

CURRICULUM VITAE

Paul S. Higgins

PRIMARY AREA OF EXPERTISE

Effects of dams and flow regulation on the aquatic and riparian ecosystems, fish passage, fish stock assessment, quantitative ecological monitoring, freshwater ecology, aquatic and riparian habitat restoration, adaptive management.

EDUCATION

Bachelor of Science (Ecology), Simon Fraser University, Burnaby, B.C. (1984)

Master of Natural Resources Management, Simon Fraser University, Burnaby, B.C. (1990)

RELEVANT EMPLOYMENT HISTORY

1992 – Present BC Hydro, Burnaby, B.C.

1987 – 1992: Consulting Biologist, Vancouver, B.C.

1985 - 1987: Research Technician, Canadian Department of Fisheries and Oceans, Science Branch; Salmon Habitat Section; Vancouver, B.C.

1981 - 1985: Research Assistant, Simon Fraser University, Department of Biology, Burnaby, B.C.

CURRENT / RECENT RESPONSIBILITIES

January 2011- Present: Manager, Environmental Program, Site C Clean Energy Project

Corporate Affairs, Site C Clean Energy Project

PO Box 49260, 1055 Dunsmuir St. Vancouver, B.C. , Canada, V7X 1V5

604-699-5239 (paul.higgins@bchydro.com)

- Responsible for leadership and administration of technical environmental (aquatic, wildlife, vegetation, geomorphology, hydrology, climate) for environmental assessment of the proposed Site C Hydroelectric.
- Key responsibilities include: Development of dam and reservoir operating regime, development and implementation of environmental mitigation/compensation program, obtaining water license and fisheries act authorizations, design and development of fish passage facilities, management of endangered species issues

August 2004 – December 2010: Manager, Environmental Resources Department

Generation Operations, Environment and Social Issues

- Responsible for leadership and administration of Environmental Resources Department to provide specialized technical support on Aquatic, Vegetation, Land Management, Wildlife, Pollution Prevention, and Archaeology disciplines (10-12 staff).
- Implementation of regulatory compliance and environmental risk management programs for system wide issues in Generation (i.e. Fish Entrainment, Fish Passage, Oil Management, Dissolved Gas Mitigation, Contaminated Sites and Reservoir Archaeological Programs).
- Responsible for cross line of business liaison for common environmental programs (i.e. PCB Elimination, Contaminated Sites, Hazardous Waste, Wildlife Management)
- Facilitation and technical support for endangered species recovery programs.
- Implementation of strategic interdisciplinary research and monitoring projects associated with assessment and mitigation of physical (geomorphic), biological (riparian and aquatic), and social (archaeological) impacts of hydroelectric facility operations.
- Provide recommendations on matters having bearing on environmental policy, hydroelectric operating practices, and environmental strategy to senior management.

- Liaison with regulatory agencies and other relevant scientific research authorities for compliance negotiation, resolution of operational impacts and long term regulatory policy development.

SELECTED REFEREED PUBLICATIONS

- Bradford, M.J.; J. Korman; P.S. Higgins and J Sneep (2010) Does more water mean more fish? A test of an environmental flow release in the Bridge River, British Columbia. *J. Freshwater Biology* (submitted)
- Failing, L. R. Gregory, and P.S. Higgins (2010). No short cuts: dealing with science and people in adaptive management. *Conservation Biology* (submitted).
- Isalm, M.D.; D.Z. Zhu and P.S. Higgins. (2010) Potential-Flow-Models to Assess Intake Induced Flow-Field: A Feasibility Study Regulated Rivers: Research and Application (submitted)
- Bhuiyan, F.;D.Z. Zhu; A. Leake; and P. S Higgins 2010. Computation of flow patterns induced by hydropower intakes for fish entrainment risk assessment. *J. Hydraulic Engineering* (submitted)
- Hall, A.; S.B. Rood and P.S. Higgins (2010) Resizing a river: A downscaled, seasonal flow regimen promotes riparian restoration. *Restoration Ecology* 23:1-9
- Decker, A.S., Bradford, M.J., and P.S. Higgins (2007). Rate of biotic colonization following flow restoration below a diversion dam in the Bridge River, British Columbia. *River Research and Applications* 23:1-8.
- Korman, J., C. Melville, and P.S. Higgins (2007) Integrating multiple sources of data on migratory timing and catchability to estimate escapement for steelhead trout (*Oncorhynchus mykiss*). *Can. J. Fish. Aquat. Sci.* 65:1101-1115
- Gregory, R., L. Failing, and P.S. Higgins. (2006) Adaptive management and environmental decision making: a case study of water use planning. *Ecological Economics* 58:434-447
- Bradford, M.J., Korman, J, and P.S. Higgins (2005). Using confidence intervals to estimate the response of salmon populations (*Oncorhynchus* sp) to experimental habitat alteration. *Can. J. Fish. Aquat. Sci.* 62:2716-2726
- Alexander, C.D., D.Marmorek, C. Peters, and P.S. Higgins. (2005) A decision analysis of adaptive management experiments for Columbia River mountain whitefish (*Prosopium williamsoni*) management: Is it worth varying flows to reduce key uncertainties? *Can. J. Fish. Aquat. Sci.* 63: 1142-1156(15)
- Stevens, L.E., Mast, J.N., J. Korman, and P.S. Higgins (in press). Regulated flows and stand development of black cottonwood (*Salicaceae: Populus triplocarpa*) in the Bridge-Seton River watershed, British Columbia. *Western North American Naturalist*.
- Failing, L., G. Horn, and P. Higgins. (2004) Using expert judgment and stakeholder values to evaluate adaptive management options. *Ecology and Society* 9(1): 13. [online]
<http://www.ecologyandsociety.org/vol9/iss1/art13>
- Weber, L. P.S. Higgins, R.I. Carlson, and D.M. Janz. (2003) Development and validation of methods for measuring multiple biochemical indices of condition in juvenile fishes. *Journal of Fish Biology* 63:637-658.
- Korman, J, R.M. Ahrens, P.S. Higgins and C.J. Walters. (2002) Effects of observer efficiency, arrival timing, and survey life on uncertainty in estimates of escapement for winter-run steelhead trout (*Oncorhynchus mykiss*) derived from repeat mark-recapture experiments. *Can. J. Fish. Aquat. Sci.*59:1116-1131
- Bradford, M.J. and P.S. Higgins. (2001) Habitat, season, and size specific variation in daily activity patterns of chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*). *Can. J. Fish. Aquat. Sci.* 58:365-374.
- Korman, J. and P.S. Higgins. (1997) Utility of escapement time series data for monitoring the response of salmon populations to habitat alteration. *Can. J. Fish. Aquat. Sci.* 54:2058-2067.
- Higgins, P.S. and M.J. Bradford. (1996) Evaluation of a large scale fish salvage to reduce the impacts of controlled flow reduction in a regulated river. *North American Journal of Fisheries Management* 16:666-673.

Bradford M.J., G. C. Taylor, J.A. Allan, and P.S. Higgins. (1995) Stranding of juvenile coho salmon and rainbow trout during rapid flow decreases in simulated winter conditions. *North American Journal of Fisheries Management* 15:473-479.

SELECTED CONFERENCE PRESENTATIONS / POSTERS

- “**Resizing a river: does more water equal more fish?**” Invited speaker at BC Ministry of Environment Annual Meeting, Kelowna, B.C. January 2010.
- “**Effectiveness of flushing flows for managing fine sediment accumulation in a coastal regulated river**” invited speaker at Instream Flow Councils High Flows Workshop presented at Flow 2008 San Antonio Texas, October 2008.
- “**Results of a formal review of recruitment failure hypotheses for white sturgeon (*Acipenser transmontanus*) from the upper Columbia River**” presented to American Fisheries Society, Ottawa, Ontario; Aug 2008.
- “**Resizing a river: a downscaled flow regime promotes the growth and reproduction of riparian cottonwoods**” presented Pacific Northwest Riparian and Aquatic Restoration conferences, Spokane Washington; March 2008
- “**Kernels of Wisdom Derived From Experience in Adaptive Management in Flow Regulated Rivers in British Columbia**” Invited speaker at Workshop sponsored by European Union and University of British Columbia School of Resource Management to assist in transfer of adaptive strategies for natural resources and ecosystems management in Canada for implementation in Southern Spain. December 5, 2007
- “**Adaptive Management in Water Use Planning in British Columbia**” Grand Canyon Monitoring and Research Center, Flagstaff Arizona, Knowledge Assessment Workshop II, July 6, 2005”
- “**Developing Naturalized Hydrographs for Riparian Cottonwood Forests Along Flow Regulated Rivers**” Canadian Department of Fisheries and Oceans Pacific Region Instream Flow Workshop, February 2003, Richmond B.C.
- “**Investigating Fish Population Dynamics to Define Impacts of Flow Regulation in Large Rivers**” present at American Fisheries Society annual Meeting (International North-Pacific Chapter), Vancouver, B.C. , April 2003.
- “**Professional judgement and habitat modeling in predicting juvenile salmonid densities in a British Columbia regulated river**” Instream Flow Assessment Workshop, Boulder Colorado, June 2003.
- “**Application of decision analysis to the design of instream flow experiments**” CALFED-Bay-Delta Modeling Forum, Monterey California, March 2000
- “**Physical habitat simulation and ecological monitoring to predict the recruitment response of stream salmonids in Bridge River: more questions than answers?**” American Fisheries Society Annual Meeting (North Pacific International Chapter), Richmond, B.C., April 1999.
- “**Design of a flow experiment to estimate the functional relationship between steelhead smolt production and instream flow**”. American Fisheries Society Annual Meeting (North Pacific International Chapter), Richmond, B.C., April 1999.
- “**Towards a common understanding towards water use planning fisheries assessments: role of adaptive management**” British Columbia Water Use Plan Instream Flow Assessment Workshop, June 1999.
- “**Influence of temperature, light and food availability on the daytime concealment behavior of juvenile Pacific salmon**”. Presented at American Society of Ichthyologists and Herpatologists and American Fisheries Society 21st Annual Larval Fish Conference, Seattle Wa., June 1997
- “**Boldly going where others have gone before: Using prior information to improve freshwater stock assessments**”. Presented at Canadian Council of Freshwater Fisheries Research Annual Meeting, January 1996.

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“Effects of flow changes on salmonids in regulated rivers: the development of ramping schedules for hydroelectric projects”. American Fisheries Society Annual Meeting (North Pacific International Chapter), Vancouver, B.C., April 1995.

“The development of flow ramping schedules to reduce impacts of flow changes at hydroelectric facilities”. Presentation to Pacific Fisheries Biologist Association Meeting, Clear Lake, California April 1994.

“Flow ramping and fish salvage at hydroelectric facilities”. Presentation to Pacific Fisheries Biologist Association Meeting, Parksville, B.C. April 1993.

CHAired SESSIONS AT INTERNATIONAL MEETINGS

Session Co-chair, Hydroelectric Impacts Section, American Fisheries Society Annual Meeting (North Pacific International Chapter), Everett, WA., April 1996.

Session Chair “Hydroelectric Utilities: Partners in Stewardship?” American Fisheries Society Annual Meeting (North Pacific International Chapter), Vancouver, B.C., April 1995.

CONFERENCE ORGANIZATION

Instream Flow Council Organizing Committee for Fall 2008 International Conference “Flow 2008 – Interdisciplinary Solutions to Instream Flow Problems” in San Antonio, Texas, U.S.A.

British Columbia Water Use Plan Instream Flow Assessment Workshop, Vancouver, B.C.; June 15-16, 1999

REVIEWER FOR SCIENTIFIC JOURNALS

Canadian Journal of Fisheries and Aquatic Sciences

North American Journal of Fisheries Management

Transactions of the American Fisheries Society

Environmental Management

Regulated Rivers: Research and Applications

EXTERNAL SCIENTIFIC ADVISORY ROLES

2009-2013 Research Management Committee for HYDRONET. 5 year program supported by National Science and Engineering Council of Canada. Collaborators successfully received a \$5M grant to conduct research on effects of hydropower on fish and fish habitat in Canada

2009 One of ten international scientists asked to participate in a 2 y program to evaluate the efficacy of flow experiments as a means for resolving instream flow issues. Supported by USGS and the U.S. Nature Conservancy and funding by National Centre for Ecological Analysis and Synthesis.

2008 Instream Flow Council Steering committee Member – Participate in international program to standardize and improve the implementation of instream flow assessment in Canada and U.S./

2007-2009 Centre For Excellence on Hydro Power Effects on Fish and Fish Habitat – Industry representative on Steering Committee for DFO/University/Industry national program to coordinate and direct research on effects of hydropower dam operation on fish and fish habitat in Canada.

2006 United States Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, Washington – Act as external reviewer on fish stranding and entrapment (flow ramping) studies in Hanford Reach associated with FERC Assessment for Priest Rapids Dam.

- 2005 United States Geological Survey, Grand Canyon Adaptive Management Program Grand Canyon Monitoring and Research Center – Participate in Adaptive Management planning workshop for the Colorado River in Grand Canyon, Arizona.
- 2004 United States Department of Interior, Trinity River Adaptive Management Program, Technical Modelling and Analysis Working Group – Participation in the design and peer review of the Broad-Scale Monitoring Program for Adaptive Environmental Assessment for the Trinity River, California.
- 2002, 2003, 2004, 2005 CALFED Environmental Restoration Program – participated on as an external scientific advisor for the development of instream flow assessment modelling protocols.
- 2002 United States Department of Interior, Trinity River Adaptive Management Program, Technical Modelling and Analysis Working Group – Participation in the design and peer review of the Broad-Scale Monitoring Program for Adaptive Environmental Assessment for the Trinity River, California.
- 2002 CALFED Environmental Restoration Program – external scientific reviewer of river channel and riparian restoration proposals.
- 2002 United States Geological Survey, Grand Canyon Adaptive Management Program Grand Canyon Monitoring and Research Center – Provide peer review for annual native and non-native fish monitoring program on the Colorado River in Grand Canyon, Arizona.
- 2001 United States Geological Survey, Grand Canyon Adaptive Management Program Grand Canyon Monitoring and Research Center, Flagstaff Arizona. Aquatic Protocol Evaluation Program Panel Member.
- 1999 – 2002: External Advisor for a three year long joint utility-regulatory agency adaptive management initiative supported by Canadian Department of Fisheries and Oceans Environmental Science Strategic Research Fund to examine the effects of hydro peaking on river ecosystems.
- 1998 – 2003: British Columbia Water Use Planning Process, Fisheries Advisory Team

SELECTED REPORTS

- Higgins, P.S. 2005. An assessment of the effectiveness of flushing flows for managing fine sediment in fish habitat of the South Alouette River. Prepared for the Alouette River Water Use Planning Process. 33 p.
- Sneep, J and P.S.Higgins. 2003. Lower Bridge River Aquatic Monitoring -Year 2002 Data Report. Report prepared for B.C. Hydro for submission to B.C. Comptroller of Water Rights. 44 p + app.
- Janz, D. M., L. P. Weber and P.S. Higgins 2003. Evaluation of biochemical measures of condition as methods for monitoring fish response to altered instream flow regimes. Final Project Completion Report prepared for B.C. Hydro Strategic Environmental Initiative Program Vancouver, B.C.
- Higgins, P.S., Korman, J, and M. Bradford. 2002. Statistical power of monitoring inferences derived from planned experimental flow comparisons for Coquitlam-Buntzen Water Use Plan. Technical Paper prepared for the Fisheries Technical Committee for the Coquitlam-Buntzen Water Use Plan. November 2002. 20 p.
- Gregory, R., Failing, L and P.S. Higgins. 2002. Adaptive Management and Environmental Decision Making: A Case Study of Water Use Planning in British Columbia. MS prepared for Water Use Planning Program, B.C. Hydro, Burnaby, B.C.
- Higgins, P.S. 2001. Using Adaptive Management for Instream Flow Assessment for Water Use Planning in British Columbia. Discussion Paper prepared for: Water Use Planning Program Fisheries Advisory Team.
- Anders, P; M Bradford (Chair); P. Higgins; K. Nislow; C. Rabeni; and C. Tate . Protocols Evaluation Program: Final Report of the Aquatic Protocol Evaluation Program Panel. November 28, 2001. presented to Grand Canyon Monitoring and Research Center, Flagstaff Arizona.
- Higgins, P.S. ,D.R. Marmorek, D.P. Bernard, C.L. Murray, C.N Peters, and J. Korman. 2000. Workshop on Instream Flow Assessment in the Water Use Planning Process: Summary Report. Prepared for: Water Use Planning Program Fisheries Advisory Team , 95 p + app.

- Higgins P.S. and J. Korman. 2000. Abundance, growth, standing stock, and components of variation of juvenile salmonids in the Bridge River: An analysis to define 'baseline conditions' and optimal sampling design. B.C. Hydro Power Supply Environment Burnaby, B.C., 67 p + app
- Higgins, P.S., A.F. Lewis, and J.G. Scouras. 1999. Diurnal and nocturnal habitat use of stream salmonids in Bridge and Seton Rivers. Prepared for B.C. Hydro Power Supply Operations, Burnaby, B.C.
- Higgins, P.S. 1999. Using adaptive management approaches for instream flow assessment for Water Use Planning in British Columbia. Prepared for: Water Use Planning Program Fisheries Advisory Team.
- Higgins, P.S. 1996. Alouette River flushing flow assessment. B.C. Hydro, Safety and Environment Division Report SFP-ALU-07. 27p.
- Scouras, J.G. and P.S. Higgins. 1995. Preliminary assessment of the upstream passage and rearing flow requirements of steelhead trout (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*) in the Salmon River (Vancouver Island). B.C. Hydro Environmental Affairs Division, Report No. ER-94-14.
- Higgins, P.S. 1995. Flow ramping at hydroelectric facilities: Approach and methodologies for impact assessment and mitigation. B.C. Hydro Environmental Affairs Division, Report No. ER-94-07.
- Groves, K. L. and P.S. Higgins. 1994. Seton Fish Diversion Overview Study. B.C. Hydro Hydroelectric Engineering Division, Report H2768.
- Cheng, W.K., L. Flint-Petersen and P.S. Higgins. 1993. Bridge River System Operation Study. B.C. Hydro Hydroelectric Engineering Division, Report No. H2721.
- Higgins P.S., 1993. Examination of the Environmental Costs of Spilling at Terzaghi and Seton Dams. B.C. Hydro Environmental Affairs Division. Report ER-93-04, 33 pp.
- Ford, B.S., P.S. Higgins, A.F. Lewis, K.L. Cooper, T.A. Watson, G.L. Ennis and R.L. Sweeting. 1992. Literature reviews of the life history, habitat requirements, and mitigation/compensation strategies for 13 species of sport fish in the Peace and Columbia River drainages of British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2203, 330 p.
- Triton Environmental Consultants Ltd. and Klohn Leonoff Ltd. 1991. Reconnaissance of fish habitat and surficial deposits of Nechako Canyon. Consultants report prepared for Kemano Completion Project. 253 p.
- Triton Environmental Consultants Ltd. 1991. Nechako River flow ramping analysis. Consultants Report Prepared for Kemano Completion Project. 55 p. + Appendices.
- Higgins, P.S. and D. Tesch. 1991. Hydroacoustic and limnological surveys of Tahltan, Tatsamenie, and Trapper Lakes. Consultants report submitted to Department of Fisheries and Oceans, Nanaimo, B.C.
- Higgins, P.S. 1990. Counting errors in aerial surveys of spawning salmon: Some effects on long term management performance and economic benefits from Wood River sockeye salmon (*Oncorhynchus nerka*). Masters Thesis, Natural Resources Management Program, Simon Fraser University, B.C. 87 p.
- Higgins, P.S. and P.J. Tschaplinski. 1989. Nechako Reservoir Fish Fauna Studies: Tahtsa Narrows and adjacent tributaries. Consultants report prepared for Kemano Completion Project. 45p.
- Higgins, P.S. et al. 1987. Some characteristics of eulachon (*Thaleichthys pacificus*) captured in the Fraser River Estuary, B.C., April 1986. Can. MS. Rep. Fish. Aquat. Sci. No. 1913, 47 p.