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Attorneys for Plaintiffs

THE HONORABLE MICHAEL H. SIMON

UNITED STATES DISTRICT COURT

DISTRICT OF OREGON

PORTLAND DIVISION

NATIONAL WILDLIFE FEDERATION, *et al.*,

Plaintiffs,

and

STATE OF OREGON,

Intervenor-Plaintiff,

v.

NATIONAL MARINE FISHERIES SERVICE, U.S. ARMY CORPS OF ENGINEERS, and U.S. BUREAU OF RECLAMATION,

Defendants,

and

No. 3:01-cv-00640-SI

DECLARATION OF BRENDAN M. CONNORS

NORTHWEST RIVERPARTNERS, INLAND PORTS AND NAVIGATION GROUP, STATE OF IDAHO, STATE OF MONTANA, STATE OF WASHINGTON, KOOTENAI TRIBE OF IDAHO, CONFEDERATED SALISH AND KOOTENAI TRIBES, and NORTHWEST POWER AND CONSERVATION COUNCIL,

Intervenor-Defendants.

I, BRENDAN M. CONNORS, state and declare as follows:

1. I am a quantitative ecologist and fishery scientist by training and experience who studies how natural- and human-mediated processes interact to shape the dynamics of fish populations. Since 2013 I have been a Senior Systems Ecologist at ESSA Technologies Ltd. in Vancouver, British Columbia, where my work has largely focused on combining statistical and simulation modeling, decision analysis, and policy evaluation to inform pressing resource management and conservation problems in Western North America. Recent examples of my work at ESSA include modeling of fish population dynamics and the bioeconomics of fisheries to inform decisions about hatchery operations, climate change impacts, and resource and fisheries management; decision analysis of management alternatives, trade-offs and uncertainties associated with the impact of hydropower facility operations, habitat enhancement, and hatchery practices on salmonids; and the development and implementation of benchmarks to assess the status of salmon populations, based on exploitation rates, stock-recruitment relationships, habitat factors and historic abundance.

2. Prior to joining ESSA, I was a postdoctoral fellow in the School of Resource and Environmental Management at Simon Fraser University where I am also currently an adjunct professor. My academic research broadly focuses on: (1) the causes and consequences of variability in fish population dynamics, (2) improving the design, assessment, and implementation of indicators of conservation status, and (3) the ecology of disease in coupled

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wild salmon/farmed salmon systems. In 2011 I received a Ph.D. in Ecology from Simon Fraser University, and in 2004 I received a B.Sc. (with distinction) in Biology from the University of Victoria. My doctoral research focused on understanding how pathogen transmission from farmed to wild salmon correlates with wild salmon behavior, survival and population dynamics. I have served as an expert witness and conducted statistical analyses evaluating relationships between salmon population dynamics and salmon aquaculture for the Government of Canada's Inquiry into the Decline of Sockeye Salmon in the Fraser River. I also provided expert testimony on salmon population dynamics and aquaculture to a Canadian House of Commons Standing Committee on Fisheries and Oceans. I have co-authored 17 peer-reviewed scientific publications and over a dozen technical reports. Attached to this Declaration, as Exhibit A, is a copy of my curriculum vitae.

A. Background

3. I have been asked to review Appendix C of the Biological Opinion on Operation of the Federal Columbia River Power System issued on January 17, 2014, by NOAA Fisheries (the "2014 BiOp") and the discussion in that Opinion related to Appendix C. I have also been asked to explain aspects of the biological process known as "density dependence" that may not be apparent from the description of density dependence in Appendix C and the 2014 BiOp. In addition, I address a number of related issues in order to put into a broader context the discussion of density dependence in Appendix C and the 2014 BiOp. As part of providing this information, I will also identify and describe additional biological processes and data that are relevant to understanding and interpreting the information presented in Appendix C.

1. Definitions

4. Quantifying geometric mean population abundance is one way of estimating the average abundance of a salmonid population over a given period of time. Geometric mean abundance over a number of years can be considered a more accurate measure of population

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abundance over time than abundance in any single year because of high interannual variation in the abundance of most salmon and steelhead species. Geometric mean abundance was calculated over a ten-year period by NOAA for the Chinook salmon and steelhead populations in the 2014 BiOp. Comparing geometric mean abundance from one ten-year time period with geometric mean abundance for a different ten-year period is one way of evaluating whether average abundance has increased or decreased over time between the two time periods. This is the approach NOAA used in the 2014 BiOp. *See* 2014 BiOp at 79-83 (discussing and comparing average abundance for an earlier and the most recent ten-year periods).

5. The number of adult recruits produced per spawner ("recruits per spawner" or "R/S") is a measure of a salmon population's productivity or lifetime survival. It is also a measure NOAA reported in the 2014 BiOp. *See* 2014 BiOp at 89-93. A population can only grow if, in the absence of harvest, the number of adult recruits (i.e., adult salmon that return to spawn) that are produced in a given generation is greater than the number of spawners that produced them, i.e., the ratio of recruits per spawner is greater than 1.0. If the ratio of recruits to spawners remains at less than 1.0, the population will not replace itself and, all other things being equal, will decline until it goes extinct. Survival during both freshwater and marine life stages together determine the ratio of recruits per spawner, and so recruits per spawner is a measure of overall population productivity that does not identify or partition survival among life stages. Factors that may lead to declines in recruits per spawner can include those affecting survival in freshwater and the marine environment, such as competition for spawning habitat and other resources in tributary habitat, mortality during migration from spawning habitat to the ocean (including, for example, mortality due to dams, in-river conditions, and conditions in the estuary), and mortality in the marine environment.

6. Life stage specific estimates of survival exist for many salmonid populations in the Columbia Basin as a result of extensive Passive Integrated Transponder ("PIT") tagging

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programs. These estimates include survival in tributary habitat (e.g., egg to out-migrating smolt survival), during migration downstream (e.g., from the Lower Granite dam to the Bonneville dam), and in the ocean (e.g., from smolts to return adults at Bonneville dam). NOAA discusses these measures of life stage specific survival, including the smolt-to-adult-return rate or SAR (the number of adults with PIT tags detected at the Lower Granite dam divided by the number of PIT tagged smolts released at the dam) but does not use SARs as one of its preferred metrics in the 2014 BiOp. 2014 BiOp at 123-125. Nonetheless, life stage specific estimates of survival can provide important insights into the processes that influence survival and abundance at different points in the life cycle of salmonids. For example, comparing life stage specific survival rates among populations that differ in total life cycle survival (e.g., recruits per spawner) can help to elucidate the life stage in which the factors contributing to the differences in overall survival are most likely to be operating.

7. Salmon survival at a given life stage can be density-dependent, i.e., dependent on the abundance of the population as a whole. This may occur, for example, because of competition for spawning habitat (e.g., Essington et al. 2000) or among juvenile salmon for rearing habitat or available resources (e.g., Einum et al. 2006), leading to survival rates being highest at low abundance and subsequently declining as abundance increases. In salmon, density dependent processes are often thought to occur primarily in freshwater habitats but would be predicted to occur at any life stages where competition for limited habitat or resources might occur, including in estuaries or the open ocean (Ruggerone and Nielsen 2004).

2. Background

8. Based on the examination of geometric mean population abundance presented in the 2014 BiOp, NOAA concludes that average abundance of Chinook and steelhead spawners from populations in the upper Columbia Basin (the Snake and upper Columbia Rivers) has generally been higher in recent brood years, roughly 2001 to present, than in brood years

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between 1980 and 2000. 2014 BiOp at 79-83. Coincident with these increases in abundance, NOAA's analysis of the most recent available data indicates that for most of these same populations, the total number of adult recruits produced per spawner has been generally lower than in the brood years between 1980 and 2000. *Id.* at 89-94. These observations led NOAA, in Appendix C of the 2014 BiOp, to consider in more detail than in past Opinions whether what are know in population biology as "density-dependent processes" may explain these patterns. *Id.* at 67-68 ("if abundance and extinction risk both show that a population is improving, but average productivity declines, what mechanism can account for this?").

9. NOAA initially described density-dependent processes in general terms in the 2008 BiOp and then more extensively in the 2010 BiOp. *Id.* In Appendix C to the 2014 BiOp, NOAA presented a formal analysis of density dependence using currently available information on spawner abundance and corresponding recruits per spawner. *Id.* at 68. Based on this analysis, NOAA concluded that there is "strong support for the hypothesis that productivity has not decreased for these populations when comparing base to recent time periods but that the decreased [recruits per spawner] resulted from density-dependent processes as a result of the increased abundance observed recently." 2014 BiOp, App. C at 1. NOAA concluded further that there is, therefore, "no support for the hypothesis that recent conditions are less productive than those experienced during the base period." *Id.* In other words, according to NOAA, their analysis, which demonstrates declines in population productivity coincident with increases in spawner abundance, is not evidence that the actions described in the RPAs since the 2008 BiOp are failing to produce predicted improvements in Chinook and steelhead survival. 2014 BiOp at 468 (effects of RPA will be the same as or better than predicted in the 2008 BiOp). Instead, NOAA concluded that the observed declines in recruits per spawner fall within the range one would expect based on within population density-dependent processes. *Id.* at 119.

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B. Discussion

10. Each of the Chinook and steelhead populations in the upper Columbia Basin that are under consideration in the 2014 BiOp and Appendix C can be thought of as an aggregate population of smaller subpopulations (a metapopulation)—groups of fish within a population that occupy semi-discrete patches of spawning and rearing habitat. These smaller groups may interact through the exchange of individuals within the overall population's habitat (e.g., Isaak et al. 2007). Such a metapopulation may see spawning and rearing subpopulations within individual habitats blink in and out depending on the number of salmon returning to the overall metapopulation, straying of individuals among habitat patches within the metapopulation and variability in the quality of each habitat patch (e.g., Isaak and Thurow 2006).

11. One consequence of this population structure is that during periods when the overall metapopulation size (abundance) is relatively low, as it currently is for almost all of the Chinook and steelhead populations in the upper Columbia Basin compared to historic abundance, only a portion of available habitat patches may be occupied because, for example, there is a contraction of spawning into a subset of available habitat (Panel B in Figure 1 below).

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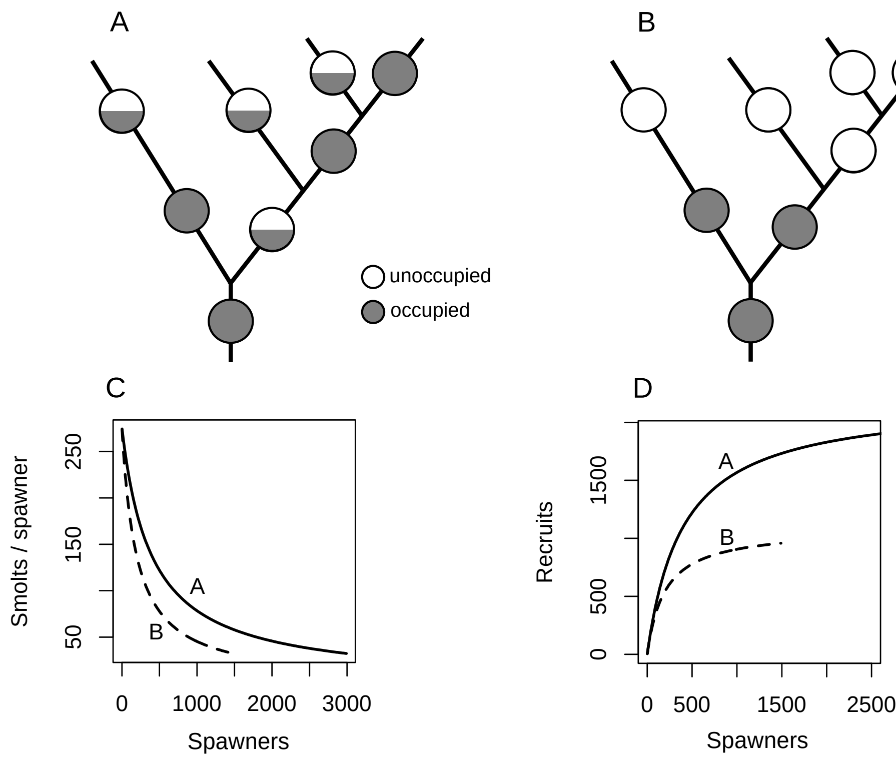

Figure 1. Two hypothetical salmon metapopulations. The metapopulation in watershed A is at relatively high abundance with all available spawning/rearing habitat (circles) utilized to some extent while the metapopulation in panel B has undergone a spatial contraction in the habitat used as a result of lower spawner abundance. As a result of the spatial contraction in B, smolt production is closer to capacity and so freshwater density dependence at the metapopulation level is stronger (panel C) and the predicted recruitment at a given spawner abundance is lower for metapopulation B relative to metapopulation A (panel D).

12. Small numbers of returning spawners may naturally concentrate to increase the probability of finding mates and successfully reproducing. Density dependent interactions can occur at the level of these individual habitat patches at low abundance resulting in the appearance of an increased density dependent response across the overall metapopulation even when overall metapopulation abundance is low and not all suitable spawning and rearing habitat is occupied (i.e., the dashed line is steeper than the solid line in panel C of Figure 1 above).

13. By contrast, when overall metapopulation abundance is higher and distributed across more of the available habitats, the overall metapopulation may exhibit weaker density

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dependence than during a period of low metapopulation abundance (i.e., solid line in panel D of Figure 1 above is higher than the dashed line and does not bend over as sharply with increasing spawner abundance). During periods of low smolt to adult survival, the *apparent* carrying capacity of the habitat may be reduced due to the combination of increased density dependence (as a result of the contraction of the population to a subset of habitat patches), and density independent mortality, or even density dependent mortality, outside the spawning habitat (for example reduced survival in the migration corridor or marine environment) which together limit a population's ability to expand into more of the available habitat (e.g., Steelhead in the Keogh River of British Columbia; Ward 2000). The *actual* carrying capacity of the metapopulation as a whole is, however, considerably higher, but is not realized until more spawners return and spread out to use all spawning and rearing habitats available to the population.

14. In short, there are at least two different circumstances in which a population may exhibit a density dependent response in tributary habitat. One circumstance is where population abundance is high and the overall available habitat within a watershed is approaching or exceeding its *true* carrying capacity. Another occurs where population abundance is relatively low and increasing only modestly such that use of the available habitat has contracted to a fraction of available habitat patches and where those patches that are occupied each individually approach their own carrying capacity. The sum of the carrying capacities of occupied patches is however much less than the true carrying capacity.

15. Current SARs are quite low for most of the Snake River and upper Columbia River Chinook and steelhead populations addressed in the 2014 BiOp. *See* Comparative Survival Study, 2014 Draft Report at 78-88 (*available at* http://www.fpc.org/documents/CSS/DRAFT_CSS_2014_Annual_Report.pdf). Likewise, as NOAA explains, the ratio of recruit to spawners in the most recent brood years for most of these populations are often below 1.0. *See* 2014 BiOp at 89-93. And the estimates of mean spawner abundance also are at low levels

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compared to the minimum viable population sizes NOAA has identified for these populations. *See* 2014 BiOp at 80 (Table 2.1-5) (compare column labeled "ICTRT Threshold Abundance Goal" with column labeled "Most Recent Ten-year Geomean Abundance"). Given these observations of relatively low abundance and depressed survival rates, yet evidence of density-dependent survival in recent years, it would be logical to consider whether the density dependence that NOAA identifies in Appendix C is occurring, at least in part, as a result of the spatial contraction of tributary habitat used in combination with depressed smolt to adult survival (dashed line in panel D of Figure 1 above), as opposed to reaching or exceeding the *true* overall carrying capacity of the population's habitat (solid line in panel D of Figure 1 above).

16. Three lines of evidence suggest that many of the populations addressed in the 2014 BiOp, may be experiencing density dependence as a result of the spatial contraction of tributary habitat use and depressed smolt to adult survival. First, many of these populations occupy near pristine wilderness tributary habitat which has not been degraded or otherwise reduced in its carrying capacity but which also is not fully utilized because current spawner abundances are well below historic abundances. Second, many of these same populations, despite their low abundance, have clear evidence of density dependent juvenile survival in tributary habitat (Walters et al. 2013). Third, SARs for many of these populations have been variable but low in recent years, often well below those identified as being necessary for population viability and recovery, *see* Comparative Survival Study, 2014 Draft Report at 71-72 (discussing Northwest Power and Conservation Council, 2009 Columbia River Basin Fish and Wildlife Program identifying range of SARs for survival and/or recovery). These factors may collectively limit the growth and productivity of Chinook and steelhead in the upper Columbia basin. This situation is likely to continue until survival outside of tributary habitat is consistently higher than it has been in recent decades.

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17. It would be logical to consider these lines of evidence and assess the nature of the density dependent processes currently occurring in tributary habitat for Snake River and upper Columbia River Chinook and steelhead. This is because in those instances where spatial contraction of occupied habitat patches occurs because of low spawner abundance, driven in part by sources of mortality outside tributary habitat, a focus on restoration of additional tributary habitat is unlikely to be sufficient to allow the overall metapopulation to increase its productivity, expand the number of habitat patches occupied and ultimately grow to the point where population viability and conservation status is improved. As described above, the spatial contraction of overall Chinook or steelhead metapopulations to a fraction of their available habitat patches may have led to a reduction in the realized carrying capacity and increased strength of density dependence. Management actions that increase survival after emigration from rearing habitat would be necessary to enable sufficient spawners to return to a metapopulation to increase the seeding of more habitat patches, allow use of more of the available carrying capacity, and improve the rate of population growth. Increasing the abundance of a metapopulation under these circumstances, by addressing mortality elsewhere in the species' life-cycle, would also be predicted to lead to an increase in population spatial structure, which will likely also lead to increased life history and genetic diversity as populations adapt to additional patch-specific habitat attributes.

18. Myriad factors outside of tributary habitats can affect salmon survival and hence SARs. These include processes that are driven by climactic and oceanographic conditions (e.g., the Pacific Decadal Oscillation) and so are largely outside management control, as well as those that can be directly influenced by management decisions (e.g., fishery regulations, or actions taken during migration down river and into the marine environment) which may increase smolt to adult survival. Variable ocean conditions have been, and will continue to be, an important factor in the interannual variation in marine survival, and hence total life cycle survival for

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salmonid species (Haeseker et al. 2012). However, given what we know of historic salmon abundance, these oceanographic conditions, which have varied across decades if not centuries, would not be expected to limit salmonid populations to their (in many cases) currently depressed levels if actions under human control were able to increase survival rates during other, non-ocean life stages. For example, it is possible that increasing spill over dams during outmigration could significantly increase smolt survival, since higher rates of spill are correlated with increased in-river and smolt to adult survival (Haeseker et al. 2012). There are, of course, other management actions that also could be taken to increase in-river survival and even marine survival in order to begin to lift Snake River and upper Columbia River Chinook and steelhead populations out of their current high-risk status.

Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge. Executed this 2nd day of December, 2014, at Vancouver, B.C., Canada.

BRENDAN M. CONNORS

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Literature Cited

Einum S., L. Sundt-Hansen, and K.H. Nislow. 2006. The partitioning of density-dependent dispersal, growth and survival throughout ontogeny in a highly fecund organism. Oikos 113: 489–496.

Essington T. E., T. P. Quinn, and V. E. Ewert. 2000. Intra- and inter-specific competition and the reproductive success of sympatric Pacific salmon. Canadian Journal of Fisheries and Aquatic Sciences 57: 205-213.

Haeseker S. L., J. A. McCann, J. Tuomikoski, and B. Chockley. 2012. Assessing freshwater and marine environmental influences on life- stage-specific survival rates of Snake River spring-summer Chinook salmon and steelhead. Transactions of the American Fisheries Society 141: 121-138.

Isaak D. J., R. F. Thurow, B. E. Rieman, and J. B. Dunham. 2007. Chinook salmon use of spawning patches: relative roles of habitat quality, size, and connectivity. Ecological Applications 17: 352-364.

Isaak D.J. and R.F. Thurow. 2006. Network-scale spatial and temporal variation in Chinook salmon (*Oncorhynchus tshawytscha*) redd distributions: patterns inferred from spatially continuous replicate surveys. Canadian Journal of Fisheries and Aquatic Sciences 63: 285-296.

Ruggerone, G.T., and J.L. Nielsen. 2004. Evidence for competitive dominance of pink salmon (*Oncorhynchus gorbuscha*) over other salmonids in the North Pacific Ocean. Reviews in Fish Biology and Fisheries 14: 371-390.

Ward B.R. 2000, Declivity in steelhead (Oncorhynchus mykiss) recruitment at the Keogh River over the past decade. Canadian Journal of Fisheries and Aquatic Sciences 57: 298-306.

Walters A. W., T. Copeland, and D. A. Venditti. 2013. The density dilemma: limitations on juvenile production in threatened salmon populations. Ecology of Freshwater Fish 22: 508-519.

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EXHIBIT A

Brendan M. Connors

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POST SECONDARY EDUCATION

- **Ph.D., Ecology**, Simon Fraser University, Burnaby, British Columbia, 2011
- **B.Sc.** (*with distinction*)**, Biology,** University of Victoria, Victoria, British Columbia, 2004

PROFESSIONAL ASSOCIATION

- American Fisheries Society
- UBC Professional Leadership Network

SPECIAL SKILLS/EXPERIENCE

- Fisheries modeling and simulation
- Ecosystem indicator development and application
- Salmonid ecology and management
- Program evaluation / review
- Research design and synthesis
- Technical review of environmental and monitoring documents

PROFESSIONAL EXPERIENCE

2013 - present	**Senior Systems ecologist**, ESSA Technologies Ltd., Vancouver, British Columbia.
2013 - present	**Adjunct Professor**, School of Resource and Environmental Management, Simon Fraser University, Burnaby, British Columbia.
2011 - 2013	**Postdoctoral fellow**, School of Resource and Environmental Management, Simon Fraser University, Burnaby, British Columbia.
2005 - 2011	**Graduate research assistant**, Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia.
2003 - 2005	**Field technician and crew leader**, Center for Mathematical Biology, University of Alberta, Edmonton, Alberta.
2004	**Laboratory technician**, Institute of Ocean Sciences, Sidney, British Columbia.
2001	**Forest health technician**, British Columbia Ministry of Forests, Nanaimo, British Columbia.

SELECT RECENT EXPERIENCE

Kemano River eulachon – *Rio Tinto Alcan*, 2014 – present: development of a prioritized eulachon work plan for mitigation, monitoring, analytical activities and other studies to help to reduce critical uncertainties affecting water management decisions in the Kemano River and eulachon populations. Simulation modeling of alternative operational procedures to minimize Kemano powerhouse impacts on eulachon to aid in development of a feasible Eulachon ramp down protocol.

Statistical power analyses of Site C environmental monitoring plans – *BC Hydro*, 2014 – present: conducting statistical power analyses to quantify the ability of proposed monitoring activates to detect changes in fish species (e.g., bull trout, mountain white fish, kokanee) abundance and composition attributable to the construction and operation of the proposed Site C dam.

Fraser River sockeye salmon status assessment - *Committee on the Status of Endangered Wildlife in Canada (COSEWIC)*, 2014 – present: compilation and analysis of the best available information on Fraser River sockeye salmon including scientific, community, and Aboriginal Traditional Knowledge to prepare a comprehensive status report that will form the basis of a COSEWIC assessment on the status of the sockeye salmon in the Fraser River drainage in Canada.

Puntledge River fish entrainment strategy action planning support – *BC Hydro*, 2014 – present: development of an action plan and life cycle model and then implementation of a decision analysis to inform management policy alternatives and key trade-offs and uncertainties associated with entrainment and performance measures for Chinook, coho and steelhead in the Puntledge River watershed.

Growth, age and survival of Artic-Yukon-Kuskokwim Chinook salmon – *AYK Sustainable Salmon Initiative / Bearing Sea Fisherman's Association*, 2013 – present: conducting statistical analyses of Chinook salmon population dynamics, growth and age to better understand the drivers of the decline of Chinook salmon in the AYK region.

Coastal First Nations regional monitoring system evaluation – *Coastal First Nations - Great Bear Initiative*, 2014: conducted a comprehensive program evaluation to identify ways in which the monitoring system can be improved to better address the ongoing and emerging information needs and concerns of Coastal First Nations communities in BC.

Incorporating external environmental costs into the economics of aquaculture in British Columbia – *David Suzuki Foundation*, 2013 – 2014: conducted a bio-economic analysis of Fraser River sockeye – aquaculture interactions to quantify potential economic costs and benefits of closed and open net-pen salmon aquaculture in BC when environmental externalities are incorporated.

Estimating bycatch in Fraser River sockeye salmon fisheries – *Fisheries and Oceans Canada*, 2014: developed a 'first pass' test fisheries predictive model that incorporates test fisheries data and commercial catch data to help to inform how reliable test fisheries are for estimating commercial fishery steelhead and sturgeon bycatch.

Marine use analysis – *Parks Canada*, 2014: Development and completion of (1) a comprehensive Environmental Effects Assessment matrix incorporating relative effects of different marine uses and the relative quality of information available to support the effects and (2) supporting background papers that identify the nature, extent and severity of potential effects on marine ecosystem structure and function.

Independent review of run-of-river hydro projects and their impacts on salmonid species in British Columbia – *Clean Energy BC and Pacific Salmon Foundation*, 2013 – 2014: conducting an independent review of the potential impacts (both negative and positive) of run-of-river hydroelectric developments in British Columbia on salmonids and their habitats.

Skeena Watershed Conservation Unit 'Snapshots' – *Pacific Salmon Foundation*, 2013 – 2014: development and implementation of benchmarks to assess the status of wild salmon Conservation Units (sockeye, pink, chum, coho and Chinook) within the Skeena Watershed based on exploitation rates, stock-recruitment relationships, habitat factors and historic abundance. Creating individual conservation unit snapshots that graphically display spawner surveys; trends in abundance and indices of productivity; key life-history attributes; and stock status.

Skeena River sockeye salmon productivity in relation to spawning channel enhancement activities – *SkeenaWild Conservation Trust* 2012 – 2013: conducted statistical analyses to evaluate the evidence for adverse impacts of enhanced sockeye salmon smolts production on the productivity of wild Skeena sockeye salmon populations.

Examination of relationships between salmon aquaculture and sockeye salmon population dynamics – *Commission of inquiry into the decline of sockeye salmon in the Fraser River (Cohen Commission)*, 2010 – 2011: conducted statistical analyses evaluating the evidence for impacts of multiple stressors (aquaculture, climate and ocean-basin competition with other salmon) on Fraser River sockeye salmon. Provided expert testimony at commission hearings.

PEER-REVIEWED PUBLICATIONS

18. Ruggerone, G.T. and **B.M. Connors**. (In review) Productivity and life history of Fraser River sockeye salmon in relation to pink and sockeye salmon abundance in the North Pacific ocean. *Canadian Journal of Fisheries and Aquatic Sciences.*
17. **Connors B.M.**, M. Krkošek, L.A. Rogers, M. Sackville and L.M. Dill. (Accepted) The cost of dispersal for a marine parasite. *PLoS ONE*.
16. **Connors B.M**., and A.B. Cooper. (2014) Determining decision thresholds and evaluating indicators when conservation status is measured as a continuum. *Conservation Biology* **28**: 1626–1635.
15. **Connors B.M**., Cooper A.B., Peterman R.M. and N.K. Dulvy. (2014) The false classification of extinction risk in noisy environments. *Proceedings of the Royal Society B* **281**: 20141787.
14. Price, M. and **B.M. Connors**. (2014) Evaluating relationships between wild Skeena River sockeye salmon productivity and the abundance of spawning channel enhanced sockeye smolts. *PLoS ONE* **9**: e95718.
13. Peacock S.J., **Connors B.M.,** Krkošek M., Irvine J.R. and M.A Lewis. (2013) Can reduced predation offset negative effects of sea louse parasites on chum salmon populations? *Proceedings of the Royal Society B* **281**:20132913.
12. Frid A., **Connors B.M.**, Cooper A.B., and J. Marliave. (2013) Size-structured abundance relationships between upper- and mid-trophic level predators in temperate rocky reefs. *Ethology, Ecology, and Evolution* **25**: 253-268.

11. **Connors B.M.**, Braun D.C., Peterman R.M., Cooper A.B., Reynolds J.D., Dill L.M., Ruggerone G.T., and M. Krkošek. (2012) Migration links ocean-scale competition and local climate with exposure to farmed salmon to shape wild salmon dynamics. *Conservation Letters* **5**: 304-312.
10. Krkošek M., **Connors B.M.**, Lewis M.A., and R. Poulin. (2012) Allee effects may slow the spread of parasites in a coastal marine ecosystem. *American Naturalist* **179**: 401-412.
9. Krkošek M., **Connors B. M.**, Morton A., Lewis M.A., Dill L.M., and R. Hilborn. (2011) Effects of parasites from salmon farms on productivity of wild salmon. *Proceedings of the National Academy of Sciences* **108**: 14700-14704.
8. **Connors B.M.**, Lagasse, C. and L.M. Dill. (2011) What's love got to do with it? Ontogenetic drivers of dispersal in a marine ectoparasite. *Behavioral Ecology* **22**: 588-59.3
7. Krkošek M., **Connors B.M.**, Ford H., Peacock S., Mages P., Ford J.S., Morton A., Volpe J.P., Hilborn R., Dill L.M., and M.A. Lewis. (2011) Fish farms, parasites, and predators: implications for salmon population dynamics. *Ecological Applications* **21**: 897-914.
6. **Connors B.M.**, Krkošek M., Ford J., and L.M. Dill. (2010) Coho salmon productivity in relation to salmon lice from infected prey and salmon farms. *Journal of Applied Ecology* **47**: 1372-1377.
5. **Connors B.M.**, Hargreaves B., Jones S.R.M., and L.M. Dill. (2010) Predation intensifies parasite exposure in a salmonid food chain. *Journal of Applied Ecology* **47**: 1365-1371.
4. McConnell A., Routledge R., and **B.M. Connors.** (2010) The effect of artificial light on marine invertebrate and fish abundance in an area of active salmon farming. *Marine Ecology Progress Series* **419**: 147-156.
3. Dill L.M., Losos C., **Connors B.M.**, and P Mages. (2009) Comment on Beamish et al. (2005) "A proposed life history strategy for the salmon louse, *Lepeophtheirus salmonis* in the subarctic Pacific". *Aquaculture* **286**: 154-155.
2. **Connors B.M.**, Krkošek M., and L.M. Dill. (2008) Sea lice escape predation on their host. *Biology Letters* **4**: 455-457.
1. **Connors B. M.**, Juarez-Colunga E., and L. M. Dill. (2008) Effects of varying salinities on *Lepeophtheirus salmonis* survival on juvenile pink and chum salmon. *Journal of Fish Biology* **72**: 1825-183.

PEER-REVIEWED TECHNICAL REPORTS

2. **Connors, B.M**., D.R. Marmorek, E. Olson, A.W. Hall, P. de la Cueva Bueno, A. Bensen, K. Bryan, C. Perrin, E. Parkinson, D. Abraham, C. Alexander, C. Murray, R. Smith, L. Grieg, and G. Farrell. 2014. Independent Review of Run-of-River Hydroelectric Projects and their Impacts on Salmonid Species in British Columbia. 157 pp + xiv.
1. **Connors B.M.** 2010. Examination of relationships between salmon aquaculture and sockeye salmon population dynamics. Cohen Commission Technical Report 5B. 115 p. Vancouver, BC.

RECENT PROFESSIONAL SERVICE

- Board of Directors, Salmon Coast Field Station, Broughton Archipelago, British Columbia.
- Mentor for UBC's Professional Leadership Network Mentorship Program.
- Review of seafood sustainability guidelines for Monterey Bay Aquarium.
- Expert testimony for the House of Commons Standing Committee on Fisheries and Oceans.
- Dozens of presentations on salmon, aquaculture and marine conservation to local angling and conservation organizations.
- Manuscript review for: Canadian Journal of Fisheries and Aquatic Sciences, Journal of Applied Ecology, Current Zoology, Hydrobiologia, PLoS One.

AWARDS

- Mathematics of Information Technology and Complex Systems Internship, 2011
- Simon Fraser University President's Research Stipend, 2010
- Best talk, Ecological and Evolutionary Ethology of Fishes Conference, 2010
- Graduate Scholarship in Coastal Studies, 2010
- Natural Sciences and Engineering Research Council Postgraduate Scholarship 2009
- Best talk, Pacific Ecology and Evolution Conference, 2009
- Fellowships in Fisheries Biology, Marine Sciences, and Biology, 2008-2009
- Natural Sciences and Engineering Research Council Industrial Scholarship, 2005
- Bamfield Marine Station Scholarship, 2004

SELECT INVITED PRESENTATIONS

"Quantifying the reliability of metrics of conservation status", Fisheries Center, University of British Columbia (2014)

"Beyond the Ivory Tower: Non-academic careers in the life sciences", Simon Fraser University (2014)

"An independent review of run-of-river hydro projects and their impacts on salmonid species in BC" Ministry of Forest Lands and Natural Resource Operations, South Coast Region (2014)

"Disease in Pacific salmon: what do we know?", Hakai Institute and Center for Coastal People and Ecosystem, Calvert Island (2012)

"Migration links ocean-scale competition and local climate with exposure to farmed salmon to shape wild salmon dynamics", Fisheries Center, University of British Columbia (2012)

"Migration links ocean-scale competition and local climate with exposure to farmed salmon to shape wild salmon dynamics", Pacific Biological Station, Fisheries and Oceans Canada (2012)

"Exploring correlations between pathogens in farmed salmon and wild salmon survival", Think Tank on Pathogens and Disease in Salmon, Center for Coastal Studies, Simon Fraser University (2011)

"Competition, disease, and the big bad ocean: what is causing declines in Fraser River sockeye salmon?", Department of Biology, University of Alberta (2011)

"Aquaculture, early marine interactions among salmonids and their population dynamics", Les Ecologistes, Simon Fraser University (2010)

"Salmon aquaculture: lessons form the Broughton Archipelago", Department of Biology, Capilano University (2009)

"Trophic transmission of sea lice in Pacific salmon", BC Society of Parasitologists annual meeting (2008)

"The behavioural ecology of sea lice", Bamfield Marine Science Center (2007)

SELECT CONFERENCE PRESENTATIONS

"Climate, competition and aquaculture impacts on the dynamics of Fraser River sockeye salmon and the economics of their fisheries", American Fisheries Society Annual Meeting, Quebec City, Canada (August 2014)

"Are there too many pink salmon in ocean? Productivity and life history of sockeye salmon in relation to pink and sockeye abundance across the North Pacific", North Pacific Marine Science Organization (PICES) Annual Meeting, Nanaimo, Canada (2013)

"How often might we cry wolf? The false classification of extinction risk in noisy environments", Canadian Society for Ecology and Evolution Annual Meeting, Kelowna, Canada (2013)

"Unraveling the influence of multiple stressors on the dynamics of Pacific salmon", Ecological Society of America Annual Meeting, Portland, USA (2012)

"Going, going, not gone? Autocorrelated noise and the false classification of extinction risk", Society for Conservation Biology North American Congress, Oakland, USA (2012)

"Allee effects and the establishment of infectious disease", Interdisciplinary Ecology of Aquatic Systems Symposium, Burnaby, Canada (2012)

"Aquaculture impacts on interactions between salmonids: From individual behaviour to population dynamics", Ecological and Evolutionary Ethology of Fishes, Vancouver, Canada (2010)

"Salmon louse trophic transmission: Patterns and consequences", International Sea Louse Conference, Victoria, Canada (2010)

"Coho salmon productivity in relation to salmon aquaculture", American Fisheries Society WA-BC chapter AGM, Nanaimo, Canada (2010)

"What makes salmon population go up and down?", Interdisciplinary Ecology of Aquatic Systems Symposium, Burnaby, Canada (2010)

"Aquaculture and predator-prey interactions: Lessons form the Broughton Archipelago", Pacific Ecology and Evolution Conference, Bamfield, Canada (2009)

"Trophic transmission of sea lice in Pacific salmonids", Canadian Society for Ecology and Evolution, Vancouver, Canada (2008)

"Trophic transmission of *Lepeophtheirus salmonis* in Pacific salmon", International Sea Louse Conference, Puerto Montt, Chile (2008)

"Parasites, predation and trophic transmission", Pacific Ecology and Evolution Conference, Eatonville, USA (2008)