Concurrent Sessions B: Columbia River Passage - Hydroturbine Passage Related Barotrauma Research in the Columbia River Basin: How Far Have We Come?

Alison Colotelo  
*Pacific Northwest National Laboratory*

Richard S. Brown  
*Pacific Northwest National Laboratory*

Brett Pfugrath  
*Pacific Northwest National Laboratory*

Katrina Cook  
*Pacific Northwest National Laboratory*

Daniel Deng  
*Pacific Northwest National Laboratory*

See next page for additional authors

Follow this and additional works at: [http://scholarworks.umass.edu/fishpassage_conference](http://scholarworks.umass.edu/fishpassage_conference)

Colotelo, Alison; Brown, Richard S.; Pfugrath, Brett; Cook, Katrina; Deng, Daniel; and Stephenson, John, "Concurrent Sessions B: Columbia River Passage - Hydroturbine Passage Related Barotrauma Research in the Columbia River Basin: How Far Have We Come?" (2013). *International Conference on Engineering and Ecohydrology for Fish Passage*. 55.  
[http://scholarworks.umass.edu/fishpassage_conference/2013/June25/55](http://scholarworks.umass.edu/fishpassage_conference/2013/June25/55)

This Event is brought to you for free and open access by the The Fish Passage Community at UMass Amherst at ScholarWorks@UMass Amherst. It has been accepted for inclusion in International Conference on Engineering and Ecohydrology for Fish Passage by an authorized administrator of ScholarWorks@UMass Amherst. For more information, please contact scholarworks@library.umass.edu.
Presenter Information
Alison Colotelo, Richard S. Brown, Brett Pflugrath, Katrina Cook, Daniel Deng, and John Stephenson

This event is available at ScholarWorks@UMass Amherst: http://scholarworks.umass.edu/fishpassage_conference/2013/June25/55
Hydroturbine passage related barotrauma research in the Columbia River Basin: How far have we come?

Richard Brown, Brett Pflugrath, Alison Colotelo*, Katrina Cook, Joanne Duncan, Daniel Deng, and John Stephenson

Pacific Northwest National Laboratory, Richland WA
Barotrauma due to Rapid Decompression

- Rapid decompression can cause barotrauma in fish
  - Turbine passage
  - Spill / especially deep spill
- Gas within fish (primarily swim bladder) follows Boyle’s Law
  - Volume of gas inversely proportional to pressure
  - When pressure is cut by $\frac{1}{2}$ the volume doubles
- Ratio of pressure change is critical
  - Acclimation pressure / exposure pressure (nadir)
  - Leads to expansion and rupture of swim bladder
  - A key cause of barotrauma
Laboratory Pressure Simulation

Lab studies starting in 1999
- Rainbow trout
- Chinook salmon
- Smallmouth bass
- Bluegill
- White sturgeon

Mobile Aquatic Barotrauma Lab
Lab studies starting in 2006
- Chinook salmon
- Steelhead
- Pacific and brook lamprey
- Barbs (Southeast Asia)
- Tetras (South America)
Estimating Mortality/Injury

- Relationship between mortality/injury and pressure change for juvenile Chinook salmon
  Brown et al. 2012 Transactions of the American Fisheries Society

Example of ratio pressure change

Used for the development of new hydroturbines to be installed in the Snake and Columbia river basins

Swim bladder 2 times bigger

Variability likely due to gass-puck reflex timing and ability
No barotrauma observed in brook and Pacific lamprey exposed to rapid and sustained decompression known to cause ~100% mortality in juvenile Chinook salmon.
Lamprey

Mortality (%) vs. Ratio of pressure change

July 25, 2013
Barotrauma in White Sturgeon

**Due to metabolism**
- Short period after first feeding
- Gas found in intestine of unexposed fish may cause injury

**Due to swim bladder**
- After inflation
Acclimation Depth

Spike data
Path of fish

Forebay
Penstock
Turbine
Draft tube
Tailrace

~12 ft
20 psia

~24 ft
25 psia

5 psia
400% increase
500% increase

Absolute pressure (psi)

Time (s)
Tag Presence Bias

Tag presence increase mortality of turbine passed fish

Mortality (%) vs. Ratio of pressure change

Tag Burden (%): 0.0, 2.0, 5.0
Turbine Survival at McNary Dam

**Balloon tag**
- **(Normandeau et al. 1999)**
- Median survival 0.98
- Mean size 154 mm
- 3 turbine passage scenarios

**Acoustic telemetry**
- **Yearlings**
  - **(Adams et al. 2011; Evans et al. 2012)**
  - Median survival 0.85
  - 5 years; 2 studies
- **Subyearlings**
  - **(Adams et al. 2011)**
  - Median survival 0.74
  - 5 years

**Radio telemetry**
- **(Absolon et al. 2003; Adams et al. 2011)**
- Median survival 0.86
- 2 spill treatments; 2 years
  - Includes bypass system

**Likely causes of survival differences**
- Acclimation
- Tag presence
- Delayed mortality
- Indirect mortality

![Survival estimates graph]

![Fish image]
Future Direction

▶ Examine differences in susceptibility to barotrauma for other species
  ■ Physoclistous fishes (closed swim bladder)

▶ Apply laboratory findings to better understand biases associated with field studies
  ■ Reconcile differences in survival estimates among different techniques

▶ Prepare for increased electricity demands
  ■ Development in new hydropower projects
  ■ Retrofitting of existing dam structures
Acknowledgments

► Pacific Northwest National Laboratory staff
  Gayle Dirkes, Ricardo Walker, Ryan Klett, Tim Linley, David Geist

► United States Army Corps of Engineers
  Brad Eppard, Brad Trumbo, Martin Ahmann