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January 26, 2024

Via Certified Mail – Return Receipt Requested (and email where indicated)

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RE: Notice of Intent to Sue for Violations of Section 7 and Section 9 of the Endangered Species Act Associated with Funding and Operating Hatcheries Under the Mitchell Act and with Operating SAFE Hatchery Programs

Dear Honorable Civil Servants,

This letter provides notice of violations of sections 7 and 9 of the Endangered Species Act ("ESA"), 16 U.S.C. §§ 1536, 1538, related to hatchery programs in the Lower Columbia River basin (i.e., below Bonneville Dam) that are funded under the Mitchell Act[1] and three Select Area Fisheries Enhancement ("SAFE") salmon hatchery programs. This letter provides notice under section 11(g) of the ESA, 16 U.S.C. § 1540(g), of Wild Fish Conservancy and The Conservation Angler's intent to sue for the violations described herein to enforce the ESA.

The National Marine Fisheries Service and Janet Coit (in her official capacity as the Assistant Administrator for Fisheries for NOAA Fisheries) (collectively, "NMFS") and the United States Department of Commerce and Gina Raimondo (in her official capacity as the Secretary of the United States Department of Commerce) (collectively, "Commerce") are violating the ESA by funding hatchery programs in a manner inconsistent with the substantive and procedural mandates of section 7 of the ESA. NMFS and Commerce are violating section 9 of the ESA by funding operations and maintenance of hatchery programs and facilities that cause unauthorized "take" of ESA-listed species.

Kelly Susewind (in his official capacity as the Director of the Washington Department of Fish and Wildlife) and the Commissioners of the Washington Fish and Wildlife Commission (in their official capacity) (collectively, "WDFW") are violating section 9 of the ESA by operating and maintaining hatchery programs and facilities that cause unauthorized "take" of ESA-listed species.

Curt Melcher (in his official capacity as the Director of the Oregon Department of Fish and Wildlife) and the Commissioners of the Oregon Fish and Wildlife Commission (in their official capacity) (collectively, "ODFW") are violating section 9 of the ESA by operating and maintaining hatchery programs and facilities that cause unauthorized "take" of ESA-listed species.

Steve Meshke (in his official capacity as the Natural Resources Manager for Clatsop County Fisheries), Clatsop County Fisheries, Don Bohn (in his official capacity as the County Manager for Clatsop County Oregon), and Clatsop County (collectively, "Clatsop County Fisheries") are violating section 9 of the ESA by operating and maintaining hatchery programs and facilities that cause unauthorized "take" of ESA-listed species.

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[1] Appended hereto as Appendix A is a table that identifies the hatchery programs in the Lower Columbia River basin (i.e., below Bonneville Dam) that are funded by Commerce and NMFS under the Mitchell Act based upon currently available information. The allegations in this Notice Letter cover all salmonid hatchery programs in the Lower Columbia River basin (i.e., below Bonneville Dam) that are funded, and/or that have been funded any time since and including 2017, by Commerce and/or NMFS under the Mitchell Act, including any such programs not identified in Appendix A.

I. **<u>Legal Framework</u>.**

A. <u>Section 7 of the ESA</u>.

Section 7 of the ESA imposes a substantive obligation on federal agencies to "*insure* that any action authorized, funded, or carried out by such agency . . . is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat" that has been designated as critical for such species. 16 U.S.C. § 1536(a)(2) (emphasis added); *Pyramid Lake Paiute Tribe of Indians v. U.S. Dep't of the Navy*, 898 F.2d 1410, 1414 (9th Cir. 1990). Such jeopardy results where an action "reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. § 402.02. Destruction or adverse modification of critical habitat occurs where there is a "direct or indirect alteration that appreciably diminishes the value of critical habitat" for both the survival and recovery of a listed species. *Id.*

In fulfilling the substantive mandates of section 7 of the ESA, federal agencies planning to fund or undertake an action (the "action agency") that "may affect" ESA-listed species or their critical habitat are required to consult with NMFS and/or the United States Fish and Wildlife Service ("FWS") (the "consulting agency") regarding the effects of the proposed action. *See id.* § 402.14(a). Actions that are likely to adversely affect a listed species or its critical habitat require formal consultation, which concludes with the consulting agency's issuance of a biological opinion ("BiOp") determining whether the action is likely to jeopardize ESA-protected species or result in adverse modification of critical habitat. *See id.* § 402.14(a), (b), (h)(1).

Once initiated, formal consultation is to conclude within 90 days unless the agencies mutually agree in writing to extend the consultation period before the close of the 90-day period. *Id.* § 402.14(e). The ESA prohibits the action agency and any permit or license applicant from making any irreversible or irretrievable commitment of resources with respect to the action that would have the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures until the completion of the consultation. 16 U.S.C. § 1536(d).

If the consulting agency concludes the action will not jeopardize listed species or adversely modify their critical habitat, the consulting agency will include with the BiOp an incidental take statement ("ITS"). *Id.* § 1536(b)(4); 50 C.F.R. § 402.14(i)(1). An ITS must specify the impact of the action by setting a numeric limit on take (or an appropriate surrogate if a numeric cap is impractical to establish), identify "reasonable and prudent measures" that will minimize impacts to protected species, and outline "terms and conditions" to implement these measures. 50 C.F.R. § 402.14(i)(1). The ITS must also include monitoring and reporting requirements for the take resulting from the action. *See id.* § 402.14(i)(3); *Wild Fish Conservancy v. Salazar*, 628 F.3d 513, 531–32 (9th Cir. 2010).

After a BiOp is issued, federal agencies have a continuing duty under section 7 of the ESA to insure that their actions will not jeopardize the continued existence of listed species nor adversely modify designated critical habitat. *Wild Fish Conservancy*, 628 F.3d at 525. An agency must re-initiate consultation whenever "the amount or extent of taking specified in the incidental take statement is exceeded," "new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered," the action in question is "subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion," or "a new species is listed or critical habitat designated that may be affected by the identified action." 50 C.F.R. § 402.16(a).

B. Section 9 of the ESA.

Section 9 of the ESA generally makes it unlawful for "any person" to "take" an endangered species. 16 U.S.C. § 1538(a)(1). "Person" includes private parties as well as local, state, and federal agencies. *Id.* § 1532(13). To "take" a protected species means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." *Id.* § 1532(19). "Harm" is defined broadly as "an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering." 50 C.F.R. § 222.102.

Section 4(d) of the ESA, 16 U.S.C. § 1533(d), allows NMFS and FWS to apply the section 9 take prohibition to species listed as threatened. NMFS has applied the take prohibition to threatened species of anadromous fish, including Chinook salmon, coho salmon, and steelhead. *See* 50 C.F.R. §§ 223.102, 223.203(a). Section 9 of the ESA prohibits violations of those regulations. 16 U.S.C. § 1538(a)(1)(G).

Take in compliance with an ITS issued under section 7 of the ESA is exempt from liability under section 9 of the ESA. *Id.* § 1536(o)(2); 50 C.F.R. § 402.14(i)(5). Where a plaintiff alleges a violation of section 9, "any person claiming the benefit of any exemption or permit under [the ESA] shall have the burden of proving that the exemption or permit is applicable, has been granted, and was valid and in force at the time of the alleged violation." 16 U.S.C. § 1539(g); 50 C.F.R. § 223.203(c); *Wild Fish Conservancy v. Wash. Dep't of Fish & Wildlife*, No. C21-169-RSL, 2023 U.S. Dist. LEXIS 20568, at *21 (W.D. Wash. Feb. 7, 2023) (defendant must prove "complete compliance with the terms of the exemption").

NMFS's regulations issued under section 4(d) of the ESA that apply the take prohibition of section 9 of the ESA to various salmonid species—known as the "4(d) Rule"—include exemptions from that take prohibition—known as the "4(d) Limits." 50 C.F.R. § 223.203. One such exemption is for artificial propagation programs for which a hatchery and genetic management plan ("HGMP") has been approved by NMFS as meeting detailed criteria. *Id.* § 223.203(b)(5). Another exemption exists for joint State-Tribe resource management plans implementing treaty fishing rights that have undergone a NMFS review and approval process. *Id.* § 223.203(b)(6).

NMFS's 4(d) Rule for salmonids specifies that the 4(d) Limits provide an affirmative defense to a claim alleging that the activity is causing "take" in violation of section 9 of the ESA. *Id.* § 223.203(c). Specifically, the regulation provides:

> Affirmative Defense. In connection with any action alleging a violation of the prohibitions of paragraph (a) of this section [(which applies the ESA section 9 "take" prohibition)] with respect to the threatened West Coast salmon ESUs and steelhead DPSs . . . , any person claiming the benefit of any limit listed in paragraph (b) of this section or § 223.204(a) shall have a defense where the person can demonstrate that the limit is applicable and was in force, and that the person fully complied with the limit at the time of the alleged violation. This defense is an affirmative defense that must be raised, pleaded, and proven by the proponent. If proven, this defense will be an absolute defense to liability under section 9(a)(1)(G) of the ESA with respect to the alleged violation.

Id.

II. **Factual Background**.

A. Affected Species and Critical Habitat.

The Lower Columbia River Chinook salmon ESU was listed as a threatened species in 1999. 64 Fed. Reg. 14,308 (Mar. 24, 1999); *see also* 70 Fed. Reg. 37,160 (June 28, 2005); 79 Fed. Reg. 20,802 (Apr. 14, 2014); 50 C.F.R. § 223.102(e). Critical habitat has been designated for this species. 50 C.F.R. § 226.212; *see also* 70 Fed. Reg. 52,630 (Sept. 2, 2005).

The Lower Columbia River coho salmon ESU was listed as a threatened species in 2005. 70 Fed. Reg. 37,160 (June 28, 2005); *see also* 79 Fed. Reg. 20,802 (Apr. 14, 2014); 50 C.F.R. § 223.102(e). Critical habitat has been designated for this species. 50 C.F.R. § 226.212; *see also* 81 Fed. Reg. 9251 (Mar. 25, 2016).

The Lower Columbia River steelhead DPS was listed as a threatened species in 1998. 63 Fed. Reg. 13,347 (Mar. 19, 1998); *see also* 71 Fed. Reg. 834 (Jan. 5, 2006); 79 Fed. Reg. 20,802 (Apr. 14, 2014); 50 C.F.R. § 223.102(e). Critical habitat has been designated for this species. 50 C.F.R. § 226.212; *see also* 70 Fed. Reg. 52,630 (Sept. 2, 2005).

The Columbia River chum salmon ESU was listed as a threatened species in 1999. 64 Fed. Reg. 14,508 (Mar. 25, 1999); *see also* 70 Fed. Reg. 37,160 (June 28, 2005); 79 Fed. Reg. 20,802 (Apr. 14, 2014); 50 C.F.R. § 223.102(e). Critical habitat has been designated for this species. 50 C.F.R. § 226.212; *see also* 70 Fed. Reg. 52,630 (Sept. 2, 2005).

The Upper Willamette River Chinook salmon ESU was listed as a threatened species in 1999. 64 Fed. Reg. 14,308 (Mar. 24, 1999); *see also* 70 Fed. 37,160 (June 28, 2005); 79 Fed. Reg. 20,802 (Apr. 14, 2014); 50 C.F.R. § 223.102(e). Critical habitat has been designated for this species. 50 C.F.R. § 226.212; *see also* 70 Fed. Reg. 52,630 (Sept. 2, 2005).

The Upper Willamette River steelhead DPS was listed as a threatened species in 1999. 64 Fed. Reg. 14,517 (Mar. 25, 1999); *see also* 71 Fed. Reg. 834 (Jan. 5, 2006); 79 Fed. Reg. 20,802 (Apr. 14, 2014). Critical habitat has been designated for this species. 50 C.F.R. § 226.212; *see also* 70 Fed. Reg. 52,630 (Sept. 2, 2005).

The Southern Resident killer whale was listed as an endangered species under the ESA in 2005. 70 Fed. Reg. 69,903 (Nov. 18, 2005); *see also* 50 C.F.R. § 224.101(h). Critical habitat has been designated for this species. 50 C.F.R. § 226.206; *see also* 71 Fed. Reg. 69,054 (Nov. 29, 2006).

B. Hatchery Programs Funded Under the Mitchell Act.

Congress enacted the Mitchell Act on May 11, 1938 in an effort to mitigate adverse effects to salmonids in the Columbia River Basin resulting from the construction of dams, water diversions, logging, and pollution. The statute includes the following authorization:

> The Secretary of Commerce is authorized and directed to establish one or more salmon-cultural stations in the Columbia River Basin in each of the States of Oregon, Washington, and Idaho.
>
> *** *** *** *** *** ***
>
> The Secretary of Commerce is further authorized and directed . . . to perform all other activities necessary for the conservation of fish in the Columbia River Basin in accordance with law.

16 U.S.C. §§ 755–756. Congress has appropriated funds under the Mitchell Act on an annual basis since 1946.

Commerce and NMFS distribute funds appropriated under the Mitchell Act that Congress has allocated to hatchery programs. Mitchell Act funding of hatchery programs totals $15 to $25 million per year. These funds currently support around 60 hatchery programs operated by WDFW, ODFW, and others that produce approximately 42 million fish annually. Mitchell Act funds support operational elements needed to run the facilities and programs and maintenance of hatchery facilities and associated equipment.

C. The SAFE Hatchery Programs.

WDFW, ODFW, and Clatsop County Fisheries operate three SAFE salmon hatchery programs in the Lower Columbia River: the SAFE Coho Salmon Program, the SAFE Spring Chinook Salmon Program, and the SAFE Type-N Coho Salmon Program. These are isolated hatchery programs intended to benefit commercial and recreational fishing.

D. Take and Other Adverse Effects from Hatchery Programs Funded Under the Mitchell Act and from the SAFE Hatchery Programs.

The hatchery programs in the Lower Columbia River basin (i.e., below Bonneville Dam) funded by Commerce and/or NMFS under the Mitchell Act and the SAFE hatchery programs take ESA-listed species identified above and otherwise adversely affect the species and their critical habitat through a variety of mechanisms.

NMFS has summarized some of the adverse impacts to the ESA-listed salmonid species and their critical habitat in the following document: Effects of Hatchery Programs on Salmon and Steelhead Populations: Reference Document for NMFS ESA Hatchery Consultations (March 7, 2011) (Revised July 29, 2020) ("Hatchery Effects Document"). A copy of the Hatchery Effects Document is appended hereto as Appendix B and incorporated herein by this reference. NMFS analyzes hatchery impacts using six factors:

(1) The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock,

(2) Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,

(3) Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean,

(4) RM&E that exists because of the hatchery program,

(5) Operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and

(6) Fisheries that would not exist but for the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

The fish removal factor considers "whether broodstock are of local origin and the biological benefits and risks of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population collected for hatchery broodstock. 'Mining' a natural population to supply hatchery broodstock can reduce population abundance and spatial structure[.]" *Id*.

NMFS assesses three aspects for the second factor: genetic effects, ecological effects, and encounters at adult collection facilities. NMFS "generally view[s] the genetic effects of hatchery programs as detrimental to the ability of a salmon population's ability to sustain itself in the wild." *Id*. "Ecological effects" means "effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels" and may be negative where increased competition or redd superimposition occurs. *Id*. The last aspect considers "effects from encounters with natural-origin fish that are incidental to broodstock collection," including from sorting, holding, and handling natural-origin fish during broodstock collection. *Id*.

The third factor similarly addresses the potential for competition, predation, and disease when the progeny of naturally spawning hatchery fish and releases share juvenile rearing areas. NMFS has found that, "A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a time near the release point. These non-migratory smolts (residuals) may compete for food and space with natural-origin juvenile salmonids of similar age (Bachman 1984; Tatara and Berejikian 2012). Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well (Parkinson et al. 2017). Adverse impacts of residual hatchery Chinook and coho salmon on natural origin salmonids can occur, especially given that the number of smolts per release is generally higher; however, the issue of residualism for these species has not been as widely investigated compared to steelhead." *Id*.

NMFS also analyzes proposed research, monitoring, and evaluation caused by the hatchery for resulting impacts to listed species and critical habitat. "Negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces uncertainty. RM&E actions can cause harmful changes in behavior and reduced survival." *Id*.

For the fifth factor, NMFS has stated, "The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles, and adults. These actions can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether." *Id*. In applying this factor, NMFS analyzes changes to riparian habitat, channel morphology, habitat complexity, in-stream substrates, and water quantity and quality resulting from operation, maintenance, and construction activities and determines whether water diversions and fish passages meet NMFS criteria.

For the sixth factor regarding impacts from fisheries existing solely due to hatchery programs, NMFS has found that, "Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations with regard to harvest of some Pacific salmon and steelhead populations." *Id*. "In any event, fisheries must be carefully evaluated and monitored based on the take, including catch and release effects, of ESA-listed species." *Id*.

The hatchery programs in the Lower Columbia River basin (i.e., below Bonneville Dam) funded by Commerce and NMFS under the Mitchell Act and the SAFE hatchery programs cause take of Southern Resident killer whales and otherwise adversely affect this species and its critical habitat by reducing the Chinook salmon and other salmonids otherwise available as prey for the whales.

E. ESA Consultations and BiOps on Hatchery Programs Funded Under the Mitchell Act and on the SAFE Hatchery Programs.

NMFS issued a BiOp on March 29, 1999 that addressed various federal and non-federal hatchery programs in the Columbia and Snake River Basins, including programs funded by NMFS under the Mitchell Act. That 1999 BiOp concluded that hatchery programs jeopardized the continued existence of Lower Columbia River steelhead and Snake River steelhead and identified reasonable and prudent alternatives to avoid such jeopardy.

Following that 1999 consultation, numerous additional salmonid species affected by the hatchery programs became protected under the ESA. In 2016, Wild Fish Conservancy filed suit against NMFS for failure to consult and/or reinitiate consultation on hatchery programs funded by NMFS under the Mitchell Act to address, *inter alia*, information developed and species listed under the ESA since the 1999 BiOp. *See Wild Fish Conservancy v. Nat'l Marine Fisheries Serv.*, Dkt. 1, No. 3:16-CV-00553-MO (D. Or. March 31, 2016). On January 15, 2017, NMFS issued a new BiOp with an ITS ("2017 Mitchell Act BiOp") on hatchery programs funded under the Mitchell Act, resulting in a settlement agreement and voluntary dismissal of Wild Fish Conservancy's lawsuit. *See Wild Fish Conservancy v. Nat'l Marine Fisheries Serv.*, Dkt. 37, No. 3:16-CV-00553-MO (D. Or. June 30, 2017).

The 2017 Mitchell Act BiOp sought to address Mitchell Act funding from 2016 through 2025 and contemplated implementation of measures—broken into three phases—intended to reduce harm to ESA-listed species. Phase I covered funding for fiscal year 2016 and generally followed prior funding practices. Phase II addressed funding for fiscal years 2017 through 2022 and required, *inter alia*, reduced production levels for specific hatchery programs and implementation of weirs in specific tributaries. Phase III addressed funding during fiscal years 2023 through 2025 and sought to implement an adaptive management strategy for further reducing harmful impacts to ESA-listed species.

The 2017 Mitchell Act BiOp found that "take" of ESA-listed species will result from the hatchery programs funded under the Mitchell Act when:

(1) fish are encountered at weirs and their survival, reproductive success, or spatial distribution is affected and when fish are handled while collecting hatchery fish for

broodstock purposes – the Proposed Action does not include the take of ESA-listed natural-origin fish for hatchery broodstock;

(2) hatchery fish spawn naturally and when they spawn on top of (i.e., superimposition) spawning areas of fish from a natural population;

(3) post-release juvenile hatchery fish use limited food and habitat resources or prey on ESA-listed natural-origin or non-marked hatchery fish;

(4) construction, operation, and maintenance of hatchery facilities cause harm (e.g., affect fish habitat);

(5) RM&E activities handle, injure, or otherwise effect the survival, reproductive fitness and spatial distribution of the fish; and

(6) through reductions in prey availability to SRKW.

The 2017 Mitchell Act BiOp included an ITS that exempted from liability under section 9 of the ESA "take" resulting from the hatchery programs. The ITS set various take limits and imposed terms and conditions to reduce and monitor take of ESA-listed species.

On August 7, 2023, NMFS notified WDFW that it was reinitiating consultation with respect to the 2017 Mitchell Act BiOp following WDFW's failure to implement certain measures required by the 2017 Mitchell Act BiOp. On September 28, 2023, NMFS issued a letter to WDFW, Yakama Nation Tribal Council, Nez Perce Tribal Executive Committee, FWS, ODFW, and Idaho Department of Fish and Game to signal its reinitiation of consultation. In this letter, NMFS stated, "It is our belief at this time that the conditions have been met for continuing coverage for grant awards through 2025, except for a set of operations by the [WDFW] . . . ."

NMFS issued a BiOp for the SAFE hatchery programs on May 3, 2021 ("2021 SAFE BiOp"). The 2021 SAFE BiOp found that "take" of ESA-listed species is reasonably certain to occur as a result of the SAFE hatchery programs as follows:

1. Take occurs when hatchery fish stray and spawn naturally in the wild with natural-origin fish, resulting in potential genetic introgression;

2. Take occurs as a result of ecological interactions between hatchery and natural salmon and steelhead, including through predation and competition;

3. Take occur from research, monitoring, and evaluation activities conducted to evaluate the hatchery programs' performance, the effects of hatchery fish, and the status of the natural-origin populations; and

4. Take occurs as a result of operations and maintenance of the hatchery and net pen

facilities used for the SAFE hatchery programs.

The 2021 SAFE BiOp included an ITS that exempted from liability under section 9 of the ESA "take" resulting from the SAFE hatchery programs. The ITS set various take limits and imposed terms and conditions to reduce and monitor take of ESA-listed species.

F. Non-Compliance With the 2017 Mitchell Act BiOp and the SAFE BiOp.

NMFS, WDFW, and ODFW have failed to comply with the 2017 Mitchell Act BiOp since it was issued. These violations include failures to implement hatchery programs and measures in the manner contemplated and consulted on by the 2017 Mitchell Act BiOp, failures to comply with terms and conditions of the 2017 Mitchell Act BiOp's ITS, and exceedances of take limits imposed by the 2017 Mitchell Act BiOp's ITS. Additionally, WDFW, ODFW, and Clatsop County Fisheries have failed to comply with the 2021 SAFE BiOp.

1. Failure to Submit Complete and Accurate Annual Reports.

NMFS has failed to comply with annual reporting requirements set forth in Term and Condition 8 of the 2017 Mitchell Act BiOp's ITS. That provision requires NMFS to "annually provide one comprehensive annual report for all Mitchell Act funded programs to NMFS' SFD on or before January 31st for the previous fiscal year." The annual report must include the following:

a. Numbers of fish released, release dates and locations, and tag/mark information for each program.

b. Estimates of the natural spawning distribution, origin, survival and contribution to fisheries and escapements for fish released for each brood year, for each program.

c. Estimates of pHOS and/or gene flow for all natural ESA-listed salmonid populations that are affected by straying from Mitchell Act funded hatchery programs.

d. Provide tables for all Mitchell Act funded facilities combined, grouped by State Authority, that include the duration (in days) of each epizootic and magnitude (% of production lost).

e. Annual water withdrawals for each hatchery/acclimation facility used by the Proposed Action and analyzed by this Opinion, including monthly estimates of the quantity removed and stream flows within the reach between the intake and hatchery outfall.

f. Compliance records with NPDES permitting requirements.

g. The number of fish encountered and killed at each weir and broodstock collection location including the species, origin (hatchery or natural-origin), life-stage, and release condition (unharmed, injured, killed).

h. Estimates of weir rejection, delay, and handling related mortality, by species, for each of the weirs operated under the Proposed Action.

i. Results of RM&E, including important findings, for:

    i. The Kalama River Research Program;

    ii. Operation of the North Fork Toutle River Fish Collection Facility;

    iii. Lower Columbia River and tributary fishery monitoring;

    iv. Monitoring of the Nez Perce Tribe's Snake River coho salmon Restoration Program;

    v. Evaluation of the benefits and risks of juvenile wild fish rescue programs;

    vi. Klickitat River Fishway (Lyle Falls); and

    vii. USFWS Hatchery Monitoring Program.

For each and every fiscal year since issuance of the 2017 Mitchell Act BiOp, NMFS has failed to timely prepare and submit the required single comprehensive annual report that includes all of the required information and data specified above.

NMFS's violations of the 2017 Mitchell Act BiOp's reporting requirements greatly undermine public transparency and accountability, as they frustrate the public's ability to determine whether there are violations of the substantive requirements of the BiOp and the extent of those violations. The violations and other non-compliance issues identified herein are based on the information currently available to Wild Fish Conservancy and The Conservation Angler given NMFS's failure to timely submit the comprehensive annual reports required by the 2017 Mitchell Act BiOp.

2. Failure to Implement Weirs by the End of Phase II.

NMFS and WDFW have failed to implement the Proposed Action in the manner contemplated by and consulted on in the 2017 Mitchell Act BiOp by failing to timely install and implement certain weirs. The 2017 Mitchell Act BiOp contemplated the installation and operation of weirs in specific tributaries by the end of Phase II—i.e., by the end of fiscal year 2022, or by September 30, 2022—in an effort to reduce the number of hatchery fish reaching spawning grounds. These measures were identified in Section 1.3 of the 2017 Mitchell Act BiOp as part of the "Proposed Action" subject to the ESA consultation. Term and Condition 1 in the 2017 Mitchell Act BiOp's ITS required NMFS to "[a]dminister Mitchell Act funds for implementing the hatchery programs and operating the hatchery facilities as described in the Proposed Action (Section 1.3) . . . ."

NMFS and WDFW have failed to timely install and implement these weirs, including but not limited to the weirs required in the following tributaries: Skamokawa River, Mill Creek, Abernathy Creek, and Germany Creek. NMFS has thereby also violated Term and Condition 1 of the ITS by administering funds for Mitchell Act hatchery programs despite the failure to implement the Proposed Action in the manner described in section 1.3 of the 2017 Mitchell Act BiOp.

3. <u>Exceedances of pHOS Take Limits for Genetic Interactions</u>.

NMFS, WDFW, ODFW, and Clatsop County Fisheries have failed to comply with requirements of the 2017 Mitchell Act BiOp and the 2021 SAFE BiOp designed to limit take of ESA-listed salmonids through genetic interactions.

The 2017 Mitchell Act BiOp's ITS included limits on the amount of "take" the hatchery programs could cause through genetic interactions on salmonid spawning grounds. The 2017 Mitchell Act BiOp used census pHOS as a surrogate to set the take limits for Chinook and coho salmon. Where gene flow has not been calculated, the 2017 Mitchell Act BiOp used census pHOS as surrogate to set genetic and ecological take limits for steelhead. Where gene flow has been calculated, the 2017 Mitchell Act BiOp used gene flow as a surrogate to set genetic take limits for steelhead and census pHOS as the surrogate to set ecological take limits for steelhead.

Term and Condition 2.a of the ITS provides that NMFS shall ensure that the funding grantee annually submits pHOS survey protocols, gene flow monitoring methods, and RM&E protocols and statements of work before January 1 of each year for NMFS's concurrence on or before March 1 of each year. Term and Condition 2.b of the ITS requires NMFS to ensure that its administration of Mitchell Act funds results in adherence to the applicable pHOS and gene flow limits. NMFS must require the funding grantees to conduct annual surveys (or other acceptable methods) to determine the timing, abundance, origin, and distribution of salmonids that spawn naturally. As noted above, Term and Condition 8.c of the ITS requires that NMFS submit a comprehensive annual report by January 31 of each year that includes, inter alia, "[e]stimates of pHOS and/or gene flow for all natural ESA-listed salmonid populations that are affected by straying from Mitchell Act funded hatchery programs."

For Chinook salmon, the 2017 Mitchell Act BiOp explained:

> Given the age structure of Chinook salmon, the pHOS for a natural population will be calculated as a four-year running arithmetic mean, with year 1 being the first year in which effects of pHOS reduction measures (weir actions and/ or program changes) can be expected to occur. NMFS will determine

annually whether take has been exceeded after four years of data become available, unless NMFS determines after two years (of the four-year running mean period) that pHOS is so high that attainment of the mean across four years is not a reasonable expectation, in which case NMFS will declare the threshold to have been exceeded at that time. Therefore, incidental take by interactions on the spawning grounds of individual populations shall not exceed the following limits:

Table 123. Maximum Chinook salmon pHOS limits by ESA-listed natural population into which hatchery Chinook salmon originating from Mitchell Act funded hatchery programs are known to stray.

Population	***Chinook salmon program type contributing to pHOS in population***	***pHOS limit***
Grays/Chinook Rivers	Isolated fall	50%
Elochoman/Skamokawa Rivers	Isolated fall	50%
Mill/Abernathy/Germany Creeks	Isolated fall	50%
Coweeman River	Isolated fall	10%
Lower Cowlitz River	Integrated fall	30%
Toutle River	Integrated fall	30%
Lewis River	Isolated fall	10%
Washougal River	Integrated fall	30%
Kalama River	Isolated spring	10%
Clackamas River	Isolated spring	10%

NMFS, WDFW, and ODFW have failed to comply with these pHOS take limits for Lower Columbia River Chinook salmon populations, including but not limited to Chinook salmon populations in the following tributaries: Coweeman River, Elochoman/Skamokawa Rivers, Mill/Abernathy/Germany Creeks, and the Toutle River.[2] Releases of Chinook salmon from ODFW's and WDFW's Lower Columbia River basin (i.e., below Bonneville Dam) hatchery programs that are funded by NMFS and Commerce under the Mitchell Act cause and contribute to these exceedances of applicable pHOS limits. NMFS has therefore also violated Term and Condition 2.b of the ITS by failing to ensure that its administration of Mitchell Act funds resulted in adherence to the applicable pHOS and gene flow limits.

For coho salmon, the 2017 Mitchell Act BiOp explained:

[2] *See* StreamNet: Fish Data for the Northwest, https://www.streamnet.org/data/trends/?index=1&perpage=10&species=Chinook+salmon&locationid=1234308462386%2C1234600462656 (last visited Jan. 5, 2024).

> Given the age-structure of coho salmon, the pHOS for a natural population will be calculated as a three-year running arithmetic mean, with year 1 being the first year in which effects of pHOS reduction measures (weir actions and/ or program changes) can be expected to occur. NMFS will determine annually whether take has been exceeded once three years of data become available, unless NMFS determines after two years (of the three-year running mean period) that pHOS is so high that attainment of the mean across three years is not a reasonable expectation, in which case NMFS will declare the threshold to have been exceeded at that time. Therefore, incidental take by interactions on the spawning grounds shall not exceed the following limits:
>
> Table 124. Maximum coho salmon pHOS limits by ESA-listed natural population where hatchery coho salmon originating from Mitchell Act funded hatchery programs are known to stray.

Population	*Coho salmon program type contributing to pHOS in population*	*pHOS limit*
Grays/Chinook Rivers	Integrated	30%
Elochoman/Skamokawa Rivers	Integrated	30%
Clatskanie River	Isolated	10%
Scappoose River	Isolated	10%
Lower Cowlitz River	Integrated late	30%
Coweeman River	Isolated	10%
South Fork Toutle	Isolated	10%
North Fork Toutle	Integrated late	30%
East Fork Lewis	Isolated	10%
Washougal River	Integrated late	30%
Clackamas River	Isolated late	10%

The 2021 SAFE BiOp used census pHOS as a surrogate to set take limits consistent with those in the 2017 Mitchell Act BiOp:

> Therefore, NMFS will rely on a surrogate, in the form of the census pHOS rate. Take from hatchery fish on the spawning grounds will not be exceeded as long as the three year rolling

> arithmetic mean census pHOS from hatchery spring Chinook salmon and coho salmon in the following population are not exceeded: . . . 30% for coho salmon in the Grays/Chinook Rivers, Elochoman/Skamokawa Rivers, Lower Cowlitz River, North Fork Toutle, Washougal; 10% for coho salmon in the Clatskanie, Scappoose, Coweeman, South Fork Toutle, East Fork Lewis, Clackamas, and Sandy.

Term and Condition 2.c of the 2021 SAFE BiOp's ITS required that ODFW, WDFW, and Clatsop County Fisheries comply with those pHOS limits:

> The program operators, with federal funding from the appropriate Action Agencies, shall monitor the straying and natural spawning of SAFE hatchery fish in the Lower Columbia River. The proportion of SAFE hatchery fish spawning naturally shall be kept to the lowest levels feasible, consistent with the pHOS levels described in NMFS (2017b) for the affected natural populations.

NMFS, WDFW, ODFW, and Clatsop County Fisheries have failed to comply with these applicable pHOS take limits for Lower Columbia River coho salmon populations, including but not limited to coho salmon populations in the following tributaries: Coweeman River, Clatskanie River, and the Washougal River. Releases of coho salmon from ODFW's and WDFW's Lower Columbia River basin (i.e., below Bonneville Dam) hatchery programs that are funded by NMFS and Commerce under the Mitchell Act and releases of coho salmon from ODFW's, WDFW's, and Clatsop County Fisheries' SAFE hatchery programs cause and contribute to these exceedances of applicable pHOS limits.

4. <u>Failure to Comply with Smolt Release Size and Number Provisions</u>.

The 2017 Mitchell Act BiOp imposed requirements on the size and number of hatchery fish released in an effort to reduce take of ESA-listed salmonids through adverse ecological interactions. Section 2.4.2.3.6 of the 2017 Mitchell Act BiOp required that hatchery operators conform to the following:

- Size of fish released. The size of the smolts released relates directly to the extent to which any interactions result in harm or mortality to natural-origin fish: the larger a smolt is at release, the more likely it could out-compete or prey on others. Average smolt size and variability should not exceed that specified in the [Biological Assessment on NMFS's Implementation of the Final Mitchell Act EIS ("BA")] (NMFS 2017).

- Number of fish released. Obviously, the more fish released, the greater the potential for ecological interactions. Typically hatchery programs tend to take eggs in excess of need (usually) to cope with possible shortfalls due to a variety of

> operation causes. This usually leads to more fish being released than plan [sic]. NMFS has considered this problem for some time and has concluded that for programs it funds that at any program no single release should exceed 105% of the target release number, and over five years, the average should not exceed 102% of target specified in the BA (NMFS 2017).

Section 2.8.1.4 of the 2017 Mitchell Act BiOp's ITS imposed limits on take resulting from ecological interactions using these same requirements as surrogates:

- Any single release of smolts in numbers that exceed 105% of the targeted release number identified above will be considered to have exceeded the expected incidental take through ecological interactions;

- Any five-year average calculation of smolt releases that exceed 102% of the applicable targeted release number identified above will be considered to have exceeded the expected incidental take through ecological interactions;

- Any change in release location from the locations identified in the HGMPs for the programs included in the Proposed Action will be considered to have exceeded the expected incidental take through ecological interactions;

- Any change from the planned average size of fish released for each program in the Proposed Action will be considered to have exceeded the expected incidental take through ecological interactions.

The 2017 Mitchell Act BiOp's ITS further imposed the following as Term and Condition 5.a to ensure and to monitor compliance with these requirements:

> 5. Limit the co-occurrence and any resulting competition and predation caused by hatchery fish to lowest feasible levels:
>
> > a. NMFS shall require funding grantees to report to NMFS the estimated number, size, release location and proposed release date for all programs funded through the Proposed Action at least 30 days prior to release.

NMFS and ODFW have failed to ensure compliance with these requirements for the Clackamas summer steelhead and Sandy River winter steelhead hatchery programs.

For example, currently available information indicates that NMFS and ODFW violated the release limit for the Clackamas summer steelhead hatchery program in 2022. The program's annual release target is 125,000 summer steelhead beginning in the Spring of 2022, but an ODFW report demonstrates that the program released 179,285 summer steelhead into the Clackamas River in the Spring of 2022.[3] As a result, the 2022 release was 143% of the targeted release number. This violation likely continued in 2023 and will likely continue beyond 2023 based on documents related to the Clackamas summer steelhead program. For example, the "draft" HGMP for the Clackamas summer steelhead program provides that ODFW will annually release 125,000 summer steelhead into the Clackamas River and 50,000 summer steelhead into the Foster Acclimation Facility, which releases fish into the Clackamas River.[4] Further, ODFW's previous Clackamas Hatchery Program Management Plan (2023) shows that ODFW planned to release 175,000 summer steelhead into the Clackamas River in 2023.[5] ODFW's current Clackamas Hatchery Program Management Plan (2024) shows that ODFW plans to release 175,000 summer steelhead into the Clackamas River in 2024.[6] Therefore, the 2022 release of Clackamas summer steelhead violated the single release limit of 105%, more than 125,000 summer steelhead were likely released into the Clackamas River in 2023, and the program is likely to continue violating the release limit based on ODFW's hatchery planning documents. Upon information and belief, including these violations of the annual release limit, NMFS and ODFW are also in violation of the 5-year average release limit of 102% of the target release for the Clackamas summer steelhead hatchery program.

NMFS and ODFW also violated the average fish size limits identified above for the Sandy River winter steelhead hatchery program. The HGMP for the Sandy River Winter Steelhead Program (the "Sandy HGMP") provides that winter steelhead will be released at a size of 6 fish per pound ("fpp").[7] ODFW's annual fish propagation reports, however, demonstrate that the Sandy River Hatchery routinely released undersized steelhead smolts from 2018 through 2022. Indeed, the average size at release during the last six years is 8.3 fpp, which is a 38% deviation from the planned release level. Such releases can increase the risk of residualization and resulting ecological harm.[8] NMFS and ODFW therefore exceeded the take limit by changing the planned average size of fish released for the Sandy River winter steelhead hatchery program.

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[3] *See* ODFW, FISH PROPAGATION ANNUAL REPORT 2022 65, 75 (Kent ed., 2023) (showing 154,035 summer steelhead smolts released into the Clackamas River and 25,250 summer steelhead smolts released into the Foster Creek Acclimation Facility, which connects to the Clackamas River).

[4] ODFW, DRAFT HATCHERY AND GENETIC MANAGEMENT PLAN FOR THE CLACKAMAS SUMMER STEELHEAD PROGRAM 52 (2016).

[5] ODFW, CLACKAMAS HATCHERY PROGRAM MANAGEMENT PLAN 2023 3 (2023).

[6] ODFW, CLACKAMAS HATCHERY PROGRAM MANAGEMENT PLAN 2024 5 (2024).

[7] ODFW, FINAL HATCHERY AND GENETIC MANAGEMENT PLAN FOR THE SANDY RIVER WINTER STEELHEAD PROGRAM 4, 69 (2013).

[8] *See* Stephen J. Hausch and Michael C. Melnychuk, *Residualization of Hatchery Steelhead: A Meta-Analysis of Hatchery Practices*, 32 N. Amer. J. of Fish. Mgmt. 905 (2012).

Table 1. Size of Sandy River winter steelhead at release

Year	fpp
2017	9.9 fpp[9]
2018	9 fpp[10]
2019	8.9 fpp[11]
2020	7.2[12]
2021	7.7[13]
2022	7.2[14]

5. Failure to Comply with Residualization Restrictions.

The 2017 Mitchell Act BiOp imposed restrictions to limit the number of hatchery-released fish that residualize. Section 2.4.2.3.6 of the 2017 Mitchell Act BiOp provided that hatchery operators must conform to the following:

> Number of residualized fish released. Ecological interactions can also increase when hatchery fish residual [sic] due to early sexual maturation (precocity). Residualism itself cannot be determined at the hatchery, but the rate of precocity serves as a logical surrogate. In any year the rate of precocity should be kept under 5%, and the 5-year average should not exceed 3%. It should be noted that while these standards are appropriate for the suite of current and planned Mitchell Act funded programs, they may have to be modified for any future funding of upstream spring and spring/summer Chinook salmon programs.

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[9] ODFW, FISH PROPAGATION ANNUAL REPORT 2017 53 (2018) (showing that the Sandy Hatchery released 147,467 winter steelhead smolts and 14,971 pounds of winter steelhead smolts).

[10] ODFW, FISH PROPAGATION ANNUAL REPORT 2018 55 (2019) (showing that the Sandy Hatchery released 159,444 winter steelhead smolts and 17,716 pounds of winter steelhead smolts).

[11] ODFW, FISH PROPAGATION ANNUAL REPORT 2019 (2020) (showing that the Sandy Hatchery released 135,002 winter steelhead smolts and 15,169 pounds of winter steelhead smolts).

[12] ODFW, FISH PROPAGATION ANNUAL REPORT 2020 59 (2021) (showing that the Sandy Hatchery released 159,137 winter steelhead smolts and 21,950 pounds of winter steelhead smolts).

[13] ODFW, FISH PROPAGATION ANNUAL REPORT 2021 58 (2022) (showing that the Sandy Hatchery released 158,991 winter steelhead smolts and 20,515 pounds of winter steelhead smolts).

[14] ODFW, FISH PROPAGATION ANNUAL REPORT 2022 65 (2023) (showing that the Sandy Hatchery released 96,001 winter steelhead smolts and 13,333 pounds of winter steelhead smolts).

The 2017 Mitchell Act BiOp's ITS included a limit on take occurring through ecological interactions resulting from residualization using a surrogate "consisting of the proportion of hatchery-origin fish that are precocially mature prior to release":

> The incidental take through ecological interactions relating specifically to residualization shall have been exceeded if the percent of yearling releases that are determined to be precocially mature exceeds 5% in any one year, or if the 5-year average exceeds 3% at any time. These are levels known to occur through review of other yearling programs (IDFG 2003).
>
> These take surrogates can be reliably measured and monitored through enumeration and tracking of release dates and numbers for hatchery salmon and steelhead. Each of these surrogates represents an independent threshold, meaning that exceedance of any one of these surrogates would result in the applicable program having exceeded the incidental take limits included in this Statement, likely necessitating the reinitiation of consultation.

Finally, the ITS included Term and Condition 5.b to ensure and monitor compliance with these restrictions:

> 5. Limit the co-occurrence and any resulting competition and predation caused by hatchery fish to lowest feasible levels:
>
>   b. NMFS shall require funding grantees to report to NMFS the estimated proportion of precocial male smolts released annually from each program.

NMFS and ODFW have failed to comply with these requirements for ODFW's Lower Columbia River (i.e., below Bonneville Dam) steelhead hatchery programs that are funded by NMFS and Commerce under the Mitchell Act. For example, currently available information indicates that ODFW has not monitored and/or reported the estimated proportion of precocial males released annually from each appliable hatchery program since issuance of the 2017 Mitchell Act BiOp and that NMFS has failed to require ODFW to report such data.

6. <u>Failure to Implement Required Genetic Monitoring for Steelhead</u>.

Section 1.3.2 of the 2017 Mitchell Act BiOp contemplated certain monitoring, evaluation, and reform ("MER") projects, including a genetic monitoring project to determine the efficacy of isolated steelhead hatchery programs. Term and Condition 1 of the 2017 Mitchell Act BiOp's ITS required NMFS to administer Mitchell Act funds for the implementation of programs as described in Section 1.3 of the 2017 Mitchell Act BiOp. Currently available information indicates that NMFS has failed to implement and complete the genetic monitoring project to determine the efficacy of isolated steelhead hatchery programs. NMFS has thereby also violated Term and Condition 1 of the ITS by failing to administer Mitchell Act funds to ensure implementation of the project.

7. Failure to Develop Plan to Address Hatchery Facility Needs.

Section 1.3.2 of the 2017 Mitchell Act BiOp contemplated that NMFS and operators of specific hatchery facilities would develop a plan by January 1, 2019 to address certain facility needs, which plan would include a timeframe for completion and a plan to secure funding for the needed improvements. Term and Condition 1 of the 2017 Mitchell Act BiOp's ITS required NMFS to administer Mitchell Act funds for the implementation of hatchery programs and operating the hatchery facilities as described in Section 1.3 of the 2017 Mitchell Act BiOp. The facility needs were identified in Table 6 of the 2017 Mitchell Act BiOp:

Hatchery Facility	Improvement Needed
Grays River Hatchery	Primary intake does not meet criteria and dewaters section of stream between intake and hatchery outfall.
Fallert Creek Hatchery	Fallert Creek intake lost in 2016 flood will need to be updated to meet current criteria and to provide passage for NOR adults. Mainstem Kalama River pump screens have been updated but may not meet 2011 criteria
Clackamas Hatchery	Mainstem Clackamas River intake does not meet criteria – new intake in River Mill Dam reservoir expected to be completed in 2017
Klaskanine Hatchery	Mainstem Intake #1 does not meet current criteria, provide adult passage and Intakes #2 and #3.
NF Toutle Hatchery	Surface intake – feasibility study completed in 2012, awaiting funding.
Beaver Creek Hatchery	Elochoman River intake being upgraded, expected to be completed in 2017.
Kalama Falls Hatchery	Intake screens updated in 2006, may not meet 2001 criteria – considered low priority.
Washougal Hatchery	Intake screens do not meet current criteria
Klickitat Hatchery	Surface intake structure does not meet current criteria – currently under negotiations on remodel of intake

NMFS and WDFW have failed to comply with these requirements. For example, currently available information indicates that a plan was not developed and/or implemented to complete the needed improvements identified in the table above for the Grays River Hatchery and the Fallert Creek Hatchery. NMFS and WDFW have thereby failed to implement the hatchery operations and maintenance in the manner contemplated by and consulted on in the 2017 Mitchell Act BiOp. NMFS has thereby also violated Term and Condition 1 of the 2017 Mitchell Act BiOp by failing to administer funds for the implementation of the activities as described in Section 1.3 of the 2017 Mitchell Act BiOp.

8. Failure to Implement Studies to Evaluate Natural Production of Primary Chinook Salmon Populations in the LCR Coast MPG.

Term and Condition 2.f of the 2017 Mitchell Act BiOp's ITS requires NMFS to do the following:

> f. Ensure that studies are implemented to evaluate the natural production status of primary Chinook salmon natural populations in the LCR Coast MPG in response to reduced pHOS.
>
> i. Convene a multiagency work group within six months of Opinion signature to develop research plans, including hypotheses, response variables, and experimental power
>
> ii. Ensure that studies described here are implemented within one year of Opinion signature

Currently available information indicates that NMFS has failed to comply with each of these requirements of the 2017 Mitchell Act BiOp's ITS.

9. Failure to Comply with Limits on Distribution Impacts from Weirs.

Installation and operation of weirs as part of hatchery program operations harm wild salmonid populations by reducing the number of wild fish that spawn upstream of the weirs. The 2017 Mitchell Act BiOp imposed a limit on take due to weir rejection using changes in spawning distribution as a surrogate take indicator. Section 2.8.1.2 of the 2017 Mitchell Act BiOp's ITS provided:

> The Proposed Action is expected to result in no more than a 10% relative increase in the distribution of spawning of natural-origin salmon and steelhead below the weirs. In recent years, redd distribution has been estimated for specific stream sections (as this is how most pHOS estimates have been compiled in Section 2.2.1), and comparing the incidence of spawning in those stream sections can be used to determine if the operation of the weirs is affecting spawning distribution. The proposed weir locations are generally within the lower sections of each tributary to the Columbia River. To apprehend changes to spawning distribution caused by placement of weirs the surrogate take indicator examines the changes in redd distribution by comparing the proportion of redds observed in each of the survey sections with

> the average proportions that were observed during the five year period prior to weir placement.
>
> For example, if the five-year running proportion of spawning in a survey section was 40 percent of all spawning in a river took place below where a weir was now placed, then the extent of take would be exceeded if the proportion increased to 50 percent in the measurement of spawning distribution in this same reach of the river. As discussed above, the expected level of take in the form of changes in spawning distribution caused by the weirs is minimal, and in any case shall not exceed an absolute increase of 10% in spawning of natural-origin salmon or steelhead in the lower sections of rivers wherever weirs are placed. Therefore, the level of incidental take described here attributable to the Proposed Action would be exceeded when a 3-year running mean of the proportion of redds below a weir site is 110% or more of the mean proportion of redds for that same geographic stretch of river using data 5-years prior to weir installation.

Section 2.8.1.2 of the ITS further provided that "NMFS will be required to ensure funding recipients monitor spawning distribution in the vicinity of each weir."

NMFS and WDFW have failed to comply with these requirements and take limits. For example, currently available information indicates that changes in spawning distribution of Chinook salmon in the Coweeman River exceed the applicable take limit. Currently available information indicates that NMFS has violated Section 2.8.1.2 of the ITS by failing to ensure that WDFW monitors changes in spawning distribution in all other tributaries where weirs have been installed, and by failing to ensure that WDFW analyzes the 5-year period before weir installation and a 3-year running mean for each and every year after each weir was installed for each such tributary.

III. <u>NMFS's Violations of Section 7 of the ESA</u>.

NMFS is in violation of the ESA by funding, authorizing, and/or approving operations and maintenance of, and improvements and upgrades to, hatchery programs without complying with the procedural and substantive requirements of section 7 of the ESA, as described below. The funding addressed by this Notice Letter encompasses each and every distribution of funds under the Mitchell Act since 2017 for operations, maintenance, improvements, and/or upgrades for WDFW's and/or ODFW's Lower Columbia River basin (i.e., below Bonneville Dam) hatchery programs, and any such distribution that occurs after the issuance of this Notice Letter. The violations addressed by this Notice Letter include all such distributions under the Mitchell Act during that time period for hatchery programs—whether or not the program is identified on the table appended hereto as Appendix A.

A. Failure to Insure Against Jeopardizing ESA-Listed Species.

NMFS and Commerce are in violation of the substantive requirement of section 7(a)(2) of the ESA to insure that actions funded, authorized, or carried out by NMFS and Commerce do not jeopardize the continued existence of ESA-listed species or destroy or adversely modify their critical habitat.

WDFW's and ODFW's salmonid hatchery programs in the Lower Columbia River basin (i.e., below Bonneville Dam) funded by NMFS and Commerce under the Mitchell Act "take" and otherwise adversely affect the ESA-listed species and critical habitat identified above in section II.A of this Notice Letter through the mechanisms described herein and in the Hatchery Effects Document attached hereto as Appendix B. These programs release tens of millions of hatchery fish into the Lower Columbia River basin every year and conduct extensive operations in and around salmonid-bearing waterbodies that inflict extensive harm on struggling ESA-listed salmonids. This harm to ESA-listed salmonids reduces prey availability for endangered Southern Resident killer whales, contributing to the species' decline.

NMFS and Commerce have continued to fund, authorize, and/or approve these hatchery programs and associated activities despite extensive non-compliance with the 2017 Mitchell Act BiOp, including but not limited to the non-compliance described above in section II.F of this Notice Letter. These violations of the 2017 Mitchell Act BiOp include failures to implement programs and actions as contemplated in and consulted on in the 2017 Mitchell Act BiOp, exceedances of take limits imposed in the ITS, and violations of the ITS's Terms and Conditions.

NMFS and Commerce have failed to ensure that ODFW's and WDFW's hatchery programs in the Lower Columbia River basin (i.e., below Bonneville Dam) that are funded by NMFS and Commerce under the Mitchell Act are not likely to jeopardize the continued existence of ESA-listed species or result in the destruction or adverse modification of their critical habitat by continuing to fund these hatchery programs despite extensive non-compliance with the 2017 Mitchell Act BiOp.

B. Unlawful Commitments of Irreversible and/or Irretrievable Resources.

NMFS and Commerce are in violation of section 7(d) of the ESA, 16 U.S.C. § 1536(d), for making irreversible and/or irretrievable commitments of resources prior to completion of consultation.

Section 7(d) of the ESA provides that, after the initiation of ESA consultation, agencies "shall not make any irreversible or irretrievable commitment of resources" that would foreclose the implementation of reasonable and prudent alternatives. NMFS issued a letter to WDFW on August 7, 2023 stating that reinitiation of consultation was necessary. NMFS then issued a second letter to WDFW, ODFW, Yakama Nation Tribal Council, Nez Perce Tribal Executive Committee, U.S. Fish and Wildlife Service, and Idaho Department of

Fish and Game on September 28, 2023 explaining that NMFS intended to reinitiate consultation under section 7 of the ESA on the 2017 Mitchell Act BiOp and its funding under the Mitchell Act.

Each and every disbursement of funds by NMFS and/or Commerce under the Mitchell Act for WDFW's and/or ODFW's Lower Columbia River basin (i.e., below Bonneville Dam) salmonid hatchery programs since reinitiating the ESA consultation violates section 7(d) of the ESA.

To the extent that NMFS and/or Commerce contend that NMFS has yet to reinitiate consultation on the 2017 Mitchell Act BiOp, NMFS and/or Commerce are in violation of the ESA for failing to reinitiate that consultation. The failures to implement programs and actions as contemplated in and consulted on in the 2017 Mitchell Act BiOp, the exceedances of take limits imposed in the ITS, and the violations of the ITS's Terms and Conditions described above in section II.F of this Notice Letter required that NMFS and Commerce reinitiate consultation. *See* 50 C.F.R. § 402.16(a).

IV. NMFS, Commerce, WDFW, ODFW and Clatsop County Fisheries' Violations of Section 9 of the ESA.

NMFS, Commerce, WDFW, ODFW, and Clatsop County Fisheries are in violation of section 9 of the ESA, 16 U.S.C. § 1538, for causing "take" of ESA-listed species.

The ODFW and WDFW salmonid hatchery programs in the Lower Columbia River basin (i.e., below Bonneville Dam) that are funded by NMFS and/or Commerce under the Mitchell Act cause "take" of the ESA-listed species identified above in section II.A of this Notice Letter. The SAFE hatchery programs operated by ODFW, WDFW, and Clatsop County Fisheries cause "take" of the ESA-listed species identified above in section II.A of this Notice Letter.

The take occurs through the mechanisms described herein, including in section II.D of this Notice Letter, and in the Hatchery Effects Document attached hereto as Appendix B. The take of ESA-listed salmonids includes:

1. Broodstock collection activities. Broodstock collection activities are those associated with the capture of returning adults to supply the programs' broodstock. These activities can include employing a weir or barrier that forces migrating adults to enter a ladder or trap or capturing adult fish using a net or a hook and line. These activities take ESA-listed salmonids, for instance, by delaying their migration to natural spawning habitat or inflicting physical injury or causing death from capture or handling. The programs cause take when the broodstock collection activities result in incidental or intentional collection, capture, trapping, and/or removal of ESA-listed salmonids. Take also occurs when the broodstock collection activities, and/or structures or devices associated therewith, harm, harass, injure, and/or kill protected fish. Broodstock collection activities also cause take when they affect the ability of

ESA-listed salmonids to migrate, including when spawning migration is delayed or prevented.

2. Genetic introgression. Fish become domesticated in a hatchery environment and are thereby less fit to survive and reproduce in the wild. Genetic adaptation to captivity can occur rapidly—in a single generation—even when wild stocks are used for broodstock in a pure "conservation" hatchery program. This presents significant threats to wild populations even for purportedly integrated programs. *See*, *e.g.*, Christie, Mark R., et al., Genetic Adaptation to Captivity Can Occur in a Single Generation, 109 Proceedings of the Nat'l Academy of Sciences 238–42 (2011); Willoughy, Janna R., et al., Long-term Demographic and Genetic Effects of Releasing Captive-Born Individuals into the Wild, 33 Conservation Biology 377–88 (2019); Willoughy, Janna R., et al., Captive Ancestry Upwardly Biases Estimates of Relative Reproductive Success, 108 Journal of Heredity 583–87 (2017). Take through genetic introgression occurs when hatchery fish spawn with ESA-listed salmonids and thereby pass maladaptive genes to the wild ESA-listed salmonid populations. The resultant offspring have markedly reduced fitness, dying at a much higher rate before spawning than would occur with two wild parents and producing on average significantly fewer surviving offspring than two wild parents when they do survive to spawn.

3. Ecological interactions. The hatchery programs cause take of ESA-listed salmonids through increased competition for food and space, including rearing and spawning territory. The hatchery programs cause take of ESA-listed salmonids through predation. This occurs when the hatchery fish, including smolts and residualized fish, prey on protected fish. The hatchery programs also cause take when hatchery fish—less fit for survival in the wild—attract predators that then consume ESA-listed salmonids. Predation also occurs when predators are attracted to fish reared in net pens under the SAFE programs or other hatchery programs, resulting in increased predation on ESA listed fish in and around the net pens. The hatchery programs cause take of ESA-listed salmonids through increased competition for spawning mates.

4. Facility effects. The hatchery programs cause take because the hatcheries create a false attractant for ESA-listed salmonids. Take occurs when the ESA-protected fish are harmed, injured, delayed, or killed when attempting to enter hatchery facilities, including facility outfalls and fish ladders. Take also occurs when the protected fish enter hatchery facilities and are thereby captured, trapped, or collected by the hatchery. Additional take occurs when ESA-listed salmonids that have entered hatchery facilities are injured or killed in the hatchery environment or during attempts to return them to the wild and when their spawning migration is delayed or prevented. The hatchery programs cause take because the effluent discharged from the hatcheries adversely affects ESA-listed salmonids. The water withdrawals at the hatcheries also cause take of ESA-listed salmonids by reducing water flow in the rivers and streams and because protected fish are harmed, injured, killed, trapped and/or captured (i.e., entrained) by the surface water intake structures. The hatchery programs also cause

take when weirs and other in-stream structures delay or prevent ESA-listed salmonids' migration abilities.

ODFW and WDFW are in violation of section 9 of the ESA, 16 U.S.C. § 1538, for causing take through operations and maintenance of their Lower Columbia River basin (i.e., below Bonneville Dam) hatchery programs and associated activities that receive funding from NMFS and/or Commerce under the Mitchell Act. NMFS and Commerce are in violation of section 9 of the ESA, 16 U.S.C. § 1538, for causing take by funding, authorizing, and/or approving operations and maintenance of those programs and activities. ODFW, WDFW, and Clatsop County Fisheries are in violation of section 9 of the ESA, 16 U.S.C. § 1538, for causing take through operations and maintenance of the SAFE hatchery programs and associated activities. These violations of section 9 of the ESA have occurred for the last five years and are continuing to occur.

Parties claiming an exemption from liability for take of ESA-listed species through an ITS issued under section 7 of the ESA "have the burden of proving that the exemption or permit is applicable, has been granted, and was valid and in force at the time of the alleged violation." 16 U.S.C. § 1539(g); *see also United States v. Charette*, 893 F.3d 1169, 1174–75 (9th Cir. 2018). Similarly, parties claiming an exemption from liability under a 4(d) Limit of NMFS's 4(d) Rule for salmonids must demonstrate that the Limit is applicable and was in force, and that the person fully complied with the Limit at the time of the alleged violation. 50 C.F.R. § 223.203(c). Accordingly, to the extent that NMFS, Commerce, WDFW, ODFW, and/or Clatsop County Fisheries contend that an applicable ITS, 4(d) Limit, and/or other authorization provides an exemption from liability for any of the violations of section 9 of the ESA alleged herein, such party(ies) must prove that the applicable exemption was in effect and that they were in full compliance therewith.

Section II.F of this Notice Letter identified extensive non-compliances, including failures to implement programs and actions as contemplated in and consulted on in the 2017 Mitchell Act BiOp, exceedances of take limits imposed in the 2017 Mitchell Act BiOp's and the 2021 SAFE BiOp's ITS, and violations of the 2017 Mitchell Act BiOp's and the 2021 SAFE BiOp's ITS's Terms and Conditions. Such non-compliance invalidates the "safe harbor provision" of the ITS authorization. *See Or. Nat. Res. Council v. Allen*, 476 F.3d 1031, 1038 (9th Cir. 2007).

The non-compliance issues identified in section II.F of this Notice Letter are examples that are based upon information currently available to Wild Fish Conservancy and The Conservation Angler. NMFS's failure to timely submit complete and comprehensive annual reports as required by Term and Condition 8 of the 2017 Mitchell Act BiOp's ITS undermines the public's ability to evaluate compliance with that BiOp and prevents a more thorough identification of non-compliance herein. Wild Fish Conservancy and The Conservation Angler intend to require NMFS, Commerce, WDFW, ODFW, and/or Clatsop County Fisheries to demonstrate complete compliance with all requirements of the 2017 Mitchell Act BiOp, the 2021 SAFE BiOp, or any other claimed exemption to ESA section 9 liability relied upon.

V. **Party Giving Notice of Intent to Sue.**

The full names, addresses, and telephone numbers of the parties giving notice are:

Wild Fish Conservancy
15629 Main Street N.E.
Duvall, Washington 98019
Tel: (425) 788-1167

The Conservation Angler
P.O. Box 13121
Portland, Oregon 97213
Tel: (971) 235-8953

VI. **Attorneys Representing Wild Fish Conservancy and The Conservation Angler.**

The attorneys representing Wild Fish Conservancy and The Conservation Angler in this matter are:

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Counsel for Wild Fish Conservancy & The Conservation Angler

THE CONSERVATION ANGLER

Rob Kirschner
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Tel: (503) 894-0439

Counsel for The Conservation Angler

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VII. <u>Conclusion</u>.

This letter provides notice under section 1l(g) of the ESA, 16 U.S.C. § 1540(g), of Wild Fish Conservancy and The Conservation Angler's intent to sue NMFS, Commerce, ODFW, WDFW, and Clatsop County Fisheries for the violations of the ESA discussed herein. Unless the ongoing and imminent violations described herein are corrected within sixty days, Wild Fish Conservancy and The Conservation Angler intend to file suit to enforce the ESA. Wild Fish Conservancy and The Conservation Angler are available during the sixty-day notice period to discuss effective remedies and actions that will assure future compliance with the ESA.

Very truly yours,

Kampmeier & Knutsen, PLLC

By: ______________________
Brian A. Knutsen

Counsel for Wild Fish Conservancy
& The Conservation Angler

The Conservation Angler

By: Rob Kirschner
Rob Kirschner

Counsel for The Conservation Angler

CERTIFICATE OF SERVICE

I, Emma A. O. Bruden, declare under penalty of perjury of the laws of the United States that I am counsel for Wild Fish Conservancy and The Conservation Angler and that on January 26, 2024, I caused copies of the foregoing Notice of Intent to Sue for Violations of Section 7 and Section 9 of the Endangered Species Act Associated with Funding and Operating Hatcheries Under the Mitchell Act and Operating SAFE Hatchery Programs to be served on the following by depositing it with the U.S. Postal Service, postage prepaid, via certified mail, return receipt requested:

Secretary Gina Raimondo
United States Department of Commerce
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Washington, D.C. 20230

United States Department of Commerce
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Washington, D.C. 20230

Assistant Administrator Janet Coit
National Marine Fisheries Service
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Silver Spring, Maryland 20910

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Clatsop County Oregon
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Astoria, Oregon 97103

EXECUTED this 26th day of January, 2024 in Portland, Oregon.

By: Emma Bruden
Emma A. O. Bruden

APPENDIX A

Mitchell Act Hatchery Program	Program Operator	Integrated or Isolated	Recent Average (2015-2016) Release Number	Maximum Number of Fish that Can Be Released by End Phase 2 (i.e., Spring of 2022)
Bonneville coho salmon	ODFW	Isolated	323,000	250,000
Bonneville fall Chinook salmon (tule)	ODFW	Isolated	2,519,000	5,000,000
Big Creek Chinook salmon (tule)	ODFW	Isolated	3,106,000	1,400,000
Big Creek coho salmon	ODFW	Isolated	543,000	735,000
Big Creek chum salmon	ODFW	Integrated	154,000	300,000
Big Creek winter steelhead	ODFW	Isolated	55,900	60,000
Gnat Creek winter steelhead	ODFW	Isolated	37,500	40,000
Klaskanine winter steelhead	ODFW	Isolated	38,900	40,000
Klaskanine fall Chinook salmon (tule)	ODFW	Isolated	2,425,000	2,475,000
Clackamas summer steelhead	ODFW	Isolated	144,000	125,000
Clackamas winter steelhead	ODFW	Integrated	106,000	165,000
Clackamas spring Chinook salmon	ODFW	Integrated	636,000	1,050,000
Grays River coho salmon	WDFW	Integrated	161,000	75,000
North Fork Toutle fall Chinook salmon (tule)	WDFW	Integrated	1,394,000	1,100,000
North Fork Toutle coho salmon	WDFW	Integrated	163,000	90,000
Kalama fall Chinook salmon (tule)	WDFW	Integrated to Isolated	5,801,000	2,600,000
Kalama coho salmon – Type N	WDFW	Integrated to Isolated	459,000	300,000
Kalama summer steelhead	WDFW	Integrated	83,000	90,000
Kalama winter steelhead	WDFW	Integrated	56,000	135,000
Washougal fall Chinook salmon (tule)	WDFW	Integrated	1,976,000	1,200,000
Washougal coho salmon	WDFW	Integrated	154,000	108,000
Deep River coho salmon (MA/SAFE)	WDFW	Isolated	787,000	700,000
Deep River fall Chinook salmon	WDFW	Isolated	903,000	0

Beaver Creek summer steelhead	WDFW	Isolated	31,000	30,000
Beaver Creek winter steelhead	WDFW	Isolated	66,000	130,000
Beaver Creek (Elochoman R) coho salmon	WDFW	Integrated	0	150,000
South Toutle summer steelhead	WDFW	Isolated	20,000	20,000
Coweeman winter steelhead	WDFW	Isolated	11,000	12,000
Cathlamet Channel Net-pen spring Chinook salmon	WDFW	Isolated	124,000	250,000
Klineline winter steelhead (Salmon Creek)	WDFW	Isolated	35,000	40,000
Washougal summer steelhead (Skamania Hatchery)	WDFW	Isolated	62,900	70,000
Washougal winter steelhead (Skamania Hatchery)	WDFW	Isolated	64,200	85,000
Kalama River early winter steelhead (Chambers)	WDFW	Isolated	58,100	0
Kalama River Skamania summer steelhead	WDFW	Isolated	30,000	0
Kalama Spring Chinook salmon	WDFW	Isolated	515,591	500,000
Sandy River spring Chinook salmon	ODFW	Integrated	132,000	
Sandy River winter steelhead	ODFW	Integrated	170,000	
Sandy River summer steelhead	ODFW	Isolated	80,000	
Sandy River coho salmon	ODFW	Isolated	300,000	

APPENDIX B

6. APPENDIX A: EFFECTS OF HATCHERY PROGRAMS ON SALMON AND STEELHEAD POPULATIONS: REFERENCE DOCUMENT FOR NMFS ESA HATCHERY CONSULTATIONS (REVISED JULY 29, 2020)[6]

NMFS applies available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. Our analysis of a Proposed Action addresses six factors:

(1) The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock,
(2) Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,
(3) Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean,
(4) RM&E that exists because of the hatchery program,
(5) Operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
(6) Fisheries that would not exist but for the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

Because the purpose of biological opinions is to evaluate if proposed actions pose unacceptable risk (jeopardy) to listed species, much of the language in this appendix addresses risk. However, we also consider that hatcheries can be valuable tools for conservation or recovery, for example when used to prevent extinction or conserve genetic diversity in a small population, or to produce fish for reintroduction.

The following sections describe each factor in detail, including as appropriate, the scientific basis for and our analytical approach to assessment of effects. The material presented in this Appendix is only scientific support for our approach; social, cultural, and economic considerations are not included. The scientific literature on effects of salmonid hatcheries is large and growing rapidly. This appendix is thus not intended to be a comprehensive literature review, but rather a periodically updated overview of key relevant literature we use to guide our approach to effects analysis. Because this appendix can be updated only periodically, it may sometimes omit very recent findings, but should always reflect the scientific basis for our analyses. Relevant new information not cited in the appendix will be cited in the other sections of the opinion that detail our analyses of effects.

In choosing the literature we cite in this Appendix, our overriding concern is our mandate to use "best available science". Generally, this means recent peer-reviewed journal

[6] This version of the appendix supersedes all earlier dated versions and the NMFS (2012) standalone document of the same name.

articles and books. However, as appropriate we cite older peer-reviewed literature that is still relevant, as well as "gray" literature. Although peer-review is typically considered the "gold standard" for scientific information, occasionally there are well-known and popular papers in the peer-reviewed literature we do not cite because we question the methodology, results, or conclusions. In citing sources, we also consider availability, and try to avoid sources that are difficult to access. For this reason, we generally avoid citing master's theses and doctoral dissertations, unless they provide unique information.

6.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

A primary consideration in analyzing and assessing effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological benefits and risks of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population collected for hatchery broodstock. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure

6.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural and hatchery fish at adult collection facilities.

There are three aspects to the analysis of this factor: genetic effects, ecological effects, and encounters at adult collection facilities. We present genetic effects first. For the sake of simplicity, we discuss genetic effects on all life stages under factor 2.

6.2.1. Genetic effects (Revised July 29, 2020)

6.2.1.1. Overview

Based on currently available scientific information, we generally view the genetic effects of hatchery programs as detrimental to the ability of a salmon population's ability to sustain itself in the wild. We believe that artificial breeding and rearing is likely to result in some degree of change of genetic diversity and fitness reduction in hatchery-origin. Hatchery-origin fish can thus pose a risk to diversity and to salmon population rebuilding and recovery when they interbreed with natural-origin fish. However, conservation hatchery programs may prevent extinction or accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford et al. 2011).

We recognize that there is considerable debate regarding aspects of genetic risk. The extent and duration of genetic change and fitness loss and the short- and long-term implications and consequences for different species (i.e., for species with multiple life-history types and species subjected to different hatchery practices and protocols) remain unclear and should be the subject of further scientific investigation. As a result, we believe that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011d). We expect the scientific uncertainty surrounding genetic risks to be reduced considerably in the next decade due to the rapidly increasing power of genomic analysis (Waples et al. 2020).

Four general processes determine the genetic composition of populations of any plant or animal species(e.g., Falconer and MacKay 1996):

- Selection- changes in genetic composition over time due to some genotypes being more successful at survival or reproduction (i.e, more fit) than others
- Migration- individuals, and thus their genes, moving from one population to another
- Genetic drift- random loss of genetic material due to finite population size
- Mutation- generation of new genetic diversity through changes in DNA

Mutations are changes in DNA sequences that are generally so rare[7] that they can be ignored for relatively short-term evaluation of genetic change, but the other three processes are considerations in evaluating the effects of hatchery programs on the productivity and genetic diversity of natural salmon and steelhead populations. Although there is considerable biological interdependence among them, we consider three major areas of genetic effects of hatchery programs in our analyses (Figure 12):

- Within-population genetic diversity
- Among-population genetic diversity/outbreeding
- Hatchery-influenced selection

The first two areas are well-known major concerns of conservation biology (e.g., Allendorf et al. 2013; Frankham et al. 2010), but our emphasis on what conservation geneticists would likely call “adaptation to captivity” (Allendorf et al. 2013, pp. 408-409) reflects the fairly unique position of salmon and steelhead among ESA-listed species. In ESA-listed Pacific salmon and steelhead, artificial propagation in hatcheries has been used as a routine management tool for many decades, and in some cases the size and scope of hatchery programs has been a factor in listing decisions.

In the sections below we discuss these three major areas of risk, but preface this with an explanation of some key terms relevant to genetic risk, and in some cases terms relevant to ecological risk as well.

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[7] For example, the probability of a random base in a DNA molecule in coho salmon is .000000008 (Rougemont et al. 2020).

- **Natural-origin recruits (NOR)** – NO fish returning to freshwater as adults or jacks. Usage varies, but typically the term refers to post-harvest fish that will either spawn in nature or used for hatchery broodstock.

- **Natural-origin spawners (NOS)**- natural-origin fish spawning in nature.

- **Natural-origin broodstock (NOB)**- natural-origin fish that are spawned in the hatchery (i.e., are used as broodstock).

These terms have led to development of three metrics that are very important to genetic risk assessment. They are commonly attributed to the Hatchery Scientific Review Group (HSRG), but were developed in 2004 technical discussions between the HSRG and scientists from the Washington Department of Fish and Wildlife (WDFW) and the Northwest Indian Fisheries Commission (HSRG 2009a). All three are typically computed as means based on multiple spawning seasons:

- **pHOS -** proportion of fish on the spawning grounds consisting of HO fish. Mathematically, pHOS = HOS/(HOS + NOS. Assuming random mating, equal reproductive success of HO and NO spawners, and no selection, pHOS is the expected genetic contribution of HO spawners to the naturally spawning population, i.e., the expected level of gene flow from HO fish into the naturally spawning population.

  Genetic risk guidelines discussed in Section 1.2.1.4 have been developed based on refinements of pHOS:

  - **$pHOS_{census}$ -** pHOS based on census information (e.g., redd counts, spawner counts). pHOS without a subscript usually means $pHOS_{census}$

  - **$pHOS_{eff}$** - $pHOS_{census}$ discounted by the spawning success of HO fish relative to that of NO fish. For example, if HO fish are assumed to be 80 percent as reproductively capable as NO fish, then $pHOS_{eff} \approx 0.8 * pHOS_{census}$[8]

Because of expected differences in spatial distribution and spawning success between HO and NO fish, we consider pHOS an estimate of maximum potential gene flow. As a surrogate metric for gene flow, $pHOS_{census}$ computed over an entire basin becomes increasingly less satisfactory as biological complexity is considered (e.g., spawner distributions, sex ratios, varying fecundity). In response, approaches for finer scaled computation of pHOS have been developed (Falcy 2019; HSRG 2017), in addition to the previously mentioned adjustment for relative reproductive success.

- **pNOB -** proportion of fish in the hatchery broodstock consisting of NO fish. Mathematically, pNOB = NOB/(HOB + NOB).

[8] We present a more precise equation in Section 1.2.1.4.

- **Proportionate natural influence (PNI) -** in a population affected by hatchery programs, the relative selective influence of the natural environment. In populations affected by integrated hatchery programs, PNI is represented mathematically as PNI ≈ pNOB/(pNOB + pHOS). PNI is a confusing concept that we explain in greater detail in Section 1.2.1.4.

6.2.1.1.1.1. pHOS and mating-type frequency

Figure 13 illustrates the expected proportion of mating types in a mixed population of NO and HO fish (denoted as N and H, respectively, in the figure) as a function of $pHOS_{census}$, assuming that NO and HO adults mate randomly[9] (Figure 14). For example, at a $pHOS_{census}$ level of 10 percent, 81 percent of the matings would be expected to be NxN, 18 percent NxH, and 1 percent HxH.

You can also interpret the curves in the diagram as probability of naturally produced progeny of specified mating types, assuming random mating and equal reproductive success of all mating types. Under this interpretation, for example, progeny produced by a population with a pHOS level of 10 percent will have an 81 percent chance of having two NO parents. This logic has specific application to Canada's Wild Salmon Policy (WSP) (DFO 2005), in which wild fish are defined as naturally produced fish whose parents were naturally produced. Withler et al. (2018) used mating type probabilities to refine and extend HSRG gene flow guidelines for compatibility with the WSP.

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[9] We made these computations using the simple mathematical binomial squared expansion $(a+b)^2=a^2 + 2ab + b^2$.

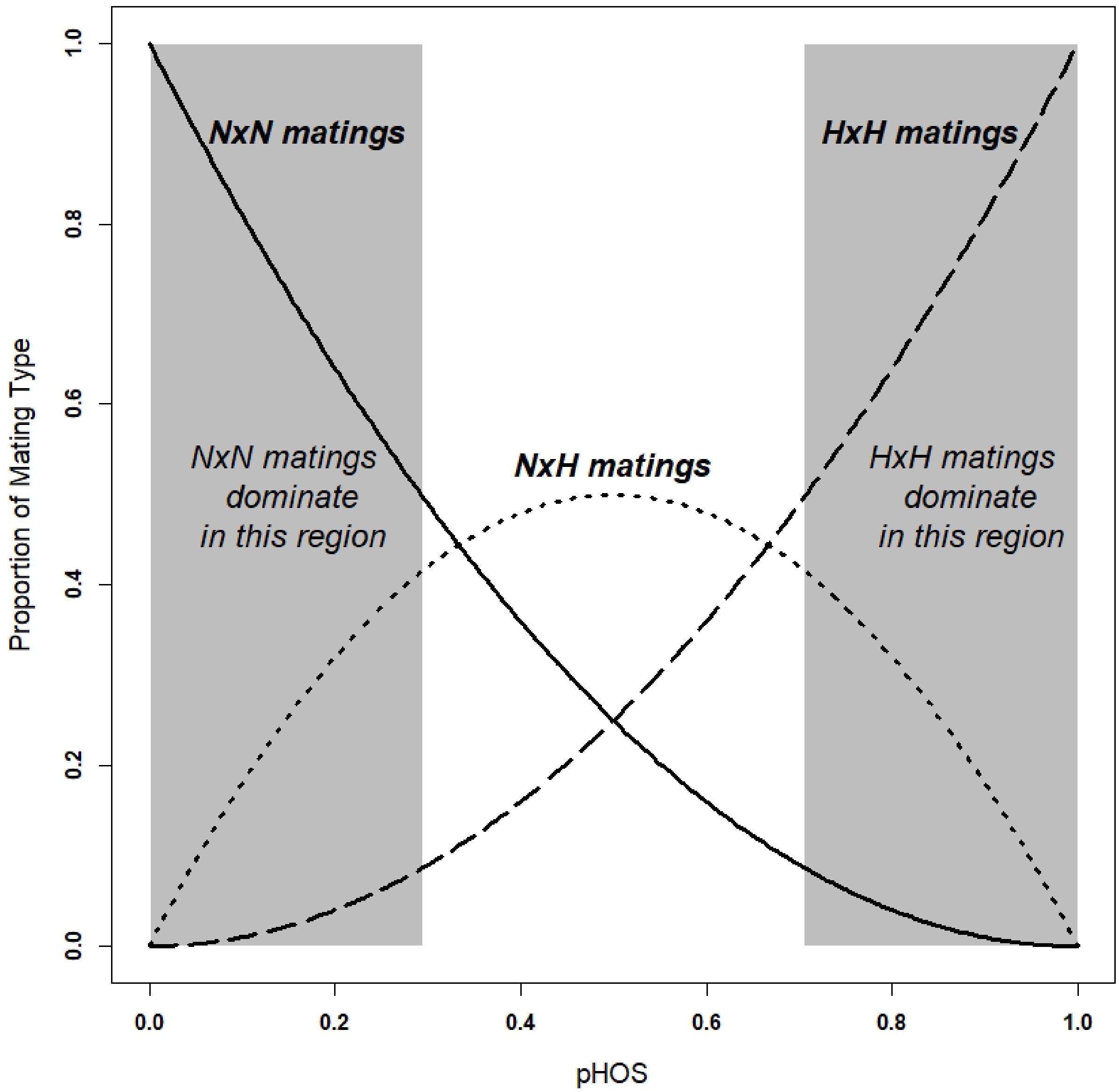

Figure 12. Relative proportions of mating types as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS), assuming random mating. Line codes: solid = NxN, dashed = NxH, dotted = HxH. Shaded rectangles on left and right denote pHOS ranges at which NxN and HxH matings are most probable, respectively.

6.2.1.2. Within-population diversity effects

Within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift. In hatchery programs diversity may also be lost through biased or nonrepresentational sampling incurred during hatchery operations, particularly broodstock collection and spawning protocols.

6.2.1.2.1. Genetic drift

Genetic drift is random loss of diversity due to population size. The rate of drift is determined not by the census population size (N_c), but rather by the effective population size (N_e). The effective size of a population is the size of a genetically "ideal" population (i.e., equal numbers of males and females, each with equal opportunity to contribute to the next generation) that will display as much genetic drift as the population being examined (e.g., Allendorf et al. 2013; Falconer and MacKay 1996)[10].

This definition can be baffling, so an example is useful. A commonly used effective-size equation is $Ne = 4 * N_m * N_f/(N_m + N_f)$, where N_m and N_f are the number of male and female parents, respectively. Suppose a steelhead hatchery operation spawns 5 males with 29 females. According to the equation, although 34 fish were spawned, the skewed sex ratio made this equivalent to spawning 17 fish (half male and half female) in terms of conserving genetic diversity because half of the genetic material in the offspring came from only 5 fish.

Various guidelines have been proposed for what levels of N_e should be for conservation of genetic diversity. A long-standing guideline is the 50/500 rule (Franklin 1980; Lande and Barrowclough 1987): 50 for a few generations is sufficient to avoid inbreeding depression, and 500 is adequate to conserve diversity over the longer term. One recent review (Jamieson and Allendorf 2012) concluded the rule still provided valuable guidance; another (Frankham et al. 2014) concluded that larger values are more appropriate, basically suggesting a 100/1000 rule. See Frankham et al. (2010) for a more thorough discussion of these guidelines.

Although Ne can be estimated from genetic or demographic data, often-insufficient information is available to do this, so for conservation purposes it is useful to estimate effective size from census size. As illustrated by the example above, N_e can be considerably smaller than N_c. This is typically the case. Frankham et al. (2014) suggested a N_e:N_c range of ~0.1-0.2 based on a large review of the literature on effective size. For Pacific salmon populations over a generation, Waples (2004) arrived at a similar range of 0.05-0.3.

In salmon and steelhead management, effective size concerns are typically dealt with using the term effective number of breeders (N_b) in a single spawning season, with per-generation N_e equal to the generation time (average age of spawners) times the average N_b (Waples 2004). We will use N_b rather than N_e where appropriate in the following discussion.

Hatchery programs, simply by virtue of being able to create more progeny than natural spawners are able to, can increase N_b in a fish population. In very small populations, this

[10] There are technically two subcategories of N_e: inbreeding effective size and variance effective size. The distinction between them is usually not a concern in our application of the concept.

increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several programs, such as the Snake River sockeye salmon program, are important genetic reserves. However, hatchery programs can also directly depress N_b by three principal pathways:

- Removal of fish from the naturally spawning population for use as hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994).

- Mating strategy used in the hatchery. N_b is reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling milt is especially problematic because when milt of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). This problem can be avoided by more structured mating schemes such as 1-to-1 mating. Factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_b (Busack and Knudsen 2007; Fiumera et al. 2004) over what would be achievable with less structured designs. Considerable benefit in N_b increase over what is achievable by 1-to-1 mating can be achieved through a factorial design as simple as a 2 x 2 (Busack and Knudsen 2007).

- Ryman-Laikre effect. On a per-capita basis, a hatchery broodstock fish can often contribute many more progeny to a naturally spawning population than a naturally spawning fish can contribute This difference in reproductive contribution causes the composite N_b to be reduced, which is called a Ryman-Laikre (R-L) effect (Ryman et al. 1995; Ryman and Laikre 1991). The key factors determining the magnitude of the effect are the numbers of hatchery and natural spawners, and the proportion of natural spawners consisting of hatchery returnees.

The initial papers on the R-L effect required knowledge of N_b in the two spawning components of the population. Waples et al. (2016) have developed R-L equations suitable for a wide variety of situations in terms of knowledge base. A serious limitation of any R-L calculation however, is that it is a snapshot in time. What happens in subsequent generations depends on gene flow between the hatchery broodstock and the natural spawners. If a substantial portion of the broodstock are NO fish, the long-term effective size depression can be considerably less than would be expected from the calculated per-generation N_b.

Duchesne and Bernatchez (2002), Tufto and Hindar (2003), and Wang and Ryman (2001) have developed analytical approaches to deal with the effective-size consequences of multiple generations of interbreeding between HO and NO fish. One interesting result of these models is that effective size reductions caused by a hatchery program can easily be countered by low levels of gene flow from other populations. Tufto (2017) recently provided us with R code (R Core Team 2019) updates to the Tufto and Hindar (2003) method that yield identical answers to the Duchesne and Bernatchez (2002) method, and we use an R (R Core Team 2019) program incorporating them to analyze the effects of hatchery programs on effective size.

Inbreeding depression, another N_e-related phenomenon, is a reduction in fitness and survival caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). Related individuals are genetically similar and produce offspring characterized by low genetic variation, low heterozygosity, lower survival, and increased expression of recessive deleterious mutations (Allendorf et al. 2013; Frankham et al. 2010; Hedrick and Garcia-Dorado 2016; Rollinson et al. 2014). Lowered fitness due to inbreeding depression exacerbates genetic risk relating to small population size and low genetic variation which further shifts a small population toward extinction (Nonaka et al. 2019). The protective hatchery environment masks the effects of inbreeding which becomes apparent when fish are released into the natural environment and experience decreased survival (Thrower and Hard 2009). Inbreeding concerns in salmonids related to hatcheries have been reviewed by Wang et al. (2002) and Naish et al. (2008).

Ne affects the level of inbreeding in a population, as the likelihood of matings between close relatives is increased in populations with low numbers of spawners. Populations exhibiting high levels of inbreeding are generally found to have low Ne (Dowell Beer et al. 2019). Small populations are at increased risk of both inbreeding depression and genetic drift (e.g., Willi et al. 2006). Genetic drift is the stochastic loss of genetic variation, which is most often observed in populations with low numbers of breeders. Inbreeding exacerbates the loss of genetic variation by increasing genetic drift when related individuals with similar allelic diversity interbreed (Willoughby et al. 2015).

Hatchery populations should be managed to avoid inbreeding depression. If hatcheries produce inbred fish which return to spawn in natural spawning areas the low genetic variation and increased deleterious mutations can lower the fitness, productivity, and survival of the natural population (Christie et al. 2014b). A captive population, which has been managed so genetic variation is maximized and inbreeding is minimized, may be used for a genetic rescue of a natural population characterized by low genetic variation and low Ne.

6.2.1.2.2. Biased/nonrepresentational sampling

Even if effective size is large, the genetic diversity of a population can be negatively affected by hatchery operations. Although many operations aspire to randomly use fish for spawning with respect to size, age, and other characteristics, this is difficult to do. For example, male Chinook salmon that mature precociously in freshwater are rarely if ever used as broodstock because they are not captured at hatchery weirs. Pressure to meet egg take goals is likely responsible for advancing run/spawn timing in at least some coho and Chinook salmon hatcheries (Ford et al. 2006; Quinn et al. 2002). Ironically, random mating, a common spawning guideline for conservation of genetic diversity has been hypothesized to be effectively selecting for younger, smaller fish (Hankin et al. 2009).

The sampling examples mentioned thus far are more or less unintentional actions. There are also established hatchery practices with possible diversity consequences that are clearly intentional. A classic example is use of jacks in spawning, where carefully considered guidelines range from random usage to near exclusion of jacks (e.g., IDFG et al. 2020; Seidel 1983). Another is the deliberate artificial selection in the hatchery of summer and winter steelhead to smolt at one year of age, which has resulted in early spawning stocks of both ecotypes (Crawford 1979).

Another source of biased sampling is non-inclusion of precocious males in broodstock. Precociousness, or early male maturation, is an alternative reproductive tactic employed by Atlantic salmon (Bagliniere and Maisse 1985; Myers et al. 1986), Chinook salmon (Bernier et al. 1993; Larsen et al. 2004), coho salmon (Iwamoto et al. 1964; Silverstein and Hershberger 1992), steelhead (McMillan et al. 2012; Schmidt and House 1979) , sockeye salmon (Ricker 1959), as well as several salmonid species in Asia and Europe (Dellefors and Faremo 1988; Kato 1991; Morita et al. 2009; Munakata et al. 2001).

Unlike anadromous males and females that migrate to the ocean to grow for a year or more before returning to their natal stream, precocious males generally stay in headwater reaches or migrate shorter distances downstream (Larsen et al. 2010) before spawning. They are orders of magnitude smaller than anadromous adults and use a 'sneaker' strategy to spawn with full size anadromous females (Fleming 1996). Precocious males are typically not subject to collection as broodstock, because of either size or location. Thus, to the extent this life history is genetically determined, hatchery programs culturing species that display precociousness unintentionally select against it.

The examples above illustrate the overlap between diversity effects and selection. Selection, natural or artificial, affects diversity, so could be regarded as a subcategory of within-population diversity. Analytically, here we consider specific effects of sampling or selection on genetic diversity. Broodstock collection or spawning guidelines that include specifications about non-random use of fish with respect to age or size, spawn timing, etc. (e.g., Crawford 1979) are of special interest. We consider general non-specific effects of unintentional selection due to the hatchery that are not related to individual traits in Section 1.2.1.4.

6.2.1.3. Among-population diversity/ Outbreeding effects

Outbreeding effects result from gene flow from other populations into the population of interest. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Keefer and Caudill 2012; Quinn 1997; Westley et al. 2013). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources.

Hatchery fish may exhibit reduced homing fidelity relative to NO fish (Goodman 2005; Grant 1997; Jonsson et al. 2003; Quinn 1997), resulting in unnatural levels of gene flow into recipient populations from strays, either in terms of sources or rates. Based on thousands of coded-wire tag (CWT) recoveries, Westley et al. (2013) concluded that species propagated in hatcheries vary in terms of straying tendency: Chinook salmon > coho salmon > steelhead. Also, within Chinook salmon, "ocean-type" fish stray more than "stream-type" fish. However, even if hatchery fish home at the same level of fidelity as NO fish, their higher abundance relative to NO fish can cause unnaturally high gene flow into recipient populations.

Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997). Based on fundamental population genetic principles, a 1995 scientific workgroup convened by NMFS concluded that aggregate gene flow from non-native HO fish from all programs combined should be kept below 5 percent (Grant 1997), and this is the recommendation NMFS uses as a reference in hatchery consultations. It is important to note that this 5% criterion was developed independently and for a different purpose than the HSRG's 5% pHOS criterion that is presented in Section 1.2.1.4.

Gene flow from other populations can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock.

In addition, unusual high rates of straying into other populations within or beyond the population's MPG, salmon ESU, or a steelhead DPS, can have a homogenizing effect, decreasing intra-population genetic variability (e.g., Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability (McElhany et al. 2000). The practice of backfilling — using eggs collected at one hatchery to compensate for egg shortages at another—has historically a key source of intentional large-scale "straying". Although it now is generally considered an unwise practice, it still is common.

There is a growing appreciation of the extent to which among-population diversity contributes to a "portfolio" effect (Schindler et al. 2010), and lack of among-population genetic diversity is considered a contributing factor to the depressed status of California Chinook salmon populations (Carlson and Satterthwaite 2011; Satterthwaite and Carlson 2015). Eldridge et al. (2009) found that among-population genetic diversity had decreased in Puget Sound coho salmon populations during several decades of intensive hatchery culture.

As discussed in Section 1.2.1.4, pHOS[11] is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects.

- Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). On the other hand, "dip-ins" can also be captured by hatchery traps and become part of the broodstock.

- Strays may not contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; e.g., Saisa et al. 2003). The causes of poor reproductive success of strays are likely similar to those responsible for reduced productivity of HO fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Leider et al. 1990; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

6.2.1.4. Hatchery-influenced selection effects

Hatchery-influenced selection (often called domestication[12]), the third major area of genetic effects of hatchery programs that NMFS analyses, occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with HO fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program.

Hatchery-influenced selection can range from relaxation of selection that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999), but in this section, for the most part, we consider hatchery-influenced selection effects that are general and unintentional. Concerns about these effects, often noted as performance

[11] It is important to reiterate that as NMFS analyzes them, outbreeding effects are a risk only when the HO fish are from a *different* population than the NO fish.

[12] We prefer the term "hatchery-influenced selection" or "adaptation to captivity" (Fisch et al. 2015) to "domestication" because in discussions of genetic risk in salmon "domestication" is often taken as equivalence to species that have been under human management for thousands of years; e.g., perhaps 30,000 yrs for dogs (Larson and Fuller 2014), and show evidence of large-scale genetic change (e.g., Freedman et al. 2016). By this standard, the only domesticated fish species is the carp (*Cyprinus carpio*) (Larson and Fuller 2014). "Adaptation to captivity", a term commonly used in conservation biology (e.g., Allendorf et al. 2013; Frankham 2008), and becoming more common in the fish literature (Christie et al. 2011; Fisch et al. 2015) is more precise for species that have been subjected to semi-captive rearing for a few decades. We feel "hatchery-influenced selection" is even more precise, and less subject to confusion.

differences between HO and NO fish have been recorded in the scientific literature for more than 60 years (Vincent 1960, and references therein).

Genetic change and fitness reduction in natural salmon and steelhead due to hatchery-influenced selection depends on:

- The difference in selection pressures presented by the hatchery and natural environments. Hatchery environments differ from natural environments in many ways (e.g., Thorpe 2004). Some obvious ones are food, density, flows, environmental complexity, and protection from predation.

- How long the fish are reared in the hatchery environment. This varies by species, program type, and by program objective. Steelhead, coho and "stream-type" Chinook salmon are usually released as yearlings, while "ocean-type" Chinook, pink, and chum salmon are usually released at younger ages.

- The rate of gene flow between HO and NO fish, which is usually expressed as pHOS for segregated programs and PNI for integrated programs.

All three factors should be considered in evaluating risks of hatchery programs. However, because gene flow is generally more readily managed than the selection strength of the hatchery environment, current efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between NO and HO fish[13]. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

6.2.1.4.1. Relative Reproductive Success Research

Although hundreds of papers in the scientific literature document behavioral, morphological and physiological differences between NO and HO fish, the most frequently cited research has focused on RRS of HO fish compared to NO fish determined through pedigree analysis. The influence of this type of research derives from the fact that it addresses fitness, the ability of the fish to produce progeny that will then return to sustain the population. The RRS study method is simple: genotyped NO and HO fish are released upstream to spawn, and their progeny (juveniles, adults, or both) are sampled genetically and matched with the genotyped parents. In some cases, multiple-generation pedigrees are possible.

RRS studies can be easy to misinterpret (Christie et al. 2014a) for at least three reasons:

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[13] Gene flow between NO and HO fish is often interpreted as meaning actual matings between NO and HO fish. In some contexts, it can mean that. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, HO spawners in the wild will either spawn with other HO fish or with NO fish. NO spawners in the wild will either spawn with other NO fish or with HO fish. But all these matings, to the extent they are successful, will generate the next generation of NO fish. In other words, all will contribute to the NO gene pool.

- RRS studies often have little experimental power because of limited sample sizes and enormous variation among individual fish in reproductive success (most fish leave no offspring and a few leave many). This can lead to lack of statistical significance for HO:NO comparisons even if a true difference does exist. Kalinowski and Taper (2005) provide a method for developing confidence intervals around RRS estimates that can shed light on statistical power.

- An observed difference in RRS may not be genetic. For example, Williamson et al. (2010) found that much of the observed difference in reproductive success between HO and NO fish was due to spawning location; the HO fish tended to spawn closer to the hatchery. Genetic differences in reproductive success require a multiple generation design, and only a handful of these studies are available.

- The history of the natural population in terms of hatchery ancestry can bias RRS results. Only a small difference in reproductive success of HO and NO fish might be expected if the population had been subjected to many generations of high pHOS (Willoughby and Christie 2017).

For several years, the bulk of the empirical evidence of fitness depression due to hatchery-influenced selection came from studies of species that are reared in the hatchery environment for an extended period— one to two years—before release (Berejikian and Ford 2004). Researchers and managers wondered if these results were applicable to species and life-history types with shorter hatchery residence, as it seemed reasonable that the selective effect of the hatchery environment would be less on species with shorter hatchery residence times (e.g., RIST 2009). Especially lacking was RRS information on "ocean-type" Chinook. Recent RRS work on Alaskan pink salmon, the species with the shortest hatchery residence time has found very large differences in reproductive success between HO and NO fish. The RRS was 0.42 for females and 0.28 for males (Lescak et al. 2019). This research suggests the "less residence time, less effect" paradigm needs to be revisited.

In addition to pink salmon, RRS results are now available for:

- Coho salmon(Theriault et al. 2011)
- Chum salmon (Berejikian et al. 2009)
- "Ocean-type" Chinook salmon (Anderson et al. 2012; Evans et al. 2019; Sard et al. 2015)
- "Stream-type" Chinook salmon (Ford et al. 2012; Ford et al. 2015; Ford et al. 2009; Hess et al. 2012; Janowitz-Koch et al. 2018; Williamson et al. 2010)
- Steelhead (Araki et al. 2007; Araki et al. 2009; Berntson et al. 2011; Christie et al. 2011)

Although the size of the effect may vary, and there may be year-to-year variation and lack of statistical significance, the general pattern is clear: HO fish have lower reproductive success than NO fish.

As mentioned above, few studies have been designed to detect unambiguously a genetic component in RRS. Two such studies have been conducted with steelhead and both detected a statistically significant genetic component in steelhead (Araki et al. 2007; Christie et al. 2011; Ford et al. 2016), but the two conducted with "stream-type" Chinook salmon have not (Ford et al. 2012; Janowitz-Koch et al. 2018).

This suggests that perhaps the impacts of hatchery-influenced selection on fitness differs between Chinook salmon and steelhead.[14] The possibility that steelhead may be more affected by hatchery-influenced selection than Chinook salmon by no means suggest that effects on Chinook are trivial, however. A small decrement in fitness per generation can lead to large fitness loss.

6.2.1.4.2. Hatchery Scientific Review Group (HSRG) Guidelines

Key concepts concerning the relationship of gene flow to hatchery-influenced selection were developed and promulgated throughout the Pacific Northwest by the Hatchery Scientific Review Group (HSRG). Because these concepts have been so influential, we devote the next few paragraphs to them.

The HSRG developed gene-flow guidelines based on mathematical models developed by Ford (2002) and by Lynch and O'Hely (2001). Guidelines for segregated programs are based on pHOS, but guidelines for integrated programs also include PNI, which is a function of pHOS and pNOB. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces.

The HSRG guidelines (HSRG 2009b) vary according to type of program and conservation importance of the population. The HSRG used conservation importance classifications that were developed by the Willamette/Lower Columbia Technical Recovery Team (McElhany et al. 2003).[15] (Table 18). In considering the guidelines, we equate "primary" with a recovery goal of "viable" or "highly viable", and "contributing" with a recovery goal of "maintain". We disregard the guidelines for "stabilizing", because we feel they are inadequate for conservation guidance.

Table 23. HSRG gene flow guidelines (HSRG 2009b).

	Program classification	
Population conservation importance	**Integrated**	**Segregated**
Primary	**PNI $\geq$ 0.67 and pHOS $\leq$ 0.30**	**pHOS $\leq$ 0.05**

[14] This would not be surprising. Although steelhead are thought of as being quite similar to the "other" species of salmon, genetic evidence suggests the two groups diverged well over 10 million years ago (Crête-Lafrenière et al. 2012).
[15] Development of conservation importance classifications varied among technical recovery teams (TRTs); for more information, documents produced by the individual TRT's should be consulted.

	Program classification	
Contributing	**PNI ≥ 0.50 and pHOS ≤ 0.30**	**pHOS ≤ 0.10**
Stabilizing	**Existing conditions**	**Existing conditions**

Although they are controversial, the HSRG gene flow guidelines have achieved a considerable level of regional acceptance. They were adopted as policy by the Washington Fish and Wildlife Commission (WDFW 2009), and were recently reviewed and endorsed by a WDFW scientific panel, who noted that the "…HSRG is the primary, perhaps only entity providing guidance for operating hatcheries in a scientifically defensible manner…" (Anderson et al. 2020). In addition, HSRG principles have been adopted by the Canadian Department of Fisheries and Oceans, with very similar gene-flow guidelines for some situations (Withler et al. 2018).

The gene flow guidelines developed by the HSRG have been implemented in areas of the Pacific Northwest for at most 15 years, so there has been insufficient time to judge their effect. They have also not been applied consistently, which complicates evaluation. However, the benefits of high pNOB (in the following cases 100 percent) has been credited with limiting genetic change and fitness loss in supplemented Chinook populations in the Yakima (Washington) (Waters et al. 2015) and Salmon (Idaho) (Hess et al. 2012; Janowitz-Koch et al. 2018) basins.

Little work toward developing guidelines beyond the HSRG work has taken place. The only notable effort along these lines has been the work of Baskett and Waples (2013), who developed a model very similar to that of Ford (2002), but added the ability to impose density-dependent survival and selection at different life stages. Their qualitative results were similar to Ford's, but the model would require some revision to be used to develop guidelines comparable to the HSRG's.

NMFS has not adopted the HSRG gene flow guidelines per se. However, at present the HSRG guidelines, along with the 5% stray guideline from Grant (1997) are the only acknowledged scientifically based quantitative guidelines for gene flow available. NMFS has considerable experience with the HSRG guidelines. They are based on a model (Ford 2002) developed by a NMFS geneticist, they have been evaluated by a NMFS-lead scientific team (RIST 2009), and NMFS scientists have extended the Ford model for more flexible application of the guidelines to complex situations (Busack 2015) (Section 1.2.1.4.3).

At minimum, we consider the HSRG guidelines a useful screening tool. For a particular program, based on specifics of the program, broodstock composition, and environment, we may consider a pHOS or PNI level to be a lower risk than the HSRG would but, generally, if a program meets HSRG guidelines, we will typically consider the risk levels to be acceptable. However, our approach to application of HSRG concepts varies somewhat from what is found in HSRG documents or in typical application of HSRG concepts. Key aspects of our approach warrant discussion here.

6.2.1.4.2.1. PNI and segregated hatchery programs

The PNI concept has created considerable confusion. Because it is usually estimated by a simple equation that is applicable to integrated programs, and applied in HSRG guidelines only to integrated programs, PNI is typically considered to be a concept that is relevant only to integrated programs. This in turn has caused a false distinction between segregated and integrated programs in terms of perceptions of risk. The simple equation for PNI is:

$PNI \approx pNOB / (pNOB + pHOS)$.

In a segregated program, pNOB equals zero, so by this equation PNI would also be zero. You could easily infer that PNI is zero in segregated programs, but this would be incorrect. The error comes from applying the equation to segregated programs. In integrated programs, PNI can be estimated accurately by the simple equation, and the simplicity of the equation makes it very easy to use. In segregated programs, however, a more complicated equation must be used to estimate PNI. A PNI equation applicable to both integrated and segregated programs was developed over a decade ago by the HSRG (HSRG 2009a, equation 9), but has been nearly completed ignored by parties dealing with the gene flow guidelines:

$$PNI \approx \frac{h^2 + (1.0 - h^2 + \omega^2) * pNOB}{h^2 + (1.0 - h^2 + \omega^2) * (pNOB + pHOS)},$$

where h^2 is heritability and ω^2 is the strength of selection in standard deviation units, squared. Ford (2002) used a range of values for the latter two variables. Substituting those values that created the strongest selection scenarios in his simulations (h^2 of 0.5 and ω^2 of 10), which is appropriate for risk assessment, results in:

$$PNI \approx \frac{0.5 + 10.5 * pNOB}{0.5 + 10.5 * (pNOB + pHOS)}$$

HSRG (2004) offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. More recently, the HSRG concluded that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs (HSRG 2014). This can be easily demonstrated using the equation presented in the previous paragraph: a pHOS of 0.05, the standard for a primary population affected by a segregated program, yields a PNI of 0.49, whereas a pHOS of 0.024 yields a PNI of 0.66, virtually the same as the standard for a primary population affected by an integrated program.

6.2.1.4.2.2. The effective pHOS concept

The HSRG recognized that HO fish spawning naturally may on average produce fewer adult progeny than NO spawners, as described above. To account for this difference, the HSRG (2014) defined *effective* pHOS as:

$$pHOS_{eff} = (RRS * HOS_{census}) / (NOS + RRS * HOS_{census}),$$

where RRS is the reproductive success of HO fish relative to that of NO fish. They then recommend using this value in place of $pHOS_{census}$ in PNI calculations.

We feel that adjustment of census pHOS by RRS for this purpose should be done not nearly as freely as the HSRG document would suggest because the Ford (2002) model, which is the foundation of the HSRG gene-flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS < 1 (compared to natural fish) due to selection in the hatchery. A component of reduced RRS of hatchery fish is therefore already incorporated in the model and by extension the calculation of PNI. Therefore, reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and therefore overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated in the model.

In some cases, adjusting pHOS downward may be appropriate, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon (Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of NO and HO spawners differs, and the HO fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate.

By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from NO broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the "effective" pNOB might be much lower than the census pNOB.

It is important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be a rough guideline to managers. We look forward to seeing this issue further clarified in the near future. In the meantime, except for cases in which an adjustment for RRS has strong justification, we feel that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

6.2.1.4.2.3. Gene flow guidelines in phases of recovery

In 2012 the HSRG expanded on the original gene flow guidelines/standards by introducing the concept of recovery phases for natural populations (HSRG 2012), and then refined the concept in later documents (HSRG 2014; HSRG 2015; HSRG 2017). They defined and described four phases:

1. Preservation
2. Re-colonization
3. Local adaptation
4. Fully restored

The HSRG provided guidance on development of quantitative "triggers" for determining when a population had moved (up or down) from one phase to another. As explained in HSRG (2015), in the preservation and re-colonization phase, no PNI levels were specified for integrated programs (Table 19). The emphasis in these phases was to "Retain genetic diversity and identity of the existing population". In the local adaptation phase, when PNI standards were to be applied, the emphasis shifted to "Increase fitness, reproductive success and life history diversity through local adaptation (e.g., by reducing hatchery influence by maximizing *PNI*)". The HSRG provided additional guidance in HSRG (2017), which encouraged managers to use pNOB to "…the extent possible…" during the preservation and recolonization phases.

Table 24. HSRG gene flow guidelines/standards for conservation and harvest programs, based on recovery phase of impacted population (Table 2 from HSRG 2015).

Natural Population		Hatchery Broodstock Management	
Designation	Status	Segregated	Integrated
Primary	Fully Restored	pHOS<5%	PNI>0.67
	Local Adaptation	pHOS<5%	PNI>0.67
	Re-colonization	pHOS<5%	Not Specified
	Preservation	pHOS<5%	Not Specified
Contributing	Fully Restored	pHOS<10%	PNI>0.50
	Local Adaptation	pHOS<10%	PNI>0.50
	Re-colonization	pHOS<10%	Not Specified
	Preservation	pHOS<10%	Not Specified
Stabilizing	Fully Restored	Current Condition	Current Condition
	Local Adaptation	Current Condition	Current Condition
	Re-colonization	Current Condition	Current Condition
	Preservation	Current Condition	Current Condition

We agree that conservation of populations at perilously low abundance may require prioritization of demographic over genetic concerns, but is concerned that high pHOS/low PNI regimes imposed on small recovering populations may prevent them from advancing to higher recovery phases[16]. A WDFW scientific panel reviewing HSRG principles and guidelines reached the same conclusion (Anderson et al. 2020).

6.2.1.4.3. Extension of PNI modeling to more than two population components

The Ford (2002) model considered a single population affected by a single hatchery program—basically two population units connected by gene flow—but the recursion equations underlying the model are easily expanded to more than two populations (Busack 2015). This has resulted in tremendous flexibility in applying the PNI concept to hatchery consultations.

A good example is a system of genetically linked hatchery programs, an integrated program in which in which returnees from a (typically smaller) integrated hatchery program are used as broodstock for a larger segregated program, and both programs contribute to pHOS (**Error! Reference source not found.**). It seems logical that this would result in less impact to the natural population than if the segregated program used only its own returnees as broodstock, but because the two-population implementation of the Ford model did not apply, there was no way to calculate PNI for this system.

Extending Ford's recursion equations (equations 5 and 6) to three populations allowed us to calculate PNI for a system of this type. We successfully applied this approach to link two spring Chinook salmon hatchery programs: Winthrop NFH (segregated) and Methow FH (integrated). By using some level of Methow returnees as broodstock for the Winthrop program, PNI for the natural population could be increased significantly[17](Busack 2015). We have since used the multi-population PNI model in numerous hatchery program consultations in Puget Sound and the Columbia basin, and have extended to it to include as many as ten hatchery programs and natural production areas.

[16] According to Andy Appleby, past HSRG co-chair, the HSRG never intended this guidance to be interpreted as total disregard for pHOS/PNI standards in the preservation and recovery phases (Appleby 2020).

[17] Such programs can lower the effective size of the system, but the model of Tufto (Section 1.2.1.3) can easily be applied to estimate this impact.

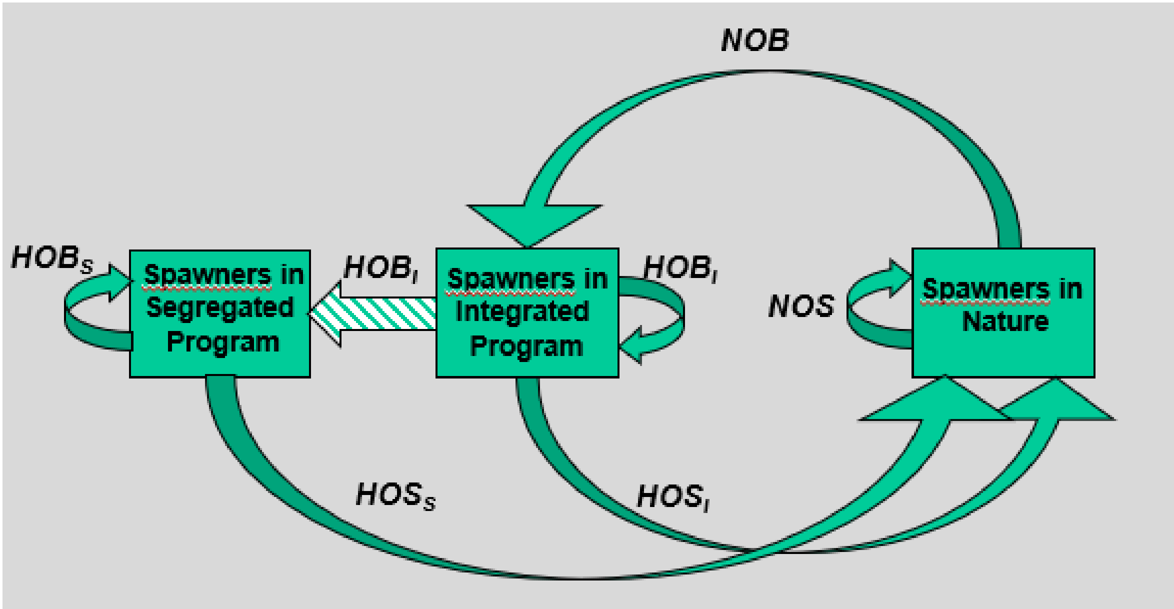

Figure 13. Example of genetically linked hatchery programs. The natural population is influenced by hatchery-origin spawners from an integrated (HOSI) and a segregated program (HOSS). The integrated program uses a mix of natural-origin (NOB) and its own returnees (HOBI) as broodstock, but the segregated uses returnees from the integrated program (HOBI above striped arrow) as all or part of its broodstock, genetically linking the two programs. The system illustrated here is functionally equivalent to the HSRG's (HSRG 2014) "stepping stone" concept.

6.2.1.4.4. California HSRG

Another scientific team was assembled to review hatchery programs in California and this group developed guidelines that differed somewhat from those developed by the "Northwest" HSRG (California HSRG 2012). The California team:

- Felt that truly isolated programs in which no HO returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept of segregated programs. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent.

- Rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by NO fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between HO and NO fish, and societal values, such as angling opportunity."

- Recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times.

- Recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population by taking too large a proportion of the population for broodstock.

6.2.2. Ecological effects

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative.

To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Gresh et al. 2000; Kline et al. 1990; Larkin and Slaney 1996; Murota 2003; Piorkowski 1995; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Bell 2001; Bilton et al. 1982; Bradford et al. 2000; Brakensiek 2002; Hager and Noble 1976; Hartman and Scrivener 1990; Holtby 1988; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Ward and Slaney 1988).

Additionally, studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (e.g., (Montgomery et al. 1996). The act of spawning also coarsens gravel in spawning reaches, removing fine material that blocks interstitial gravel flow and reduces the survival of incubating eggs in egg pockets of redds.

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences, such as increased competition, and potential for redd superimposition. Although males compete for access to females, female spawners compete for spawning sites. Essington et al. (2000) found that aggression of both sexes increases with spawner density, and is most intense with conspecifics. However, females tended to act aggressively towards heterospecifics as well. In particular, when there is spatial overlap between natural-and hatchery-origin spawners, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

6.2.3. Adult Collection Facilities

The analysis also considers the effects from encounters with natural-origin fish that are incidental to broodstock collection. Here, NMFS analyzes effects from sorting, holding, and handling natural-origin fish in the course of broodstock collection. Some programs collect their broodstock from fish voluntarily entering the hatchery, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. The more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on natural- and hatchery-origin fish that are intended to spawn naturally and on ESA-listed species. The information NMFS uses for this analysis includes a description of the facilities, practices, and protocols for collecting broodstock, the environmental conditions under which broodstock collection is conducted, and the encounter rate for ESA-listed fish.

NMFS also analyzes the effects of structures, either temporary or permanent, that are used to collect hatchery broodstock, and remove hatchery fish from the river or stream and prevent them from spawning naturally, on juvenile and adult fish from encounters with these structures. NMFS determines through the analysis, for example, whether the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection, usually a weir or ladder.

6.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migratory corridor, estuary, and ocean (Revised June 1, 2020)

NMFS also analyzes the potential for competition, predation, and disease when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas.

6.3.1. Competition

Competition and a corresponding reduction in productivity and survival may result from direct or indirect interactions. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before natural-origin fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmon behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Several studies suggest that salmonid species and migratory forms that spend longer periods of time in lotic habitats (e.g., coho salmon and steelhead) are more aggressive than those that outmigrate at an earlier stage Hutchison and Iwata (1997). The three least aggressive species generally outmigrate to marine (chum salmon) or lake (kokanee and sockeye salmon) habitats as post-emergent fry. The remaining (i.e., more aggressive) species all spend one year or more in stream habitats before outmigrating. Similarly, Hoar (1951) did not observe aggression or territoriality in fry of early migrants (chum and pink salmon), in contrast to fry of a later migrating species (coho salmon) which displayed high levels of each. Hoar (1954) rarely observed aggression in sockeye salmon fry, and observed considerably less aggression in sockeye than coho salmon smolts. Taylor (1990) found that Chinook salmon populations that outmigrate as fry are less aggressive than those that outmigrate as parr, which are less aggressive than those that outmigrate as yearlings.

Although *intraspecific* interactions are expected to be more frequent/intense than *interspecific* interactions (e.g., Hartman 1965; Tatara and Berejikian 2012), this apparent relationship between aggression and stream residence appears to apply to *interspecific* interactions as well. For example, juvenile coho salmon are known to be highly aggressive toward other species (e.g., Stein et al. 1972; Taylor 1991). Taylor (1991) found that coho salmon were much more aggressive toward size-matched *ocean*-type Chinook salmon (early outmigrants), but only moderately more aggressive toward size-matched *stream*-type Chinook salmon (later outmigrants). Similarly, the findings of Hasegawa et al. (2014) indicate that masu salmon (*O. masou*) , which spend 1 to 2 years in streams before outmigrating, dominate and outcompete the early-migrating chum salmon.

A few exceptions to this general stream residence-aggression pattern have been observed (e.g., Hasegawa et al. 2004; Lahti et al. 2001; Young 2003; Young 2004), but all the species and migratory forms evaluated in these studies spend one year or more in stream habitat prior to outmigrating. Other than the Taylor (1991) and Hasegawa et al. (2014) papers noted above, we are not aware of any other studies that have looked specifically at interspecific interactions between early-outmigrating species (e.g., sockeye, chum, and pink salmon) and those that rear longer in streams.

En masse hatchery salmon and steelhead smolt releases may cause displacement of rearing natural-origin juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or to premature out-migration by natural-origin juveniles. Pearsons et al. (1994) reported small-scale displacement of naturally produced juvenile rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and natural-origin juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a time near the release point. These non-migratory smolts (residuals) may compete for food and space with natural-origin juvenile salmonids of similar age (Bachman 1984; Tatara and Berejikian 2012). Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well (Parkinson et al. 2017). Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is generally higher; however, the issue of residualism for these species has not been as widely investigated compared to steelhead. Therefore, for all species, monitoring of natural stream areas near hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

The risk of adverse competitive interactions between hatchery- and natural-origin fish can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile natural-origin fish in freshwater (California HSRG 2012; Steward and Bjornn 1990)
- Rearing hatchery fish to a size sufficient to ensure that smoltification occurs
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing by natural-origin juveniles
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with natural-origin juveniles is likely

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[18] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

6.3.2. Predation

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish, the progeny of naturally spawning

[18] "Action area," in ESA section 7 analysis documents, means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.

hatchery fish, and avian and other predators attracted to the area by an abundance of hatchery fish.

Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage, so they are more likely to migrate quickly to the ocean, can prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to natural-origin fish (Rensel et al. 1984). Due to their location in the stream, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is believed to be greatest immediately upon emergence from the gravel and then their vulnerability decreases as they move into shallow, shoreline areas (USFWS 1994). Emigration out of important rearing areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (HSRG 2004; Pearsons and Fritts 1999), but other studies have concluded that salmonid predators prey on fish up to 1/3 their length (Beauchamp 1990; Cannamela 1992; CBFWA 1996; Daly et al. 2009; Hillman and Mullan 1989; Horner 1978). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Bachman 1984; Olla et al. 1998; Sosiak et al. 1979).

Size is an important determinant of how piscivorous hatchery-origin fish are. Keeley and Grant (2001) reviewed 93 reports detailing the relationship between size and piscivory in 17 species of stream-dwelling salmonids. *O. mykiss* and Pacific salmon were well represented in the reviewed reports. Although there is some variation between species, stream-dwelling salmonids become piscivorous at about 100 mm FL, and then piscivory rate increases with increasing size. For example:

- For 140 mm fish, 15% would be expected to have fish in their diet but would not be primarily piscivorous; 2% would be expected to be primarily piscivorous (> 60% fish in diet).
- For 200 mm fish, those figures go to 32% (fish in diet) and 11% (primarily piscivorous).

The implication for hatchery-origin fish is pretty clear: larger hatchery-origin fish present a greater predation risk because more of them eat fish, and more of them eat primarily fish.

There are several steps that hatchery programs can implement to reduce or avoid the threat of predation:

- Ensuring that a high proportion of the hatchery fish have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery- and natural-origin fish present within, and downstream of, release areas.
- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs to minimize the potential for residualism.

6.3.3. Disease

The release of hatchery fish and hatchery effluent into juvenile rearing areas can lead to transmission of pathogens, contact with chemicals or altering of environmental parameters (e.g., dissolved oxygen) that can result in disease outbreaks. Fish diseases can be subdivided into two main categories: infectious and non-infectious. Infectious diseases are those caused by pathogens such as viruses, bacteria, and parasites. Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Pathogens can also be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have little to no history of occurrence within state boundaries. For example, *Oncorhynchus masou* virus (OMV) would be considered an exotic pathogen if identified anywhere in Washington state. Endemic pathogens are native to a state, but may not be present in all watersheds.

In natural fish populations, the risk of disease associated with hatchery programs may increase through a variety of mechanisms (Naish et al. 2008), including:

- Introduction of exotic pathogens
- Introduction of endemic pathogens to a new watershed
- Intentional release of infected fish or fish carcasses
- Continual pathogen reservoir
- Pathogen amplification

The transmission of pathogens between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Naish et al. 2008; Steward and Bjornn 1990). This lack of reporting is because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., *Renibacterium salmoninarum,* the cause of Bacterial Kidney Disease).

Adherence to a number of state, federal, and tribal fish health policies limits the disease risks associated with hatchery programs (IHOT 1995; ODFW 2003; USFWS 2004; WWTIT and WDFW 2006). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

In addition to the state, federal, and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery facility through the treatment of incoming water (e.g., by using ozone) or by leaving the hatchery through hatchery effluent (Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2008).

Treating the hatchery effluent would also minimize amplification, but would not reduce disease outbreaks within the hatchery itself caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Chlorine levels in the hatchery effluent, specifically, are monitored with a National

Pollutant Discharge Elimination System (NPDES) permit administered by the Environmental Protection Agency. Other chemicals are discharged in accordance with manufacturer instructions. The NPDES permit also requires monitoring of settleable and unsettleable solids, temperature, and dissolved oxygen in the hatchery effluent on a regular basis to ensure compliance with environmental standards and to prevent fish mortality.

In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short period of time. One group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies because of the vast literature available on successful rearing of salmon and trout in aquaculture.

6.3.4. Ecological Modeling

While competition, predation, and disease are important effects to consider, they are events which can rarely, if ever, be observed and directly calculated. However, these behaviors have been established to the point where NMFS can model these potential effects to the species based on known factors that lead to competition or predation occurring. In our Biological Opinions, we use the Predation, Competition, Decrement (PCD) Risk model version 3.2 based on Pearsons and Busack (2012). PCD Risk is an individual-based model that simulates the potential number of ESA-listed natural-origin juveniles lost to competition, predation, and disease from the release of hatchery-origin juveniles in the freshwater environment.

The PCD Risk model has undergone considerable modification since 2012 to increase supportability and reliability. Notably, the current version no longer operates in a Windows environment and no longer has a probabilistic mode. We also further refined the model by allowing for multiple hatchery release groups of the same species to be included in a single run.

There have also been a few recent modifications to the logic of the model. The first was the elimination of competition equivalents and replacement of the disease function with a delayed mortality parameter. The rationale behind this change was to make the model more realistic; competition rarely directly results in death in the model because it takes many competitive interactions to suffer enough weight loss to kill a fish. Weight loss is how adverse competitive interactions are captured in the model. However, fish that are competed with and suffer some degree of weight loss are likely more vulnerable to mortality from other factors such as disease. Now, at the end of each run, the competitive impacts for each fish are assessed, and the fish has a probability of delayed mortality based on the competitive impacts. This function will be subject to refinement based on research. For now, the probability of delayed mortality is equal to the proportion of a fish's weight loss. For example, if a fish has lost 10% of its body weight due to competition and a 50% weight loss kills a fish, then it has a 20% probability of delayed death, (0.2 = 0.1/0.5).

The second logic change was to the habitat segregation parameter to make it size-independent or size-dependent based on hatchery species. Some species, such as coho salmon, are more aggressive competitors than other species, such as chum and sockeye salmon. To represent this difference in behavior more accurately in the model, for less aggressive species such as chum and sockeye salmon, hatchery fish segregation is random, whereas for more aggressive species, segregation occurs based on size, with the largest fish eliminated from the model preferentially.

6.3.5. Acclimation

One factor that can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be released) of hatchery juveniles before release. Acclimation of hatchery juveniles before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas.

Acclimating fish for a time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. Dittman and Quinn (2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2014). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Dunnigan 1999; Quinn 1997; YKFP 2008).

Dittman and Quinn (2008) reference numerous experiments that indicated that a critical period for olfactory imprinting is during the parr-smolt transformation, which is the period when the salmonids go through changes in physiology, morphology, and behavior in preparation for transitioning from fresh water to the ocean (Beckman et al. 2000; Hoar 1976). Salmon species with more complex life histories (e.g., sockeye salmon) may imprint at multiple times from emergence to early migration (Dittman et al. 2010). Imprinting to a particular location, be it the hatchery, or an acclimation pond, through the acclimation and release of hatchery salmon and steelhead is employed by fisheries managers with the goal that the hatchery fish released from these locations will return to that particular site and not stray into other areas (Bentzen et al. 2001; Fulton and Pearson 1981; Hard and Heard 1999; Kostow 2009; Quinn 1997; Westley et al. 2013). However, this strategy may result in varying levels of success in regards to the proportion of the returning fish that stray outside of their natal stream. (e.g., (Clarke et al. 2011; Kenaston et al. 2001).

Increasing the likelihood that hatchery salmon and steelhead home to a particular location is one measure that can be taken to reduce the proportion of hatchery fish in the naturally spawning population. When the hatchery fish home to a particular location, those fish can be removed (e.g., through fisheries, use of a weir) or they can be isolated from primary spawning areas. Factors that can affect the success of acclimation as a tool to improve homing include:

- The timing of acclimation, such that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation
- A water source unique enough to attract returning adults
- Whether or not the hatchery fish can access the stream reach where they were released
- Whether or not the water quantity and quality is such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries.

6.4. Factor 4. Research, monitoring, and evaluation that exists because of the hatchery program

NMFS also analyzes proposed RM&E for its effects on listed species and on designated critical habitat. Negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces uncertainty. RM&E actions can cause harmful changes in behavior and reduced survival; such actions include, but are not limited to:

- Observation during surveying
- Collecting and handling (purposeful or inadvertent)
- Sampling (e.g., the removal of scales and tissues)
- Tagging and fin-clipping, and observing the fish (in-water or from the bank)

NMFS also considers the overall effectiveness of the RM&E program. There are five factors that NMFS takes into account when it assesses the beneficial and negative effects of hatchery RM&E: (1) the status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties concerning effects on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E, and before it makes any recommendations to the action agency(s) NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost.

6.4.1. Observing/Harassing

For some activities, listed fish would be observed in-water (e.g., by snorkel surveys, wading surveys, or observation from the banks). Direct observation is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting fishes' behavior.

Fish frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. These avoidance behaviors are expected to be in the range of normal predator and disturbance behaviors.

6.4.2. Capturing/handling

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). Primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and holding vessel), dissolved oxygen conditions, the amount of time fish are held out of the water, and physical trauma. Stress increases rapidly if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Fish transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival can result from high stress levels, and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998).

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000; NMFS 2008) that have been incorporated as terms and conditions into section 7 opinions and section 10 permits for research and enhancement. Additional monitoring principles for supplementation programs have been developed by the (Galbreath et al. 2008).

6.4.3. Fin clipping and tagging

Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied, but fin clips do not generally alter fish growth (Brynildson and Brynildson 1967; Gjerde and Refstie 1988). Mortality among fin-clipped fish is variable, but can be as high as 80 percent (Nicola and Cordone 1973). In some cases, though, no significant difference in mortality was found between clipped and un-clipped fish (Gjerde and Refstie 1988; Vincent-Lang 1993). The mortality rate typically depends on which fin is clipped. Recovery rates are generally higher for adipose- and pelvic-fin-clipped fish than for those that have clipped pectoral, dorsal, or anal fins (Nicola and Cordone 1973), probably because the adipose and pelvic fins are not as important as other fins for movement or balance (McNeil and Crossman 1979).

However, some work has shown that fish without an adipose fin may have a more difficult time swimming through turbulent water (Buckland-Nicks et al. 2011; Reimchen and Temple 2003).

In addition to fin clipping, PIT tags and CWTs are additional ways available to differentially mark fish. PIT tags are inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled. Thus, tagging needs to take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a recovery tank.

Most studies have concluded that PIT tags generally have very little effect on growth, mortality, or behavior. Early studies of PIT tags showed no long-term effect on growth or survival (Prentice et al. 1987; Prentice and Park 1984; Rondorf and Miller 1994). In a study between the tailraces of Lower Granite and McNary Dams (225 km), Hockersmith et al. (2000) concluded that the performance of yearling Chinook salmon was not adversely affected by orally or surgically implanted sham radio tags or PIT tags. However, (Knudsen et al. 2009) found that, over several brood years, PIT tag induced smolt-adult mortality in Yakima River spring Chinook salmon averaged 10.3 percent and was at times as high as 33.3 percent.

Coded-wire tags are made of magnetized, stainless-steel wire and are injected into the nasal cartilage of a salmon and thus cause little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs should be inserted are similar to those required for PIT tags. A major advantage to using CWTs is that they have a negligible effect on the biological condition or response of tagged salmon (Vander Haegen et al. 2005); however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

Mortality from tagging is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release—it can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

6.4.4. Masking

Hatchery actions also must be assessed for risk caused by masking effects, defined as when hatchery fish included in the Proposed Action are not distinguishable from other fish. Masking undermines and confuses RM&E, and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects. When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking, and whether and to what extent listed salmon and steelhead are at increased risk as a result of misidentification in status evaluations. The analysis also takes into account the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important RM&E.

6.5. Factor 5. Construction, operation, and maintenance, of facilities that exist because of the hatchery program

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles, and adults. These actions can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS analyzes changes to: riparian habitat, channel morphology, habitat complexity, in-stream substrates, and water quantity and quality attributable to operation, maintenance, and construction activities. NMFS also confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria.

6.6. Factor 6. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis:

1) Fisheries that would not exist but for the program that is the subject of the Proposed Action, and listed species are inadvertently and incidentally taken in those fisheries.
2) Fisheries that are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed salmon ESU or steelhead DPS, from spawning naturally.

"Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations with regard to harvest of some Pacific salmon and steelhead populations. For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans" (NMFS 2005). In any event, fisheries must be carefully evaluated and monitored based on the take, including catch and release effects, of ESA-listed species.

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