No. 100112-6

SUPREME COURT OF THE STATE OF WASHINGTON

PROTECT ZANGLE COVE; COALITION TO PROTECT PUGET SOUND HABITAT; and WILD FISH CONSERVANCY,

Petitioners,

v.

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE; JOE STOHR, Acting Director of the Washington Department of Fish and Wildlife; and PACIFIC NORTHWEST AQUACULTURE, LLC,

Respondents,

and

TAYLOR SHELLFISH COMPANY, INC.,

Respondent-Intervenor.

THE CONSERVATION ANGLER'S AMICUS CURIAE MEMORANDUM IN SUPPORT OF REVIEW

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I. INTRODUCTION

The Conservation Angler ("TCA") urges the Court to grant the Petition for Review so that it may correct a significant error of law below and restore the Hydraulic Code's ability to protect Washington's wild fish.

TCA supports the request for discretionary review because the robust enforcement of the Hydraulic Code is a matter of vital public interest. *See* RAP 13.4(b)(4). Such enforcement is crucial to protect the habitat necessary for wild fish to survive and thrive. If we fail to protect this habitat from further degradation, we will also fail to prevent the extinction of many species of wild fish, including salmon. Not only are these wild fish populations of great historical, cultural, economic, and recreational importance, but they are also central to the health of Washington's aquatic ecosystems. If these wild fish disappear, we will also lose other wildlife that depends upon them for survival, including the critically endangered Southern Resident Killer Whales.[1]

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[1] *See* Southern Resident Orca Task Force, Report and Recommendations (November 16, 2018), available at:

Specifically, TCA seeks to call the Court's attention to the important role the Hydraulic Code should play in regulating finfish aquaculture, *i.e.* net pens. Washington is the only state on the Pacific Coast that permits commercial net pen facilities, the construction and operation of which can pose significant dangers to wild Pacific salmon and steelhead populations. If Washington continues to allow net pens, it is essential that it also have an effective means of regulating them to protect wild fish populations. With the Hydraulic Code, the state Legislature provided the Washington Department of Fish and Wildlife ("WDFW") with a powerful tool to protect fish life from the dangers posed by finfish aquaculture. WDFW has not only refused to use this tool— it has unlawfully sought to exempt the entire

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https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_reportandrecommendations_11.16.18.pdf, at 43 (discussing the importance of enforcement of the Hydraulic Code as part of its third recommendation for preventing the extinction of Southern Resident Killer Whales, to "[a]pply and enforce laws that protect habitat").

The National Marine Fisheries Service ("NMFS") listed the Southern Resident Killer Whale Distinct Population Segment ("DPS") as an endangered species in 2005, and identified inadequate prey availability, specifically salmon, as a primary limiting factor. 70 Fed. Reg. 69,903, 69,908 (Nov. 18, 2005).

aquaculture industry from the requirements that virtually every other Washington business and private individual must follow.

By overruling the Court of Appeals and invalidating WAC 220-660-040(2)(l), the Court would clear the way for the full and effective enforcement of the Hydraulic Code to protect fish life from net pen aquaculture,

II. IDENTITY AND INTEREST OF *AMICUS CURIAE*

TCA is a subsidiary of Wild Salmon Rivers, a nonprofit 501(c)(3) organization incorporated in Washington and headquartered in Edmonds, Washington. TCA works to support wild fish, fisheries, and marine ecosystems, and to protect and conserve wild steelhead, salmon, trout, and char throughout their Pacific range, from the Pacific Northwest all the way to Russia's Kamchatka Peninsula.

TCA is a watchdog organization—holding public agencies, countries, and nations accountable for protecting and conserving wild fish for present and future generations. TCA uses education, legal, administrative, and political means to prevent the extinction of wild fish, and foster the long-term recovery of wild steelhead trout, salmon, and char to fishable and, ultimately, harvestable abundance. TCA administers publication of *The Osprey: International Journal of Salmon and Steelhead Conservation*, which presents the latest scientific research, policy, news, and opinion about wild Pacific salmon and steelhead conservation.

The Hydraulic Code is one of Washington's most important environmental protection statutes, and the only one whose sole purpose is to protect fish life. The Hydraulic Code places crucial restrictions on projects that affect the state's lakes, rivers, wetlands, estuaries, tidelands, and other waterways, in order to preserve the conditions necessary for wild fish to spawn, grow, forage, shelter, and thrive. TCA believes it is essential that WDFW fully implement and aggressively enforces the terms of the Hydraulic Code to protect and preserve Washington's wild fish populations. Ensuring robust enforcement of the Hydraulic Code is thus crucial to TCA's mission to protect and conserve wild steelhead, salmon, trout, and char within Washington's waters.

III. STATEMENT OF THE CASE

TCA accepts the facts, legislative history, and procedure of that have been set forth by the Court of Appeals' published opinion, and by the briefing of Petitioners.

However, the Court of Appeals and all the parties have focused almost exclusively on the exemption that WAC 220-660-040(2)(l) provides to industrial *shellfish* aquaculture facilities. What TCA believes has been overlooked is that WDFW has also exempted *finfish* aquaculture facilities from the requirements of the Hydraulic Code. *See id.* (exempting the "[i]nstallation or maintenance of tideland and floating private sector commercial fish and shellfish culture facilities").

If not for the exemption provided by WAC 220-660-040(2)(l), the net pen facilities used by the finfish aquaculture industry would clearly qualify for regulation under the Hydraulic Code. *See* RCW 77.55.011(11) (regulating "the construction or performance of work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or freshwaters of the state").

A net pen is "basically a cage in the open water" for farmed fish.[2] Eggs are hatched at freshwater hatcheries, and the fish are

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[2] Washington Dep't of Ecology, DRAFT Guidance for Marine Net Pen Aquaculture in Washington State: Regulations, Risk and Management (2021), available at: https://ecology.wa.gov/DOE/files/4a/4aa93ffc-e37b-427d-993c-3d12c7b94054.pdf ("Ecology Draft Guidance"), at 15.

cultured to a certain size prior to transfer to the marine net pens, where they are reared in a saltwater environment until they reach desired harvest size.[3] Net pen facilities keep fish tightly packed in crowded conditions, which have been likened to concentrated animal feeding operations (also known as CAFOs) on land.[4]

Multiple pens are joined together to create an "array," a vast floating facility that may extend over several acres.[5] A typical net pen array in Puget Sound includes individual net pens that are joined together and then surrounded by a single, stronger net to keep out predators.[6] The arrays are typically attached to floating walkways, with additional overwater structures that include places for boats to dock, and nearby barges from which staff feed and

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[3] *See* description and citations in Appellants' Opening Brief, *Wild Fish Conservancy, et al. v. Washington Department of Fish and Wildlife*, No. 99263-1 (Wash. Mar. 19, 2021) ("WFC Brief"), at 9.

[4] *Id.* at 10.

[5] Swinomish Indian Tribal Community's Amicus Curiae Brief, *Wild Fish Conservancy, et al. v. Washington Department of Fish and Wildlife*, No. 99263-1 (Wash. Aug. 13, 2021) ("Swinomish Brief"), at 4, 9 (describing the Cook Aquaculture Hope Island net pen proposed for the mouth of the North Fork of the Skagit River, a 12.65-acre aquaculture facility that would be designed to hold 350,000 steelhead).

[6] Ecology Draft Guidance at 15.

tend the fish.[7] Varied materials are used for the extensive construction elements of net pens, including the nets, anchors, floats, lines, walkways, docks, and barges.[8]

Net pens must be anchored in saltwater areas that are deep enough so that they will not touch the sediment bottom even during low tide.[9] They depend upon a constant inflow of fresh water to maintain the health of the farmed fish, which in turn washes out concentrated amounts of fish feces and fish pellets into the open waters.[10]

Net pen facilities thus involve extensive "construction," including floating pens, docks, and walkways, and the anchors that attach to the pens to the bed of saltwater areas. Since they are open pens through which the ocean water flows, they also, by their very

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[7] Ecology Draft Guidance at 15.

[8] *Id.*

[9] *Id.*

[10] *Id.*; Swinomish Brief at 5; *see also* Report of John Volpe, Ph.D, *In the Matter of: Wild Fish Conservancy v. Cooke Aquaculture*, No. 2:17-cv-01708-JCC (W.D. Wash. April 10, 2019) ("Volpe Report") (attached hereto as Exhibit A), at 5 ("Net pens are "open" in the sense that their mesh walls retain production animals but permit fresh, oxygenated water to freely flow into the pen while biological wastes flow out – subsidies which increase the profitability of the enterprise.").

nature, "use, divert, obstruct, or change the natural flow" of ocean water. *See* RCW 77.55.011(11) (defining activities regulated by the Hydraulic Code).

Yet due to the exemption created by WAC 220-660-040(2)(l), Washington net pens are not subjected to the requirements of the Hydraulic Code, which would provide an extra layer of protection to prevent or mitigate the dangers that net pens pose to wild fish populations.

IV. ARGUMENT

A. Poorly Regulated Finfish Aquaculture Poses Serious Threats to Washington's Wild Fish Populations

Washington is the only state on the Pacific Coast that permits commercial net pen facilities, the construction and operation of which can pose significant dangers to fish populations. Net pens pose a variety of significant dangers to wild fish:

- The closely confined quarters of net pens breed pathogens and sea lice that spread from farmed fish to wild fish. Even if the wild fish are not killed by the infection or infestation, they may be weakened and susceptible to secondary infections.[11]

- Some escapes from net pens are inevitable, through gradual "leakage" through holes in the nets.[12] If the physical construction of a net pen is inadequate, or poorly maintained, the farmed fish may escape in huge numbers—as happened during the catastrophic failure of the Cook Aquaculture net pet in 2017, which released an estimated 300,000 adult Atlantic salmon into the Pacific.[13]

- Escapes of farmed fish present well-documented threats to wild fish, caused by farmed fish competing for scarce resources such as habitat and food, preying on juvenile wild fish and their food; spreading parasites and disease widely

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[11]Volpe Report at 18-19.

[12] *See* discussion and references in WFC Brief at 10; Volpe Report at 5 (escapes are so inevitable that the United Nations FAO has declared that they should be considered a purposeful introduction into the wild).

[13] *Id.* at 11.

among wild populations; and depending on the species, mating with wild fish and weakening their genetics.[14]

- When net pen operators use vacuum pumps to harvest their fish, native herring and juvenile salmonids that are drawn to the food in the pens, including federally protected juvenile Chinook salmon, may be sucked up by the vacuum pumps.[15]

The physical obstructions created by the net pen facilities cause additional damage to the surrounding ecosystem, including natural fisheries. As Swinomish tribal leaders, elders, and fishers have argued, net pens violate their treaty fishing rights because the anchor lines damage their nets, entangle their crab pots, and force tribal fishers to steer clear of productive salmon fishing areas.[16]

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[14] *See id.* at 13, 17-18, 21. Volpe describes the extensive adverse impacts on wild salmonids of the large-scale escape of farmed Atlantic salmon from Cooke's net pens in 2017, along with smaller scale chronic leakage.

[15] *See* Report of Nick Gayeski, Ph.D., *In the Matter of Wild Fish Conservancy v. U.S. Envtl. Prot. Agency, et al.,* No. 2:15-cv-01731-BJR (W.D. Wash. May 7, 2018) (attached as Exhibit B), at 14.

[16] Swinomish Brief"), at 2, 4-5, 9. During the public comment period on Cooke's application, the Tribe submitted extensive comments expressing concerns with Cooke's application and

B. Enforcement of Hydraulic Code Could Mitigate Potential Harms of Net Pen Aquaculture

The purpose of the Hydraulic Code is to "ensure that construction or performance of work is done in a manner that protects fish life." WAC 220-660-010. All hydraulic projects must achieve "no net loss" of fish life. WAC 220-660-080(1). This may mean Hydraulic Code permits cannot be granted for some projects that pose an inherent risk to fish life that cannot be mitigated, or that such permits might be granted only under certain conditions.

For example, a Hydraulic Code permit could limit activity to certain "timing windows" during the year to minimize the impact on fish (WAC 220-660-330); prevent the removal of plants and other habitat features (WAC 220-660-290, -360(4)(b)-(c)); impose limitations on the construction of docks, floats and buoys (WAC 220-660-380); and regulate the use of equipment, materials, and potential contaminants (WAC 220-660-360(7)&(8)). Additional restrictions may be imposed for "saltwater habitats of special concern," including eelgrass beds

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explained how net pen structures physically interfere with access to the Tribe's treaty-reserved fishing rights and resources, and pose an unacceptable threat to the region's imperiled salmon populations. *Id.* at 5-6.

and forage fish spawning areas, which "provide essential functions in the developmental life history of fish life." WAC 220-660-320(2)(b) & (3).

Such restrictions could be meaningful in mitigating the potential harmful impacts of commercial net pen aquaculture. But WAC 220-660-040(2)(l) has undercut the fundamental purpose of the Hydraulic Code—to protect fish life—by preventing it from being enforced against commercial shellfish and finfish aquaculture operations. If not for that exemption, the Hydraulic Code could be a powerful tool to help mitigate the harmful effects of commercial aquaculture —not only when used by WDFW, but also by the citizens that the Legislature has empowered to help enforce the Hydraulic Code. *See* RCW 77.55.021(8)(a) (granting a "person with standing" the right to appeal the "issuance, denial, conditioning, or modification of a permit.").

V. CONCLUSION

This case implicates several issues of enormous public interest—the health of Washington's waterways, the protection of its endangered wild fish, and the survival of its Southern Resident Killer Whales. If WAC 220-660-040(2)(l) is an unlawful rule, then it is working contrary to the intent of the state Legislature, and eliminating one of the state's best tools to protect fish life and aquatic ecosystems. TCA urges the Court to grant discretionary review under RAP 13.4(b)(4) to decide this issue of substantial public interest.

Respectfully submitted this 19th day of October 2021.

In accordance with RAP 18.17(b), I certify that the foregoing memorandum contains 2,278 words, not including the title sheet, tables, signature blocks, or this certificate of compliance.

____
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CERTIFICATE OF SERVICE

I hereby certify that on October 19, 2021, I caused to be served a copy of the foregoing document to be delivered in the manner indicated below to the following persons at the following addresses:

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DATED: October 19, 2021

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EXHIBIT A

Report of John Volpe, Ph.D.

In the Matter of:

Wild Fish Conservancy v. Cooke Aquaculture Pacific, LLC

W.D. Wash. No. 2:17-cv-01708-JCC

April 10, 2019

I. INTRODUCTION.

I have been retained by Wild Fish Conservancy to provide opinions in this matter on two issues: (1) Cooke Aquaculture Pacific's ("Cooke") efforts to track and report the number of farmed Atlantic salmon escaping its net pens; and (2) possible effects to wild salmonids resulting from releases of farmed Atlantic salmon from Cooke's net pens in Puget Sound, including the release that occurred as a result of one of Cooke's net pens collapsing during the summer of 2017.

With respect to Cooke's efforts to track fish escaping from its net pens, it is my opinion that Cooke's Puget Sound net pens almost certainly experience slow chronic escapes of farmed fish and that Cooke is failing to accurately track and account for those releases.

With respect to impacts from fish escaping Cooke's net pens, it is my opinion that, due to the multiple and mutually independent pathways of impact, there is an overwhelming probability that the large-scale escape of farmed Atlantic salmon beginning August 19 2017, together with long term smaller scale chronic leakage of farm fish, results in adverse impacts on wild salmonids.

II. QUALIFICATIONS AND MATERIALS REVIEWED.

In my capacity as a university professor I have, over the past 18 years, specialized in the study of aquaculture-environment interactions. I have published widely in the peer-reviewed academic literature on this topic and am the only scientist in the world that has specialized in the effects of farm-escaped Atlantic salmon in the Pacific Ocean. Prior to joining the academy, I was employed by the BC Ministry of Environment, Fish Culture Section, where oversight of salmonid hatcheries and fish transportation were core responsibilities. My complete curriculum vitae is attached hereto, which provides more details on my qualifications and includes a complete list of the publications that I have authored during at least the last ten years. The only matter in which I have testified at trial or by deposition during the last four years is *Wild Fish Conservancy v. U.S. Envtl. Prot. Agency*, W.D. Wash. 2:15-cv-001731-BJR. I am being compensated for my work in this matter at my hourly rate of $150 USD.

In addition to drawing on my extensive knowledge and experience, particularly with respect to the ecological impacts of Atlantic salmon escapees in the Salish Sea, I have reviewed the materials cited herein and the following materials in developing my opinions described herein:

1. Report by Washington State agencies dated January 30, 2018, titled "2017 Cypress Island Atlantic Salmon Net Pen Failure: An Investigation and Review," and associated appendices;
2. Tables summarizing PRV testing results for Atlantic salmon recovered from Puget Sound;
3. Cooke Aquaculture Pacific's Responses to Plaintiff's Third Set of Interrogatories and Second Set of Requests for Production dated February 7, 2018 from ESA litigation;

4. Draft Report by Dr. Nick Gayeski dated April 17, 2018, titled "Discussion Segment on the estimated number of the Atlantic salmon that escaped from Cypress Island net pen #2 that were PRV-positive;
5. Letter from Douglas J. Steding to Washington State officials dated January 29, 2018, regarding "Draft Incident Review Board Report;"
6. Excel spread sheet obtained from a Washington State agency titled "Deep Water Bay Cooke Escapees;"
7. Purcell, et al., Molecular testing of adult Pacific salmon and trout (Oncorhynchus spp.) for several RNA viruses demonstrates widespread distribution of piscine orthoreovirus in Alaska and Washington, J. Fish Dis. 2017, 1–9;
8. Powerpoint obtained from a Washington State agency titled "Atantic salmon commercial aquaculture in Washington State, Briefing for WDFW Commission, Kenneth I. Warheit, Phd (Dec. 9, 2017);
9. Document obtained from Washington State agency titled "WDFW Draft: October 25, 2017; Atlantic salmon monitoring summary for multi-agency review panel conference call;
10. Office of the Auditor General of Canada Independent Auditor's Report titled "Reports of the Commissioner of the Environment and Sustainable Development of the Parliament of Canada, Salmon Farming (Spring 2018);
11. Online mapping tool provided by the Washington State Department of Fish and Wildlife identifying reports of Atlantic salmon caught in and around Puget Sound since the 2017 escape event.
12. Fleming et al. 2000. Lifetime success and interactions of farm salmon invading a native population. Proceedings of the Royal Society B-Biological Sciences (267)1517-1523.
13. Gayeski et al. 2011. Historical abundance of Puget Sound steelhead, *Oncorhynchus mykiss*, estimated from catch record data. Canadian Journal of Fisheries and Aquatic Sciences (68) 498-510.
14. Jonsson et al. 2006. Cultured Atlantic salmon in nature: a review of their ecology and interaction with wild fish. ICES Journal of Marine Science (63) 1162-1181.
15. Orlov et al. 2006. The feeding behaviour of cultured and wild Atlantic salmon, Salmo salar L., in the Louvenga River, Kola Peninsula, Russia. ICES Journal of Marine Science (63) 1297-1303.
16. Volpe, J.P. 200. Ecology of Atlantic salmon (*Salmo salar*) in British Columbia.
17. Volpe et al. 2000. Evidence of natural reproduction of aquaculture-escaped Atlantic salmon in a coastal British Columbia river. Conservation Biology (14) 899-903.
18. Volpe et al. Competition among juvenile Atlantic salmon (*Salmo salar*) and steelhead (*Oncorhynchus mykiss*): relevance to invasion potential in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences (58) 197-207.
19. McGinnity et al. 2003. Impact of naturally spawning captive-bred Atlantic salmon on wild populations: depressed recruitment and increased risk of climate-mediated extinction. Proceedings of the Royal Society B-Biological Sciences, (1673) 3601–3610.
20. Forseth et al. 2017. The major threats to Atlantic salmon in Norway. ICES Journal of Marine Science (74) 1496-1513.

21. Karlsson et al. 2016. Widespread genetic introgression of escaped farmed Atlantic salmon in wild salmon populations. ICES Journal of Marine Science (73) 2488–2498.
22. Defendant's Supplemental Responses to Plaintiff's First Set of Interrogatories, Requests for Production, and Requests for Admission to Defendant Cooke Aquaculture, LLC in ESA litigation.
23. Reports provided to Wild Fish Conservancy that Cooke generated from FishTalk.
24. Cooke's National Pollutant Discharge Elimination System Permits.
25. Cooke's annual fish release reports from 2012 through 2017.
26. Parsons Vol.2 Deposition March 01, 2016 and Exhibits 42 through 44 from the deposition
27. Cooke's Fish Escape Prevention Plan (Updated January 2017)
28. FAO 1996 Precautionary Approach to Capture Fisheries and Species Introductions. Rome 60pg
29. Fiske, P., Lund, R.A. & Hansen, L.P. 2006a. Relationships between the frequency of farmed Atlantic salmon, *Salmo salar* L., in wild salmon populations and fish farming activity in Norway, 1989-2004. ICES Journal of Marine Science 63: 1182-1189.
30. Jackson, D. et al. 2015. A pan-European valuation of the extent, causes and cost of escape events from sea cage fish farming. Aquaculture 436:21-26
31. Morton, A. and J.P. Volpe. 2002. A Description of Escaped Farmed Atlantic Salmon *Salmo salar* Captures and Their Characteristics in One Pacific Salmon Fishery Area in British Columbia, Canada, in 2000. Alaska Fisheries Research Bulletin (9)102-110.
32. Schiermeier, Q. 2003. Fish farms' threat to salmon exposed. Nature 425: 753.
33. Skilbrei, O.T., Heino, M., Svåsand T. 2015 Using simulated escape events to assess the annual numbers and destinies of escaped farmed Atlantic salmon of different life stages from farm sites in Norway. ICES Journal of Marine Science (72) 670–685
34. Thorstad et al. 2008. Incidence and impacts of escaped farmed Atlantic salmon *Salmo salar* in nature. NINA Special Report 36.

III. COOKE'S TRACKING AND REPORTING OF ESCAPED FISH.

Cooke's National Pollutant Discharge Elimination System ("NPDES") require that Cooke track number of fish in its net pens and those lost to mortality, predation, and escapement. The permits further require that Cooke submit annual reports on fish escapements. The relevant permit terms are as follows:

> The Permittee must maintain a Fish Release Prevention and Monitoring Plan… The Fish Release and Monitoring Plan must include, but not be limited to, the following elements:
>
> 6. Procedures for routinely tracking the number of fish within the pens, the number of fish lost due to predation and mortality, and the number of fish lost due to escapement.

> The Permittee must submit an Annual Fish Release Report to Ecology by January 30th of each year covering the previous calendar year…. The Annual Fish Release Report must include, to the extent possible, all fish released or escaped to state waters, including all Significant Fish Releases (see S8).

Cooke states that it uses software called FishTalk to comply with these requirements. Aside from the large release at a net pen in 2017, Cooke's annual reports since 2012 report that there have not been any releases from the net pens.

A. Inevitability of Large Catastrophic and Small Chronic Escapes.

"Open net pens" are the global norm for industrial-scale fish farming operations in marine, brackish and fresh waters. A net pen is a system that confines production animals in a mesh enclosure suspended from a rigid frame at the surface. Net pens are "open" in the sense that their mesh walls retain production animals but permit fresh, oxygenated water to freely flow into the pen while biological wastes flow out – subsidies which increase the profitability of the enterprise.

Indeed, the greater the integration of the farm with the broader marine environment (minimizing impedance), the better the economic performance of the farm. However, maximizing integration so as to best leverage natural subsidies also invites challenges such as dramatically increasing the probability production fish will escape. The context here is straight forward; utilize escape-proof "closed" infrastructure and assume the costs of maintaining an independent farm environment (water filtration, water cooling, waste collection etc.) or deploy net pens to consume those natural subsidies and absorb the cost of some proportion of production fish escaping. If the cost of escaping fish is less than the capital and operational costs of their retention, there is a business case to be made for "leaky pens". The fact that open net pens remain the global standard speaks volumes in this regard.

Net pen escape events result from numerous causes. Reports by fish farming companies to the Norwegian Fisheries Directorate following escape events during the period from 2001 to 2006 indicate that escapes can be categorised broadly into i) structural failure caused by winds, waves and currents (52%); ii) operational related failure such as collisions with boats, incorrect handling of nets or damage to nets by boat propellers (31%); and iii) biological (e.g. predators) and/or other causes (17%). A recent pan-European study by Jackson et al. (2015) concluded that 75% of the 820,158 Atlantic salmon *reported* escaped in the study did so as a result of structural failure or operational error – typically leading to large-scale escape events.

So inevitable are open net-pen escapes that the United Nations FAO has declared "*the introduction of aquatic organisms for aquaculture should be considered as a purposeful introduction into the wild*". This is particularly relevant in this case given that the UN's conclusion reflects data derived almost exclusively from large-scale escape events reported by fish farmers. Very little is known regarding the contribution of unknown and/or unreported escapes to the total escapement, however, numerous independent peer-reviewed assessments conclude that official statistics appear to greatly underestimate the numbers of escaped farmed salmon owing to non-reporting or under-reporting from some escape events (e.g. Fiske et al. 2006). In particular smaller scale, cryptic and chronic "leakage" of fish resulting from holes in net pens can go unnoticed for some period of time. Sægrov & Urdal (2006) estimate only 12-29% (dependent on a number of assumptions) of the actual number of escaped farmed salmon is reported. This is consistent with the Jackson et al. (2015) survey of European salmon farmers that concluded

> *"By far the most significant cause in terms of numbers of escape incidents was a hole in the net due to either biting (16%), predator damage (14%) or other causes. When the causes of holes in the net are examined (Fig. 3) it can be seen that taken together, net biting and predator damage, account for almost half (47%) of escape incidents due to a hole in the net.*"

These data underscore not only the cryptic nature of most escape events and therefore the inherent challenge of enumerating escapees, but also the ill-advised tendency to use the number of Atlantic salmon captured in the wild as a proxy for escape data. For example, the distance separating the number of *reported* captured farmed salmon and the actual number of free-ranging escapees was explicitly assessed in 2000 in British Columbia coastal waters. An active on-site survey of fishers, packers and processors documented 10,826 Atlantic salmon captured in the commercial fishery. The survey was conducted across only 17 days and was restricted to only Management Area 12, covering less than one half of one percent of the of the 47 Management Areas across coastal BC. What is of particular interest here is that the official DFO reported number of Atlantic salmon captured, for the entire year, for the entire coast, was 7,834. Thus, in one small corner of the BC coast, in a brief snapshot of time, a proactive and comprehensive survey documented ~40% more captured salmon than were reported through official channels, across the entire coast, for the entire year. These data force the observer to draw the same conclusion as with farm escape data: official *reported* numbers of both escapes and captures are likely to underestimate, often significantly, the real numbers.

B. Cooke's Tracking and Reporting of Fish Escapes.

This conclusion is reflected in the analysis of Cooke's FishTalk data base. FishTalk is a commercial database software tailored for aquaculture applications. The data which I have assessed are the day-to-day farm production and operational data entered by Cooke employees (i.e. not FishTalk-generated data or projections). In my opinion these data are certain to contain meaningfully significant error. Further, the distribution of error is non-random and skews in favour of eliminating the appearance of escapes from Cooke's open net-pen operations. This conclusion is based on the following four evidentiary themes.

1) Cooke's data exhibit significant deviation from globally accepted salmon aquaculture norms with respect to escape numbers

Science Advisory Report 2013/50 from the Canadian federal government regulator Fisheries and Oceans Canada distills the global reality of salmon farming; "*Despite improvements in technology and operational procedures, escapes of farmed salmon reared in* *marine net pens are inevitable, and based on current recapture methods, attempts to recover them are generally not successful."* Escapes are simply a reality of net pen aquaculture, both infrequent large-scale catastrophic events and small-scale though much more common, "leakage" events resultant from holes in nets made by predators, storms or operators (e.g. engine props) and by operator error (e.g. fish lost during transfers into/out of net pens). I reviewed operational data covering the production and harvest of 6.1 million Cooke Atlantic salmon in Puget Sound over four years which details no fewer than 33 categories of mortality and yet reports only a single escape event. The absolute absence of reported escape events, save one catastrophic and unignorable event, beggars belief and calls into question the credibility of the entire data set. I have to conclude as any knowledgeable dispassionate observer would: Cooke's FishTalk escapee data cannot be accurate.

Norway is the world leader in not only farmed salmon production but also in volume, breadth and precision of salmon farm data. This is in part due to the government – environmentalist – industry landscape of Norwegian salmon farms being significantly less fractious than for instance, that which the North American industry inhabits. The result is significantly greater industry transparency in Norway, where industry, academic, eNGO, and government researchers typically collaborate on research agendas.

In this less agonistic environment, industry is more transparent with regard to its challenges (and opportunities) – including escape data. Here, escape events are a given. This is not to say that every effort is not being made to reduce escape numbers and indeed significant progress appears to have been achieved. But, "zero escapes" save for one catastrophic and therefore undeniable pen failure would be rightly labelled as fiction. Analysis of 2014-2016 industry-reported escape numbers (years absent major catastrophic events) to Norway's federal Directorate of Fisheries, yields an expected escape ratio of 1 salmon per ~1500 harvested salmon. Even given the relative transparency of the Norwegian industry the Directorate takes pains to highlight that "*the Directorate of Fisheries is aware that escapes occur beyond those that are reported"* and it publishes *reported* numbers that are known to be underestimates of reality.

Recent peer reviewed published research (Skilbrei et al) show the real number of escapes is two- to four-fold greater than the values reported by the Directorate. The causal mechanisms underlying the discrepancy cannot be discretely quantified but are likely a mix of under- or non-reporting by farmers and escapes that are simply unobservable owing to the nature of the event. If we take the conservative Norwegian estimate of 1 escaped salmon per 1500 successfully grown out and harvested, instead of the 'zero' reported I would expect to see ~4100 escaped salmon reported by Cooke (above and beyond the those reported from the single catastrophic event) given the number of harvested salmon over the four year period examined.

2) Excessive and unexplained deviation in *fish in* versus *fish out* numbers

Cooke's FishTalk inventory control data expose a number of significantly problematic issues with regard to data accuracy, precision and uncontrolled error.

Cooke's explanation of FishTalk (Defendant's Supplemental Interrogatory Responses) states that

"Employees at individual sites and the hatchery are responsible for routinely entering data to the FishTalk regarding the following parameters:

...

8. Fish opening and closing stock counts, calculated based on the number of fish that entered the pen, minus mortality counts and harvest numbers.

Employees are to record the fate of all production fish as either *harvested* or *pre-harvest mortality*, without provision of possible other fates such as *escaped*. This suggests implicit instruction to staff that escape events are not to be recorded. This observation helps explain the significant magnitude of error evidenced in the FishTalk data under the column "*Deviation count in period*" which quantifies the number of fish unaccounted for in the FishTalk inventory control system.

Over 214 operational units (individual cycles of fish in to harvest) I assessed, deviation counts ranged from -6,590 fish to +6,661. The former value (-ve) means 6,590 salmon were lost and unaccounted for – neither harvested nor a pre-harvest mortality - though not a single fish is reported to have escaped. The latter value (+ve) means 6,661 more salmon were harvested than were thought to occupy that net-pen unit. Therefore, as percent of total harvested salmon, the error in Cooke's inventory control ranged from -26.6% to +24.0%. Though these are the extreme values in each direction, instances of unaccountably losing or alternatively overcounting one quarter of the inventory signals significant issues of confidence in inventory control procedures – procedures Cooke holds up as sole evidence of the absence of escapes. The mean deviation value for the 42 production units that unaccountably lost fish is -1205 salmon whereas the 172 units that apparently underestimated fish going in (or overestimated mortality losses) was on average +1339 salmon. The average count of harvested salmon from the units assessed was 28,920 salmon per unit. Thus, on average Cooke underestimates losses by 4.2% or alternatively overestimates occupancy by 4.6% yielding a range of average error of 8.8%.

The above analysis reflects data from 214 of 226 operational units for which there was not a single reported escaped salmon – a monumental outlier of industry norms. The analysis omitted an additional 12 units, ten of which were the Cypress Island Site 2 units involved in the catastrophic collapse event of August 2017. Eight of these ten units are recorded as losing the entire complement of salmon (157,214). The remaining two Cypress Island units are reported as losing either a partial complement as escapes (Unit 221) or none at all (Unit 212). However, it is clear both units suffered considerable destruction as mortality counts due to "mechanical damage" were 29,760 and 29,565 salmon, respectively. These data paint a picture of carnage in which the vast majority of production fish in both pens were killed by the collapsing cage infrastructure. And yet, amid such chaos the count deviation for both units is recorded as "zero" – perfect agreement between the number of salmon thought to occupy those pens and the number reported post-collapse.

In addition to the ten Cypress Island units discussed above, only two additional units, Bainbridge Island, Fort Ward (F01 and F02) closing 2014, were recorded as having perfect agreement (i.e. zero deviance) between fish in and fish out estimates. These two units are also highly anomalous in that production fish resided in the units for only three weeks (F01) and five weeks (F02) but lost 60% of production fish in those brief time spans. Losses were categorized as 33% being lost due to "mechanical damage" and 5% each to "predators" and "unspecified" causes (plus a further 17% to other factors). Despite what appears to be deeply flawed and problematic production units, the tally of fish in - fish out estimates are in perfect agreement and not a single escaped fish is reported for either unit. These data are extremely difficult to accept and again undermine confidence in the entire dataset.

The enumeration of the partial loss of Cypress Island Unit 221 salmon to escape has profound implications. Cooke's FishTalk data ask the analyst to accept a scenario where the number of escapes exactly matches the value necessary to balance the inventory control sheet. Of course, any reasonable observer would conclude that Cooke employees did not actually observe the 2953 salmon escaping the scene, but instead that this value is *assumed* to be the escapee count given the other available data. I conclude that this approach is systemic throughout the Cooke inventory data vis-à-vis escape counts: escape events are unobservable and therefore cannot be enumerated unless evoked as part of a catastrophic event in which case escape counts are assumed. The underlying logic of this conclusion is borne out by the Unit 212 (no escapes) data. Here a net-pen collapses killing over 29,000 salmon, and yet somehow results in not a single escape. Here escapes are not required to be invoked in order balance inventory (see i) and ii) below) and therefore escapes are recorded as "zero". I submit that none of the reportedly escaped 160,167 salmon were empirically enumerated and instead this figure represents an assumed value of unknown accuracy. I extend this conclusion to all of Cooke's reported escapement values – which are calculated and assumed figures reported without empirical support.

Delving more deeply into the substantial magnitudes of count deviations I note two additional sources of significant error:

i) *a putative error rate of 2% of automated fish counters used to enumerate fish*

Cooke utilizes automated fish counting technologies rated by its manufacturer VAKI as 99% accurate. Cooke states its VAKI instruments operate at only 98% accuracy. Given the volume of fish at issue, even a 1% error rate is significant, a 2% error rate would be financially injurious. By far the costliest operational line item of any farm is feed consumption. Optimization of feed is critical to financial success and therefore I find it hard to believe Cooke would willingly operate inventory control with error rates double the industry standard given the obvious financial implications and presence of readily available solutions on the market. Notwithstanding, if we accept the 2% error rate at face value we find that 154 of 214 production units with deviations in excess of 2% (184 of 214 units in excess of 1%).

ii) *an arbitrary "mortality" of 5% of smolts during transport to marine sites.*

A second and seemingly inexplicable source of variance in Cooke's inventory tracking is the practice of arbitrarily erasing five percent of fish from its accounts when smolts are transferred from the hatchery to the farm. Staff testify that this is to account for a 5% *assumed* mortality during transport. Over my years of involvement in the BC government hatchery program or as an analyst of aquaculture best practices, I have never observed such a practice.

There is every reason to have as accurate a count as possible at every stage of grow out. Transportation of smolts does incur mortality and is expected; however, anything greater than 1% would attract the attention of managers and be cause for further investigation and corrective measures. Further, the vast majority of transport-related mortalities result from mechanical injury and thus fish could be recovered and counted directly and entered into the FishTalk database in order to maintain maximum accuracy.

Cooke's five percent assumed mortality is not only at least five times higher than industry norms, but is also not based on any empirical study or experimentation. I find this unsurprising as any competent technician should be capable of consistently transporting smolts to net pens with less than one percent mortality. Given that the practice of arbitrarily assigning a standard mortality rate, especially one so inflated, lays far outside industry norms, I advise that there should be no reliance on this assumed five percent mortality figure in balancing Cooke's inventory records.

Indeed, assuming a standard invariant transport mortality rate (of any magnitude) actually introduces two sources of uncontrolled variance. The first being the arbitrary figure itself, and the second is the real mortality which will vary independently, meaning in some cases the real mortality will be additive and in others compensatory. Cooke has at their disposal equipment explicitly designed to minimize such guesswork and generate as accurate an estimate of real standing stock as possible, but have actively chosen not to utilize it. Given that all farm costs (and therefore profits) are dependent on accurate inventory control I conclude the practice of intentionally introducing compounded and uncontrolled variation into the inventory control data is motivated to satisfy an unstated alternative objective which an unbiased observer could reasonably conclude to be to "hide" losses due to escape.

3) The unrecognized association between predation events and escape events.

Of the 33 categories of mortality tracked by Cooke staff, predation is consistently among the most prevalent. On average, 714 salmon (median 430) were reported lost to predation per unit-cycle although there was significant variability across units with a range of 4 to 5039 salmon lost per unit or <1% to 32% of total unit production. Suffice to say that predation is a significant issue at these sites. The vast majority of these losses are due to sealions and harbour seals.

The typical farm arrangement sees the production fish contained in a series of "stock nets" each adjacent to others, typically in a two-row array. The array of stock nets is in turn encircled by "predator nets" which, as the name implies, are deployed to keep marine predators from immediate access to the salmon. A predator needs not necessarily predate salmon to have an effect. The mere presence of a seal or sealion at the stock net will understandably stress salmon and stressed salmon have lower growth rates and higher susceptibility to disease so the importance of predator nets is multifactorial. However, as Cooke's data attest, predators are doing much more than just stressing production stock.

A successful predation event by a seal/sealion demands first that the predator net be breached. This is typically accomplished by biting and tearing the net until a hole large enough for the animal to fit through is created. Once inside the predator net the animal will go to work in similar fashion on the stock net. Predator nets are coarser and more robust than stock nets and so if an animal has successfully breached it, there is little expectation for a stock net to be impenetrable. However, stock nets need not be fully breached for the predator to be successful. An animal may attack a salmon through an intact stock net, biting the salmon and net together and then attempt to tear the salmon through the net. Sometimes in so doing the animal may create a hole large enough to pull the salmon through other times, not.

The preceding paragraphs highlight three important points. First, every predation event is carried out by an animal proven to be able to breach a net. Second, predation events are inferred, and very rarely witnessed. Third, predation events create holes through which salmon may pass.

Scuba divers are a constant presence at marine grow out facilities. Their main duties in addition to general monitoring of the sub-surface environment are the collection of dead salmon inside the stock nets and repair of holes to both predator and stock nets. Cooke's predation count data are based on the number of recovered dead salmon that show signs of having been predated upon. What these data do not capture – cannot capture – are the number of salmon fully consumed because no (or nearly so) predation event is actually witnessed but is instead inferred. The assumption built into the data is that every predation event results in a partially consumed salmon carcass. While this does happen on occasion (there is no literature available that quantifies this) the scientific literature contains numerous studies that document predators successfully removing the whole fish and in so doing creating holes in stock nets. Therefore, I conclude Cooke's predation count data are an underestimate of an unknown degree. Further, given the magnitude of predation evidenced it is inconceivable that stock nets have not been breached a great many times, creating ample opportunity for undocumented escape of stock fish.

4) The high proportion of unknowable "mortalities" which are more correctly termed "losses"

Of the 33 mortality categories tracked Cooke's FishTalk database, four are populated with calculated and inferred values. Of the three years of data I assessed 202,536 salmon are listed as "mortality – unspecified", 212,202 as "mortality – mechanical damage" and 161,288 as "mortality – predation" and "escapes". Each of these categories carries unknowable degrees of uncertainty and together comprise 35% of all reported mortalities. The point here is that more than a third of all losses come with unknowable but likely substantial error. Despite this abundance of uncertainty, escapes are recorded as absolutely invariant at "zero" in 217 of 226 production cycles (the balance being involved in the 2017 catastrophic collapse). I find a high degree of incongruence here. There appears to be a high tolerance for inferred, error-laden estimates but a refusal to do the same with escape estimates. Given the extreme density of production fish in stock nets a conservative release estimate is likely to be ~ 30 fish per hole-hour (one every two minutes). Such an estimate is conservative and is as simple (simplistic) and accurate as many of Cooke's other data categories.

C. Behaviour is not an Acceptable Method of Escape Enumeration.

Finally, I consider the means by which Cooke generates escape counts. In testimony, Cooke staff explain that escapes are enumerated via behavioural monitoring by farm staff. I trust any reader of this report immediately recognizes the folly of such an approach. In brief, it is the belief of Cooke staff that an escape event manifests a detectable and reliable change in behaviour of remaining fish. Therefore, if this (undescribed) behaviour does not manifest, there are assumed to have been no escapes. For the sake of unpacking this, I will temporarily accept this position and pose some rhetorical questions:

1) Does this behaviour manifest with the escape of a single fish or is there a threshold of escape numbers necessary to trigger it?

2) How are escapes enumerated during the majority of the day and all of the night when there are not eyes on the fish?

3) What are the rates and magnitudes of Type I or Type II errors? (false positive / false negative)?

Obviously, one could carry on for some time exposing the absurdity of such an extraordinary claim. In short, no such methodology is recognized, anywhere. Further, and at the risk of stating the obvious, one cannot quantify a variable (number of escapes) by using a two-factor state space (behaviour expressed = yes or no). To state this plainly, monitoring a cage population for the appearance of a certain behaviour permits in no way, shape or form, the capacity to enumerate escapes. Therefore, given Cooke's methodology, "zero escapes" across the board is not only unsurprising, it is the unavoidable outcome. This exercise in fiction is further enabled and abetted by Cooke's willful blunting of accuracy of its own bookkeeping as described in the sections above.

D. Conclusion on Cooke's Fish Tracking Efforts.

In sum, it is my opinion that Cooke is not appropriately tracking and reporting the number of fish lost from its Puget Sound salmon farms to escapement. This stems from Cooke's insertion of unsupported assumptions into its tracking data that masks the number of fish lost to leakage; including Cooke's assumption that its electronic counters are only 98% accurate and the assumption that 5% of the farmed fish are lost during transport to the marine net pen. Further, when Cooke's own data shows fish that are unaccounted for, even with these unsupported assumptions, Cooke does not report the fish as escapes, but instead writes off its own data.

IV. ECOLOGICAL HARM FROM ESCAPES.

Beginning on or around August 19, 2017 "Net Pen #2" of Cooke Aquaculture Pacific's ("Cooke") Cypress Island operation suffered a catastrophic failure resulting in the release to Puget Sound of a large number of Atlantic salmon – a species officially considered "invasive" by Washington State Department of Fish and Wildlife ("WDFW"). Cooke represents that the failed pens contained approximately 305,000 adult fish that were between 24 and 28 months of age, having spent 9 to 12 months in freshwater and 15 months in saltwater. The fish were both male and female. The State of Washington estimates that between 243,000 and 263,000 fish escaped into Puget Sound and that, of those, between 186,000 and 206,000 were not recovered and remain unaccounted for.

In addition to large escapes such as this, smaller escapes are known to occur more regularly when underwater nets are torn by tidal conditions, predators, or from other causes. These two types of escapes can have cumulative impacts to wild salmonids.

A. Modes of Interaction.

The release of farm Atlantic salmon into Puget Sound creates numerous potential pathways for negative impacts on native fauna. Native salmonids are especially susceptible; the taxonomic proximity of native Pacific salmonids to Atlantic salmon greatly increases the likelihood of interaction, each seeking similar habitats, prey etc. at each life history stage. Sympatry (occurrence in the same place, at the same time) whilst seeking similar resources ensures significant interaction, a prerequisite for direct impact. The magnitude of impact of exotic or invasive individuals on native populations can be modulated by many factors, however the overriding consideration is one of demographics. The greater the number of invaders (*aka* propagule pressure) the greater the potential impact. However, the receiving environment and native populations play a role here too. Degraded environments and/or distressed native populations are significantly more likely to be negatively affected by a given propagule pressure relative to heathy environments and populations. The logic here is self-evident, the greater the number of invaders and the less abundant and/or resilient the native populations, the greater the likely impact on the native populations.

The modes of interaction between farm-escaped Atlantic salmon and native Pacific salmon may occur via five general pathways; competition for limited resources (e.g. food, optimal nest sites), predation, transfer of parasites and/or disease, hybridization, and colonization (long term occupancy altering foundational ecological processes). I will consider each of these individually in turn, though it is important to recognize that these impacts can be cumulative as they are not mutually exclusive.

1. Competition.

Competition ensues when demand for a limited resource exceeds supply. Competition is by definition a negative interaction for all parties. In the ecological context the winner of a competition is the party that maximizes their cost:benefit ratio, or put another way, the party that losses least overall. Key resources for which competition may arise between farm-escaped Atlantic salmon and native salmonids is habitat/food, nest sites, and/or mates, all of which are relevant in freshwaters whereas habitat/food competition will also occur in marine waters.

In the freshwater environment juvenile salmon are territorial. An individual maintains a territory so as to maintain exclusivity to food that is in or passes through that territory. An optimal territory is one that is both rich in feeding opportunities and provides some protection from predators (typically large resident trout, sculpin and birds). Juvenile Atlantic salmon in freshwater are almost entirely insectivorous and therefore direct predation on native juvenile salmon is highly unlikely. However, negative impact does manifest through agonism directed at native salmon that are subsequently forced into suboptimal territories yielding fewer feeding opportunities and/or increased susceptibility to predators, both of which leading to increased mortality rates.

This is precisely the mechanism that was long thought to explain why despite dozens of attempts between 1905-1933 to purposely establish Atlantic salmon in British Columbia, all efforts eventually failed. Attempts in Washington State (1951, 1980, 1981) ended similarly. Though no organized research was ever conducted, general consensus was that juvenile Atlantic salmon are competitively inferior to native Pacific salmonids (all stocking events were of juveniles into freshwaters). Before such qualitative assumptions can be used to predict the fate of any Cypress Island progeny we must first understand *why* those introductions failed and ask if conditions are the same today.

I spent five years conducting research to answer the question "*why did historical introductions of Atlantic salmon fail?*". In summary of this research (and the only Atlantic salmon-Pacific salmon competition research ever conducted in the Pacific), historical introductions failed because of "prior residency effect" of native salmonids. Before explaining this in detail, it is worth exploring the details of the experiments as they are relevant to the present issue.

In July 1999 a large population (116 individuals) of naturally spawned and reared juvenile Atlantic salmon consisting of two size/age classes (fry and parr) was found in Amor de Cosmos Creek, 35 km north of Campbell River, Vancouver Island, British Columbia. The size/age classes present confirmed these fish were the product of two successive years of natural reproduction. This wild population presented the first ever opportunity for empirical, *in situ* evaluation of wild-reared Atlantic in Pacific waters. In particular we focused on quantifying the interaction between juvenile Atlantic salmon and native salmonids. To do this we compared habitat use, agonistic behaviour, foraging efficiency and condition factor between sympatric native salmonids and feral Atlantic salmon to control populations from the same river not exposed to Atlantic salmon. Our objective was to evaluate if competitive superiority of native salmonids is likely to constitute biological resistance to Atlantic salmon colonization, and thus explaining the failure of past introductions.

The study area was bisected by a water fall. Below the falls were both Atlantic and Pacific (Chinook, coho, cutthroat and rainbow/steelhead) salmonids. Above the falls only the Pacific salmonids were present. Therefore, the falls created a natural experiment, a single contiguous system with two sections, one with and one without Atlantic salmon. We conducted 1038 five-minute in-water observations of focal fish (>86 hrs total) across both sections. The results were:

- Significant habitat-partitioning between Atlantic salmon and Pacific salmon was evident. Juvenile Atlantic salmon (both fry and parr) resided exclusively in high-energy reaches together with juvenile steelhead. Atlantic salmon interacted exclusively with steelhead. Interactions with juveniles of other native species; coho, cutthroat and Chinook, were too rare to analyze as these species remained in slower waters at the stream margins and around woody debris only very rarely interacting with either steelhead or Atlantic salmon in the mid-channel, high-energy waters.

- Significant micro-habitat partitioning was evident between mid-stream steelhead and Atlantic salmon. Steelhead aggressively defended a broad vertical range relative to Atlantic salmon, which typically adopted a still, demersal position on the stream bottom. However, those steelhead sympatric with Atlantic salmon exploited a statistically significant smaller stream area relative to steelhead not sympatric with Atlantic salmon.

- The presence of Atlantic salmon significantly increased steelhead intraspecific agonism. Steelhead sympatric with Atlantic salmon showed a significant bias towards intraspecific agonism, being 11.8 times more likely to attack another steelhead rather than an Atlantic salmon. This magnitude of intraspecific bias was unexpected considering the nearest fish in every case was a focal Atlantic salmon. As for Atlantic salmon agonism, an individual was nearly three times more likely to attack a steelhead than another Atlantic salmon.

- In terms of foraging efficiency, Atlantic salmon were found to be ~42% more efficient than sympatric steelhead, potentially helping to explain the 15% better condition factor of the Atlantic salmon.

In summary, the first ever (and to date only) ecological analysis of a "wild" Atlantic salmon population in Pacific waters demonstrated that wild-reared Atlantic salmon are capable of surviving and perhaps thriving. Further, significant agonistic interaction with wild salmonids was targeted at juvenile steelhead though numerous other salmonid species were present. These data suggest that wild reared juvenile Atlantic salmon are not "inferior" to Pacific salmon as has been presumed.

These conclusions align with other studies examining the performance of cultured vs wild Atlantic salmon. A recent summary article distilling all published data on wild vs farm salmon states "*When cultured Atlantic salmon are released into the wild they compete with wild fish for food, space, and breeding partners. As a result of morphological, physiological, ecological, and behavioural changes that occur in hatcheries, their competitive ability often differs from that of wild fish. These changes are partly phenotypic and partly genetic … faster growing…cultured parr's greater aggression often allows them to dominate wild parr.*" In short, farm fish are more aggressive than wild counterparts leading to demonstrable impact on sympatric wild individuals.

However, these works still leave unresolved the mechanism(s) responsible for historical failures of introductions and apparent present-day successes. To resolve this, I undertook a series of controlled mesocosm experiments where communities were 'assembled' by introducing farm-derived juvenile Atlantic salmon and similarly aged/size wild steelhead in different orders across time. A total of 1810 five-minute focal fish observations (62.7 hours) post assembly were undertaken across 22 replicates of 120 individuals each of steelhead and Atlantic salmon.

The results were as dramatic as they were clear: an individual that had the benefit of prior residency in a habitat outcompeted all subsequent 'invaders', regardless of species. In other words, when Atlantic salmon have unfettered access to a habitat for as little as three days before being confronted by steelhead, those Atlantic salmon proved competitively superior – every time. Likewise, when steelhead had prior access, they proved superior to Atlantic salmon, again, every time. The prior residency effect proved equally strong when either steelhead or Atlantic salmon resident populations were 'invaded' by conspecifics, again those with prior residence dominated every time. Numerous variables were measured throughout the experiment but the one most relevant in the current context is weight gain/loss. Invaders demonstrated their competitive inferiority by losing significant weight relative to superior residents over the course of the experiments.

It is my opinion that the prior residency effect is the key to understanding historical introduction failures why those experiences have little relevance today – the coastal environment has changed dramatically in the intervening years. The 'prior residency effect' is now recognized as a preeminent predictor of success in salmonid introductions be they intentional or not.

Historically, Atlantic salmon were introduced into habitats already at or near saturation with native competitors ensuring immediate and strong competition for the naïve Atlantic salmon who had no opportunity to establish territories. Today, abundance of native salmonid stocks, and especially the niche-equivalent steelhead have declined sharply resulting in a surplus of underutilized habitat available to a potential transplant such as Atlantic salmon. Puget Sound steelhead are estimated to be at 1-4% of their historical abundance. Any biological system that experiences a 96% decline of abundance of a high-level consumer will be at a diminished capacity to retard the establishment of a niche equivalent invader - in this case Atlantic salmon. Further, the far greater likelihood of successful acquisition of territory by present-day Atlantic salmon invaders increases the risk of prolonged exposure to native individuals by larger, aggressive competitors which is surely to lead to negative impact.

If unimpeded access to prime habitat is a key factor in successful establishment of Atlantic salmon, the threatened status of Puget Sound steelhead is likely to markedly increase the chances of Atlantic salmon colonization and attendant impacts on ESA-listed individuals. These data further suggest that the presence of farm-derived Atlantic salmon will result in significantly increased competitive pressure on Puget Sound steelhead, a population already devastated by staggering demographic decline.

Both Atlantic and Pacific salmon are anadromous, meaning adults build nets, spawn and deposit eggs in freshwater streams. Fertilized eggs remain buried beneath gravel for weeks to months, depending on species and temperature variables. Buried, eggs depend on constant exposure to clean, oxygen rich water to filter through the gravel. Therefore, egg survival depends on nests being located in areas of high flow, but not so high that nests will be destroyed or alternatively in areas where sediment may accumulate and suffocate eggs. This is to say that nest location plays a significant role in reproduction success and not surprisingly there is competition among spawning adults for not only the best mate but also for what are perceived to be the best nest sites.

My work with adult farmed Atlantic salmon demonstrated farm fish taken straight from cage culture and deposited in natural habitat (simulating an 'escape') do build nests and generally behave as one would expect wild fish to perform. However, with the fish I have worked with sexual maturation and spawning occurs very late in the season relative to fall spawning Pacific salmon. The fish I worked with did not spawn until mid-late January (however my stream surveys document adult putative spawners entering rivers as early as July). Had these same fish been involved in an actual escape and ascended a river they would find themselves with unfettered access to the entire river channel, including optimal nest sites given most Pacific salmon adults would have spawned and died by mid-January – leading to a high probability of nest superimposition. Further, the few adult fish the Atlantic salmon would likely interact / compete with are early-run winter steelhead which ascend rivers mid-November through February. Puget Sound steelhead are comprised of both the extremely depressed early-run fish and a marginally more abundant later (March-May) spawning component. The spawn timing of early-run Puget Sound steelhead is likely to put them in direct competition with farm-escaped Atlantic salmon.

My work further demonstrated that farm-raised female Atlantic salmon (females are responsible for choosing / competing for the nest site and its construction) chose only optimal sites to construct nests when given access to a gradient of nest habitat options. Therefore, an additional pathway of impact of farm-escaped Atlantic salmon is "nest imposition"; late-spawning female Atlantic salmon excavating optimal nest sites for their own eggs and in doing so destroying the nests of earlier spawning Pacific salmonids. The magnitude of this impact is a matter of demographics of both species:

- The more Atlantic salmon there are in a system, the greater the incidence of nest imposition.

- The per-imposition impact is directly related to the health of the population imposed upon. For a robust population, the loss of a nest may be negligible. For a listed population the loss of a nest is highly significant, not just demographically but also from the perspective of lost genetic diversity.

Therefore, it is my opinion that the probability of nest imposition is significant for native Puget Sound salmonids, including Puget Sound steelhead and Chinook.

2. Predation.

When the number of predators is artificially increased (such as in salmon farm escape events), demand on the prey base increases to the detriment of all. There are no data regarding such scenarios that are inclusive of farm-escaped Atlantic salmon however the consensus of studies of escaped farm salmon conclude that some proportion (typically a minority) of farm escapees successfully transition to wild forage. A recent review of anthropogenic-derived threats to wild Norwegian Atlantic salmon identified farm-escaped salmon as by far the greatest threat. The review panel pointed to significant genetic introgression of farmed salmon demonstrating not only the capacity for farm-escapees to spawn *en masse*, but that the observed introgression is facilitated by farm-escapees transitioning to wild feed; they document significant catches of foraging escaped farmed salmon on the North Atlantic feeding grounds. Ergo, escaped farmed salmon do successfully predate in the wild.

The ramifications of this with regard to native Puget Sound salmonids are self-evident. Angler catch records of Atlantic salmon compiled by Washington Fish and Wildlife indicate that the majority of escapees remained resident in Puget Sound marine waters. While the available data set is relatively small, stomach analyses of caught individuals suggest the rate of successful transition to wild feed for the farm-escapees is ~4%. Further, numerous Puget Sound anglers report catching Atlantic salmon using herring as bait, further evidence of transition to wild feed of some escapees. Using the 4% estimate, we can expect a minimum of 8,333 foraging adult Atlantic salmon (assuming an at-large population of 200K).

3. Parasites / Disease.

Narratives regarding salmon farms and parasites/disease are almost wholly focused on cage populations resident inside the cages. The hyper-density of hosts inside a cage but constantly exposed to pathogenic vectors by virtue of the permeable open net-pen construction sets in motion an epidemiological "perfect storm". Consistent exposure from external environment drives high infection rates, near perfect fish-fish transmission rates drive exponential pathogen growth and absence of predation to harvest sick enfeebled individuals, further prolongs / maximizes pathogen production. The result can often be analogous to industrial scale pathogenic culturing. However, as a result of porous open net pens, pathogens are pushed back out into the natural environment where significant spikes in the pathogen loads of wild populations are often observed.

My lab's work assessing sea lice infection rates of wild salmon found infective stage lice were 73x more abundant around farms relative to reference sites inducing mortality increases of 9-95% in wild juvenile salmonids and because of dominant unidirectional currents, we were able to observe this effect up to 80 km from the farm site. The take-away points here are:

- Open net pen fish farms unintentionally precipitate large scale epidemiological events
- Pathogenic effects of fish farms can have extraordinarily large footprints
- It is not uncommon to have extremely high infection rates of stock fish on farms

When an escape event such as Cypress Island occurs, from an epidemiological perspective the major consideration is the change in density and spatial distribution of pathogenic host fish. While contained in the net pen, pathogenic fish cumulatively represent a point source of pathogen release, potentially creating a high density pathogen zone around the farm. Risk of wild fish infection is a function of its proximity to the farm. Post escape, infected fish disperse potentially creating a much larger spatial distribution of farm-derived pathogens, but at lower density (dependent on the number of pathogenic hosts per unit area). Clearly, predicting epidemiological processes becomes far more challenging once farm fish disperse post-escape. Rather than a spatially explicit zone of impact typical of intact farms, free-ranging infected farm fish create scenarios of broad spatial scale, but lower intensity (i.e. cryptic) impacts.

Adding to the challenge of characterizing post-escape epidemiology is the phenomenon of “co-infections”. Simply put, an infected individual often has increased susceptibility to other secondary infection(s). Thus, the cumulative effect of an infection event extends past the clinical effects of the initial infection and by extension, the realized impact on a wild population typically cannot be bound by the clinical expectations of the single, initial infection.

4. Hybridization.

To date there has been no rigorous study of the likelihood of hybridization between Atlantic salmon and the six pacific salmon species. What little information is available suggests Atlantic x Pacific salmon hybridization has very low probability of producing viable offspring.

5. Colonization.

Colonization of exotic species is the second greatest threat to global biodiversity after habitat loss. Vulnerable native species are affected through predation, agonism, competition for resources, and habitat alteration and/or exclusion. The magnitude of impact is typically related to the relative abundances of invader and native species. In the present context, colonization of Atlantic salmon in Washington State waters extends the duration of impact of escapees on native Puget Sound salmonid populations. If colonization does not occur, impacts are expected to cease with the death of the last invaders. With colonization, impacts not only continue indefinitely, but due to the action of natural selection acting on the colonizing population, the magnitude and diversity of impacts on native fish species would both be expected to increase.

Will farm-escaped Atlantic salmon colonize the North American Pacific coast? is a question that is as complex as it is contentious. The short answer is “maybe” … citing the research above, it is my opinion that the probability is much higher today than it ever has been before. However, some (typically with vested industry interests) argue it is not nearly as complicated as people like myself make it out to be. It is instructive then to review past, equally strident positions held by industry and United States and Canadian governments:

“They can't escape” – confronted with evidence to the contrary the narrative changes to

“They'll escape but not survive” - confronted again, and another change

“They'll survive but not spawn” – and again

“They'll spawn but the progeny won't compete successfully” – confronted again this brings us to the present day

“Feral progeny may be able to compete but not complete their life cycle.”

And so, we have reached the very last assumed barrier to Atlantic salmon colonization: *there is no evidence that wild- spawned juveniles are capable of going to sea and returning as adults to complete the life-cycle*. Of course, there is no evidence to suggest they won't. My point here is that the farm salmon debate is characterized by a long history of assumptions favoring expansion of the industry that have fallen when tested, such as;

> "*[Atlantic] salmon have no home stream to return to in order to spawn. Instead, they would return (if they survived that long) to their home fish farm. Without a freshwater spawning ground they would be unable to reproduce.*"

1987- BC Ministry of Agriculture and Fisheries, Aquaculture and Commercial Fisheries Branch. The salmon farm debate is rife with such statements – equal parts willful ignorance and political expediency.

The final step, completion of the life cycle, is the most difficult to pursue because it depends on surveying natural river systems as opposed to testing the hypothesis in the lab. My lab group is the only such group that has ever undertaken long term, structured and rigorous Atlantic salmon surveys in the Pacific Northwest (focused in Vancouver Island rivers). We have found hundreds of free-swimming Atlantic salmon – wild reared fry, parr, smolts and migratory spawning adults. However, our collective survey effort is statistically zero, given the tiny fraction of one percent of the tens of thousands of kilometers of salmon bearing rivers on Vancouver Island we can survey, let alone mainland BC, Washington State and Alaska. In this light, I reject outright statements that conclude colonization is not possible when we cannot, with any statistical confidence, state that colonization hasn't already occurred. The simple fact is that research to date makes clear that it is possible, perhaps likely, but certainly neither impossible or a foregone conclusion.

Colonization as a concept seems straightforward but in fact it is not. Much discourse around the Cypress Island event centers around "will those escaped fish colonize?". This reflects a fundamental misunderstanding of the colonization process. It is not these specific fish that will or will not "colonize", it is their progeny, should they be produced, and their progeny after them and so on. The worst-case scenario regarding the Cypress Island fish is that some subset successfully reproduces.

As worrisome as this may be, this is not "colonization", but is a necessary precursor. Any escapees that survive to spawn (likely a small cohort relative to total escape numbers) distinguish themselves from the larger group by completing this task. They are, by definition superior to those that did not survive – and possess traits that will be passed on to progeny. This first generation (F_1) of wild fish would be reared under natural conditions and most importantly, subject to natural selection that will remove from the population individuals that perform poorly under wild conditions. Those fish that reach sexual maturity are high quality individuals, proof of which being their continued existence. When these fish spawn, they produce an entire generation (F_2) carrying only the genes of proven survivors. Natural selection again prunes the population leaving only "the best" to form the next spawning generation. With each subsequent generation survivorship is expected to grow (i.e. increasing abundance) as does the *per capita* impact of each Atlantic salmon individual, reflecting continuous tailoring of the invasive population with its host environment.

It is here that the insidious nature of colonization and its effects on native species resides. Most forms of pollution have a dose-specific impact that remains static through time. Exotic species (incl. pathogens and Atlantic salmon) however are not static, their *per capita* potential impact grows with each generation as a result of natural selection.

The take home here is that very little will be resolved immediately with regard to the colonization issue. Natural reproduction of the initial escapee cohort, should it occur, will in all likelihood be undocumented given the absence of any appropriate monitoring. A *post-hoc* occupancy modelling analysis of three years of intensive freshwater surveys concluded that when they were present Atlantic salmon were detected in surveyed streams at best 2/3 of the time (~33% of surveys erroneously conclude Atlantic salmon are absent), illustrating even the most targeted survey efforts are far from error-free.

Be that as it may, a recent report from the Washington Department of Ecology states "*The limited numbers of Atlantic salmon found in the freshwater system appear healthy. There is no evidence that they were feeding in the freshwater system nor were they sexually mature. The Atlantic salmon in freshwater may survive for some time.*" This is consistent with normal spawning behaviour for Atlantic salmon which, once returned to freshwater do not feed, with all resources instead routed to gamete production. So, the first piece of a colonization scenario is in place, with apparently healthy adults ascending rivers, which a salmon only does for one purpose. We may expect similar scenarios to be playing out up and down our coast with catches of putatively escaped fish being caught throughout Puget Sound (and north to Vancouver Island waters). Analyses from other jurisdictions however demonstrate threat of colonization by farm-escaped Atlantic – and all the attendant challenges to native stocks – is greatest in those systems most proximate to the escape site. Thus, while impacts associated with Cypress Island farm escapees may manifest far afield, all available data suggest the Puget Sound ecosystem is most at risk.

B. Conclusion on Effects of Fish Escapements.

Competition, predation, pathogen dissemination/transfer and colonization are recognized throughout the salmon farming world as being among the major pathways of impact of farm-escapees on native salmonids. The magnitude of impact is a factor of both number of escapees and population health of potentially impacted native populations. The exceptional scale of the escape event renders any knowledgeable and impartial observer to conclude that level of impact on native Puget Sound salmonids is high. Further, the extremely precarious status of the Puget Sound's three ESA-listed salmonid populations greatly reduces the invasion resistance of the Puget Sound ecosystem which greatly increases the probability of Atlantic salmon colonization and with it permanent increased predation, competition and pathogen transfer to native salmonids.

By: ______________________________

John Volpe, Ph.D.

ATTACHMENT

John P. Volpe

Associate Professor

AREAS OF EXPERTISE
Aquaculture
Ecogastronomy
[Sea]Food Ecology
Macroecology
Terroir

FUNDING TO DATE
$4,112,427

UNDERGRADUATES TAUGHT
4499 Students

GRAD DEGREES SUPERVISED
25 MSc | 6 PhD | 1 MA

EDUCATION
BSc U of Guelph 1991
MSc U of Guelph 1994
PhD U of Victoria 2001

EMPLOYMENT HISTORY
2012-Pres. Assoc. Professor UVic
2015-17 2Lt Can Armed Forces
2005-11 Asst. Professor UVic
2001-04 Asst. Professor Alberta
2000 Lecturer ENVI UVic
1995-96 Fish Bio BC Min Env

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PERSONAL SUMMARY
I and my students use data intensive approaches to uncover linkages between ecological and social sustainability, particularly with regard to sustainable food, wine, aquaculture and marine resources.

APPOINTMENTS & HONOURS
2013 Research Excellence Award - Faculty of Social Science, UVic
2010 Appointed Associate Professor University of Victoria
2007 Nominated – NSERC Steacie Fellow
2006 Nominated – NSERC Steacie Fellow
2005 Appointed Assistant Professor University of Victoria
2004 Nominated - Canada Research Chair Tier II, U of Victoria
2004 Nominated - Pew Fellow
2003 Adjunct Professor, Fisheries Centre, U. of British Columbia
2003 Adjunct Professor, Biology Department, U. of Victoria
2001 Appointed Asst Professor University of Alberta
2001 Nominated - Canada Research Chair Tier II, U of Alberta
2001 NSERC Post Doctoral Fellowship (declined)
2000 "*133 Young Leaders of the New Millennium*" Globe and Mail

UVIC COURSES
ES 200 Introduction to Environmental Studies
ES 240 Ecological Processes
ES 341 Ecological Restoration
ES 381 Ecology and Culture of Food
ES 431 History, Science & Culture of Wine
ES 446 Sustainable Fisheries
ES 482 Natural History and Ecology of Biological Invasions
ES 482 Complex Systems in Nature
ES 500 Environmental Theories, Methods and Skills I
ES 501 Environmental Theories, Methods and Skills II
ES 503 / 603 Environmental Studies Graduate Colloquium

REFEREED PUBLISHED ARTICLES (Supervised Students during research)

2019 Stewart, F.E.C., J.P. Volpe, J.T. Fisher. The debate about bait is a red herring in conservation research. **Journal of Wildlife Management** *Accepted*.

Frey, S., J.P. Volpe, N.A. Heim, J. Paczjowski, and J.T. Fisher. Carnivore species alter activity patterns and temporal niche partitioning in response to anthropogenic landscape change. **Journal of Applied Ecology**. *Submitted.*

2018 Heim, N.A., J.T. Fisher, J.P. Volpe, A.P. Clevenger, J. Paczkowski. Carnivore community responses to anthropogenic landscape change: species-specificity foils generalizations. *In Review* **Biological Conservation** BIOC_2018_1428

Stewart, F.E.C., S. Darlington, J.P. Volpe, M. McAdie, J.T. Fisher. The matrix matters: natural habitat within working landscapes predicts functional connectivity better than protected areas. *In Review* **Journal of Applied Ecology**

Stewart, F.E.C., J.P. Volpe, B.R. Eaton, G.A. Hood, D. Vujnovic, and J.T. Fisher. Protected area networks are only as valuable as the landscapes they conserve. *In Review* **Biological Conservation**

Stewart, F.E.C., J.T. Fisher, A.C. Burton, and J.P. Volpe. Species occurrence data reflect the magnitude of animal movements better than the proximity of animal space-use. **Ecosphere** 9(2):ecs2.2112

Burgar J.M., F.E.C. Stewart, J.P. Volpe, J.T. Fisher and A.C. Burton. 2018. Estimating density for species conservation: comparing camera trap spatial count models to genetic spatial capture-recapture models. **Global Ecology and Conservation** (15:e0014)

2017 Frey, S.A., J.T. Fisher, A.C. Burton and J.P. Volpe. 2017. Investigating animal activity patterns and temporal niche partitioning using camera trap data: Challenges and Opportunities. **Remote Sensing in Ecology and Conservation** 3(3):123-132

Stewart, F.E.C., J.P. Volpe, J.S. Taylor, J. Bowman, P.J. Thomas, M.J. Pybus and J.T. Fisher. Distinguishing reintroduction from recolonization with genetic testing. **Biological Conservation** 214:242-249

Heim, N.A., J.T. Fisher, A.P. Clevenger, J. Paczkowski, J.P. Volpe. Cumulative effects of climate and landscape change drive spatial distribution of Rocky Mountain wolverine. **Ecology and Evolution** 7(21):8903-8914

2016 Stewart F.E.C., N.A. Heim, A.P. Clevenger, J. Paczkowski , J.P. Volpe, and J.T. Fisher. Wolverine behaviour varies spatially with anthropogenic footprint: implications for conservation and inferences about declines. **Ecology and Evolution** 6:1493-1503

Lancaster, D., P. Dearden, D.R. Haggarty, J.P. Volpe, N.C. Ban. 2016. Effectiveness of shore-based remote camera monitoring for quantifying recreational fisher compliance in marine conservation areas. **Aquatic Conservation** 27(4):804-813

2014 Fisher, J.T., C. Pasztor, A. Wilson, J.P. Volpe, and B. Anholt. 2014. Recolonizing sea otters spatially segregate from pinnipeds on the Canadian Pacific coastline: The implications of segregation for species conservation. **Biological Conservation** 177:148-155.

Fisher, A.C., J.P. Volpe and J.T. Fisher. 2014. Occupancy dynamics of escaped farmed Atlantic salmon in Canadian Pacific coastal salmon streams. **Biological Invasions** 16:2137-2146.

2013 Price, M. A. Morton, J.G. Eriksson and J.P. Volpe. 2013. Fish processing facilities: new challenge to marine biosecurity in Canada. **Journal of Aquatic Animal Health** 25:290-294.

Volpe, J.P., J.L.M. Gee, V.A. Ethier, M. Beck, A.J. Wilson and J.M.S. Stoner. 2013. Global Aquaculture Performance Index (GAPI): The first global environmental assessment of marine fish farming. **Sustainability** 5:3976-3991.

Fisher, J.T, S. Bradbury, B. Anholt, L. Nolan, L. Roy, J.P. Volpe, and M. Wheatley. 2013. Wolverines on the Rocky Mountain slopes: natural heterogeneity and landscape alteration as predictors of distribution. **Canadian Journal of Zoology**. 91:706-716

Fisher, J.T., B. Anholt, S. Bradbury, M. Wheatley, and J.P. Volpe. 2013. Spatial segregation of sympatric marten and fishers: the influence of landscapes and species-scapes. **Ecography** 36:240-248.

2011 Fisher, J.T., B. Anholt, and J.P. Volpe. 2011. Body mass explains characteristic scales of habitat selection in terrestrial mammals. **Ecology and Evolution** 1:517-528.
Liu, Y. R.U. Sumaila, J.P. Volpe. 2011. The potential ecological and economic impacts of sea lice from farmed salmon on wild salmon fisheries. **Ecological Economics** 70: 1746-1755.

Krkosek, M.K., B.M. Connors, H.A. Ford, S. Peacock, P. Mages, J.S. Ford, A. Morton, J.P. Volpe, L.M. Dill, M.A. Lewis. 2011. Fish farms, parasites, and predators: implications for salmon population dynamics. **Ecological Applications** 21:897-914.

2009 Krkosek, M.K., A. Morton, J.P. Volpe, M.A. Lewis. 2009. Sea lice and salmon population dynamics: Effects of exposure for migratory fish. 2009. **Proceedings of the Royal Society of London, Series B**. 276:2819-2828.

Volpe, J.P. 2009. The efficiency trap. **Food Ethics** 4: 41-42.

2008 Kelly, J.R., H. Proctor and J.P. Volpe. 2008. Displacement of native eelgrass (*Zostera marina* L.) by introduced oysters (*Crassostrea gigas* Thunberg) significantly alters intertidal community structure. **Hydrobiologia** 596:57-66.

Kelly, J.R., and J.P. Volpe. 2008. Effects of non-native oyster (*Crassostrea gigas* Thunberg) on native eelgrass (*Zostera marina* L.) in the Strait of Georgia, British Columbia. **Botanica Marina** 50:143-150.

2007 Volpe, J.P. 2007. Reconciling fisheries with conservation and the ecological footprint of aquaculture. 4th World Fisheries Congress. **American Fisheries Society Symposium** 49:587-589.

Rodtka, M.C. and J.P. Volpe. 2007. Effects of water temperature on interspecific competition between juvenile bull trout and brook trout in an artificial stream. **Transaction of the American Fisheries Society** 136: 1714-1727.
Sumaila, U.R., J. Volpe and Y. Liu 2007. Potential economic benefits from sablefish farming in British Columbia. **Marine Policy** 31: 81-84.

2006 Krkošek, M., M.A. Lewis, A. Morton, L.N. Frazer and J.P. Volpe, 2006. Epizootics of wild fish induced by farm fish. **Proceedings of the National Academy of Sciences USA** 103: 15506-15510.

Krkošek, M., M.A. Lewis, J.P. Volpe and A. Morton. 2006. Fish farms and sea lice infestations in wild juvenile salmon in the Broughton Archipelago – A rebuttal to Brooks (2005). **Reviews in Fisheries Science** 14: 1-11.

2005 Krkošek, M., A. Morton, J.P. Volpe. 2005. Non-lethal assessment of juvenile Pacific salmon for parasitic sea lice infections **Transactions of the American Fisheries Society** 134: 711-716.

Naylor, R., K. Hindar, I. Fleming, R. Goldburg,S. Williams, J.P. Volpe, F. Whoriskey, J. Eagle, D. Kelso, M. Mangel. 2005. Fugitive Salmon: A Framework for Assessing Risks of Escaped Fish from Aquaculture. **BioScience** 55: 427-437.

Krkošek, M., M.A. Lewis and J.P. Volpe. 2005. Transmission dynamics of parasitic sea lice from farm to wild salmon. **Proceedings of the Royal Society of London, Series B**. 272:689-696.

Volpe, J.P. 2005. Reply to Allen: Dollars without sense: The bait for big-money tuna ranching around the world. **BioScience**. 55:644.

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2002 Morton, A. and J.P. Volpe. 2002. A description of Atlantic salmon *Salmo salar* in the Pacific salmon fishery in British Columbia, Canada, in 2000. **Alaska Fishery Research Bulletin** 9: 102-110.

2001 Volpe, J.P., B.W. Glickman and B.R. Anholt. 2001. Reproduction of Atlantic salmon (*Salmo salar*) in a controlled stream channel on Vancouver Island, British Columbia.

Transactions of the American Fisheries Society 130: 489-494.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 2001. Competition among juvenile Atlantic salmon (*Salmo salar*) and steelhead trout (*Oncorhynchus mykiss*): Relevance to invasion potential in British Columbia. **Canadian Journal of Fisheries and Aquatic Sciences** 58: 197-207.

Volpe, J.P. and B.R. Anholt. 2001. Atlantic salmon (*Salmo salar*) in British Columbia. *In* **Marine Bioinvasions: Proceedings of the First National Conference** (January 24-27 1999; edited by J. Pederson). Massachusetts Institute of Technology, Cambridge, MA. pp. 256-259.

2000 Volpe, J.P. and G. Horne. 2000. A simple and inexpensive method for providing natural forage in a laboratory environment. **North American Journal of Fisheries Management**. 20: 801-803.

Volpe, J.P., E.B. Taylor, D.W. Rimmer, B.W. Glickman. 2000. Natural reproduction of aquaculture escaped Atlantic salmon (*Salmo salar*) in a coastal British Columbia river. **Conservation Biology** 14: 899-903.

1997 Taylor, E.B., Harvey, S., Pollard, and J. Volpe. 1997. Postglacial genetic differentiation between reproductive ecotypes of kokanee (*Oncorhynchus nerka*) in Okanagan Lake, British Columbia. **Molecular Ecology** 6: 503-517.

1996 da Cruz, A.D., J.P. Volpe, V. Saddi, J. Curry, M.P. Curado, B.W. Glickman. 1997. Radiation risk estimation in human populations: Lessons from the radiological accident in Brazil. **Mutation Research**. 373: 207-217.

Volpe, J.P. and M.M. Ferguson. 1996. Molecular genetic examination of the polymorphic Arctic charr, *Salvelinus alpinus*, of Thingvallavatn, Iceland. **Molecular Ecology** 5: 763-772.

BOOK CHAPTERS

Siddique, M. A. L and J.P. Volpe. 2009. Chapter 9. Eco-friendly sustainable shrimp aquaculture in Bangladesh: A way of minimizing coastal degradation. *In* Moksness, Dahl, Strotrupp (eds.) **Integrated Coastal Zone Management**. Blackwell Publishing, UK.

Volpe, J.P. and K. Shaw. 2008. Fish farms and neoliberalism: Salmon aquaculture in British Columbia. *In* C. Gore and P. Stoett (eds.) **Environmental Challenges & Opportunities: Local-Global Perspectives on Canadian Issues.** Emond Montgomery, Toronto.

Volpe, J.P. 2006. “Salmon sovereignty” and the dilemma of intensive Atlantic salmon aquaculture development in British Columbia. *In* Parrish, C.C., N.J. Turner, and S.M. Solberg (eds.). **Resetting the Kitchen Table: Food Security, Culture, Health and Resilience in Coastal Communities**. Hauppague, NY: Nova Science Publishers

Dai, Hahn, Hawryshan, Lee, Temple, Kennedy, Neis, Parrish, Russo, Garrido, Stanley, Turner, Volpe, and Wroblewski. 2005. Future Options I: Aquaculture, Hatcheries, Tourism, Transportation, and Local Initiatives. *In* Ommer, R.E. and the Coasts Under Stress research project team. **Coasts Under Stress: Restructuring and Social-Ecological Health**. Montreal, PQ: McGill-Queen's University Press.

Wroblewski, J., J.P. Volpe and D. Bavington. 2005. Manufacturing fish: Transition from wild harvest to aquaculture. *In* Sinclair, P.R. and R.E. Ommer (eds.) **Power and Restructuring: Canada's Coastal Society and Environment**. St. John's, NL: ISER Books.

OTHER PUBLICATIONS & RESEARCH PRODUCTS

Volpe, J.P. 2017. Comment: The science is in - Salmon farms need to be out. Times Colonist November 19.

Volpe, J.P., J. Gee, M. Beck, V. Ethier. 2011. How Green Is Your Eco-label? Comparing the Environmental Benefits of Marine Aquaculture Standards. University of Victoria, Victoria, British Columbia, Canada. 56pgs. <www.gapi.ca>

Volpe, J.P., M. Beck, V. Ethier, J. Gee, A. Wilson. 2010. Global Aquaculture Performance Index. University of Victoria, Victoria, British Columbia, Canada. 116pgs <www.gapi.ca>

Volpe, J.P. 2009. Salmoni come polli. **Slow Food Journal** 39: 60-62 (in Italian)

Sumaila, U.R., J.P. Volpe and Y. Liu. 2005 Ecological and Economic Impact Assessment of Sablefish Aquaculture in British Columbia. **Fisheries Centre Research Reports** 13: 3

Volpe, J.P. 2004. Book review: *Imperfect Symmetry: Thermodynamics in Ecology and Evolution* by Lionel Johnson. **Fish and Fisheries**. 5:346-347.

Volpe, J.P. 2004. Salmon Scare? Guest Columnist. **Seattle Post Intelligencer**. 1-25-04

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Volpe, J.P. 2001. Invasion ecology of Atlantic salmon (*Salmo salar*) in British Columbia. **Ph.D. Thesis**. University of Victoria, British Columbia.

Volpe, J.P. 2001. Farming uncertainty in coastal British Columbia. **The Steelhead Release** Autumn 2001: 20-25.

Volpe, J.P. 2000. How do we know what we don't know? Atlantic salmon in British Columbia: A review. *In* P. Gallaugher and C. Orr (*eds*.) Aquaculture and the Protection of Wild Salmon: Speaking for the Salmon Workshop Proceedings, Simon Fraser University March 1-3 2000 pp. 28-33.

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Volpe, J.P. Salmon Roulette: Are we risking our Pacific salmon heritage for Atlantic salmon aquaculture? **The National Post**. October 20 1999 (*Editorial*).

Volpe, J.P. 1999. The occurrence of Atlantic salmon in coastal streams of southern British Columbia during 1998. British Columbia Ministry of Environment Lands and Parks Regional File Report. Nanaimo, British Columbia.

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Volpe, J.P. Pennask Lake Broodstock Management Plan. Technical File. Fish Culture Section, Fisheries Branch B.C. Min. of Environment, Lands & Parks. January 1996. 36p.

Volpe, J.P. Premier Lake Broodstock Management Plan. Technical File. Fish Culture Section, Fisheries Branch B.C. Min. of Environment, Lands & Parks. January 1996. 43p.

Volpe, J.P. *Broodstock Summary Database*, Ver. 1.0. and User's Manual. *MSAccess & VBasic*. Fish Culture Section, B.C. Min. of Environment, Lands & Parks. March 1996. 10p.

Volpe, J.P. *Fish Transfer Database*, Ver. 2.0. and User's Manual. *MSAccess* & *VBasic*. Fish Culture Section, Fisheries Branch B.C. Min. of Environment, Lands & Parks. March 1996. 22p.

Volpe, J.P. 1994. A molecular genetic examination of the polymorphic Arctic charr, *Salvelinus alpinus*, of Thingvallavatn, Iceland. M.Sc. Thesis. University of Guelph, Guelph, Ontario.

Danzmann, R.G., M.J. Joyce and J.P. Volpe. 1991. Mitochondrial DNA variability in brook charr (*Salvelinus fontinalis*) populations sampled from the Lake Huron drainage: Management and conservation implications. Ontario Ministry of Natural Resources Technical Report.

INVITED LECTURES & ADDRESSES (Invited & Fully Sponsored)

2016 Aquaculture Innovation Workshop (Keynote) - Roanoke Virginia Aug 21

2015 Slow Food Canada AGM Montreal March 22-26

2014 Terra Madre, Turin Italy. The Challenge of Slow Seafood Oct 23-27

2013 Yale University School of Forestry and Environmental Studies. Feb 20-22

2012 McGuinness Institute Wellington, NZ. Aquaculture and Global Protein., Dec 23.

The Atlantic Salmon Federation. Land-Based Closed-Containment Conference. Keynote Speaker and Panelist October 10-11. Saint John, NB

Seattle WA. Aquaculture Innovation Workshop Keynote Speaker and Panelist May 15 -16. Supported by Tides Canada Foundation.

U of Tasmania. Managing Marine Farming: have we achieved best practice? Keynote Speaker March 8 Hobart, Tasmania, Australia

2011 Seafood Summit. Salmon is Just the Tip of the Iceberg—Using New Science Tools to Assess and Shift the Current Trajectory of Marine Aquaculture. Invited speaker and panelist. Jan 31-Feb 2 Vancouver BC

2010 Seafood Summit. The Global Aquaculture Performance Index. Invited speaker and panelist. Jan 22-25 Paris, France

Chile (multiple locations) Leader of exotic (farm) salmon expedition through Chilean Patagonia rivers. Sponsored by and in collaboration with Oceania. Public presentations and one-on-one meetings with federal fisheries minister and government decision makers (Santiago). May 30-June 6.

WWF International Salmon Aquaculture Dialogue. Speaker and respondent. . November 13-19 Bergen, Norway

Columbia University. Respondent – Ecological Performance Index. Board of Directors Meeting. Dec 17-19 New York City

2009 Annual meeting of the American Association for the Advancement of Science (AAAS). Aquaculture impacts, standards and sustainability. Feb 12-16 Chicago IL

Seafood Summit. USA 2009 The Global Aquaculture Performance Index. Invited speaker and panelist San Diego, CA Jan 22-25

2008 Seafood Summit.. "The Global Aquaculture Performance Index". Invited speaker. Barcelona, Spain January 27-30

2007 University of Las Lagos. Genetic impacts of escaped farm salmon. Invited speaker Valapariso, Chile Dec 17-20

Simon Fraser University The challenge of seafood sustainability. Center for Dialogue. Vancouver, Oct. 11.

Oregon State University-Department of Fisheries and Wildlife Science Friction: Commercial salmon aquaculture in British Columbia. Eugene, Oregon Oct 10

SlowFish. Slow Food International Conference. The myth of efficiency and the future of seafood. *Invited speaker & panelist* Genova, Italy May 4-7

University of Las Lagos. Potential impacts of exotic aquaculture escaped salmon *Invited speaker* Puerto Montt, Chile Jan 13-17

2006 Stanford University. Transcending Borders: Pacific salmon and interdisciplinary approaches to fisheries conservation. Palo Alto, CA,. *Invited speaker* Feb 1-2 2006

Integrating aquaculture and ecological sciences for sustainable offshore aquaculture.. Florence, Italy May 10-13

2004 International Seafood Summit. Chicago, Il Oct 26-28. *Invited Speaker*

Stanford University. International Sustainability Days October 13-16. *Invited Speaker* Palo Alto, CA

University of Victoria. Annual Meeting of the Society for Ecological Restoration Plenary Address. Victoria, BC August 24-26.

Culinary Institute of America - Annual Joint Meeting of the Association of the Study of Food and Society and the Agriculture, Food and Human Values Society. *Invited Speaker* Hyde Park, NY June 10-13.

4th World Fisheries Congress - Forum on the Sustainable Seafood Movement Invited speaker and Forum presenter, May 3-6. Vancouver, BC

2003 U. of Victoria, School of Environmental Studies *Recruitment lecture* Victoria, BC Oct 8.

Pacific States Marine Fisheries Commission Portland, Invited speaker. Oregon. November 17-19.

Canadian Assoc. of Geographers Annual Meeting, Invited speaker. Victoria, BC May 30.

WWF Canada - Public Forum on Aquaculture, Invited speaker. Prince Rupert, BC May 3.

UC Davis Biological Invasions and Biocultural Diversity Symposium. Invited speaker Davis, CA April 24-27

UBC, Centre for Applied Conservation Research - Salmon Conservation and Aquaculture; *A Public Forum*. Invited speaker Vancouver, BC March 25

2002 North-West Salmon Summit. Invited speaker. Bellingham, WA Oct 18.

US Aquatic Nuisance Species Task Force AGM. Invited speaker October 17 Olympia, WA

First Nations Aquaculture Summit. Tsleil-Waututh Nation Cultural Centre, Invited speaker. Vancouver, BC Sept. 24-26.

Simon Fraser University - Center for Dialogue. Invited speaker. Vancouver, BC Oct. 11.

Stanford University Invited speaker Palo Alto, CA September 17

American Society of Limnology and Oceanography Annual Meeting. Invited speaker. Victoria, BC June 10-14.

American Society of Ichthyologists and Herpetologists Annual Meeting. Invited speaker. Kansas City, MO - July 3-8.

U.S. Forest Service. Invited speaker. Juneau, AK April 2-4.

Simon Fraser University-Biological Sciences Department. Burnaby, BC March 22

Simon Fraser University - *Speaking of Science Lecture Series.* Harbour Centre Campus Vancouver, BC March 21.

2001 Canadian Museum of Nature - National Workshop on Invasive Alien Species. Invited Panelist. Ottawa, Ont Nov 5-7.

Prince Rupert Aquaculture Forum. Invited panelist. Prince Rupert, BC Oct 19-20.

Pacific States Marine Fisheries Commission. Portland Oregon. Sept 17 (cancelled – 9/11)

University of Alberta-Biology Department *Recruitment lecture* Edmonton, AB Feb 1.

2000 US Fish and Wildlife Atlantic Salmon Identification Workshop. Workshop Coordinator & Leader Lacey, WA June 19.

Seattle Central Community College. Invited speaker. Seattle, WA May 4.

Vancouver Aquarium-*Hot Topics Lecture Series*. Vancouver, BC March 29.

Simon Fraser University - Speaking for the Salmon International Workshop. Invited speaker. March 1-3. Burnaby, BC

CONTRIBUTED ACADEMIC / SCHOLARLY ORAL PRESENTATIONS

(Students underlined; **presenter in bold**)

Stewart, F.E.C., E.J.B. McIntire, R. Winder, J.P. Volpe, and J.T. Fisher. 2019. Managing wildlife in a complicated world; applying lessons learnt to boreal caribou. The Wildlife Society BC, Kelowna, BC

Gorgopa, S. M., J.P. Volpe. 2018. "Can Sport SCUBA Divers Provide Reliable Data for Rockfish Conservation?". Salish Sea Ecosystem Conference, Seattle, WA,

Gillian Chow-Fraser, Nicole Heim, John Paczowski, John P. Volpe, Jason T. Fisher. 2018. Indirect effects of anthropogenic features on competitive pressures between intra-guild carnivores North American Congress of Conservation Biology, Toronto ON.

Darlington, S., F.E.C. Stewart, J.T. Fisher, A.C. Burton, J. Volpe. 2018. Deer on the move: white-tailed deer anti-predator movement response to industrial features in northeastern Alberta. Canadian Society for Ecology & Evolution, University of Guelph ON

Stewart, F.E.C., J.P. Volpe, G.A. Hood, D. Vujnovic, and J.T. Fisher. 2018. Protected areas are only as valuable as the working landscapes they conserve. Canadian Society for Ecology and Evolution, Guelph, Ontario. July 17-21 2018. *****Awarded best presentation (3rd place)***

Gillian Chow-Fraser, Laura Finnegan, Barry Nobert, John P. Volpe, Jason T. Fisher. 2018. No room for mistakes for caribou mothers on multi-predator and disturbed landscapes Canadian Society of Ecology and Evolution, Guelph ON.

Gorgopa, S.M., J.P. Volpe. 2018. "Can Sport SCUBA Divers Provide Reliable Data for Rockfish Conservation?". Pacific Ecology and Evolution Conference, Bamfield, B.C., Canada.

Gillian Chow-Fraser, Nicole Heim, John Paczowski, John P. Volpe, Jason T. Fisher. 2018. Friend or foe: fine-scale spatiotemporal co-occurrence of wolverine (*Gulo gulo*) and coyote (*Canis latrans*) on disturbed and undisturbed landscapes Alberta Chapter of the Wildlife Society (ACTWS), Lethbridge AB. ****Awarded Best Student Presentation (3rd place)**

Gorgopa, S.M., J.P. Volpe. 2017. "Evaluating the reliability of citizen science SCUBA surveys for long term monitoring of marine life". Pacific Ecology and Evolution Conference, Bamfield, B.C., Canada.

Bulger, D. S, J.P. Volpe, and J.T. Fisher. 2018. Evaluating British Columbia's artificial reefs in a conservation context: Potential abundance and diversity trade-offs for groundfish Canadian Society for Ecology and Evolution, Guelph, ON.

Gillian Chow-Fraser, J.T. Fisher, and J. Volpe. 2017. Influence of predation risk and human footprint on boreal and central mountain caribou neonate mortality Pacific Ecology and Evolution Conference (PEEC), Bamfield BC.

Darlington, S., J.T. Fisher, J. Volpe. 2017. Anthropogenic disturbance affects energetic trade-offs with predation risk in white-tailed deer (*Odocoileus virginianus*). Canadian Society for Ecology & Evolution, Victoria BC.

Stewart, F.E.C., A.C. Burton, M. Pybus, D. Vujnovic, G. Hood, J.P. Volpe, and J.T. Fisher. 2017. Biological interpretation, accuracy, and precision of species occurrence data. The Alberta Chapter of the Wildlife Society, Lac LaBiche, Alberta.

Gillian Chow-Fraser, J.T. Fisher, and J. Volpe. 2017. Mother knows best: the influence of female caribou habitat selection on calf mortality during calving season. Canadian Society for Ecology and Evolution, Victoria BC.

Burgar, J., **F.E.C. Stewart**, A.C. Burton, J.P. Volpe, and J.T. Fisher. 2017. A comparison of multiple spatial capture-recapture models for estimating mammal densities in a changing landscape. 12th International Mammal Congress, Perth, Australia, July 9-16th, 2017.

Stewart, F.E.C., J.P. Volpe, J.S. Taylor, J. Bowman, P.J. Thomas, M.J. Pybus, and J.T. Fisher. 2017. Distinguishing reintroduction from recolonization with genetic testing. The Wildlife Society, Albuquerque, NM. ****Awarded best student presentation***

Burke, Lily, Jason T. Fisher, John P. Volpe. 2017. Fish on film in the temperate deep: an underwater method comparison. Canadian Society for Ecology and Evolution Conference, May 7 - 11, 2017, Victoria, British Columbia, Canada.

Gillian Chow-Fraser, J.T. Fisher, and J. Volpe. 2017. Mother knows best: the influence of female caribou habitat selection on calf mortality during calving season Alberta Chapter of the Wildlife Society, Lac La Biche AB. ****Awarded Best Student Presentation (3rd place)**

Darlington, S., J.T. Fisher, J. Volpe. 2017. Predator avoidance and seasonal resource selection by white-tailed deer (*Odocoileus virginianus*) in Northern Alberta. Alberta Chapter of the Wildlife Society, Lac La Biche AB.

Burgar, J.*, **F.E.C. Stewart**, A.C. Burton, J.P. Volpe, and J.T. Fisher. 2017. A comparison of multiple spatial capture-recapture models for estimating carnivore densities using field data. Canadian Society of Ecology and Evolution, Victoria, BC, May 7-11 2017.

Stewart, F.E.C., A.C. Burton, J.P. Volpe, and J.T. Fisher. 2017. What does species occurrence data really mean when individuals are mobile? Pacific Ecology and Evolution Conference, Bamfield, British Columbia. ****Awarded best presentation***

Stewart, F.E.C., A.C. Burton, M. Pybus, D. Vujnovic, G. Hood, J.P. Volpe, and J.T. Fisher. 2017. Species occurrence data tells us where animals are, but more importantly where they move. The Canadian Society for Ecology and Evolution, Victoria, British Columbia.

Darlington, S., J.T. Fisher, J. Volpe. 2018. Modelling predator avoidance by white-tailed deer in the Alberta boreal forest. Pacific Ecology & Evolution Conference, Bamfield BC.

Fisher, T.J., N.A. Heim, F.E.C. Stewart, C. James, S. Frey, and J.P. Volpe. 2016. Three's a crowd: anthropogenic footprint affects species-species interactions. The Wildlife Society, Raleigh, North Carolina.

Stewart, F.E.C., N. Heim, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2015. Wolverine behaviour varies with anthropogentic footprint: Implications for conservation and inferences about declines. The Canadian Society for Ecology and Evolution, Saskatoon, Saskatchewan.

Stewart, F.E.C., **N. Heim**, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2016. Using behaviour as a metric of landscape change. WeaselFest, Gavin Lake, British Columbia.

Stewart, F.E.C., J. S. Taylor, J.P. Volpe, and J.T. Fisher. 2016. Questioning fisher re-introduction success in central Alberta; genetic evidence for provincial scale connectivity. WeaselFest, Gavin Lake, British Columbia.

Stewart, F.E.C., M. Pybus, D. Vujnovic, G. Hood, J.P. Volpe, and J.T. Fisher. 2016. Genetic evidence for fisher recolonization success in central Alberta: implications for provincial-scale connectivity. The Alberta Chapter of the Wildlife Society, Drumheller, Alberta.

Stewart, F.E.C., **N. Heim**, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2015. Landscape-scale behavioral response by wolverines (*Gulo gulo*) to landscape development: evidence for a human-driven landscape of fear? The Alberta Chapter of the Wildlife Society. Edmonton, Alberta.

Stewart, F.E.C., N. Heim, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2015. Wolverine behavior varies with anthropogenic footprint: Implications for conservation and inferences about declines. The Canadian Society for Ecology and Evolution, Saskatoon, Saskatchewan.

Stewart, F.E.C., N. Heim, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2015. Wolverine landscapes-of-fear; assessing landscape-scale human impacts on wolverine behaviour in the Eastern Rockies. Pacific Ecology and Evolution Conference. Bamfield, British Columbia.

Beck, M., J.P. Volpe and L.M. Horborg. 2013. Victoria Natural History Society Feb 12th

Beck, M., J.P. Volpe and L.M. Horborg. 2013. Pacific Ecology and Evolution March 1-3 Bamfield Marine Science Center

Gee, J., J.P. Volpe. 2013. Aquaculture Information Management System: Website User-Based Interfaces. Food and Agriculture Organization of the UN / Department of Fisheries, Thailand. Terminal Workshop. Bangkok, Thailand. January 14

Beck, M., J.P. Volpe and L.M. Horborg. 2013. WA-BC American Fisheries Society Chapter AGM March 25-28 Lake Chelan, Washington

Beck, M., J.P. Volpe and L.M. Horborg. 2013. International Conference on Aquatic Invasive Species (ICAIS) Niagara Falls, Ontario April 21-25

Gee, J. and J.P. Volpe. 2013. Policy and Regulatory Mandates and Objectives for an Aquaculture Information System. Food and Agriculture Organization of the UN / Department of Fisheries, Thailand. Terminal Workshop. Bangkok, Thailand. January 14.

Beck, M., J.P. Volpe and L.M. Horborg. 2013. Canadian Aquatic Invasive Species Network II AGM May 2-3 Kananaskis, Alberta

Gee, J. and J.P. Volpe 2013. Policy and Regulatory Mandates and Objectives for an Aquaculture Information System. Food and Agriculture Organization of the UN / Department of Fisheries, Thailand. Terminal Workshop. National Training Course on Aquaculture Information Management System in Thailand. Bangkok, Thailand. January 10.

Beck, M., J.P. Volpe and L.M. Horborg. 2013. Canadian Society for Ecology and Evolution. Kelowna, BC May 12-15

Beck, M., J.P. Volpe and L.M. Horborg. 2013. International Conference of Marine Bioinvasions, August 20-22 University of British Columbia, Vancouver BC

Volpe, J.P. The Beef or the Fish? 2012. How Putting Aquaculture in the Context of Global Protein Production Can Inform/Impact our Seafood Choices. 10th Seafood Summit. Hong Kong. Sept. 6-8.

Beck, M., J.P. Volpe and L.M. Horborg. 2012. Reconciling Large-scale Model Predictionswith Small-scale – Impacts and interactions of the invasive smallmouth bass (*Micropterus* *dolomieu*) with native species in British Columbian lakes. International Conference on Aquatic Invasive Species April 21-25, Niagara Falls ON

Beck, M., J.P. Volpe and L.M. Horborg. 2012. Small mouths lead to big problems? Non-native Smallmouth bass (*Micropterus dolomieu*) in British Columbian lakes. American Fisheries Society Meeting May 15-17, Victoria, BC.

Mucciarelli, V.M., J.P. Volpe, B. Starzomski, and D. Biffard. 2011. Investigating the drivers of biodiversity on an artificial reef in a subtidal marine ecosystem. International Marine Conservation Congress May 14th-18th, Victoria BC

Volpe, J.P., 2011. Fat fish and sacred cows: The first global mariculture performance assessment forces a re-evaluation of fish farming's role in sustainable seafood. International Marine Conservation Congress May 14th-18th, Victoria BC

Fisher, J.T., C. Pasztor, A. Wilson, J.P. Volpe and B. Anholt. 2011. Conservation of re-introduced sea otters in British Columbia: Habitat selection on a coastline of fear. International Marine Conservation Congress May 14th-18th, Victoria BC

Park, A. and Volpe, J.P. 2011. Out of the pan into the fire: Unforeseen consequences of a chemical therapeutant used on salmon farms. International Marine Conservation Congress May 14th-18th, Victoria BC

Park, A and Volpe, J.P. 2011. Biological effects of SLICE on non-target spot prawn (*Pandalus platyceros*). Commercial Prawn Fishermen Annual General Meeting March 30th Courtenay BC

Park, A. and Volpe, J. 2010. Detection of emamectin benzoate (SLICE) in non-target spot prawn (*Pandalus platyceros*) and determination of biological effects. Pacific Ecology and Evolution Conference March 5-7th, Bamfield BC.

Park, A. 2009. The effect of emamectin benzoate (SLICETM) application by salmon farms on non-target spot prawn (*Pandalus platyceros*). Fisheries and Marine Ecosystems Conference April 17-19th, White Rock BC.

Park, A. 2009. Environmental impacts of salmon aquaculture prophylactic chemical application. Pacific Ecology and Evolution Conference February 20-22, Bamfield BC.

Fisher, J.T., B. Anholt, and J.P. Volpe. 2009. Patterns of multi-scale habitat selection by mammalian carnivores in a subalpine landscape. 3rd Annual Canadian Society for Ecology and Evolution Conference, Halifax, N.S.

Volpe, J.P. 2009. Sustainability and the myth of sustainability. NetSci 2009 June 29-July 3, Venice, Italy.

Peet, C., J.P. Volpe, A. Mazumder, and A. Morton. 2007. The impact of salmon farming on the host parasite relationship between sea lice and juvenile salmon: implications for the health of wild salmon populations. Society for Conservation Biology 21st Annual Meeting July 1-5, Port Elizabeth, South Africa.

Peet, C., J.P. Volpe, A. Mazumder, and A. Morton. 2007. The impact of salmon farming on the host parasite relationship between sea lice and juvenile salmon: implications for the health of wild salmon populations. American Fisheries Society Annu7al Meeting, San Francisco, Sept. 2-6.

Volpe, J.P. 2006. Swimming Against the Sustainability Current: The Growing Problem with Seafood. Annual meeting of the Agriculture, Food and Human Values Society. Boston, MA. June 7-11.

Saini, J.S. and J.P. Volpe. 2006. Food Writing in Developing Sustainable Gastronomy. Annual meeting of the Agriculture, Food and Human Values Society. Boston, MA. June 7-11.

Peet, C., J.P. Volpe, and A. Mazumder. 2005. Interactions between the salmon louse and juvenile salmonids in British Columbia. 21st Annual Pink and Chum Salmon Workshop.

Ketchikan, AK Feb 23-26.

Peet, C., J.P. Volpe, and A. Mazumder. 2005. Possible impact of salmon farming on wild salmon populations. Society for Conservation Biology Annual Meeting. Brasilia, Brazil. July 15-19.

Sumaila, U.R., J.P. Volpe and Y. Liu. 2005. Ecological and economic analysis of sablefish aquaculture in British Columbia. 2005 Forum of the North American Association of Fisheries Economists. University of British Columbia, Vancouver. May 25-27.

Popowich, R.C., E.B. Taylor, J.D. Stelfox, and J.P. Volpe. 2005. Bull Trout x Brook Trout Hybrids: Using Genetics to Validate Morphological and Meristic Identification Techniques. Canadian Conference for Fisheries Research. Windsor, ON January 7.

Popowich R.C. and J.P. Volpe. 2004. Troubled waters: Cumulative anthropogenic activity and a declining bull trout population in the Elbow River watershed. Forest Land Fish Conference II. Edmonton, AB April 26-28. (*awarded "Best Student Paper").

Rodtka, M.C. and J.P. Volpe. 2004. Effects of stream temperature on interspecific competition between juvenile brook and bull trout. Forest Land Fish Conference II. Edmonton, AB April 26-28.

Williamson, C. and J.P. Volpe. 2004. Variable stable isotope (δ15N) enrichment across tissues in juvenile Atlantic salmon (*Salmo salar*) attributable to nutritional stress. Annual Meeting of the North American Benthological Society. Vancouver, BC June 6-10.

Volpe, J.P. and M. Skladany. Going beyond the box: Social, political and cultural dimensions of setting organic aquaculture standards. 2nd International Organic Aquaculture Workshop. Minneapolis, MN, July 15-17 2003.

Popowich, R.C. and J.P. Volpe. 2003. Competitive Interactions: Determining How Bull Trout/Brook Trout Hybrids Affect Native Albertan Bull Trout Populations. Alberta Conservation Association Partners In Conservation Conference. Edmonton, Alberta. January 24.

Volpe, J.P. Atlantic salmon (*Salmo salar*) in British Columbia and the biology of invasion: The sequel. Second International Conference on Marine Bioinvasions. New Orleans, Louisiana. April 9-11 2001.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 2000. Ecology of aquaculture escaped Atlantic salmon (*Salmo salar*) in British Columbia, Canada. Annual Meeting of the Society for Conservation Biology. Missoula, Montana. June 8-12.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 1999. Invasion ecology of aquaculture escapee Atlantic salmon (*Salmo salar*) on the Pacific coast. Aquaculture Canada 1999. Victoria, British Columbia. October 26-29.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 1999. Atlantic salmon (*Salmo salar*) in British Columbia and the biology of invasion. Annual Meeting of the International Northwest Chapter of the American Fisheries Society. Richmond, British Columbia. February 15-17.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 1999. Atlantic salmon (*Salmo salar*) in British Columbia and the biology of invasion. First National Conference on Marine Bioinvasions. Massachusetts Institute of Technology, Cambridge, Massachusetts. January 24-27.

Volpe, J.P. and S.M. Pollard. 1998. Describing units for conservation: when molecular genetic tools only tell half the story. Gene Conservation: Identification and Management of Genetic Diversity: A special session of the VII International Congress of Ecology. Florence, Italy. July 19-25, 1998.

Volpe, J.P. and B.W. Glickman. 1998. Coastal British Columbia: A case study of the colonization biology of Atlantic salmon (*Salmo salar*). 1998 Annual General Meeting of the American Fisheries Society, North Pacific International Chapter. Union, Washington. March 18-20 1998.

Volpe, J.P. and B.W. Glickman. 1997. It may be the "King of Fish" but can British Columbia afford Atlantic salmon (*Salmo salar*)? Annual Meeting of the Society for Conservation Biology. University of Victoria. June 6-9 1997.

Volpe, J.P., L. Bernatchez and M.M. Ferguson. 1993. Molecular genetic variation in four sympatric morphs of Icelandic Arctic charr (*Salvelinus alpinus alpinus*). Canadian Conference on Freshwater Fisheries Research. Trent University. January 3-5 1993.

Volpe, J.P., L. Bernatchez and M.M. Ferguson. 1993. Genetic variation found in the Arctic charr (*Salvelinus alpinus*) population of Thingvallavatn, Iceland using direct nucleotide sequencing. 32nd Annual Meeting of the Canadian Society of Zoologists. University of Guelph.

Volpe, J.P., L. Bernatchez and M.M. Ferguson. 1993. Genetic variation found in the Arctic charr (*Salvelinus alpinus*) population of Thingvallavatn, Iceland using direct nucleotide sequencing. International Symposium for the Genetics of Subarctic Fish and Shellfish. May17-19 1993, Juneau, Alaska.

CONTRIBUTED SCHOLARLY POSTER PRESENTATIONS (students underlined)

Bulger, D. S. and J.P. Volpe. 2017. Evaluating British Columbia's artificial reefs in a conservation context: Potential abundance and diversity trade-offs for groundfish. Pacific Ecology and Evolution Conference, Bamfield, BC.

Bulger, D. S. and J.P. Volpe. 2017. Evaluating British Columbia's Artificial Reefs in a conservation context: Potential abundance and diversity trade-offs for groundfish. Canadian Society for Ecology and Evolution conference (May, 2017), Victoria, BC.

Bulger, D. S., J. P. Volpe, and J. T. Fisher. 2017. Evaluating British Columbia's Artificial Reefs in a conservation context: Potential abundance and diversity trade-offs for groundfish. North American Congress for Conservation Biology Toronto, ON.

Park, A. and Volpe, J.P. 2010. Detection of emamectin benzoate (SLICE) in non-target spot prawn (*Pandalus platyceros*) and determination of biological effects (Poster). International Sea Lice Conference May 9-12th, Victoria BC

Hahn, R.L., B.R. Anholt, A.C. Hill, A. Mazumder and J.P. Volpe. 2006. Salmon farm wastes as a potential source of nutrients to adjacent intertidal communities in Clayoquot Sound, British Columbia. American Society of Limnology and Oceanography. Victoria, BC. June 4-9.

Krkosek, M., M.A. Lewis, and J.P. Volpe. 2004. Modeling parasite transmission from farm to wild salmon. MITACS 5th Annual Conference, Dalhousie University, Halifax, NS. June 9-12.

Rodtka, M. and J.P. Volpe. 2004. Effects of stream temperature on interspecific competition between juvenile brook and bull trout. 4th World Fisheries Congress. Vancouver, BC May 3-6.

Peet, C.R., A. Mazumder, and J.P. Volpe. 2004. Interactions between the salmon louse (*L. salmonis)* and juvenile salmonids in British Columbia. 4th World Fisheries Congress. Vancouver, BC May 3-6.

Edwards, A., R. Nordin, J.P. Volpe, C. Peet, M. Kainz, A. Mazumder. 2003. Trophic position and mercury in sport and commercial fish from coastal Vancouver Island. Annual meeting of the Collaborative Mercury Research Network. St. Andrews, NB Nov 21-23.

Krkosek, M., M. Lewis, and J.P. Volpe 2003. The mathematical epidemiology of sea lice (*L. salmonis*) in salmon farms and the interaction between aquaculture and wild Pacific salmon. 6th International Conference on Sea Lice. St Andrews, New Brunswick, July 1-4.

<u>Williamson, C.,</u> <u>M. Rodtka</u> and J.P. Volpe. 2003. Invasion of brook trout into a small Alberta stream: Insights into trophic shifts and effects on native bull trout. Alberta Conservation Association Partners In Conservation Conference. Edmonton, Alberta. January 24-25.

<u>Rodtka, M.</u> and J.P. Volpe. 2003. Effects of stream temperature on juvenile interspecific competition between exotic brook trout and native bull trout. Alberta Conservation Association Partners In Conservation Conference. Edmonton, AB January 24-25.

<u>Hahn, L.</u> B.R. Anholt, A. Mazumder, D. Duffus, B.W. Glickman and J.P. Volpe. 2001. Effects of salmon farm effluent on adjacent intertidal and *Zostera marina* communities. Pacific Ecology Conference, Bamfield, BC February 16-18.

Volpe, J.P., M.M. Ferguson. 1995. De-coupling of the genotype and phenotype in Arctic charr (*Salvelinus alpinus alpinus*) of Thingvallavatn, Iceland. Fisheries Society of the British Isles International Symposium - 1995. Plymouth, U.K. July 10-13 1995

UVIC TEACHING

(year course semester # students)

year	course	semester	# students
2000	ES400C	Fall	39
2004	ES335B	Summer	17
2005	ES200	Spring	71
	ES200	Summer	50
	ES341	Fall	69
2006	ES446	Spring	35
	ES482A	Spring	13
	ES200	Fall	146
2007	ES200	Spring	143
	ES446	Spring	50
	ES240	Fall	115
	ES500	Fall	9
2008	ES200	Spring	150
	ES341	Summer	18
	ES240	Fall	150
	ES500	Fall	12
2009	ES341	Spring	60
	ES240	Fall	150
	ES500	Fall	10
2010	ES446	Spring	30
	ES501	Spring	10
	ES500	Fall	10
2011	ES501	Spring	10
	ES240	Fall	120
	ES482A	Fall	15
2013	ES240	Spring	100
	ES446	Spring	37
	ES240	Fall	110
	ES503	Fall	12
2014	ES240	Spring	97
	ES482A	Spring	9
	ES503	Spring	12
	ES240	Fall	106
2015	ES240	Spring	90
	ES503	Spring	12
	ES240	Fall	98
	ES503	Fall	12
2016	ES240	Spring	98
	ES481	Spring	33
	ES240	Fall	99
	ES446	Fall	24
2017	ES240	Spring	98
	ES481	Spring	25
	ES240	Fall	127
	ES482B	Fall	16
2018	ES240	Spring	125
	ES382	Spring	46
	ES240	Fall	109
	ES431	Fall	35

ES 200 Introduction to Environmental Studies
ES 240 Ecological Processes
ES 341 Ecological Restoration
ES 446 Sustainable Fisheries
ES 482A Complex Systems
ES 482B Invasion Biology
ES 431 (481 <2019) History, Science & Culture of Wine
ES 500 Environmental Theories, Methods and Skills I
ES 501 Environmental Theories, Methods and Skills II
ES 503 / 603 Environmental Studies Graduate Colloquium

Student Supervision

(*co-supervisor*) * NSERC Graduate Scholar †AB Ingenuity Graduate Scholar

Mitch Macfarlane	MSc	in program – vineyard management / terroir
Andrew Watts	MSc	in program – determinants of wine grape ripeness

Alexandra Francis	MSc (Fisher)	in program – moose conservation	
Joanna Burger	PDF (Fisher&Burton)	2018 – conservation & predator-prey dynamics	
Katie Baillie-David	MSc (Fisher)	in program – mesocarnivore conservation	
Stefania Gorgopa	MSc	2018	
Siobhan Darlington*	MSc(Fisher)	2018 - ungulate coexistence models	
Gillian Fraser*	MSc(Fisher)	2018 - predator macroecology	
Desiree Bulger	MSc	in program - efficacy of artificial reefs	
Sandra Frey*	MSc (*Fisher*)	2018 - temporal structuring of predator interactions	
Gray Daniels	MSc	in program - molecular tunneling & metabolic ecology	
Lily Burke	MSc	2018	Staff Scientist, DFO
Frances Stewart*	PhD (*Fisher*)	2018	PDF Pacific Forestry Centre
Nikki Heim*	MSc (*Fisher*)	2015	Parks Canada Biologist Technician
Hannah Roessler	MA (Stephenson)	2013	Instructor - Pacific Rim College
Martina Beck	MSc	2013	Biologist, BC Min FLNRO
Valerie Ethier*	MSc	2013	Independent Aquaculture Contractor
Valerie Mucciarelli*	MSc	2014	Teacher, Victoria BC
Ashley Park*	MSc	2013	Biologist - Archipelago Inc
Dane Stabel	MSc	2011	Dive Tourism - Owner
Helen Ford	MSc	2011	Biologist-Parks Can
Hillary Harrup Archibald*	MSc (*Schaefer*)	2010	PhD Student- U of Western Australia
Amy Deveau*	MSc	2011	Independent GIS Analyst
Jennifer Gee	MSc	2010	UN FAO Analyst
Lise Townsend *	MSc (*Schaefer*)	2010	Consulting Biologist
Jason Fisher†	PhD (*Anholt*)	2011	Sr. Research Scientist - Alberta Innovates
Martin Krkošek*	PhD (Lewis)	2009	Assistant Professor - U of Toronto
Corey Peet	MSc. (Mazumder)	2007	Project Manager - Aquaculture Blueyou AG
Latif Saddique	M. Mar. Pol. (Dalhousie)	2006	PhD Candidate - Australia
Ryan Popowich	MSc	2005	Biologist – Golder Associates
Mike Rodtka*	MSc	2005	Biologist – Alberta Conservation Association
Jenn Kelly*	MSc	2005	Sr. Lab Instructor - UBC
Chris Williamson†	MSc	2005	Teacher – Bella Bella, BC
Preston McEachern	PhD	2004	Biologist – Province of Alberta
Theron Miller	PhD	2004	Biologist – State of Utah
Mike Sullivan†	PhD	2003	Biologist – Province of Alberta

Graduate Student Supervisory Committee Member

Cameron Freshwater	Juanes	UVic Biol	PhD	2017
Kira Hoffman	Starzomski	ENVI	PhD	2018
Nancy Shackelford	Starzomski	ENVI	PhD	2017
Lara Puetz	Tunnicliffe	UVic Biol	MSc	2014
Jason Straka	Starzomski	ENVI	MSc	2012
Katharine Corriveau	Starzomski	ENVI	MSc	2012
Brooke Campbell	Pauly	UBC Fisheries	MSc	2011
Thomas Child	Turner	ENVI	MSc	2011
Alison Edwards	Mazumder	UVic Biol	MSc	2011
Brian Kopach	Duffus	UVic Geog	PhD	transfer-UCalgary
Leanne Harris	Perlman	UVic Biol	MSc	2008
Severn Suzuki-Cullis	Turner	ENVI	MSc	2007

Yajie Liu	Sumaila	UBC Fisheries	PhD	2007
Jennifer Chow	Riemchen	UVic Biol	MSc	2007
Louise Hahn	Anholt	UVic Biol	MSc	2005
Heidi Swanson	Schindler	Alberta Biol	MSc	2004
Erin Kelly	St. Louis	Alberta Biol	MSc	2004
Stephanie Neufeld	Proctor	Alberta Biol	MSc	2004

Graduate Defence External Examiner

Maximilien Genest	UVic SEOS	MSc	2018
Andy Szabo	UVic Geog	MSc	2004
Christine Weldrick	UVic Geog	MSc	2011

Chair of Graduate Oral Defence

Nancy Wilde	UVic Psych	PhD	2005
Paul Teel	UVic Phil	MA	2006
Alvin Bergen	UVic M. Eng	PhD	2008
Nishad Khanna	UVic Educ	MSc	2011
Colette Starheim	UVic Geog	MSc	2011
Karyn Suchy	UVic Biol	PhD	2014
Francis Harrison	UVic Comp Sci	MSc	2015

Undergraduate Research Supervision

2018	Sheldon Vos	Undergraduate Honours Project (GEOG)
2017	Sheldon Vos	Undergraduate Honours Project (GEOG)
2013	Francine Beaujot	Undergraduate Honours Project (EOS)
2011	Elisabeth Sargeant	Undergraduate Honours Project (BIOL)
2010	Megan Adams	Undergraduate Honours Project (BIOL)
	Jenna Stoner	NSERC USRA Scholar
2009	Megan Adams	NSERC USRA Scholar
	Erin Webb	MITACS Co-Op Summer Scholar
2008	Melanie Page	NSERC USRA Scholar
2002	Jenn Kelly	Undergraduate Honours Project (Alberta)
	Jenn Kelly	NSERC USRA Scholar (Alberta)
2007	Ashley Park	NSERC USRA Scholar
	Brock Ramshaw	NSERC USRA Scholar
2006	Stephanie Peacock	NSERC USRA Scholar
	Helen Ford	NSERC USRA Scholar
2005	Pamela Tudge	Environmental Studies Final Project
2002	Jean-Francios Buoffard	Undergraduate Honours Project (Alberta)
	Jean-Francios Buoffard	NSERC USRA Scholar (Alberta)

RESEARCH FUNDING *(unsuccessful proposals italicized and noted from 2014 onwards)*

2019	€3,137,000	Erasmus Mundus – Erasmus+ (PI-Philippe Mongondry, ESA France-pending)
2018	27,900	France-Canada Research Fund (pending)
	82,500	BC Investment Agriculture Foundation (awarded)
	38,855	Canadian Habitat Stewardship Program (awarded - Galiano Conservancy)

	90,000	Six student MITACS awards @$15K (all awarded)
2017	47,762	Canadian Habitat Stewardship Program (awarded - Galiano Conservancy)
	45,000	Three MSc student MITACS awards @$15K (all awarded)
	24,000	Cumulative effects of metal on freshwater invertebrates (BC Gov) (awarded)
2016	*468,100*	NSERC (5 yr Discovery) *(not funded)*
	30,000	Two MSc student MITACS awards @$15K (all awarded)
2015	*10,000*	Vancouver Foundation *(not funded)*
	25,016	Seaworld Busch Gardens Conservation Fund *(not funded)*
	63,358	Mitsubishi Corporation *(not funded)*
	71,933	Canadian Habitat Stewardship Program (awarded - Galiano Conservancy)
	24,000	PICS Graduate Student Fellowship *(not funded)*
	1,522	British Columbia Jobs Grant *(not funded)*
	10,600	PADI Foundation *(not funded)*
2014	16,450	Canadian Wildlife Federation (awarded)
	24,000	PICS Graduate Student Fellowship *(not funded)*
	7,000	UVic Internal Research Grant (awarded)
	100,000	MEOPAR (awarded PI Natalie Ban)
2012	15,210	Intervet (Schering-Plough)
	5,000	David Suzuki Foundation
	5,600	Fishwise (awarded)
	49,000	Monterey Bay Aquarium Seafood Watch Program
	10,000	Sea Choice
2011	187,000	Pew Charitable Trusts
	15,000	MITACS (awarded)
	66,200	Canadian Aquatic Invasive Species Network (CAISN-NSERC)
2010	287,000	Pew Charitable Trusts
	30,000	MITACS Accelerate
2009	5,000	Watershed Watch Society
	80,000	MITACS
	204,000	Lenfest Ocean Program
2008	10,000	Pew Charitable Trusts
	10,000	Canadian Sablefish Association
	45,000	Pacific Salmon Forum
2007	86,500	NSERC Discovery (over 5 years)
2006	47,100	Invasive Alien Species Partnership Program (PI Purnima Govindarajulu)
	27,000	Pacific Salmon Forum
	35,000	National Geographic Society
	£180,000	Darwin Foundation (Co-PI)
2005	18,000	U of Victoria Start-up
2004	17,000	Canadian Sablefish Association
	30,000	Alberta Conservation Association
2003	5,000	Canadian Wildlife Federation
	102,158	Canadian Foundation for Innovation (CFI) - New Opportunities
	102,158	AB Science & Research Investments Program
2002	28,000	Alberta Conservation Association
	993,551	Canadian Foundation for Innovation (CFI) – Innovation Fund (ACCRU) (Co-PI)
	90,000	NSERC Discovery (over 5 years)
2001	156,000	NSERC/ SHRC – Major Collaborative Research Initiative (Coasts Under Stress)
	80,000	University of Alberta Start-up

270,000	BC Habitat Conservation Trust

PROFESIONAL SERVICE

Testimony

Washington Supreme Court - Wild Fish Conservancy vs. US EPA 2018
New Zealand Federal Board of Inquiry in Salmon Aquaculture November 2012
BC Superior Court - Mainstream Canada v Staniford Dec 2011 Vancouver BC
BC Legislative Committee on Sustainable Aquaculture. Oct 18 2006. Victoria, BC
Alaska State Senate. May 24 2004. Juneau, AK.
Leggatt Inquiry Into BC Aquaculture. October 10 2001. Vancouver, BC.
Canadian Federal Senate Fisheries Committee. May 9 2001. Vancouver, BC.
Canadian Federal Senate Fisheries Committee. March 30 2000. Duncan, BC
Canadian Fed. Parliamentary Comm. on Fisheries and Oceans. Feb.16 2000. Victoria, BC.
Washington State Senate. Sept. 16 1999. Olympia, WA

Nonacademic Appointments

2017-18	IFOAM Global Aquaculture Standards Team
2014-18	Rockfish Conservation Foundation – Scientific Advisor
2002-05; 2014-18	Seafood Watch Program of Monterey Bay Aquarium - Scientific Advisory Board
2001-04	Raincoast Conservation Society - Scientific Advisory Board
2004-present	Slow Food International - Canadian Ark of Taste Review Board

Administrative Appointments and Duties

External

2015	External Program Reviewer - U Waterloo Environ & Resource Studies

UVic

2015	Dean's Advisory Committee
2014	UVic Faculty Pension Fund Trustee (*unsuccessful in election*)
2008-09	UVic Senate – Soc Sci Representative
2008-11; 2014-2018	UVic Marine Safety Committee
2007-11	Graduate Advisor – School of Environmental Studies
2005-11	Restoration of Natural Systems Program Advisory Board
2005	SS&M (DTB) Building Committee
2005	Social Science Internal Grant Review Committee

School of Environmental Studies

2018	Search Committee – CRC ENVI Political Ecology (Failed Search)
2017-present	ENVI Library representative
2015-18	ENVI Graduate Committee
2015	Search Committee - Ethnoecology tenure track position (Matthews)
2013	Director - School of Environmental Studies (6 month term)
2010	Search Committee - ENVI Director (Stephenson)
2008-09	Search Committee - Ian McTaggart-Cowan Chair (Starzomski)
2008	Search Committee - Ethnoecology Limited Term (Schrieber)
2008	Search Committee - Ethnoecology tenure track position (Lantz)
2007	Search Committee - Sr. Lab Instructor (Beckwith)
2005	Search Committee - LEEF Chair – *Cultures and Ecosystems at Risk*
2005	Search Committee - RNS Director (Schaefer)

2007-11	ENVI Graduate Student Advisor
2005-present	ENVI ARPT Committee

EXHIBIT B

Report of Nick Gayeski, Ph.D.

In the Matter of:

Wild Fish Conservancy v. U.S. Envtl. Prot. Agency, et al.

W.D. Wash. No. 2:15-cv-01731-BJR

May 7, 2018

I. INTRODUCTION.

I am an aquatic ecologist employed at Wild Fish Conservancy and, as part of that employment, have been requested to provide opinions on potential take of Chinook salmon protected under the Endangered Species Act ("ESA") through procedures implemented to capture and remove farmed Atlantic salmon following the collapse of a net pen during the summer of 2017. I have further been requested to provide opinions on potential take of ESA-listed Chinook salmon from standard harvesting procedures at the Atlantic salmon net pens in Puget Sound.

II. QUALIFICATIONS AND MATERIALS REVIEWED.

I have been employed as a fisheries ecologist by Wild Fish Conservancy since 1996. In this capacity my duties have included evaluations of salmon harvest and hatchery policies and management of salmon, steelhead, and trout under the ESA. I have provided public comment on behalf of Wild Fish Conservancy to the National Marine Fisheries Service ("NMFS") and the U.S. Fish and Wildlife Service on ESA listing and critical habitat decision documents over the past eighteen years.

I have conducted several field research projects related to salmon ecology and salmon freshwater food webs. Among these projects have been four funded by Bonneville Power Administration under the Columbia Basin Fish and Wildlife Plan. The projects included assessments of the distribution and genetic integrity of native resident trout populations in the Yakima, Wenatchee, and Pend Oreille River basins and an assessment of the biotic integrity of tributary streams and mainstem rivers of the upper Yakima and Naches River basins based on sampling the aquatic invertebrate community. From 1999 to 2005 I also conducted field work on native salmonids, with a particular focus on steelhead, in western Kamchatka, Russia as a member of a joint U.S.-Russian conservation research program involving scientists from the Department of Ichthyology at Moscow State University and the University of Montana.

From 2006 to 2012 I was the principal investigator of a research program investigating the ecology of native fishes in Icicle Creek, funded by the Icicle Fund, with participation from the University of Idaho and the Conservation Biology Division of NMFS's Northwest Regional Office. I co-authored a paper published in October 2014 in the journal Conservation Genetics that reports on the genetic structure of rainbow trout in upper Icicle Creek and their relationship to Wenatchee River steelhead.

I received a Ph.D. in Systems Ecology at the University of Montana in 2015. My dissertation concerned the estimation of salmon and steelhead populations in the late nineteenth and early twentieth centuries (1880 to 1920) using historical commercial harvest and related land use data, and the application of these estimates to current ESA recovery. I have published two papers related to this project that are listed in my *curriculum vita*.

My complete curriculum vitae is attached hereto at Attachment A, which provides more details on my qualifications and includes a complete list of the publications that I have authored during at least the last ten years. I have not testified at trial or in a deposition during the last four years. I am providing this opinion as part of my employment at Wild Fish Conservancy and am not receiving additional compensation beyond the terms of my employment.

In addition to drawing upon my knowledge and experience, I have reviewed the articles cited through this report and the following materials in preparing the opinions expressed herein:

- Wild Fish Conservancy. 2011. Cypress Island Aquatic Reserve Pilot Nearshore Fish Use Assessment ,March – October 2009, prepared for Washington State Department of Natural Resources by Wild Fish Conservancy, June 2011.

- Beamer, E.M., A. McBride, R. Henderson, and J. Griffith. 2006. Habitat and fish use of pocket estuaries in the Whidbey Basin and north Skagit County bays, 2004 and 2005. Skagit River System Cooperative publication.

- Beamer, E.M., A. McBride, R. Henderson, K. Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: an emerging priority for restoration. Skagit River Systems Cooperative publication.

- Greene, C, E. Beamer, J. Anderson. 2015. Study Plan and Summary of Results for the Skagit River Estuary Intensively Monitored Watershed Project. Report to Washington Salmon Recovery Funding Board Monitoring Panel.

- D Clark, K Lee, K Murphy, A Windrope. 2017 Cypress Island Atlantic Salmon Net Pen Failure: An Investigation and Review. Washington Department of Natural Resources, Olympia, WA.

- Cooke Aquaculture Pacific-Cypress Island site 2 Excepted Fish Recovery Response Report, November 9, 2017.

- Video and photograph files of the operation of the farmed Atlantic salmon harvest and salvage operations obtained from the Washington Department of Natural Resources through its websites and in response to requests for public records and from the Washington Department of Ecology, the Washington Department of Fish and Wildlife, and the Washington Department of Natural Resources obtained through public record requests submitted to by DNR during the salvage operations conducted by Cooke aquaculture following the catastrophic failure of Net Pen #2 at Deepwater Bay on August 19, 2017.

- Salmon Mortality Counts from Net Pen Recovery Operations at Cooke Aquaculture's Atlantic Salmon Farm in Deepwater Bay (Cypress Island, Wa), version 2.0. January 19, 2018.

- Aerial video files of harvest operations being conducted at net pens in Rich Passage of Puget Sound that were created by John Gussman on January 30, 2018.

- Data on incidental catch at marine finfish aquaculture sites in British Columbia available at the following website maintained by the Government of Canada: https://open.canada.ca/data/en/dataset/0bf04c4e-d2b0-4188-9053-08dc4a7a2b03.

- Update to the Biological Evaluation Submitted April 17 and August 6, 2008, Regarding EPA Action on Washington's Marine Finfish Rearing Facility Provision Contained in the Sediment Management Standards, prepared by the U.S. Environmental Protection Agency (Dec. 13, 2010).

III. OPINIONS.

In developing my opinions on the potential impacts from efforts taken to remove Atlantic salmon following the collapse of a net pen in August 2017, I first evaluated the likelihood that ESA-listed threatened juvenile Puget Sound Chinook salmon were present in the vicinity of the Cypress Island net pens during the time of the various removal operations. I then evaluated the likelihood that those fish were taken during the three separate types of removal actions undertaken.

I conclude that there is a reasonably high probability that ESA-listed juvenile Chinook salmon were present in the nearshore habitats of Deepwater Bay ("action area") at the times of the removal operations. It is my opinion that there is a significantly high probability that one or more listed juvenile Chinook was taken as a result of the salvage operations.

I followed as similar procedure in developing my opinions on the potential impacts from standard harvesting procedures implemented by Cooke Aquaculture Pacific, LLC ("Cooke") at its Puget Sound net pens. I first evaluated the likelihood that ESA-listed juvenile Puget Sound Chinook salmon are present within the net pens during the time standard harvest procedures occur. I then evaluated the likelihood that any of those fish present are harmed or killed by harvest operations.

I conclude that ESA-listed juvenile Chinook salmon are almost certainly present in the vicinity and within the Atlantic salmon net pens located in Puget Sound, including those in Rich Passage south of Bainbridge Island and at Deepwater Bay of Cypress Island, during normal harvesting procedures from April through October. Such fish are likely attracted to the net pens by the presence of odors from the pens and the presence of feed. It is my opinion that some of the ESA-listed juvenile Chinook salmon are very likely to be taken during the harvesting operations.

A. <u>Summary of Puget Sound Chinook Salmon Life-History.</u>

Nearshore salmon (including Chinook) rearing habitats in the Whidbey Basin, Skagit and Bellingham Bays, the San Juan islands, and adjacent channels have been the focus of several studies starting in the late 1990s and continuing to the present (Beamer et al. 2003, 2006, Wilf Fish Conservancy 2011, Greene et al. 2015). Collaboration by state, tribal, federal, university and independent researchers involved in these nearshore studies has resulted in the identification and standard employment of appropriate field methods, data acquisition, and statistical analyses.

This has made it possible to compare the results of studies conducted in adjacent areas (for example, Skagit Bay and Cypress Island) to build a coherent picture of common patterns of nearshore habitat use by different populations of chinook salmon in northern Puget Sound.

Puget Sound Chinook salmon exhibit two basic juvenile life-histories commonly referred to as “ocean-type” and “stream-type”. Most Chinook salmon in Puget Sound are ocean-type.

Ocean-type (commonly called “Fall”) Chinook salmon typically reside in shallow riverine habitats for a period of no more than a few weeks to months after emerging as fry from the gravels in which their parents spawned. After this brief period, Chinook fry (typically ranging in size from about one to three inches in length) migrate as “smolts” to shallow estuarine and nearshore environments. There, they feed on small zooplankton and forage fishes for periods of several weeks to several months before migrating to more open marine habitats where most of their adult growth will occur. In addition, many newly-emerged Chinook “fry” migrate directly to nearshore marine environments soon after emerging. These fry migrants are typically less than 50 millimeters in length, which is significantly shorter than smolt migrants (65 to 100 mm in length) that have reared in freshwater for several weeks to one or two months before migrating (Greene et al. 2015).

Stream-type (commonly called “Spring”) Chinook salmon typically reside in freshwater riverine habitats for a year following emergence from spawning gravels. These fish then migrate to the marine environment as “smolts” in the spring, at lengths of 100 mm or more.

The majority of juvenile Fall and Spring Chinook begin migrating to nearshore marine habitats in May and June and are found in nearshore rearing habitats from June to October. A minority may migrate earlier, soon after emerging from spawning gravels in late March and April. Many Puget Sound juvenile Spring Chinook, such as those from the Skagit River near Cypress Island, may rear for periods of several weeks or months in adjacent nearshore habitats before migrating to open marine areas. Nearshore rearing habitats are consequently crucial for the survival and growth of Puget Sound Chinook salmon, which are currently listed as “threatened” under the ESA.

B. <u>Opinions on Potential Harm to Juvenile Chinook Salmon from Efforts to Capture and Remove Farmed Atlantic Salmon Following the Net Pen Failure</u>.

As noted above, to evaluate the potential impacts from efforts taken to remove Atlantic salmon following the collapse of a net pen in August 2017, I first evaluated the likelihood that ESA-listed threatened juvenile Puget Sound Chinook salmon were present in the vicinity of the Cypress Island net pens during the time of the various removal operations. I then evaluated the likelihood that those fish were taken during the three separate types of removal actions undertaken.

1. **Opinions on the Presence of Juvenile Salmon in Nearshore Habitats of Cypress Island Following the Net Pen Failure.**

The net pens that failed during the summer of 2017 were located in Deepwater Bay at the southeast end of Cypress Island in Puget Sound. The former location of these facilities is depicted in a figure attached as Appendix A.

Cypress Island net pen #2 was located in water 65 to 100 feet deep, approximately 200 feet from shore (Clark et al. 2017, page 21). The bottom substrate beneath the pen is described as "variously cobble, sand, and silt with considerable shell hash in places. Closer to the shore (west) the substrate features large rock and cobble" (ibid). These substrates are similar to those observed on the east side of Cypress Island in studies conducted by Wild Fish Conservancy in 2009 (Wild Fish Conservancy 2011, pp. 15-20; 27-29), described in detail below.

In 2009, Wild Fish Conservancy was contracted by the Washington State Department of Natural Resources (WDNR) to conduct a pilot nearshore fish use assessment of the Cypress Island Aquatic Reserve. "Designated in 2007, the Cypress Island Aquatic Reserve withdraws approximately 5910 surface acres of state-owned tidelands and subtidal bedlands adjoining Cypress Island, and the adjacent Strawberry, Towhead, and Cone Islands, from leasing and development" (Cypress Island Aquatic Reserve Pilot Nearshore Fish Use Assessment, p. 8). This includes all of the nearshore salmon rearing habitats surrounding Cypress Island, including Deepwater Bay where three of Cooke Aquaculture's farmed Atlantic salmon net pens are located, including pen #2 that failed catastrophically on or around August 19, 2017. The pilot nearshore assessment employed experienced field crews and supervised, trained volunteers to conduct systematic surveys of 11 sites around the Island, employing standard beach seine sampling gear and protocols. Sites were visited approximately every 12 to 14 days beginning in late February and ending in late October 2009.

The primary purpose of this pilot monitoring project was to provide "baseline data for future monitoring of status trends for marine fish species, particularly targeting native salmonids, forage fish and groundfish stocks, and federal and state listed threatened species and species of concern including Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), Bull trout (*Salvelinus confluentes*) and steelhead trout (*Oncorhynchus mykiss*)". The data acquired during this study are the most current data on juvenile salmon use of Cypress Island nearshore rearing habitats available to date.

The majority of sites sampled during the 2009 pilot project (7 of the 11 sites) were on the east (Bellingham Channel) side of the Island, the side on which Deepwater Bay is located. Wild Fish Conservancy was unable to sample within Deepwater Bay and the vicinity of the Secret Harbor pocket estuary, though the latter is likely a hotspot for use by juvenile salmon (Beamer et al. 2003, 2006, Greene et al. 2015), and possibly forage fish and juvenile groundfish as well, as noted in Wild Fish Conservancy 2011 (page 14). Despite the inability to conduct sampling in Deepwater Bay and Secret Harbor located at the extreme south end of the Bay, several sites near and to the north of Deepwater Bay on the east side of the Island were sampled, including two embayments on either side of Cypress Head immediately to the north of the Bay, and the larger embayments at Eagle Harbor, and Bridge Rock Point, as well as beach habitats similar to those in the Bay that lie to the north (East Beach) and south (South Beach) (see map, Figure 2.2, on page 13 of the Wild Fish Conservancy 2011.). These habitats and the presence of Chinook in them are very likely to be representative of the use of Deepwater Bay rearing habitats by juvenile Chinook and other salmonid and non-salmonid (forage) fishes. Together, habitats at these sites are very likely to be representative of the types and condition of rearing habitats present in Deepwater Bay and Secret Harbor.

Importantly, in my expert opinion, rearing in Deepwater Bay by juvenile salmonids, including ESA-listed Chinook, is likely greater than the protected embayments and beaches to the north and south of the Bay. This is because Deepwater Bay is in a more protected location compared to the rest of the Eastside of Cypress Island due to its more southerly orientation and its great areal extent of protected nearshore habitat. Consequently, it is my opinion that the 2009 pilot study data for the presence of juvenile Chinook salmon at the sample sites on the east side of Cypress Island provide a conservative, minimum estimate of the numbers of juvenile Chinook salmon that were likely to have been present in Deepwater Bay salmon rearing habitats at the time of the August 19 catastrophic failure of pen #2 and during the salvage operations conducted by Cooke Aquaculture over the several weeks following the failure.

The results for sampling at eastside island sites conducted in August and September are the ones most relevant to the issue of potential impacts during the salvage operations. Sampling was conducted at five of the seven eastside sites on all four biweekly sampling session in August and September 2009, and at the two remaining sites during three of the four periods in August and September. Both wild (natural, river-spawned)-origin and hatchery juvenile Chinook salmon were commonly observed at sampling sites on the east and south coast of the island from the first week of June through the third week of September. Juvenile Chinook were documented to be present at or in the vicinity offshore of all eastside sample site throughout this period. Importantly, there was an increase in juvenile Chinook presence in mid-August and September at most eastside sites, a pattern that has often been reported for Chinook salmon smolts in the north Puget Sound nearshore by researchers at the Skagit systems Cooperative and others.

Coded-wire tags from hatchery-origin juvenile Chinook salmon caught on the eastside of the island during the 2009 pilot project were dominated by fish from the Samish and Skagit River Chinook hatcheries, the former a Fall Chinook hatchery and the latter a spring Chinook hatchery. It is also likely that wild and hatchery juvenile Chinook from the Nooksack River were present given their proximity and similar rearing behaviors to Chinook from the Samish and Skagit rivers. DNA analysis of 67 fin clips from wild juvenile Chinook salmon captured during the project showed that the majority (79.5%) were from Whidbey Basin rivers, primarily the Skagit, which are listed under the ESA. The remaining 20.5% were from unlisted Canadian, Washington State or tribal hatchery populations.

While most juvenile Chinook salmon rearing in nearshore environments during the summer and early fall are less than 120 millimeters (4.5 inches) in fork length, it is noteworthy that one sub-adult hatchery Chinook salmon around 290 millimeters fork length was netted at Eagle Harbor to the north of Deepwater Bay on October 18. This suggests that some juvenile Chinook are rearing in nearshore habitats on the eastside of Cypress Island for a year or longer.

In order to estimate the abundance (numbers) of fish of a given species present in the vicinity of each sample site during each sampling period, catch was calculated in two ways: as catch-per-unit-effort (CPUE) and density. CPUE is calculated as the number of fish of a species of interest (Chinook) captured in a standard period of time. In the case of the beach seining method employed by the pilot project, the standard period of time is 1.5 minutes, which is the average length of time taken to set the net in the water from the starting location until the semi-circle was closed by the terminal end of the seine reaching the shore, thereby encircling the fish in the net. The net is then hauled onto shore and fish removed and counted. Fish density was calculated as CPUE divided by the area of habitats sampled (enclosed by the seine) in hectares. This enables the results of the catch from each beach seine set to be expanded to an estimate (with confidence limits) of total numbers of fish in a larger area, such as the entire beach or embayment area of the site at which the seining occurred, as numbers of fish (of a species of interest) per hectare.

During the four August and September sampling periods, the average CPUE for Chinook (over all 7 eastside island sites) ranged from 1 to 3 fish per beach seine set (sampling event). Densities were estimated for each site. During the August-September period, estimated Chinook densities at eastside island sites ranged from 10+ to more than 100 per hectare. In my professional opinion, there is a very high probability (verging on certainty) that densities of juvenile Chinook salmon are generally higher in Deepwater Bay than elsewhere on the eastside of the island throughout the period of primary juvenile Chinook use (June through September), which encompasses the days and weeks immediately following the catastrophic failure of net pen #2 on August 19, 2017 when salvage operations were conducted.

Some of the juvenile Chinook salmon that were likely present in Deepwater Bay in the vicinity of net pen #2 were likely to have been in the collapsed net itself. The net enclosing the farmed Atlantic salmon are small enough to prevent the growing farmed salmon from swimming out of the net, but large enough to easily allow juvenile Chinook salmon and other small fishes to enter. In addition, not all of the pellet feed is consumed by farmed salmon before it falls out of the net, either by dropping out of the bottom of the net or being carried out of the sides of the net by tidal current. This feed provides a ready attractant for native rearing juvenile salmon.

I conclude that it is a near-certainty that ESA-listed juvenile Chinook were present in the action area at the time(s) that removal efforts were conducted. Although the nets are located in water deeper than water in which subyearling juvenile Chinook salmon, typically between 70 and 120 millimeters in length, rear, juvenile Chinook of this size would easily find shelter and protection from current in the immediate vicinity on the outside of the nets and within the nets, especially given the severe fouling of the mesh of the pens themselves by bi-valves (described in Clark et al. 2017; for example, figure 7, page 27). That is, the nets and other physical structures of the net pens provide shelter from tidal currents sufficient to permit juvenile Chinook to feed near and within the pens. This is confirmed by video of harvest operations at one of Cooke's Rich Passage net pen on the south side of Bainbridge Island discussed below. In addition, juvenile Chinook larger than 100 millimeters fork length are capable of swimming and foraging in these deeper waters, and Wild Fish Conservancy 2011 noted that "at some Cypress sites (Eagle Harbor in particular [located on the east side of Cypress Island]) juveniles were consistently observed leaping from the surface in close-by offshore waters during the mid-summer sample sessions when no salmon were netted at the nearshore beach site."

2. <u>Description of the Harvest and Salvage Operations Implemented in Response to the Net Pen Failure</u>.

Following the collapse of a net pen near Cypress Island in August 2017, three different types of actions were taken in an effort to remove the farmed fish from Puget Sound. Descriptions of these activities are provided in a report jointly prepared by the Washington Department of Ecology ("DOE"), the Washington Department of Fish and Wildlife ("WDFW"), and WDNR (Clark et al. 2017). These three activities are as follows:

- Immediately following the net pen failure, Cooke attempted to harvest live Atlantic salmon that remained in the collapsed cages; essentially standard harvest procedures were utilized; this occurred on August 20 and 21, 2017;
- Cooke staff implemented beach seining (i.e., netting) procedures on the shorelines of Deepwater Bay and Secret Harbor; this occurred on August 22–25 and 29, 2017; and
- Divers removed dead farmed Atlantic salmon from the bottom of cages within the collapsed net pens; this occurred between August 26 and 30, 2017.

Cooke's standard net pen harvesting equipment and procedures are described in Clark et al. 2017, page 36. During these operations, the harvest vessel Harvestor was employed to pump farmed Atlantic salmon from the cages of the collapsed net pen (pen #2). These operations were conducted by using vacuum pumps to suck adult Atlantic salmon aboard the harvest vessel. The hose attached to the Harvestor pump used to suck live (and dead) farmed Atlantic salmon is 12 inches in diameter and creates a suction force powerful enough to suck salmon weighing 6 to 12 pounds from the water and raise them a height of more than 10 vertical feet to bring them onboard the vessel.

Review by Clark et al. 2017 of the video of the salvage dive operation employed to recover dead fish determined that the maximum pumping rate during the salvage dive operations was 132 fish per minute (fpm). This maximum rate is indicative of the suction force of the pump, although it appears that the pumping rate during live extraction operations does not consistently achieve this high a rate and more frequently operated in the neighborhood of one-half of this maximum rate (66 fpm).

During the first two days following the collapse of net pen #2 (ending August 21), seines were used to gather live fish that remained in the damaged pen and the fish were then sucked using the pump and brought onboard Harvestor. These activities followed normal Atlantic salmon farm harvesting procedures (Clark et al. 2017, page 36). Clark et al. 2017 (Table 4, page 111) states that 5,166 live Atlantic salmon were extracted by these activities. Data on the duration (total time) that the pump was on in order to bring this number of fish onboard was not available to Clark et al., but based on the maximum rate (132 fpm) and half of that rate (66 fmp), the pump was likely operating a minimum of 39 (5166/132) to 78 (5166/66) minutes.

Beginning on August 26, the pump was used by contracted salvage divers to suck dead Atlantic salmon on the bottom of the cages of the collapsed net pen and deliver them aboard Harvestor. Dead fish from the bottom of the collapsed cages were extracted using this method from August 26 until August 30 (Clark et al. 2017, Table 4, page 111). Clark et al.'s review of the video footage of these operations showed that the total time that the pump was running and used to extract dead fish and pump them onboard the vessel Harvestor during these dates was 4 hours 16 minutes and 35 seconds (256.5 minutes) (Clark et al. page 109). The total number of dead fish extracted during the entire period of dive salvage was estimated to be between 34,000 and 53,700.

According to Clark et al. 2017 (page 97), beach seining in Deepwater Bay was conducted from August 22 to 25 and on August 29, 2017 by employees of Cooke operating under an emergency permit issued by Washington Department of Fish and Wildlife ("WDFW") to Cooke on August 21, 2017. The seines (nets) were made of braided nylon with a mesh size of 1.25 inches and measured 80 feet in length and 40 or 20 feet in depth (Cooke Response Summary Report, page 2). Seines include a top cork line with floats spaced evenly across the length of the net to keep the top of the net at or near the surface of the water and a bottom lead line to keep the bottom of the net on or near the bottom.

As described in the report summary "[a] work skiff dropped Cooke personnel on the targeted beach areas, and one end of the seine net was secured to the shore. The work skiff deployed the seine net over the bow of the vessel while circling back to the shore. The float line and lead line were handed to personnel on the beach creating a purse. The seine net was pulled into shore, shallowed up, and staff were equipped to use a small meshed nylon dip net to remove any non-target salmonids, which as mentioned above was not needed" (ibid, page 1). Cooke reported that a total of "390 escaped Atlantic salmon were recaptured using this method" (ibid, page 2) and reported that no non-target salmonids were captured.

3. <u>Likely Impacts to ESA-Listed Chinook salmon from Efforts to Harvest Live Atlantic Salmon Following the Net Pen Failure</u>.

As discussed above, Cooke attempted to remove live Atlantic salmon that remained in the cages for two days following the collapse of the net pen. The procedures generally followed Cooke's standard harvesting techniques. It is my opinion that it is likely that one or more juvenile Chinook salmon was entrained and killed during these efforts.

As discussed above, it is likely that some ESA-listed juvenile Chinook salmon were present in net pen #2 during the August 20-21 live salvage operations. These fish would have been subject to possible entrainment by the Harvestor pump. The negative pressure required to raise adult Atlantic salmon from the pens and deliver them onboard the harvest vessel will easily vacuum up any native juvenile salmon in the immediate vicinity of the hose opening. Due to their small size, these juvenile fish would be injured or killed outright due to the negative pressure experienced in the pump (unlike the larger farmed Atlantic salmon). Juvenile Chinook salmon entrained in the pump and sucked onboard the Harvestor would be tossed overboard. It is highly unlikely that such fish would have survived, as they would have been extremely vulnerable to predators if they did not simply succumb to their injuries.

I have reviewed video clips of typical harvest operations conducted by Cooke employees on January 30, 2018, aboard the vessel Harvestor at Cooke's Rich Passage net pens on the south side of Bainbridge Island. Several screenshots from these videos are provided herewith as Appendix C. Appendix D contains screenshots of the videos that have been zoomed-in with markings added to point out certain areas. The video clips themselves are also provided as Appendix E. These videos plainly demonstrate that these is bycatch associated with Cooke's harvest procedures.

The videos show Cooke employees tossing small fish the size of juvenile Chinook salmon overboard from a table onto which the adult-sized Atlantics salmon are pumped from the net pen. Harbor seals are observed immediately adjacent to the Harvestor vessel and dozens of seagulls swarm in and over the waters adjacent to the vessel Harvestor to feed on these fish. Well over 50 such small fishes appear to have been tossed overboard during less than two minutes of harvest operations observed in the videos. Many of these fish are likely juvenile Chinook and coho salmon that are present in the net pens themselves and are sucked from the pens and delivered on board the harvest vessel during normal net pen harvest operations. The video clips clearly show that these fish are readily preyed upon (or consumed dead) immediately upon being tossed overboard.

The existence of bycatch associated with net pen harvest activities is further demonstrated by data maintained by the Government of Canada. Finfish aquaculture operators are required to maintain logs of incidental catch of wild dead finish associated with harvest and transfer events. These data, provided herewith as Appendix F, demonstrate that wild salmonids are taken through aquaculture harvest activities, including Chinook salmon.

Based on the observations, data, including the data regarding the presence of ESA-listed juvenile Chinook in the immediate vicinity of net pen #2, and the basic life history and physiological capabilities of juvenile chinook in the sizes shown to be present in August and September throughout the east side of Cypress Island, it is my professional opinion that it is more likely than not that at least one ESA-listed juvenile Chinook salmon was killed during the August 20-21 live fish salvage operations conducted at net pen #2.

4. <u>Likely Impacts to ESA-Listed Chinook Salmon from Beach Seine Activities Taken to Remove Atlantic Salmon Following the Net Pen Failure</u>.

As described above, Cooke staff implemented beach seining procedures on the shorelines of Deepwater Bay and Secret Harbor on August 22–25 and 29, 2017.

The size of the mesh of the seines used to capture the escaped Atlantic salmon (1.25 inches) in Deepwater Bay is much larger than the mesh used in standard beach seines used to sample juvenile salmon and forage fishes (1/8 inch, Wild Fish Conservancy 2011). Juvenile salmon would likely fit through this mesh. It is, therefore, unlikely that juvenile Chinook would have been captured and brought onshore by the nearshore beach seine operations in Deepwater Bay and Secret harbor that resulted in the capture of 390 farmed Atlantic salmon.

However, because the nylon netting used was coarser (and hence stronger) than the netting used in sampling juvenile salmon in nearshore environments (1/8 inch square, Wild Fish Conservancy 2011, page 30), juvenile salmon that encountered the net material or the bottom lead line when it was being pulled ashore to capture the adult Atlantic salmon could have been subject to de-scaling or outright physical injury. This is especially likely to have been the case when the primary objective of the operators of the beach seines was to quickly bring the farmed Atlantics to the beach and remove them from the water.

Further, based on observation of some of the seine operations by biologists experienced in nearshore sampling of juvenile salmon using beach seines, the Cooke employees conducting the seine operations were not experienced in the use of beach seines and consequently were not careful in the manner by which they closed the net and hauled it onto the beach (Kurt Beardslee, personal observation). This increases the probability that juvenile Chinook and other salmonids in the area in which the beach seine salvage was conducted may have been injured by contact with the beach seine during salvage operations, though none would likely have been captured by the seine and brought onto shore.

It is therefore my professional opinion that it is as likely as not that at least one ESA-listed juvenile Chinook salmon was harmed by the beach seine salvage operations conducted by Cooke staff during the dates in question.

5. Likely Impacts to ESA-Listed Chinook salmon from Salvage Dive Activities Following the Net Pen Failure.

The final efforts taken to recover Atlantic salmon following the summary 2017 failure of a net were salvage dive operations that removed dead Atlantic salmon from within the collapsed net pen. It is my opinion that it is very unlikely that ESA-listed juvenile Chinook would have been present in the collapsed pen and therefore susceptible to harm at the times (August 26 – 30) during which the operations were conducted.

The conditions reported by Clark et al. 2017 indicate that oxygen levels were low and that many of the Atlantic salmon salvaged by the dive operations had died as a result of low oxygen in the collapsed pen. In addition, normal processes of decomposition had begun that likely would have further lowered oxygen levels, making the area unsuitable for rearing juvenile Chinook salmon. Further, although the water visibility in the collapsed net pen was low due to turbidity, based on observations of several videos of the salvage dive operation, few live fish were observed and visibility appeared to be great enough that divers could have avoided entraining any juvenile salmonids or other small fishes in the pump. Further, WDFW's review of the salvage video did not report any live fish the size of rearing juvenile salmon in any of the video footage (Washington Department of Fish and Wildlife 2018).

C. <u>Opinions on Potential Impacts from Standard Atlantic Salmon Harvest Procedures</u>.

To evaluate the potential impacts to ESA-listed Chinook salmon from Cooke's standard harvest procedures at its net pens throughout Puget Sound, I used a process similar to that employed for my opinions discussed above. I first evaluated the likelihood that ESA-listed threatened juvenile Puget Sound Chinook salmon are present in the net pens during harvest operations. I then evaluated the likelihood that those fish are taken during harvests. It is my opinion that these operations, at times, likely entrain and kill ESA-listed Chinook salmon.

It is my understanding that Cooke generally conducts harvest activities between July and September. Reports submitted to WDOE by Cooke from December 2015 to September 2017 indicate that the month during which the net pens contained the maximum weight of farmed salmon ranged from March (Clam Bay) to August (Port Angeles). The three pens at Deepwater Bay and the pens at Fort Ward, Hope Island, and Orchard Rocks attained maximum weight in July. To the best of my understanding, partial harvest of the largest, fastest-growing fish in a pen may occur without harvesting all fish in a pen. Final harvest of all fish in a pen would therefore occur one or more months after some of the largest fish have been removed. This appears to have been the case at Deepwater Bay, at which Cooke planned to delay full harvest of all pens, including the failed net pen #2 until September (Clark et al. 2017). This data suggests that a significant amount, if not all, harvest of Puget Sound net pens often occurs between July and September.

During this time period, juvenile Chinook salmon are present at adjacent nearshore habitats and actively feeding. These fish would be particularly susceptible to being attracted to the net pens due to the presence of fish odors and food, as described above during this period of July to September (as well as in the late spring and late fall).

In addition to providing conditions that have a high probability of attracting juvenile Chinook to the net pens, all Puget Sound Atlantic salmon farms are located in proximity to the nearshore environments in which juvenile Chinook will be rearing (approximately 200 feet (Clark et al. 2017, page 21). The maximum water depth below the pens at Deepwater Bay (Cypress Island) is among the deepest of all farms. Only the Port Angeles pen is deeper (NMFS 2010, page 53). Several pens are in shallower water than those at Deepwater Bay, including Fort Ward, Orchard Rocks, Calm Bay and Hope Island (NMFS 2010, ibid.). All of these Puget Sound farms are similarly located no further than 200 feet from shore. Thus, all Puget Sound farms are at least as likely as those at Deepwater Bay to attract juvenile Chinook to the pens, if not more likely to do so due to shallower depths below the pens.

As described above, video clips of Cooke's harvest activities and data maintained by the Government of Canada demonstrate incidental bycatch associated with finfish aquaculture harvest operations.

It is my professional opinion, based on knowledge of the behavior and ecology of juvenile Chinook salmon rearing in Puget Sound nearshore habitats that juvenile Chinook (and other native juvenile salmon) are more likely than not to be in the vicinity and within Atlantic salmon net pens during the months of late spring (May) through fall (October) and that such fish are, at times, very probably entrained in the harvest pump during standard farm (Atlantic) salmon harvest operations. It is further my opinion that any such juvenile salmonids, including ESA-listed Chinook salmon, entrained in the harvest pump are injured or killed as a direct result of being entrained. Any entrained juveniles that may survive entrainment would, with very high probability, be consumed by avian or marine mammal predators immediately upon being tossed overboard, during standard harvest operations as described in Clark et al. 2017 (page 36). This appears to be the case based on the video footage during normal harvest operations observed at Rich Passage.

IV. CONCLUSION.

In conclusion, I repeat that it is my professional opinion that several ESA-listed juvenile Chinook salmon were present throughout Deepwater Bay (including Secret Harbor) at the time of the catastrophic collapse of net pen #2 on August 19, 2017 and during the two week period immediately following during which salvage operation in Deepwater Bay were conducted. It is further my professional opinion that some juvenile Chinook salmon present in Deepwater Bay were very likely to have been in the immediate vicinity and within net pen #2 at the time of the catastrophic collapse and/or immediately thereafter and that one or more of those fish was captured by the suction pump during the salvage recovery of live farmed Atlantic salmon on August 20-21.

It is also my professional opinion that there is as likely as not that at least one ESA-listed juvenile Chinook salmon was injured or killed during the beach seine operations conducted Cooke Aquaculture staff along the nearshore of Deepwater Bay, including Secret Harbor, on August 22-25 and August 29.

Finally, it is my professional opinion that some juvenile Chinook salmon are entrained by the harvest pump during Cooke's standard harvest procedures at its Puget Sound net pens and that some of those fish are injured or killed as a direct result.

By: ________________________________
Nick Gayeski, Ph.D.

EXHIBIT A

Report of John Volpe, Ph.D.

In the Matter of:

Wild Fish Conservancy v. Cooke Aquaculture Pacific, LLC

W.D. Wash. No. 2:17-cv-01708-JCC

April 10, 2019

I. INTRODUCTION.

I have been retained by Wild Fish Conservancy to provide opinions in this matter on two issues: (1) Cooke Aquaculture Pacific's ("Cooke") efforts to track and report the number of farmed Atlantic salmon escaping its net pens; and (2) possible effects to wild salmonids resulting from releases of farmed Atlantic salmon from Cooke's net pens in Puget Sound, including the release that occurred as a result of one of Cooke's net pens collapsing during the summer of 2017.

With respect to Cooke's efforts to track fish escaping from its net pens, it is my opinion that Cooke's Puget Sound net pens almost certainly experience slow chronic escapes of farmed fish and that Cooke is failing to accurately track and account for those releases.

With respect to impacts from fish escaping Cooke's net pens, it is my opinion that, due to the multiple and mutually independent pathways of impact, there is an overwhelming probability that the large-scale escape of farmed Atlantic salmon beginning August 19 2017, together with long term smaller scale chronic leakage of farm fish, results in adverse impacts on wild salmonids.

II. QUALIFICATIONS AND MATERIALS REVIEWED.

In my capacity as a university professor I have, over the past 18 years, specialized in the study of aquaculture-environment interactions. I have published widely in the peer-reviewed academic literature on this topic and am the only scientist in the world that has specialized in the effects of farm-escaped Atlantic salmon in the Pacific Ocean. Prior to joining the academy, I was employed by the BC Ministry of Environment, Fish Culture Section, where oversight of salmonid hatcheries and fish transportation were core responsibilities. My complete curriculum vitae is attached hereto, which provides more details on my qualifications and includes a complete list of the publications that I have authored during at least the last ten years. The only matter in which I have testified at trial or by deposition during the last four years is *Wild Fish Conservancy v. U.S. Envtl. Prot. Agency*, W.D. Wash. 2:15-cv-001731-BJR. I am being compensated for my work in this matter at my hourly rate of $150 USD.

In addition to drawing on my extensive knowledge and experience, particularly with respect to the ecological impacts of Atlantic salmon escapees in the Salish Sea, I have reviewed the materials cited herein and the following materials in developing my opinions described herein:

1. Report by Washington State agencies dated January 30, 2018, titled "2017 Cypress Island Atlantic Salmon Net Pen Failure: An Investigation and Review," and associated appendices;
2. Tables summarizing PRV testing results for Atlantic salmon recovered from Puget Sound;
3. Cooke Aquaculture Pacific's Responses to Plaintiff's Third Set of Interrogatories and Second Set of Requests for Production dated February 7, 2018 from ESA litigation;

4. Draft Report by Dr. Nick Gayeski dated April 17, 2018, titled "Discussion Segment on the estimated number of the Atlantic salmon that escaped from Cypress Island net pen #2 that were PRV-positive;
5. Letter from Douglas J. Steding to Washington State officials dated January 29, 2018, regarding "Draft Incident Review Board Report;"
6. Excel spread sheet obtained from a Washington State agency titled "Deep Water Bay Cooke Escapees;"
7. Purcell, et al., Molecular testing of adult Pacific salmon and trout (Oncorhynchus spp.) for several RNA viruses demonstrates widespread distribution of piscine orthoreovirus in Alaska and Washington, J. Fish Dis. 2017, 1–9;
8. Powerpoint obtained from a Washington State agency titled "Atantic salmon commercial aquaculture in Washington State, Briefing for WDFW Commission, Kenneth I. Warheit, Phd (Dec. 9, 2017);
9. Document obtained from Washington State agency titled "WDFW Draft: October 25, 2017; Atlantic salmon monitoring summary for multi-agency review panel conference call;
10. Office of the Auditor General of Canada Independent Auditor's Report titled "Reports of the Commissioner of the Environment and Sustainable Development of the Parliament of Canada, Salmon Farming (Spring 2018);
11. Online mapping tool provided by the Washington State Department of Fish and Wildlife identifying reports of Atlantic salmon caught in and around Puget Sound since the 2017 escape event.
12. Fleming et al. 2000. Lifetime success and interactions of farm salmon invading a native population. Proceedings of the Royal Society B-Biological Sciences (267)1517-1523.
13. Gayeski et al. 2011. Historical abundance of Puget Sound steelhead, *Oncorhynchus mykiss*, estimated from catch record data. Canadian Journal of Fisheries and Aquatic Sciences (68) 498-510.
14. Jonsson et al. 2006. Cultured Atlantic salmon in nature: a review of their ecology and interaction with wild fish. ICES Journal of Marine Science (63) 1162-1181.
15. Orlov et al. 2006. The feeding behaviour of cultured and wild Atlantic salmon, Salmo salar L., in the Louvenga River, Kola Peninsula, Russia. ICES Journal of Marine Science (63) 1297-1303.
16. Volpe, J.P. 200. Ecology of Atlantic salmon (*Salmo salar*) in British Columbia.
17. Volpe et al. 2000. Evidence of natural reproduction of aquaculture-escaped Atlantic salmon in a coastal British Columbia river. Conservation Biology (14) 899-903.
18. Volpe et al. Competition among juvenile Atlantic salmon (*Salmo salar*) and steelhead (*Oncorhynchus mykiss*): relevance to invasion potential in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences (58) 197-207.
19. McGinnity et al. 2003. Impact of naturally spawning captive-bred Atlantic salmon on wild populations: depressed recruitment and increased risk of climate-mediated extinction. Proceedings of the Royal Society B-Biological Sciences, (1673) 3601–3610.
20. Forseth et al. 2017. The major threats to Atlantic salmon in Norway. ICES Journal of Marine Science (74) 1496-1513.

21. Karlsson et al. 2016. Widespread genetic introgression of escaped farmed Atlantic salmon in wild salmon populations. ICES Journal of Marine Science (73) 2488–2498.
22. Defendant's Supplemental Responses to Plaintiff's First Set of Interrogatories, Requests for Production, and Requests for Admission to Defendant Cooke Aquaculture, LLC in ESA litigation.
23. Reports provided to Wild Fish Conservancy that Cooke generated from FishTalk.
24. Cooke's National Pollutant Discharge Elimination System Permits.
25. Cooke's annual fish release reports from 2012 through 2017.
26. Parsons Vol.2 Deposition March 01, 2016 and Exhibits 42 through 44 from the deposition
27. Cooke's Fish Escape Prevention Plan (Updated January 2017)
28. FAO 1996 Precautionary Approach to Capture Fisheries and Species Introductions. Rome 60pg
29. Fiske, P., Lund, R.A. & Hansen, L.P. 2006a. Relationships between the frequency of farmed Atlantic salmon, *Salmo salar* L., in wild salmon populations and fish farming activity in Norway, 1989-2004. ICES Journal of Marine Science 63: 1182-1189.
30. Jackson, D. et al. 2015. A pan-European valuation of the extent, causes and cost of escape events from sea cage fish farming. Aquaculture 436:21-26
31. Morton, A. and J.P. Volpe. 2002. A Description of Escaped Farmed Atlantic Salmon *Salmo salar* Captures and Their Characteristics in One Pacific Salmon Fishery Area in British Columbia, Canada, in 2000. Alaska Fisheries Research Bulletin (9)102-110.
32. Schiermeier, Q. 2003. Fish farms' threat to salmon exposed. Nature 425: 753.
33. Skilbrei, O.T., Heino, M., Svåsand T. 2015 Using simulated escape events to assess the annual numbers and destinies of escaped farmed Atlantic salmon of different life stages from farm sites in Norway. ICES Journal of Marine Science (72) 670–685
34. Thorstad et al. 2008. Incidence and impacts of escaped farmed Atlantic salmon *Salmo salar* in nature. NINA Special Report 36.

III. COOKE'S TRACKING AND REPORTING OF ESCAPED FISH.

Cooke's National Pollutant Discharge Elimination System ("NPDES") require that Cooke track number of fish in its net pens and those lost to mortality, predation, and escapement. The permits further require that Cooke submit annual reports on fish escapements. The relevant permit terms are as follows:

> The Permittee must maintain a Fish Release Prevention and Monitoring Plan… The Fish Release and Monitoring Plan must include, but not be limited to, the following elements:
>
> 6. Procedures for routinely tracking the number of fish within the pens, the number of fish lost due to predation and mortality, and the number of fish lost due to escapement.

> The Permittee must submit an Annual Fish Release Report to Ecology by January 30th of each year covering the previous calendar year…. The Annual Fish Release Report must include, to the extent possible, all fish released or escaped to state waters, including all Significant Fish Releases (see S8).

Cooke states that it uses software called FishTalk to comply with these requirements. Aside from the large release at a net pen in 2017, Cooke's annual reports since 2012 report that there have not been any releases from the net pens.

A. Inevitability of Large Catastrophic and Small Chronic Escapes.

"Open net pens" are the global norm for industrial-scale fish farming operations in marine, brackish and fresh waters. A net pen is a system that confines production animals in a mesh enclosure suspended from a rigid frame at the surface. Net pens are "open" in the sense that their mesh walls retain production animals but permit fresh, oxygenated water to freely flow into the pen while biological wastes flow out – subsidies which increase the profitability of the enterprise.

Indeed, the greater the integration of the farm with the broader marine environment (minimizing impedance), the better the economic performance of the farm. However, maximizing integration so as to best leverage natural subsidies also invites challenges such as dramatically increasing the probability production fish will escape. The context here is straight forward; utilize escape-proof "closed" infrastructure and assume the costs of maintaining an independent farm environment (water filtration, water cooling, waste collection etc.) or deploy net pens to consume those natural subsidies and absorb the cost of some proportion of production fish escaping. If the cost of escaping fish is less than the capital and operational costs of their retention, there is a business case to be made for "leaky pens". The fact that open net pens remain the global standard speaks volumes in this regard.

Net pen escape events result from numerous causes. Reports by fish farming companies to the Norwegian Fisheries Directorate following escape events during the period from 2001 to 2006 indicate that escapes can be categorised broadly into i) structural failure caused by winds, waves and currents (52%); ii) operational related failure such as collisions with boats, incorrect handling of nets or damage to nets by boat propellers (31%); and iii) biological (e.g. predators) and/or other causes (17%). A recent pan-European study by Jackson et al. (2015) concluded that 75% of the 820,158 Atlantic salmon *reported* escaped in the study did so as a result of structural failure or operational error – typically leading to large-scale escape events.

So inevitable are open net-pen escapes that the United Nations FAO has declared "*the introduction of aquatic organisms for aquaculture should be considered as a purposeful introduction into the wild*". This is particularly relevant in this case given that the UN's conclusion reflects data derived almost exclusively from large-scale escape events reported by fish farmers. Very little is known regarding the contribution of unknown and/or unreported escapes to the total escapement, however, numerous independent peer-reviewed assessments conclude that official statistics appear to greatly underestimate the numbers of escaped farmed salmon owing to non-reporting or under-reporting from some escape events (e.g. Fiske et al. 2006). In particular smaller scale, cryptic and chronic "leakage" of fish resulting from holes in net pens can go unnoticed for some period of time. Sægrov & Urdal (2006) estimate only 12-29% (dependent on a number of assumptions) of the actual number of escaped farmed salmon is reported. This is consistent with the Jackson et al. (2015) survey of European salmon farmers that concluded

> *"By far the most significant cause in terms of numbers of escape incidents was a hole in the net due to either biting (16%), predator damage (14%) or other causes. When the causes of holes in the net are examined (Fig. 3) it can be seen that taken together, net biting and predator damage, account for almost half (47%) of escape incidents due to a hole in the net.*"

These data underscore not only the cryptic nature of most escape events and therefore the inherent challenge of enumerating escapees, but also the ill-advised tendency to use the number of Atlantic salmon captured in the wild as a proxy for escape data. For example, the distance separating the number of *reported* captured farmed salmon and the actual number of free-ranging escapees was explicitly assessed in 2000 in British Columbia coastal waters. An active on-site survey of fishers, packers and processors documented 10,826 Atlantic salmon captured in the commercial fishery. The survey was conducted across only 17 days and was restricted to only Management Area 12, covering less than one half of one percent of the of the 47 Management Areas across coastal BC. What is of particular interest here is that the official DFO reported number of Atlantic salmon captured, for the entire year, for the entire coast, was 7,834. Thus, in one small corner of the BC coast, in a brief snapshot of time, a proactive and comprehensive survey documented ~40% more captured salmon than were reported through official channels, across the entire coast, for the entire year. These data force the observer to draw the same conclusion as with farm escape data: official *reported* numbers of both escapes and captures are likely to underestimate, often significantly, the real numbers.

B. Cooke's Tracking and Reporting of Fish Escapes.

This conclusion is reflected in the analysis of Cooke's FishTalk data base. FishTalk is a commercial database software tailored for aquaculture applications. The data which I have assessed are the day-to-day farm production and operational data entered by Cooke employees (i.e. not FishTalk-generated data or projections). In my opinion these data are certain to contain meaningfully significant error. Further, the distribution of error is non-random and skews in favour of eliminating the appearance of escapes from Cooke's open net-pen operations. This conclusion is based on the following four evidentiary themes.

1) Cooke's data exhibit significant deviation from globally accepted salmon aquaculture norms with respect to escape numbers

Science Advisory Report 2013/50 from the Canadian federal government regulator Fisheries and Oceans Canada distills the global reality of salmon farming; "*Despite improvements in technology and operational procedures, escapes of farmed salmon reared in* *marine net pens are inevitable, and based on current recapture methods, attempts to recover them are generally not successful."* Escapes are simply a reality of net pen aquaculture, both infrequent large-scale catastrophic events and small-scale though much more common, "leakage" events resultant from holes in nets made by predators, storms or operators (e.g. engine props) and by operator error (e.g. fish lost during transfers into/out of net pens). I reviewed operational data covering the production and harvest of 6.1 million Cooke Atlantic salmon in Puget Sound over four years which details no fewer than 33 categories of mortality and yet reports only a single escape event. The absolute absence of reported escape events, save one catastrophic and unignorable event, beggars belief and calls into question the credibility of the entire data set. I have to conclude as any knowledgeable dispassionate observer would: Cooke's FishTalk escapee data cannot be accurate.

Norway is the world leader in not only farmed salmon production but also in volume, breadth and precision of salmon farm data. This is in part due to the government – environmentalist – industry landscape of Norwegian salmon farms being significantly less fractious than for instance, that which the North American industry inhabits. The result is significantly greater industry transparency in Norway, where industry, academic, eNGO, and government researchers typically collaborate on research agendas.

In this less agonistic environment, industry is more transparent with regard to its challenges (and opportunities) – including escape data. Here, escape events are a given. This is not to say that every effort is not being made to reduce escape numbers and indeed significant progress appears to have been achieved. But, "zero escapes" save for one catastrophic and therefore undeniable pen failure would be rightly labelled as fiction. Analysis of 2014-2016 industry-reported escape numbers (years absent major catastrophic events) to Norway's federal Directorate of Fisheries, yields an expected escape ratio of 1 salmon per ~1500 harvested salmon. Even given the relative transparency of the Norwegian industry the Directorate takes pains to highlight that "*the Directorate of Fisheries is aware that escapes occur beyond those that are reported"* and it publishes *reported* numbers that are known to be underestimates of reality.

Recent peer reviewed published research (Skilbrei et al) show the real number of escapes is two- to four-fold greater than the values reported by the Directorate. The causal mechanisms underlying the discrepancy cannot be discretely quantified but are likely a mix of under- or non-reporting by farmers and escapes that are simply unobservable owing to the nature of the event. If we take the conservative Norwegian estimate of 1 escaped salmon per 1500 successfully grown out and harvested, instead of the 'zero' reported I would expect to see ~4100 escaped salmon reported by Cooke (above and beyond the those reported from the single catastrophic event) given the number of harvested salmon over the four year period examined.

2) Excessive and unexplained deviation in *fish in* versus *fish out* numbers

Cooke's FishTalk inventory control data expose a number of significantly problematic issues with regard to data accuracy, precision and uncontrolled error.

Cooke's explanation of FishTalk (Defendant's Supplemental Interrogatory Responses) states that

> *"Employees at individual sites and the hatchery are responsible for routinely entering data to the FishTalk regarding the following parameters:*
> *...*
> *8. Fish opening and closing stock counts, calculated based on the number of fish that entered the pen, minus mortality counts and harvest numbers.*

Employees are to record the fate of all production fish as either *harvested* or *pre-harvest mortality*, without provision of possible other fates such as *escaped*. This suggests implicit instruction to staff that escape events are not to be recorded. This observation helps explain the significant magnitude of error evidenced in the FishTalk data under the column "*Deviation count in period*" which quantifies the number of fish unaccounted for in the FishTalk inventory control system.

Over 214 operational units (individual cycles of fish in to harvest) I assessed, deviation counts ranged from -6,590 fish to +6,661. The former value (-ve) means 6,590 salmon were lost and unaccounted for – neither harvested nor a pre-harvest mortality - though not a single fish is reported to have escaped. The latter value (+ve) means 6,661 more salmon were harvested than were thought to occupy that net-pen unit. Therefore, as percent of total harvested salmon, the error in Cooke's inventory control ranged from -26.6% to +24.0%. Though these are the extreme values in each direction, instances of unaccountably losing or alternatively overcounting one quarter of the inventory signals significant issues of confidence in inventory control procedures – procedures Cooke holds up as sole evidence of the absence of escapes. The mean deviation value for the 42 production units that unaccountably lost fish is -1205 salmon whereas the 172 units that apparently underestimated fish going in (or overestimated mortality losses) was on average +1339 salmon. The average count of harvested salmon from the units assessed was 28,920 salmon per unit. Thus, on average Cooke underestimates losses by 4.2% or alternatively overestimates occupancy by 4.6% yielding a range of average error of 8.8%.

The above analysis reflects data from 214 of 226 operational units for which there was not a single reported escaped salmon – a monumental outlier of industry norms. The analysis omitted an additional 12 units, ten of which were the Cypress Island Site 2 units involved in the catastrophic collapse event of August 2017. Eight of these ten units are recorded as losing the entire complement of salmon (157,214). The remaining two Cypress Island units are reported as losing either a partial complement as escapes (Unit 221) or none at all (Unit 212). However, it is clear both units suffered considerable destruction as mortality counts due to "mechanical damage" were 29,760 and 29,565 salmon, respectively. These data paint a picture of carnage in which the vast majority of production fish in both pens were killed by the collapsing cage infrastructure. And yet, amid such chaos the count deviation for both units is recorded as "zero" – perfect agreement between the number of salmon thought to occupy those pens and the number reported post-collapse.

In addition to the ten Cypress Island units discussed above, only two additional units, Bainbridge Island, Fort Ward (F01 and F02) closing 2014, were recorded as having perfect agreement (i.e. zero deviance) between fish in and fish out estimates. These two units are also highly anomalous in that production fish resided in the units for only three weeks (F01) and five weeks (F02) but lost 60% of production fish in those brief time spans. Losses were categorized as 33% being lost due to "mechanical damage" and 5% each to "predators" and "unspecified" causes (plus a further 17% to other factors). Despite what appears to be deeply flawed and problematic production units, the tally of fish in - fish out estimates are in perfect agreement and not a single escaped fish is reported for either unit. These data are extremely difficult to accept and again undermine confidence in the entire dataset.

The enumeration of the partial loss of Cypress Island Unit 221 salmon to escape has profound implications. Cooke's FishTalk data ask the analyst to accept a scenario where the number of escapes exactly matches the value necessary to balance the inventory control sheet. Of course, any reasonable observer would conclude that Cooke employees did not actually observe the 2953 salmon escaping the scene, but instead that this value is *assumed* to be the escapee count given the other available data. I conclude that this approach is systemic throughout the Cooke inventory data vis-à-vis escape counts: escape events are unobservable and therefore cannot be enumerated unless evoked as part of a catastrophic event in which case escape counts are assumed. The underlying logic of this conclusion is borne out by the Unit 212 (no escapes) data. Here a net-pen collapses killing over 29,000 salmon, and yet somehow results in not a single escape. Here escapes are not required to be invoked in order balance inventory (see i) and ii) below) and therefore escapes are recorded as "zero". I submit that none of the reportedly escaped 160,167 salmon were empirically enumerated and instead this figure represents an assumed value of unknown accuracy. I extend this conclusion to all of Cooke's reported escapement values – which are calculated and assumed figures reported without empirical support.

Delving more deeply into the substantial magnitudes of count deviations I note two additional sources of significant error:

i) *a putative error rate of 2% of automated fish counters used to enumerate fish*

Cooke utilizes automated fish counting technologies rated by its manufacturer VAKI as 99% accurate. Cooke states its VAKI instruments operate at only 98% accuracy. Given the volume of fish at issue, even a 1% error rate is significant, a 2% error rate would be financially injurious. By far the costliest operational line item of any farm is feed consumption. Optimization of feed is critical to financial success and therefore I find it hard to believe Cooke would willingly operate inventory control with error rates double the industry standard given the obvious financial implications and presence of readily available solutions on the market. Notwithstanding, if we accept the 2% error rate at face value we find that 154 of 214 production units with deviations in excess of 2% (184 of 214 units in excess of 1%).

ii) *an arbitrary "mortality" of 5% of smolts during transport to marine sites.*

A second and seemingly inexplicable source of variance in Cooke's inventory tracking is the practice of arbitrarily erasing five percent of fish from its accounts when smolts are transferred from the hatchery to the farm. Staff testify that this is to account for a 5% *assumed* mortality during transport. Over my years of involvement in the BC government hatchery program or as an analyst of aquaculture best practices, I have never observed such a practice.

There is every reason to have as accurate a count as possible at every stage of grow out. Transportation of smolts does incur mortality and is expected; however, anything greater than 1% would attract the attention of managers and be cause for further investigation and corrective measures. Further, the vast majority of transport-related mortalities result from mechanical injury and thus fish could be recovered and counted directly and entered into the FishTalk database in order to maintain maximum accuracy.

Cooke's five percent assumed mortality is not only at least five times higher than industry norms, but is also not based on any empirical study or experimentation. I find this unsurprising as any competent technician should be capable of consistently transporting smolts to net pens with less than one percent mortality. Given that the practice of arbitrarily assigning a standard mortality rate, especially one so inflated, lays far outside industry norms, I advise that there should be no reliance on this assumed five percent mortality figure in balancing Cooke's inventory records.

Indeed, assuming a standard invariant transport mortality rate (of any magnitude) actually introduces two sources of uncontrolled variance. The first being the arbitrary figure itself, and the second is the real mortality which will vary independently, meaning in some cases the real mortality will be additive and in others compensatory. Cooke has at their disposal equipment explicitly designed to minimize such guesswork and generate as accurate an estimate of real standing stock as possible, but have actively chosen not to utilize it. Given that all farm costs (and therefore profits) are dependent on accurate inventory control I conclude the practice of intentionally introducing compounded and uncontrolled variation into the inventory control data is motivated to satisfy an unstated alternative objective which an unbiased observer could reasonably conclude to be to "hide" losses due to escape.

3) The unrecognized association between predation events and escape events.

Of the 33 categories of mortality tracked by Cooke staff, predation is consistently among the most prevalent. On average, 714 salmon (median 430) were reported lost to predation per unit-cycle although there was significant variability across units with a range of 4 to 5039 salmon lost per unit or <1% to 32% of total unit production. Suffice to say that predation is a significant issue at these sites. The vast majority of these losses are due to sealions and harbour seals.

The typical farm arrangement sees the production fish contained in a series of "stock nets" each adjacent to others, typically in a two-row array. The array of stock nets is in turn encircled by "predator nets" which, as the name implies, are deployed to keep marine predators from immediate access to the salmon. A predator needs not necessarily predate salmon to have an effect. The mere presence of a seal or sealion at the stock net will understandably stress salmon and stressed salmon have lower growth rates and higher susceptibility to disease so the importance of predator nets is multifactorial. However, as Cooke's data attest, predators are doing much more than just stressing production stock.

A successful predation event by a seal/sealion demands first that the predator net be breached. This is typically accomplished by biting and tearing the net until a hole large enough for the animal to fit through is created. Once inside the predator net the animal will go to work in similar fashion on the stock net. Predator nets are coarser and more robust than stock nets and so if an animal has successfully breached it, there is little expectation for a stock net to be impenetrable. However, stock nets need not be fully breached for the predator to be successful. An animal may attack a salmon through an intact stock net, biting the salmon and net together and then attempt to tear the salmon through the net. Sometimes in so doing the animal may create a hole large enough to pull the salmon through other times, not.

The preceding paragraphs highlight three important points. First, every predation event is carried out by an animal proven to be able to breach a net. Second, predation events are inferred, and very rarely witnessed. Third, predation events create holes through which salmon may pass.

Scuba divers are a constant presence at marine grow out facilities. Their main duties in addition to general monitoring of the sub-surface environment are the collection of dead salmon inside the stock nets and repair of holes to both predator and stock nets. Cooke's predation count data are based on the number of recovered dead salmon that show signs of having been predated upon. What these data do not capture – cannot capture – are the number of salmon fully consumed because no (or nearly so) predation event is actually witnessed but is instead inferred. The assumption built into the data is that every predation event results in a partially consumed salmon carcass. While this does happen on occasion (there is no literature available that quantifies this) the scientific literature contains numerous studies that document predators successfully removing the whole fish and in so doing creating holes in stock nets. Therefore, I conclude Cooke's predation count data are an underestimate of an unknown degree. Further, given the magnitude of predation evidenced it is inconceivable that stock nets have not been breached a great many times, creating ample opportunity for undocumented escape of stock fish.

4) The high proportion of unknowable "mortalities" which are more correctly termed "losses"

Of the 33 mortality categories tracked Cooke's FishTalk database, four are populated with calculated and inferred values. Of the three years of data I assessed 202,536 salmon are listed as "mortality – unspecified", 212,202 as "mortality – mechanical damage" and 161,288 as "mortality – predation" and "escapes". Each of these categories carries unknowable degrees of uncertainty and together comprise 35% of all reported mortalities. The point here is that more than a third of all losses come with unknowable but likely substantial error. Despite this abundance of uncertainty, escapes are recorded as absolutely invariant at "zero" in 217 of 226 production cycles (the balance being involved in the 2017 catastrophic collapse). I find a high degree of incongruence here. There appears to be a high tolerance for inferred, error-laden estimates but a refusal to do the same with escape estimates. Given the extreme density of production fish in stock nets a conservative release estimate is likely to be ~ 30 fish per hole-hour (one every two minutes). Such an estimate is conservative and is as simple (simplistic) and accurate as many of Cooke's other data categories.

C. Behaviour is not an Acceptable Method of Escape Enumeration.

Finally, I consider the means by which Cooke generates escape counts. In testimony, Cooke staff explain that escapes are enumerated via behavioural monitoring by farm staff. I trust any reader of this report immediately recognizes the folly of such an approach. In brief, it is the belief of Cooke staff that an escape event manifests a detectable and reliable change in behaviour of remaining fish. Therefore, if this (undescribed) behaviour does not manifest, there are assumed to have been no escapes. For the sake of unpacking this, I will temporarily accept this position and pose some rhetorical questions:

1) Does this behaviour manifest with the escape of a single fish or is there a threshold of escape numbers necessary to trigger it?

2) How are escapes enumerated during the majority of the day and all of the night when there are not eyes on the fish?

3) What are the rates and magnitudes of Type I or Type II errors? (false positive / false negative)?

Obviously, one could carry on for some time exposing the absurdity of such an extraordinary claim. In short, no such methodology is recognized, anywhere. Further, and at the risk of stating the obvious, one cannot quantify a variable (number of escapes) by using a two-factor state space (behaviour expressed = yes or no). To state this plainly, monitoring a cage population for the appearance of a certain behaviour permits in no way, shape or form, the capacity to enumerate escapes. Therefore, given Cooke's methodology, "zero escapes" across the board is not only unsurprising, it is the unavoidable outcome. This exercise in fiction is further enabled and abetted by Cooke's willful blunting of accuracy of its own bookkeeping as described in the sections above.

D. Conclusion on Cooke's Fish Tracking Efforts.

In sum, it is my opinion that Cooke is not appropriately tracking and reporting the number of fish lost from its Puget Sound salmon farms to escapement. This stems from Cooke's insertion of unsupported assumptions into its tracking data that masks the number of fish lost to leakage; including Cooke's assumption that its electronic counters are only 98% accurate and the assumption that 5% of the farmed fish are lost during transport to the marine net pen. Further, when Cooke's own data shows fish that are unaccounted for, even with these unsupported assumptions, Cooke does not report the fish as escapes, but instead writes off its own data.

IV. ECOLOGICAL HARM FROM ESCAPES.

Beginning on or around August 19, 2017 "Net Pen #2" of Cooke Aquaculture Pacific's ("Cooke") Cypress Island operation suffered a catastrophic failure resulting in the release to Puget Sound of a large number of Atlantic salmon – a species officially considered "invasive" by Washington State Department of Fish and Wildlife ("WDFW"). Cooke represents that the failed pens contained approximately 305,000 adult fish that were between 24 and 28 months of age, having spent 9 to 12 months in freshwater and 15 months in saltwater. The fish were both male and female. The State of Washington estimates that between 243,000 and 263,000 fish escaped into Puget Sound and that, of those, between 186,000 and 206,000 were not recovered and remain unaccounted for.

In addition to large escapes such as this, smaller escapes are known to occur more regularly when underwater nets are torn by tidal conditions, predators, or from other causes. These two types of escapes can have cumulative impacts to wild salmonids.

A. Modes of Interaction.

The release of farm Atlantic salmon into Puget Sound creates numerous potential pathways for negative impacts on native fauna. Native salmonids are especially susceptible; the taxonomic proximity of native Pacific salmonids to Atlantic salmon greatly increases the likelihood of interaction, each seeking similar habitats, prey etc. at each life history stage. Sympatry (occurrence in the same place, at the same time) whilst seeking similar resources ensures significant interaction, a prerequisite for direct impact. The magnitude of impact of exotic or invasive individuals on native populations can be modulated by many factors, however the overriding consideration is one of demographics. The greater the number of invaders (*aka* propagule pressure) the greater the potential impact. However, the receiving environment and native populations play a role here too. Degraded environments and/or distressed native populations are significantly more likely to be negatively affected by a given propagule pressure relative to heathy environments and populations. The logic here is self-evident, the greater the number of invaders and the less abundant and/or resilient the native populations, the greater the likely impact on the native populations.

The modes of interaction between farm-escaped Atlantic salmon and native Pacific salmon may occur via five general pathways; competition for limited resources (e.g. food, optimal nest sites), predation, transfer of parasites and/or disease, hybridization, and colonization (long term occupancy altering foundational ecological processes). I will consider each of these individually in turn, though it is important to recognize that these impacts can be cumulative as they are not mutually exclusive.

1. Competition.

Competition ensues when demand for a limited resource exceeds supply. Competition is by definition a negative interaction for all parties. In the ecological context the winner of a competition is the party that maximizes their cost:benefit ratio, or put another way, the party that losses least overall. Key resources for which competition may arise between farm-escaped Atlantic salmon and native salmonids is habitat/food, nest sites, and/or mates, all of which are relevant in freshwaters whereas habitat/food competition will also occur in marine waters.

In the freshwater environment juvenile salmon are territorial. An individual maintains a territory so as to maintain exclusivity to food that is in or passes through that territory. An optimal territory is one that is both rich in feeding opportunities and provides some protection from predators (typically large resident trout, sculpin and birds). Juvenile Atlantic salmon in freshwater are almost entirely insectivorous and therefore direct predation on native juvenile salmon is highly unlikely. However, negative impact does manifest through agonism directed at native salmon that are subsequently forced into suboptimal territories yielding fewer feeding opportunities and/or increased susceptibility to predators, both of which leading to increased mortality rates.

This is precisely the mechanism that was long thought to explain why despite dozens of attempts between 1905-1933 to purposely establish Atlantic salmon in British Columbia, all efforts eventually failed. Attempts in Washington State (1951, 1980, 1981) ended similarly. Though no organized research was ever conducted, general consensus was that juvenile Atlantic salmon are competitively inferior to native Pacific salmonids (all stocking events were of juveniles into freshwaters). Before such qualitative assumptions can be used to predict the fate of any Cypress Island progeny we must first understand *why* those introductions failed and ask if conditions are the same today.

I spent five years conducting research to answer the question "*why did historical introductions of Atlantic salmon fail?*". In summary of this research (and the only Atlantic salmon-Pacific salmon competition research ever conducted in the Pacific), historical introductions failed because of "prior residency effect" of native salmonids. Before explaining this in detail, it is worth exploring the details of the experiments as they are relevant to the present issue.

In July 1999 a large population (116 individuals) of naturally spawned and reared juvenile Atlantic salmon consisting of two size/age classes (fry and parr) was found in Amor de Cosmos Creek, 35 km north of Campbell River, Vancouver Island, British Columbia. The size/age classes present confirmed these fish were the product of two successive years of natural reproduction. This wild population presented the first ever opportunity for empirical, *in situ* evaluation of wild-reared Atlantic in Pacific waters. In particular we focused on quantifying the interaction between juvenile Atlantic salmon and native salmonids. To do this we compared habitat use, agonistic behaviour, foraging efficiency and condition factor between sympatric native salmonids and feral Atlantic salmon to control populations from the same river not exposed to Atlantic salmon. Our objective was to evaluate if competitive superiority of native salmonids is likely to constitute biological resistance to Atlantic salmon colonization, and thus explaining the failure of past introductions.

The study area was bisected by a water fall. Below the falls were both Atlantic and Pacific (Chinook, coho, cutthroat and rainbow/steelhead) salmonids. Above the falls only the Pacific salmonids were present. Therefore, the falls created a natural experiment, a single contiguous system with two sections, one with and one without Atlantic salmon. We conducted 1038 five-minute in-water observations of focal fish (>86 hrs total) across both sections. The results were:

- Significant habitat-partitioning between Atlantic salmon and Pacific salmon was evident. Juvenile Atlantic salmon (both fry and parr) resided exclusively in high-energy reaches together with juvenile steelhead. Atlantic salmon interacted exclusively with steelhead. Interactions with juveniles of other native species; coho, cutthroat and Chinook, were too rare to analyze as these species remained in slower waters at the stream margins and around woody debris only very rarely interacting with either steelhead or Atlantic salmon in the mid-channel, high-energy waters.

- Significant micro-habitat partitioning was evident between mid-stream steelhead and Atlantic salmon. Steelhead aggressively defended a broad vertical range relative to Atlantic salmon, which typically adopted a still, demersal position on the stream bottom. However, those steelhead sympatric with Atlantic salmon exploited a statistically significant smaller stream area relative to steelhead not sympatric with Atlantic salmon.

- The presence of Atlantic salmon significantly increased steelhead intraspecific agonism. Steelhead sympatric with Atlantic salmon showed a significant bias towards intraspecific agonism, being 11.8 times more likely to attack another steelhead rather than an Atlantic salmon. This magnitude of intraspecific bias was unexpected considering the nearest fish in every case was a focal Atlantic salmon. As for Atlantic salmon agonism, an individual was nearly three times more likely to attack a steelhead than another Atlantic salmon.

- In terms of foraging efficiency, Atlantic salmon were found to be ~42% more efficient than sympatric steelhead, potentially helping to explain the 15% better condition factor of the Atlantic salmon.

In summary, the first ever (and to date only) ecological analysis of a "wild" Atlantic salmon population in Pacific waters demonstrated that wild-reared Atlantic salmon are capable of surviving and perhaps thriving. Further, significant agonistic interaction with wild salmonids was targeted at juvenile steelhead though numerous other salmonid species were present. These data suggest that wild reared juvenile Atlantic salmon are not "inferior" to Pacific salmon as has been presumed.

These conclusions align with other studies examining the performance of cultured vs wild Atlantic salmon. A recent summary article distilling all published data on wild vs farm salmon states "*When cultured Atlantic salmon are released into the wild they compete with wild fish for food, space, and breeding partners. As a result of morphological, physiological, ecological, and behavioural changes that occur in hatcheries, their competitive ability often differs from that of wild fish. These changes are partly phenotypic and partly genetic … faster growing…cultured parr's greater aggression often allows them to dominate wild parr.*" In short, farm fish are more aggressive than wild counterparts leading to demonstrable impact on sympatric wild individuals.

However, these works still leave unresolved the mechanism(s) responsible for historical failures of introductions and apparent present-day successes. To resolve this, I undertook a series of controlled mesocosm experiments where communities were 'assembled' by introducing farm-derived juvenile Atlantic salmon and similarly aged/size wild steelhead in different orders across time. A total of 1810 five-minute focal fish observations (62.7 hours) post assembly were undertaken across 22 replicates of 120 individuals each of steelhead and Atlantic salmon.

The results were as dramatic as they were clear: an individual that had the benefit of prior residency in a habitat outcompeted all subsequent 'invaders', regardless of species. In other words, when Atlantic salmon have unfettered access to a habitat for as little as three days before being confronted by steelhead, those Atlantic salmon proved competitively superior – every time. Likewise, when steelhead had prior access, they proved superior to Atlantic salmon, again, every time. The prior residency effect proved equally strong when either steelhead or Atlantic salmon resident populations were 'invaded' by conspecifics, again those with prior residence dominated every time. Numerous variables were measured throughout the experiment but the one most relevant in the current context is weight gain/loss. Invaders demonstrated their competitive inferiority by losing significant weight relative to superior residents over the course of the experiments.

It is my opinion that the prior residency effect is the key to understanding historical introduction failures why those experiences have little relevance today – the coastal environment has changed dramatically in the intervening years. The 'prior residency effect' is now recognized as a preeminent predictor of success in salmonid introductions be they intentional or not.

Historically, Atlantic salmon were introduced into habitats already at or near saturation with native competitors ensuring immediate and strong competition for the naïve Atlantic salmon who had no opportunity to establish territories. Today, abundance of native salmonid stocks, and especially the niche-equivalent steelhead have declined sharply resulting in a surplus of underutilized habitat available to a potential transplant such as Atlantic salmon. Puget Sound steelhead are estimated to be at 1-4% of their historical abundance. Any biological system that experiences a 96% decline of abundance of a high-level consumer will be at a diminished capacity to retard the establishment of a niche equivalent invader - in this case Atlantic salmon. Further, the far greater likelihood of successful acquisition of territory by present-day Atlantic salmon invaders increases the risk of prolonged exposure to native individuals by larger, aggressive competitors which is surely to lead to negative impact.

If unimpeded access to prime habitat is a key factor in successful establishment of Atlantic salmon, the threatened status of Puget Sound steelhead is likely to markedly increase the chances of Atlantic salmon colonization and attendant impacts on ESA-listed individuals. These data further suggest that the presence of farm-derived Atlantic salmon will result in significantly increased competitive pressure on Puget Sound steelhead, a population already devastated by staggering demographic decline.

Both Atlantic and Pacific salmon are anadromous, meaning adults build nets, spawn and deposit eggs in freshwater streams. Fertilized eggs remain buried beneath gravel for weeks to months, depending on species and temperature variables. Buried, eggs depend on constant exposure to clean, oxygen rich water to filter through the gravel. Therefore, egg survival depends on nests being located in areas of high flow, but not so high that nests will be destroyed or alternatively in areas where sediment may accumulate and suffocate eggs. This is to say that nest location plays a significant role in reproduction success and not surprisingly there is competition among spawning adults for not only the best mate but also for what are perceived to be the best nest sites.

My work with adult farmed Atlantic salmon demonstrated farm fish taken straight from cage culture and deposited in natural habitat (simulating an 'escape') do build nests and generally behave as one would expect wild fish to perform. However, with the fish I have worked with sexual maturation and spawning occurs very late in the season relative to fall spawning Pacific salmon. The fish I worked with did not spawn until mid-late January (however my stream surveys document adult putative spawners entering rivers as early as July). Had these same fish been involved in an actual escape and ascended a river they would find themselves with unfettered access to the entire river channel, including optimal nest sites given most Pacific salmon adults would have spawned and died by mid-January – leading to a high probability of nest superimposition. Further, the few adult fish the Atlantic salmon would likely interact / compete with are early-run winter steelhead which ascend rivers mid-November through February. Puget Sound steelhead are comprised of both the extremely depressed early-run fish and a marginally more abundant later (March-May) spawning component. The spawn timing of early-run Puget Sound steelhead is likely to put them in direct competition with farm-escaped Atlantic salmon.

My work further demonstrated that farm-raised female Atlantic salmon (females are responsible for choosing / competing for the nest site and its construction) chose only optimal sites to construct nests when given access to a gradient of nest habitat options. Therefore, an additional pathway of impact of farm-escaped Atlantic salmon is "nest imposition"; late-spawning female Atlantic salmon excavating optimal nest sites for their own eggs and in doing so destroying the nests of earlier spawning Pacific salmonids. The magnitude of this impact is a matter of demographics of both species:

- The more Atlantic salmon there are in a system, the greater the incidence of nest imposition.

- The per-imposition impact is directly related to the health of the population imposed upon. For a robust population, the loss of a nest may be negligible. For a listed population the loss of a nest is highly significant, not just demographically but also from the perspective of lost genetic diversity.

Therefore, it is my opinion that the probability of nest imposition is significant for native Puget Sound salmonids, including Puget Sound steelhead and Chinook.

2. Predation.

When the number of predators is artificially increased (such as in salmon farm escape events), demand on the prey base increases to the detriment of all. There are no data regarding such scenarios that are inclusive of farm-escaped Atlantic salmon however the consensus of studies of escaped farm salmon conclude that some proportion (typically a minority) of farm escapees successfully transition to wild forage. A recent review of anthropogenic-derived threats to wild Norwegian Atlantic salmon identified farm-escaped salmon as by far the greatest threat. The review panel pointed to significant genetic introgression of farmed salmon demonstrating not only the capacity for farm-escapees to spawn *en masse*, but that the observed introgression is facilitated by farm-escapees transitioning to wild feed; they document significant catches of foraging escaped farmed salmon on the North Atlantic feeding grounds. Ergo, escaped farmed salmon do successfully predate in the wild.

The ramifications of this with regard to native Puget Sound salmonids are self-evident. Angler catch records of Atlantic salmon compiled by Washington Fish and Wildlife indicate that the majority of escapees remained resident in Puget Sound marine waters. While the available data set is relatively small, stomach analyses of caught individuals suggest the rate of successful transition to wild feed for the farm-escapees is ~4%. Further, numerous Puget Sound anglers report catching Atlantic salmon using herring as bait, further evidence of transition to wild feed of some escapees. Using the 4% estimate, we can expect a minimum of 8,333 foraging adult Atlantic salmon (assuming an at-large population of 200K).

3. Parasites / Disease.

Narratives regarding salmon farms and parasites/disease are almost wholly focused on cage populations resident inside the cages. The hyper-density of hosts inside a cage but constantly exposed to pathogenic vectors by virtue of the permeable open net-pen construction sets in motion an epidemiological "perfect storm". Consistent exposure from external environment drives high infection rates, near perfect fish-fish transmission rates drive exponential pathogen growth and absence of predation to harvest sick enfeebled individuals, further prolongs / maximizes pathogen production. The result can often be analogous to industrial scale pathogenic culturing. However, as a result of porous open net pens, pathogens are pushed back out into the natural environment where significant spikes in the pathogen loads of wild populations are often observed.

My lab's work assessing sea lice infection rates of wild salmon found infective stage lice were 73x more abundant around farms relative to reference sites inducing mortality increases of 9-95% in wild juvenile salmonids and because of dominant unidirectional currents, we were able to observe this effect up to 80 km from the farm site. The take-away points here are:

- Open net pen fish farms unintentionally precipitate large scale epidemiological events
- Pathogenic effects of fish farms can have extraordinarily large footprints
- It is not uncommon to have extremely high infection rates of stock fish on farms

When an escape event such as Cypress Island occurs, from an epidemiological perspective the major consideration is the change in density and spatial distribution of pathogenic host fish. While contained in the net pen, pathogenic fish cumulatively represent a point source of pathogen release, potentially creating a high density pathogen zone around the farm. Risk of wild fish infection is a function of its proximity to the farm. Post escape, infected fish disperse potentially creating a much larger spatial distribution of farm-derived pathogens, but at lower density (dependent on the number of pathogenic hosts per unit area). Clearly, predicting epidemiological processes becomes far more challenging once farm fish disperse post-escape. Rather than a spatially explicit zone of impact typical of intact farms, free-ranging infected farm fish create scenarios of broad spatial scale, but lower intensity (i.e. cryptic) impacts.

Adding to the challenge of characterizing post-escape epidemiology is the phenomenon of "co-infections". Simply put, an infected individual often has increased susceptibility to other secondary infection(s). Thus, the cumulative effect of an infection event extends past the clinical effects of the initial infection and by extension, the realized impact on a wild population typically cannot be bound by the clinical expectations of the single, initial infection.

4. Hybridization.

To date there has been no rigorous study of the likelihood of hybridization between Atlantic salmon and the six pacific salmon species. What little information is available suggests Atlantic x Pacific salmon hybridization has very low probability of producing viable offspring.

5. Colonization.

Colonization of exotic species is the second greatest threat to global biodiversity after habitat loss. Vulnerable native species are affected through predation, agonism, competition for resources, and habitat alteration and/or exclusion. The magnitude of impact is typically related to the relative abundances of invader and native species. In the present context, colonization of Atlantic salmon in Washington State waters extends the duration of impact of escapees on native Puget Sound salmonid populations. If colonization does not occur, impacts are expected to cease with the death of the last invaders. With colonization, impacts not only continue indefinitely, but due to the action of natural selection acting on the colonizing population, the magnitude and diversity of impacts on native fish species would both be expected to increase.

Will farm-escaped Atlantic salmon colonize the North American Pacific coast? is a question that is as complex as it is contentious. The short answer is "maybe" … citing the research above, it is my opinion that the probability is much higher today than it ever has been before. However, some (typically with vested industry interests) argue it is not nearly as complicated as people like myself make it out to be. It is instructive then to review past, equally strident positions held by industry and United States and Canadian governments:

"They can't escape" – confronted with evidence to the contrary the narrative changes to

"They'll escape but not survive" - confronted again, and another change

"They'll survive but not spawn" – and again

"They'll spawn but the progeny won't compete successfully" – confronted again this brings us to the present day

"Feral progeny may be able to compete but not complete their life cycle."

And so, we have reached the very last assumed barrier to Atlantic salmon colonization: *there is no evidence that wild- spawned juveniles are capable of going to sea and returning as adults to complete the life-cycle*. Of course, there is no evidence to suggest they won't. My point here is that the farm salmon debate is characterized by a long history of assumptions favoring expansion of the industry that have fallen when tested, such as;

> "*[Atlantic] salmon have no home stream to return to in order to spawn. Instead, they would return (if they survived that long) to their home fish farm. Without a freshwater spawning ground they would be unable to reproduce.*"

1987- BC Ministry of Agriculture and Fisheries, Aquaculture and Commercial Fisheries Branch. The salmon farm debate is rife with such statements – equal parts willful ignorance and political expediency.

The final step, completion of the life cycle, is the most difficult to pursue because it depends on surveying natural river systems as opposed to testing the hypothesis in the lab. My lab group is the only such group that has ever undertaken long term, structured and rigorous Atlantic salmon surveys in the Pacific Northwest (focused in Vancouver Island rivers). We have found hundreds of free-swimming Atlantic salmon – wild reared fry, parr, smolts and migratory spawning adults. However, our collective survey effort is statistically zero, given the tiny fraction of one percent of the tens of thousands of kilometers of salmon bearing rivers on Vancouver Island we can survey, let alone mainland BC, Washington State and Alaska. In this light, I reject outright statements that conclude colonization is not possible when we cannot, with any statistical confidence, state that colonization hasn't already occurred. The simple fact is that research to date makes clear that it is possible, perhaps likely, but certainly neither impossible or a foregone conclusion.

Colonization as a concept seems straightforward but in fact it is not. Much discourse around the Cypress Island event centers around "will those escaped fish colonize?". This reflects a fundamental misunderstanding of the colonization process. It is not these specific fish that will or will not "colonize", it is their progeny, should they be produced, and their progeny after them and so on. The worst-case scenario regarding the Cypress Island fish is that some subset successfully reproduces.

As worrisome as this may be, this is not "colonization", but is a necessary precursor. Any escapees that survive to spawn (likely a small cohort relative to total escape numbers) distinguish themselves from the larger group by completing this task. They are, by definition superior to those that did not survive – and possess traits that will be passed on to progeny. This first generation (F_1) of wild fish would be reared under natural conditions and most importantly, subject to natural selection that will remove from the population individuals that perform poorly under wild conditions. Those fish that reach sexual maturity are high quality individuals, proof of which being their continued existence. When these fish spawn, they produce an entire generation (F_2) carrying only the genes of proven survivors. Natural selection again prunes the population leaving only "the best" to form the next spawning generation. With each subsequent generation survivorship is expected to grow (i.e. increasing abundance) as does the *per capita* impact of each Atlantic salmon individual, reflecting continuous tailoring of the invasive population with its host environment.

It is here that the insidious nature of colonization and its effects on native species resides. Most forms of pollution have a dose-specific impact that remains static through time. Exotic species (incl. pathogens and Atlantic salmon) however are not static, their *per capita* potential impact grows with each generation as a result of natural selection.

The take home here is that very little will be resolved immediately with regard to the colonization issue. Natural reproduction of the initial escapee cohort, should it occur, will in all likelihood be undocumented given the absence of any appropriate monitoring. A *post-hoc* occupancy modelling analysis of three years of intensive freshwater surveys concluded that when they were present Atlantic salmon were detected in surveyed streams at best 2/3 of the time (~33% of surveys erroneously conclude Atlantic salmon are absent), illustrating even the most targeted survey efforts are far from error-free.

Be that as it may, a recent report from the Washington Department of Ecology states "*The limited numbers of Atlantic salmon found in the freshwater system appear healthy. There is no evidence that they were feeding in the freshwater system nor were they sexually mature. The Atlantic salmon in freshwater may survive for some time.*" This is consistent with normal spawning behaviour for Atlantic salmon which, once returned to freshwater do not feed, with all resources instead routed to gamete production. So, the first piece of a colonization scenario is in place, with apparently healthy adults ascending rivers, which a salmon only does for one purpose. We may expect similar scenarios to be playing out up and down our coast with catches of putatively escaped fish being caught throughout Puget Sound (and north to Vancouver Island waters). Analyses from other jurisdictions however demonstrate threat of colonization by farm-escaped Atlantic – and all the attendant challenges to native stocks – is greatest in those systems most proximate to the escape site. Thus, while impacts associated with Cypress Island farm escapees may manifest far afield, all available data suggest the Puget Sound ecosystem is most at risk.

B. Conclusion on Effects of Fish Escapements.

Competition, predation, pathogen dissemination/transfer and colonization are recognized throughout the salmon farming world as being among the major pathways of impact of farm-escapees on native salmonids. The magnitude of impact is a factor of both number of escapees and population health of potentially impacted native populations. The exceptional scale of the escape event renders any knowledgeable and impartial observer to conclude that level of impact on native Puget Sound salmonids is high. Further, the extremely precarious status of the Puget Sound's three ESA-listed salmonid populations greatly reduces the invasion resistance of the Puget Sound ecosystem which greatly increases the probability of Atlantic salmon colonization and with it permanent increased predation, competition and pathogen transfer to native salmonids.

By: ____

John Volpe, Ph.D.

ATTACHMENT

John P. Volpe

Associate Professor

AREAS OF EXPERTISE
Aquaculture
Ecogastronomy
[Sea]Food Ecology
Macroecology
Terroir

FUNDING TO DATE
$4,112,427

UNDERGRADUATES TAUGHT
4499 Students

GRAD DEGREES SUPERVISED
25 MSc | 6 PhD | 1 MA

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I and my students use data intensive approaches to uncover linkages between ecological and social sustainability, particularly with regard to sustainable food, wine, aquaculture and marine resources.

APPOINTMENTS & HONOURS
2013 Research Excellence Award - Faculty of Social Science, UVic
2010 Appointed Associate Professor University of Victoria
2007 Nominated – NSERC Steacie Fellow
2006 Nominated – NSERC Steacie Fellow
2005 Appointed Assistant Professor University of Victoria
2004 Nominated - Canada Research Chair Tier II, U of Victoria
2004 Nominated - Pew Fellow
2003 Adjunct Professor, Fisheries Centre, U. of British Columbia
2003 Adjunct Professor, Biology Department, U. of Victoria
2001 Appointed Asst Professor University of Alberta
2001 Nominated - Canada Research Chair Tier II, U of Alberta
2001 NSERC Post Doctoral Fellowship (declined)
2000 *"133 Young Leaders of the New Millennium"* Globe and Mail

UVIC COURSES
ES 200 Introduction to Environmental Studies
ES 240 Ecological Processes
ES 341 Ecological Restoration
ES 381 Ecology and Culture of Food
ES 431 History, Science & Culture of Wine
ES 446 Sustainable Fisheries
ES 482 Natural History and Ecology of Biological Invasions
ES 482 Complex Systems in Nature
ES 500 Environmental Theories, Methods and Skills I
ES 501 Environmental Theories, Methods and Skills II
ES 503 / 603 Environmental Studies Graduate Colloquium

REFEREED PUBLISHED ARTICLES (Supervised Students during research)

2019 Stewart, F.E.C., J.P. Volpe, J.T. Fisher. The debate about bait is a red herring in conservation research. **Journal of Wildlife Management** *Accepted*.

Frey, S., J.P. Volpe, N.A. Heim, J. Paczjowski, and J.T. Fisher. Carnivore species alter activity patterns and temporal niche partitioning in response to anthropogenic landscape change. **Journal of Applied Ecology**. *Submitted.*

2018 Heim, N.A., J.T. Fisher, J.P. Volpe, A.P. Clevenger, J. Paczkowski. Carnivore community responses to anthropogenic landscape change: species-specificity foils generalizations. *In Review* **Biological Conservation** BIOC_2018_1428

Stewart, F.E.C., S. Darlington, J.P. Volpe, M. McAdie, J.T. Fisher. The matrix matters: natural habitat within working landscapes predicts functional connectivity better than protected areas. *In Review* **Journal of Applied Ecology**

Stewart, F.E.C., J.P. Volpe, B.R. Eaton, G.A. Hood, D. Vujnovic, and J.T. Fisher. Protected area networks are only as valuable as the landscapes they conserve. *In Review* **Biological Conservation**

Stewart, F.E.C., J.T. Fisher, A.C. Burton, and J.P. Volpe. Species occurrence data reflect the magnitude of animal movements better than the proximity of animal space-use. **Ecosphere** 9(2):ecs2.2112

Burgar J.M., F.E.C. Stewart, J.P. Volpe, J.T. Fisher and A.C. Burton. 2018. Estimating density for species conservation: comparing camera trap spatial count models to genetic spatial capture-recapture models. **Global Ecology and Conservation** (15:e0014)

2017 Frey, S.A., J.T. Fisher, A.C. Burton and J.P. Volpe. 2017. Investigating animal activity patterns and temporal niche partitioning using camera trap data: Challenges and Opportunities. **Remote Sensing in Ecology and Conservation** 3(3):123-132

Stewart, F.E.C., J.P. Volpe, J.S. Taylor, J. Bowman, P.J. Thomas, M.J. Pybus and J.T. Fisher. Distinguishing reintroduction from recolonization with genetic testing. **Biological Conservation** 214:242-249

Heim, N.A., J.T. Fisher, A.P. Clevenger, J. Paczkowski, J.P. Volpe. Cumulative effects of climate and landscape change drive spatial distribution of Rocky Mountain wolverine. **Ecology and Evolution** 7(21):8903-8914

2016 Stewart F.E.C., N.A. Heim, A.P. Clevenger, J. Paczkowski , J.P. Volpe, and J.T. Fisher. Wolverine behaviour varies spatially with anthropogenic footprint: implications for conservation and inferences about declines. **Ecology and Evolution** 6:1493-1503

Lancaster, D., P. Dearden, D.R. Haggarty, J.P. Volpe, N.C. Ban. 2016. Effectiveness of shore-based remote camera monitoring for quantifying recreational fisher compliance in marine conservation areas. **Aquatic Conservation** 27(4):804-813

2014 Fisher, J.T., C. Pasztor, A. Wilson, J.P. Volpe, and B. Anholt. 2014. Recolonizing sea otters spatially segregate from pinnipeds on the Canadian Pacific coastline: The implications of segregation for species conservation. **Biological Conservation** 177:148-155.

Fisher, A.C., J.P. Volpe and J.T. Fisher. 2014. Occupancy dynamics of escaped farmed Atlantic salmon in Canadian Pacific coastal salmon streams. **Biological Invasions** 16:2137-2146.

2013 Price, M. A. Morton, J.G. Eriksson and J.P. Volpe. 2013. Fish processing facilities: new challenge to marine biosecurity in Canada. **Journal of Aquatic Animal Health** 25:290-294.

Volpe, J.P., J.L.M. Gee, V.A. Ethier, M. Beck, A.J. Wilson and J.M.S. Stoner. 2013. Global Aquaculture Performance Index (GAPI): The first global environmental assessment of marine fish farming. **Sustainability** 5:3976-3991.

Fisher, J.T, S. Bradbury, B. Anholt, L. Nolan, L. Roy, J.P. Volpe, and M. Wheatley. 2013. Wolverines on the Rocky Mountain slopes: natural heterogeneity and landscape alteration as predictors of distribution. **Canadian Journal of Zoology**. 91:706-716

Fisher, J.T., B. Anholt, S. Bradbury, M. Wheatley, and J.P. Volpe. 2013. Spatial segregation of sympatric marten and fishers: the influence of landscapes and species-scapes. **Ecography** 36:240-248.

2011 Fisher, J.T., B. Anholt, and J.P. Volpe. 2011. Body mass explains characteristic scales of habitat selection in terrestrial mammals. **Ecology and Evolution** 1:517-528.
Liu, Y. R.U. Sumaila, J.P. Volpe. 2011. The potential ecological and economic impacts of sea lice from farmed salmon on wild salmon fisheries. **Ecological Economics** 70: 1746-1755.

Krkosek, M.K., B.M. Connors, H.A. Ford, S. Peacock, P. Mages, J.S. Ford, A. Morton, J.P. Volpe, L.M. Dill, M.A. Lewis. 2011. Fish farms, parasites, and predators: implications for salmon population dynamics. **Ecological Applications** 21:897-914.

2009 Krkosek, M.K., A. Morton, J.P. Volpe, M.A. Lewis. 2009. Sea lice and salmon population dynamics: Effects of exposure for migratory fish. 2009. **Proceedings of the Royal Society of London, Series B**. 276:2819-2828.

Volpe, J.P. 2009. The efficiency trap. **Food Ethics** 4: 41-42.

2008 Kelly, J.R., H. Proctor and J.P. Volpe. 2008. Displacement of native eelgrass (*Zostera marina* L.) by introduced oysters (*Crassostrea gigas* Thunberg) significantly alters intertidal community structure. **Hydrobiologia** 596:57-66.

Kelly, J.R., and J.P. Volpe. 2008. Effects of non-native oyster (*Crassostrea gigas* Thunberg) on native eelgrass (*Zostera marina* L.) in the Strait of Georgia, British Columbia. **Botanica Marina** 50:143-150.

2007 Volpe, J.P. 2007. Reconciling fisheries with conservation and the ecological footprint of aquaculture. 4th World Fisheries Congress. **American Fisheries Society Symposium** 49:587-589.

Rodtka, M.C. and J.P. Volpe. 2007. Effects of water temperature on interspecific competition between juvenile bull trout and brook trout in an artificial stream. **Transaction of the American Fisheries Society** 136: 1714-1727.
Sumaila, U.R., J. Volpe and Y. Liu 2007. Potential economic benefits from sablefish farming in British Columbia. **Marine Policy** 31: 81-84.

2006 Krkošek, M., M.A. Lewis, A. Morton, L.N. Frazer and J.P. Volpe, 2006. Epizootics of wild fish induced by farm fish. **Proceedings of the National Academy of Sciences USA** 103: 15506-15510.

Krkošek, M., M.A. Lewis, J.P. Volpe and A. Morton. 2006. Fish farms and sea lice infestations in wild juvenile salmon in the Broughton Archipelago – A rebuttal to Brooks (2005). **Reviews in Fisheries Science** 14: 1-11.

2005 Krkošek, M., A. Morton, J.P. Volpe. 2005. Non-lethal assessment of juvenile Pacific salmon for parasitic sea lice infections **Transactions of the American Fisheries Society** 134: 711-716.

Naylor, R., K. Hindar, I. Fleming, R. Goldburg,S. Williams, J.P. Volpe, F. Whoriskey, J. Eagle, D. Kelso, M. Mangel. 2005. Fugitive Salmon: A Framework for Assessing Risks of Escaped Fish from Aquaculture. **BioScience** 55: 427-437.

Krkošek, M., M.A. Lewis and J.P. Volpe. 2005. Transmission dynamics of parasitic sea lice from farm to wild salmon. **Proceedings of the Royal Society of London, Series B**. 272:689-696.

Volpe, J.P. 2005. Reply to Allen: Dollars without sense: The bait for big-money tuna ranching around the world. **BioScience**. 55:644.

Volpe, J.P. 2005. Dollars without sense: The bait for big-money tuna ranching around the world. **BioScience**. 55:301-302.

2002 Morton, A. and J.P. Volpe. 2002. A description of Atlantic salmon *Salmo salar* in the Pacific salmon fishery in British Columbia, Canada, in 2000. **Alaska Fishery Research Bulletin** 9: 102-110.

2001 Volpe, J.P., B.W. Glickman and B.R. Anholt. 2001. Reproduction of Atlantic salmon (*Salmo salar*) in a controlled stream channel on Vancouver Island, British Columbia.

Transactions of the American Fisheries Society 130: 489-494.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 2001. Competition among juvenile Atlantic salmon (*Salmo salar*) and steelhead trout (*Oncorhynchus mykiss*): Relevance to invasion potential in British Columbia. **Canadian Journal of Fisheries and Aquatic Sciences** 58: 197-207.

Volpe, J.P. and B.R. Anholt. 2001. Atlantic salmon (*Salmo salar*) in British Columbia. *In* **Marine Bioinvasions: Proceedings of the First National Conference** (January 24-27 1999; edited by J. Pederson). Massachusetts Institute of Technology, Cambridge, MA. pp. 256-259.

2000 Volpe, J.P. and G. Horne. 2000. A simple and inexpensive method for providing natural forage in a laboratory environment. **North American Journal of Fisheries Management**. 20: 801-803.

Volpe, J.P., E.B. Taylor, D.W. Rimmer, B.W. Glickman. 2000. Natural reproduction of aquaculture escaped Atlantic salmon (*Salmo salar*) in a coastal British Columbia river. **Conservation Biology** 14: 899-903.

1997 Taylor, E.B., Harvey, S., Pollard, and J. Volpe. 1997. Postglacial genetic differentiation between reproductive ecotypes of kokanee (*Oncorhynchus nerka*) in Okanagan Lake, British Columbia. **Molecular Ecology** 6: 503-517.

1996 da Cruz, A.D., J.P. Volpe, V. Saddi, J. Curry, M.P. Curado, B.W. Glickman. 1997. Radiation risk estimation in human populations: Lessons from the radiological accident in Brazil. **Mutation Research**. 373: 207-217.

Volpe, J.P. and M.M. Ferguson. 1996. Molecular genetic examination of the polymorphic Arctic charr, *Salvelinus alpinus*, of Thingvallavatn, Iceland. **Molecular Ecology** 5: 763-772.

BOOK CHAPTERS

Siddique, M. A. L and J.P. Volpe. 2009. Chapter 9. Eco-friendly sustainable shrimp aquaculture in Bangladesh: A way of minimizing coastal degradation. *In* Moksness, Dahl, Strotrupp (eds.) **Integrated Coastal Zone Management**. Blackwell Publishing, UK.

Volpe, J.P. and K. Shaw. 2008. Fish farms and neoliberalism: Salmon aquaculture in British Columbia. *In* C. Gore and P. Stoett (eds.) **Environmental Challenges & Opportunities: Local-Global Perspectives on Canadian Issues.** Emond Montgomery, Toronto.

Volpe, J.P. 2006. "Salmon sovereignty" and the dilemma of intensive Atlantic salmon aquaculture development in British Columbia. *In* Parrish, C.C., N.J. Turner, and S.M. Solberg (eds.). **Resetting the Kitchen Table: Food Security, Culture, Health and Resilience in Coastal Communities**. Hauppague, NY: Nova Science Publishers

Dai, Hahn, Hawryshan, Lee, Temple, Kennedy, Neis, Parrish, Russo, Garrido, Stanley, Turner, Volpe, and Wroblewski. 2005. Future Options I: Aquaculture, Hatcheries, Tourism, Transportation,

and Local Initiatives. *In* Ommer, R.E. and the Coasts Under Stress research project team. **Coasts Under Stress: Restructuring and Social-Ecological Health**. Montreal, PQ: McGill-Queen's University Press.

Wroblewski, J., J.P. Volpe and D. Bavington. 2005. Manufacturing fish: Transition from wild harvest to aquaculture. *In* Sinclair, P.R. and R.E. Ommer (eds.) **Power and Restructuring: Canada's Coastal Society and Environment**. St. John's, NL: ISER Books.

OTHER PUBLICATIONS & RESEARCH PRODUCTS

Volpe, J.P. 2017. Comment: The science is in - Salmon farms need to be out. Times Colonist November 19.

Volpe, J.P., J. Gee, M. Beck, V. Ethier. 2011. How Green Is Your Eco-label? Comparing the Environmental Benefits of Marine Aquaculture Standards. University of Victoria, Victoria, British Columbia, Canada. 56pgs. <www.gapi.ca>

Volpe, J.P., M. Beck, V. Ethier, J. Gee, A. Wilson. 2010. Global Aquaculture Performance Index. University of Victoria, Victoria, British Columbia, Canada. 116pgs <www.gapi.ca>

Volpe, J.P. 2009. Salmoni come polli. **Slow Food Journal** 39: 60-62 (in Italian)

Sumaila, U.R., J.P. Volpe and Y. Liu. 2005 Ecological and Economic Impact Assessment of Sablefish Aquaculture in British Columbia. **Fisheries Centre Research Reports** 13: 3

Volpe, J.P. 2004. Book review: *Imperfect Symmetry: Thermodynamics in Ecology and Evolution* by Lionel Johnson. **Fish and Fisheries**. 5:346-347.

Volpe, J.P. 2004. Salmon Scare? Guest Columnist. **Seattle Post Intelligencer**. 1-25-04

Volpe, J.P. 2003. Farming uncertainty in coastal British Columbia. **The Osprey** 44: 1, 6-8.

Volpe, J.P. 2001. Super-Unnatural BC: Atlantic salmon in British Columbia. David Suzuki Foundation, Vancouver B.C. 32pp.

Volpe, J.P. 2001. Invasion ecology of Atlantic salmon (*Salmo salar*) in British Columbia. **Ph.D. Thesis**. University of Victoria, British Columbia.

Volpe, J.P. 2001. Farming uncertainty in coastal British Columbia. **The Steelhead Release** Autumn 2001: 20-25.

Volpe, J.P. 2000. How do we know what we don't know? Atlantic salmon in British Columbia: A review. *In* P. Gallaugher and C. Orr (*eds.*) Aquaculture and the Protection of Wild Salmon: Speaking for the Salmon Workshop Proceedings, Simon Fraser University March 1-3 2000 pp. 28-33.

Volpe, J.P. 2000. The occurrence of Atlantic salmon in coastal streams of southern British Columbia during 1999. British Columbia Ministry of Environment Lands and Parks Regional File Report. Nanaimo, British Columbia

Volpe, J.P. 2000. Atlantic salmon vs. Pacific salmon in British Columbia, Canada. **Aliens** 10: 21-22.

Volpe, J.P. Salmon Roulette: Are we risking our Pacific salmon heritage for Atlantic salmon aquaculture? **The National Post**. October 20 1999 (*Editorial*).

Volpe, J.P. 1999. The occurrence of Atlantic salmon in coastal streams of southern British Columbia during 1998. British Columbia Ministry of Environment Lands and Parks Regional File Report. Nanaimo, British Columbia.

Volpe, J.P. 1998. The occurrence of Atlantic salmon in coastal streams of southern British Columbia during 1997. British Columbia Ministry of Environment Lands and Parks Regional File Report. Nanaimo, British Columbia.

Volpe, J.P. Pennask Lake Broodstock Management Plan. Technical File. Fish Culture Section, Fisheries Branch B.C. Min. of Environment, Lands & Parks. January 1996. 36p.

Volpe, J.P. Premier Lake Broodstock Management Plan. Technical File. Fish Culture Section, Fisheries Branch B.C. Min. of Environment, Lands & Parks. January 1996. 43p.

Volpe, J.P. *Broodstock Summary Database*, Ver. 1.0. and User's Manual. *MSAccess & VBasic*. Fish Culture Section, B.C. Min. of Environment, Lands & Parks. March 1996. 10p.

Volpe, J.P. *Fish Transfer Database*, Ver. 2.0. and User's Manual. *MSAccess* & *VBasic*. Fish Culture Section, Fisheries Branch B.C. Min. of Environment, Lands & Parks. March 1996. 22p.

Volpe, J.P. 1994. A molecular genetic examination of the polymorphic Arctic charr, *Salvelinus alpinus*, of Thingvallavatn, Iceland. M.Sc. Thesis. University of Guelph, Guelph, Ontario.

Danzmann, R.G., M.J. Joyce and J.P. Volpe. 1991. Mitochondrial DNA variability in brook charr (*Salvelinus fontinalis*) populations sampled from the Lake Huron drainage: Management and conservation implications. Ontario Ministry of Natural Resources Technical Report.

INVITED LECTURES & ADDRESSES (Invited & Fully Sponsored)

2016 Aquaculture Innovation Workshop (Keynote) - Roanoke Virginia Aug 21

2015 Slow Food Canada AGM Montreal March 22-26

2014 Terra Madre, Turin Italy. The Challenge of Slow Seafood Oct 23-27

2013 Yale University School of Forestry and Environmental Studies. Feb 20-22

2012 McGuinness Institute Wellington, NZ. Aquaculture and Global Protein., Dec 23.
The Atlantic Salmon Federation. Land-Based Closed-Containment Conference. Keynote Speaker and Panelist October 10-11. Saint John, NB
Seattle WA. Aquaculture Innovation Workshop Keynote Speaker and Panelist May 15 -16. Supported by Tides Canada Foundation.
U of Tasmania. Managing Marine Farming: have we achieved best practice? Keynote Speaker March 8 Hobart, Tasmania, Australia

2011 Seafood Summit. Salmon is Just the Tip of the Iceberg—Using New Science Tools to Assess and Shift the Current Trajectory of Marine Aquaculture. Invited speaker and panelist. Jan 31-Feb 2 Vancouver BC

2010 Seafood Summit. The Global Aquaculture Performance Index. Invited speaker and panelist. Jan 22-25 Paris, France
Chile (multiple locations) Leader of exotic (farm) salmon expedition through Chilean Patagonia rivers. Sponsored by and in collaboration with Oceania. Public presentations and one-on-one meetings with federal fisheries minister and government decision makers (Santiago). May 30-June 6.
WWF International Salmon Aquaculture Dialogue. Speaker and respondent. . November 13-19 Bergen, Norway
Columbia University. Respondent – Ecological Performance Index. Board of Directors Meeting. Dec 17-19 New York City

2009 Annual meeting of the American Association for the Advancement of Science (AAAS). Aquaculture impacts, standards and sustainability. Feb 12-16 Chicago IL

Seafood Summit. USA 2009 The Global Aquaculture Performance Index. Invited speaker and panelist San Diego, CA Jan 22-25

2008 Seafood Summit.. "The Global Aquaculture Performance Index". Invited speaker. Barcelona, Spain January 27-30

2007 University of Las Lagos. Genetic impacts of escaped farm salmon. Invited speaker Valapariso, Chile Dec 17-20

Simon Fraser University The challenge of seafood sustainability. Center for Dialogue. Vancouver, Oct. 11.

Oregon State University-Department of Fisheries and Wildlife Science Friction: Commercial salmon aquaculture in British Columbia. Eugene, Oregon Oct 10

SlowFish. Slow Food International Conference. The myth of efficiency and the future of seafood. *Invited speaker & panelist* Genova, Italy May 4-7

University of Las Lagos. Potential impacts of exotic aquaculture escaped salmon *Invited speaker* Puerto Montt, Chile Jan 13-17

2006 Stanford University. Transcending Borders: Pacific salmon and interdisciplinary approaches to fisheries conservation. Palo Alto, CA,. *Invited speaker* Feb 1-2 2006

Integrating aquaculture and ecological sciences for sustainable offshore aquaculture.. Florence, Italy May 10-13

2004 International Seafood Summit. Chicago, Il Oct 26-28. *Invited Speaker*

Stanford University. International Sustainability Days October 13-16. *Invited Speaker* Palo Alto, CA

University of Victoria. Annual Meeting of the Society for Ecological Restoration Plenary Address. Victoria, BC August 24-26.

Culinary Institute of America - Annual Joint Meeting of the Association of the Study of Food and Society and the Agriculture, Food and Human Values Society. *Invited Speaker* Hyde Park, NY June 10-13.

4th World Fisheries Congress - Forum on the Sustainable Seafood Movement Invited speaker and Forum presenter, May 3-6. Vancouver, BC

2003 U. of Victoria, School of Environmental Studies *Recruitment lecture* Victoria, BC Oct 8.

Pacific States Marine Fisheries Commission Portland, Invited speaker. Oregon. November 17-19.

Canadian Assoc. of Geographers Annual Meeting, Invited speaker. Victoria, BC May 30.

WWF Canada - Public Forum on Aquaculture, Invited speaker. Prince Rupert, BC May 3.

UC Davis Biological Invasions and Biocultural Diversity Symposium. Invited speaker Davis, CA April 24-27

UBC, Centre for Applied Conservation Research - Salmon Conservation and Aquaculture; *A Public Forum*. Invited speaker Vancouver, BC March 25

2002 North-West Salmon Summit. Invited speaker. Bellingham, WA Oct 18.

US Aquatic Nuisance Species Task Force AGM. Invited speaker October 17 Olympia, WA

First Nations Aquaculture Summit. Tsleil-Waututh Nation Cultural Centre, Invited speaker. Vancouver, BC Sept. 24-26.

Simon Fraser University - Center for Dialogue. Invited speaker. Vancouver, BC Oct. 11.

Stanford University Invited speaker Palo Alto, CA September 17

American Society of Limnology and Oceanography Annual Meeting. Invited speaker. Victoria, BC June 10-14.

American Society of Ichthyologists and Herpetologists Annual Meeting. Invited speaker. Kansas City, MO - July 3-8.
U.S. Forest Service. Invited speaker. Juneau, AK April 2-4.
Simon Fraser University-Biological Sciences Department. Burnaby, BC March 22
Simon Fraser University - *Speaking of Science Lecture Series.* Harbour Centre Campus Vancouver, BC March 21.

2001 Canadian Museum of Nature - National Workshop on Invasive Alien Species. Invited Panelist. Ottawa, Ont Nov 5-7.
Prince Rupert Aquaculture Forum. Invited panelist. Prince Rupert, BC Oct 19-20.
Pacific States Marine Fisheries Commission. Portland Oregon. Sept 17 (cancelled – 9/11)
University of Alberta-Biology Department *Recruitment lecture* Edmonton, AB Feb 1.

2000 US Fish and Wildlife Atlantic Salmon Identification Workshop. Workshop Coordinator & Leader Lacey, WA June 19.
Seattle Central Community College. Invited speaker. Seattle, WA May 4.
Vancouver Aquarium-*Hot Topics Lecture Series*. Vancouver, BC March 29.
Simon Fraser University - Speaking for the Salmon International Workshop. Invited speaker. March 1-3. Burnaby, BC

CONTRIBUTED ACADEMIC / SCHOLARLY ORAL PRESENTATIONS

(Students underlined; **presenter in bold**)

Stewart, F.E.C., E.J.B. McIntire, R. Winder, J.P. Volpe, and J.T. Fisher. 2019. Managing wildlife in a complicated world; applying lessons learnt to boreal caribou. The Wildlife Society BC, Kelowna, BC

Gorgopa, S. M., J.P. Volpe. 2018. "Can Sport SCUBA Divers Provide Reliable Data for Rockfish Conservation?". Salish Sea Ecosystem Conference, Seattle, WA,

Gillian Chow-Fraser, Nicole Heim, John Paczowski, John P. Volpe, Jason T. Fisher. 2018. Indirect effects of anthropogenic features on competitive pressures between intra-guild carnivores North American Congress of Conservation Biology, Toronto ON.

Darlington, S., F.E.C. Stewart, J.T. Fisher, A.C. Burton, J. Volpe. 2018. Deer on the move: white-tailed deer anti-predator movement response to industrial features in northeastern Alberta. Canadian Society for Ecology & Evolution, University of Guelph ON

Stewart, F.E.C., J.P. Volpe, G.A. Hood, D. Vujnovic, and J.T. Fisher. 2018. Protected areas are only as valuable as the working landscapes they conserve. Canadian Society for Ecology and Evolution, Guelph, Ontario. July 17-21 2018. *****Awarded best presentation (3rd place)***

Gillian Chow-Fraser, Laura Finnegan, Barry Nobert, John P. Volpe, Jason T. Fisher. 2018. No room for mistakes for caribou mothers on multi-predator and disturbed landscapes Canadian Society of Ecology and Evolution, Guelph ON.

Gorgopa, S.M., J.P. Volpe. 2018. "Can Sport SCUBA Divers Provide Reliable Data for Rockfish Conservation?". Pacific Ecology and Evolution Conference, Bamfield, B.C., Canada.

Gillian Chow-Fraser, Nicole Heim, John Paczowski, John P. Volpe, Jason T. Fisher. 2018. Friend or foe: fine-scale spatiotemporal co-occurrence of wolverine (*Gulo gulo*) and coyote (*Canis latrans*) on disturbed and undisturbed landscapes Alberta Chapter of the Wildlife Society (ACTWS), Lethbridge AB. ****Awarded Best Student Presentation (3rd place)**

Gorgopa, S.M., J.P. Volpe. 2017. "Evaluating the reliability of citizen science SCUBA surveys for long term monitoring of marine life". Pacific Ecology and Evolution Conference, Bamfield, B.C., Canada.

Bulger, D. S, J.P. Volpe, and J.T. Fisher. 2018. Evaluating British Columbia's artificial reefs in a conservation context: Potential abundance and diversity trade-offs for groundfish Canadian Society for Ecology and Evolution, Guelph, ON.

Gillian Chow-Fraser, J.T. Fisher, and J. Volpe. 2017. Influence of predation risk and human footprint on boreal and central mountain caribou neonate mortality Pacific Ecology and Evolution Conference (PEEC), Bamfield BC.

Darlington, S., J.T. Fisher, J. Volpe. 2017. Anthropogenic disturbance affects energetic trade-offs with predation risk in white-tailed deer (*Odocoileus virginianus*). Canadian Society for Ecology & Evolution, Victoria BC.

Stewart, F.E.C., A.C. Burton, M. Pybus, D. Vujnovic, G. Hood, J.P. Volpe, and J.T. Fisher. 2017. Biological interpretation, accuracy, and precision of species occurrence data. The Alberta Chapter of the Wildlife Society, Lac LaBiche, Alberta.

Gillian Chow-Fraser, J.T. Fisher, and J. Volpe. 2017. Mother knows best: the influence of female caribou habitat selection on calf mortality during calving season. Canadian Society for Ecology and Evolution, Victoria BC.

Burgar, J., **F.E.C. Stewart**, A.C. Burton, J.P. Volpe, and J.T. Fisher. 2017. A comparison of multiple spatial capture-recapture models for estimating mammal densities in a changing landscape. 12th International Mammal Congress, Perth, Australia, July 9-16th, 2017.

Stewart, F.E.C., J.P. Volpe, J.S. Taylor, J. Bowman, P.J. Thomas, M.J. Pybus, and J.T. Fisher. 2017. Distinguishing reintroduction from recolonization with genetic testing. The Wildlife Society, Albuquerque, NM. ***Awarded best student presentation***

Burke, Lily, Jason T. Fisher, John P. Volpe. 2017. Fish on film in the temperate deep: an underwater method comparison. Canadian Society for Ecology and Evolution Conference, May 7 - 11, 2017, Victoria, British Columbia, Canada.

Gillian Chow-Fraser, J.T. Fisher, and J. Volpe. 2017. Mother knows best: the influence of female caribou habitat selection on calf mortality during calving season Alberta Chapter of the Wildlife Society, Lac La Biche AB. ****Awarded Best Student Presentation (3rd place)**

Darlington, S., J.T. Fisher, J. Volpe. 2017. Predator avoidance and seasonal resource selection by white-tailed deer (*Odocoileus virginianus*) in Northern Alberta. Alberta Chapter of the Wildlife Society, Lac La Biche AB.

Burgar, J.*, **F.E.C. Stewart**, A.C. Burton, J.P. Volpe, and J.T. Fisher. 2017. A comparison of multiple spatial capture-recapture models for estimating carnivore densities using field data. Canadian Society of Ecology and Evolution, Victoria, BC, May 7-11 2017.

Stewart, F.E.C., A.C. Burton, J.P. Volpe, and J.T. Fisher. 2017. What does species occurrence data really mean when individuals are mobile? Pacific Ecology and Evolution Conference, Bamfield, British Columbia. ***Awarded best presentation***

Stewart, F.E.C., A.C. Burton, M. Pybus, D. Vujnovic, G. Hood, J.P. Volpe, and J.T. Fisher. 2017. Species occurrence data tells us where animals are, but more importantly where they move. The Canadian Society for Ecology and Evolution, Victoria, British Columbia.

Darlington, S., J.T. Fisher, J. Volpe. 2018. Modelling predator avoidance by white-tailed deer in the Alberta boreal forest. Pacific Ecology & Evolution Conference, Bamfield BC.

Fisher, T.J., N.A. Heim, F.E.C. Stewart, C. James, S. Frey, and J.P. Volpe. 2016. Three's a crowd: anthropogenic footprint affects species-species interactions. The Wildlife Society, Raleigh, North Carolina.

Stewart, F.E.C., N. Heim, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2015. Wolverine behaviour varies with anthropogentic footprint: Implications for conservation and inferences about declines. The Canadian Society for Ecology and Evolution, Saskatoon, Saskatchewan.

Stewart, F.E.C., **N. Heim**, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2016. Using behaviour as a metric of landscape change. WeaselFest, Gavin Lake, British Columbia.

Stewart, F.E.C., J. S. Taylor, J.P. Volpe, and J.T. Fisher. 2016. Questioning fisher re-introduction success in central Alberta; genetic evidence for provincial scale connectivity. WeaselFest, Gavin Lake, British Columbia.

Stewart, F.E.C., M. Pybus, D. Vujnovic, G. Hood, J.P. Volpe, and J.T. Fisher. 2016. Genetic evidence for fisher recolonization success in central Alberta: implications for provincial-scale connectivity. The Alberta Chapter of the Wildlife Society, Drumheller, Alberta.

Stewart, F.E.C., **N. Heim**, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2015. Landscape-scale behavioral response by wolverines (*Gulo gulo*) to landscape development: evidence for a human-driven landscape of fear? The Alberta Chapter of the Wildlife Society. Edmonton, Alberta.

Stewart, F.E.C., N. Heim, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2015. Wolverine behavior varies with anthropogenic footprint: Implications for conservation and inferences about declines. The Canadian Society for Ecology and Evolution, Saskatoon, Saskatchewan.

Stewart, F.E.C., N. Heim, A.P. Clevenger, J. Paczkowski, J.P. Volpe, and J.T. Fisher. 2015. Wolverine landscapes-of-fear; assessing landscape-scale human impacts on wolverine behaviour in the Eastern Rockies. Pacific Ecology and Evolution Conference. Bamfield, British Columbia.

Beck, M., J.P. Volpe and L.M. Horborg. 2013. Victoria Natural History Society Feb 12th

Beck, M., J.P. Volpe and L.M. Horborg. 2013. Pacific Ecology and Evolution March 1-3 Bamfield Marine Science Center

Gee, J., J.P. Volpe. 2013. Aquaculture Information Management System: Website User-Based Interfaces. Food and Agriculture Organization of the UN / Department of Fisheries, Thailand. Terminal Workshop. Bangkok, Thailand. January 14

Beck, M., J.P. Volpe and L.M. Horborg. 2013. WA-BC American Fisheries Society Chapter AGM March 25-28 Lake Chelan, Washington

Beck, M., J.P. Volpe and L.M. Horborg. 2013. International Conference on Aquatic Invasive Species (ICAIS) Niagara Falls, Ontario April 21-25

Gee, J. and J.P. Volpe. 2013. Policy and Regulatory Mandates and Objectives for an Aquaculture Information System. Food and Agriculture Organization of the UN / Department of Fisheries, Thailand. Terminal Workshop. Bangkok, Thailand. January 14.

Beck, M., J.P. Volpe and L.M. Horborg. 2013. Canadian Aquatic Invasive Species Network II AGM May 2-3 Kananaskis, Alberta

Gee, J. and J.P. Volpe 2013. Policy and Regulatory Mandates and Objectives for an Aquaculture Information System. Food and Agriculture Organization of the UN / Department of Fisheries, Thailand. Terminal Workshop. National Training Course on Aquaculture Information Management System in Thailand. Bangkok, Thailand. January 10.

Beck, M., J.P. Volpe and L.M. Horborg. 2013. Canadian Society for Ecology and Evolution. Kelowna, BC May 12-15

Beck, M., J.P. Volpe and L.M. Horborg. 2013. International Conference of Marine Bioinvasions, August 20-22 University of British Columbia, Vancouver BC

Volpe, J.P. The Beef or the Fish? 2012. How Putting Aquaculture in the Context of Global Protein Production Can Inform/Impact our Seafood Choices. 10^{th} Seafood Summit. Hong Kong. Sept. 6-8.

Beck, M., J.P. Volpe and L.M. Horborg. 2012. Reconciling Large-scale Model Predictionswith Small-scale – Impacts and interactions of the invasive smallmouth bass (*Micropterus* *dolomieu*) with native species in British Columbian lakes. International Conference on Aquatic Invasive Species April 21-25, Niagara Falls ON

Beck, M., J.P. Volpe and L.M. Horborg. 2012. Small mouths lead to big problems? Non-native Smallmouth bass (*Micropterus dolomieu*) in British Columbian lakes. American Fisheries Society Meeting May 15-17, Victoria, BC.

Mucciarelli, V.M., J.P. Volpe, B. Starzomski, and D. Biffard. 2011. Investigating the drivers of biodiversity on an artificial reef in a subtidal marine ecosystem. International Marine Conservation Congress May 14th-18th, Victoria BC

Volpe, J.P., 2011. Fat fish and sacred cows: The first global mariculture performance assessment forces a re-evaluation of fish farming's role in sustainable seafood. International Marine Conservation Congress May 14th-18th, Victoria BC

Fisher, J.T., C. Pasztor, A. Wilson, J.P. Volpe and B. Anholt. 2011. Conservation of re-introduced sea otters in British Columbia: Habitat selection on a coastline of fear. International Marine Conservation Congress May 14th-18th, Victoria BC

Park, A. and Volpe, J.P. 2011. Out of the pan into the fire: Unforeseen consequences of a chemical therapeutant used on salmon farms. International Marine Conservation Congress May 14th-18th, Victoria BC

Park, A and Volpe, J.P. 2011. Biological effects of SLICE on non-target spot prawn (*Pandalus platyceros*). Commercial Prawn Fishermen Annual General Meeting March 30th Courtenay BC

Park, A. and Volpe, J. 2010. Detection of emamectin benzoate (SLICE) in non-target spot prawn (*Pandalus platyceros*) and determination of biological effects. Pacific Ecology and Evolution Conference March 5-7th, Bamfield BC.

Park, A. 2009. The effect of emamectin benzoate (SLICETM) application by salmon farms on non-target spot prawn (*Pandalus platyceros*). Fisheries and Marine Ecosystems Conference April 17-19th, White Rock BC.

Park, A. 2009. Environmental impacts of salmon aquaculture prophylactic chemical application. Pacific Ecology and Evolution Conference February 20-22, Bamfield BC.

Fisher, J.T., B. Anholt, and J.P. Volpe. 2009. Patterns of multi-scale habitat selection by mammalian carnivores in a subalpine landscape. 3rd Annual Canadian Society for Ecology and Evolution Conference, Halifax, N.S.

Volpe, J.P. 2009. Sustainability and the myth of sustainability. NetSci 2009 June 29-July 3, Venice, Italy.

Peet, C., J.P. Volpe, A. Mazumder, and A. Morton. 2007. The impact of salmon farming on the host parasite relationship between sea lice and juvenile salmon: implications for the health of wild salmon populations. Society for Conservation Biology 21st Annual Meeting July 1-5, Port Elizabeth, South Africa.

Peet, C., J.P. Volpe, A. Mazumder, and A. Morton. 2007. The impact of salmon farming on the host parasite relationship between sea lice and juvenile salmon: implications for the health of wild salmon populations. American Fisheries Society Annu7al Meeting, San Francisco, Sept. 2-6.

Volpe, J.P. 2006. Swimming Against the Sustainability Current: The Growing Problem with Seafood. Annual meeting of the Agriculture, Food and Human Values Society. Boston, MA. June 7-11.

Saini, J.S. and J.P. Volpe. 2006. Food Writing in Developing Sustainable Gastronomy. Annual meeting of the Agriculture, Food and Human Values Society. Boston, MA. June 7-11.

Peet, C., J.P. Volpe, and A. Mazumder. 2005. Interactions between the salmon louse and juvenile salmonids in British Columbia. 21st Annual Pink and Chum Salmon Workshop.

Ketchikan, AK Feb 23-26.

Peet, C., J.P. Volpe, and A. Mazumder. 2005. Possible impact of salmon farming on wild salmon populations. Society for Conservation Biology Annual Meeting. Brasilia, Brazil. July 15-19.

Sumaila, U.R., J.P. Volpe and Y. Liu. 2005. Ecological and economic analysis of sablefish aquaculture in British Columbia. 2005 Forum of the North American Association of Fisheries Economists. University of British Columbia, Vancouver. May 25-27.

Popowich, R.C., E.B. Taylor, J.D. Stelfox, and J.P. Volpe. 2005. Bull Trout x Brook Trout Hybrids: Using Genetics to Validate Morphological and Meristic Identification Techniques. Canadian Conference for Fisheries Research. Windsor, ON January 7.

Popowich R.C. and J.P. Volpe. 2004. Troubled waters: Cumulative anthropogenic activity and a declining bull trout population in the Elbow River watershed. Forest Land Fish Conference II. Edmonton, AB April 26-28. (*awarded "Best Student Paper").

Rodtka, M.C. and J.P. Volpe. 2004. Effects of stream temperature on interspecific competition between juvenile brook and bull trout. Forest Land Fish Conference II. Edmonton, AB April 26-28.

Williamson, C. and J.P. Volpe. 2004. Variable stable isotope (δ15N) enrichment across tissues in juvenile Atlantic salmon (*Salmo salar*) attributable to nutritional stress. Annual Meeting of the North American Benthological Society. Vancouver, BC June 6-10.

Volpe, J.P. and M. Skladany. Going beyond the box: Social, political and cultural dimensions of setting organic aquaculture standards. 2nd International Organic Aquaculture Workshop. Minneapolis, MN, July 15-17 2003.

Popowich, R.C. and J.P. Volpe. 2003. Competitive Interactions: Determining How Bull Trout/Brook Trout Hybrids Affect Native Albertan Bull Trout Populations. Alberta Conservation Association Partners In Conservation Conference. Edmonton, Alberta. January 24.

Volpe, J.P. Atlantic salmon (*Salmo salar*) in British Columbia and the biology of invasion: The sequel. Second International Conference on Marine Bioinvasions. New Orleans, Louisiana. April 9-11 2001.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 2000. Ecology of aquaculture escaped Atlantic salmon (*Salmo salar*) in British Columbia, Canada. Annual Meeting of the Society for Conservation Biology. Missoula, Montana. June 8-12.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 1999. Invasion ecology of aquaculture escapee Atlantic salmon (*Salmo salar*) on the Pacific coast. Aquaculture Canada 1999. Victoria, British Columbia. October 26-29.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 1999. Atlantic salmon (*Salmo salar*) in British Columbia and the biology of invasion. Annual Meeting of the International Northwest Chapter of the American Fisheries Society. Richmond, British Columbia. February 15-17.

Volpe, J.P., B.R. Anholt and B.W. Glickman. 1999. Atlantic salmon (*Salmo salar*) in British Columbia and the biology of invasion. First National Conference on Marine Bioinvasions. Massachusetts Institute of Technology, Cambridge, Massachusetts. January 24-27.

Volpe, J.P. and S.M. Pollard. 1998. Describing units for conservation: when molecular genetic tools only tell half the story. Gene Conservation: Identification and Management of Genetic Diversity: A special session of the VII International Congress of Ecology. Florence, Italy. July 19-25, 1998.

Volpe, J.P. and B.W. Glickman. 1998. Coastal British Columbia: A case study of the colonization biology of Atlantic salmon (*Salmo salar*). 1998 Annual General Meeting of the American Fisheries Society, North Pacific International Chapter. Union, Washington. March 18-20 1998.

Volpe, J.P. and B.W. Glickman. 1997. It may be the "King of Fish" but can British Columbia afford Atlantic salmon (*Salmo salar*)? Annual Meeting of the Society for Conservation Biology. University of Victoria. June 6-9 1997.

Volpe, J.P., L. Bernatchez and M.M. Ferguson. 1993. Molecular genetic variation in four sympatric morphs of Icelandic Arctic charr (*Salvelinus alpinus alpinus*). Canadian Conference on Freshwater Fisheries Research. Trent University. January 3-5 1993.

Volpe, J.P., L. Bernatchez and M.M. Ferguson. 1993. Genetic variation found in the Arctic charr (*Salvelinus alpinus*) population of Thingvallavatn, Iceland using direct nucleotide sequencing. 32nd Annual Meeting of the Canadian Society of Zoologists. University of Guelph.

Volpe, J.P., L. Bernatchez and M.M. Ferguson. 1993. Genetic variation found in the Arctic charr (*Salvelinus alpinus*) population of Thingvallavatn, Iceland using direct nucleotide sequencing. International Symposium for the Genetics of Subarctic Fish and Shellfish. May17-19 1993, Juneau, Alaska.

CONTRIBUTED SCHOLARLY POSTER PRESENTATIONS (students underlined)

Bulger, D. S. and J.P. Volpe. 2017. Evaluating British Columbia's artificial reefs in a conservation context: Potential abundance and diversity trade-offs for groundfish. Pacific Ecology and Evolution Conference, Bamfield, BC.

Bulger, D. S. and J.P. Volpe. 2017. Evaluating British Columbia's Artificial Reefs in a conservation context: Potential abundance and diversity trade-offs for groundfish. Canadian Society for Ecology and Evolution conference (May, 2017), Victoria, BC.

Bulger, D. S., J. P. Volpe, and J. T. Fisher. 2017. Evaluating British Columbia's Artificial Reefs in a conservation context: Potential abundance and diversity trade-offs for groundfish. North American Congress for Conservation Biology Toronto, ON.

Park, A. and Volpe, J.P. 2010. Detection of emamectin benzoate (SLICE) in non-target spot prawn (*Pandalus platyceros*) and determination of biological effects (Poster). International Sea Lice Conference May 9-12th, Victoria BC

Hahn, R.L., B.R. Anholt, A.C. Hill, A. Mazumder and J.P. Volpe. 2006. Salmon farm wastes as a potential source of nutrients to adjacent intertidal communities in Clayoquot Sound, British Columbia. American Society of Limnology and Oceanography. Victoria, BC. June 4-9.

Krkosek, M., M.A. Lewis, and J.P. Volpe. 2004. Modeling parasite transmission from farm to wild salmon. MITACS 5th Annual Conference, Dalhousie University, Halifax, NS. June 9-12.

Rodtka, M. and J.P. Volpe. 2004. Effects of stream temperature on interspecific competition between juvenile brook and bull trout. 4th World Fisheries Congress. Vancouver, BC May 3-6.

Peet, C.R., A. Mazumder, and J.P. Volpe. 2004. Interactions between the salmon louse (*L. salmonis)* and juvenile salmonids in British Columbia. 4th World Fisheries Congress. Vancouver, BC May 3-6.

Edwards, A., R. Nordin, J.P. Volpe, C. Peet, M. Kainz, A. Mazumder. 2003. Trophic position and mercury in sport and commercial fish from coastal Vancouver Island. Annual meeting of the Collaborative Mercury Research Network. St. Andrews, NB Nov 21-23.

Krkosek, M., M. Lewis, and J.P. Volpe 2003. The mathematical epidemiology of sea lice (*L. salmonis*) in salmon farms and the interaction between aquaculture and wild Pacific salmon. 6th International Conference on Sea Lice. St Andrews, New Brunswick, July 1-4.

Williamson, C., M. Rodtka and J.P. Volpe. 2003. Invasion of brook trout into a small Alberta stream: Insights into trophic shifts and effects on native bull trout. Alberta Conservation Association Partners In Conservation Conference. Edmonton, Alberta. January 24-25.

Rodtka, M. and J.P. Volpe. 2003. Effects of stream temperature on juvenile interspecific competition between exotic brook trout and native bull trout. Alberta Conservation Association Partners In Conservation Conference. Edmonton, AB January 24-25.

Hahn, L. B.R. Anholt, A. Mazumder, D. Duffus, B.W. Glickman and J.P. Volpe. 2001. Effects of salmon farm effluent on adjacent intertidal and *Zostera marina* communities. Pacific Ecology Conference, Bamfield, BC February 16-18.

Volpe, J.P., M.M. Ferguson. 1995. De-coupling of the genotype and phenotype in Arctic charr (*Salvelinus alpinus alpinus*) of Thingvallavatn, Iceland. Fisheries Society of the British Isles International Symposium - 1995. Plymouth, U.K. July 10-13 1995

UVIC TEACHING

year	course	semester	# students
2000	ES400C	Fall	39
2004	ES335B	Summer	17
2005	ES200	Spring	71
	ES200	Summer	50
	ES341	Fall	69
2006	ES446	Spring	35
	ES482A	Spring	13
	ES200	Fall	146
2007	ES200	Spring	143
	ES446	Spring	50
	ES240	Fall	115
	ES500	Fall	9
2008	ES200	Spring	150
	ES341	Summer	18
	ES240	Fall	150
	ES500	Fall	12
2009	ES341	Spring	60
	ES240	Fall	150
	ES500	Fall	10
2010	ES446	Spring	30
	ES501	Spring	10
	ES500	Fall	10
2011	ES501	Spring	10
	ES240	Fall	120
	ES482A	Fall	15
2013	ES240	Spring	100
	ES446	Spring	37
	ES240	Fall	110
	ES503	Fall	12
2014	ES240	Spring	97
	ES482A	Spring	9
	ES503	Spring	12
	ES240	Fall	106
2015	ES240	Spring	90
	ES503	Spring	12
	ES240	Fall	98
	ES503	Fall	12
2016	ES240	Spring	98
	ES481	Spring	33
	ES240	Fall	99
	ES446	Fall	24
2017	ES240	Spring	98
	ES481	Spring	25
	ES240	Fall	127
	ES482B	Fall	16
2018	ES240	Spring	125
	ES382	Spring	46
	ES240	Fall	109
	ES431	Fall	35

ES 200 Introduction to Environmental Studies
ES 240 Ecological Processes
ES 341 Ecological Restoration
ES 446 Sustainable Fisheries
ES 482A Complex Systems
ES 482B Invasion Biology
ES 431 (481 <2019) History, Science & Culture of Wine
ES 500 Environmental Theories, Methods and Skills I
ES 501 Environmental Theories, Methods and Skills II
ES 503 / 603 Environmental Studies Graduate Colloquium

Student Supervision

(*co-supervisor*) * NSERC Graduate Scholar †AB Ingenuity Graduate Scholar

Mitch Macfarlane	MSc	in program – vineyard management / terroir
Andrew Watts	MSc	in program – determinants of wine grape ripeness

Alexandra Francis	MSc (Fisher)	in program – moose conservation	
Joanna Burger	PDF (Fisher&Burton)	2018 – conservation & predator-prey dynamics	
Katie Baillie-David	MSc (Fisher)	in program – mesocarnivore conservation	
Stefania Gorgopa	MSc	2018	
Siobhan Darlington*	MSc(Fisher)	2018 - ungulate coexistence models	
Gillian Fraser*	MSc(Fisher)	2018 - predator macroecology	
Desiree Bulger	MSc	in program - efficacy of artificial reefs	
Sandra Frey*	MSc (*Fisher*)	2018 - temporal structuring of predator interactions	
Gray Daniels	MSc	in program - molecular tunneling & metabolic ecology	
Lily Burke	MSc	2018	Staff Scientist, DFO
Frances Stewart*	PhD (*Fisher*)	2018	PDF Pacific Forestry Centre
Nikki Heim*	MSc (*Fisher*)	2015	Parks Canada Biologist Technician
Hannah Roessler	MA (Stephenson)	2013	Instructor - Pacific Rim College
Martina Beck	MSc	2013	Biologist, BC Min FLNRO
Valerie Ethier*	MSc	2013	Independent Aquaculture Contractor
Valerie Mucciarelli*	MSc	2014	Teacher, Victoria BC
Ashley Park*	MSc	2013	Biologist - Archipelago Inc
Dane Stabel	MSc	2011	Dive Tourism - Owner
Helen Ford	MSc	2011	Biologist-Parks Can
Hillary Harrup Archibald*	MSc (*Schaefer*)	2010	PhD Student- U of Western Australia
Amy Deveau*	MSc	2011	Independent GIS Analyst
Jennifer Gee	MSc	2010	UN FAO Analyst
Lise Townsend *	MSc (*Schaefer*)	2010	Consulting Biologist
Jason Fisher†	PhD (*Anholt*)	2011	Sr. Research Scientist - Alberta Innovates
Martin Krkošek*	PhD (Lewis)	2009	Assistant Professor - U of Toronto
Corey Peet	MSc. (Mazumder)	2007	Project Manager - Aquaculture Blueyou AG
Latif Saddique	M. Mar. Pol. (Dalhousie)	2006	PhD Candidate - Australia
Ryan Popowich	MSc	2005	Biologist – Golder Associates
Mike Rodtka*	MSc	2005	Biologist – Alberta Conservation Association
Jenn Kelly*	MSc	2005	Sr. Lab Instructor - UBC
Chris Williamson†	MSc	2005	Teacher – Bella Bella, BC
Preston McEachern	PhD	2004	Biologist – Province of Alberta
Theron Miller	PhD	2004	Biologist – State of Utah
Mike Sullivan†	PhD	2003	Biologist – Province of Alberta

Graduate Student Supervisory Committee Member

Cameron Freshwater	Juanes	UVic Biol	PhD	2017
Kira Hoffman	Starzomski	ENVI	PhD	2018
Nancy Shackelford	Starzomski	ENVI	PhD	2017
Lara Puetz	Tunnicliffe	UVic Biol	MSc	2014
Jason Straka	Starzomski	ENVI	MSc	2012
Katharine Corriveau	Starzomski	ENVI	MSc	2012
Brooke Campbell	Pauly	UBC Fisheries	MSc	2011
Thomas Child	Turner	ENVI	MSc	2011
Alison Edwards	Mazumder	UVic Biol	MSc	2011
Brian Kopach	Duffus	UVic Geog	PhD	transfer-UCalgary
Leanne Harris	Perlman	UVic Biol	MSc	2008
Severn Suzuki-Cullis	Turner	ENVI	MSc	2007

Yajie Liu	Sumaila	UBC Fisheries	PhD	2007
Jennifer Chow	Riemchen	UVic Biol	MSc	2007
Louise Hahn	Anholt	UVic Biol	MSc	2005
Heidi Swanson	Schindler	Alberta Biol	MSc	2004
Erin Kelly	St. Louis	Alberta Biol	MSc	2004
Stephanie Neufeld	Proctor	Alberta Biol	MSc	2004

Graduate Defence External Examiner

Maximilien Genest	UVic SEOS	MSc	2018
Andy Szabo	UVic Geog	MSc	2004
Christine Weldrick	UVic Geog	MSc	2011

Chair of Graduate Oral Defence

Nancy Wilde	UVic Psych	PhD	2005
Paul Teel	UVic Phil	MA	2006
Alvin Bergen	UVic M. Eng	PhD	2008
Nishad Khanna	UVic Educ	MSc	2011
Colette Starheim	UVic Geog	MSc	2011
Karyn Suchy	UVic Biol	PhD	2014
Francis Harrison	UVic Comp Sci	MSc	2015

Undergraduate Research Supervision

2018	Sheldon Vos	Undergraduate Honours Project (GEOG)
2017	Sheldon Vos	Undergraduate Honours Project (GEOG)
2013	Francine Beaujot	Undergraduate Honours Project (EOS)
2011	Elisabeth Sargeant	Undergraduate Honours Project (BIOL)
2010	Megan Adams	Undergraduate Honours Project (BIOL)
	Jenna Stoner	NSERC USRA Scholar
2009	Megan Adams	NSERC USRA Scholar
	Erin Webb	MITACS Co-Op Summer Scholar
2008	Melanie Page	NSERC USRA Scholar
2002	Jenn Kelly	Undergraduate Honours Project (Alberta)
	Jenn Kelly	NSERC USRA Scholar (Alberta)
2007	Ashley Park	NSERC USRA Scholar
	Brock Ramshaw	NSERC USRA Scholar
2006	Stephanie Peacock	NSERC USRA Scholar
	Helen Ford	NSERC USRA Scholar
2005	Pamela Tudge	Environmental Studies Final Project
2002	Jean-Francios Buoffard	Undergraduate Honours Project (Alberta)
	Jean-Francios Buoffard	NSERC USRA Scholar (Alberta)

RESEARCH FUNDING *(unsuccessful proposals italicized and noted from 2014 onwards)*

2019	€3,137,000	Erasmus Mundus – Erasmus+ (PI-Philippe Mongondry, ESA France-pending)
2018	27,900	France-Canada Research Fund (pending)
	82,500	BC Investment Agriculture Foundation (awarded)
	38,855	Canadian Habitat Stewardship Program (awarded - Galiano Conservancy)

	90,000	Six student MITACS awards @$15K (all awarded)
2017	47,762	Canadian Habitat Stewardship Program (awarded - Galiano Conservancy)
	45,000	Three MSc student MITACS awards @$15K (all awarded)
	24,000	Cumulative effects of metal on freshwater invertebrates (BC Gov) (awarded)
2016	*468,100*	NSERC (5 yr Discovery) *(not funded)*
	30,000	Two MSc student MITACS awards @$15K (all awarded)
2015	*10,000*	Vancouver Foundation *(not funded)*
	25,016	Seaworld Busch Gardens Conservation Fund *(not funded)*
	63,358	Mitsubishi Corporation *(not funded)*
	71,933	Canadian Habitat Stewardship Program (awarded - Galiano Conservancy)
	24,000	PICS Graduate Student Fellowship *(not funded)*
	1,522	British Columbia Jobs Grant *(not funded)*
	10,600	PADI Foundation *(not funded)*
2014	16,450	Canadian Wildlife Federation (awarded)
	24,000	PICS Graduate Student Fellowship *(not funded)*
	7,000	UVic Internal Research Grant (awarded)
	100,000	MEOPAR (awarded PI Natalie Ban)
2012	15,210	Intervet (Schering-Plough)
	5,000	David Suzuki Foundation
	5,600	Fishwise (awarded)
	49,000	Monterey Bay Aquarium Seafood Watch Program
	10,000	Sea Choice
2011	187,000	Pew Charitable Trusts
	15,000	MITACS (awarded)
	66,200	Canadian Aquatic Invasive Species Network (CAISN-NSERC)
2010	287,000	Pew Charitable Trusts
	30,000	MITACS Accelerate
2009	5,000	Watershed Watch Society
	80,000	MITACS
	204,000	Lenfest Ocean Program
2008	10,000	Pew Charitable Trusts
	10,000	Canadian Sablefish Association
	45,000	Pacific Salmon Forum
2007	86,500	NSERC Discovery (over 5 years)
2006	47,100	Invasive Alien Species Partnership Program (PI Purnima Govindarajulu)
	27,000	Pacific Salmon Forum
	35,000	National Geographic Society
	£180,000	Darwin Foundation (Co-PI)
2005	18,000	U of Victoria Start-up
2004	17,000	Canadian Sablefish Association
	30,000	Alberta Conservation Association
2003	5,000	Canadian Wildlife Federation
	102,158	Canadian Foundation for Innovation (CFI) - New Opportunities
	102,158	AB Science & Research Investments Program
2002	28,000	Alberta Conservation Association
	993,551	Canadian Foundation for Innovation (CFI) – Innovation Fund (ACCRU) (Co-PI)
	90,000	NSERC Discovery (over 5 years)
2001	156,000	NSERC/ SHRC – Major Collaborative Research Initiative (Coasts Under Stress)
	80,000	University of Alberta Start-up

270,000	BC Habitat Conservation Trust

PROFESIONAL SERVICE

Testimony

Washington Supreme Court - Wild Fish Conservancy vs. US EPA 2018
New Zealand Federal Board of Inquiry in Salmon Aquaculture November 2012
BC Superior Court - Mainstream Canada v Staniford Dec 2011 Vancouver BC
BC Legislative Committee on Sustainable Aquaculture. Oct 18 2006. Victoria, BC
Alaska State Senate. May 24 2004. Juneau, AK.
Leggatt Inquiry Into BC Aquaculture. October 10 2001. Vancouver, BC.
Canadian Federal Senate Fisheries Committee. May 9 2001. Vancouver, BC.
Canadian Federal Senate Fisheries Committee. March 30 2000. Duncan, BC
Canadian Fed. Parliamentary Comm. on Fisheries and Oceans. Feb.16 2000. Victoria, BC.
Washington State Senate. Sept. 16 1999. Olympia, WA

Nonacademic Appointments

2017-18	IFOAM Global Aquaculture Standards Team
2014-18	Rockfish Conservation Foundation – Scientific Advisor
2002-05; 2014-18	Seafood Watch Program of Monterey Bay Aquarium - Scientific Advisory Board
2001-04	Raincoast Conservation Society - Scientific Advisory Board
2004-present	Slow Food International - Canadian Ark of Taste Review Board

Administrative Appointments and Duties

External

2015	External Program Reviewer - U Waterloo Environ & Resource Studies

UVic

2015	Dean's Advisory Committee
2014	UVic Faculty Pension Fund Trustee (*unsuccessful in election*)
2008-09	UVic Senate – Soc Sci Representative
2008-11; 2014-2018	UVic Marine Safety Committee
2007-11	Graduate Advisor – School of Environmental Studies
2005-11	Restoration of Natural Systems Program Advisory Board
2005	SS&M (DTB) Building Committee
2005	Social Science Internal Grant Review Committee

School of Environmental Studies

2018	Search Committee – CRC ENVI Political Ecology (Failed Search)
2017-present	ENVI Library representative
2015-18	ENVI Graduate Committee
2015	Search Committee - Ethnoecology tenure track position (Matthews)
2013	Director - School of Environmental Studies (6 month term)
2010	Search Committee - ENVI Director (Stephenson)
2008-09	Search Committee - Ian McTaggart-Cowan Chair (Starzomski)
2008	Search Committee - Ethnoecology Limited Term (Schrieber)
2008	Search Committee - Ethnoecology tenure track position (Lantz)
2007	Search Committee - Sr. Lab Instructor (Beckwith)
2005	Search Committee - LEEF Chair – *Cultures and Ecosystems at Risk*
2005	Search Committee - RNS Director (Schaefer)

2007-11	ENVI Graduate Student Advisor
2005-present	ENVI ARPT Committee

EXHIBIT B

Report of Nick Gayeski, Ph.D.

In the Matter of:

Wild Fish Conservancy v. U.S. Envtl. Prot. Agency, et al.

W.D. Wash. No. 2:15-cv-01731-BJR

May 7, 2018

I. INTRODUCTION.

I am an aquatic ecologist employed at Wild Fish Conservancy and, as part of that employment, have been requested to provide opinions on potential take of Chinook salmon protected under the Endangered Species Act ("ESA") through procedures implemented to capture and remove farmed Atlantic salmon following the collapse of a net pen during the summer of 2017. I have further been requested to provide opinions on potential take of ESA-listed Chinook salmon from standard harvesting procedures at the Atlantic salmon net pens in Puget Sound.

II. QUALIFICATIONS AND MATERIALS REVIEWED.

I have been employed as a fisheries ecologist by Wild Fish Conservancy since 1996. In this capacity my duties have included evaluations of salmon harvest and hatchery policies and management of salmon, steelhead, and trout under the ESA. I have provided public comment on behalf of Wild Fish Conservancy to the National Marine Fisheries Service ("NMFS") and the U.S. Fish and Wildlife Service on ESA listing and critical habitat decision documents over the past eighteen years.

I have conducted several field research projects related to salmon ecology and salmon freshwater food webs. Among these projects have been four funded by Bonneville Power Administration under the Columbia Basin Fish and Wildlife Plan. The projects included assessments of the distribution and genetic integrity of native resident trout populations in the Yakima, Wenatchee, and Pend Oreille River basins and an assessment of the biotic integrity of tributary streams and mainstem rivers of the upper Yakima and Naches River basins based on sampling the aquatic invertebrate community. From 1999 to 2005 I also conducted field work on native salmonids, with a particular focus on steelhead, in western Kamchatka, Russia as a member of a joint U.S.-Russian conservation research program involving scientists from the Department of Ichthyology at Moscow State University and the University of Montana.

From 2006 to 2012 I was the principal investigator of a research program investigating the ecology of native fishes in Icicle Creek, funded by the Icicle Fund, with participation from the University of Idaho and the Conservation Biology Division of NMFS's Northwest Regional Office. I co-authored a paper published in October 2014 in the journal Conservation Genetics that reports on the genetic structure of rainbow trout in upper Icicle Creek and their relationship to Wenatchee River steelhead.

I received a Ph.D. in Systems Ecology at the University of Montana in 2015. My dissertation concerned the estimation of salmon and steelhead populations in the late nineteenth and early twentieth centuries (1880 to 1920) using historical commercial harvest and related land use data, and the application of these estimates to current ESA recovery. I have published two papers related to this project that are listed in my *curriculum vita*.

My complete curriculum vitae is attached hereto at Attachment A, which provides more details on my qualifications and includes a complete list of the publications that I have authored during at least the last ten years. I have not testified at trial or in a deposition during the last four years. I am providing this opinion as part of my employment at Wild Fish Conservancy and am not receiving additional compensation beyond the terms of my employment.

In addition to drawing upon my knowledge and experience, I have reviewed the articles cited through this report and the following materials in preparing the opinions expressed herein:

- Wild Fish Conservancy. 2011. Cypress Island Aquatic Reserve Pilot Nearshore Fish Use Assessment ,March – October 2009, prepared for Washington State Department of Natural Resources by Wild Fish Conservancy, June 2011.

- Beamer, E.M., A. McBride, R. Henderson, and J. Griffith. 2006. Habitat and fish use of pocket estuaries in the Whidbey Basin and north Skagit County bays, 2004 and 2005. Skagit River System Cooperative publication.

- Beamer, E.M., A. McBride, R. Henderson, K. Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: an emerging priority for restoration. Skagit River Systems Cooperative publication.

- Greene, C, E. Beamer, J. Anderson. 2015. Study Plan and Summary of Results for the Skagit River Estuary Intensively Monitored Watershed Project. Report to Washington Salmon Recovery Funding Board Monitoring Panel.

- D Clark, K Lee, K Murphy, A Windrope. 2017 Cypress Island Atlantic Salmon Net Pen Failure: An Investigation and Review. Washington Department of Natural Resources, Olympia, WA.

- Cooke Aquaculture Pacific-Cypress Island site 2 Excepted Fish Recovery Response Report, November 9, 2017.

- Video and photograph files of the operation of the farmed Atlantic salmon harvest and salvage operations obtained from the Washington Department of Natural Resources through its websites and in response to requests for public records and from the Washington Department of Ecology, the Washington Department of Fish and Wildlife, and the Washington Department of Natural Resources obtained through public record requests submitted to by DNR during the salvage operations conducted by Cooke aquaculture following the catastrophic failure of Net Pen #2 at Deepwater Bay on August 19, 2017.

- Salmon Mortality Counts from Net Pen Recovery Operations at Cooke Aquaculture's Atlantic Salmon Farm in Deepwater Bay (Cypress Island, Wa), version 2.0. January 19, 2018.

- Aerial video files of harvest operations being conducted at net pens in Rich Passage of Puget Sound that were created by John Gussman on January 30, 2018.

- Data on incidental catch at marine finfish aquaculture sites in British Columbia available at the following website maintained by the Government of Canada: https://open.canada.ca/data/en/dataset/0bf04c4e-d2b0-4188-9053-08dc4a7a2b03.

- Update to the Biological Evaluation Submitted April 17 and August 6, 2008, Regarding EPA Action on Washington's Marine Finfish Rearing Facility Provision Contained in the Sediment Management Standards, prepared by the U.S. Environmental Protection Agency (Dec. 13, 2010).

III. OPINIONS.

In developing my opinions on the potential impacts from efforts taken to remove Atlantic salmon following the collapse of a net pen in August 2017, I first evaluated the likelihood that ESA-listed threatened juvenile Puget Sound Chinook salmon were present in the vicinity of the Cypress Island net pens during the time of the various removal operations. I then evaluated the likelihood that those fish were taken during the three separate types of removal actions undertaken.

I conclude that there is a reasonably high probability that ESA-listed juvenile Chinook salmon were present in the nearshore habitats of Deepwater Bay ("action area") at the times of the removal operations. It is my opinion that there is a significantly high probability that one or more listed juvenile Chinook was taken as a result of the salvage operations.

I followed as similar procedure in developing my opinions on the potential impacts from standard harvesting procedures implemented by Cooke Aquaculture Pacific, LLC ("Cooke") at its Puget Sound net pens. I first evaluated the likelihood that ESA-listed juvenile Puget Sound Chinook salmon are present within the net pens during the time standard harvest procedures occur. I then evaluated the likelihood that any of those fish present are harmed or killed by harvest operations.

I conclude that ESA-listed juvenile Chinook salmon are almost certainly present in the vicinity and within the Atlantic salmon net pens located in Puget Sound, including those in Rich Passage south of Bainbridge Island and at Deepwater Bay of Cypress Island, during normal harvesting procedures from April through October. Such fish are likely attracted to the net pens by the presence of odors from the pens and the presence of feed. It is my opinion that some of the ESA-listed juvenile Chinook salmon are very likely to be taken during the harvesting operations.

A. <u>Summary of Puget Sound Chinook Salmon Life-History.</u>

Nearshore salmon (including Chinook) rearing habitats in the Whidbey Basin, Skagit and Bellingham Bays, the San Juan islands, and adjacent channels have been the focus of several studies starting in the late 1990s and continuing to the present (Beamer et al. 2003, 2006, Wilf Fish Conservancy 2011, Greene et al. 2015). Collaboration by state, tribal, federal, university and independent researchers involved in these nearshore studies has resulted in the identification and standard employment of appropriate field methods, data acquisition, and statistical analyses.

This has made it possible to compare the results of studies conducted in adjacent areas (for example, Skagit Bay and Cypress Island) to build a coherent picture of common patterns of nearshore habitat use by different populations of chinook salmon in northern Puget Sound.

Puget Sound Chinook salmon exhibit two basic juvenile life-histories commonly referred to as "ocean-type" and "stream-type". Most Chinook salmon in Puget Sound are ocean-type.

Ocean-type (commonly called "Fall") Chinook salmon typically reside in shallow riverine habitats for a period of no more than a few weeks to months after emerging as fry from the gravels in which their parents spawned. After this brief period, Chinook fry (typically ranging in size from about one to three inches in length) migrate as "smolts" to shallow estuarine and nearshore environments. There, they feed on small zooplankton and forage fishes for periods of several weeks to several months before migrating to more open marine habitats where most of their adult growth will occur. In addition, many newly-emerged Chinook "fry" migrate directly to nearshore marine environments soon after emerging. These fry migrants are typically less than 50 millimeters in length, which is significantly shorter than smolt migrants (65 to 100 mm in length) that have reared in freshwater for several weeks to one or two months before migrating (Greene et al. 2015).

Stream-type (commonly called "Spring") Chinook salmon typically reside in freshwater riverine habitats for a year following emergence from spawning gravels. These fish then migrate to the marine environment as "smolts" in the spring, at lengths of 100 mm or more.

The majority of juvenile Fall and Spring Chinook begin migrating to nearshore marine habitats in May and June and are found in nearshore rearing habitats from June to October. A minority may migrate earlier, soon after emerging from spawning gravels in late March and April. Many Puget Sound juvenile Spring Chinook, such as those from the Skagit River near Cypress Island, may rear for periods of several weeks or months in adjacent nearshore habitats before migrating to open marine areas. Nearshore rearing habitats are consequently crucial for the survival and growth of Puget Sound Chinook salmon, which are currently listed as "threatened" under the ESA.

B. Opinions on Potential Harm to Juvenile Chinook Salmon from Efforts to Capture and Remove Farmed Atlantic Salmon Following the Net Pen Failure.

As noted above, to evaluate the potential impacts from efforts taken to remove Atlantic salmon following the collapse of a net pen in August 2017, I first evaluated the likelihood that ESA-listed threatened juvenile Puget Sound Chinook salmon were present in the vicinity of the Cypress Island net pens during the time of the various removal operations. I then evaluated the likelihood that those fish were taken during the three separate types of removal actions undertaken.

1. <u>Opinions on the Presence of Juvenile Salmon in Nearshore Habitats of Cypress Island Following the Net Pen Failure.</u>

The net pens that failed during the summer of 2017 were located in Deepwater Bay at the southeast end of Cypress Island in Puget Sound. The former location of these facilities is depicted in a figure attached as Appendix A.

Cypress Island net pen #2 was located in water 65 to 100 feet deep, approximately 200 feet from shore (Clark et al. 2017, page 21). The bottom substrate beneath the pen is described as "variously cobble, sand, and silt with considerable shell hash in places. Closer to the shore (west) the substrate features large rock and cobble" (ibid). These substrates are similar to those observed on the east side of Cypress Island in studies conducted by Wild Fish Conservancy in 2009 (Wild Fish Conservancy 2011, pp. 15-20; 27-29), described in detail below.

In 2009, Wild Fish Conservancy was contracted by the Washington State Department of Natural Resources (WDNR) to conduct a pilot nearshore fish use assessment of the Cypress Island Aquatic Reserve. "Designated in 2007, the Cypress Island Aquatic Reserve withdraws approximately 5910 surface acres of state-owned tidelands and subtidal bedlands adjoining Cypress Island, and the adjacent Strawberry, Towhead, and Cone Islands, from leasing and development" (Cypress Island Aquatic Reserve Pilot Nearshore Fish Use Assessment, p. 8). This includes all of the nearshore salmon rearing habitats surrounding Cypress Island, including Deepwater Bay where three of Cooke Aquaculture's farmed Atlantic salmon net pens are located, including pen #2 that failed catastrophically on or around August 19, 2017. The pilot nearshore assessment employed experienced field crews and supervised, trained volunteers to conduct systematic surveys of 11 sites around the Island, employing standard beach seine sampling gear and protocols. Sites were visited approximately every 12 to 14 days beginning in late February and ending in late October 2009.

The primary purpose of this pilot monitoring project was to provide "baseline data for future monitoring of status trends for marine fish species, particularly targeting native salmonids, forage fish and groundfish stocks, and federal and state listed threatened species and species of concern including Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), Bull trout (*Salvelinus confluentes*) and steelhead trout (*Oncorhynchus mykiss*)". The data acquired during this study are the most current data on juvenile salmon use of Cypress Island nearshore rearing habitats available to date.

The majority of sites sampled during the 2009 pilot project (7 of the 11 sites) were on the east (Bellingham Channel) side of the Island, the side on which Deepwater Bay is located. Wild Fish Conservancy was unable to sample within Deepwater Bay and the vicinity of the Secret Harbor pocket estuary, though the latter is likely a hotspot for use by juvenile salmon (Beamer et al. 2003, 2006, Greene et al. 2015), and possibly forage fish and juvenile groundfish as well, as noted in Wild Fish Conservancy 2011 (page 14). Despite the inability to conduct sampling in Deepwater Bay and Secret Harbor located at the extreme south end of the Bay, several sites near and to the north of Deepwater Bay on the east side of the Island were sampled, including two embayments on either side of Cypress Head immediately to the north of the Bay, and the larger embayments at Eagle Harbor, and Bridge Rock Point, as well as beach habitats similar to those in the Bay that lie to the north (East Beach) and south (South Beach) (see map, Figure 2.2, on page 13 of the Wild Fish Conservancy 2011.). These habitats and the presence of Chinook in them are very likely to be representative of the use of Deepwater Bay rearing habitats by juvenile Chinook and other salmonid and non-salmonid (forage) fishes. Together, habitats at these sites are very likely to be representative of the types and condition of rearing habitats present in Deepwater Bay and Secret Harbor.

Importantly, in my expert opinion, rearing in Deepwater Bay by juvenile salmonids, including ESA-listed Chinook, is likely greater than the protected embayments and beaches to the north and south of the Bay. This is because Deepwater Bay is in a more protected location compared to the rest of the Eastside of Cypress Island due to its more southerly orientation and its great areal extent of protected nearshore habitat. Consequently, it is my opinion that the 2009 pilot study data for the presence of juvenile Chinook salmon at the sample sites on the east side of Cypress Island provide a conservative, minimum estimate of the numbers of juvenile Chinook salmon that were likely to have been present in Deepwater Bay salmon rearing habitats at the time of the August 19 catastrophic failure of pen #2 and during the salvage operations conducted by Cooke Aquaculture over the several weeks following the failure.

The results for sampling at eastside island sites conducted in August and September are the ones most relevant to the issue of potential impacts during the salvage operations. Sampling was conducted at five of the seven eastside sites on all four biweekly sampling session in August and September 2009, and at the two remaining sites during three of the four periods in August and September. Both wild (natural, river-spawned)-origin and hatchery juvenile Chinook salmon were commonly observed at sampling sites on the east and south coast of the island from the first week of June through the third week of September. Juvenile Chinook were documented to be present at or in the vicinity offshore of all eastside sample site throughout this period. Importantly, there was an increase in juvenile Chinook presence in mid-August and September at most eastside sites, a pattern that has often been reported for Chinook salmon smolts in the north Puget Sound nearshore by researchers at the Skagit systems Cooperative and others.

Coded-wire tags from hatchery-origin juvenile Chinook salmon caught on the eastside of the island during the 2009 pilot project were dominated by fish from the Samish and Skagit River Chinook hatcheries, the former a Fall Chinook hatchery and the latter a spring Chinook hatchery. It is also likely that wild and hatchery juvenile Chinook from the Nooksack River were present given their proximity and similar rearing behaviors to Chinook from the Samish and Skagit rivers. DNA analysis of 67 fin clips from wild juvenile Chinook salmon captured during the project showed that the majority (79.5%) were from Whidbey Basin rivers, primarily the Skagit, which are listed under the ESA. The remaining 20.5% were from unlisted Canadian, Washington State or tribal hatchery populations.

While most juvenile Chinook salmon rearing in nearshore environments during the summer and early fall are less than 120 millimeters (4.5 inches) in fork length, it is noteworthy that one sub-adult hatchery Chinook salmon around 290 millimeters fork length was netted at Eagle Harbor to the north of Deepwater Bay on October 18. This suggests that some juvenile Chinook are rearing in nearshore habitats on the eastside of Cypress Island for a year or longer.

In order to estimate the abundance (numbers) of fish of a given species present in the vicinity of each sample site during each sampling period, catch was calculated in two ways: as catch-per-unit-effort (CPUE) and density. CPUE is calculated as the number of fish of a species of interest (Chinook) captured in a standard period of time. In the case of the beach seining method employed by the pilot project, the standard period of time is 1.5 minutes, which is the average length of time taken to set the net in the water from the starting location until the semi-circle was closed by the terminal end of the seine reaching the shore, thereby encircling the fish in the net. The net is then hauled onto shore and fish removed and counted. Fish density was calculated as CPUE divided by the area of habitats sampled (enclosed by the seine) in hectares. This enables the results of the catch from each beach seine set to be expanded to an estimate (with confidence limits) of total numbers of fish in a larger area, such as the entire beach or embayment area of the site at which the seining occurred, as numbers of fish (of a species of interest) per hectare.

During the four August and September sampling periods, the average CPUE for Chinook (over all 7 eastside island sites) ranged from 1 to 3 fish per beach seine set (sampling event). Densities were estimated for each site. During the August-September period, estimated Chinook densities at eastside island sites ranged from 10+ to more than 100 per hectare. In my professional opinion, there is a very high probability (verging on certainty) that densities of juvenile Chinook salmon are generally higher in Deepwater Bay than elsewhere on the eastside of the island throughout the period of primary juvenile Chinook use (June through September), which encompasses the days and weeks immediately following the catastrophic failure of net pen #2 on August 19, 2017 when salvage operations were conducted.

Some of the juvenile Chinook salmon that were likely present in Deepwater Bay in the vicinity of net pen #2 were likely to have been in the collapsed net itself. The net enclosing the farmed Atlantic salmon are small enough to prevent the growing farmed salmon from swimming out of the net, but large enough to easily allow juvenile Chinook salmon and other small fishes to enter. In addition, not all of the pellet feed is consumed by farmed salmon before it falls out of the net, either by dropping out of the bottom of the net or being carried out of the sides of the net by tidal current. This feed provides a ready attractant for native rearing juvenile salmon.

I conclude that it is a near-certainty that ESA-listed juvenile Chinook were present in the action area at the time(s) that removal efforts were conducted. Although the nets are located in water deeper than water in which subyearling juvenile Chinook salmon, typically between 70 and 120 millimeters in length, rear, juvenile Chinook of this size would easily find shelter and protection from current in the immediate vicinity on the outside of the nets and within the nets, especially given the severe fouling of the mesh of the pens themselves by bi-valves (described in Clark et al. 2017; for example, figure 7, page 27). That is, the nets and other physical structures of the net pens provide shelter from tidal currents sufficient to permit juvenile Chinook to feed near and within the pens. This is confirmed by video of harvest operations at one of Cooke's Rich Passage net pen on the south side of Bainbridge Island discussed below. In addition, juvenile Chinook larger than 100 millimeters fork length are capable of swimming and foraging in these deeper waters, and Wild Fish Conservancy 2011 noted that "at some Cypress sites (Eagle Harbor in particular [located on the east side of Cypress Island]) juveniles were consistently observed leaping from the surface in close-by offshore waters during the mid-summer sample sessions when no salmon were netted at the nearshore beach site."

2. Description of the Harvest and Salvage Operations Implemented in Response to the Net Pen Failure.

Following the collapse of a net pen near Cypress Island in August 2017, three different types of actions were taken in an effort to remove the farmed fish from Puget Sound. Descriptions of these activities are provided in a report jointly prepared by the Washington Department of Ecology ("DOE"), the Washington Department of Fish and Wildlife ("WDFW"), and WDNR (Clark et al. 2017). These three activities are as follows:

- Immediately following the net pen failure, Cooke attempted to harvest live Atlantic salmon that remained in the collapsed cages; essentially standard harvest procedures were utilized; this occurred on August 20 and 21, 2017;

- Cooke staff implemented beach seining (i.e., netting) procedures on the shorelines of Deepwater Bay and Secret Harbor; this occurred on August 22–25 and 29, 2017; and

- Divers removed dead farmed Atlantic salmon from the bottom of cages within the collapsed net pens; this occurred between August 26 and 30, 2017.

Cooke's standard net pen harvesting equipment and procedures are described in Clark et al. 2017, page 36. During these operations, the harvest vessel Harvestor was employed to pump farmed Atlantic salmon from the cages of the collapsed net pen (pen #2). These operations were conducted by using vacuum pumps to suck adult Atlantic salmon aboard the harvest vessel. The hose attached to the Harvestor pump used to suck live (and dead) farmed Atlantic salmon is 12 inches in diameter and creates a suction force powerful enough to suck salmon weighing 6 to 12 pounds from the water and raise them a height of more than 10 vertical feet to bring them onboard the vessel.

Review by Clark et al. 2017 of the video of the salvage dive operation employed to recover dead fish determined that the maximum pumping rate during the salvage dive operations was 132 fish per minute (fpm). This maximum rate is indicative of the suction force of the pump, although it appears that the pumping rate during live extraction operations does not consistently achieve this high a rate and more frequently operated in the neighborhood of one-half of this maximum rate (66 fpm).

During the first two days following the collapse of net pen #2 (ending August 21), seines were used to gather live fish that remained in the damaged pen and the fish were then sucked using the pump and brought onboard Harvestor. These activities followed normal Atlantic salmon farm harvesting procedures (Clark et al. 2017, page 36). Clark et al. 2017 (Table 4, page 111) states that 5,166 live Atlantic salmon were extracted by these activities. Data on the duration (total time) that the pump was on in order to bring this number of fish onboard was not available to Clark et al., but based on the maximum rate (132 fpm) and half of that rate (66 fmp), the pump was likely operating a minimum of 39 (5166/132) to 78 (5166/66) minutes.

Beginning on August 26, the pump was used by contracted salvage divers to suck dead Atlantic salmon on the bottom of the cages of the collapsed net pen and deliver them aboard Harvestor. Dead fish from the bottom of the collapsed cages were extracted using this method from August 26 until August 30 (Clark et al. 2017, Table 4, page 111). Clark et al.'s review of the video footage of these operations showed that the total time that the pump was running and used to extract dead fish and pump them onboard the vessel Harvestor during these dates was 4 hours 16 minutes and 35 seconds (256.5 minutes) (Clark et al. page 109). The total number of dead fish extracted during the entire period of dive salvage was estimated to be between 34,000 and 53,700.

According to Clark et al. 2017 (page 97), beach seining in Deepwater Bay was conducted from August 22 to 25 and on August 29, 2017 by employees of Cooke operating under an emergency permit issued by Washington Department of Fish and Wildlife ("WDFW") to Cooke on August 21, 2017. The seines (nets) were made of braided nylon with a mesh size of 1.25 inches and measured 80 feet in length and 40 or 20 feet in depth (Cooke Response Summary Report, page 2). Seines include a top cork line with floats spaced evenly across the length of the net to keep the top of the net at or near the surface of the water and a bottom lead line to keep the bottom of the net on or near the bottom.

As described in the report summary "[a] work skiff dropped Cooke personnel on the targeted beach areas, and one end of the seine net was secured to the shore. The work skiff deployed the seine net over the bow of the vessel while circling back to the shore. The float line and lead line were handed to personnel on the beach creating a purse. The seine net was pulled into shore, shallowed up, and staff were equipped to use a small meshed nylon dip net to remove any non-target salmonids, which as mentioned above was not needed" (ibid, page 1). Cooke reported that a total of "390 escaped Atlantic salmon were recaptured using this method" (ibid, page 2) and reported that no non-target salmonids were captured.

3. <u>Likely Impacts to ESA-Listed Chinook salmon from Efforts to Harvest Live Atlantic Salmon Following the Net Pen Failure</u>.

As discussed above, Cooke attempted to remove live Atlantic salmon that remained in the cages for two days following the collapse of the net pen. The procedures generally followed Cooke's standard harvesting techniques. It is my opinion that it is likely that one or more juvenile Chinook salmon was entrained and killed during these efforts.

As discussed above, it is likely that some ESA-listed juvenile Chinook salmon were present in net pen #2 during the August 20-21 live salvage operations. These fish would have been subject to possible entrainment by the Harvestor pump. The negative pressure required to raise adult Atlantic salmon from the pens and deliver them onboard the harvest vessel will easily vacuum up any native juvenile salmon in the immediate vicinity of the hose opening. Due to their small size, these juvenile fish would be injured or killed outright due to the negative pressure experienced in the pump (unlike the larger farmed Atlantic salmon). Juvenile Chinook salmon entrained in the pump and sucked onboard the Harvestor would be tossed overboard. It is highly unlikely that such fish would have survived, as they would have been extremely vulnerable to predators if they did not simply succumb to their injuries.

I have reviewed video clips of typical harvest operations conducted by Cooke employees on January 30, 2018, aboard the vessel Harvestor at Cooke's Rich Passage net pens on the south side of Bainbridge Island. Several screenshots from these videos are provided herewith as Appendix C. Appendix D contains screenshots of the videos that have been zoomed-in with markings added to point out certain areas. The video clips themselves are also provided as Appendix E. These videos plainly demonstrate that these is bycatch associated with Cooke's harvest procedures.

The videos show Cooke employees tossing small fish the size of juvenile Chinook salmon overboard from a table onto which the adult-sized Atlantics salmon are pumped from the net pen. Harbor seals are observed immediately adjacent to the Harvestor vessel and dozens of seagulls swarm in and over the waters adjacent to the vessel Harvestor to feed on these fish. Well over 50 such small fishes appear to have been tossed overboard during less than two minutes of harvest operations observed in the videos. Many of these fish are likely juvenile Chinook and coho salmon that are present in the net pens themselves and are sucked from the pens and delivered on board the harvest vessel during normal net pen harvest operations. The video clips clearly show that these fish are readily preyed upon (or consumed dead) immediately upon being tossed overboard.

The existence of bycatch associated with net pen harvest activities is further demonstrated by data maintained by the Government of Canada. Finfish aquaculture operators are required to maintain logs of incidental catch of wild dead finish associated with harvest and transfer events. These data, provided herewith as Appendix F, demonstrate that wild salmonids are taken through aquaculture harvest activities, including Chinook salmon.

Based on the observations, data, including the data regarding the presence of ESA-listed juvenile Chinook in the immediate vicinity of net pen #2, and the basic life history and physiological capabilities of juvenile chinook in the sizes shown to be present in August and September throughout the east side of Cypress Island, it is my professional opinion that it is more likely than not that at least one ESA-listed juvenile Chinook salmon was killed during the August 20-21 live fish salvage operations conducted at net pen #2.

4. Likely Impacts to ESA-Listed Chinook Salmon from Beach Seine Activities Taken to Remove Atlantic Salmon Following the Net Pen Failure.

As described above, Cooke staff implemented beach seining procedures on the shorelines of Deepwater Bay and Secret Harbor on August 22–25 and 29, 2017.

The size of the mesh of the seines used to capture the escaped Atlantic salmon (1.25 inches) in Deepwater Bay is much larger than the mesh used in standard beach seines used to sample juvenile salmon and forage fishes (1/8 inch, Wild Fish Conservancy 2011). Juvenile salmon would likely fit through this mesh. It is, therefore, unlikely that juvenile Chinook would have been captured and brought onshore by the nearshore beach seine operations in Deepwater Bay and Secret harbor that resulted in the capture of 390 farmed Atlantic salmon.

However, because the nylon netting used was coarser (and hence stronger) than the netting used in sampling juvenile salmon in nearshore environments (1/8 inch square, Wild Fish Conservancy 2011, page 30), juvenile salmon that encountered the net material or the bottom lead line when it was being pulled ashore to capture the adult Atlantic salmon could have been subject to de-scaling or outright physical injury. This is especially likely to have been the case when the primary objective of the operators of the beach seines was to quickly bring the farmed Atlantics to the beach and remove them from the water.

Further, based on observation of some of the seine operations by biologists experienced in nearshore sampling of juvenile salmon using beach seines, the Cooke employees conducting the seine operations were not experienced in the use of beach seines and consequently were not careful in the manner by which they closed the net and hauled it onto the beach (Kurt Beardslee, personal observation). This increases the probability that juvenile Chinook and other salmonids in the area in which the beach seine salvage was conducted may have been injured by contact with the beach seine during salvage operations, though none would likely have been captured by the seine and brought onto shore.

It is therefore my professional opinion that it is as likely as not that at least one ESA-listed juvenile Chinook salmon was harmed by the beach seine salvage operations conducted by Cooke staff during the dates in question.

5. <u>Likely Impacts to ESA-Listed Chinook salmon from Salvage Dive Activities Following the Net Pen Failure</u>.

The final efforts taken to recover Atlantic salmon following the summary 2017 failure of a net were salvage dive operations that removed dead Atlantic salmon from within the collapsed net pen. It is my opinion that it is very unlikely that ESA-listed juvenile Chinook would have been present in the collapsed pen and therefore susceptible to harm at the times (August 26 – 30) during which the operations were conducted.

The conditions reported by Clark et al. 2017 indicate that oxygen levels were low and that many of the Atlantic salmon salvaged by the dive operations had died as a result of low oxygen in the collapsed pen. In addition, normal processes of decomposition had begun that likely would have further lowered oxygen levels, making the area unsuitable for rearing juvenile Chinook salmon. Further, although the water visibility in the collapsed net pen was low due to turbidity, based on observations of several videos of the salvage dive operation, few live fish were observed and visibility appeared to be great enough that divers could have avoided entraining any juvenile salmonids or other small fishes in the pump. Further, WDFW's review of the salvage video did not report any live fish the size of rearing juvenile salmon in any of the video footage (Washington Department of Fish and Wildlife 2018).

C. <u>Opinions on Potential Impacts from Standard Atlantic Salmon Harvest Procedures</u>.

To evaluate the potential impacts to ESA-listed Chinook salmon from Cooke's standard harvest procedures at its net pens throughout Puget Sound, I used a process similar to that employed for my opinions discussed above. I first evaluated the likelihood that ESA-listed threatened juvenile Puget Sound Chinook salmon are present in the net pens during harvest operations. I then evaluated the likelihood that those fish are taken during harvests. It is my opinion that these operations, at times, likely entrain and kill ESA-listed Chinook salmon.

It is my understanding that Cooke generally conducts harvest activities between July and September. Reports submitted to WDOE by Cooke from December 2015 to September 2017 indicate that the month during which the net pens contained the maximum weight of farmed salmon ranged from March (Clam Bay) to August (Port Angeles). The three pens at Deepwater Bay and the pens at Fort Ward, Hope Island, and Orchard Rocks attained maximum weight in July. To the best of my understanding, partial harvest of the largest, fastest-growing fish in a pen may occur without harvesting all fish in a pen. Final harvest of all fish in a pen would therefore occur one or more months after some of the largest fish have been removed. This appears to have been the case at Deepwater Bay, at which Cooke planned to delay full harvest of all pens, including the failed net pen #2 until September (Clark et al. 2017). This data suggests that a significant amount, if not all, harvest of Puget Sound net pens often occurs between July and September.

During this time period, juvenile Chinook salmon are present at adjacent nearshore habitats and actively feeding. These fish would be particularly susceptible to being attracted to the net pens due to the presence of fish odors and food, as described above during this period of July to September (as well as in the late spring and late fall).

In addition to providing conditions that have a high probability of attracting juvenile Chinook to the net pens, all Puget Sound Atlantic salmon farms are located in proximity to the nearshore environments in which juvenile Chinook will be rearing (approximately 200 feet (Clark et al. 2017, page 21). The maximum water depth below the pens at Deepwater Bay (Cypress Island) is among the deepest of all farms. Only the Port Angeles pen is deeper (NMFS 2010, page 53). Several pens are in shallower water than those at Deepwater Bay, including Fort Ward, Orchard Rocks, Calm Bay and Hope Island (NMFS 2010, ibid.). All of these Puget Sound farms are similarly located no further than 200 feet from shore. Thus, all Puget Sound farms are at least as likely as those at Deepwater Bay to attract juvenile Chinook to the pens, if not more likely to do so due to shallower depths below the pens.

As described above, video clips of Cooke's harvest activities and data maintained by the Government of Canada demonstrate incidental bycatch associated with finfish aquaculture harvest operations.

It is my professional opinion, based on knowledge of the behavior and ecology of juvenile Chinook salmon rearing in Puget Sound nearshore habitats that juvenile Chinook (and other native juvenile salmon) are more likely than not to be in the vicinity and within Atlantic salmon net pens during the months of late spring (May) through fall (October) and that such fish are, at times, very probably entrained in the harvest pump during standard farm (Atlantic) salmon harvest operations. It is further my opinion that any such juvenile salmonids, including ESA-listed Chinook salmon, entrained in the harvest pump are injured or killed as a direct result of being entrained. Any entrained juveniles that may survive entrainment would, with very high probability, be consumed by avian or marine mammal predators immediately upon being tossed overboard, during standard harvest operations as described in Clark et al. 2017 (page 36). This appears to be the case based on the video footage during normal harvest operations observed at Rich Passage.

IV. CONCLUSION.

In conclusion, I repeat that it is my professional opinion that several ESA-listed juvenile Chinook salmon were present throughout Deepwater Bay (including Secret Harbor) at the time of the catastrophic collapse of net pen #2 on August 19, 2017 and during the two week period immediately following during which salvage operation in Deepwater Bay were conducted. It is further my professional opinion that some juvenile Chinook salmon present in Deepwater Bay were very likely to have been in the immediate vicinity and within net pen #2 at the time of the catastrophic collapse and/or immediately thereafter and that one or more of those fish was captured by the suction pump during the salvage recovery of live farmed Atlantic salmon on August 20-21.

It is also my professional opinion that there is as likely as not that at least one ESA-listed juvenile Chinook salmon was injured or killed during the beach seine operations conducted Cooke Aquaculture staff along the nearshore of Deepwater Bay, including Secret Harbor, on August 22-25 and August 29.

Finally, it is my professional opinion that some juvenile Chinook salmon are entrained by the harvest pump during Cooke's standard harvest procedures at its Puget Sound net pens and that some of those fish are injured or killed as a direct result.

By: ________________________________

Nick Gayeski, Ph.D.

THE CONSERVATION ANGLER

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