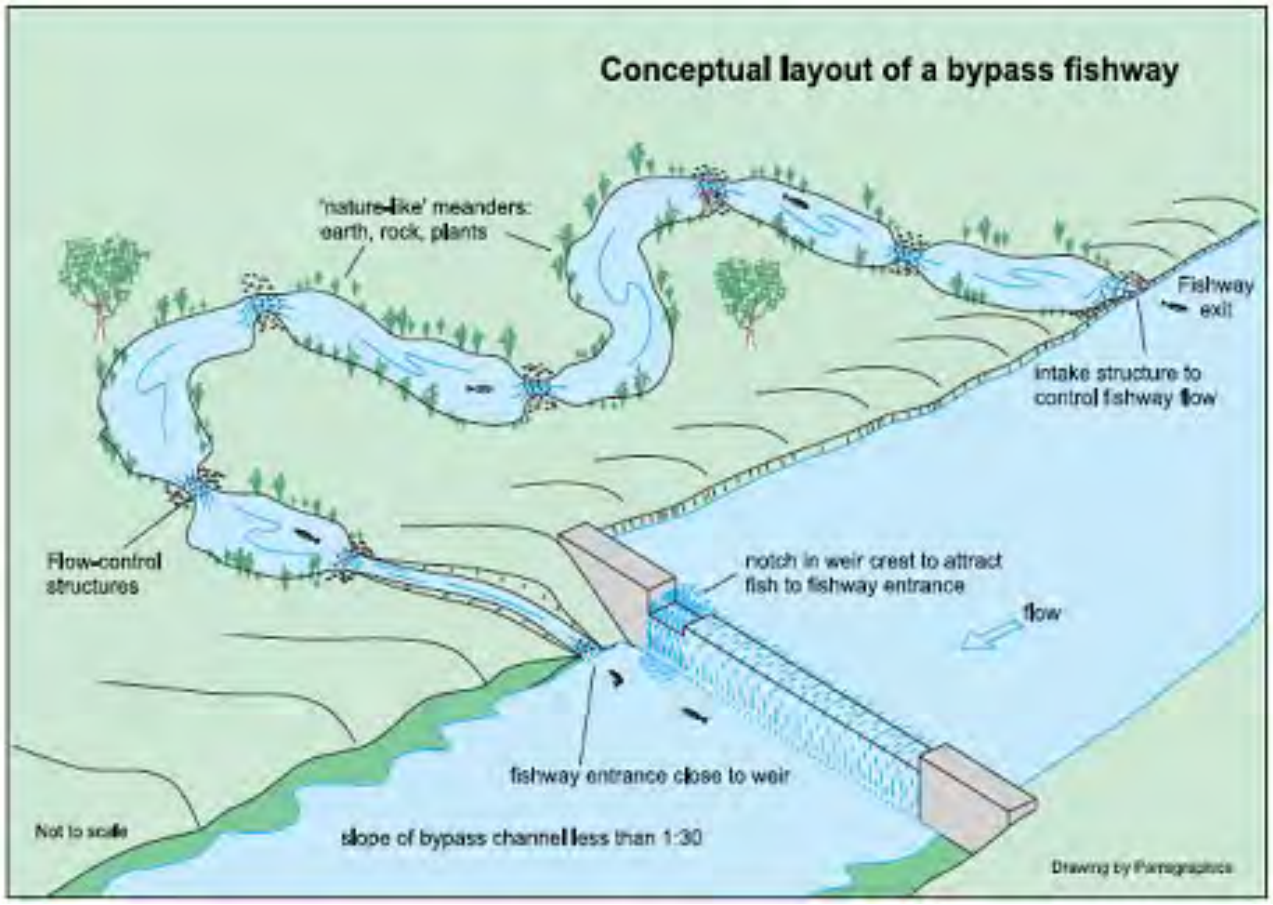
Rock Ramps and Bypass Channels

Simulate conditions of natural rapids. May be designed and constructed to:

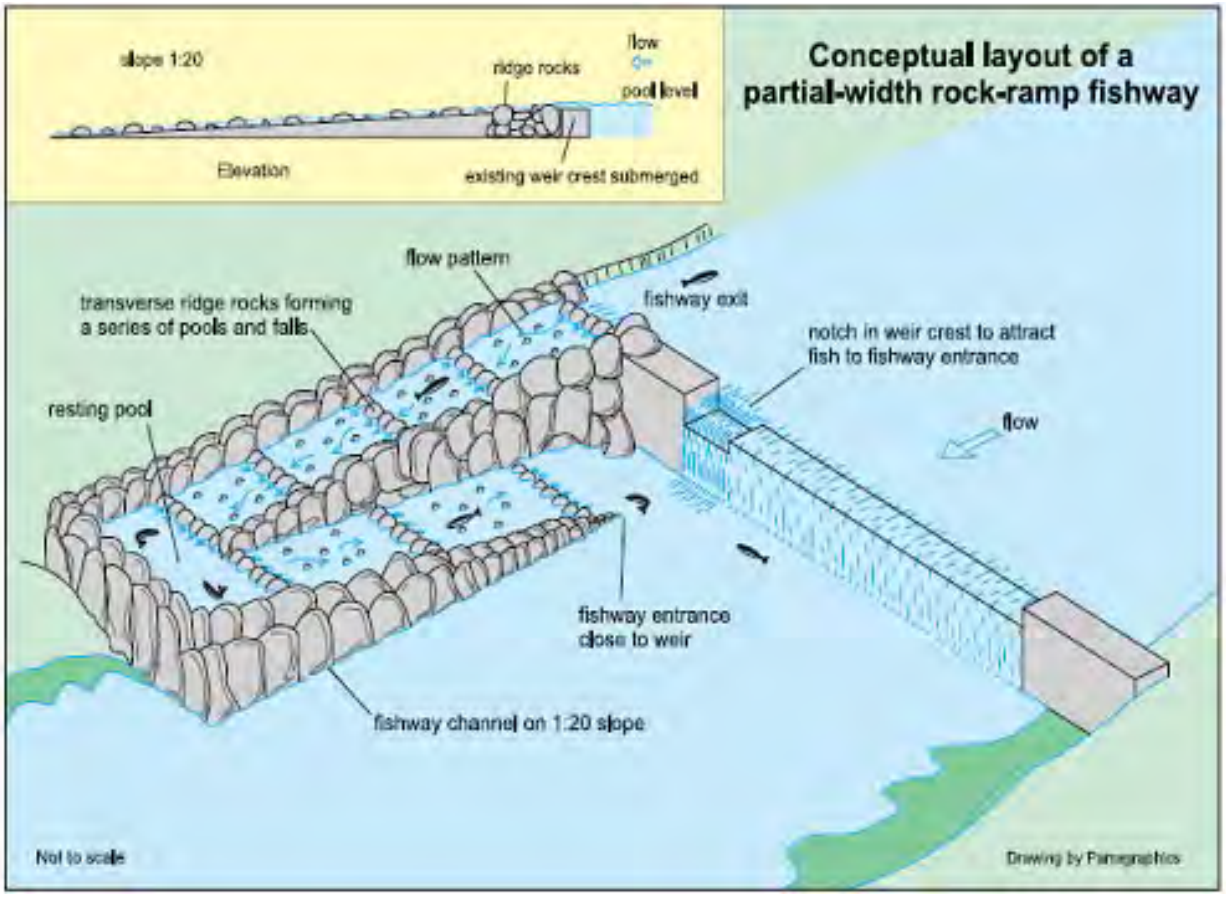
- Create continuous rapids where most of the ramp is turbulent with higher velocities

- Create pool/riffle conditions where head loss occurs at steps with resting pools
- Fish react to flow and bathymetric cues. Channels similar to natural channels tend to limit migratory disorientation
- Natural channels may simulate spawning, as well as passage habitat
- Use of natural substrates provides roughness and interstitial spaces that allow small fish and benthos to pass and colonize the habitat

Rock Ramps and Bypass Channels



Rock Ramps and Bypass Channels



Nature-Like Fish Passage: Costs

Limited regional information; too few projects

National Average Cost/Foot (2017, NOAA/USACE) for rock ramps and bypass channel construction, installation, and operations:

Least Costly = Approximately $ 8,000 – $10,000

Mid-Range = Approximately $ 15,000 – $ 25,000

Most Costly = Approximately $30,000 - $ 60,000

Costs determined as part of total project restoration costs for 9 projects sited in the U.S. and Canada; (Royal River, ME), (Piscataquis River, ME),(Acushnet River, MA), (Town Brook, MA),(Pawcatuck River, RI), (East River, CT),(2 projects on the Naugatuck River, CT), (Churchill River, Winnipeg, Canada),

A Few Thoughts About American Eel (*Anguilla rostrata*)

Upstream Passage (Climbing Ramps)

Adult eels have the ability to surmount some dams by:

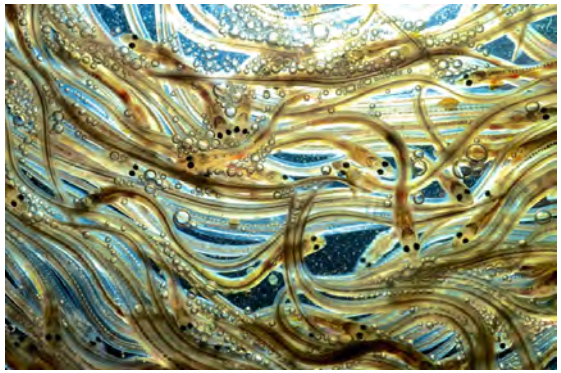
- Leaving the water and moving along adjacent substrate to re-enter the head pond;
- Using some existing passage structures (steeppass, pool and weir, nature-like);
- Using an eel climbing ramp.

Juveniles (Y-O-Y and elvers) will require an eel climbing ramp:

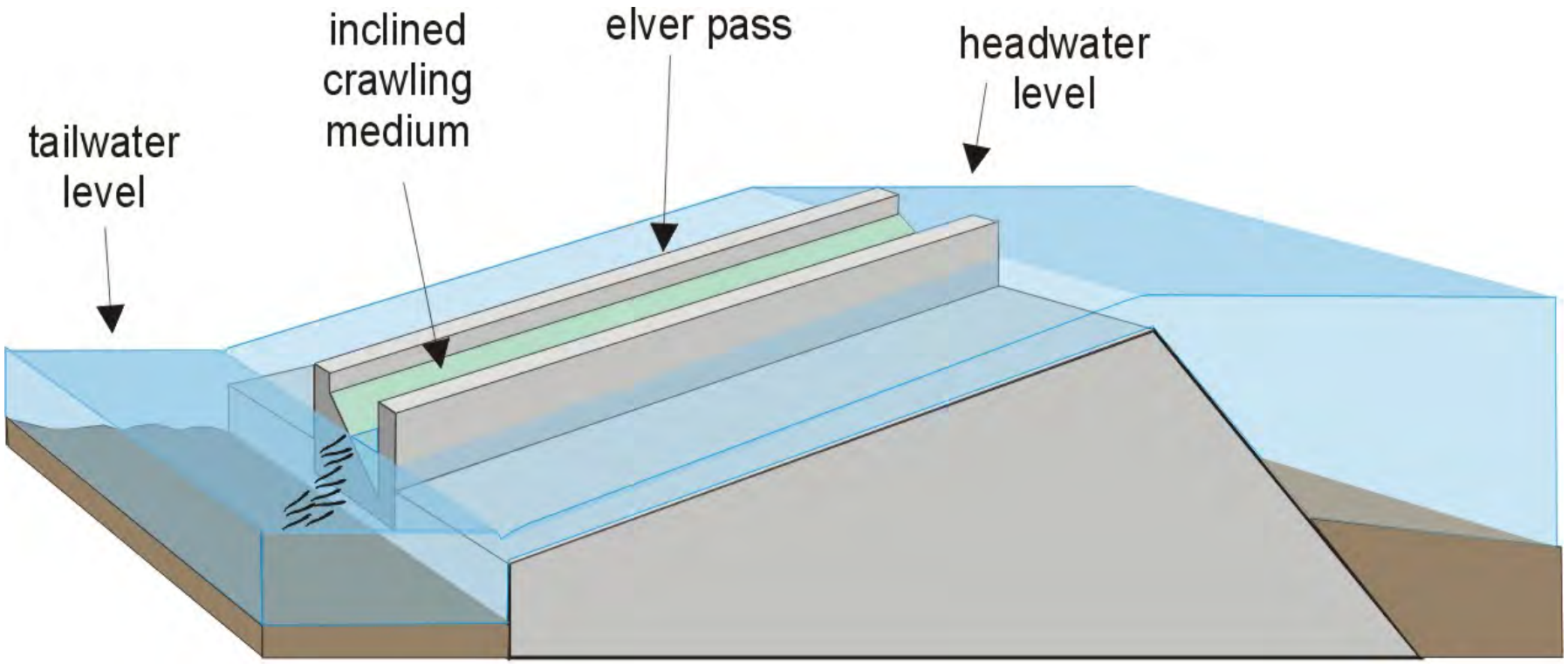
- Eel ramps are generally inexpensive;
- May be deployed seasonally.

A Few More Thoughts About American Eel (*Anguilla rostrata*)

Goal of a substrate-based climbing ramp is to provide a sloping waterway carrying a limited discharge, with the substrate slowing water flow to provide purchase for eels and elvers to use natural crawling and climbing ability.

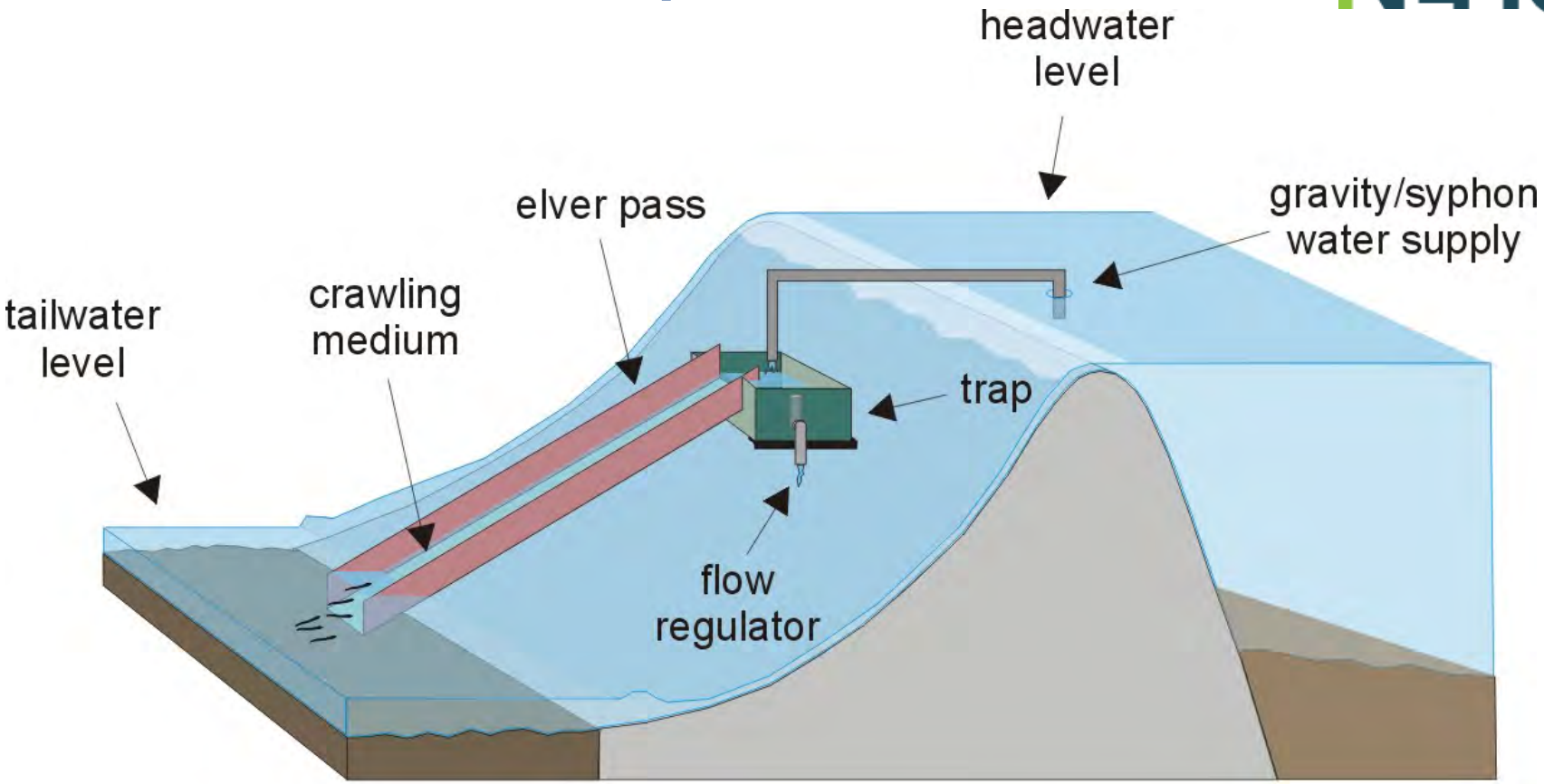


American Eels – Standard Pass



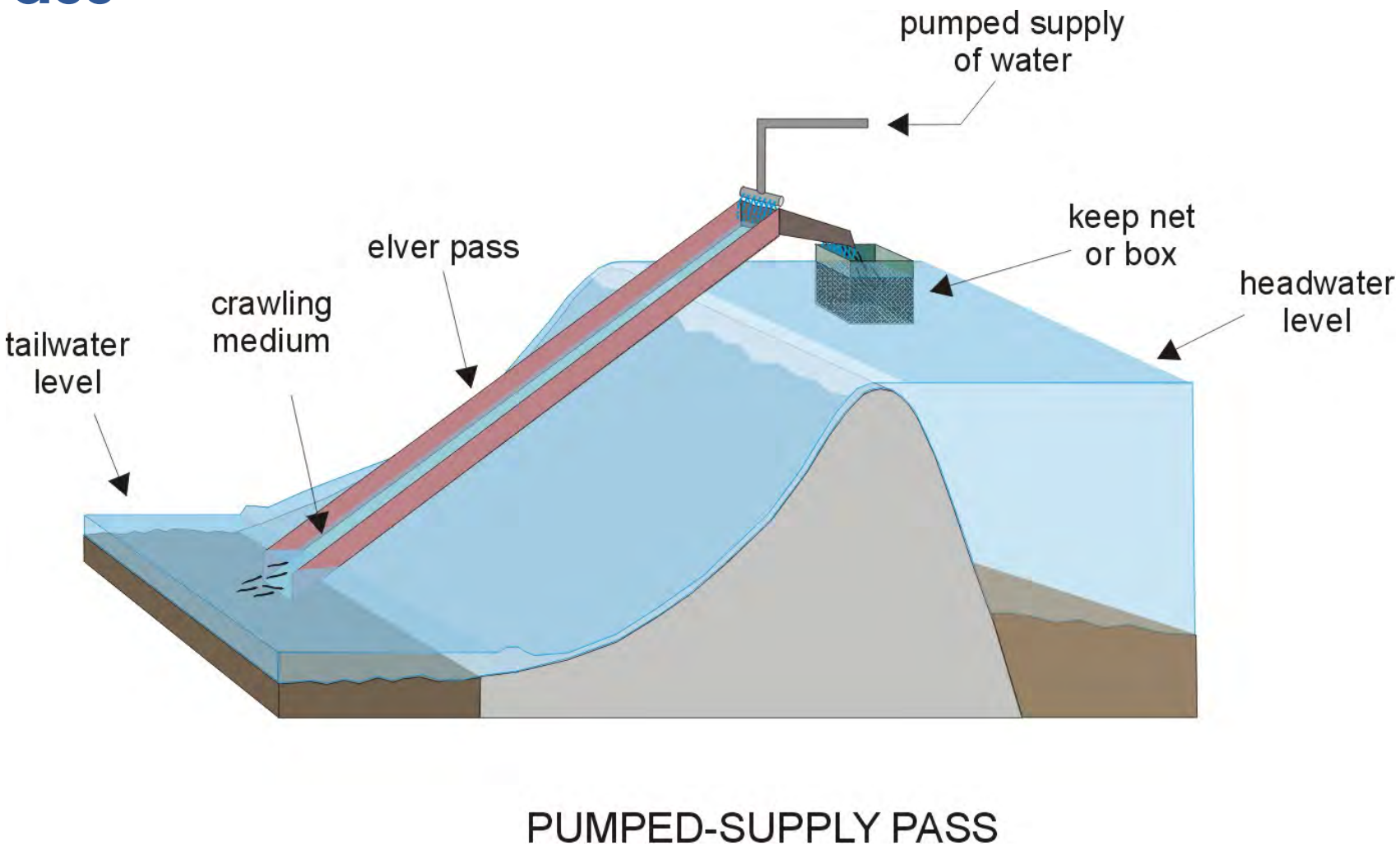
STANDARD PASS

American Eels – Trap Pass



TRAP PASS

American Eels – Pumped-Supply Pass

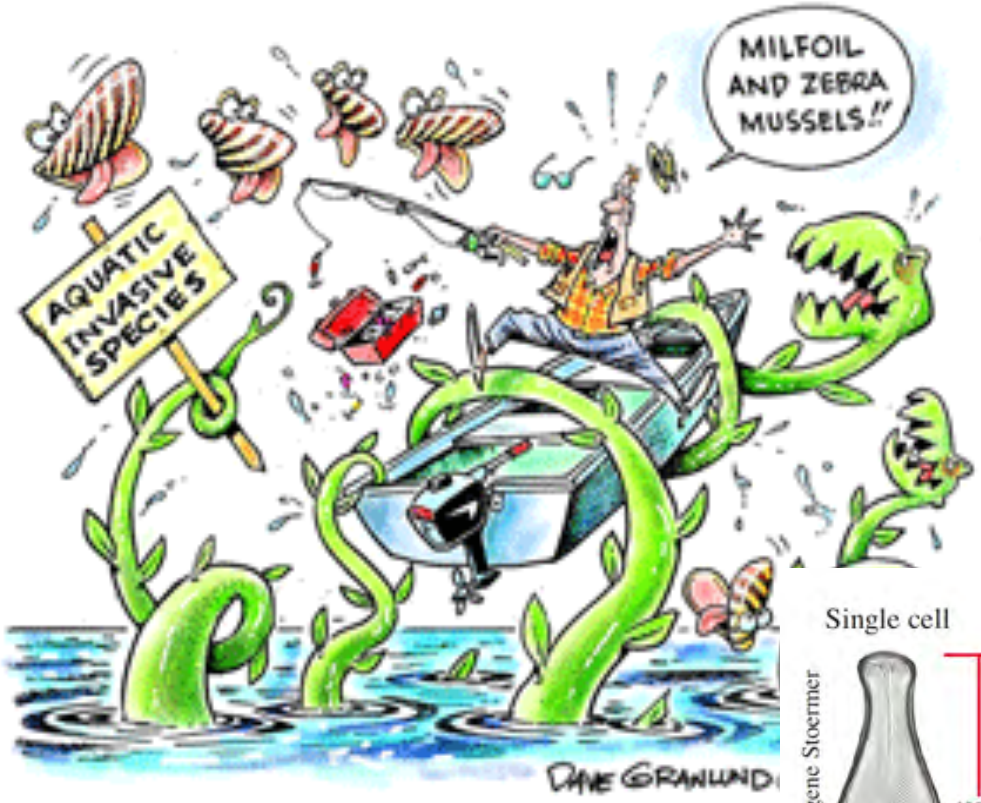


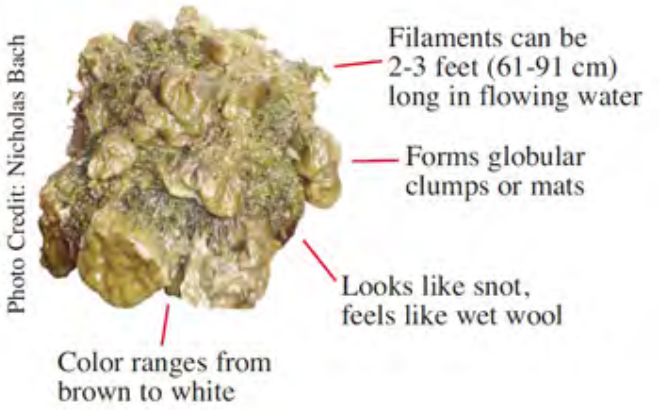
Aquatic Nuisance Species (ANS)

Nonindigenous species unintentionally introduced into a waterway (or fish passage)that threaten diversity/ abundance of native species, ecological stability, or commercial or recreational activities dependent on such waters.

Types of Aquatic-Nuisance-Species Impacts		
Environmental Effects	Economic Impacts	Public Health
Predation	Industrial Water Users	Disease Epidemics
Parasitism	Municipal Water Supplies	West Nile Virus
Competition	Nuclear Power Plants	Cholera Risks
Introduction of new pathogens	Commercial Fisheries	Parasites
Genetic	Recreational Fishing	
Habitat Alterations	Shipping	

Aquatic Nuisance Species (ANS)





And Now For Something Totally Different and Innovative

Whooshh Innovations

- Description of Technology
- Testing and Proof of Concept
- Costs

- NB: Visualizations of WFTS in several configurations

Archimedes Screw Turbine Generator (AST)

- The AST for small scale hydro on existing low head dams is an innovative and proven use of technology
- NEHC is the first implementer of this technology in the U.S. and has partners who have implemented and built over 100 similar installations in Europe and the UK
- Federal and State environmental agencies have signed off on AST as fish friendly with no adverse consequences to run-of-the-river and conduit installations
- 50 year plus useful life; durable, debris tolerant and low maintenance
- 70% mechanical efficiency
- Capacity utilization averages 55%, with some sites as high as 80%
- Operates year round in cold climates

Archimedes Screw Turbines