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OF HATCHERIES AND HABITAT: OLD AND NEW CONSERVATION ASSUMPTIONS IN THE PACIFIC SALMON TREATY

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ABSTRACT

The 1985 Pacific Salmon Treaty between Canada and the United States was negotiated to deal with evidence that Pacific salmon stocks originating in Canada and the United States were in decline. The Pacific Salmon Treaty sought to establish total annual fishing limits for Canada and the United States that were consistent with the sustainable conservation of Pacific salmon stocks, and to base the total allowable catch for Canadian fishermen on forecasts of the total abundance of salmon. As the Pacific Salmon Treaty has been implemented, however, there has been a re-occurring pattern of annual abundance forecasts overestimating the actual abundance of salmon stocks. This article posits that these discrepancies between Pacific Salmon Treaty abundance forecasts and actual reported abundance levels are due in large part to a

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conservation model that fails to take proper account of the differences and relationship between wild (naturally-spawning) salmon and salmon artificially-propagated in hatcheries. Once these differences and relationships are better understood, it becomes clear that expanding hatcheries may lead to the continuing decline of Pacific salmon stocks rather than their restoration, and that the Pacific Salmon Treaty conservation model may need to focus less on hatcheries and more on improving freshwater conditions and habitat for wild salmon. Recent amendments to the Pacific Salmon Treaty, which went into effect in 2019, may provide a potential mechanism to bring the conservation of wild salmon stocks and their habitat into the Pacific Salmon Treaty's abundance forecasting model.

"The regulation of the times, methods, and apparatus of the fisheries should be such as to assure the largest opportunity practicable for reproduction under natural conditions. Artificial propagation should be invoked as an aid and not as a substitute for reproduction under natural conditions."

United States Commissioner of Fisheries (1894)[1]

[1] WILD FISH CONSERVANCY NORTHWEST, THE EFFECTS OF HATCHERY PRODUCTION ON WILD SALMON AND TROUT 21 (last visited Feb. 25, 2020), http://wildfishconservancy.org/what-we-do/advocacy/steelhead-hatchery-reform/the-effects-of-hatchery-production-on-wild-salmon-and-trout/view.

INTRODUCTION
Actual Decline in the Midst of Forecast Abundance

When Canada and the United States of America ("United States") entered into the Pacific Salmon Treaty in 1985, a primary mutual concern was to curtail overfishing at sea to avoid depletion of salmon stocks originating in Canadian and United States freshwater streams.[2] To further the conservation of such salmon stocks, the Pacific Salmon Treaty contains provisions to encourage and reward Canada and the United States for increasing the production of salmon originating in their respective streams.[3]

To increase the production of salmon, Canada and the United States often focused on artificial propagation in hatcheries rather than preserving spawning grounds and natural habitat for wild salmon.[4] This focus on hatcheries to produce salmon coincided with a period of more intensive on-stream dam building, more intensive logging of slopes adjacent to and upland of salmon spawning grounds, and more intensive diversion of water out-of-stream for farms and cities that reduced instream flow.[5] The artificially-propagated salmon from hatcheries were intended to replace the wild salmon runs displaced because of habitat loss due to dams, logging and diversions.[6]

In terms of implementation of the Pacific Salmon Treaty, the interplay between increased hatchery salmon production and the conservation objective of preventing overfishing occurs through the Pacific Salmon Commission's "abundance forecasts," which serve as the basis to establish the total joint catch limits for the Canadian and United States fishing fleets.[7] Under the current methodology used by the Pacific Salmon Commission, the volume of salmon released by hatcheries is a key input in forecasting future abundance of salmon.[8] Pursuant to this conservation methodology, an increase in hatchery salmon production translates into higher abundance forecasts, which in turn justifies higher limits for the total joint catch of salmon at sea.[9]

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[2] *See generally* M.P. SHEPARD & A.W. ARGUE, THE 1985 PACIFIC SALMON TREATY: SHARING CONSERVATION BURDENS AND BENEFITS (2005).
[3] *Id* at 80. See also Article III(1)(B) of Pacific Salmon Treaty, which provides for "each party to receive benefits equivalent to the production of salmon originating in its waters."
[4] JIM LICHATOWICH, SALMON WITHOUT RIVERS: A HISTORY OF THE PACIFIC SALMON CRISIS 60-66, 71-80 (1999).
[5] *See generally id.*
[6] *Id.*
[7] STATE OF ALASKA, PACIFIC SALMON TREATY TRANSPARENCY (April 2018).
[8] *Id.* at 8.
[9] *Id.*

The above-described conservation model for the Pacific Salmon Treaty might have initially made some sense in the abstract, but it has worked poorly in practice. This is because the Pacific Salmon Commission's abundance forecasts, which are based in considerable part on data regarding the volume of salmon produced in hatcheries, have generally *over-estimated* abundance as compared with actually documented abundance.[10] The result is that the Pacific Salmon Commission has often set total joint catch limits too high given actual (as opposed to forecast) abundance of salmon stocks.

This article analyzes the frequent discrepancy between actual abundance of Pacific salmon stocks and the Pacific Salmon Commission's abundance forecasts, and posits that this discrepancy may be the result of a fundamental faulty assumption in the Pacific Salmon Treaty's conservation model. This faulty assumption is that of continuing to treat wild salmon and artificially-propagated hatchery salmon as similar in terms of anticipated survival and reproduction rates, and also the failure to take account of scientific studies documenting that salmon released from hatcheries tend to outcompete wild salmon stocks as the "mixed stocks" move downstream together to the ocean. This research therefore indicates that hatchery salmon are not supplementing wild salmon stocks so much as directly contributing to the decline of wild salmon stocks.[11] In this sense, hatcheries may more accurately be understood as a cause of salmon stock declines rather than a solution to such declines.[12]

The identification of these faulty assumptions and missing elements in the Pacific Salmon Commission's conservation model suggests that the restoration of Pacific salmon stocks, and of achieving actual improvement in abundance, may ultimately depend on the restoration of wild salmon stocks. The restoration of Pacific wild salmon stocks may therefore hinge more on improving instream conditions and habitat, which in practical terms means facilitating the upstream and downstream passage of salmon, reducing logging on slopes adjacent to and upland of streams where salmon spawn, and curtailing out-of-stream diversions to ensure there is adequate instream flow to maintain cooler instream temperatures.

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[10] RANDALL M. PETERMAN, RAY BEAMSHELF & BRIAN BLUE, REVIEW OF METHODS FOR FORECASTING CHINOOK SALMON ABUNDANCE IN THE PACIFIC SALMON TREATY AREAS, REPORT TO THE PACIFIC SALMON COMMISSION 6 (2016).
[11] *See generally* LICHATOWICH, *supra* note 5.
[12] *Id*.

I. LIFE-CYCLE AND HABITAT NEEDS OF PACIFIC SALMON SPECIES

Pacific salmon are anadromous, which means they spawn and spend the first phase of their life in freshwater rivers, streams, creeks or lakes.[13] The juvenile salmon then migrate downstream to the Pacific Ocean where they spend a period of time in saltwater, ultimately returning back upstream to their natal freshwater river, stream, creek or lake.[14] Some of the major watersheds in the United States and Canada where Pacific salmon spawn and migrate through are (moving from north to south): the Yukon River watershed in Alaska; the Fraser River watershed in British Columbia; the Columbia River-Snake River watershed in Washington, Oregon and Idaho; the Klamath River-Trinity River watershed in Oregon and California; and the Sacramento River-San Joaquin River watershed in California.

Beyond the need for downstream and upstream passage between the ocean and freshwater spawning grounds, Pacific salmon have other fundamental habitat needs. Salmon are cold-water fish with limited tolerance for higher water temperatures.[15] Salmon prefer water temperatures below 55 degrees (Fahrenheit), suffer reduced growth and survival rates as water temperatures get close to 60 degrees (Fahrenheit) and are generally unable to survive in water warmer than 60 degrees (Fahrenheit).[16] Instream water temperatures can rise when instream flow is reduced either because water is retained in reservoirs behind dams or when significant amounts of water are diverted out of stream.[17]

In terms of spawning, many salmon require shallow clear water to lay their eggs, which is often found in smaller tributaries rather than in the mainstem of larger rivers.[18] When logging takes place on slopes upland and adjacent to natural spawning grounds, this can result in erosion in which rain washes exposed soils downhill and into such

[13] *Id.* at 11.
[14] *Id.*
[15] JACK E. WILLIAMS ET AL., TROUT UNLIMITED, HEALING TROUBLED WATERS: PREPARING TROUT AND SALMON HABITAT FOR A CHANGING CLIMATE (2007).
[16] *See* Michael J. Angiletta et al., *Big Dams and Salmon Evolution: Changes in Thermal Regimes and Their Potential Evolutionary Consequences*, 1 Evolutionary Application 286, 286-299 (2008).
[17] CAL. DEP'T OF FISH & GAME, EFFECT OF WATER TEMPERATURE ON ANADROMOUS SALMONIDS IN THE SAN JOAQUIN RIVER BASIN 1 (Feb. 2010) ("DFG believes that one critical factor limiting anadromous salmon and steelhead population abundance is high water temperatures which exist during critical life-stages in the tributaries and the main-stem. This results largely from water diversions, hydroelectric power operations, water operations and other factors.").
[18] *See id.* at 22, 78.

grounds causing them either to fill in completely or suffer siltation adversely affecting water clarity.[19]

Although all Pacific salmon species are anadromous, have similar general habitat parameters, and undertake the roundtrip journey from freshwater to ocean and back to freshwater, there are some important differences between pink salmon and other salmon species such as Chinook, coho, and sockeye. According to a 2010 report by the Yale Center for Environmental Law and Policy, titled *Hatch 22: The Problem with the Pacific Salmon Resurgence*:

> When young salmon from around the Pacific Rim leave their rivers, they enter a fierce competition for finite food resources in the great mixing chamber that is the North Pacific…there are winners and losers out there – and those results may have profound implications for hatchery management, international fisheries agreements and the future of Pacific Salmon…The winners? Pink salmon…Much of their success lies in the pinks' two-year life cycle. Young pink salmon hatch in early spring of an even-numbered year, overwinter in the ocean and then return to spawn – usually in the lower reaches of coastal rivers – in the autumn of the following odd-numbered year.[20]
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> …
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> Other species [Chinook, coho, and sockeye] have longer, more complicated life cycles. Sockeye salmon typically spawn in or near lakes. They live in freshwater for their first two years, then spend two years in the ocean before making the journey back to the spawning lake. That journey to and from the lake can be epic. One run of sockeye spawns in Redfish Lake, Idaho – 900 miles from the Pacific. Chinook and coho also spend a lot of their lives in rivers, where they're susceptible to the wear and tear of dams, industrial pollution, high temperatures, low oxygen and a sketchier food supply caused by loss of habitat. It's no coincidence that a majority of federally listed threatened or endangered Pacific salmon species [under the United States Endangered Species Act] are Chinook, coho, sockeye, and chum

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[19] *See* BRITISH COLUMBIA DEP'T OF RECREATION & CONSERVATION, FISH & WILDLIFE BRANCH, PREVENT LOGGING DAMAGE TO STREAMS (1966).

[20] Bruce Barcott, *Hatch-22: The Problem with The Pacific Salmon Resurgence*, YALE ENV'T 360, 361-62 (Nov. 1, 2010), https://e360.yale.edu/features/hatch-22_the_problem_with_the_pacific_salmon_resurgence.

> that spend at least part of their lives in two of the West's most industrialized water systems, Puget Sound and the Columbia River.
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> …
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> Pinks, by contrast, are built for 21st century reproductive success: Dash to the ocean, avoid the human-based threats in the river, eat like fiends, then make the short-sprint home to spawn. Pink salmon are conspicuous by their absence from the endangered species list.[21]

In addition to the fact that pink salmon tend to spawn in the lower-reaches of coastal rivers while Chinook, coho, and sockeye tend to spawn in the higher-reaches of watersheds, pink salmon tend to return to the natal spawning grounds after just two years while Chinook, coho, and sockeye salmon usually take about five years to complete their anadromous journey.[22] The differences in the life cycles and migratory patterns of pink salmon versus other species of salmon is relevant in the context of the Pacific Salmon Treaty for at least two reasons.

First, pink salmon tend to be of lower commercial value while Chinook, coho and sockeye salmon tend to be of higher commercial value.[23] As a result, from the economic perspective of Canadian and Japanese fishermen, a decline in the abundance of high value Chinook, coho, and sockeye salmon stocks is not compensated for by an increase in the abundance of low value pink salmon.[24]

Second, as mentioned briefly in this article's introduction and discussed more fully below, in the period from the 1920s to the 1970s, numerous on-stream dams were constructed on many salmon-bearing rivers in the Pacific northwest, particularly in the United States in the Columbia River-Snake River watershed, Klamath River-Trinity River watershed and the Sacramento River-San Joaquin River watershed.[25] The construction of these dams impeded salmon migration to the upper portions of these watersheds, which had a more pronounced adverse impact on wild Chinook, and coho.[26] This is because the natural

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[21] *Id.* at 362.
[22] *Id.*
[23] GORDON GISLASON ET. AL, ECONOMIC IMPACTS OF PACIFIC SALMON FISHERIES 15 (July 2017) ("Pink and chum are much lower value species than sockeye, coho or chinook.").
[24] *Id.*
[25] *See generally* LICHATOWICH, *supra* note 5.
[26] *See* Barcott, *supra* note 21.

spawning grounds of Chinook, coho are located in the upper portions of these watersheds.[27]

II. 1995 PACIFIC SALMON TREATY – KEY PRINCIPLES, STRUCTURE AND TERMS

The original Pacific Salmon Treaty between Canada and the United States was signed in 1995. Since 1995, Canada and the United States have agreed to amendments to the Pacific Salmon Treaty in 1999, 2002 and most recently in 2018.[28] In terms of objectives, there are three core principles that underlie the Pacific Salmon Treaty: the conservation principle, the equity principle, and the existing fishing principle. The conservation principle, which is the focus of this study, calls for Canadian and United States fishermen collectively to prevent overfishing to avoid reducing the overall abundance of Pacific salmon.[29] The equity principle calls for a fair allocation of the economic benefits of salmon fishing between Canada and the United States based on a comparison of the volume of salmon that originate (or are produced) respectively in the Canadian and United States inland freshwater.[30] The existing fishing principle provides that, to the extent possible, implementation of the Pacific Salmon Treaty should seek to avoid interfering with or requiring a reduction of existing fishing levels by Canadian and United States salmon fishermen.[31] The equity principle and the existing fishing principle are important components of the Pacific Salmon Treaty regime, but are generally outside the scope of this study.

In regard to implementation of the conservation principle, there are certain key provisions and terms set forth in the Pacific Salmon Treaty. Article III of the treaty provides that "each Party shall conduct its fisheries and its salmon enhancement programs so as to: (a) prevent overfishing and provide for optimum production; and (b) provide for each Party to receive benefits equivalent to the production of salmon originating in its waters."[32]

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[27] *Id.*
[28] *The Pacific Salmon Treaty*, PAC. SALMON COMM'N (last visited Feb. 28, 2020), https://www.psc.org/publications/pacific-salmon-treaty/.
[29] SHEPARD & ARGUE, *supra* note 3, at 94-119.
[30] *Id.* at 80.
[31] *Id.* at 81.
[32] TREATY BETWEEN THE GOVERNMENT OF CANADA AND THE GOVERNMENT OF THE UNITED STATES OF AMERICAN CONCERNING PACIFIC SALMON, PAC. SALMON COMM'N 5 (Jan. 2020), available at https://www.psc.org/publications/pacific-salmon-treaty/ [hereinafter PACIFIC SALMON TREATY].

Article I of the Pacific Salmon Treaty provides certain definitions to clarify aspects of the Article III conservation principle. First, Article I clarifies that "stocks subject to this Treaty" refers to "Pacific salmon stocks which originate in the waters of one Party."[33] Of particular significance, the definition of "stocks subject to the treaty" does not distinguish between wild salmon and salmon artificially propagated in hatcheries. Second, Article I defines "enhancement" to mean "man-made improvements to natural habitat or application of artificial fish culture technology that will lead to an increase in salmon stocks."[34] The explicit reference to "artificial fish culture technology" in the definition of "enhancement" seems to indicate that the drafters of the Pacific Salmon Treaty anticipated and expected that hatchery-produced salmon would be factored into assessments of the volume of salmon "produced" in and "originating" in Canada and the United States. It should also be noted that Article I of the treaty does not provide a definition of what constitutes "optimum production" as that term is used in Article III.

Structurally, primary authority for implementing the Pacific Salmon Treaty is vested in the Pacific Salmon Commission.[35] Article II (3) of the treaty provides that the Pacific Salmon Commission shall consist of eight Commissioners, with four Commissioners appointed by Canada and four Commissions appointed by the United States.[36] To assist the Pacific Salmon Commission in its work, Article II (18) and (19) provide that "[t]he Commission shall establish Panels as specified in Annex I [of the treaty]" and that "[t]he Panels shall provide information and make recommendations to the Commission with respect to the functions of the Commission and carry out such other functions as the Treaty may specify or as the Commission may direct."[37]

Article IV 3(a) and (b) of the Pacific Salmon Treaty provides that "[e]ach year the State of origin [Canada or the United States] shall submit preliminary information for the ensuing year to the other Party and to the Commission, including: (a) the estimated size of the run" and "(b) the interrelationship between stocks."[38] Based on this information from the parties, the Pacific Salmon Commission then prepares abundance forecasts for different Pacific salmon stocks in different

[33] *Id.* at 2.
[34] *Id.*
[35] *Id.* at 3.
[36] *Id.*
[37] *Id.* at 5.
[38] *Id.* at 6.

regions and then develops a total joint catch limit for fishing based on these abundance forecasts.[39]

The definition of "enhancement" in Article I includes "improvements to natural habitat" but the remainder of the Pacific Salmon Treaty provides little guidance on how such habitat improvements should be factored into abundance forecasts or determinations of the volume of salmon "produced" in or "originating" in the respective inland waters of Canada and the United States.[40] The exception here is Chapter 8 of the treaty which deals specifically with salmon stocks originating in the Yukon River in Alaska. For Yukon River salmon stocks, Section 30(a) of Chapter 8 of the treaty provides that "salmon should be afforded unobstructed access to and from, and use of, existing migration, spawning and rearing habitats."[41] Attachment C of Chapter 8 establishes a Restoration and Enhancement Fund for Yukon River salmon stocks and direct that "[a]rtificial propagation shall not be used as a substitute for effective fishery regulation, stock and habitat management or protection" and that "[t]he priorities for implementing programs and projects with the Fund shall be in this order…: (a) restoring habitat and wild stocks; (b) conserving habitat and wild stocks; (c) enhancing habitat; and (d) enhancing wild stocks."[42] Chapter 8 further provides that, in terms of salmon stocks originating in the Yukon River, the term "restoration" of such stocks means "returning a wild salmon stock to its natural production level."[43]

Although Chapter 8 contains provisions to protect habitat and migratory passage for Yukon River salmon stocks, and that restoration of Yukon River salmon should focus on wild salmon rather than artificial propagation of salmon in hatcheries, these Yukon River-specific provisions were not made generally applicable to other salmon stocks covered by the Pacific Salmon Treaty. This is perhaps explained by the fact that, unlike in the other major Pacific watersheds where salmon are present, there are no significant on-stream dams located in the Yukon River watershed.

The absence of provisions in the Pacific Salmon Treaty to establish general obligations to protect and enhance habitat and migratory passage for wild salmon stocks was noted by fisheries law scholar Brent R. H. Johnson in his 1998 article *Swimming Against a Legal Current: A Critical Analysis of the Pacific Salmon Treaty*, published in the

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[39] PACIFIC SALMON TREATY TRANSPARENCY, *supra* note 8.
[40] PACIFIC SALMON TREATY, *supra* note 33, at 2.
[41] *Id.* at 131.
[42] *Id.* at 134.
[43] *Id.* at 125.

Dalhousie Journal of Legal Studies (Dalhousie University School of Law in Halifax, Nova Scotia, Canada). In this 1998 article, Johnson wrote: "The dependence of salmon on fresh water however, requires protected inland habitats and unobstructed water routes from the ocean to inland spawning grounds. Clearly, this can only effectively be provided for by the state in which the habitats and water routes are located."[44] Johnson continues: "It is somewhat curious that while the parties have specifically encouraged salmon enhancement, there is no particular obligation to ensure the preservation of salmon habitats."[45] Johnson further noted: "[T]he failure to include habitat protection obligations appears to undermine the principle of conservation contained in article III, paragraph 1(a). Although this provision requires the parties in principle to ensure the 'optimum production' of stocks, the parties are not made directly responsible under the *Treaty* for the protection of salmon environments within their boundaries."[46]

III. ROLE OF ABUNDANCE FORECASTS IN THE PACIFIC SALMON TREATY CONSERVATION MODEL

As noted above, the total catch limits for different Pacific salmon stocks in different regions is derived from "abundance forecasts" for the coming season. The data and information upon which such abundance forecasts rely tends to come from the parties to the Pacific Salmon Treaty, Canada, and the United States, rather than being generated by the Pacific Salmon Commission.[47] An April 2018 publication by the State of Alaska, titled *Pacific Salmon Treaty Transparency*, explains the relationship between the Preseason Abundance Index ("Preseason AI") and the Postseason Abundance Index ("Postseason AI") as used by the Pacific Salmon Commission in setting harvest limits:[48] "Preseason AI, the metrics upon which harvest limits are set by the Pacific Salmon Commission, is based on forecasts of driver stocks and projected maturation rates, while Postseason AI is based on observed survival and observed maturation rates."[49] In short, higher abundance forecasts allow for and justify higher harvest/fishing levels.

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[44] Brent R. H. Johnston, *Swimming Against a Legal Current: A Critical Analysis of the* Pacific Salmon Treaty, 7 DALHOUSIE J. OF LEGAL STUD. 125, 129, 141 (1998).
[45] *Id.*
[46] *Id.* at 154.
[47] REVIEW OF METHODS FOR FORECASTING CHINOOK SALMON ABUNDANCE IN THE PACIFIC SALMON TREATY AREAS, *in* PACIFIC SALMON TREATY TRANSPARENCY, *supra* note 8, at 59.
[48] *Id.* at 20.
[49] *Id.*

As author Kathleen A. Miller noted in her report *North American Pacific Salmon: A Case of Fragile Cooperation*, abundance forecasting is not a simple or easy task:

> A particular weakness [of the Pacific Salmon Treaty] is the fact that effective implementation of abundance-based management requires that the parties agree on the indices of abundance that will be used to set their harvest targets. Abundance, however, is very difficult to forecast in advance of the arrival of the runs. Forecasting models are imperfect, and data inadequacies and the uncertain and uneven impacts of variable marine and river conditions impair the accuracy of the forecasts.[50]

In recent decades, fishery biologists expressed concern with the reliability and accuracy of salmon abundance forecasting due to the tendency of such forecasting not distinguishing between salmon originating from natural spawning grounds and salmon originating from hatcheries. A 2010 article *titled Magnitude and Trends in Abundance of Hatchery and Wild Pink Salmon, Chum Salmon, and Sockeye Salmon in the North Pacific Ocean*, published by the American Fisheries Society, concluded:

> Hatchery salmon may reduce variability in harvests but this benefit to fishermen may come with a cost to wild salmon productivity. Additionally, there can be substantial straying of hatchery fish into natural spawning areas, which can degrade the fitness and biological diversity of the wild populations…Resource agencies often do not separately estimate and report hatchery and wild salmon in the catch, let alone the spawner counts. The presence of numerous hatchery salmon can reduce the accuracy of wild salmon abundance and productivity estimates, which are important for setting goals for harvest rates and spawning abundances. [51]

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[50] KATHLEEN A. MILLER, NORTH AMERICAN PACIFIC SALMON: A CASE OF FRAGILE COOPERATION, *in* Papers Presented at the Norway-FAO Expert Consultation on the Management of Shared Fish Stocks (2002).

[51] Gregory T. Ruggerone, Randall M. Peterman, Brigitte Dorner, and Katherine W. Myers, *Magnitude and Trends in Abundance of Hatchery and Wild Pink Salmon, Chum Salmon, and Sockeye Salmon in the North Pacific Ocean*, MARINE AND COASTAL FISHERIES: DYNAMICS, MANAGEMENT, AND ECOSYSTEM SCIENCE, 306, 322 (2010).

As implementation of the Pacific Salmon Treaty's abundance-based conservation model unfolded a reoccurring pattern began to emerge, consistent with concerns noted in the 2010 article published by the American Fisheries Society. The Pacific Salmon Commission's abundance forecasts (or Preseason AI) tended to significantly *over-estimate* the abundance of many salmon stocks as compared with actually observed abundance (or Postseason AI).[52] The pattern led the Pacific Salmon Commission to organize a conference in Portland, Oregon, in early 2016 to consider the matter as it related to declining Pacific Chinook salmon stocks, and to appoint a three-person Independent Technical Panel ("ITP") to issue a report on the findings of the conference.[53] In November 2016, the members of the ITP – Randall M. Peterman, Ray Beamshelf, and Brian Blue – submitted a report to the Pacific Salmon Commission titled *Review of Methods for Forecasting Chinook Salmon Abundance in the Pacific Salmon Treaty Areas* ("*2016 ITP Abundance Forecasting Report*").

The *20I6 ITP Abundance Forecasting Report* notes some of the assumptions that go into developing Preseason AI. According to the ITP, a chief assumption for abundance forecasting is that there is no difference between the marine survival rates of wild Chinook and hatchery Chinook salmon.[54] The *2016 Abundance Forecasting Report* also notes that, under the Pacific Salmon Commission's existing Chinook model, hatchery stocks are treated as "surrogates for wild stocks."[55] These statements reflect that, under the current conservation model used pursuant to the Pacific Salmon Treaty, it does not appear that differences between wild salmon stocks and hatchery stocks or interactions between wild salmon stocks and hatchery salmon stocks are part of the core assumptions or methodology that goes into abundance forecasting under the Pacific Salmon Treaty.

The *20I6 ITP Abundance Forecasting Report* documents several instances of significant discrepancies between Preseason AI and Postseason AI. For example, the ITP reported that for the Columbia Upriver Summer Chinook stocks, the Pacific Salmon Commission abundance forecast overestimated the actual abundance by a mean absolute percent error of 22%.[56] Additionally, the ITP reported that for

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52 Randall M. Peterman, Ray Beamshelf & Brian Blue, *Review of Methods for Forecasting Chinook Salmon Abundance in the Pacific Salmon Treaty Areas*, PACIFIC SALMON COMMISSION TECHNICAL REPORT NO. 35, 6 (2016).
53 *Id.* at 15-17.
54 *Id.* at 45-46.
55 *Id.* at 18.
56 *Id.* at 5.

the North Oregon Coast Chinook stocks, the Pacific Salmon Commission abundance forecast overestimated the actual abundance by a mean absolute percent error of 31%.[57]

In terms of identifying the particular flaws or shortcoming in the Pacific Salmon Treaty conservation model that accounted for these overestimates and discrepancies, the *20I6 ITP Abundance Forecasting Report* was less than specific, concluding:

> Causes of the recent large discrepancies between the pre- and post-season AIs are unclear. However, the strong positive correlation in discrepancies across AABM [Aggregate Abundance Based Management] areas, along with other evidence, suggests that both the PSC [Pacific Salmon Commission] model and the agencies' stock-specific forecasting methods do not properly represent changes in key factors such as time-varying maturation rates, marine survival rates, or exploitation rates.[58]

The *2016 ITP Abundance Forecasting Report* did not provide further guidance as to whether the failure of the current conservation model to properly "represent changes" in factors such as "time-varying maturation rates" and "marine survival rates" might relate to differences and interactions between wild salmon stocks and hatchery stocks, or might relate to interactions between different species of Pacific salmon (such as pink salmon interactions with Chinook, Coho and sockeye salmon). These differences and interactions between wild salmon stocks and hatchery salmon stocks (which are in turn related to differences and interactions between different species of Pacific salmon) may be the missing element in the Pacific Salmon Treaty conservation model that accounts for and explains the pattern of overestimating abundance forecasting.

IV. THE REPLACEMENT ASSUMPTION AND THE ADVERSE EFFECTS OF HATCHERIES ON WILD SALMON

Many of the larger on-stream dams in the Pacific Northwest were built in the period from 1930 to 1970.[59] At the time these on-stream dams were constructed, the proponents of such dams were aware that the structures would impede upstream and downstream migration of certain

[57] *Id.*
[58] *Id.* at 11.
[59] LICHATOWICH, *supra* note 5, at 76.

existing wild salmon runs.[60] The original strategy to mitigate the anticipated adverse impacts of dams on salmon stocks was to construct and operate salmon hatcheries below the dams.[61] Under this strategy, the hatcheries would release large volumes of juvenile salmon in the lower reaches of rivers and these salmon would then return to spawn in these lower reaches, thereby "replacing" the wild salmon runs lost due to the dams' blockage of downstream and upstream passage from traditional spawning grounds in the higher reaches of the watershed.[62] Thus was born the "replacement assumption" which maintained that dams and robust salmon stocks were compatible because lost wild salmon stocks could be replaced by operating hatcheries (to artificially propagate salmon) below the dams.

In his 1999 book Salmon Without Rivers: A History of the Pacific Salmon Crisis, fisheries biologist Jim Lichatowich explains:

> Fundamentally, the salmon's decline has been the consequence of a vision based on flawed assumptions and unchallenged myths – a vision that has guided the relationship between salmon and humans for the past 150 years. We assumed we could control the biological productivity of salmon and improve upon natural processes we didn't even try to understand. We assumed we could have salmon without rivers…Placing misguided confidence in technological solutions, salmon managers accepted the myth that controlling salmon production in hatcheries would ultimately lead to increased productivity. Despite the best of intentions, these hard-working people produced disaster because their efforts were based on false assumptions.[63]
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> …
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> The plans to relocate upriver stocks to the lower river using artificial propagation was a straw that politicians readily grasped to promote the belief that power and salmon were compatible.[64]

In Salmon Without Rivers, Lichatowich continues:

> Today, as proof of their success, hatchery advocates note that artificially propagated salmon make up 80 percent or more of the total number of salmon on the Columbia [River Basin], but they

[60] *Id.*
[61] *Id.* at 187.
[62] *Id.* at 8.
[63] *Id.* at 7-8.
[64] *Id.* at 188-189.

> fail to mention that the total run has crashed to less than 5 percent of its historical abundance. Measuring success by the percentage of hatchery fish in a shrinking production base was not only scientifically invalid but also insidiously enhanced the illusion of hatchery success. At the same time the percentage of hatchery fish in the run increased, hatcheries were contributing to the decline of wild salmon.[65]

Lichatowich further observes:

> One of the most troubling consequences of this flawed vision was that it diverted salmon managers' attention from the root causes of the salmon's decline. As a result, significant problems such as habitat destruction and overharvest were consistently ignored. Agency budgets and staff energy were devoted to artificial propagation instead of habitat protection.[66]

The analysis and conclusions of Lichatowich have been confirmed and echoed by many other studies that have assessed the effect of salmon hatcheries on wild salmon stocks and overall salmon abundancy. For example, in 2014 the Hatchery Scientific Review Group submitted a report to the United States Congress titled *On the Science of Hatcheries: An Updated Perspective on the Role of Hatcheries in Salmon and Steelhead Management in the Pacific Northwest*.[67] The Hatchery Scientific Review Group was created as part of the Hatchery Reform Project established by the United States Congress in 2000.[68] In its 2014 report On the Science of Hatcheries, the Hatcheries Scientific Review Group found:

> However, the traditional mitigation policy of replacing wild populations with hatchery fish is not consistent with today's conservation goals, environmental values, and scientific theories. Hatcheries cannot replace lost fish habitat and the natural populations that rely on it. It is now clear that the widespread use

[65] *Id.* at 198.
[66] *Id.* at 130.
[67] *See* HATCHERY SCI. REVIEW GRP., REPORT TO CONGRESS ON THE SCIENCE OF HATCHERIES: AN UPDATED PERSPECTIVE ON THE ROLE OF HATCHERIES IN SALMON AND STEELHEAD MANAGEMENT IN THE PACIFIC NORTHWEST (2014).
[68] *Id.* at 1.

> of traditional hatchery programs has actually contributed to the overall decline of wild populations.[69]

Similarly, in the report *The Effects of Hatchery Production on Wild Salmon and Trout*, the group Wild Fish Conservancy determined the following in terms of the survival and reproduction rates of hatchery salmon: "Domestication selection by hatchery practices derails the 'survival of the fittest' concept. Those with the greatest fitness in a captive environment produce offspring that perform the worst in the wild."[70] Wild Fish Conservancy went on to find that after 130 years of hatchery production, "Management continues to rely on hatchery production to mitigate for losses of wild fish abundance and habitat," despite clear evidence that "[a]rtificial propagation contributes to declines in the survival and reproductive capacity of endangered wild fish..."[71]

As a final example, in her 2004 article *The Salmon Hatchery Myth: When Bad Policy Happens to Good Science*, Melanie Kleiss reports:

> [W]e have blindly depended upon hatcheries to compensate for overfishing and habitat destruction, even though science and historical trends indicate that hatcheries fail to meet this intended function. Despite widespread hatchery development, over 100 major Pacific salmon runs have gone extinct, and many of the remaining 200-plus runs are at risk of disappearing. Even though studies indicate that hatchery fish may accelerate the extinction of salmon runs, faith in hatcheries continues.[72]

Kleiss notes:

> The scientific literature as a whole provides a stunningly consistent message: hatchery fish could drive salmon populations closer to extinction…Many studies find that juvenile hatchery salmon show more aggression and exhibit different predator avoidance behaviors than their wild counterparts.[73]…[T]he scientific literature shows almost without exception that hatchery salmon have lower overall survival rates

[69] *Id.* at 2.
[70] WILD FISH CONSERVANCY NORTHWEST, *supra* note 1, at 26.
[71] *Id.* at 49.
[72] Melanie Kleiss, *The Salmon Hatchery Myth: When Bad Policy Happens to Good Science*, 6 MINN. J. L. SCI. & TECH. 431, 431 (2004).
[73] *Id.* at 436.

> and significantly lower breeding success rates.[74]…Therefore, while hatchery juveniles released into natural streams have a competitive advantage over wild fish due to increased aggression, size, or sheer number, their impaired ability to survive to adulthood and breed successfully can translate into an overall reduction in salmon population size.[75]

Kleiss goes on to conclude, "Hatcheries cannot replace wild populations and must remain secondary to habitat conservation as a recovery strategy for salmon populations. Nature simply does the job better."[76]

These studies all suggest that the replacement assumption—which for more than a century has served as the basis for Pacific salmon management and the foundation for claims that on-stream dams and salmon conservation are compatible—has now been shown to be flawed and incorrect. The continuation of misplaced reliance on the replacement assumption, in turn, helps to explain the pattern of inaccuracies and overestimates with abundance forecasts under the Pacific Salmon Treaty. If more hatchery salmon are not the answer to declining Pacific salmon stocks, and in fact contribute to such a decline, then where does the answer lie?

V. Habitat Instead of Hatcheries – Reorienting The Pacific Salmon Treaty

With an enhanced understanding of the ways that hatcheries adversely affect wild Pacific salmon and contribute to declines in the overall abundance of Pacific salmon stocks, there is emerging consensus that expanding salmon hatchery production will not solve the problem of Pacific salmon decline.[77] There is also emerging consensus that the more viable strategy to restore declining Pacific salmon stocks is to improve natural habitat conditions (such as reducing out of stream diversions to maintain cooler instream temperatures and avoiding logging on slopes upland/adjacent to salmon spawning grounds) and to avoid or remove obstacles (such as dams) that impede downstream and upstream fish passage.[78]

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[74] *Id.* at 437.
[75] *Id.* at 438.
[76] *Id.* at 440.
[77] *See generally* LICHATOWICH, *supra* note 5.
[78] *Id.* at 226.

In his 1998 article*, Swimming Against a Legal Current: A Critical Analysis of the Pacific Salmon Treaty*, Brent Johnston suggests:

> The parties [to the Pacific Salmon Treaty] need to reevaluate the manner in which the Treaty gives practical expression to the principle of conservation. This may include providing the PSC [Pacific Salmon Commission] with the responsibility for overseeing designated salmon habitat areas or including an annex to the Treaty which outlines obligations to ensure against habitat degradation.[79]

Similarly, in their article *Pacific Salmon at the Crossroads: Stocks at Risks from California, Oregon, Idaho and Washington*, fisheries biologists Willa Nehlsen, Jack E. Williams and James A. Lichatowich found:

> The decline in native salmon, steelhead, and sea-run cutthroat populations has resulted from habitat loss and damage, and inadequate passage and flows caused by hydropower, agriculture, logging and other developments; overfishing, primarily of weaker stocks in mixed-stock fisheries; and negative interaction with other fishes, including nonnative hatchery salmon and steelhead. While some attempts at remedying these threats have been made, they have not been enough to prevent the broad decline of stocks along the West Coast. A new paradigm that advances habitat restoration and ecosystem function rather than hatchery production is needed for many of these stocks to survive and prosper into the next century.[80]

The prospects for the Pacific Salmon Treaty to focus more on instream habitat conditions and removal of obstacles to downstream and upstream passage may be impacted by recent amendments to the treaty at the end of 2018 that went into effect January 1, 2019 (hereinafter the "2019 Treaty Amendments").[81] While these recent amendments to the Pacific Salmon Treaty do not specifically address changes to the model and methodology used for abundance forecasts, they do suggest greater recognition of differences between wild salmon stocks and hatchery stocks while also emphasizing the need to strengthen habitat protection.

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[79] Johnston, *supra* note 45, at 158.
[80] Willa Nehlsen, Jack E. Williams & James A. Lichatowich*, Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington*, 16 FISHERIES 4, 4 (1999).
[81] *See* PACIFIC SALMON TREATY, *supra* note 33, at 111.

Attachment E to the 2019 Treaty Amendments, titled *Habitat and Restoration*, provides in its preamble:

> Considering the agreements between the Parties to implement abundance-based management regimes designed to prevent overfishing;
>
> Taking into account the decline in the abundance and productivity of important naturally spawning stocks of Pacific salmon subject to this Treaty;
>
> Recognizing that **it is vital to protect and restore the salmon habitat** and to maintain adequate water quality and quantity in order to improve spawning, the safe passage of adult and juvenile salmon and, therefore, to optimize the production of important naturally spawning stocks;
>
> Recognizing that **the Parties can achieve the principles and objectives of this Treaty only if they maintain and increase the production of natural stocks;**
>
> Recognizing that a carefully designed enhancement program would contribute significantly to the restoration of depressed natural stocks and help the Parties optimize production.[82]

Attachment E to the 2019 Treaty Amendments further states:

> The parties agree: 1. To use their best efforts, consistent with applicable law, to (a) **protect and restore the habitat to promote the safe passage** of adult and juvenile salmon and to achieve high levels of **natural production**…(b) maintain and, as needed, **improve safe passage of salmon to and from their natal streams**; and…(c) maintain adequate water quality and quantity.[83]
>
> …
>
> To…promote these objectives by requesting that the [Pacific Salmon] Commission…(b) periodically review and discuss information on the **habitat of naturally spawning stocks**

[82] *See id.* at 119 (bold added).
[83] *Id.* (bold added).

> subject to this Treaty that cannot be restored through harvest controls alone any non-fishing factors that affect the **safe passage** or survival of salmon, options for addressing non-fishing constraints and restoring optimum production, and progress of the Parties to achieve the objectives for the stocks under this Treaty.[84]

The 2019 Treaty Amendments also include new language in Chapter 3 on Chinook Salmon that states: "The parties agree that…while fishing has contributed to the decline of some Chinook stocks, the **continued status of Chinook stocks that are considered depressed generally reflects the long-term cumulative effects of other factors, particularly chronic habitat degradation**" and "deleterious **hatchery** practices."[85] The 2019 Treaty Amendment on Chapter 3 also added: "The parties shall…report annually on **naturally spawning Chinook stocks** in relation to agreed MSY [Maximum Sustainable Yield] or other biologically-based escapement objectives, rebuilding exploitation rate objectives, or other metrics, and evaluate trends in the status of stocks and report on progress in the **rebuilding of naturally spawning Chinook stocks**."[86]

In addition to the new habitat-focused and passage-focused provisions in Attachment E and Chapter 3, the 2019 Treaty Amendments also added Appendix A to Annex IV of the Pacific Salmon Treaty.[87] The new Appendix A to Annex IV concerned the work of the Chinook Technical Committee ("CTC") that reports to the Pacific Salmon Commission, and provides: "The **CTC** shall…report annually on **naturally spawning Chinook stocks** in relation to the agreed MSY of other biologically-based escapement objectives, rebuilding exploitation rate objectives, or other metrics, and evaluate trends in the status of stocks and **report on progress in the rebuilding of naturally spawning Chinook stocks**."[88] Pursuant to Appendix A, going forward it therefore appears that in addition to receiving annual data from Canada and the United States about the volume of fish propagated in and released from hatcheries, the Pacific Salmon Commission will also receive annual reports from the CTC focused specifically on wild salmon stocks and efforts to rebuild such stocks.

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[84] *Id.* at 119-120 (bolded added).
[85] *Id.* at 48 (bold added).
[86] *Id.* at 51 (bold added).
[87] *Id.* at 67.
[88] *Id.* (bold added).

The changes reflected in the 2019 Treaty Amendments provide a potential foundation and opportunity for the Pacific Salmon Treaty to develop a more scientifically credible and robust model for assessing the overall health of Pacific salmon stocks generally. In terms of how this more scientifically credible and robust model might affect how the Pacific Salmon Treaty operates in practice, it is important keep in mind what the Pacific Salmon Commission can and cannot do.

Of particular significance, the Pacific Salmon Commission cannot order the Canadian and United States governments to remove particular dams, install fish passage on particular dams, prohibit logging in areas upland of streams where salmon spawn, release water from upstream reservoirs, or reduce out-of-stream diversions to maintain instream water temperatures. These measures may be critical to providing safe passage for wild salmon and to preserve habitat for wild salmon, but these are not measures that the Pacific Salmon Treaty authorizes the Pacific Salmon Commission to take. Given the current structure of the Pacific Salmon Treaty, such measures can only be ordered and enforced by the national government (or perhaps provincial/state governments) of Canada and the United States.

Although the Pacific Salmon Commission may lack the authority to order the fish habitat and fish passage measures noted above, the Pacific Salmon Commission is still positioned to play an important role in shifting the focus of salmon management. This shift includes moving from a reliance on hatcheries to a focus on improving habitat protection and passage. There are at least two ways in which the Pacific Salmon Commission can play this role, and neither require any substantive changes to the Pacific Salmon Treaty.

First, in terms of its abundance forecasting, the model used by the Pacific Salmon Commission and the committees that provide guidance to the Pacific Salmon Commission can be recalibrated so that it takes into account that reliance on hatcheries to produce salmon is detrimental to the long-term abundance of Pacific salmon, and investments in improving passages and habitats enhances the long-term abundance of Pacific salmon. With this recalibration, expanded reliance on hatcheries to produce salmon would result in a downward adjustment, rather than an upward adjustment, of the total catch and fishing limits for Canadian and United States fishermen.

Second, in relation to the equity principle in the Pacific Salmon Treaty, and the fair allocation of fishing rights between Canadian and United States fishermen, this recalibration would impact how fishing rights are allocated between the two countries.[89] For example, if the United States is relying more on hatcheries to artificially produce salmon instead of maintaining passages and habitats for the production of wild salmon, then consistent with current science the Pacific Salmon Commission should correspondingly reduce the United States allocation of fishing rights. Conversely, if Canada is improving the production of wild salmon by maintaining and enhancing passages and habitats, then the Pacific Salmon Commission should correspondingly increase Canada's allocation of fishing rights. At present, the Pacific Salmon Commission's allocation of fishing rights between Canada and the United States is based on the volume of salmon that originate in each respective country but little if any attention is paid to whether the originations are hatchery salmon or wild salmon.[90] This is something the Pacific Salmon Commission can change.

Building on the 2019 Treaty Amendments, these are tangible changes that the Pacific Salmon Commission can make to help rebuild declining Pacific salmon stocks – to achieve "optimum production" per Article III of the Pacific Salmon Treaty.

CONCLUSION
Wild Salmon and Hatchery Salmon are Not the Same

When considering the relationship between salmon habitats and salmon hatcheries, and the relationship between wild salmon stocks and hatchery-produced salmon, it is useful to return to the definition of "enhancement" set forth in Article I of the Pacific Salmon Treaty. In Article I, "enhancement" is defined as "man-made improvements to natural habitat or application of artificial fish culture technology that will lead to an **increase** in salmon stocks."[91] This definition suggests that Pacific salmon artificially propagated in hatcheries are only consistent with the Pacific Salmon Treaty to the extent that the production of such hatchery salmon result in an "increase in salmon stocks."

It would follow then, that salmon hatchery activities and practices that are shown to result in a long-term *decrease* in salmon stocks (e.g. due to the low survival and reproductive rates of hatchery salmon and the adverse effects on wild salmon stocks of interactions with hatchery salmon) would be inconsistent with the Pacific Salmon Treaty's notion of "enhancement" as well as the Pacific Salmon Treaty's objective of

[89] *See* SHEPARD & ARGUE, *supra* note 2, at 94-119.
[90] *Id.*
[91] PACIFIC SALMON TREATY, *supra* note 33, at 2 (bold added).

"optimum production."[92] It difficult to see how a hatchery-reliant system of producing salmon that results in the long-term decrease of salmon stocks could be considered "optimum."[93]

To return to this study's starting point, of explaining and correcting the Pacific Salmon Commission's pattern of overestimates in its abundance forecasting for Pacific salmon, it appears the Pacific Salmon Treaty finds itself at a crossroads. The Pacific Salmon Treaty's approach to setting fishing levels was premised in considerable part on the replacement assumption – that high levels of abundance (and therefore high levels of fishing) could be maintained through hatchery production even if dams, logging, and out-of-stream diversions continued to degrade the natural habitat for wild salmon stocks. Now that the replacement assumption has been shown to be faulty, there is a fundamental disconnect between science and policy. The methodology underlying the Pacific Salmon Treaty's conservation model still relies extensively on hatcheries to maintain salmon abundance even through it is now understood that such hatcheries are contributing to the long-term decline of such abundance.

The 2019 Amendments to the Pacific Salmon Treaty reveal an emerging recognition of this disconnect between science and policy, and of the need to refocus on what can be done to improve instream habitat conditions (cooler water temperatures, protecting spawning grounds from siltation caused by logging) and downstream/upstream passage for wild salmon stocks.[94] By recalibrating its abundance forecasts and its allocation of fishing rights to better reflect this science, there are meaningful changes the Pacific Salmon Commission can make to help shift this focus. The direct actions to improve passages and habitats for salmon, however, will need to be undertaken at the national level.

As we look to the prospect of action at the national level by Canada and the United States in closing, we can note some examples of how this might work in relation to dams. In the United States multiple dam removals have had a large impact on the nearby salmon habitats, Golden Ray Dam on the Rogue River in Oregon[95], San Clemente Dam on the Carmel River in California[96] and two dams on the Elwha River in

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[92] *Id.* at 5.
[93] *Id*.
[94] *See id.* at 119.
[95] WaterWatch, *Gold Ray Dam Comes Down*, WATERWATCH, https://waterwatch.org/gold-ray-dam-removal/ (2019) (last visited Feb. 4, 2020).
[96] Teresa L. Carey, *With San Clemente Dam Gone, Are Steelhead Trout About to Make Comeback on the Carmel River?*, SAN JOSE MERCURY NEWS (July 7, 2017, 6:00 AM), https://www.mercurynews.com/2017/07/07/with-san-clemente-dam-gone-are-steelhead-trout-about-to-make-comeback-on-the-carmel-river/.

Washington state were recently removed[97], and plans are underway to remove four dams in the Oregon-California Klamath River basin.[98] The calls for removal of dams on the Rogue River, Carmel River, Elwha River and Klamath River were prompted in part by salmon-related considerations, hoping that removing the dams will allow salmon passage and access to traditional spawning grounds in the higher reaches of these watersheds.[99]

As the Oregon-based conservation group WaterWatch reported in regard to the removal of Golden Ray Dam on the Rogue River: "The dam was a significant barrier to fish and its removal allows better access to 333 miles of salmon and steelhead spawning habitat upstream of the former dam. Gold Ray removal also reclaimed approximately 1.5 miles of salmon spawning habitat that was buried beneath the dam's impounded waters. Since removal, spawning surveys upstream of the former dam site show that use of this now-viable spawning ground has risen exponentially."[100]

And in Canada, there is the example of Moran Dam on the Fraser River in British Columbia. Moran Dam was a 720-foot-high structure proposed in the 1950s that would have been constructed on the mainstem of the Fraser River 200-miles from the river's mouth.[101] The proponents of Moran Dam conceded that the structure would have significant adverse effects on Fraser River sockeye salmon, but consistent with the replacement assumption, proposed hatcheries below the dam to offset the anticipated damage to wild stocks. [102]

In 1960, as the controversy over Moran Dam unfolded, the International Pacific Salmon Fisheries Commission ("IPSFC") based in British Columbia published a report titled *Sockeye and Pink Salmon Production in Relation to Proposed Dams in the Fraser River System*.[103] This 1960 report concluded: "At the present time, artificial propagation

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[97] Kate Schimel*, After its Dams Came Down, a River is Reborn*, HIGH COUNTRY NEWS (Sept. 4, 2017), https://www.hcn.org/issues/49.15/rivers-six-years-after-its-dams-came-down-a-river-is-reborn.

[98] Jacques Leslie, Op-Ed, *Four Dams in the West are Coming Down – a victory wrapped in a defeat for smart water policy*, L.A. TIMES (November 2, 2017, 4:00 AM), https://www.latimes.com/opinion/op-ed/la-oe-leslie-klamath-dam-removal-20171102-story.html.

[99] Schimel, *supra* note 98; Leslie, *supra* note 99; WaterWatch, *supra* note 96; Carey, *supra* note 97.

[100] WaterWatch, *supra* note 98.

[101] LICHATOWICH, *supra* note 5, at 195-196.

[102] *Id.* (citing F. J. Andrew & G. H. Green, *Sockeye and Pink Salmon Production in Relation to Proposed Dams in the Fraser River System*, Bull. No. 11, Int'l Pac. Salmon Fisheries Comm'n, New Westminister, British Columbia (1960)).

[103] *Id*. at 196.

is not a proven method of maintaining even small localized stocks of Fraser River sockeye and pink salmon."[104] As a consequence of the 1960 IPSFC report, Moran Dam was not built and wild stocks in the Fraser River watershed today remain generally healthier and more abundant than in watersheds such as the Columbia River where on-stream dams were built in the lower reaches.[105]

The experience in the United States with dam removal, and the experience in Canada with the decision to forego construction of Moran Dam on the Fraser River, provide examples of what it can mean in practice to restore and maintain the habitat conditions and passages needed for healthy abundant salmon stocks. These examples give a sense of the actions Canada and the United States can undertake going forward to give substance to the provisions of Attachment E to the 2019 amendments to the Pacific Salmon Treaty requiring the parties to "protect and restore the habitat to promote the safe passage of adult and juvenile salmon and to achieve high levels of natural production"[106] and to maintain and improve "safe passage of salmon to and from their natal streams."[107]

By bringing its abundance forecast model and fishing limits more in line with current science, which recognizes that ultimately salmon hatcheries cannot replace wild salmon stocks, the Pacific Salmon Commission can highlight that "enhancement"[108] and maintenance of "optimum production"[109] of Pacific salmon stocks are critically dependent on the extent to which Canada and the United States maintain habitat conditions and passage for wild salmon stocks.

[104] *Id*. at 195-196
[105] LICHATOWICH, *supra* note 5, at 196-97.
[106] *See* PACIFIC SALMON TREATY, *supra* note 33, at 119.
[107] *Id*.
[108] *Id.* at 2
[109] *Id.* at 5.