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ANCHOR QEA

Memorandum

To: Wells, Rocky Reach, and Rock Island HCP Hatchery Committees and Priest Rapids Coordinating Committee Hatchery Subcommittee

Document Date: May 15, 2024

From: Tracy Hillman, HCP Hatchery Committees Chairman and PRCC Hatchery Subcommittee Facilitator

cc: Larissa Rohrbach and Natasha Winnacott, Anchor QEA

Re: Minutes of the April 17, 2024, HCP Hatchery Committees and PRCC Hatchery Subcommittee Meetings

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plan Hatchery Committees (HCP-HCs) and Priest Rapids Coordinating Committee's Hatchery Subcommittee (PRCC HSC) meetings were held in person at the Douglas PUD Auditorium and virtually on Wednesday, April 17, 2024, from 10:00 a.m. to 1:30 p.m. Attendees are listed in Attachment A to these meeting minutes.

Action Item Summary

Long-Term

Joint HCP Hatchery Committees and PRCC Hatchery Subcommittee

- Keely Murdoch and Mike Tonseth will obtain estimates of pre-spawn mortality (PSM) from Andrew Murdoch to update the retrospective analysis for Wenatchee spring Chinook Salmon (Item I-A). *(Note: This item is ongoing; expected completion date to be determined.)*
  - Mike Tonseth will reach out the Kevin See to inquire whether PSM values presented at the Upper Columbia Science Conference can be used by the Committees.
- Members of the HCP-HCs and PRCC HSC will provide feedback to the Washington Department of Fish and Wildlife (WDFW)-revised version of questions on recalculation for Policy Committees (Item I-A). *(Note: This item is ongoing.)*
- K. Murdoch will create a group to review the Wenatchee Spring Chinook Salmon sliding-scale Proportionate Natural Influence (PNI) targets using more recent escapement data (Item I-A). *(Note: This item is ongoing.)*

Near-Term (to be completed by next meeting)

Joint HCP Hatchery Committees and PRCC Hatchery Subcommittee

- Catherine Willard will research feasibility questions around planning for potential emergency Okanogan Sockeye Salmon broodstock collection, including the following (Item I-A) *(Note: This item is ongoing.)*:
  - Flexibility around quarantine requirements for transporting adult fish into Canada
  - Minimum feasible program size under an emergency scenario
- Tracy Hillman will follow up with Brett Farman to seek National Oceanic and Atmospheric Administration (NOAA) Fisheries' approval of the technical sections of the 10-Year Comprehensive review (Item II-A).
- The HCP-HCs and PRCC HSC parties will compile management and monitoring recommendations for discussion in the May 15, 2024, meeting (Item II-A).
- The HCP-HCs and PRCC HSC members will consider the range of options for broodstock collection in the Wenatchee Basin that could be included in future permit applications (Item II-B).

Decision Summary

- HCP-HCs and PRCC HSC representatives present approved Chelan PUD's *BY 2023 to 2025 Wenatchee Steelhead Release Plan* (Item IV-A).

Agreements

- HCP-HCs and PRCC HSC representatives present agreed to final revisions to the technical sections of the 10-Year Comprehensive Summary Report, and Brett Farman agreed on May 15, 2024 (Item II-A).

Review Items

- Douglas PUD's proposal to change steelhead size-at-release targets was distributed on March 13, with additional responses to comments by email on March 29 for approval in the May 15, 2024, meeting (Item III-A).

Finalized Documents

- The Rock Island/Rocky Reach HCP Hatchery Committee-approved *BY 2023 to 2025 Wenatchee Steelhead Release Plan* was distributed on May 1, 2024.

I. Welcome

A. Agenda, Approval of Past Minutes, Action Item Review

Tracy Hillman welcomed the HCP-HCs and PRCC HSC and reviewed the agenda. Hillman asked for any additions or changes to the agenda. Hillman added an agenda item to create an agenda for the White River meeting on April 18, 2024. No other revisions were requested by HCP-HCs and PRCC HSC representatives. No NOAA Fisheries representatives were present at today's meeting.

The revised meeting minutes from March 20, 2024, were reviewed and approved by representatives that attended that meeting.

Action items from the HCP-HCs and PRCC HSC March 20, 2024, meeting were reviewed.
(Note: Italicized text below corresponds to action items from the previous meeting.)

Long-Term

Joint HCP Hatchery Committees and PRCC Hatchery Subcommittee

- *Keely Murdoch and Mike Tonseth will obtain estimates of PSM from Andrew Murdoch to update the retrospective analysis for Wenatchee spring Chinook Salmon (Item I-A). (Note: This item is ongoing; expected completion date to be determined.)*
    - *Mike Tonseth will reach out the Kevin See to inquire whether PSM values presented at the Upper Columbia Science Conference can be shared with the Committees.*

  Mike Tonseth said the issue is not whether these data can be made available to the Committees, but whether they would be useful in updating the management plan. Hillman added that Committee members can obtain See's presentation online (https://www.ucsrb.org/meetings-events/conferences-workshop/uc2024/).
- *Members of the HCP-HCs and PRCC HSC will provide feedback to the WDFW-revised version of questions on recalculation for Policy Committees (Item I-A). (Note: This item is ongoing.)*
  No updates were provided.

Near-Term (to be completed by next meeting)

Joint HCP Hatchery Committees and PRCC Hatchery Subcommittee

- *Catherine Willard will research feasibility questions around planning for potential emergency Okanogan Sockeye Salmon broodstock collection, including the following (Item II-F): (Note: This item is ongoing.)*
    - *Flexibility around quarantine requirements for transporting adult fish into Canada*
    - *Minimum feasible program size under an emergency scenario.*

Willard said she continues to work on this item and had no update at this time.

- *The HCP-HCs and PRCC HSC will continue their review of steelhead, summer Chinook Salmon, and fall Chinook Salmon in the 10-Year Comprehensive review (Item II-C).*
  Hillman said that he received comments from some Committee members, and from his understanding, members that did not comment will not be providing comments. Pending Hillman receiving approval of the technical portion of the report from Brett Farman, this item is complete.
- *K. Murdoch will create a group to review the Wenatchee Spring Chinook sliding-scale PNI targets using more recent escapement data (Item II-E).*
  K. Murdoch was not present to comment during this portion of the meeting, and no updates were provided.

PRCC Hatchery Subcommittee

- *PRCC HSC members will consider questions and monitoring approaches to evaluate potential ecological interactions between natural-origin juveniles in Hanford Reach and earlier-released Priest Rapids Hatchery fall Chinook Salmon juveniles in 2025 (Item I-A).*
  Rod O'Connor said that he will update the PRCC HSC when he receives information at the end of the summer or early fall. This item is complete.

II. Joint HCP Hatchery Committees and PRCC HSC

A. 10-Year Comprehensive Summary Report – Remaining Species Program Summaries

Tracy Hillman reviewed the comments he had received and made changes in the report during the meeting.

Hillman reminded the Committees that the 10-Year Comprehensive Summary Report has two components: one that is technical (determines whether objectives were met) and the other identifies management and monitoring and evaluation (M&E) recommendations. He said the goal today is to approve the technical component of the report. Members will then identify management and M&E recommendations.

Twisp Steelhead

Referring to Objective 2-2.1, relationships between proportion of hatchery-origin spawners and juvenile productivity, it was noted that the analysis was not conclusive because of the lack of contrast in proportion of hatchery-origin spawners (pHOS) values (no values below 0.48) and static pHOS during the 10 years of the relative reproductive success study. Estimates of emigrant production also do not account for fry migrants, the contribution of which to total emigrants remains unknown and may differ with spawner abundance. The data will be included in the annual reports, but stock-recruitment (e.g., Beverton-Holt) estimates will not be provided in the comprehensive summary report.

Keely Murdoch commented on the Twisp steelhead key results, asking whether the variation in redd counts results from variation in hatchery returns and whether there is a relationship between steelhead redd counts and different life histories (e.g., age-0 emigration that is not well monitored) that may explain low emigrants per redd estimates. Kahler described the different relationships between ages observed, and Cory Kamphaus requested that this discussion be retained in the document comments to support management recommendations. Several comments were left in the document to be retained for revising the M&E Plan.

Kirk Truscott commented on Objective 7-7.4 for Methow steelhead. He said to add to a U.S. Fish and Wildlife Service (USFWS) comment that it should be explained that the current management is a relatively new approach to managing steelhead in the Methow Basin (i.e., it is a relatively new management strategy).

For the fall Chinook Salmon section on genetics, there was discussion around changing “mixed” to “inconclusive.” Kamphaus said “mixed” should be changed to “inconclusive” because there are positive and negative results, and “inconclusive” is consistent with the terms chosen throughout the rest of the report.

HCP Hatchery Committee and PRCC HSC representatives present approved the technical section of the 10-Year Comprehensive Summary Report with the exception of Truscott, who abstained from voting because he did not have a sufficient amount of time to review the report. Hillman will follow up with Brett Farman to seek approval because he was not present at today’s meeting.

Hillman will retain two versions of the revised 10-Year Comprehensive Summary Report (Attachment B): a clean version with approved technical content and a version with comments pertaining to monitoring and management recommendations retained to support conversations about revising the M&E Plan.

Monitoring and Management Recommendations

Hillman asked the HCP Hatchery Committee and PRCC HSC representatives to prepare their lists of potential management and M&E recommendations, which will be discussed during the May meeting. The M&E recommendations will guide revisions to the M&E Plan. Hillman said he wants the M&E Plan updated and approved before the end of the year because an approved plan is needed before the PUDs develop contracts with the monitoring entities. Hillman asked that recommendations be sent to him and Larissa Rohrbach. They will compile the recommendations before the May meeting. John Rohrback asked what the goal for the May meeting will be. Hillman said the HCP Hatchery Committee and PRCC HSC representatives will discuss each recommendation and decide unanimously which ones will be implemented and which were considered but not supported by all.

Kamphaus noted that the Yakama Nation (YN) had proposed convening the Hatchery Evaluation Technical Team (HETT) for this task. Catherine Willard said Chelan PUD would not support convening the HETT. She said the HCP-HCs and PRCC HSC are the technical Committees and should make these decisions. Kamphaus said he may invite other technical leads to attend meetings and advise the process with their knowledge or capacity. Kahler replied that HCs and HSC meetings are not a forum closed to other personnel of the Parties to the respective agreements, and technical staff are always welcome to attend and participate in the meetings. Truscott said in the past, the HETT was supposed to provide the Committees with evaluation and recommendations and asked for clarification why Willard did not think the HETT should take on this task. Willard said when the HETT was most recently convened to discuss changes in Wenatchee steelhead monitoring, it was difficult to have a productive and unbiased discussion when one of the participating entities was being funded to implement the work. She said the HCP does not designate the need for a HETT specifically. Truscott suggested it was convened in the past because the HCP-HCs did not have the right expertise to address the technical tasks. Willard continued that the discussions would ultimately come back to the HCP-HCs and PRCC HSC and so Chelan PUD would prefer to hold the discussions in this forum.

B. Hatchery Genetic Management Plan Updates

Catherine Willard explained the need to prepare for upcoming permit renewals by revising Hatchery Genetic Management Plans (HGMPs), starting with Wenatchee spring Chinook Salmon, which has the earliest expiration date.

Willard asked that the HCP-HCs and PRCC HSC representatives start to consider how spring Chinook Salmon broodstock could be collected if Tumwater Dam were no longer there or if it were modified. Because multiple programs collect broodstock at Tumwater Dam, the Committees need to discuss alternatives for collecting broodstock if broodstock cannot be collected at Tumwater Dam.
Mike Tonseth added that changes to Tumwater Dam would also affect broodstock collection for other species as well (steelhead, Coho Salmon, and summer Chinook Salmon).

Cory Kamphaus asked how the options would be considered in the HGMP if one option is excluded prematurely because it is not likely to be feasible. Willard said in other HGMPs, they evaluated all potential options and then identified the preferred alternatives. Tonseth added that given that the next permit would cover a 10-year period, the Committees want to make sure that alternatives are part of the consultation package. If, over the 10-year period, the programs make a shift from collecting broodstock at Tumwater Dam, alternatives have already been considered and there will not be a delay in implementing changes. He agreed with Willard that we need to start conversations now.

Hillman asked whether the Committees wanted to discuss possible alternatives now. Without getting into the weeds, members offered the following ideas.

The Chiwawa program uses a weir in the Chiwawa River, while the Nason Creek program does not. A weir or tangle netting would be needed in Nason Creek. Kamphaus said that the YN would likely propose a weir in Nason Creek. O'Connor said that proposed weir sites would be on federal lands. Tonseth replied that it is not all federal land—there may be other viable options.

Truscott asked Willard to confirm that the Chiwawa weir has provided enough broodstock in recent years. Willard said for the past 3 years it has, but because USFWS Ecological Services reviewed this program and trapping constraints are different this year, the PUD will continue to monitor the performance of the weir. Truscott said he does not want the Committees to conclude that the Chiwawa weir is fine and thus not consider other options. He said the future is changing, so the Committees need to think about alternatives now.

Willard said Tumwater Dam could look different; maybe fish could be passed in river, and the programs could collect fish on the left bank. She said that is a long way away, and programs also need something that they would be able to implement relatively soon.

Todd Pearsons asked whether there is any ability to capture spring Chinook Salmon brood at Dryden Dam. Tonseth replied that fish can be captured there, but being able to differentiate the upper Wenatchee program fish from Leavenworth National Fish Hatchery (LNFH) fish would be difficult. Pearsons said the managers should be able to come up with a way to distinguish those fish, but he and Tonseth said a lot of fish would have to be sorted to find differences. A challenge is whether there is enough adult holding capacity to sort through that many fish. Tonseth said he is talking about transporting fish to another facility; if there are adipose fin-clipped, coded-wire-tagged fish coming out of the upper Wenatchee basin, and hatchery-origin fish for broodstock are needed, genetic screening needs to occur, but this is probably too far into the weeds at this time.

Tonseth said that the programs are moving away from the collection on the mainstream Wenatchee River to more of a tributary collection. Pearsons asked if the holding issue would go away and allow fish to be held at Dryden Dam using different marking/tagging systems to distinguish the upper Wenatchee from LNFH. Tonseth replied maybe, but low trap efficiency during spring Chinook Salmon movement means that it is not possible to capture the fish needed. Kamphaus said the spring flows at Dryden Dam make the traps extremely inefficient in the spring. Truscott said the

Committees also need to think about Tumwater Dam's use in M&E—for example, conducting the relative reproductive success study would not have happened without Tumwater Dam.

Kamphaus said it would be good to understand how long this process for updating HGMPs will take and the deadline. Tonseth said it would be ideal to have the HGMP submitted to NOAA Fisheries before the expiration of the permit. Previously, the permit holders requested an extension on the permit while NOAA Fisheries was reviewing it. It would be ideal not to have to request an extension like this again. An hour should be set aside during each monthly meeting to discuss and sort through viable alternatives to meet broodstock, adult management, and run composition data.

Hillman suggested, starting with Wenatchee spring Chinook Salmon, identifying scenarios the Committees want NOAA Fisheries to think about for discussion in next month's meeting. Tonseth said the conversations should be well documented because alternatives may affect other programs (e.g., Coho Salmon) because there will be a trickledown effect. The HCP-HCs and PRCC HSC representatives will start considering spring Chinook Salmon and different scenarios for NOAA Fisheries and USFWS to evaluate.

III. Wells HC

A. Douglas PUD Steelhead Size-at-Release Targets

John Rohrback reminded the HCP Hatchery Committee and PRCC HSC representatives that Douglas PUD is proposing to the Committee to change size-at-release targets from six fish per pound (fpp) to eight fpp for Douglas PUD steelhead programs. This was discussed during last month's meeting.

Rohrback discussed questions raised by Kirk Truscott after last month's meeting. Rohrback wrote up answers to questions proposed, and Larissa Rohrbach distributed them to the Committee members on March 29, but he has not heard back from anyone. He is happy to take more questions. He clarified that he is not expecting a decision during this month's meeting but is hoping for one during next month's meeting.

Truscott said if this change is made and fish start being released below the target, in the range of 10 to 12 fpp, then he will have an issue with that. He still believes that there's good evidence that size matters for survival, as long as they are active migrants. Rohrback said that the hatchery staff believe eight fpp is an achievable target, and that he is very confident that Douglas PUD will be able to successfully rear steelhead to eight fpp even after modifying the feed regime these fish currently experience under which it is a challenge to reach the current target of six fpp.

Truscott said the issue of cleaning waste around the center drain with a net and not feeding the rest of day is an odd procedure. Rohrback replied that he has faith that the hatchery staff are following best management practices. Cory Kamphaus asked what those practices are. Rohrback reiterated that because of the intensive feeding regime that Methow Conservation steelhead are subjected to in an attempt to reach the size-at-release target, unconsumed fish feed may accumulate at the bottom of the round tanks, especially later in the rearing cycle when larger sized fish pellets are being used. When hatchery staff notice accumulated unconsumed feed, it is removed from the ponds with a net.

Truscott said that the change in feeding regimen may result in a potential to get a larger coefficient of variation (CV). Rohrback replied that the opposite may also be the case—he has spoken with hatchery staff who believe that they can rear fish with tighter CVs at an eight-fpp size-at-release target. Truscott asked whether the fish could be size graded (separated by size). Typically, that results in smaller CVs.

Mat Maxey asked whether this has to be a programmatic change or whether it could be an experimental change that is evaluated to see how well the proposed change works. He asked whether Douglas PUD could conduct a study with a change to a portion of the production and evaluate how the population outmigrates and returns over a set period of time. Rohrback said Mike Tonseth had asked about separating a pond to rear half to eight fpp and half to six fpp. Rohrback said that Douglas PUD cannot do that because they do not have the infrastructure. Hillman said this could be done as a before-after study to test whether CV and size requirements are being met. Evaluating adult performance will be more problematic with a before-after study.

Tonseth said that another idea is to raise Methow Safety Net (MSN) fish to eight fpp and Columbia Safety Net (CSN) fish to six fpp, then compare the groups. However, there is bias in this because they use different fish as the broodstock for each program. If they could get sufficient Winthrop National Fish Hatchery (WNFH) returns to satisfy both program needs, they may be able to make a comparison. Tonseth said one of his concerns is related to marking. Right now, they are not able to differentiate MSN and CSN adult returns. If the MSN and CSN groups were reared to different sizes, Tonseth would want to see marking implemented that allows us to conduct post-release assessments. That would include using passive integrated transponder-tag groups for MSN and CSN components, because coded-wire tags (CWT) cannot be used to differentiate CSN returns from MSN returns (only the WNFH releases have CWTs). Rohrback said there is one way they could have a comparison: by releasing the MSN component into Columbia River and not into the Methow River. However, that is a programmatic change and not just an alteration to size at release. Tonseth said WDFW would not support that at this time.

Hillman said Rohrback would like a decision on the proposal during the May 15, 2024, meeting. There may be an option to approve an experimental approach that would be conducted and evaluated over a few years. Rohrback requested that HCP Hatchery Committee and PRCC HSC representatives send him additional questions as soon as possible.

IV. Rock Island/Rocky Reach HCP Hatchery Committee

A. DECISION: Brood Year 2023 to 2025 Wenatchee Steelhead Release Plan

The brood year 2023 to 2025 Wenatchee Steelhead Release Plan was sent out on March 21, 2024, and was discussed during last month's meeting. Catherine Willard reminded the HCP Hatchery Committee and PRCC HSC representatives that the primary objective is to evaluate whether steelhead at the Chiwawa River that are truck planted into the upper Wenatchee River return as adults. She provided a calendar of the general schedule for when the activities will occur. She has not received any comments since the last meeting and asked the HCP Hatchery Committee and PRCC HSC representatives present if they had any.

Kirk Truscott commented that he has reservations about being able to evaluate the secondary objectives because of a potential bias in the releases and asked whether the wild-by-wild (WxW) progeny would be released before the hatchery-by-hatchery (HxH) progeny. Willard clarified that there would not be a bias, because although the indoor-reared WxW fish will be released first, there are also WxW and HxH fish being reared in the raceways, and they will be released at the same time. Truscott replied that he would support the plan.

No members had any further comments. The HCP Hatchery Committee and PRCC HSC representatives present approved the brood year 2023 to 2025 Wenatchee Steelhead Release Plan. Brett Farman approved via email.

V. PRCC HSC

A. White River Spring Chinook Salmon Hatchery Meeting Planning

Tracy Hillman said he would like to identify the specific objectives and potential outcomes for the White River spring Chinook Salmon hatchery program discussion tomorrow. He reviewed the 2018 White River Memorandum decision tree, and the following topics were discussed:

- Regarding whether the Wenatchee spring Chinook Salmon population is meeting the viable salmon population criteria in 2025, Keely Murdoch said the PRCC HSC know the answer is probably "no." Hillman agreed and said that NOAA Fisheries will need to provide the PRCC HSC with an official response as noted in the table.
- K. Murdoch suggested reviewing the March 2020 email with responses from NOAA Fisheries to develop goals for the day.
- K. Murdoch said that, when looking at the decision tree, Task 3 is the expert panel review. She suggested time to discuss panel member qualifications, when it will occur (what is the timeline), and whether it will be in person. She thinks that the PRCC HSC should focus on Steps 1, 2, and 3 of the decision tree before moving to Step 4 (feasibility). She said that the PRCC HSC needs to

discuss the selection criteria for the expert panel (what qualifications and expertise) and describe what "independent" means in the selection of the expert panel.

- K. Murdoch said, regarding the sub-questions in Table 1 of the White River Memorandum, that the PRCC HSC needs to make sure there is nothing more they would like to provide to the expert panel.
- K. Murdoch said that by Step 4 of the decision tree, the PRCC HSC are considering whether it is possible to collect sufficient broodstock. This is the first part of the feasibility analysis that only kicks in if the expert panel says it recommends adult-based supplementation. Steps 4, 5, and 6 of the decision tree compose the feasibility analysis. Moving forward, the PRCC HSC will not be able to make a decision on this because they do not have the facts and understanding from the expert panel.
- Todd Pearsons said he understands that there may not be a clean path between the decision tree and Table 1 in the White River Memorandum. He does not see how the expert panel would be able to evaluate the benefits and costs of a program if it does not understand the challenges with broodstock collection, which include potential unintended impacts to other targets, and that type of information should be made available to the expert panel in its decision. K. Murdoch disagreed and thinks there is a clear path. She thinks that they should not muddy the expert panel's view with whether it is feasible or not, but rather provide it with the information that it needs to decide whether it can be done. The question of whether a facility and infrastructure can be acquired is not being asked to the expert panel. It will be answering questions in Table 1 of the White River Memorandum, and based on the expert panel's recommendations, it can be done, then the PRCC HSC can move forward with the question of whether they can get enough broodstock. Pearsons said he does not know how one could answer Question 3 in Table 1 of the White River Memorandum without understanding the direct and indirect effects of broodstocking. K. Murdoch replied that the PRCC HSC worded these questions in this way for a reason, and suggested reviewing each question in tomorrow's meeting to see what data are available, highlight new data sources, and make sure that PRCC HSC are still happy with each question.
- Pearsons agreed on the topics to be discussed during the meeting tomorrow and in the future. Hillman agreed to review the decision tree and table and identify specific agenda items for tomorrow's meeting.
- Rod O'Connor mentioned the broodstock collection risk matrix that Grant PUD has prepared, and Hillman said it should also be reviewed and discussed tomorrow.
- Truscott said that some of the responses from NOAA Fisheries in March 2020 were inconclusive and could be interpreted multiple ways. Hillman said that NOAA Fisheries will need to review their responses and provide more clarity if necessary.

Hillman asked whether everyone approved the draft agenda topics for tomorrow; all PRCC HSC representatives present approved them.

A. Next Meetings

The HCP Hatchery Committee and PRCC HSC representatives present agreed to adjust the June meeting to June 20, 2024, to accommodate the Juneteenth holiday.

The next meetings of the HCP-HCs and PRCC HSC will be held on May 15, June 20, and July 17, 2024. Meetings will be held in person at Douglas PUD.

VI. Attachments

Attachment A List of Attendees
Attachment B 10-Year Hatchery M&E Technical Report Summary

Attachment A
List of Meeting Attendees

Name	Organization
Natasha Winnacott	Anchor QEA
Larissa Rohrbach	Anchor QEA
Tracy Hillman	BioAnalysts, Inc.
Ross Renick	Chelan PUD
Catherine Willard*	Chelan PUD
Tom Kahler*	Douglas PUD
John Rohrback*	Douglas PUD
Betsy Bamberger°	Douglas PUD
Brandon Kilmer°	Douglas PUD
Rod O'Connor‡	Grant PUD
Todd Pearsons‡°	Grant PUD
Tim Taylor	Grant PUD
Katy Shelby°	Washington Department of Fish and Wildlife
Mike Tonseth*‡°	Washington Department of Fish and Wildlife
Mathew Maxey*‡°	U.S. Fish and Wildlife Service
Keely Murdoch*‡°	Yakama Nation
Cory Kamphaus*‡	Yakama Nation
Kirk Truscott*‡	Confederated Tribes of the Colville Reservation

Notes:
* Denotes HCP-HCs member or alternate
‡ Denotes PRCC HSC member or alternate
° Joined remotely

MONITORING AND EVALUATION OF THE CHELAN, DOUGLAS, AND GRANT COUNTY PUDs HATCHERY PROGRAMS

TEN-YEAR COMPREHENSIVE TECHNICAL REPORT SUMMARY

April 17, 2024

Prepared by:
HCPs Hatchery Committees and the PRCC Hatchery Sub-Committee
Wenatchee, East Wenatchee, and Ephrata, WA

Citation: HCP Hatchery Committees and PRCC Hatchery Subcommittee. 2024. Monitoring and evaluation of the Chelan, Douglas, and Grant County PUDs hatchery programs: Ten-Year Comprehensive Technical Report Summary. Wenatchee, East Wenatchee, and Ephrata, WA.

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PREFACE

The Rock Island, Rocky Reach and Wells Habitat Conservation Plans (HCP) require that the HCP hatchery programs undergo a program review incorporating new information from the monitoring and evaluation program. The program review will determine if the hatchery program goals and objectives as defined in the monitoring and evaluation plan for PUD hatchery programs (Hillman et al. 2019) and the Section 10 of the ESA permits have been met or sufficient progress is being made toward their achievement. The review shall include a determination of whether hatchery production objectives are being achieved and a review to identify adjustments to the monitoring and evaluation programs. The HCP Hatchery Committees shall be responsible for conducting the hatchery program review and developing a summary report.

This comprehensive summary report is the result of an extensive amount of field work and data analyses conducted since the initiation of the hatchery programs to collect the data needed to monitor the performance of the Chelan, Douglas, and Grant County PUD Hatchery Programs. This work was directed and coordinated by the Rock Island, Rocky Reach and Wells Habitat Conservation Plans (HCP) Hatchery Committees and the Priest Rapids Coordinating Committee (PRCC) Hatchery Sub-Committee.

The approach to monitoring the hatchery programs was guided by the monitoring and evaluation plan for PUD hatchery programs (Hillman et al. 2019). Technical aspects of the monitoring and evaluation program were developed by the Hatchery Evaluation Technical Team (HETT). The plan also directs the analyses of hypotheses developed by the HETT. The analyses outlined in the monitoring and evaluation plan were followed in this report.

Chelan, Douglas, and Grant PUDs funded most of the work reported in this document. Bonneville Power Administration funded various components including some of the Passive Integrated Transponder (PIT) tags that were used to mark juvenile Chinook and steelhead captured in tributaries, several of the PIT-tag arrays in the Upper Columbia, a portion of the screw trap efforts in Nason Creek, and development of models used to help estimate spawning escapements of steelhead and Chinook Salmon. The Army Corps of Engineers and Washington Department of Fish and Wildlife co-funded monitoring activities associated with the Hanford Reach Fall Chinook Salmon.

SECTION 1: INTRODUCTION

Douglas, Chelan, and Grant PUDs implement hatchery programs as part of their respective agreements related to the operation of Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids Hydroelectric Projects. The fish resource management agencies developed the following general goal statements for the hatchery programs, which were adopted by the HCP Hatchery Committees and PRCC Hatchery Sub-Committee (hereafter, Hatchery Committees):

1. *Support the recovery of ESA-listed species by increasing the abundance of the natural adult population, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity.*
2. *Increase the abundance of the natural adult population of unlisted plan species, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity. In addition, provide harvest opportunities in years when spawning escapement is sufficient to support harvest.*
3. *Provide salmon for harvest and increase harvest opportunities, while segregating returning adults from natural tributary spawning populations.*

Following the development of the Hatchery and Genetic Management Plans (HGMPs), artificial propagation programs are now characterized into three categories. The first type, integrated conservation programs, are intended to support or restore natural populations. These programs focus on increasing the natural production of targeted fish populations. A fundamental assumption of this strategy is that adults spawned in the hatchery will produce more adult offspring than if they were left to spawn in the river and ultimately provide a demographic boost to the natural population. The second type, safety-net programs, are extensions of conservation programs, but are intended to function as reserve capacity for conservation programs in years of low returns. The safety-net provides a demographic and genetic reserve for the natural population. That is, in years of abundant returns, they function like segregated programs, and in years of low returns, they can be managed as conservation programs. Lastly, harvest augmentation programs are intended to increase harvest opportunities while limiting interactions with natural-origin counterparts.

Monitoring is needed to determine if the hatchery programs are meeting the intended management objectives of conservation, safety-net, or harvest augmentation programs. Objectives for hatchery programs are generally grouped into three categories of performance indicators:

1. In-Hatchery Indicators: Are the programs meeting the hatchery production objectives?
2. In-Nature Indicators: How do hatchery fish from the programs perform after release?
   a. Conservation Programs:
      - How do the programs affect target population abundance and productivity?
      - How do the programs affect target population long-term fitness?
   b. Safety-Net Programs:
      - How do the programs affect target population long-term fitness?

   c. Harvest Augmentation Programs:
      - Do the programs provide harvest opportunities?

3. Risk Assessment Indicators: Do the programs pose risks to other populations?

The specific objectives identified in the monitoring and evaluation plan are as follows:

1. *Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.*
2. *Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.*
3. *Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.*
4. *Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.*
5. *Determine if the migration timing, spawn timing, and spawning distribution of both the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.*
6. *Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.*
7. *Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.*
8. *Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.*
9. *Determine if hatchery fish were released at the programmed size and number.*
10. *Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.*

Two additional regional objectives that were not explicit in the goals specified above but were included in the updated monitoring and evaluation plan because they relate to goals and concerns of all artificial production programs include:

11. *Determine if the incidence of disease has increased in the natural and hatchery populations.*
12. *Determine if the release of hatchery fish affects non-target taxa of concern (NTTOC) within acceptable limits.*

Objective 12 was completed using an extensive risk assessment that concluded risks from the PUD hatchery programs were within containment objectives approved by the Hatchery Committees (Pearsons et al. 2012; Mackey et al. 2014).

Objectives in the plan have been organized in a hierarchy where productivity indicators are the primary metrics used to assess if conservation and safety-net program goals have been met; harvest rates and effects on non-targeted populations are used for harvest programs. In cases where productivity indicators are not available, or results are equivocal, monitoring indicators may be used to help evaluate the performance of the program. Evaluations of monitoring indicators may not provide sufficiently powerful conclusions on which to base management actions; although, they may provide insight as to why a productivity indicator did or did not meet the program goal. Therefore, the relationship between hatchery programs and indicators can be viewed in a chain-of-causation: management actions within the hatchery programs affect the status of monitoring indicators, which in turn influence productivity indicators (Figure 1.1).

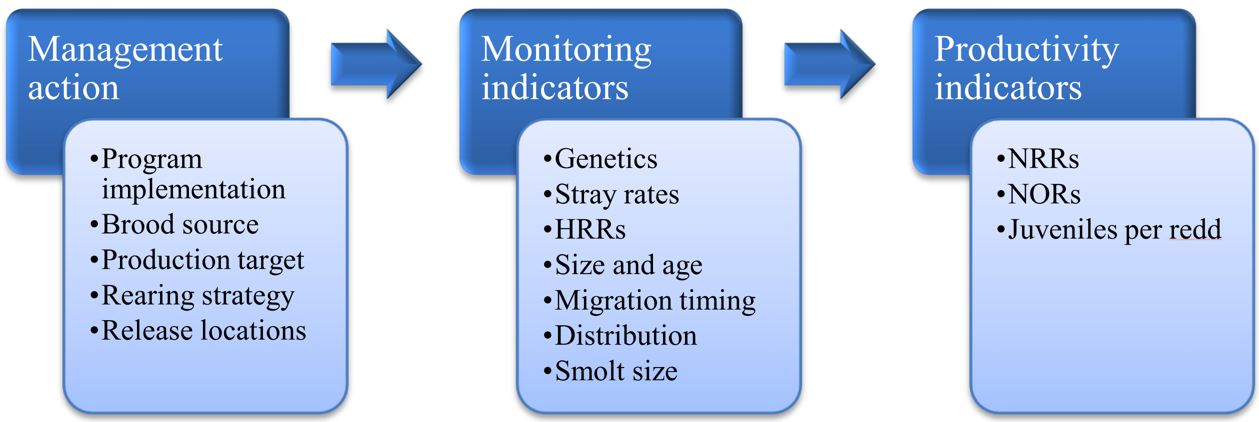

Figure 1.1. Relationship of indicators to the assessment of propagation programs. Management actions affect monitoring indicators, which influence productivity indicators. Monitoring indicators may be used to hypothesize the magnitude of influence on productivity.

Attending each objective is one or more testable hypotheses (see Hillman et al. 2019). Each hypothesis will be tested statistically following the routines identified in the updated monitoring and evaluation plan.

Both monitoring and productivity indicators will be used to evaluate the success of the hatchery programs. If the statistical power of tests that involve productivity indicators is insufficient to inform sound management decisions, some of the monitoring indicators may be used to guide management. Figure 1.2 shows the categories of indicators associated with each component of monitoring.

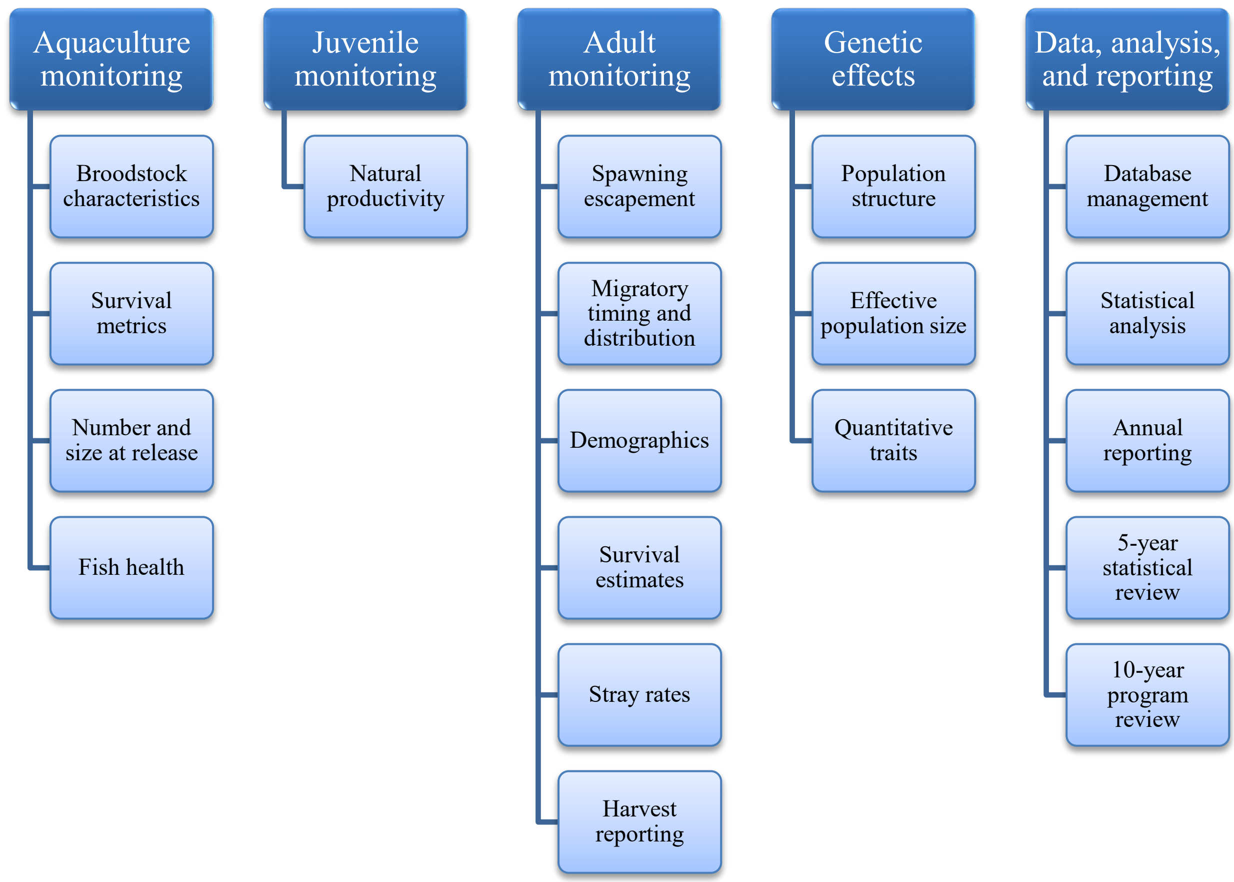

Figure 1.2. Overview of monitoring and evaluation plan categories and components (not including regional objectives).

The purpose of this report is to present a summary of results from the comprehensive evaluation of the hatchery programs. It is important to point out that the analyses included all available data, not just data collected within the past 5-10 years. This report was greatly informed by the comprehensive reports recently completed by the PUDs (Kahler 2023; Pearsons 2023a, 2023b, and 2023c). Those reports presented findings by objective, not by hatchery program. In addition, those reports reflected the integrated information across PUD hatchery programs and discussed the relationship of findings to other programs. Although the Hatchery Committees and Hatchery Subcommittee had the opportunity to review the draft reports, not all comments or edits were accepted and some of the findings and recommendations did not reflect the views of the Hatchery Committees. This report, which was developed by the Hatchery Committees, is organized by species and hatchery program, does not make comparisons among hatchery programs, and reflects the views of the Hatchery Committees. A detailed description of the methods used to evaluate the program is provided in the monitoring and evaluation plan for PUD hatchery programs (Hillman et al. 2019) and the PUD comprehensive reports (Kahler 2023; Pearsons 2023a, 2023b, and 2023c).

SECTION 2: SUMMER STEELHEAD

The PUDs fund several summer steelhead programs. The Wenatchee steelhead conservation and safety-net program is funded by Chelan PUD, while the Twisp steelhead conservation program is funded by Douglas PUD. Douglas PUD also funds the Wells Columbia River safety-net program and the Methow safety-net program. In addition, Grant PUD supports the Okanogan River summer steelhead program operated by the Confederated Tribes of the Colville Reservation (CTCR). The CTCR monitors this program and generates separate reports.

2.1 Wenatchee Summer Steelhead Program

Introduction

The goal of summer steelhead supplementation in the Wenatchee River basin is to use artificial production to replace adult production lost because of mortality at Rock Island and Rocky Reach dams, as well as inundation compensation for Rocky Reach Dam, while not reducing the natural production or long-term fitness of steelhead in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Rock Island and Rocky Reach Anadromous Fish Agreement and Habitat Conservation Plans.

Prior to 1998, steelhead eggs were received from Wells Hatchery (adult broodstock were collected at Wells Dam); fish were reared at Eastbank Fish Hatchery and then released into the Wenatchee River. Beginning in 1998, the program changed to collecting broodstock within the Wenatchee River basin. Currently, adult hatchery-origin steelhead are collected from the run-at-large at the right and left-bank traps at Dryden Dam, and at Tumwater Dam if the weekly quotas cannot be achieved at Dryden Dam. Natural-origin adult steelhead are collected from the run-at-large at Tumwater Dam.

Before 2012, the goal was to collect up to 208 adult steelhead (50% natural-origin fish and 50% hatchery-origin fish) for the Wenatchee steelhead program. In 2011, the Hatchery Committees reevaluated the amount of hatchery compensation needed to achieve NNI. Based on that evaluation, the goal of the program was revised to collect 136 adult steelhead (68 natural-origin and 68 hatchery-origin steelhead) for a 247,300 smolt release goal. The adult broodstock collection goal changes slightly from year to year, with an average of 133 adult steelhead collection goal from 2011-2021. The number of broodstock collected cannot exceed 33% of the natural-origin Wenatchee steelhead population. Broodstock collection occurs from about 1 July through 15 November at Dryden and Tumwater dams, with trapping occurring up to 24 hours per day, five days a week. The intent of the current program is to target adults necessary to meet a 50% natural-origin, conservation-oriented program and a 50% hatchery-origin safety-net program.

Before the 2012 brood year, adult steelhead were held and spawned at Wells Fish Hatchery because of unsuitable adult holding temperatures at Eastbank Fish Hatchery. Beginning with the 2012 brood year, holding and spawning of adult steelhead occurs at Eastbank Fish Hatchery with the installation of a water chiller system. Before 2012, juvenile steelhead were reared at a combination of facilities including Eastbank, Chelan, Turtle Rock, Rocky Reach Annex, and Chiwawa facilities. Juvenile steelhead reared in these facilities were trucked to release locations on the

Wenatchee River, Chiwawa River, and Nason Creek. A percentage of the fish were also released volitionally from Blackbird Pond and Rolfing Pond. Beginning in the fall of 2012, the entire Wenatchee steelhead program overwinters at the Chiwawa Acclimation Facility. Some of these fish were transferred to short-term remote acclimation sites (e.g., Blackbird Pond and Rolfing Pond), while others were planted from trucks throughout the Wenatchee River, Nason Creek, and Chiwawa River.

Before 2012, the production goal for the Wenatchee steelhead supplementation program was to release 400,000 yearling smolts into the Wenatchee Basin at six fish per pound. Since 2012, the revised production goal was to release 247,300 smolts (123,650 for conservation and 123,650 for safety net). The target for fork length coefficient of variation (CV) is 9.0 and the target size at release is 6 fish per pound. Over 96% of these fish receive CWTs. In addition, from 2006 to 2009, juvenile steelhead from different parental-cross groups (e.g., WxW, HxW, and HxH) were PIT tagged annually. No intentional HxW crosses have been part of the Wenatchee steelhead program since brood year 2009.

Beginning in 2010 and consistent with ESA Section 10(a)(1)(A) permit 18583, adult management activities have been conducted as needed to remove excess hatchery-origin steelhead before they spawn in the natural environment. This is accomplished through removal at Tumwater Dam and/or through conservation fisheries. The objective of these activities is to achieve proportion of hatchery-origin spawners (pHOS) and Proportionate Natural Influence (PNI) goals for the Wenatchee steelhead program. Results of adult management activities through conservation fisheries are submitted to NOAA Fisheries in a separate annual report by 31 August of the year the adult management was concluded.

Key Results

Key results from analyses conducted on Wenatchee River steelhead are presented as findings and comments by M&E Plan objective in Table 2.1 and summarized below to facilitate interpretation.

Because there were no reliable pre-supplementation data or reference populations to compare with Wenatchee River steelhead, we evaluated steelhead population dynamics using stock-recruitment models and trend analyses. Adults collected and spawned in the hatchery produced considerably more adult recruits per spawner than those that spawned in the natural environment. Hatchery replacement rates averaged 11.0 (median = 7.9) and at no time did they fall below 1.0 or were less than natural replacement rates. For the 28 years of data (brood years 1989-2016), abundance of total spawners, natural-origin spawners, natural-origin adult recruits, and density-adjusted productivity of Wenatchee River steelhead trended downward or remained static over time. During this time period, natural replacement rates exceeded 1.0 in 4 of the years and averaged 0.7 (median = 0.4). The Ricker stock-recruitment model indicated that 1,333 spawners are needed to produce the maximum number of adult recruits in the Wenatchee River. Replacement of the population is estimated to occur at about 715 spawners. Although the total abundance of natural-origin spawners trended downward, while the total abundance of hatchery-origin spawners trended upward over time, there was no correlation between the proportion of hatchery-origin spawners (pHOS) and the number of natural-origin adult recruits or natural replacement rates. In addition, there was no correlation between pHOS and the residuals from the Ricker stock-recruitment model. This suggests that factors other than hatchery-origin spawners are affecting the abundance and productivity of natural-origin steelhead in the Wenatchee River basin; however, the pHOS data lack contrast with virtually no observations in the lower half of the pHOS range.

Since 2012, during years in which there was PNI management, the target for Wenatchee River steelhead was not met (there was no PNI management before 2012). The 5-year PNI mean ranged from 0.54-0.57 and therefore did not equal or exceed the target of 0.67 in any year during the period 2012-2018. On an annual basis, the target was not met in any year from 2012-2018. In addition, based on genetic evaluations, the supplementation program may have affected genetic diversity and population structure of steelhead in the Wenatchee River basin. Hatchery collections had higher levels of linkage disequilibrium and lower estimates of effective numbers of breeders (N_b) than collections from natural-origin steelhead. This is likely the result of strong family structure and the small number of parents spawned. In addition, contemporary hatchery collections were genetically distant from natural baseline and contemporary collections. This suggests genetic drift is occurring in the hatchery collection to a higher degree than in the naturally spawning population. This pattern is likely due to the low number of steelhead used as broodstock.

The effects of the Wenatchee River steelhead supplementation program on phenotypic and life-history characteristics varied. The migration timing of natural- and hatchery-origin steelhead in the Wenatchee River differed significantly with hatchery-origin steelhead arriving about 7-12 days earlier than natural-origin fish. Differences in migration timing between natural- and hatchery-origin steelhead in the Wenatchee River basin did not translate into differences in spawn timings. Both natural- and hatchery-origin steelhead spawned at similar times. In addition to differences in migration timing, age at maturity and size at maturity also differed between hatchery- and natural-origin steelhead in the Wenatchee River basin. For both males and females, hatchery-origin fish generally returned at a younger salt age than did natural-origin fish, but the predominate age at maturity was similar between hatchery- and natural-origin fish. The size at maturity of returning adults was significantly affected by age, sex, and origin. However, when matched by age and sex, the differences in size at maturity by origin that were statistically significant were minor (<3 cm) and likely of little biological relevance. Fecundity metrics were significantly affected by fish size and weight, but fecundity did not differ between natural- and hatchery-origin steelhead in the Wenatchee River basin.

Hatchery-origin steelhead from the Wenatchee River program strayed into the Entiat, Methow, and Okanogan subbasins but rarely made up more than 5% of the recipient populations there. Since 2014, based on return-year analyses, hatchery-origin steelhead from the Wenatchee River program have made up less than 4% of recipient populations. Based on brood year analysis, on average, about 3% of the 2011-2016 brood years strayed into non-target streams. In contrast, on average, 23% of the 2005-2010 brood years strayed into non-target streams. Virtually no fish strayed into non-target hatcheries. Although hatchery steelhead are released into the Chiwawa River, Nason Creek, and the Wenatchee River, since 2011, hatchery-origin fish have spawned in all major tributaries in the Wenatchee River basin and in some years have made up large percentages of the spawners within those streams.

The Wenatchee River steelhead program met its release goals in most years since the first recalculation period (since brood year 2012). For brood years 2012-2017, the target of 247,300 (±10%) was met in 5 of 6 brood years; one brood-year release was below the target. In contrast, for the same brood years, the program did not meet the FPP or CV targets. Releases were generally greater than the 6 FPP target and they consistently exceeded the CV target of <9.0. Wenatchee River steelhead exhibited near-isometric growth with a mean condition factor of 1.12.

Since its initiation, the Wenatchee River steelhead program produced fish that have contributed to recreational and Columbia River fisheries (a mix of tribal and non-tribal harvest). Virtually no

Wenatchee River hatchery-origin steelhead were harvested in the ocean. From 2006-2018, recreational steelhead harvest occurred in the Wenatchee River in 8 of the 12 years. During this period, 56-444 hatchery-origin steelhead were harvested from the Wenatchee River (this represents 0.6-3.7% of the escapement of Wenatchee hatchery-origin fish to Priest Rapids Dam).

Table 2.1. Summary of monitoring and evaluation results for Wenatchee River summer steelhead by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Not Met: Total steelhead spawner abundance varied widely (610-4,209; median = 1,445) with no apparent trend over time (BYs 1989-2016).	There were no reliable before-supplementation data or reference populations for comparisons with the supplementation period. This limits our ability to assess the effects of supplementation on total spawners. Removal of hatchery fish to meet pHOS targets limits the total number of steelhead spawners.
1.2 Natural-Origin Spawners (NOS)	Not Met: The abundance of natural-origin steelhead spawners varied widely (392-3,030; median = 864) with a discernable downward trend over time (BYs 1989-2016).	There were no reliable before-supplementation data or reference populations for comparisons with the supplementation period. This limits our ability to assess the effects of supplementation on natural-origin spawners.
1.3 Natural-Origin Recruits (NOR)	Not Met: The number of natural-origin steelhead recruits varied widely (183-1,760; median = 871) with a discernable downward trend over time (BYs 1989-2016).	There were no reliable before-supplementation data or reference populations for comparisons with the supplementation period. This limits our ability to assess the effects of supplementation on natural-origin recruits.
1.4 Adjusted Productivity (NRR)	Not Met: Adjusted natural-origin productivities of steelhead varied widely (0.14-2.40; median = 0.76) with a discernable downward trend over time (BYs 1989-2016). During that period, adjusted NRRs exceeded 1.00 in 4 of the 19 years.	There were no reliable before-supplementation data or reference populations for comparisons with the supplementation period. This limits our ability to assess the effects of supplementation on adult productivity.
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Inconclusive: No data available to conduct juvenile productivity estimates.	In addition to a lack of data to conduct stock-recruitment analysis with juveniles, there are no reference populations or before-supplementation data available for more robust analyses.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		

M&E Objective	Findings	Comments
3.1 HRR > NRR	Met: HRR ≥ NRR in 15 of 15 years and the mean HRR was significantly larger than the mean NRR ($P < 0.01$).	
3.2 HRR ≥ Target	Met: HRRs ranged from 3.63-33.48 (Mean = 11.00; target 6.9). HRR has met the target in four of the last five years (2008-2012).	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Not Met: During the period when there were PNI targets for the Wenatchee River steelhead population (2012-present; however, the time series for the comprehensive review was 2012-2018), the 5-year PNI mean ranged from 0.54-0.57 and therefore did not equal or exceed the target of 0.67. On an annual basis, the target was not met in any of the 7 years.	In recent years, the focus was on managing escapement rather than PNI. This is because of the low run size.
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Not Met: The migration timing of PIT-tagged hatchery- and natural-origin steelhead adults at Tumwater Dam differed significantly ($P < 0.01$). Hatchery-origin fish arrived earlier than did natural-origin fish at Tumwater Dam. Natural-origin fish completed their passage at Tumwater Dam earlier than did hatchery-origin fish. Differences in day of the year for the 10th, 50th, and 90th percentiles varied from 7-12 days.	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.2 Spawn timing	Met: Hatchery- and natural-origin steelhead adults had similar spawn timing ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.3 Spawn distribution	Inconclusive: No data are available at the reach scale to evaluate spawning distribution of hatchery- and natural-origin steelhead adults.	
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual brood year donor stray percentage for hatchery-origin steelhead releases ranged from 0.0-31.4%.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: Wenatchee River hatchery-origin steelhead strayed into the Entiat, Methow, and Okanogan rivers; however, the steelhead program did not exceed the 5%	

M&E Objective	Findings	Comments
	out of basin stray rate target in most years. It exceeded 5% during spawn-years 2011-2013 in the Entiat River and 2011 and 2013 in the Methow River.	
6.3 Return Year Recipient Stray Targets (Within Basin)	No Target: At this time, non-target spawning areas have not been identified in the Wenatchee River basin.	
6.4 Brood Year Recipient Stray Rates	No Target: For brood years 2011-2016, the mean recipient stray percentage for the Wenatchee River steelhead program was 3.3% (range 0.0-9.0%).	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Not Met: Pairwise AMOVA based on allele frequencies among collections within populations showed contemporary collections had less diversity than baseline collections, and most hatchery-origin collections had less diversity than natural-origin collections.	These allele frequency changes suggest that genetic drift has affected the populations, as expected for populations that declined to low abundance and required hatchery intervention.
7.2 Population Genetics (Linkage Disequilibrium)	Inconclusive: Mann-Whitney tests showed significant differences among most pairwise comparisons of collections within population in the amount of linkage disequilibrium, which was not informative.	This was likely a statistical power issue; with 239 SNP loci we had sufficient power to detect small differences between collections. Small differences may not be of conservation concern.
7.3 Population Genetics (Genetic Distance)	Not Met: Within the Wenatchee population, contemporary hatchery-origin adults were genetically different from baseline and contemporary natural-origin adults.	
7.4 Population Genetics (Effective Spawning Population)	Not Met: Hatchery-origin collections had much lower *N*b estimates than natural-origin collections and this low *N*b reduced the *N*b/*N* ratio in the entire population, which was not unexpected due to the nature of demographic and genetic trade-offs associated with hatchery programs.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not Met: Age at maturity (salt age) was significantly different between hatchery- and natural-origin female ($P < 0.01$) and male ($P < 0.01$) adults. For both sexes, hatchery-origin fish returned at a younger age than did natural-origin fish.	

M&E Objective	Findings	Comments
8.2 Phenotype Similarity (Size at Maturity)	Not Met: Size at maturity differed significantly between hatchery- and natural-origin adults and was affected by age, sex, and origin (P < 0.01). However, differences in lengths between natural- and hatchery-origin fish were generally less than 3 cm.	
8.3 Phenotype Similarity (Size and Fecundity)	Met: There were no differences in relationships between hatchery- and natural-origin females for weight and fecundity (P = 0.34), mean egg weight (P = 0.34), and fork length and gonadal mass (P = 0.86).	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2012-2017, the target of 247,300 (±10%) was met in 5 of 6 brood years; one brood-year release was below the target. For brood years before 2012 (before recalculation), the program met the target release number of 400,000 (±10%) in 1 of 14 brood years.	
9.2 Size-at-release (FPP)	Not Met: For brood years 2012-2017, the target of 6 FPP (±10%) was rarely met. Releases were generally greater than 6 FPP (range 6-17 FPP). For brood years before 2012 (before recalculation), the program met the target of 6 FPP (±10%) in 9 of 14 brood years.	
9.3 Size-at-release (CV)	Not Met: For brood years 2012-2017, the CV target of <9.0 was not met for any brood years. CVs ranged from 9.4-22.0. For brood years before 2012 (before recalculation), the program met the CV target of <9.0 in 1 of 14 brood years.	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: Wenatchee River hatchery-origin steelhead contributed to recreational and Columbia River fisheries (a mix of tribal and non-tribal harvest). Virtually no fish were harvested in the ocean. From 2006-2018, recreational steelhead harvest occurred in the Wenatchee River in 8 of the 12 years. During this period, 56-444 hatchery-origin steelhead were harvested from the Wenatchee River (this represents 0.6-3.7% of the escapement of Wenatchee	

M&E Objective	Findings	Comments
	hatchery-origin fish to Priest Rapids Dam).	

2.2 Twisp River Summer Steelhead Conservation Program

Introduction

The Twisp River Conservation Summer Steelhead Program began with brood year 2011. Prior to brood year 2011, broodstock for the entire Methow summer steelhead program (including releases to the Twisp River) were collected from the run-at-large at the fishway traps at Wells Dam and from Wells Hatchery volunteer channel, with the broodstock comprising 80% to 90% hatchery-origin fish. Spawning, incubation, and rearing all occurred at Wells Hatchery, and smolts were trucked to and released in roughly equal proportions to the Twisp, Chewuch, and upper Methow rivers. Release numbers to the Twisp from brood year 1997 through brood year 2010 averaged 105,880 smolts (range 74,766-136,680).

Beginning in brood year 2011, the Twisp River program was separated from the Methow River program with a distinct brood source and release strategy, and the Methow River program continued with broodstock collection from the run-at-large at Wells Dam and Hatchery for brood year 2012. From brood years 2011 to 2016, natural-origin broodstock for the Twisp River program were collected from the Twisp River weir and spawned at the Methow Hatchery. The progeny of those WxW crosses were incubated and reared to the fry stage at the Methow Hatchery, transferred to Wells Hatchery for rearing, then spring-acclimated in the Twisp Acclimation Pond until volitional release to the Twisp River. The smolt-release target from 2011 through 2018 was 48,000 smolts and averaged 55,514 from brood year 2011 through brood year 2018 (range 41,170-78,390).

Beginning with brood year 2017 (2018 release year), the 48,000-smolt release target was divided so that WNFH produced 24,000 2-year smolts for direct release to the Twisp River at Buttermilk Bridge, while Douglas PUD produced 24,000 1-year smolts for direct release at the same location. Since brood year 2017, natural-origin broodstock were collected at the Twisp River weir for the Douglas PUD program and taken to Winthrop National Fish Hatchery for spawning. Progeny for the 1-year smolt program remained at WNFH for early incubation before transfer to Wells Hatchery at the eyed-egg stage for continued incubation and rearing to the smolt stage, at which point they were transferred to the Twisp River for direct release. Broodstock for the 2-year smolt program included natural-origin fish collected at the Twisp River weir, and also via angling in the Methow River above the Twisp River confluence. Finally, in 2016, WNFH released 11,214 Methow Conservation smolts to the Twisp River at Buttermilk Bridge, in addition to the 48,013 Twisp origin smolts released by Douglas PUD, for a total of 59,227 smolts. Likewise in 2017, WNFH released 24,093 Methow Conservation smolts to the Twisp River at Buttermilk Bridge, in addition to the 54,297 Twisp smolts released by Douglas PUD, for a total of 78,390 smolts.

Key Results

Key results from analyses conducted on Twisp River steelhead are presented as findings and comments by M&E Plan objective in Table 2.2 and summarized below to facilitate interpretation.

For brood years 2011-2016, total spawners and hatchery-origin spawners declined in the Twisp River, while natural-origin spawners increased slightly, indicating that the decline in total spawners resulted primarily from fewer hatchery-origin returns. At the same time, NRR declined slightly and never achieved replacement. HRR declined but was highly variable, consistently exceeded replacement and NRR, but never achieved the target value.

The analysis of the Twisp River population identified strong evidence for density-dependent mortality between spawning and emigrant life stages but did not account for age-0 migrants in this analysis but was unable to identify an effect of pHOS on juvenile recruitment or juveniles per redd because of various analytical and data quantity/quality limitations. Small sample size resulted in low power to detect an effect of pHOS. This, and violation of model assumptions and insufficient contrast in pHOS (lacking years with low pHOS), limited analysis and resulted in poor fit for stock-recruitment models. Nevertheless, emigrants per redd declined significantly with increasing redd counts, and the variation in redd counts primarily resulted from variation in hatchery returns.

Spawn timing was similar for natural- and hatchery-origin returns, despite later arrival timing at Wells Dam by hatchery-origin returns for the 10^{th} and 50^{th} percentiles of the run. Release-number targets were achieved each year since the Twisp program became independent from the Methow program, but fish were smaller than the target size and the size CVs exceeded the target.

The generally small size of the steelhead hatchery programs appears to have resulted in lower allelic richness and allele frequencies, higher levels of linkage disequilibrium, reduced N_b, and divergence of hatchery-origin collections from baseline and contemporary collections. Genetic drift is likely occurring at a higher rate in the hatchery programs than in natural populations. Management for increased abundance and PNI goals may exacerbate these shifts by removing natural-origin adults from the spawning grounds for use as broodstock, releasing numbers of juvenile fish that annually exceed pHOS targets upon returning as adults, and use of already small broodstock populations.

Table 2.2. Summary of monitoring and evaluation results for Twisp River summer steelhead by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Based on analysis of data from the 2022 annual report, total spawners declined from BY 2011 to 2016.	No pre-supplementation or reference population data available for steelhead.
1.2 Natural-Origin Spawners (NOS)	Based on analysis of data from the 2022 annual report, NOSs increased slightly from BY 2011 to BY 2016.	No pre-supplementation or reference population data available for steelhead.
1.3 Natural-Origin Recruits (NOR)	Based on analysis of data from the 2022 annual report, NOSs increased slightly from BY 2011 to BY 2016.	No pre-supplementation or reference population data available for steelhead.
1.4 Adjusted Productivity (NRR)	Based on analysis of data from the 2022 annual report, for BY 2011-2016, Twisp NRR declined and never achieved replacement, median NRR = 0.266 (range 0.064-0.334).	No pre-supplementation or reference population data available for steelhead.
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	<u>Inconclusive</u>: pHOS contrast and statistical power insufficient for analytical purposes. There was no relationship	There are no reference populations or before-supplementation data available for more robust analyses. The static pHOS

M&E Objective	Findings	Comments
	between pHOS and juvenile productivity (P > 0.05).	target of 0.50 (range 0.48-0.55) from 2010 to 2015 to prioritize the RRS study was preceded by seven years where pHOS ranged from 0.72 to 0.89; providing limited contrast in pHOS (no low values to improve parameter estimation for stock-recruit models) and introducing an apparent temporal trend in pHOS that confounded any temporal changes in juvenile productivity. The analysis includes all age classes (excluding age 0) steelhead captured in the Twisp River basin. Analysis revealed evidence of density dependence, with fewer redds producing more emigrants per redd.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	Met: HRR ≥ NRR for all 6 brood years from 2011-2016. The difference was statistically significant (P = 0.01).	
3.2 HRR ≥ Target	Not Met: Mean HRR for brood years 2011-2016 was 11.8 (target 26.5). During this period, the HRR target was not met in any year.	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	No specific PNI target for the Twisp program, but the Twisp contributes to the subbasin-scale target. Not Met: For brood years 2014-18, overall Methow subbasin PNI was below the goal of 0.67 for all five years (average = 0.5, range = 0.43-0.59). pHOS in conservation areas of the Methow Subbasin (includes the Twisp) exceeded the goal of 0.25 for all five years (average = 0.44, range = 0.36-0.61)	A primary reason why PNI and pHOS targets in conservation areas and basin-wide were not achieved from BY2014-BY2018 is that pHOS was held constant at 0.5 in the Twisp from BY2009-BY2018, and Twisp spawners are a substantial component of conservation area spawning. Additionally, conservation harvest was intended as a critical strategy for managing basin-wide and conservation area pHOS; however, harvest was not implemented after return year 2015. Net natural-origin steelhead escapement was fewer than 500 steelhead in brood years 2017 and 2018. In these years, the population was managed to meet 500 total spawners, rather than the PNI goal.
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Not Met: The days of the year at which 10 and 50 percent of PIT-tagged hatchery-origin adults had arrived at Wells Dam was significantly later than the arrival date of their natural origin counterparts (P < 0.05), but there was no significant	Differences in arrival timing to Bonneville Dam were not significant. At Wells Dam, the tenth percentile of natural-origin steelhead arrived, on average, 14 days before the tenth percentile of hatchery-origin steelhead. For the 50th percentile at

M&E Objective	Findings	Comments
	difference between the mean arrival date of the 90th percentile.	Wells Dam, natural-origin steelhead arrived, on average, 11 days earlier.
5.2 Spawn timing	Met: Hatchery- and natural-origin adults had similar spawn timing in the Twisp.	
5.3 Spawn distribution	Inconclusive: Additional data collection and analysis would need to occur to identify specific spawning locations of hatchery- and natural-origin steelhead.	
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual donor stray percentage ranged from 7.1-16.7% (mean = 13.2%) to non-target streams from 2000-2018.	Donor stray rates for natural- and hatchery-origin steelhead were not significantly different.
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: The Twisp steelhead program did not exceed the 5% out-of-basin stray rate target from 2014-2018.	No out-of-basin strays reported from the Twisp program.
6.3 Return Year Recipient Stray Targets (Within Basin)	Not Met: The Twisp steelhead program exceeded the 10% within-basin stray rate target from 2003-2005, and 2010-2017.	
6.4 Brood Year Recipient Stray Rates	No Target, and not reported for Twisp steelhead.	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Not Met: The 2017 Twisp hatchery collection also had the most fixed loci (22) of any collection, likely a result of relatedness in the hatchery broodstock. Effective number of breeders was much lower for hatchery than wild collections, which is expected in small programs with few brood, particularly when pHOS is high.	Shifts in allele frequencies among collections may be influenced by small broodstock populations and releasing numbers of juvenile fish that annually exceed pHOS targets upon returning as adults. The generally small numbers of broodstock used in steelhead hatchery programs appears to have resulted in lower allelic richness and allele frequencies and divergence of hatchery-origin collections from baseline and contemporary collections. Genetic drift is likely occurring at a higher rate in the hatchery programs than in natural populations.
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Twisp hatchery collections had significantly higher linkage disequilibrium than corresponding natural collections, indicating reduced diversity likely due to relatedness.	
7.3 Population Genetics (Genetic Distance)	Not Met: Significant genetic distance between contemporary Twisp hatchery and wild collections indicates that the hatchery broodstock did not well represent	

M&E Objective	Findings	Comments
	the population (also expected with few fish in the broodstock).	
7.4 Population Genetics (Effective Spawning Population)	Not Met: Hatchery-origin collections had much lower Nb estimates than natural-origin collections and this low Nb reduced the Nb/N ratio in the entire population, which is expected in small programs with few brood, particularly when pHOS is high.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Met: For the Twisp steelhead program, from 2009-2018, age at maturity did not differ between hatchery- and natural-origin female steelhead ($P = 0.96$), but a difference did exist between hatchery- and natural-origin males ($P = 0.04$). For 2015-2018, age at maturity did not differ between hatchery- and natural-origin males but differed between hatchery- and natural-origin females ($P = 0.001$).	For the full time-series, Twisp steelhead program, a higher proportion of hatchery-origin males (0.78) returned as salt-age 1 than their natural-origin counterparts (0.72). For 2015-2018, ratios of salt-age were equal for natural-origin females, but more hatchery-origin females returned as salt-age 2.
8.2 Phenotype Similarity (Size at Maturity)	Met: From 2009-2018, and 2015-2018, for the Twisp steelhead program, the main effect of origin on size at maturity was significant ($P < 0.01$). Slightly larger natural-origin fish were observed in both male and female steelhead.	Within age and sex classes, differences in mean fork length between natural- and hatchery-origin steelhead were less than two centimeters.
8.3 Phenotype Similarity (Size and Fecundity)	Met: For the 2014-2018 Twisp steelhead program, there was no difference between hatchery- and natural-origin steelhead fecundity ($P = 0.62$), average egg weight ($P = 0.18$), or total egg mass ($P = 0.41$) after controlling for size.	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2011-2018, the target of 48,000 (±10%) was met every year except 2011. The program met or exceeded the target release number of 99,666 in 10 of 14 brood years prior to brood year 2011.	
9.2 Size-at-release (FPP)	Not Met: For brood years 2011-2018, the target of 6 FPP (±10%) was only met in two years (range 5.6-10.5, mean = 8.1).	Fish were smaller than 6 FPP (±10%) in all years but one, and larger in one year.
9.3 Size-at-release (CV)	Not Met: For brood years 2011-2018, the CV target of <9.0 was exceeded every year (range 9.9-16, mean = 13.1).	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		

M&E Objective	Findings	Comments
10.1 Harvest Contribution	NA: Not analyzed for the Twisp program.	

2.3 Methow River Summer Steelhead Safety-Net Program

Introduction

Releases of Wells Hatchery steelhead to the Methow River began in the early 1970s, but this analysis focuses on more recent programs beginning in the 1990s and continuing through brood year 2018 for some objectives. Methow River release targets were 320,000 smolts through brood year 2011, when they were reduced to 100,000. This period of analysis encompasses the first several years of the Methow Safety-Net program, which began in brood year 2013.

Prior to brood year 2011, broodstock for the entire Methow summer steelhead program were collected from the run-at-large at the fishway traps at Wells Dam and from Wells Hatchery volunteer channel, with the broodstock comprising 80% to 90% hatchery-origin fish. Spawning, incubation, and rearing all occurred at Wells Hatchery, and smolts were trucked to and released in roughly equal proportions to the Twisp, Chewuch, and upper Methow rivers. Additionally, a variable component (typically 100,000 smolts) of that Methow River production spawned at Wells Hatchery was transferred as eyed eggs to Winthrop National Fish Hatchery (WNFH) for incubation, rearing, acclimation, and release directly from that facility.

Beginning in brood year 2011, the Twisp River program was separated from the Methow River program with a distinct brood source and release strategy, and the Methow River program continued with broodstock collection from the run-at-large at Wells Dam and Hatchery for brood year 2012. From brood years 2011 to 2016, natural-origin broodstock for the Twisp River program were collected from the Twisp River weir and spawned at Methow Hatchery. The progeny of those WxW crosses were incubated and reared to the fry stage at Methow Hatchery, transferred to Wells Hatchery for rearing, then spring-acclimated in the Twisp Acclimation Pond until volitional release to the Twisp River. In 2008, WNFH began collecting broodstock within the Methow basin. By 2010, WNFH was collecting 50% of total egg take within basin.

Beginning with brood year 2013 and continuing to the present, WNFH has functioned as the conservation hatchery program for the Methow Basin, excluding the Twisp River (until BY 2017), and used natural-origin broodstock collected via hook-and-line angling in the Methow River, and hatchery-origin returns collected similarly (or from hatchery traps) as necessary to fill the program. The last year that WNFH received eyed eggs from Wells Hatchery was 2014. Also in brood year 2013, the Methow safety-net program (HxH) began with brood comprised of F1 returns from the Twisp and WNFH programs collected at the Twisp River weir and WNFH, and spawning and incubation at Methow Hatchery, and rearing occurring at Wells Hatchery. Methow safety-net pre-smolts from brood years 2013 and 2014 were spring-acclimated at and released from Methow Hatchery, but progeny from brood years 2015-2017 remained at Wells Hatchery until release and were trucked to the lower Methow River for release at the lower Burma Bridge.

The entirety of the Methow safety-net program is adipose-fin clipped and receives no coded wire tag. This mark and tag combination also occurs in the Columbia River steelhead safety-net program, essentially rendering the hatchery releases from these two programs indistinguishable from each other. Because of this, analysis of the Methow safety-net program is often a pooled sample of the two safety-net programs.

Key Results

Key results from analyses conducted on Methow steelhead are presented as findings and comments by M&E Plan objective in Table 2.3 and summarized below to facilitate interpretation.

Natural production and spawning objectives for the Methow steelhead program were analyzed without pre-supplementation or reference population data. For brood years 1992-2013, total spawners were highly variable and increased in the Methow River, but natural-origin spawners remained static at very low abundance. Increases in total spawners resulted from hatchery recruits. NRR declined slightly and only achieved replacement in 1 of 22 years. Following the reduction in Douglas PUD hatchery steelhead released into the Methow River from 320,000 to 100,000 per year, total steelhead spawners in the Methow basin appeared to decline.

In the Methow River basin, there was no significant effect of pHOS on juvenile recruitment or juveniles per redd. All juveniles were included in the analysis except for age-0 steelhead. Small sample sizes, high variance, and the potential for large measurement error limited analysis and resulted in poor fit for stock recruitment models. This led to low confidence in estimated model parameters and an inability to detect a relationship between pHOS and juvenile productivity or smolts per redd if such a relationship exists.

Since 1998, when data collection began, HRR has exceeded NRR for every brood year. The overall mean HRR from 1998-2012 exceeded the target (26.5), but the HRR target was met or exceeded in 8 of 15 years. The Methow Safety Net program began with brood year 2013, and for brood years 2013-2016, HRR exceeded NRR each year. However, the HRR target was met only for BY 2013, and was not met for BYs 2014-2018.

The effects of the Methow steelhead program on phenotypic and life-history characteristics varied. A pooled sample of all hatchery-origin steelhead that arrived at Wells Dam did so later than their natural-origin steelhead counterparts at the tenth and fiftieth percentiles of the run at large, but there was no statistically significant difference in arrival date at the ninetieth percentile, and hatchery-origin and natural-origin steelhead had similar spawn timing. Donor stray rates of the Methow steelhead program ranged from 0-25%, and the mean percent Methow program return year recipient stray rate in the Okanogan River from 2014-2018 was 12.3%, which exceeded the 5% goal. For the same time period, the brood year recipient stray rate in the Methow River was 5.5%.

Reductions in allelic richness and allele frequencies within the Methow Safety-Net steelhead program, and the divergence of hatchery-origin collections from baseline and contemporary collections may have been exacerbated by small broodstock populations and by releasing numbers of juvenile fish created from these small broodstock populations that annually exceed pHOS targets upon returning as adults. Genetic results run counter to long-term conservation goals and may impact the long-term viability of these populations.

Table 2.3. Summary of monitoring and evaluation results for Methow River summer steelhead by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Met: For BY 1992-2013, total steelhead spawners in the Methow River subbasin were highly variable and increased. The increase was driven almost entirely by hatchery-origin spawners. Met: For BY 2011-2021, total steelhead spawners in the Methow River subbasin ranged from 1,246-4,204. The average number of spawners was 2,441, and the standard deviation was 891. Total spawners in the Methow River subbasin appeared to decline following the reduction in hatchery-origin releases beginning in BY 2011.	No pre-supplementation or reference population data available for steelhead.
1.2 Natural-Origin Spawners (NOS)	Met: For BY 1992-2021, natural-origin spawners remained static at low abundance in the Methow River subbasin Met: For BY 2011-2021, natural-origin spawners in the Methow River subbasin ranged from 386-1,103. The average number of wild spawners was 700, and the standard deviation was 248.	No pre-supplementation or reference population data available for steelhead.
1.3 Natural-Origin Recruits (NOR)	Met: For BY 1992-2013, Methow River subbasin adult steelhead recruit abundance ranged from 65 to 1,076 with a median of 427. Recruits exhibited a positive trend, presumably related to the increase in abundance of spawners, mostly influenced by hatchery-origin spawners. Met: For BY 2011-2016, Methow River subbasin adult steelhead recruit abundance ranged from 288-1371, with a median of 897.	No pre-supplementation or reference population data available for steelhead.
1.4 Adjusted Productivity (NRR)	Not Met: For BY 1992-2013, Methow River subbasin NRR remained static and achieved replacement in 1 of 22 years, median NRR = 0.189 (range 0.026-3.805). Not Met: For BY 2011-2021, Methow River subbasin NRR did not achieve replacement. Median NRR was 0.312 (range 0.089-0.365).	No pre-supplementation or reference population data available for steelhead.
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		

M&E Objective	Findings	Comments
2.1 pHOS on Juvenile Productivity (smolts/spawner)	This objective does not apply to the Methow River steelhead safety net program; however, we examined this objective to better understand steelhead production in the Methow River basin. The analysis was unable to detect a relationship between pHOS and juvenile productivity ($P > 0.05$), primarily because of limited contrast in pHOS and insufficient statistical power.	There are no reference populations or before-supplementation data available for more robust analyses. The analysis includes all age classes except age-0 steelhead captured in the Twisp River basin.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	This objective does not apply to the Methow River steelhead safety net program; however, we examined this objective to better understand steelhead production in the Methow River basin. HRR ≥ NRR for all 15 brood years from 1998-2012. The difference was statistically significant ($P < 0.01$).	
3.2 HRR ≥ Target	Not Met: Mean HRR for brood years 1998-2012 was 30.15 (target 26.5). During this period, the HRR target was met or exceeded in 8 of 15 years, but the HRR was less than the target in 4 of the last 5 years. Not Met: Mean HRR for brood years 2011-2016 was 15.1 (target 26.5). During this period the HRR target was never met.	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	No target during evaluation period: PNI and pHOS targets began with Permit 23163 in December 2019, which anticipated achieving a PNI target of 0.67 by 2023 by applying adult management to returns from the latest brood years within this evaluation period. For brood years 2014-18, overall Methow subbasin PNI was below 0.67 for all five years (average = 0.5, range = 0.43-0.59). The pHOS in conservation areas exceeded 0.25 for all five years (average = 0.44, range = 0.36-0.61).	Net natural-origin steelhead escapement was fewer than 500 steelhead in brood years 2017 and 2018. In these years, the population was managed to meet 500 total spawners, rather than the PNI goal.
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	This objective does not apply to the Methow River steelhead safety net program; however, we examined this objective to better understand steelhead	Differences in arrival timing to Bonneville Dam were not significant. At Wells Dam, the tenth percentile of natural-origin steelhead arrived, on average, 14 days

M&E Objective	Findings	Comments
	production in the Methow River basin. The days of the year at which 10 and 50 percent of PIT-tagged hatchery-origin adults had arrived at Wells Dam was significantly later than the arrival date of their natural origin counterparts ($P < 0.05$), but there was no significant difference between the mean arrival date of the 90th percentile.	before the tenth percentile of hatchery-origin steelhead. For the 50th percentile at Wells Dam, natural-origin steelhead arrived, on average, 11 days earlier.
5.2 Spawn timing	This objective does not apply to the Methow River steelhead safety net program; however, we examined this objective to better understand steelhead production in the Methow River basin. Hatchery- and natural-origin adults had similar spawn timing.	
5.3 Spawn distribution	This objective does not apply to the Methow River steelhead safety net program; however, we examined this objective to better understand steelhead production in the Methow River basin. Additional data collection and analysis would need to occur to identify specific spawning locations of hatchery- and natural-origin steelhead. However, PIT tagged MSN adult returners have been detected in all monitored tributaries and reaches of the Methow River where steelhead are known to spawn.	
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual donor stray percentage ranged from 0.0-25.0% (mean = 12.6%) to non-target streams from 2000-2018.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Not Met: From 2014-2018, the mean percent Methow Program hatchery stray steelhead observed in the Okanogan subbasin was 12.3%, exceeding the 5% goal.	
6.3 Return Year Recipient Stray Targets (Within Basin)	NA: Not analyzed for the Methow program.	
6.4 Brood Year Recipient Stray Rates	No Target: For the period of 2014-2018, the mean recipient stray percentage in the Methow River was 5.5%.	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		

M&E Objective	Findings	Comments
7.1 Population Genetics (Allele Frequency)	Not Met: Pairwise AMOVA based on allele frequencies among collections within populations showed differences in contemporary collections compared to baseline collections, and most hatchery-origin collections had less diversity than natural-origin collections.	Shifts in allele frequencies among collections may be influenced by small broodstock populations and releasing numbers of juvenile fish that annually exceed pHOS targets upon returning as adults. The generally small numbers of broodstock used in steelhead hatchery programs appears to have resulted in lower allelic richness and allele frequencies and divergence of hatchery-origin collections from baseline and contemporary collections. Genetic drift is likely occurring at a higher rate in the hatchery programs than in natural populations.
7.2 Population Genetics (Linkage Disequilibrium)	Not met: Mann-Whitney tests showed contemporary hatchery-origin collections had higher levels of linkage disequilibrium than baseline collections.	
7.3 Population Genetics (Genetic Distance)	Not Met: Within the Methow population, contemporary hatchery-origin adults were genetically different from baseline and contemporary natural-origin adults.	
7.4 Population Genetics (Effective Spawning Population)	Not met: Hatchery-origin collections had much lower Nb estimates than natural-origin collections and this low Nb reduced the Nb/N ratio in the entire population.	The intent of the programs is to link genetically across generations from the natural-origin brood stock incorporated into the conservation programs. This is a new management strategy.
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Met: For the Methow steelhead program, from 1998-2018, age at maturity of steelhead sampled at Wells dam differed between hatchery- and natural-origin female steelhead ($P < 0.01$), but not males ($P = 0.33$). Met: From 2014-2018, there was no difference in age at maturity between hatchery- and natural-origin females ($P=0.47$), but there was a difference between hatchery- and natural-origin males ($P=.02$)	Because Columbia Safety Net and Methow Safety Net steelhead programs are marked similarly (adipose clip, no coded wire tag), returns from these programs were pooled for analysis. For the Methow steelhead program from 1998-2018, a higher proportion of hatchery-origin females (0.62) returned as salt-age 2 than their natural-origin counterparts (0.55). From 2014-2018, a higher proportion of hatchery-origin males (0.73) returned as salt-age 1 than their natural-origin counterparts (0.61).
8.2 Phenotype Similarity (Size at Maturity)	Met: From 1998-2018, for the Methow steelhead program, there was no difference between hatchery- and natural-origin size at maturity ($P = 0.33$). Met: From 2014-2018, there was a significant difference for origin size at maturity ($P<0.01$), with natural-origin fish	Because Columbia Safety Net and Methow Safety Net steelhead programs are marked similarly (adipose clip, no coded wire tag), returns from these programs were pooled for analysis.

M&E Objective	Findings	Comments
	being slightly larger on average than the hatchery-origin cohort.	
8.3 Phenotype Similarity (Size and Fecundity)	Met: From BY 2014-2018, there was no significant difference in fecundity and egg characteristics between broodstock used in the MSN and MCP programs (P = 0.18).	Because Columbia Safety Net and Methow Safety Net steelhead programs are marked similarly (adipose clip, no coded wire tag), returns from these programs were pooled for analysis. The Methow Conservation Program uses natural-origin broodstock.
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2012-2017, the target of 100,000 (±10%) was met in 5 of 6 years. The program met or exceeded the target release number of 320,000 in 5 of 20 brood years before brood year 2012.	
9.2 Size-at-release (FPP)	Met: For brood years 2012-2017, the target of 6 FPP (±10%) was met in 5 of 6 years. one brood-year release was less than the target.	
9.3 Size-at-release (CV)	Not Met: For brood years 2012-2017, the CV target of <9.0 was met in 1 of 6 years.	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: Methow steelhead contributed to recreational and Columbia River Tribal fisheries. From 2002-2018, recreational steelhead harvest occurred in the Methow in 13 of 18 years. During this period, the average percentage of hatchery-origin steelhead escapement harvested was 20.2%.	Harvest of steelhead in the Methow River has not occurred in years when MSN steelhead adults have returned.

2.4 Wells Hatchery Summer Steelhead Safety-Net Program

Introduction

The Wells Columbia Safety-Net (CSN) steelhead program originated with the HCP Hatchery Committees' 2011 recalculation of hatchery obligations and the development of the Hatchery Genetic Management Plans for all hatchery programs within the Upper Columbia Summer Steelhead Distinct Population Segment mandated by NOAA Fisheries in 2008. The CSN program was permitted as a safety-net program for steelhead conservation programs upstream of Wells Dam, releasing 160,000 of Douglas PUD's 300,000 inundation-compensation obligation directly to the Columbia River from Wells Hatchery. Prior to the initiation of CSN production, all 300,000 of those steelhead smolts were released either in the Methow or Okanogan subbasins. Direct releases to the Columbia River from Wells Hatchery began with brood year 2011, but brood years 2011 and 2012 were transitional, and the full production of the 160,000-smolt release did not occur until brood year 2013.

The entirety of the CSN program is adipose fin clipped and receives no coded wire tag. This mark and tag combination also occurs in the MSN program, essentially rendering the hatchery releases from these two programs indistinguishable from each other. Because of this, analysis of the Methow safety-net program is often a pooled sample of the two safety-net programs.

Key Results

Key results from analyses conducted on Wells Hatchery steelhead are presented as findings and comments by M&E Plan objective in Table 2.4 and summarized below to facilitate interpretation.

Because the Wells CSN program is a safety-net program with releases directly to the Columbia River, rather than to a target tributary population, many of the M&E Plan objectives were not analyzed for the CSN program or were analyzed in common with fish from the MSN steelhead programs. For brood years 2013-2017, the Wells CSN program achieved the release target of 160,000 (±10%) smolts in four of five years and exceeded the target in two years. The mean FPP (6.0) for those brood years also met target, achieving target in four of five individual years. However, the CV target (<9) was not achieved in any year.

HRR was greater than replacement in every year analyzed but met the target of 26.5 in only one of the last five brood years. For return years 2014-2018, strays from the Wells CSN program comprised a mean of 5.2% of spawners in the Entiat subbasin (range 0.0%-19.8%).

The contemporary genetic collections from the Wells Hatchery CSN program were generally similar to baseline collections and did not show high levels of genetic drift or family structure as did other steelhead programs above Wells. This is presumably because the broodstock for the Wells program historically has and likely still draws from all populations upstream of Wells.

Brood year donor stray rate to the Entiat River has been high in some years, as has return-year recipient stray rate.

Wells steelhead contributed to recreational and Columbia River Tribal fisheries. From 2010-2016, when recreational steelhead harvest occurred above Wells Dam, an average of 32.9% of ad-clipped steelhead were retained in the recreational fishery.

Table 2.4. Summary of monitoring and evaluation results for Wells Hatchery summer steelhead by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	NA: Not analyzed for the Wells CSN program.	
1.2 Natural-Origin Spawners (NOS)	NA: Not analyzed for the Wells CSN program.	
1.3 Natural-Origin Recruits (NOR)	NA: Not analyzed for the Wells CSN program.	
1.4 Adjusted Productivity (NRR)	NA: Not analyzed for the Wells CSN program.	
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	NA: Not analyzed for the Wells CSN program.	
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	NA: Not analyzed for the Wells CSN program.	
3.2 HRR ≥ Target	Not Met: Mean HRR for brood years 1996-2016 (range 2.5 to 91.4) was 25.5 (target 26.5). During this period, the HRR target was met or exceeded in 9 of 21 years, but the HRR was less than the target in 4 of the last 5 complete brood years, and during those years (2012-2016) the mean was 13.5 (range 2.5 to 29.4).	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	NA: Not analyzed for the Wells CSN program.	Although there is no PNI goal for this program, a primary reason why PNI and pHOS targets in conservation areas and basin-wide were not achieved from BY2014-BY2018 is that pHOS was held constant at 0.5 in the Twisp from BY2009-BY2018, and Twisp spawners are a substantial component of conservation area spawning. Additionally, conservation harvest was intended as a critical strategy for managing basin-wide and conservation area pHOS; however, harvest was not implemented after return year 2015.
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		

M&E Objective	Findings	Comments
5.1 Migration timing	NA: Not analyzed for the Wells CSN program.	
5.2 Spawn timing	NA: Not analyzed for the Wells CSN program.	
5.3 Spawn distribution	NA: Not analyzed for the Wells CSN program.	
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: For brood years 2012-2018, annual donor stray percentage ranged from 0.0-50.0% (mean = 19.8%) to non-target streams.	Steelhead stray rates are calculated from the PIT tags detected in returning adults from a juvenile release group. They are hampered by low sample sizes and should be interpreted cautiously.
6.2 Return Year Recipient Stray Targets (Out of Basin)	Not Met: From 2014-2018, the mean percent Wells CSN Program stray steelhead observed in the Entiat subbasin was 5.2% (range 0.0% to 13.6%).	Steelhead stray rates are calculated from the PIT tags detected in returning adults from a juvenile release group. They are hampered by low sample sizes and should be interpreted cautiously.
6.3 Return Year Recipient Stray Targets (Within Basin)	NA: Not analyzed for the Wells CSN program. All strays from the CSN program to tributaries are considered out-of-basin strays.	
6.4 Brood Year Recipient Stray Rates	NA: Not analyzed for the Wells CSN program.	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Met: The contemporary collections from the Wells Hatchery CSN program were generally similar to baseline collections and did not show high levels of genetic drift or family structure as did other programs above Wells. This is presumably because the broodstock for the Wells program likely draws from all populations above Wells.	
7.2 Population Genetics (Linkage Disequilibrium)	Not reported.	
7.3 Population Genetics (Genetic Distance)	Not reported.	
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: Wells contemporary hatchery-origin Nb estimates were low but overlapped baseline and contemporary natural-origin confidence intervals.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		

M&E Objective	Findings	Comments
8.1 Phenotype Similarity (Age at Maturity)	Met: From 1998-2018, age at maturity of steelhead sampled at Wells dam differed between hatchery- and natural-origin female steelhead ($P < 0.01$), but not males ($P = 0.33$)	Because Columbia Safety Net and Methow Safety Net steelhead programs are marked similarly (adipose clip, no coded wire tag), returns from these programs were pooled for analysis. For the Wells steelhead program, a higher proportion of hatchery-origin females (0.62) returned as salt-age 2 than their natural-origin counterparts (0.55).
8.2 Phenotype Similarity (Size at Maturity)	Met: From 1998-2018, for the Wells steelhead program, there was no difference between hatchery- and natural-origin size at maturity ($P = 0.33$).	Because Columbia Safety Net and Methow Safety Net steelhead programs are marked similarly (adipose clip, no coded wire tag), returns from these programs were pooled for analysis.
8.3 Phenotype Similarity (Size and Fecundity)	Met: For the Wells steelhead program, there was no significant difference in fecundity and egg characteristics between the hatchery-origin broodstock used in the CSN program and natural-origin broodstock used in Methow Conservation programs ($P = 0.18$).	Because Columbia Safety Net and Methow Safety Net steelhead programs are marked similarly (adipose clip, no coded wire tag), returns from these programs were pooled for analysis.
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2013-2017, the target of 160,000 (±10%) was met in 4 of 5 years and exceeded in 2 of those years.	
9.2 Size-at-release (FPP)	Met: For brood years 2013-2017, the target of 6 FPP (±10%) was met in 4 of 5 years. The average size of one brood-year release was smaller than the target (mean = 6 FPP).	
9.3 Size-at-release (CV)	Not Met: For brood years 2013-2017, the CV target of <9.0 was not met in any years (all greater than 9.0).	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: Wells steelhead contributed to recreational and Columbia River Tribal fisheries. From 2010-2016, when recreational steelhead harvest was open above Wells Dam, an average of 32.6% of ad-clipped steelhead were retained in the recreational fishery.	

SECTION 3: SPRING CHINOOK SALMON

The PUDs fund five spring Chinook Salmon conservation programs. The Chiwawa River program is funded by Chelan PUD, the Nason Creek and White River programs are funded by Grant PUD, and the Twisp River and Methow-Chewuch River programs are funded by Douglas PUD, Chelan PUD, and Grant PUD. The goal of these programs is to help achieve "No Net Impact" (NNI) to the productivity of spring Chinook Salmon caused by operation of hydroelectric projects owned and operated by the PUDs. Hatchery production of spring Chinook Salmon compensates for up to 7% of the unavoidable project mortality associated with the operation of each of the hydroelectric projects.

3.1 Chiwawa River Spring Chinook Salmon Program

Introduction

The goal of Chiwawa spring Chinook Salmon supplementation is to achieve NNI to the abundance of spring Chinook Salmon caused by the operation of the Rock Island Hydroelectric Project. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Rock Island and Rocky Reach Anadromous Fish Agreement and Habitat Conservation Plans.

Adult spring Chinook Salmon are collected for broodstock at the Chiwawa Weir and Tumwater Dam. From 2011 through 2013, all spring Chinook Salmon broodstock were collected at the Chiwawa Weir in order to reduce passage delays caused by trapping at Tumwater Dam. Before 2009, the goal was to collect up to 379 adult spring Chinook Salmon for the program with natural-origin fish making up not less than 33% of the broodstock. In 2011, the Hatchery Committees reevaluated the amount of hatchery compensation needed to achieve NNI. Based on that evaluation, the goal of the program was revised with a goal to collect up to 75 natural-origin spring Chinook Salmon beginning with brood year 2012. The number collected cannot exceed 33% of the natural-origin spring Chinook Salmon returns to Tumwater Dam. Beginning in 2014, previously PIT-tagged natural-origin Chiwawa spring Chinook Salmon were collected at Tumwater Dam, while the Chiwawa Weir was used to collect the remaining natural-origin brood required for the Chiwawa spring Chinook Salmon program.

Adult spring Chinook Salmon are spawned and reared at Eastbank Fish Hatchery. Juvenile spring Chinook Salmon are transferred from the hatchery to the Chiwawa Acclimation Facility in late September or early October. Volitional releases are initiated in April of the following spring and any fish that remain are forced out by early May.

The production goal for the Chiwawa spring Chinook Salmon supplementation program up to brood year 2009 was to release 672,000 yearling smolts into the Chiwawa River at 12 fish per pound. Brood years 2010-2011 were transition years in which the program was reduced to 298,000 smolts. The brood year 2012 production of 204,542 smolts was a post-recalculation mitigation obligation that was an aggregate production obligation for Chelan PUD of 144,026 spring Chinook Salmon for the Chiwawa program and 60,516 for the Methow (Chewuch) spring Chinook Salmon program.[1] For brood years 2013 through 2021, the revised production goal was to release 144,026 smolts as part of a conservation program at 18 fish per pound. Smolt release size targets for fork length coefficient of variation (CV) and weight are 9.0 and 25.2 g, respectively.

With issuance of ESA Section 10 permit 18121 in 2013 (this permit expires in 2026), adult management (i.e., removal of excess hatchery-origin adults at dams, traps, and weirs, and in conservation fisheries) was implemented in 2014 to help achieve pHOS and PNI goals for the Chiwawa spring Chinook Salmon program.

Key Results

Key results from analyses conducted on Chiwawa River spring Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 3.1 and summarized below to facilitate interpretation.

Comparisons between Chiwawa River spring Chinook Salmon and stream-type Chinook Salmon in reference (un-supplemented) streams located outside the Upper Columbia were made using a BACI design to evaluate whether supplementation changed abundance of total spawners, natural-origin adult recruits, natural-origin spawners, and density-adjusted adult productivity. Adults collected and spawned in the hatchery produced considerably more adult recruits per spawner than those that spawned in the natural environment. Abundance of total spawners, natural-origin spawners, natural-origin adult recruits, and density-adjusted productivity in the Chiwawa River decreased more or increased less during supplementation compared to reference streams, although few of the results were statistically significant. However, this evaluation was not able to evaluate factors unrelated to supplementation, for example, habitat-restoration projects, differences in migration corridors, and differential predation rates on adults. Additionally, for total spawner abundance, implementation of adult management (removal of excess hatchery-origin fish prior to spawning), which was implemented in 2012, resulted in fewer adults potentially spawning in the Chiwawa River basin. Based on these analyses, spring Chinook Salmon supplementation has not measurably improved abundance or productivity of natural-origin spring Chinook Salmon in the Chiwawa River basin, relative to un-supplemented, reference populations located outside the Upper Columbia Basin.

There was no evidence that supplementation increased or decreased productivity of natural-origin juvenile spring Chinook Salmon in the Chiwawa River basin. Higher pHOS did not appear to lower juvenile productivity, where juvenile productivity was measured as the number of yearling smolts per spawner produced within the Chiwawa River basin. However, no other life history pathways were included in this analysis. For all three stock-recruitment models considered, there was often high uncertainty in model parameter estimates even when the models could be fit to the data. Given all the complicating factors associated with these analysis (e.g., no reference populations or before-supplementation data, uncertainty in model parameters, insufficient statistical power for analytical purposes, and using correlation analysis), only the most extreme effect of pHOS on juvenile productivity could have been detected. Thus, we caution against concluding that supplementation had no effect on juvenile productivity in the Chiwawa River basin.

[1] This was a one-year agreement while Chelan PUD and Douglas PUD worked through a facility use agreement.

Since 2012, during years in which there was PNI management, the sliding-scale target[2] for Wenatchee River spring Chinook Salmon upstream from Tumwater Dam was met in 6 of the 7 spawn years for the period 2012-2018 (there was no PNI management before 2012). The 5-year PNI mean ranged from 0.56-0.62 and therefore did not equal or exceed the target of 0.67 in any year during the period 2012-2018. Within the Chiwawa River basin, the 5-year PNI mean ranged from 0.57-0.62 and therefore did not equal or exceed the target of 0.67. On an annual basis, the sliding-scale target was met in 2 of the 7 years. In addition, based on genetic evaluations, the supplementation program may have affected genetic diversity and population structure of spring Chinook Salmon in the Wenatchee River basin. Genetic data from baseline (1989-1993) and contemporary (2017 and 2018) collections of hatchery- and natural-origin samples within the Wenatchee River basin indicated genetic changes among spawning aggregates over time. During baseline, Chiwawa River, Nason Creek, and White River collections were different from each other, while the contemporary collections for these populations, along with the Little Wenatchee, were indistinguishable from each other.

The effects of the Chiwawa River spring Chinook Salmon Program on phenotypic and life-history characteristics varied. Although there was no difference in migration timing and spawn timing of hatchery- and natural-origin spring Chinook Salmon in the Chiwawa River basin, the spawning distributions of hatchery-and natural-origin spring Chinook Salmon differed in the basin. A higher proportion of hatchery-origin spring Chinook Salmon spawned in the lower portions of the Chiwawa River, while a higher proportion of natural-origin spring Chinook Salmon spawned in the upper portions of the river. In addition, age at maturity and size at maturity differed between hatchery- and natural-origin spring Chinook Salmon in the Chiwawa River basin. Hatchery-origin fish generally returned at a younger age than natural-origin fish, but the predominate age at maturity was similar between hatchery- and natural-origin fish. The size at maturity of returning adults was significantly affected by age, sex, and period (i.e., before or after supplementation). However, when matched by age and sex, the differences in size at maturity by origin and period that were statistically significant were minor and likely of little biological relevance. For all populations, the fecundity metrics were significantly affected by fish size and weight, but fecundity did not differ between origins for Chiwawa River spring Chinook Salmon.

For return years 2014 to 2018, hatchery-origin spring Chinook Salmon from the Chiwawa Program strayed into populations outside the Wenatchee River basin but rarely made up more than 5% of the recipient population, except for the Entiat spring Chinook Salmon population in some return years. In contrast, they did stray into all non-target spawning aggregates within the Wenatchee River basin and often exceeded the threshold of 10% of the spawning aggregate. Chiwawa spring Chinook Salmon contributed most to the Nason Creek and Upper Wenatchee spawning escapements. In addition, based on brood year analysis, on average, about 15% of the brood year 2012 to 2016 returns (returns after the first hatchery recalculation) strayed into non-target

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[2] For the Wenatchee River spring Chinook Salmon population upstream from Tumwater Dam, PNI criteria are implemented in accordance with Permits 18118, 18120, and 18121 and the Wenatchee Basin Spring Chinook Management Plan (CCT et al. 2010) to achieve an upper-basin, five-year running average of PNI $\geq$ 0.67. The Wenatchee Basin Spring Chinook Management Plan identified sliding-scale PNI targets (goals) for each major spawning aggregate and for the proportion of the population upstream from Tumwater Dam. Annual sliding-scale targets are based on the number of natural-origin fish spawning within each aggregate and for the entire area upstream from Tumwater Dam.

spawning areas compared to 29% for the previous 10 brood years (brood years 2002 to 2011). Virtually no hatchery-origin fish strayed into non-target hatcheries.

The Chiwawa River spring Chinook Salmon Program met its release goals in most years since the first recalculation period (since brood year 2012). For brood years 2012-2017, the target of 144,026 (±10%) was met in 5 of 6 brood years; one brood-year release exceeded the target. Likewise, during the same brood years, the program met the FPP target in all but one year. On the other hand, the program was less successful in meeting the CV target for length. Chiwawa spring Chinook Salmon exhibited near-isometric growth with a mean condition factor of 1.19.

Since its initiation, the Chiwawa River spring Chinook Salmon Program produced fish that have contributed to ocean and freshwater (tribal, commercial, and recreational) fisheries. Before brood year 2012, total harvest ranged from 0.0-94.7%; total harvest on brood years 2012-2016 ranged from 5.3-12.5%. Tribal and recreational fisheries captured the highest percentage of Chiwawa Program fish. Few were captured in the ocean fishery.

Table 3.1. Summary of monitoring and evaluation results for Chiwawa River spring Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Inconclusive: Non-significant comparisons with out-of-basin references. Chiwawa spawners decreased while references both increased and decreased (MBACI Contrast = -0.555, P = 0.15).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks); adult management also affects total spawners.
1.2 Natural-Origin Spawners (NOS)	Not Met: Chiwawa NOS decreased while references increased (MBACI Contrast = -1.074; P = 0.01).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks); However, without supplementation, the Chiwawa NOS may have decreased significantly.
1.3 Natural-Origin Recruits (NOR)	Inconclusive: Non-significant comparisons with out-of-basin references. Chiwawa and references increased but references increased more (MBACI Contrast = -0.686, P = 0.08).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks).
1.4 Adjusted Productivity (NRR)	Inconclusive: Non-significant comparisons with out-of-basin references. Chiwawa and references increased but references increased more (MBACI Contrast = -0.337, P = 0.10).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks); Importantly, supplementation did not decrease NRR.

M&E Objective	Findings	Comments
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Inconclusive: pHOS contrast and statistical power insufficient for analytical purposes. There was no relationship between pHOS and juvenile productivity ($P > 0.05$).	There are no reference populations or before-supplementation data available for more robust analyses. The analysis only includes yearlings produced within the Chiwawa River basin.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	Met: HRR ≥ NRR in 21 of 22 years and mean HRR was significantly larger than mean NRR ($P < 0.01$).	
3.2 HRR ≥ Target	Met: HRRs ranged from 0.41-24.71 (Mean = 7.75; target 6.7). HRR has met the target in four of the last five years (2008-2012).	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Not Met: During the period when there were PNI targets for the portion of the Wenatchee River spring Chinook Salmon population upstream from Tumwater Dam (2012-present; however, the time series for the comprehensive review was 2012-2018), the 5-year PNI mean ranged from 0.56-0.62 and therefore did not equal or exceed the target of 0.67. On an annual basis, the sliding-scale target was met in 6 of the 7 years. Within the Chiwawa River basin, the 5-year PNI mean ranged from 0.57-0.62 and therefore did not equal or exceed the target of 0.67. On an annual basis, the sliding-scale target was met in 2 of the 7 years.	
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Met: The migration timing of PIT-tagged hatchery- and natural-origin adults at Tumwater Dam was nearly identical ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.2 Spawn timing	Met: Hatchery- and natural-origin adults had similar spawn timing ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.

M&E Objective	Findings	Comments
5.3 Spawn distribution	Not Met: Both hatchery- and natural-origin adults spawned throughout the Chiwawa River and within each reach; however, there was a significant difference in the distribution of hatchery- and natural-origin spawners among historical survey reaches for years 1993-2018 (P < 0.01).	Although the M&E Plan does not include pHOS analysis at the reach scale, pHOS ranged from 0.44-0.89 among the seven reaches in the Chiwawa River. The highest proportions were in reaches 1 and 2 near the acclimation facility. Spawning location can have a significant effect on fitness of spring Chinook Salmon.
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual brood year donor stray percentage for hatchery-origin Chiwawa River spring Chinook Salmon releases ranged from 8.3-55.6%.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: The Chiwawa River spring Chinook Salmon Program did not exceed the 5% out of basin stray rate target in 6 out of 8 years for recipient populations. It did exceed the 5% target in the Entiat River in 2 out of 6 years.	Since return year 2014 (after the reduction in hatchery production), Chiwawa spring Chinook Salmon from the Chiwawa Program have made up a low percentage of the spawning escapement in the Entiat River.
6.3 Return Year Recipient Stray Targets (Within Basin)	Not Met: The Chiwawa River spring Chinook Salmon Program exceeded the 10% in-basin stray rate target.	
6.4 Brood Year Recipient Stray Rates	No Target: For brood years 2089-2016, the mean recipient stray percentage for the Chiwawa River spring Chinook Salmon program was 27.0% (range 0.0-80.6%).	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Not Met: The AMOVA tests indicated that there were significant differences (P < 0.05) in allele frequencies between baseline and contemporary collections from the same tributary and different tributaries, and between natural and hatchery collections from the same river.	These allele frequency changes suggest that genetic drift has affected the populations, as expected for populations that declined to low abundance and required hatchery intervention.
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences (P < 0.05) in the number of locus pairs in linkage disequilibrium in comparisons of baseline and contemporary collections.	Collections with high linkage had incorporated large family groups.
7.3 Population Genetics (Genetic Distance)	Not Met: Among the Wenatchee collections, all genetic distance comparisons of collections from the same river in different time frames were	These distances were affected by changes in effective population size and likely reflected straying as well as genetic drift.

M&E Objective	Findings	Comments
	significantly different from zero (P < 0.05).	
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: The monitoring question for this objective was to assess changes over time in the ratio of N_b (effective number of breeders) to census size (N); however, the N_b was difficult to evaluate due to small collection sizes and non-random sampling of family members.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not Met: Age at maturity was significantly different between hatchery- and natural-origin adults (P < 0.01). Hatchery-origin fish returned at a younger age.	
8.2 Phenotype Similarity (Size at Maturity)	Not Met: Size at maturity differed significantly between hatchery- and natural-origin adults and was affected by age, sex, and origin (P = 0.01). However, differences in lengths between natural- and hatchery-origin fish were generally less than 3 cm.	
8.3 Phenotype Similarity (Size and Fecundity)	Met: There were no differences in relationships between hatchery- and natural-origin females for weight and fecundity (P = 0.07) and fork length and gonadal mass (P = 0.47). There was a difference between fork length and mean egg weight (P = 0.04).	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2012-2017, the target of 144,026 (±10%) was met in 5 of 6 brood years; one brood-year release exceeded the target in 1 year. For brood years before 2012 (before recalculation), the program met the target release number of 672,000 (±10%) in 3 of 21 brood years.	
9.2 Size-at-release (FPP)	Met: For brood years 2012-2017, the target of 18 FPP (±10%) was met in 5 of 6 brood years; one brood-year release was less than the target. For brood years before 2012 (before recalculation), the program met the target of 12 FPP (±10%) in 8 of 21 brood years.	
9.3 Size-at-release (CV)	Not Met: For brood years 2012-2017, the CV target of <9.0 was met in 2 of 6 brood years.	Changes in feed, FPP, and other unknown factors may have affected the CVs.

M&E Objective	Findings	Comments
	For brood years before 2012 (before recalculation), the program met the CV target of <9.0 in 17 of 21 brood years.	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: Before brood year 2012, the average percent of the brood year return harvested was 19.0% (range 0.0-94.7%); for brood years 2012 to 2016, the average percent of the brood year return harvested was 7.9% (range 5.3-12.5%).	

3.2 Nason Creek Spring Chinook Salmon Program

Introduction

The goals of the Nason Creek spring Chinook Salmon supplementation program are to conserve, aid in the recovery, and prevent the extinction of naturally spawning spring Chinook Salmon in Nason Creek, and to meet the mitigation responsibilities of Grant County PUD. In 1998, a spring Chinook Salmon captive-broodstock program was initiated for the Nason Creek population to reduce the risk of extinction. Improvements in adult escapement in Nason Creek have reduced the near-term risk of extinction and therefore the captive-broodstock program was discontinued with the 1999 brood year (F1) and the juvenile release in 2005. An adult-based supplementation program began with the collection of broodstock in 2013. The first releases of the program occurred from the Nason Creek Acclimation Facility in the spring of 2015.

In 2013, natural-origin adult spring Chinook Salmon were collected for broodstock at Tumwater Dam and from Nason Creek using tangle and dip nets. In 2014, all natural-origin broodstock were collected from Nason Creek using tangle and dip nets. While these brood collection methods were successful at collecting adults from the Nason Creek spawning aggregate, they were unable to collect the necessary number of adults to meet mitigation production goals in 2013 and 2014. The PRCC Hatchery Subcommittee decided to implement the Nason Creek conservation program using a composite of Nason and Chiwawa natural-origin broodstock beginning with brood year 2015 in order to be able to consistently meet program goals. The decision was also made to collect all the brood at Tumwater Dam.

The production goal for the Nason Creek program for BY 2022 requires collection of about 118 adult spring Chinook Salmon (68 natural-origin fish and 50 hatchery-origin fish). However, the Section 10 permit requirements restrict the number of natural-origin adults collected and collection cannot exceed 33% of the natural-origin spring Chinook Salmon estimates to Tumwater Dam.

Adult spring Chinook Salmon broodstock are spawned and reared at Eastbank Fish Hatchery. Juvenile spring Chinook Salmon are transferred from the hatchery to the Nason Creek Acclimation Facility in late September or early October. Fish are reared in 30-foot dual-drain circular tanks throughout winter at the Nason Creek Acclimation Facility. Yearling Chinook Salmon were released volitionally during April and May in 2015. Beginning in 2016, all fish were force released at night to improve survival and reduce ecological risks.

The current production goal for brood year 2022 is to release 203,650 smolts (125,000 for conservation and 78,650 for safety net), a reduction from the production goal of 223,670 for brood years 2012-2021. Juveniles released from the Nason facility are intended to be 100% tagged with CWTs and a minimum of 5,000 fish are PIT tagged annually (additionally, the safety net component receives an adipose-fin clip). Recent evaluations have found that adipose clipping and coded wire tagging have been less than 100%.

Key Results

Key results from analyses conducted on Nason Creek spring Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 3.2 and summarized below to facilitate interpretation.

Comparisons between Nason Creek spring Chinook Salmon and stream-type Chinook Salmon in reference (un-supplemented) streams located outside the Upper Columbia were made using a

BACI design to evaluate whether supplementation changed abundance of total spawners, natural-origin adult recruits, natural-origin spawners, and density-adjusted adult productivity. Adults collected and spawned in the hatchery produced considerably more adult recruits per spawner than those that spawned in the natural environment. Abundance of total spawners, natural-origin spawners, natural-origin adult recruits, and density-adjusted productivity in Nason Creek decreased more or increased less during supplementation compared to reference streams, although few of the results were statistically significant. However, this evaluation was not able to evaluate factors unrelated to supplementation, for example, habitat-restoration projects, differences in migration corridors, and differential predation rates on adults. Additionally, for total spawner abundance, implementation of adult management (removal of excess hatchery-origin fish prior to spawning), which was implemented in 2012, resulted in fewer adults potentially spawning in Nason Creek. Based on these analyses, spring Chinook Salmon supplementation has not measurably improved abundance or productivity of natural-origin spring Chinook Salmon in Nason Creek, relative to un-supplemented, reference populations located outside the Upper Columbia Basin.

There was no evidence that supplementation increased or decreased productivity of natural-origin juvenile spring Chinook Salmon in Nason Creek. Higher pHOS did not appear to lower juvenile productivity, where juvenile productivity was measured as the number of yearling smolts per spawner produced within Nason Creek. However, no other life history pathways were included in this analysis. Due to limitations in the data, only the Ricker model was considered for stock-recruitment. There was high uncertainty in model parameter estimates even when the model could be fit to the data. Given all the complicating factors associated with these analyses (e.g., no reference populations or before-supplementation data, uncertainty in model parameters, insufficient statistical power for analytical purposes, and using correlation analysis), only the most extreme effect of pHOS on juvenile productivity could have been detected. Thus, we caution against concluding that supplementation had no effect on juvenile productivity in Nason Creek.

Since 2012, during years in which there was PNI management, the sliding-scale target[3] for Wenatchee River spring Chinook Salmon upstream from Tumwater Dam was met in 6 of the 7 spawn years for the period 2012-2018 (there was no PNI management before 2012). The 5-year PNI mean ranged from 0.56-0.62 and therefore did not equal or exceed the target of 0.67 in any year during the period 2012-2018. Within the Nason Creek watershed, the 5-year PNI mean ranged from 0.64-0.66 and therefore did not equal or exceed the target of 0.67. On an annual basis, the sliding-scale target was met in 6 of the 6 years (2013-2018). In addition, based on genetic evaluations, the supplementation program may have affected genetic diversity and population structure of spring Chinook Salmon in the Wenatchee River basin. Genetic data from baseline (1989-1993) and contemporary (2017 and 2018) collections of hatchery- and natural-origin samples within the Wenatchee River basin indicated genetic changes among spawning aggregates over time. During baseline, Chiwawa River, Nason Creek, and White River collections were

[3] For the Wenatchee River spring Chinook Salmon population upstream from Tumwater Dam, PNI criteria are implemented in accordance with Permits 18118, 18120, and 18121 and the Wenatchee Basin Spring Chinook Management Plan (CCT et al. 2010) to achieve an upper-basin, five-year running average of PNI ≥ 0.67. The Wenatchee Basin Spring Chinook Management Plan identified sliding-scale PNI targets (goals) for each major spawning aggregate and for the proportion of the population upstream from Tumwater Dam. Annual sliding-scale targets are based on the number of natural-origin fish spawning within each aggregate and for the entire area upstream from Tumwater Dam.

different from each other, while the contemporary collections for these populations, along with the Little Wenatchee, were indistinguishable from each other.

The effects of the Nason Creek spring Chinook Salmon Program on phenotypic and life-history characteristics varied. There was no difference in migration timing and spawn timing of hatchery- and natural-origin spring Chinook Salmon in Nason Creek, and differences in the spawning distributions of hatchery-and natural-origin spring Chinook Salmon are unknown because adults from the Nason Creek Program only began to return 2016. In addition, age at maturity differed but not size at maturity between hatchery- and natural-origin spring Chinook Salmon in Nason Creek. Hatchery-origin fish generally returned at a younger age than natural-origin fish, but the predominate age at maturity was similar between hatchery- and natural-origin fish. Analysis of the size at maturity of returning adults was limited by the small sample available (2016-2018 returns). The fecundity metrics were significantly affected by fish size and weight, but fecundity did not differ between origins for Nason Creek spring Chinook Salmon.

For return years 2014 to 2018, hatchery-origin spring Chinook Salmon from the Nason Creek Program did not exceed the out-of-basin stray target of 5% or the in-basin recipient stray target of 10%. However, the mean recipient stray percentage in Nason Creek was 41.85% for 2014-2018 and was influenced by non-Nason Creek programs.

The Nason Creek spring Chinook Salmon Program met its release goals of 223,670 ± 10% in 4 of 5 years, including 2016 releases into the Chiwawa River, as part of Grant PUD's production. Likewise, during the same brood years, the program's average FPP met the FPP target in all years. On the other hand, the program was less successful in meeting the CV target for length.

There is insufficient data to assess contributions to harvest for the Nason Creek Program. However, harvest trends are likely similar to those for the Chiwawa spring Chinook Salmon hatchery program.

Table 3.2. Summary of monitoring and evaluation results for Nason Creek spring Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	<u>Inconclusive:</u> Non-significant comparisons with out-of-basin references. Nason increased, but references increased more (MBACI contrast: -0.231, $P > 0.05$).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks); adult management also affects total spawners.
1.2 Natural-Origin Spawners (NOS)	<u>Not met:</u> Significant comparisons with out-of-basin references. Nason increased, but references increased more (MBACI contrast: -1.142, $P < 0.05$).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks); However, without supplementation, the Nason NOS may have decreased significantly.

M&E Objective	Findings	Comments
1.3 Natural-Origin Recruits (NOR)	Inconclusive: Non-significant comparisons with out-of-basin references. Nason increased, but references increased more (MBACI contrast: -0.627, P > 0.05).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks).
1.4 Adjusted Productivity (NRR)	Inconclusive: Non-significant comparisons with out-of-basin references. Nason decreased while references increased (MBACI contrast: -0.522, P > 0.05).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks).
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Inconclusive: pHOS contrast and statistical power insufficient for analytical purposes. There was no relationship between pHOS and juvenile productivity (P > 0.05).	There are no reference populations or before-supplementation data available for more robust analyses. The analysis only includes yearlings produced within Nason Creek.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	Inconclusive: Due to the timeline of the Nason Creek Program, there have been insufficient brood year returns to make a determination.	
3.2 HRR ≥ Target	Inconclusive: Due to the timeline of the Nason Creek Program, there have been insufficient brood year returns to make a determination.	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Not Met: During the period when there were PNI targets for the portion of the Wenatchee River spring Chinook Salmon population upstream from Tumwater Dam (2012-present; however, the time series for the comprehensive review was 2012-2018), the 5-year PNI mean ranged from 0.56-0.62 and therefore did not equal or exceed the target of 0.67. On an annual basis, the sliding-scale target was met in 6 of the 7 years. Within the Nason Creek watershed, the 5-year PNI mean ranged from 0.64-0.66 and therefore did not equal or exceed the target of 0.67. On an annual basis, the sliding-scale target was met in 6 of the 6 years (2013-2018).	

M&E Objective	Findings	Comments
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Met: The migration timing of PIT-tagged hatchery- and natural-origin adults at Tumwater Dam was nearly identical ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.2 Spawn timing	Met: Hatchery- and natural-origin adults had similar spawn timing ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.3 Spawn distribution	Inconclusive: Due to the timing of the Nason Creek Program, adults from the Nason Creek Program began returning in 2016.	
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual donor stray percentage for hatchery-origin Nason spring Chinook Salmon ranged from 0.0 – 7.3%.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: The Nason Creek Program did not exceed the out-of-basin recipient stray target of 5%.	
6.3 Return Year Recipient Stray Targets (Within Basin)	Met: The Nason Creek Program did not exceed the in-basin recipient stray target of 10%. However, the mean recipient stray percentage in Nason Creek was 41.85% for 2014-2018 and was influenced by non-Nason Creek programs.	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Not Met: The AMOVA tests indicated that there were significant differences ($P < 0.05$) in allele frequencies between baseline and contemporary collections from the same tributary and different tributaries, and between natural and hatchery collections from the same river.	These allele frequency changes suggest that genetic drift has affected the populations, as expected for populations that declined to low abundance and required hatchery intervention.
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences ($P < 0.05$) in the number of locus pairs in linkage disequilibrium in comparisons of baseline and contemporary collections.	Collections with high linkage had incorporated large family groups.

M&E Objective	Findings	Comments
7.3 Population Genetics (Genetic Distance)	Not Met: Among the Wenatchee collections, all genetic distance comparisons of collections from the same river in different time frames were significantly different from zero (P < 0.05).	These distances were affected by changes in effective population size and likely reflected straying as well as genetic drift.
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: The monitoring question for this objective was to assess changes over time in the ratio of N_b (effective number of breeders) to census size (N); however, the N_b was difficult to evaluate due to small collection sizes and non-random sampling of family members.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not Met: Age at maturity was significantly different between hatchery- and natural-origin adults (P < 0.01). Hatchery-origin fish returned at a younger age.	
8.2 Phenotype Similarity (Size at Maturity)	Met: Size at maturity did not differ significantly (P = 0.12) between hatchery- and natural-origin females or males in Nason Creek, but these results only account for a small sample of Nason Program adults (2016-2018 returns).	
8.3 Phenotype Similarity (Size and Fecundity)	Met: There were no significant differences in relationships between hatchery- and natural-origin fish for female size and fecundity (P = 0.16), mean egg weight (P = 0.71), and gonadal mass (P = 0.14).	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: the release target of 223,670 ± 10% was achieved in 4 of 5 years (including 2016 releases into Chiwawa River as part of GPUD's production).	
9.2 Size-at-release (FPP)	Met: Target = 18-24; range 16-22 for the conservation program (average = 20 FPP); range 16-24 for the safety net program (average = 21 FPP)	
9.3 Size-at-release (CV)	Not Met: CV; Target = 9; range 7-8 for the conservation program (average = 7); range 6-13 for the safety net program (average = 9)	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		

M&E Objective	Findings	Comments
10.1 Harvest Contribution	Inconclusive: Insufficient data to evaluate harvest contribution but probably similar to Chiwawa River hatchery program harvest.	

3.3 White River Spring Chinook Salmon Program

Introduction

The White River spring Chinook Salmon captive brood program began in 1997 with goals to conserve, aid in the recovery, and prevent the extinction of naturally spawning spring Chinook Salmon in the White River, and to meet the mitigation responsibilities of Grant County PUD. Collection of eggs or juveniles from the White River (brood years 1997-2009) made up the first-generation (F1) component of the White River captive brood program. Initially, rearing occurred at the AquaSeed Aquaculture facility in Rochester, Washington, but transitioned to the Little White Salmon National Fish Hatchery near Cook, Washington, in 2006. The F1 component was reared to maturation and spawned within the hatchery. The resulting progeny (F2) were then reared in the hatchery until final acclimation and released in the upper Wenatchee River basin. The first large release of F2 juveniles was in 2007. The last release of juveniles from the captive brood program occurred in 2015 (brood year 2013).

The production goal for the White River captive brood program following the 2013 hatchery recalculation was to release 74,556 yearling smolts into the upper Wenatchee River basin at 18-24 fish per pound. Fish lengths and weights for the recent broods were manipulated to evaluate different approaches for reducing precocious maturation. All fish were intended to be 100% marked with an adipose-fin clip in conjunction with CWTs. In addition, from 2008 through 2015, a portion of juvenile spring Chinook Salmon were PIT tagged annually.

Since its inception, the captive brood program underwent several adaptive changes designed to improve program success. These changes included: (1) use of a pedigree approach to reduce the use of stray fish in the broodstock, (2) transfer of fish from Aquaseed to the Little White Salmon National Fish Hatchery to improve fish quality, (3) injection of hormones into F1 females to improve maturation of eggs, (4) manipulation of diet and ration for the F2 fish to reduce precocious maturation of males, (5) use of temporary tanks and natural enclosures during acclimation to improve homing, and (6) trucking juvenile fish around Lake Wenatchee to improve survival.

Key Results

Key results from analyses conducted on White River spring Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 3.3 and summarized below to facilitate interpretation.

Comparisons between White River spring Chinook Salmon and stream-type Chinook Salmon in reference (un-supplemented) streams located outside the Upper Columbia were made using a BACI design to evaluate whether supplementation changed abundance of total spawners and natural-origin spawners. Comparisons could not be made for natural-origin adult recruits and adjusted adult productivity due to insufficient White River spring Chinook Salmon adult return data. The abundance of total spawners and natural-origin spawners in the White River decreased more or increased less during supplementation compared to reference streams, and neither comparison was statistically significant. However, this evaluation was not able to evaluate factors unrelated to supplementation, for example, habitat-restoration projects, differences in migration corridors, and differential predation rates on adults. Additionally, the 2012 implementation of adult management (i.e., removal of excess hatchery-origin fish prior to spawning) resulted in fewer adults potentially spawning in the White River basin and may have affected total spawner abundance.

There was no statistical support to suggest that supplementation increased or decreased productivity of natural-origin juvenile spring Chinook Salmon in the White River basin. Higher pHOS did not appear to lower juvenile productivity, where juvenile productivity was measured as the number of yearling smolts per spawner produced within the White River basin. However, no other life history pathways were included in this analysis. For all three stock-recruitment models considered, there was often high uncertainty in model parameter estimates even when the models could be fit to the data. There were numerous, complicating factors associated with these analyses, including no reference populations or before-supplementation data, uncertainty in model parameters, and insufficient statistical power for analytical purposes and using correlation analysis; only the most extreme effect of pHOS on juvenile productivity could have been detected. Thus, we caution against concluding that supplementation had no effect on juvenile productivity in the White River basin.

Since 2012, during years in which there was PNI management, the sliding-scale target[4] for Wenatchee River spring Chinook Salmon upstream from Tumwater Dam was met in 6 of the 7 spawn years for the period 2012-2018 (there was no PNI management before 2012). The 5-year PNI mean ranged from 0.56-0.62 and therefore did not equal or exceed the target of 0.67 in any year during the period 2012-2018. Within the White River watershed, the sliding-scale target was not met for spawn years 2012-2013 (although the captive brood program was from 2001-2013, there was no PNI management before spawn year 2012). Because the captive brood program ended with brood year 2013, there are insufficient years to evaluate whether the White River program met the PNI management target. In addition, genetic evaluations suggest that the supplementation program may have affected the diversity and population structure of spring Chinook Salmon in the Wenatchee River basin. Genetic data from baseline (1989-1993) and contemporary (2017 and 2018) collections of hatchery- and natural-origin samples within the Wenatchee River basin indicated genetic changes among spawning aggregates over time. During the microsatellite loci genotyping baseline, Chiwawa River, Nason Creek, and White River collections were different from each other; the contemporary collections genotyped using SNP loci for these populations were indistinguishable from each other (including the Little Wenatchee). The cause of these differences may be due to differing genotyping technology or genetic changes over time whereby the White River spawning aggregate has become more genetically similar to other spring Chinook Salmon Wenatchee spawning aggregates.

The effects of the White River spring Chinook Salmon program on phenotypic and life-history characteristics varied. There was no difference in migration timing, spawn timing, or spawning distribution of hatchery- and natural-origin spring Chinook Salmon in the White River basin.

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[4] For the Wenatchee River spring Chinook Salmon population upstream from Tumwater Dam, PNI criteria are implemented in accordance with Permits 18118, 18120, and 18121 and the Wenatchee Basin Spring Chinook Management Plan (CCT et al. 2010) to achieve an upper-basin, five-year running average of PNI ≥ 0.67. The Wenatchee Basin Spring Chinook Management Plan identified sliding-scale PNI targets (goals) for each major spawning aggregate and for the proportion of the population upstream from Tumwater Dam. Annual sliding-scale targets are based on the number of natural-origin fish spawning within each aggregate and for the entire area upstream from Tumwater Dam.

Hatchery- and natural-origin spring Chinook Salmon spawned in roughly equal proportions across each historical reach – the majority of fish spawned in the middle section of the White River. In addition, age-at-maturity differed between hatchery- and natural-origin spring Chinook Salmon in the White River basin. Hatchery-origin fish generally returned at a younger age than natural-origin fish. The effects of origin, sex, and age on size-at-maturity could not be assessed due to low sample size. White River spring Chinook Salmon fecundity was also not evaluated because broodstock were collected as eyed eggs or fry from the White River. No comparative fecundity data similar to what was done for other programs were collected for the White River program.

For return years 2014 to 2018, hatchery-origin spring Chinook Salmon from the White River program strayed into populations outside the Wenatchee River basin but rarely made up more than 5% of the recipient population. White River spring Chinook Salmon did stray into the upper Wenatchee and Nason Creek spawning aggregates within the Wenatchee River basin but did not exceed the threshold of 10% of the spawning aggregate. Despite not exceeding the target, the recipient stray percentage in the White River was 17.3% and was influenced by non-White River programs. For return years 2000-2018, the White River spring Chinook Salmon donor stray percentage ranged from 49% to 80%. The White River program had the highest donor stray rate of all upper Columbia spring Chinook Salmon populations reviewed and was likely influenced by the convoluted sequence of fish transportation and fish acclimation.

The White River spring Chinook Salmon Program did not meet its release goals in almost all years the program was active. For brood years 2002-2013, the target of 150,000 (±10%) was met in 1 of 12 brood years. Likewise, during the same brood years, the program met the FPP target in only half of all years. This program did not have a CV target, and there was insufficient data to determine if the White River spring Chinook Salmon program contributed to harvest.

Table 3.3. Summary of monitoring and evaluation results for White River spring Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Inconclusive: Non-significant comparisons with out-of-basin references. White River total spawners increased, but references increased more (MBACI Contrast -0.415, P > 0.05).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks); adult management also affects total spawners.
1.2 Natural-Origin Spawners (NOS)	Inconclusive: Non-significant comparisons with out-of-basin references. White River NOS decreased while references increased (MBACI Contrast = -0.643; P > 0.05).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks); However, without supplementation, the White NOS may have decreased significantly.

M&E Objective	Findings	Comments
1.3 Natural-Origin Recruits (NOR)	Inconclusive: Unable to interpret results due to a lack of annual adult return data.	
1.4 Adjusted Productivity (NRR)	Inconclusive: Unable to interpret results due to a lack of annual adult return data.	
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Inconclusive: pHOS contrast and statistical power insufficient for analytical purposes. There was no relationship between pHOS and juvenile productivity ($P > 0.05$).	There are no reference populations or before-supplementation data available for more robust analyses. The analysis only includes yearlings produced within the White River basin.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	Not Met: HRR ≥ NRR in 0 of 8 years and the mean NRR was significantly larger than the mean HRR ($P = 0.04$).	The type of approach used to calculate hatchery recruitment influenced these results. The grandparent HRR (GHRR; based on female equivalence that produced the eggs to produce the F2 adults) resulted in GHRR>GNRR.
3.2 HRR ≥ Target	Not Met: HRRs ranged from 0.00-0.28 (Mean = 0.05; target 6.7). HRR has not met the target in the last five years (2008-2012).	Please see above for relevancy of comparison of HRR to a target value for a captive broodstock program
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Not Met: During the period when there were PNI targets for the portion of the Wenatchee River spring Chinook Salmon population upstream from Tumwater Dam (2012-present; however, the time series for the comprehensive review was 2012-2018), the 5-year PNI mean ranged from 0.56-0.62 and therefore did not equal or exceed the target of 0.67. On an annual basis, the sliding-scale target was met in 6 of the 7 years. Within the White River basin, the sliding-scale target was not met for spawn years 2012-2013 (although the captive brood program was from 2001-2013, there was no PNI management before spawn year 2012). Because the captive brood program ended with brood year 2013, there are insufficient years to evaluate whether the White River program met the PNI management target.	

M&E Objective	Findings	Comments
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Met: The migration timing of PIT-tagged hatchery- and natural-origin adults at Tumwater Dam was nearly identical ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.2 Spawn timing	Met: Hatchery- and natural-origin adults had similar spawn timing ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.3 Spawn distribution	Met: Both hatchery- and natural-origin adults spawned throughout the White River and within all three historical reaches. There was no significant difference in the distribution of hatchery- and natural-origin spawners among historical survey reaches for years 1993-2018 ($P = 0.93$).	Although the M&E Plan does not include pHOS analysis at the reach scale, pHOS ranged from 0.29-0.45 among the three reaches in the White River. The highest proportions were in reaches 2 and 3. Spawning location can have a significant effect on fitness of spring Chinook Salmon.
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual donor stray percentages for hatchery-origin White River spring Chinook Salmon ranged from 49.1% to 79.5% for return years 2000-2018.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: The White River spring Chinook Salmon Program did not exceed the 5% out-of-basin stray rate target.	
6.3 Return Year Recipient Stray Targets (Within Basin)	Met: The White River spring Chinook Salmon Program did not exceed the 10% in-basin stray rate target. However, recipient stray percentage in the White River was 17.3% from 2014-2018 and was influenced by non-White River programs.	Size of the recipient population and the donor stray rates affect return year stray rates.
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Not Met: The AMOVA tests indicated that there were significant differences ($P < 0.05$) in allele frequencies between baseline and contemporary collections from the same tributary and different tributaries, and between natural and hatchery collections from the same river.	These allele frequency changes suggest that genetic drift has affected the populations, as expected for populations that declined to low abundance and required hatchery intervention.

M&E Objective	Findings	Comments
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences (P < 0.05) in the number of locus pairs in linkage disequilibrium in comparisons of baseline and contemporary collections.	Collections with high linkage had incorporated large family groups.
7.3 Population Genetics (Genetic Distance)	Not Met: Among the Wenatchee collections, all genetic distance comparisons of collections from the same river in different time frames were significantly different from zero (P < 0.05).	These distances were affected by changes in effective population size and likely reflected straying as well as genetic drift.
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: The monitoring question for this objective was to assess changes over time in the ratio of N_b (effective number of breeders) to census size (N); however, the N_b was difficult to evaluate due to small collection sizes and non-random sampling of family members.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not Met: Age at maturity was significantly different between hatchery- and natural-origin female adults (P < 0.01). Most hatchery-origin fish returned at a younger age. The difference was less apparent in males (P = 0.08).	
8.2 Phenotype Similarity (Size at Maturity)	Inconclusive: Sample sizes were too small to statistically evaluate the effects of origin, sex, and age on size-at-maturity of spring Chinook Salmon in the White River.	
8.3 Phenotype Similarity (Size and Fecundity)	Inconclusive: No comparative fecundity data similar to what was done for other programs were collected for the White River program.	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Not Met: For brood years 2002-2013, the target of 150,000 (±10%) was met in 1 of 12 brood years. The captive brood program ended with brood year 2013.	The White River spring Chinook Salmon program was in-development for all of its history and tested numerous fish culture and release strategies.
9.2 Size-at-release (FPP)	Not Met: For brood years 2002-2013, the target of 18-24 FPP was met in 6 of 12 brood years. The average FPP was 18 and ranged from 4 to 31. The captive brood program ended with brood year 2013.	The White River spring Chinook Salmon program was in-development for all of its history and tested numerous fish culture and release strategies.
9.3 Size-at-release (CV)	No Target: There was no CV target for the White River spring Chinook Salmon program.	

M&E Objective	Findings	Comments
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Inconclusive: Insufficient data to evaluate harvest contributions.	

3.4 Methow-Chewuch River Spring Chinook Salmon Program

Introduction

The Methow-Chewuch spring Chinook Salmon hatchery program is intended to supplement the Methow and Chewuch rivers and was initiated with broodstock collection in 1992. The first smolts were released in 1994, and the first hatchery fish returned in 1995. The Methow Hatchery is on the right bank of the Methow River at RKM 82, approximately 2 km upstream from the mouth of the Chewuch River. Broodstock have been collected at Fulton Dam at RKM 1.8 on the Chewuch River; Foghorn Dam at RKM 82.5 on the Methow River; and at the Methow Hatchery outfall. Since 2007, broodstock has been collected at Wells Dam on the Columbia River. Broodstock were assigned to the Methow-Chewuch or Twisp spawning aggregates using genetic methods. Adult brood fish were spawned, incubated, and reared at the Methow Hatchery. Final acclimation in the spring occurred primarily at the Methow Hatchery or at an acclimation pond on the Chewuch River at RKM 13.3. However, in some years, a portion of the fish from the Methow Hatchery have been spring-acclimated and released by the Yakama Nation from remote ponds on small tributaries to the Methow River upstream from the Methow Hatchery, including one on Wolf Creek (RKM 88; broods 2002, 2008, and 2009), Mid-Valley Pond (RKM 90; broods 2010, 2011, and 2012), and Goat Wall Pond (RKM 117; broods 2015-2017).

Before brood year 2001, resource managers attempted to maintain genetic distinction between Chewuch and Methow production, releasing progeny of presumed Chewuch-origin adults (based on capture location or CWT) only to the Chewuch River, and likewise releasing progeny of presumed Methow-origin adults only to the Methow. However, beginning with brood year 2001, resource managers composited production of Methow and Chewuch stocks into the single Methow-Chewuch stock due to chronic difficulties collecting sufficient broodstock to maintain a distinct Chewuch program. The loss of trapping facilities at Fulton Dam in 2005 ended broodstock collection efforts in the Chewuch River. With the historic challenges obtaining natural-origin broodstock, the proportion of natural-origin fish used in the broodstock (pNOB) has varied under pressure from fisheries managers to maintain production targets.

The production goal for the Methow-Chewuch program for brood-years 1992 through 1997 was variable depending upon brood availability, with the nominal target of 500,000 yearling smolts. Releases ranged from 16,000 to 495,000 (mean, 223,000) yearling smolts, due to inconsistent broodstock-trapping efficiency at Fulton Dam on the Chewuch River and Foghorn Dam on the Methow River, and collection efforts at these locations were supplemented with collection at the Methow Hatchery outfall and Wells Dam beginning in 1996. Average pNOB during this period was 45% and ranged from 0 to 79%.

For brood years 1998 through 2011, the nominal production goal was 366,000 yearling smolts. However, with consistent shortfalls in brood collection in the Twisp River, resource managers compensated for resultant shortfalls in Twisp River smolt production by increasing production in the Methow-Chewuch program commensurate with the Twisp River shortfall in each brood year. Smolt production for the Methow-Chewuch program averaged 357,000 (range, 196,000-498,000) yearling smolts for brood years 1998-2011. Average pNOB during this period was 19% and ranged from 0 to 58%. Since brood year 2012, the production goal of 193,000 yearling smolts, which included 60,516 yearling smolts released in the Chewuch River, has been consistently achieved, and pNOB has averaged 71% (range 30% to 99%).

All spring Chinook Salmon produced for the Methow-Chewuch program were tagged with CWTs, and prior to brood year 2000, were also adipose-fin clipped. For brood years 1992- 2017, the annual CWT tag rate ranged from 88-100 percent. A portion of the releases were also PIT tagged prior to release in 2003, 2004, and every year since 2010.

Key Results

Key results from analyses conducted on Methow-Chewuch River spring Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 3.4 and summarized below to facilitate interpretation.

Comparisons between Methow-Chewuch spring Chinook Salmon and stream-type Chinook Salmon in reference (un-supplemented) streams located outside the Upper Columbia were made using a BACI design to evaluate whether supplementation changed abundance of total spawners, natural-origin adult recruits, natural-origin spawners, and density-adjusted adult productivity. In the Methow and Chewuch Rivers, adults collected and spawned in the hatchery produced considerably more adult recruits per spawner than those that spawned in the natural environment, and hatchery return rate has met the program target in each of the past five years. Abundance of total spawners, natural-origin spawners, natural-origin adult recruits, and density-adjusted productivity in the Methow-Chewuch decreased more or increased less during supplementation compared to reference streams, although the only statistically significant result was that of adjusted productivity. This evaluation was not able to evaluate factors unrelated to supplementation, for example, habitat-restoration projects, differences in migration corridors, and differential predation rates on adults. Additionally, for total spawner abundance, adult management (removal of excess hatchery-origin fish prior to spawning), which was implemented annually beginning in 2015, resulted in fewer adults potentially spawning in the Methow River basin. Based on these analyses, spring Chinook Salmon supplementation has not measurably improved abundance or productivity of natural-origin spring Chinook Salmon in the Methow-Chewuch rivers, relative to un-supplemented, reference populations located outside the Upper Columbia Basin.

In the Methow River basin, there was no significant effect of pHOS on juvenile recruitment or juveniles per redd. Juveniles were defined as yearlings assumed to be emigrating to the ocean, and other life history pathways that may represent an important component of the population (e.g., age 0+ spring Chinook migrants) were not included in the analysis. Small sample sizes, high variance, and the potential for large measurement error limited analysis and resulted in poor fit for stock recruitment models. This led to low confidence in estimated model parameters and an inability to detect any relationship between pHOS and juvenile productivity or smolts per redd.

A PNI target of 0.67, derived from a three-population model incorporating the proportion of hatchery fish from conservation programs, safety net programs, and the natural-origin spring Chinook Salmon on the spawning grounds was set for the Methow River subbasin in 2017. The target was not met for brood year 2017 or 2018. In 2005 and 2006, genetic samples acquired from natural-origin spring Chinook spawners in the Chewuch and Methow rivers were found to have diverged from their respective genetic baselines. By 2017, natural-origin spawners in the two rivers were genetically indistinguishable. This is not surprising, given the program's composite broodstock.

The effects of the Methow-Chewuch spring Chinook Salmon Program on phenotypic and life-history characteristics varied. Migration timing at Wells Dam and spawn timing of hatchery- and natural-origin spring Chinook Salmon in the Methow and Chewuch rivers were similar, but the spawning distributions of hatchery- and natural-origin spring Chinook Salmon differed. Methow-Chewuch spring Chinook Salmon rarely strayed to out-of-basin streams. However, within basin straying was common, and the Chewuch released fish often comprised greater than 10% of the spawning aggregate in the Methow river.

The Methow-Chewuch spring Chinook Salmon Program met its release and fork length CV targets in most years since the first recalculation period (brood year 2012). Weight targets were met more often than not for brood years after 2012.

Fish released in both the Methow and Chewuch rivers contributed to harvest in ocean, commercial, tribal, and recreational fisheries. The average percentage of brood years harvested from 2004-2012 was 5.1% and 4.6%, respectively.

Table 3.4. Summary of monitoring and evaluation results for Methow-Chewuch River spring Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Inconclusive: Non-significant comparisons with out-of-basin references. Methow-Chewuch decreased while references both increased and decreased (MBACI Contrast -0.37, P = 0.26).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks); adult management also affects total spawners.
1.2 Natural-Origin Spawners (NOS)	Inconclusive: Non-significant comparisons with out-of-basin references. Methow-Chewuch NOS increased and references increased (MBACI Contrast = -0.15; P = 0.73).	Same as above.
1.3 Natural-Origin Recruits (NOR)	Inconclusive: Non-significant comparisons with out-of-basin references. Methow-Chewuch decreased while references increased (MBACI Contrast: -0.77, P = 0.06).	Same as above.
1.4 Adjusted Productivity (NRR)	Not Met: Methow-Chewuch combined decreased while references increased (MBACI Contrast = -0.56, P = 0.01).	Same as above.
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Inconclusive: pHOS contrast and statistical power insufficient for analytical purposes. There was no relationship between pHOS and juvenile productivity (P > 0.05).	There are no reference populations or before-supplementation data available for more robust analyses. The analysis only includes yearlings produced within the Methow River basin.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		

M&E Objective	Findings	Comments
3.1 HRR > NRR	Met: HRR ≥ NRR in 19 of 21 years and mean HRR was significantly larger than mean NRR ($P < 0.01$).	
3.2 HRR ≥ Target	Met: HRRs ranged from 0.29-11.61 (Mean = 4.71; target 3.8). HRR has met the target in each of the last five years (2008-2012).	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Not Met: During the period when there were PNI targets for the Methow Subbasin (2017-present), the three-population target was not met in brood year 2017 (PNI = 0.38) or 2018 (PNI = 0.44). There was no PNI management before 2017.	
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Met: The migration timing of PIT-tagged hatchery- and natural-origin adults at Wells Dam was similar ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.2 Spawn timing	Met: Hatchery- and natural-origin adults had similar spawn timing ($P > 0.05$).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.3 Spawn distribution	Not Met: Both hatchery- and natural-origin adults spawned throughout the Methow and Chewuch rivers and within each reach; however, there was a significant difference in the distribution of hatchery- and natural-origin spawners among historical survey reaches of both rivers for years 1996-2018 ($P < 0.01$).	Although the M&E Plan does not include pHOS analysis at the reach scale, pHOS ranged from 0.31-0.92 among the 13 reaches in the Chewuch River and from 0.00-1.00 among the 17 reaches in the Methow River. The highest proportions generally occurred in the lower portions of each river. Spawning location can have a significant effect on fitness of spring Chinook Salmon.
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual brood year donor stray percentage for Chewuch River releases ranged from 0.0-54.3% (mean = 27.6%) to in-basin non-target streams, and from 0.0%-1.8% (mean = 0.5%) for out-of-basin streams. Annual brood year donor stray percentage for Methow River releases ranged from 0.0-10.5% (mean = 2.3%) to in-basin non-target streams, and	

M&E Objective	Findings	Comments
	from 0.0%-1.7% (mean = 0.2%) for out-of-basin streams.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: Neither Chewuch River nor Methow River released fish exceeded the 5% target for out of basin recipient populations.	
6.3 Return Year Recipient Stray Targets (Within Basin)	Not Met: Chewuch River released spring Chinook Salmon Program exceeded the 10% in-basin stray rate target to the Methow River in 14 of 23 years (mean = 11.8%).	Because spring Chinook released in the Methow and Chewuch rivers are produced from the same composite broodstock, straying between the two rivers is not a genetic concern. For Methow-Chewuch hatchery-origin spawners from BYs 1998 and 2000, in-basin stray rate cannot be determined because releases into each river had the same CWT number.
	Met: Methow River released spring Chinook exceeded the 10% in-basin stray rate target to the Chewuch River in one of 23 years (mean = 4.2%)	Because spring Chinook released in the Methow and Chewuch rivers are produced from the same composite broodstock, straying between the two rivers is not a genetic concern. For Methow-Chewuch hatchery-origin spawners from BYs 1998 and 2000, in-basin stray rate cannot be determined because releases into each river had the same CWT number.
6.4 Brood Year Recipient Stray Rates	No Target: For the period of 2014-2018, the mean recipient stray percentage in the Chewuch River was 21.4% and the mean recipient stray percentage in the Methow River was 13.1%.	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Not Met: The AMOVA tests indicated that there were significant differences ($P < 0.05$) in allele frequencies between baseline and contemporary collections from the same tributary and different tributaries, and between natural and hatchery collections from the same river.	These allele frequency changes suggest that genetic drift has affected the populations, as expected for populations that declined to low abundance and required hatchery intervention. This result is expected as an outcome of combining the Chewuch and Methow broodstock in the hatchery.
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences ($P < 0.05$) in the number of locus pairs in linkage disequilibrium in comparisons of baseline and contemporary collections.	Collections with high linkage had incorporated large family groups.
7.3 Population Genetics (Genetic Distance)	Not Met: Among the Methow collections, all genetic distance comparisons of collections from the same river in	These distances were affected by changes in effective population size and likely reflected straying as well as genetic drift.

M&E Objective	Findings	Comments
	different time frames were significantly different from zero (P < 0.05).	
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: The monitoring question for this objective was to assess changes over time in the ratio of N_b (effective number of breeders) to census size (N); however, the N_b was difficult to evaluate due to small collection sizes and non-random sampling of family members.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not Met: Age at maturity was significantly different between hatchery- and natural-origin adults (P < 0.01). Hatchery-origin fish returned at a younger age.	
8.2 Phenotype Similarity (Size at Maturity)	Met: Size at maturity was significantly affected by sex and age (P < 0.01), but not by origin (P = 0.051). Differences in lengths between natural- and hatchery-origin fish were generally less than 3 cm.	
8.3 Phenotype Similarity (Size and Fecundity)	Met: There were no significant differences in relationships between hatchery- and natural-origin fish for size and fecundity (P = 0.52), mean egg weight (P = 0.57), or fork length and gonadal mass (P = 0.15).	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2012-2017, the Chewuch target of 60,516 (±10%) was met in 3 of 5 brood years and exceeded in 2 of 5 brood years. The Methow release target of 133,249 (±10%) was exceeded in 5 of 6 years and not met in one year. Prior to brood year 2012, the Chewuch target of 183,333 (±10%) was exceeded in eight of 18 releases, and not met in ten of 18 releases. The Methow target of 183,333 (±10%) was met in four of 17 releases, exceeded in seven of 17 releases, and not met in six of 17 releases.	The first brood year for the Chewuch program was 1992. There was no Chewuch program for brood years 1995, 1999, and 2012. The first brood year for the Methow program was 1993. For brood years 1998 and 2000, fish released into the Methow and Chewuch rivers had the same CWT number, making adult returns indistinguishable between the release groups.
9.2 Size-at-release (FPP)	Met: For brood years 2012-2017, the target of 15 FPP (±10%) was met in three of six brood years for Methow releases; three brood-year releases were smaller than the target. The Chewuch releases met the target in three of five brood years; two years were smaller than the target. Prior to brood year 2012, the Methow program met the target in eight of 17	The first brood year for the Chewuch program was 1992. There was no Chewuch program for brood years 1995, 1999, and 2012. The first brood year for the Methow program was 1993. For brood years 1998 and 2000, fish released into the Methow and Chewuch rivers had the same CWT number, making

M&E Objective	Findings	Comments
	brood years and the Chewuch program met the target in seven of 18 brood years.	adult returns indistinguishable between the release groups.
9.3 Size-at-release (CV)	Met: For brood years 2012-2017, the CV target of <9.0 was met in six of six brood years for Methow releases and two of five brood years for Chewuch releases. Prior to brood year 2012, both Methow and Chewuch releases met the CV target in four of the 13 years for which data are available.	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: For brood years 2004-2012, the average percent of the brood year harvested for the Methow, Chewuch, and Twisp rivers was 5.1%, 5.8%, and 4.6%, respectively.	

3.5 Twisp River Spring Chinook Salmon Program

Introduction

The hatchery program intended to supplement the Twisp River spawning aggregate was initiated with broodstock collection in 1992 and was implemented in a similar manner as the Methow-Chewuch program. Broodstock were collected at a trap in the Twisp River or at Wells Dam with subsequent genetic assignment to the Twisp River. Adult brood fish were spawned, incubated, and reared at the Methow Hatchery. Final acclimation in the spring occurred at an acclimation pond on the Twisp River at RKM 11.5.

The nominal production goal for the Twisp River program for brood-years 1992 through 1997 was 250,000 yearling smolts (average pNOB of 65%; range 0 to 100%). For brood years 1998 through 2011, the nominal production goal was 183,000 yearling smolts (average pNOB of 34%; range 0 to 75%). From brood year 2012 to 2018, the production goal was 30,000 yearling smolts (average pNOB of 74%; range 41% to 100%).

To maintain genetic distinction between the Twisp River spawning aggregate and the Methow-Chewuch composite aggregate, resource managers limited broodstock for the Twisp River program to either natural- or hatchery-origin fish from the Twisp River. Difficulty in obtaining Twisp-origin brood resulted in consistent brood limitation for the Twisp River program. Thus, annual smolt production averaged approximately 52,000 (range 0 to 116,000) over the life of the program, with consistent production of approximately 30,000 smolts beginning with brood year 2012. All spring Chinook Salmon produced for the Twisp program were tagged with CWTs, and prior to brood year 2000, were also adipose-fin clipped. For brood years 1992-2017, the annual CWT tag rate ranged from 94-100 percent. A portion of the releases were also PIT tagged prior to release in 2003, 2004, and every year since 2010.

In 1996 and 1997, resource managers implemented a captive brood program for the Twisp spawning aggregate by vacuuming a small number of eggs from redds of naturally spawning fish in the Twisp River. Subsequent brood years through 2002 reserved 45 eggs from each crossing of Twisp broodstock for the captive brood program (goal of 30 families). Incubation and initial rearing occurred at Methow Hatchery for the 1996 and 1997 broods, but progeny from subsequent brood years were reared at the AquaSeed Corporation facility in Rochester, Washington. The captive brood program contributed little to total annual smolt production for the Twisp River program, and captive production ended with the release of F2 smolts that were progeny of F1 adults from eggs collected from adults returning to the Twisp River in 2002.

Key Results

Key results from analyses conducted on Twisp River spring Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 3.5 and summarized below to facilitate interpretation.

Comparisons between Twisp spring Chinook Salmon and stream-type Chinook Salmon in reference (un-supplemented) streams located outside the Upper Columbia were conducted using a BACI design to evaluate whether supplementation changed abundance of total spawners, natural-origin adult recruits, natural-origin spawners, and density-adjusted adult productivity. In the Twisp River, adults collected and spawned in the hatchery produced considerably more adult recruits per spawner than those that spawned in the natural environment. Despite that, hatchery return rate has met the program target in only 6 of 15 years and only 2 of the past 5 years.

Of the four sub-objectives under Objective 1, the Twisp spring Chinook Salmon program met one and did not meet three: The abundance of total spawners decreased in the Twisp, while not changing or increasing in reference streams, resulting in a significantly negative MBACI contrast. For total spawner abundance, adult management (removal of excess hatchery-origin fish prior to spawning), which was implemented annually beginning in 2015, may have resulted in fewer adults spawning naturally in the Twisp River basin. Natural-origin spawners increased in both the Twisp and reference streams but increased (not significantly) less in the Twisp. Natural-origin adult recruits decreased in the Twisp, while increasing in reference streams, resulting in a significantly negative MBACI contrast. Density-adjusted productivity decreased significantly in the Twisp, while changing little or increasing in reference streams. This evaluation was not able to account for factors differentially affecting the Twisp and reference streams unrelated to supplementation, such as habitat-restoration projects, differences in migration corridors, and differential predation or harvest rates on adults. Thus, we cannot attribute observed differences between the Twisp and reference populations to supplementation effects. Nevertheless, the Twisp population decreased in three of four sub-objectives under Objective 1, irrespective of reference comparisons. Only natural-origin spawners increased (albeit less than in reference streams) during the monitoring interval.

The analysis of the Twisp River population identified density-dependent mortality between spawner data collection and smolt data collection but was unable to identify an effect of pHOS on juvenile recruitment or juveniles per redd because of various analytical and data quantity/quality limitations. Juveniles were defined for study purposes as yearlings emigrating to the ocean (assumed), and other life-history pathways that may represent an important component of the population (e.g., age 0+ spring Chinook Salmon migrants) were not explicitly included in the analysis. Small sample size resulted in low power to detect an effect of pHOS. This, and high variance, violation of model assumptions, the potential for large measurement error, and insufficient contrast in pHOS, limited analysis and resulted in poor fit for stock-recruitment models. These factors combined led to low confidence in estimated model parameters and an inability to detect any relationship between pHOS and juvenile productivity or smolts per redd. Negative autocorrelation in the model residuals suggested that the stock-recruitment models evaluated do not adequately account for population dynamics in the Twisp, and other methods may be necessary to identify a relationship between pHOS and juvenile productivity should one exist.

A subbasin-wide PNI target of 0.67, derived from a three-population model incorporating the proportion of hatchery fish from conservation programs, safety-net programs, and the natural-origin spring Chinook Salmon on the spawning grounds was set for the Methow River subbasin in 2017. This target included a PNI sliding scale varying with spawner escapement. However, neither a PNI target nor sliding scale was set for the Twisp watershed. Therefore, we report only the subbasin-wide target. The target was not met in either spawn year 2017 or 2018.

Updated genetic analyses identified that within the last 10 years, the Twisp program broodstock has diverged further (than observed in the 2007 analysis) from the Twisp baseline but remained relatively similar to the Twisp in-river spawners, while the Twisp in-river spawners have also diverged from the baseline. The relationship between in-river spawners in the Twisp, Chewuch, and Methow suggests that fish have strayed among these rivers. Allele frequencies for contemporary Twisp spawners now cluster with contemporary Chewuch and Methow spawners, whereas in previous analyses Twisp spawners clustered distinctly. Over the last 25 years, straying between tributaries contributed to an increase in the genetic diversity of Twisp natural spawners relative to baseline collections, but at the cost of decreased differentiation between Methow Subbasin subpopulations including Winthrop Hatchery collections.

The effects of the Twisp spring Chinook Salmon Program on phenotypic and life-history characteristics varied. Migration timing at Wells Dam and spawn timing of hatchery- and natural-origin spring Chinook Salmon in the Twisp River were similar, but the spawning distributions of hatchery- and natural-origin spring Chinook Salmon differed, with greater proportions of hatchery-origin than natural-origin spawners in the five lower reaches, and vice versa in the four upper reaches. Nevertheless, hatchery-origin returns spawned throughout the Twisp, generally overlapping natural-origin spawners by river kilometer, and with nearly equal proportions in the most productive reaches (T6 and T7).

Adults from the Twisp spring Chinook Salmon Program returned at a younger age than natural-origin fish but did not differ by origin in size at maturity. Additionally, no differences were observed between fish weight and fecundity or fish fork length and total egg weight, for Twisp hatchery- and natural-origin fish. However, there were significant differences between Twisp hatchery- and natural-origin fish for fork length and fecundity, and fork length and mean egg weight.

Twisp spring Chinook Salmon rarely strayed to out-of-basin streams. In contrast, within-basin straying by Twisp returns was common, with a mean brood-year stray rate (no target) for brood years 2002, and 2010-2015 of 33%. However, Twisp strays never comprised greater than 1% of the spawners in any return year in any out-of-basin stream, or greater than 10% of the spawners in any return year in the Methow or Chewuch rivers. Mean contributions of strays from other rivers/programs to total return-year spawners in the Twisp never exceeded 10% (1999-2018) and did not exceed 5% of the total spawners in the Twisp from 2014-2018.

The Twisp spring Chinook Salmon Program met its release-number and fork-length CV targets in every year since the first recalculation period (brood year 2012).

Table 3.5. Summary of monitoring and evaluation results for Twisp River spring Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Not met: Total Spawners decreased in the Twisp while staying the same or increasing in the references (MBACI Contrast = -0.944; P = 0.02).	There are differences between the supplemented population and the reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including predation risks).
1.2 Natural-Origin Spawners (NOS)	Met: NOS increased in both the Twisp and reference streams but increased more in references than in the Twisp (MBACI Contrast = -0.646; P = 0.17).	Same as above.

M&E Objective	Findings	Comments
1.3 Natural-Origin Recruits (NOR)	Not Met: NORs decreased in the Twisp but increased in reference streams (MBACI Contrast = -1.362, P = 0.01).	Same as above.
1.4 Adjusted Productivity (NRR)	Inconclusive: NRR decreased in the Twisp, while generally changing little in reference streams (MBACI Contrast = -0.733, P < 0.01).	Same as above.
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Inconclusive: pHOS contrast and statistical power insufficient for analytical purposes, resulted in the inability to detect any relationship between pHOS and juvenile productivity or smolts per redd.	There are no reference populations or before-supplementation data available for more robust analyses. The analysis only includes yearlings produced within the Twisp River basin.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	Met: HRR ≥ NRR in 14 of 15 years (1999-2013) and mean HRR (3.6) was 6.1 times higher (P < 0.01) than mean NRR (0.59); HRR range = 0.93-10.37; NRR range = 0.03-2.03.	
3.2 HRR ≥ Target	Not Met: HRR was greater than the target of 2.7 in only 6 of 15 years (1999-2013). HRR was less than the target in 3 of the last 5 years of the dataset analyzed (2008-2012).	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Not Met: The Methow Subbasin PNI target is a subbasin-scale target, rather than a Twisp-specific target, and has only been defined by permit since 2017. The target was not achieved in either 2017 or 2018.	
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Met: Arrival timing at Wells Dam of Twisp PIT-tagged hatchery- and natural-origin spring Chinook was nearly identical (P > 0.05).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10^{th}, 50^{th}, and 90^{th} percentiles.
5.2 Spawn timing	Met: Hatchery- and natural-origin adults had similar spawn timing (P > 0.05).	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10^{th}, 50^{th}, and 90^{th} percentiles.

M&E Objective	Findings	Comments
5.3 Spawn distribution	Not Met: The distributions of hatchery- and natural-origin spawners differed significantly (P < 0.01) among historical survey reaches.	Although the M&E Plan does not include pHOS analysis at the reach scale, pHOS ranged from 0.33-0.88 among the nine reaches in the Twisp River. The highest proportions were in the lower four reaches of the river near the acclimation facility. Spawning location can have a significant effect on fitness of spring Chinook Salmon.
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Twisp mean brood year stray rates (BY 2002, 2010-2015) were 33% within-basin, and less than 1% out-of-basin	Despite the high within-basin brood-year stray rate, the small size (number of smolts released) of the Twisp program limits the contribution of Twisp strays to total spawners within those recipient subpopulations (see Objective 6.3).
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: Twisp strays did not comprise more than 1% of spawners in out-of-basin populations.	
6.3 Return Year Recipient Stray Targets (Within Basin)	Met: Twisp strays did not comprise more than 10% of spawners in any in-basin subpopulations (2014-2018 in-basin stray range = 0%-8.8%; average = 0.84%).	See comment on Objective 6.1.
6.4 Brood Year Recipient Stray Rates	No Target: Mean stray rates into the Twisp did not exceed 10% in any period (1999-2018 = 6.13%; 2009-2018 = 9.86%; 2014-2018 = 7.77%); no program contributed 5% or more to the Twisp from 2014-2018.	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Not Met: The AMOVA tests indicated that there were significant differences (P < 0.05) in allele frequencies between baseline and contemporary collections from the same tributary and different tributaries, and between natural and hatchery collections from the same river.	These allele frequency changes suggest that genetic drift has impacted the populations, as expected for populations that declined to low abundance and required hatchery intervention. There was significantly higher expected heterozygosity in the Twisp natural contemporary collection than in the Twisp baseline collection from 1992. The genetic homogenization of Methow Subbasin spring Chinook Salmon is a product of both straying from the Twisp program to the Chewuch and Methow rivers and straying into the Twisp River from the Met-Chew and Winthrop National Fish Hatchery programs.

M&E Objective	Findings	Comments
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences ($P < 0.05$) in the number of locus pairs in linkage disequilibrium in comparisons of baseline and contemporary collections.	Collections with high linkage had incorporated large family groups.
7.3 Population Genetics (Genetic Distance)	Not Met: Among the Methow collections, all genetic distance comparisons of collections from the same river in different time frames were significantly different from zero ($P < 0.05$).	These distances were affected by changes in effective population size and likely reflected straying as well as genetic drift.
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: The monitoring question for this objective was to assess changes over time in the ratio of N_b (effective number of breeders) to census size (N); however, the N_b was difficult to evaluate due to small collection sizes and non-random sampling of family members.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not Met: Twisp natural- and hatchery-origin fish exhibited significantly different ($P < 0.01$) age at maturity, with the latter returning at a younger age.	
8.2 Phenotype Similarity (Size at Maturity)	Met: The size at maturity for returns to the Twisp River was significantly affected by sex and age ($P < 0.01$), but not by origin ($P = 0.233$). Differences in lengths between natural- and hatchery-origin fish were generally less than 2 cm.	
8.3 Phenotype Similarity (Size and Fecundity)	Met: There were no differences between hatchery- and natural-origin fish for weight and fecundity ($P = 0.06$) or fork length and total egg weight ($P = 0.98$). Not Met: There were significant differences between hatchery- and natural-origin fish for fork length and fecundity ($P = 0.03$), and fork length and mean egg weight ($P = 0.03$).	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2012-2017, the target of 30,000 ± 10% was achieved every year and exceeded in 3 of 6 years (mean = 36,137; range 29,333-48,924). For brood years 2002-2011, the target of 183,000 ± 10% was not achieved in any year (mean = 60,892; range 15,470-139,770).	

M&E Objective	Findings	Comments
9.2 Size-at-release (FPP)	Met: The Twisp mean FPP for 2012-2018 was 16 (range 15-18), and the annual target was 15.	
9.3 Size-at-release (CV)	Met: The Twisp CV target was less than 9, and for 2012-2018 the mean CV was 9 (range 6-11).	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	No Target: For brood years 2004-2012, the average percent of the brood year return harvested was 4.6% (range 0.0%-23.5%).	The Twisp River spring Chinook Salmon program was not intended to support harvest, and thus the M&E Plan provides no target rate for harvest contribution.

SECTION 4: SUMMER CHINOOK SALMON

The PUDs fund four summer Chinook Salmon hatchery programs in the Upper Columbia River basin. The Wenatchee River program is funded by Chelan and Grant PUDs, the Chelan Falls program is funded by Chelan PUD, the Methow River program is funded by Grant PUD, and the Wells (yearling and subyearling) program is funded by Douglas PUD. In addition, the three PUDs also support the Okanogan River summer Chinook Salmon program operated by the Confederated Tribes of the Colville Reservation (CTCR). Under a contract with the Bonneville Power Administration, the CTCR monitors this program and generates separate reports.

4.1 Wenatchee River Summer Chinook Salmon Program

Introduction

The goal of summer Chinook Salmon supplementation in the Wenatchee River basin is to use artificial production to replace juveniles lost to unavoidable juvenile project mortality at Priest Rapids, Wanapum, and Rock Island dams, while not reducing the natural production or long-term fitness of summer Chinook Salmon in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD and subsequently Grant PUD began cost-sharing the program in 2012. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans as well as the Priest Rapids Project Salmon and Steelhead Settlement Agreement.

Adult summer Chinook are collected for broodstock from the run-at-large at the right and left-bank traps at Dryden Dam and at Tumwater Dam if weekly quotas cannot be achieved at Dryden Dam. Before 2012, the goal was to collect up to 492 natural-origin adult summer Chinook for the Wenatchee program for an annual release of 864,000 smolts. In 2011, the Hatchery Committees reevaluated the amount of hatchery compensation needed to achieve No Net Impact (NNI). Based on that evaluation, the program's production target was reduced. Chelan PUD's smolt production obligation is 318,185 and Grant PUD's smolt production obligation is 181,816 between 2014-2023. Broodstock collection occurs from about 24 June through 15 September with trapping occurring up to 24 hours per day, seven days a week. If natural-origin broodstock collection falls short of expectation, hatchery-origin adults can be collected to meet the collection quota. From 2012 to 2018, the collection goal ranged from 252 to 278 for adult natural-origin summer Chinook Salmon for an annual release of 500,001 smolts. For brood year 2022, the collection target was 288 adult natural-origin summer Chinook Salmon for an annual release of 500,000 smolts.

Adult summer Chinook Salmon are spawned at Eastbank Fish Hatchery typically from September to early November. The majority of juvenile summer Chinook Salmon at Eastbank Fish Hatchery are ponded in mid- to late-April and reared in raceways with a portion typically in a partial re-use system in circular tanks. Juvenile summer Chinook Salmon are transferred from the hatchery to Dryden Acclimation Pond in early- to mid-March. They are volitionally-released from the Dryden Acclimation Pond in mid- to late-April as yearlings. If all yearlings do not exit Dryden Pond volitionally, they are typically force released by 30 April.

Before 2012, the production goal for the Wenatchee River summer Chinook Salmon supplementation program was to release 864,000 yearling smolts into the Wenatchee River at ten fish per pound. Beginning with the 2012 brood, the revised production goal is to release 500,001 yearling smolts into the Wenatchee River at 18 fish per pound. The target for coefficient of variation (CV) is 9.0. Over 95% of these fish are tagged with CWTs. In addition, since 2012, about 20,000 juvenile summer Chinook have been PIT tagged annually.

Key Results

Key results from analyses conducted on Wenatchee River summer Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 4.1 and summarized below to facilitate interpretation.

Comparisons between Wenatchee River summer Chinook Salmon and ocean-type Chinook Salmon in a reference (un-supplemented) stream located outside the Upper Columbia was made using a BACI design to evaluate whether supplementation changed abundance of total spawners, natural-origin adult recruits, natural-origin spawners, and density-adjusted adult productivity. Adults collected and spawned in the hatchery produced significantly more adult recruits per spawner than those that spawned in the natural environment. Abundance of total spawners and natural-origin spawners decreased in the Wenatchee River, while the same metrics increased in the reference stream. These differences were statistically significant. Natural-origin recruits increased in both streams but increased more in the Wenatchee River. The result was not statistically significant. Density-adjusted productivity in the Wenatchee River increased, while adjusted productivity in the reference stream decreased; however, the difference was not significant. This is likely because of the high variability in productivity estimates over time. This evaluation was not able to evaluate factors unrelated to supplementation, for example, habitat-restoration projects and differences in migration corridors (e.g., number of dams that each populations must cross). Based on these analyses, summer Chinook Salmon supplementation has not measurably improved abundance of natural-origin summer Chinook Salmon in the Wenatchee River basin, relative to an un-supplemented reference population located outside the Upper Columbia Basin.

There was no evidence that supplementation increased or decreased productivity of natural-origin juvenile summer Chinook Salmon in the Wenatchee River basin. Higher pHOS did not appear to lower juvenile productivity, where juvenile productivity was measured as the number of subyearling emigrants per spawner produced within the Wenatchee River basin. However, no other life history pathways were included in this analysis (e.g., yearling smolts). For all three stock-recruitment models considered, there was often high uncertainty in model parameter estimates even when the models could be fit to the data. Given all the complicating factors associated with these analysis analyses (e.g., no reference populations or before-supplementation data, uncertainty in model parameters, insufficient statistical power for analytical purposes, and using correlation analysis), only the most extreme effect of pHOS on juvenile productivity could have been detected. Thus, we caution against concluding that supplementation had no effect on juvenile productivity in the Wenatchee River basin.

Since 2012, during years in which there was PNI management, the five-year-mean PNI target (PNI ≥ 0.67) for Wenatchee River summer Chinook Salmon was met in all spawn years (there was no PNI management before 2012). The 5-year-mean PNI ranged from 0.90-0.91. On an annual basis, the target was met in all years (PNI ≥ 0.67). In addition, based on genetic evaluations, the supplementation program did not appear to affect genetic diversity or population structure of summer Chinook Salmon in the Wenatchee River basin. Measures of genetic diversity (allelic richness, heterozygosity, linkage disequilibrium, and effective number of breeders) showed little differentiation between baseline and contemporary collections. Although not significant, there was an indication that genetic drift and homogenization among stocks has occurred over time. Overall, there is little evidence for neutral genetic divergence between contemporary and baseline samples.

The effects of the Wenatchee River summer Chinook Salmon program on phenotypic and life-history characteristics varied. There was a significant difference in migration and spawn timing of natural- and hatchery-origin summer Chinook Salmon in the Wenatchee River. Hatchery-origin fish generally arrived later and spawned later than did natural-origin fish. Differences in timing averaged from 1.0 to 2.5 weeks. Consistent with the management objective, a higher proportion of hatchery-origin summer Chinook Salmon spawned in the lower portions of the Wenatchee River, while a higher proportion of natural-origin summer Chinook Salmon spawned in the upper portions of the river. Similar to migration and spawn-timing metrics, age at maturity and size at maturity differed between hatchery- and natural-origin summer Chinook Salmon in the Wenatchee River basin. Hatchery-origin fish generally returned at a younger age than natural-origin fish, but the predominate age at maturity was similar between hatchery- and natural-origin fish of the same sex. The size at maturity of returning adults was significantly affected by age, sex, and origin. However, when matched by age and sex, the differences in size at maturity by origin that were statistically significant were minor and likely of little biological relevance. Because natural-origin fish are collected for broodstock, we were unable to compare fecundities between natural- and hatchery-origin fish. The fecundity metrics for natural-origin fish were significantly affected by fish size and weight.

For return years 1994 to 2018, hatchery-origin summer Chinook Salmon from the Wenatchee River program strayed into populations outside the Upper Columbia River basin but did not make up more than 5% of the recipient population. They also strayed into non-target spawning areas within the Upper Columbia basin but rarely exceeded the threshold of 10% of the spawning aggregate. Few Wenatchee River summer Chinook Salmon contributed to the Methow, Okanogan, Chelan, and Entiat escapements and to the fall Chinook Salmon escapement on the Hanford Reach. Based on brood year analysis, on average, about 3.1% of the brood year returns strayed into non-target spawning areas. In contrast, on average, about 14.0% of the brood year returns strayed into non-target hatcheries. Several of these fish were intercepted at Chief Joseph Hatchery.

The Wenatchee River summer Chinook Salmon program met its release goal of 500,001 (±10%) in all years since the first recalculation period (since brood year 2012). Before 2012, the program met its release goal of 864,000 (±10%) in 10 of the 23 brood years. Likewise, for brood years 2012-2017, the program met the FPP target in 4 of the 6 brood years. On the other hand, the program was less successful in meeting the CV target for length. For brood years 2012-2017, the CV target was met in 1 of the 6 brood years. Wenatchee River summer Chinook Salmon exhibited near-isometric growth with a mean condition factor of 1.04.

Since its initiation, the Wenatchee River summer Chinook Salmon program produced fish that have contributed to ocean and freshwater (tribal, commercial, and recreational) fisheries. For brood years 1989-2012, the average percent of the brood year return harvested was 58.5% (range 25.4-80.2%), with the most fish captured in ocean fisheries (34-100% of the fish harvested).

Table 4.1. Summary of monitoring and evaluation results for Wenatchee River summer Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Not Met: Wenatchee total spawners decreased while reference population spawners increased (BACIP Contrast = -0.732, P < 0.01).	There are differences between the supplemented and reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including the number of dams that each population must cross). Differences were small between supplemented and reference populations.
1.2 Natural-Origin Spawners (NOS)	Not Met: Wenatchee NOS decreased while reference NOS increased (BACIP Contrast = -1.930; P < 0.01).	There are differences between the supplemented and reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including the number of dams that each population must cross). Differences were small between supplemented and reference populations.
1.3 Natural-Origin Recruits (NOR)	Inconclusive: Non-significant comparisons with out-of-basin reference. Wenatchee and reference populations increased but the Wenatchee increased more (BACIP Contrast = 0.352, P = 0.40).	There are differences between the supplemented and reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including the number of dams that each population must cross). Differences were small between supplemented and reference populations.
1.4 Adjusted Productivity (NRR)	Inconclusive: Non-significant comparisons with out-of-basin reference. Wenatchee increased while the reference decreased (BACIP Contrast = 0.575, P = 0.08).	There are differences between the supplemented and reference populations that are independent of supplementation (e.g., downstream and upstream migration differences, including the number of dams that each population must cross). High variability resulted in non-significant effects.
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Inconclusive: pHOS contrast and statistical power insufficient for analytical purposes. There was no relationship between pHOS and juvenile productivity (P = 0.72).	There are no reference populations or before-supplementation data available for more robust analyses. Currently, there is little evidence of density dependence in the Wenatchee population.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		

M&E Objective	Findings	Comments
3.1 HRR > NRR	Met: HRR ≥ NRR in 19 of 24 years and mean HRR was significantly larger than mean NRR ($P < 0.01$).	
3.2 HRR ≥ Target	Met: HRRs ranged from 0.29-31.23 (Mean = 9.58; target 5.7). HRR has met the target in all of the last five years (2008-2012).	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Met: During the period when there was a PNI target for the Wenatchee River summer Chinook Salmon population (2012-present; however, the time series for the comprehensive review was 2012-2018), the 5-year PNI mean ranged from 0.90-0.91 and therefore exceeded the target of 0.67. On an annual basis, PNI exceeded 0.67 in all years (2012-2018).	
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Not Met: The migration timing of hatchery- and natural-origin adults at Dryden Dam differed significantly ($P < 0.05$) with an average difference of 2.5 weeks. Hatchery-origin fish arrived later than natural-origin fish.	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.2 Spawn timing	Not Met: The spawn timing of hatchery- and natural-origin adults differed significantly ($P < 0.05$) with at most a difference of 7 days. Hatchery-origin fish spawned later than natural-origin fish.	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.3 Spawn distribution	Met: Both hatchery- and natural-origin adults spawned throughout the Wenatchee River and within each reach; however, there was a significant difference in the distribution of hatchery- and natural-origin spawners among historical survey reaches ($P < 0.01$). Consistent with the management objective, fewer hatchery-origin fish spawned in the upper river than did natural-origin fish.	Although the M&E Plan does not include pHOS analysis at the reach scale, pHOS ranged from 0.04-0.37 among the ten reaches in the Wenatchee River. The highest proportions were in reaches 1 through 6, which is consistent with the management objective.
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual brood year donor stray percentage for hatchery-origin Wenatchee River summer Chinook Salmon releases ranged from 6.1-35.0%.	

M&E Objective	Findings	Comments
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: The Wenatchee River summer Chinook Salmon Program did not exceed the 5% out of basin stray rate target.	A small number of Wenatchee River hatchery-origin summer Chinook Salmon have been detected at Lower Granite Dam on the Snake River, at Three Mile Dam on the Umatilla River, in Big and Sand Hollow creeks, and in the Baker and Elway rivers.
6.3 Return Year Recipient Stray Targets (Within Basin)	Met: The Wenatchee River summer Chinook Salmon Program rarely exceeded the 10% in-basin stray rate target.	Wenatchee River hatchery-origin summer Chinook Salmon have strayed into the Methow, Okanogan, Chelan, and Entiat rivers and to the Hanford Reach. Since 2012, they have made up less than 10% of the spawning escapements in those streams.
6.4 Brood Year Recipient Stray Rates	No Target: For brood years 1989-2016, the mean recipient stray percentage for the Wenatchee River summer Chinook Salmon program was 3.1% (range 0.0-16.7%).	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Met: The AMOVA tests indicated that there was no significant differences ($P > 0.05$) in allele frequencies between baseline and contemporary collections and no difference in average expected heterozygosity among baseline and contemporary collections.	
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences ($P < 0.05$) in the number of locus pairs in linkage disequilibrium in comparisons of baseline and contemporary collections.	Weaker linkage disequilibrium existed within hatchery contemporary collections than within baseline natural collections.
7.3 Population Genetics (Genetic Distance)	Met: Contemporary hatchery-origin adults were not significantly different from natural-adults ($P > 0.05$); however, there was some evidence of homogenization among stocks.	
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: There was no clear pattern in baseline versus contemporary N_b (effective number of breeders) to census size (N); however, N was not available for several baseline populations.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not Met: Age at maturity (salt age) was significantly different between hatchery- and natural-origin female ($P < 0.01$) and male ($P < 0.01$) adults. For both sexes,	

M&E Objective	Findings	Comments
	hatchery-origin fish returned at a younger age than did natural-origin fish.	
8.2 Phenotype Similarity (Size at Maturity)	Not Met: Size at maturity differed significantly between hatchery- and natural-origin adults and was affected by age, sex, and origin (P < 0.01). However, differences in lengths between natural- and hatchery-origin fish were generally less than 4 cm.	Significant differences in mean sizes are a function of the large sample size and may not represent a biological effect.
8.3 Phenotype Similarity (Size and Fecundity)	Inconclusive: Natural-origin fish are collected for broodstock; therefore, there are no comparisons between natural- and hatchery-origin fish.	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2012-2017, the target of 500,001 (±10%) was met for all 6 brood years. For brood years before 2012 (before recalculation), the program met the target release number of 864,000 (±10%) in 10 of 23 brood years.	
9.2 Size-at-release (FPP)	Met: For brood years 2012-2017, the target of 10-15 FPP and 18 FPP (±10%) was met in 4 of 6 brood years; two brood-year releases were less than the target. For brood years before 2012 (before recalculation), the program met the target of 10 FPP (±10%) in 13 of 23 brood years.	
9.3 Size-at-release (CV)	Not Met: For brood years 2012-2017, the CV target of <9.0 was met in 1 of 6 brood years. For brood years before 2012 (before recalculation), the program met the CV target of <9.0 in 0 of 23 brood years.	Changes in feed, FPP, and other unknown factors may have affected the CVs.
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: For brood years 1989-2012, the average percent of the brood year return harvested was 58.5% (range 25.4-80.2%), with the most fish captured in ocean fisheries (34-100% of the fish harvested).	

4.2 Methow Summer Chinook Salmon Program

Introduction

The original goal of summer Chinook Salmon supplementation in the Methow River basin was in part to use artificial production to replace adult production lost because of mortality at Wells, Rocky Reach, and Rock Island dams, while not reducing the natural production or long-term fitness of summer Chinook Salmon in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans. Beginning with broodstock collection in 2012, Grant PUD took over the summer Chinook Salmon supplementation program in the Methow River basin. Grant PUD constructed a new overwinter acclimation facility adjacent to the Carlton Acclimation Pond and the first fish released from this facility was 2014 and these fish were spring acclimated. The first fish that were overwinter acclimated in the facility were released in 2015. The new facility includes eight, 30-foot diameter dual-drain circular tanks.

Presently, adult summer Chinook Salmon are collected for broodstock from the run-at-large at the west-ladder trapping facility at Wells Dam. Before 2012, the goal was to collect up to 222 natural-origin adult summer Chinook Salmon for the Methow program. In 2011, the Hatchery Committees reevaluated the amount of hatchery compensation needed to achieve NNI. Based on that evaluation, the goal of the program was revised. The next goal (beginning in 2012 and ending in 2021) was to collect up to about 136 natural-origin summer Chinook Salmon for the Methow program. Broodstock collection occurs from about 1 July through 15 September with trapping occurring no more than 16 hours per day, three days a week. If natural-origin broodstock collection falls short of expectation, hatchery-origin adults can be collected to make up the difference.

Adult summer Chinook Salmon are spawned and reared at Eastbank Fish Hatchery. Juvenile summer Chinook Salmon were transferred from the hatchery to Carlton Acclimation Pond in March until overwinter acclimation was initiated with the 2013 brood year. They are now transferred to the Carlton Acclimation Facility in October or November and released in mid-April to early May as yearlings.

Before 2012, the production goal for the Methow summer Chinook Salmon supplementation program was to release 400,000 yearling smolts into the Methow River at ten fish per pound. From 2012 to 2021 2018 brood, the release goal was 200,000 yearling smolts. Beginning in 2022, The smolt release target was revised to 164,533 with a continuing fish per pound target of 13-18. Targets for fork length coefficient of variation (CV) and weight are 9.0 and 25.2-34.9 g, respectively. Over 90% of these fish are tagged with CWTs. In addition, since 2009, juvenile summer Chinook Salmon have been PIT tagged annually.

Key Results

Key results from analyses conducted on Methow River summer Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 4.2 and summarized below to facilitate interpretation.

Comparisons between Methow River summer Chinook Salmon and ocean-type Chinook Salmon in a reference (un-supplemented) stream located outside the Upper Columbia was made using a BACI design to evaluate whether supplementation changed abundance of total spawners, natural-origin adult recruits, natural-origin spawners, and density-adjusted adult productivity. Adults collected and spawned in the hatchery produced significantly more adult recruits per spawner than those that spawned in the natural environment. The abundance of total spawners and natural-origin spawners increased similarly in both the Methow River and reference stream. In contrast, natural-origin recruits in the Methow River increased significantly compared to the reference population. Although density-adjusted productivity in the Methow River increased while adjusted productivity in the reference stream decreased, the difference was not significant. This is likely because of the high variability in productivity estimates over time. This evaluation was not able to evaluate factors unrelated to supplementation, for example, habitat-restoration projects, differences in migration corridors, and differential predation rates on adults. Based on these analyses, summer Chinook Salmon supplementation has not measurably increased abundance of natural-origin summer Chinook Salmon in the Methow River basin, relative to an un-supplemented reference population located outside the Upper Columbia Basin, but the number of adult recruits did increase.

There was no evidence that supplementation increased or decreased productivity of natural-origin juvenile summer Chinook Salmon in the Methow River basin. Higher pHOS did not appear to lower juvenile productivity, where juvenile productivity was measured as the number of subyearling emigrants per spawner produced within the Methow River basin. However, no other life history pathways were included in this analysis. For all three stock-recruitment models considered, there was often high uncertainty in model parameter estimates even when the models could be fit to the data. Given all the complicating factors associated with these analysis (e.g., no reference populations or before-supplementation data, uncertainty in model parameters, insufficient statistical power for analytical purposes, and using correlation analysis), only the most extreme effect of pHOS on juvenile productivity could have been detected. Thus, we caution against concluding that supplementation had no effect on juvenile productivity in the Methow River basin.

Since 2012, during years in which there was PNI management, the five-year-mean PNI target (PNI $\geq$ 0.67) for Methow River summer Chinook Salmon was met in all spawn years (there was no PNI management before 2012). The 5-year-mean PNI ranged from 0.77-0.79. On an annual basis, the target was met in all years (PNI $\geq$ 0.67). Based on genetic evaluations, the supplementation program may have affected the genetic diversity or population structure of summer Chinook Salmon in the Methow River basin. There was a significant difference in allele frequencies between baseline natural-origin collections and contemporary hatchery collections. However, there was no difference in average expected heterozygosity among baseline and contemporary collections. Although not significant, there was an indication that genetic drift and homogenization among stocks has occurred over time.

The effects of the Methow River summer Chinook Salmon program on phenotypic and life-history characteristics varied. There was no difference in migration timing of natural- and hatchery-origin summer Chinook Salmon at Wells Dam. On the other hand, spawn timing differed significantly, with hatchery-origin fish spawning about one week later than natural-origin fish in the Methow River. Consistent with the management objective, a higher proportion of hatchery-origin summer Chinook Salmon spawned in the lower portions of the Methow River, while a higher proportion of natural-origin summer Chinook Salmon spawned in the upper portions of the river. Both age at maturity and size at maturity differed between hatchery- and natural-origin summer Chinook Salmon in the Methow River basin. Hatchery-origin fish generally returned at a younger age than natural-origin fish. The size at maturity of returning adults was significantly affected by age, sex, and origin. However, when matched by age and sex, the differences in size at maturity by origin that were statistically significant were minor and likely of little biological relevance. Because natural-origin fish are collected for broodstock, we were unable to compare fecundities between natural- and hatchery-origin fish. The fecundity metrics for natural-origin fish were significantly affected by fish size and weight.

For return years 1994 to 2018, hatchery-origin summer Chinook Salmon from the Methow River program strayed into populations outside the Upper Columbia River basin but did not make up more than 5% of the recipient population. They also strayed into non-target spawning areas within the Upper Columbia basin but did not exceed the threshold of 10% of the spawning aggregate. Few Methow River summer Chinook Salmon contributed to the Wenatchee, Okanogan, Chelan, and Entiat escapements and to the fall Chinook Salmon escapement on the Hanford Reach. Based on brood year analysis, on average, about 3.1% of the brood year returns strayed into non-target spawning areas. In contrast, on average, about 7.0% of the brood year returns strayed into non-target hatcheries.

Since 2012 (period following the first recalculation), the Methow River summer Chinook Salmon program met its release goal of 200,000 (±10%) in 3 of the 6 brood years. Before 2012, the program met its release goal of 400,000 (±10%) in 16 of the 23 brood years. Likewise, for brood years 2012-2017, the program met the FPP target in 4 of the 6 brood years. On the other hand, the program was less successful in meeting the CV target for length. For brood years 2012-2017, the CV target was met in 3 of the 6 brood years. Methow River summer Chinook Salmon exhibited near-isometric growth with a mean condition factor of 1.12.

Since its initiation, the Methow River summer Chinook Salmon program produced fish that have contributed to ocean and freshwater (tribal, commercial, and recreational) fisheries. For brood years 1989-2012, the average percent of the brood year return harvested was 50.5% (range 17.6-75.6%), with the most fish captured in ocean fisheries (13-99% of the fish harvested).

Table 4.2. Summary of monitoring and evaluation results for Methow River summer Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Inconclusive: Both the Methow and reference population spawners increased (BACIP Contrast = 0.276, P = 0.25).	There are differences between the supplemented and reference populations that are independent of supplementation (e.g., habitat-restoration projects, differences in migration corridors, and differential predation rates on adults).
1.2 Natural-Origin Spawners (NOS)	Inconclusive: Both the Methow and reference population NOS increased (BACIP Contrast = 0.036; P = 0.87).	There are differences between the supplemented and reference populations that are independent of supplementation (e.g., habitat-restoration projects, differences in migration corridors, and differential predation rates on adults).
1.3 Natural-Origin Recruits (NOR)	Met: Methow NORs increased significantly compared to the reference	There are differences between the supplemented and reference populations

M&E Objective	Findings	Comments
	population (BACIP Contrast = 1.017, P = 0.02).	that are independent of supplementation (e.g., habitat-restoration projects, differences in migration corridors, and differential predation rates on adults).
1.4 Adjusted Productivity (NRR)	Inconclusive: Non-significant comparisons with out-of-basin reference. Methow increased while the reference decreased (BACIP Contrast = 0.436, P = 0.14).	There are differences between the supplemented and reference populations that are independent of supplementation (e.g., habitat-restoration projects, differences in migration corridors, and differential predation rates on adults). High variability resulted in non-significant effects.
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Inconclusive: pHOS contrast and statistical power insufficient for analytical purposes. There was no relationship between pHOS and juvenile productivity (P = 0.98).	There are no reference populations or before-supplementation data available for more robust analyses.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	Met: HRR ≥ NRR in 16 of 24 years and mean HRR was significantly larger than mean NRR (P = 0.01).	
3.2 HRR ≥ Target	Met: HRRs ranged from 0.15-24.42 (Mean = 6.01; target 3.0). HRR has met the target in all of the last five years (2008-2012).	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Met: During the period when there was a PNI target for the Methow River summer Chinook Salmon population (2012-present; however, the time series for the comprehensive review was 2012-2018), the 5-year PNI mean ranged from 0.77-0.79 and therefore exceeded the target of 0.67. On an annual basis, PNI ≥ 0.67 in all years (2012-2018).	
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Met: The migration timing of hatchery- and natural-origin adults at Wells Dam did not differ significantly (P > 0.05) with an average difference of less than 5 days.	Comparisons were made by evaluating cumulative frequency plots of hatchery- and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.2 Spawn timing	Not Met: The spawn timing of hatchery- and natural-origin adults differed	Comparisons were made by evaluating cumulative frequency plots of hatchery-

M&E Objective	Findings	Comments
	significantly (P < 0.03) with at most a difference of 7 days. Hatchery-origin fish spawned later than natural-origin fish.	and natural-origin fish and by statistically comparing any differences at the 10th, 50th, and 90th percentiles.
5.3 Spawn distribution	Met: Both hatchery- and natural-origin adults spawned throughout the Methow River and within most reaches; however, there was a significant difference in the distribution of hatchery- and natural-origin spawners among historical survey reaches (P < 0.01). Consistent with the management objective, fewer hatchery-origin fish spawned in the upper river than did natural-origin fish.	Although the M&E Plan does not include pHOS analysis at the reach scale, pHOS ranged from 0.00-0.67 among the seven reaches in the Methow River. The highest proportions were in reaches 1 through 4, which is consistent with the management objective.
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual brood year donor stray percentage for hatchery-origin Methow River summer Chinook Salmon releases ranged from 0.0-23.1%.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: The Methow River summer Chinook Salmon Program did not exceed the 5% out of basin stray rate target.	A small number of Methow River hatchery-origin summer Chinook Salmon have been detected in Noble Creek in the Coos River basin.
6.3 Return Year Recipient Stray Targets (Within Basin)	Met: The Methow River summer Chinook Salmon Program did not exceed the 10% in-basin stray rate target.	Methow River hatchery-origin summer Chinook Salmon have strayed into the Wenatchee, Okanogan, Chelan, and Entiat rivers and to the Hanford Reach. They made up less than 2.5% of the spawning escapements in those streams.
6.4 Brood Year Recipient Stray Rates	No Target: For brood years 1989-2016, the mean recipient stray percentage for the Methow River summer Chinook Salmon program was 3.1% (range 0.0-11.9%).	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Met: The AMOVA tests indicated that there was a significant differences (P < 0.05) in allele frequencies between baseline and contemporary collections; however, there was no difference in average expected heterozygosity among baseline and contemporary collections.	
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences (P < 0.05) in the number of locus pairs in linkage disequilibrium in comparisons of baseline and contemporary collections.	Weaker linkage disequilibrium existed within hatchery contemporary collections than within baseline natural collections.

M&E Objective	Findings	Comments
7.3 Population Genetics (Genetic Distance)	<u>Met</u>: Contemporary hatchery-origin adults were not significantly different from natural-adults ($P > 0.05$); however, there was some evidence of homogenization among stocks.	
7.4 Population Genetics (Effective Spawning Population)	<u>Inconclusive</u>: There was no clear pattern in baseline versus contemporary N_b (effective number of breeders) to census size (N); however, N was not available for several baseline populations.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	<u>Not Met</u>: Age at maturity (salt age) was significantly different between hatchery- and natural-origin female ($P < 0.01$) and male ($P < 0.01$) adults. For both sexes, hatchery-origin fish returned at a younger age than did natural-origin fish.	
8.2 Phenotype Similarity (Size at Maturity)	<u>Not Met</u>: Size at maturity differed significantly between hatchery- and natural-origin adults and was affected by age, sex, and origin ($P < 0.01$). However, differences in lengths between natural- and hatchery-origin fish were generally less than 4 cm.	Significant differences in mean sizes are a function of the large sample size and may not represent a biological effect.
8.3 Phenotype Similarity (Size and Fecundity)	<u>Inconclusive</u>: Natural-origin fish are collected for broodstock; therefore, there are no comparisons between natural- and hatchery-origin fish.	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	<u>Not Met</u>: For brood years 2012-2017, the target of 200,000 (±10%) was met for 3 of the 6 brood years. For brood years before 2012 (before recalculation), the program met the target release number of 400,000 (±10%) in 16 of 23 brood years.	
9.2 Size-at-release (FPP)	<u>Met</u>: For brood years 2012-2017, the target of 13-18 FPP was met in 4 of 6 brood years; one brood-year release was less than the target, while the other was greater than the target. For brood years before 2012 (before recalculation), the program met the target of 10 FPP (±10%) in 8 of 23 brood years.	
9.3 Size-at-release (CV)	<u>Not Met</u>: For brood years 2012-2017, the CV target of <9.0 was met in 3 of 6 brood years.	Changes in feed, FPP, and other unknown factors may have affected the CVs.

M&E Objective	Findings	Comments
	For brood years before 2012 (before recalculation), the program met the CV target of <9.0 in 5 of 23 brood years.	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: For brood years 1989-2012, the average percent of the brood year return harvested was 50.5% (range 17.6-75.6%), with the most fish captured in ocean fisheries (13-99% of the fish harvested).	

4.3 Chelan Falls Summer Chinook Salmon Program

Introduction

The Chelan Falls summer Chinook Salmon program (formerly the Turtle Rock program) included the production of 200,000 fish for No Net Impact (NNI) compensation for unavoidable juvenile project mortalities associated with Rocky Reach Dam and a 400,000 subyearling/yearling program for compensation for lost spawning habitat as a result of the construction of Rocky Reach Dam (i.e., inundation compensation). In 2011, as part of the periodic recalculation of NNI for Rocky Reach Dam, the previous 200,000 NNI program was reduced to 176,000 fish. This reduced the combined Chelan Falls summer Chinook Salmon production from 600,000 to 576,000 yearling smolts beginning with the 2012 brood. In 2022, the production target was revised to 535,283 yearling smolts (400,000 inundation and 135,283 NNI).

Before 2012, broodstock were collected at the Wells Dam volunteer trap (WDVT). Summer Chinook Salmon were spawned at Wells Fish Hatchery and fertilized eggs were then transferred to Eastbank Fish Hatchery for hatching and rearing. In 2012, adults were collected at the WDVT and then transferred to Eastbank Fish Hatchery for spawning, hatching, and rearing. Beginning in 2013, broodstock collection was initiated at the Eastbank Fish Hatchery Outfall. With returns to the Outfall diminishing, a pilot broodstock collection program was initiated in 2016 at the outlet structure of the water conveyance canal for the Chelan Tailrace Pump Station (Chelan Falls Canal Trap) and continued through 2018. Concurrently, while collection of broodstock from the Chelan Falls Canal Trap was evaluated, the Entiat National Fish Hatchery and WDVT were used as backup broodstock collection sites. Beginning in 2019, a weir was installed in the habitat channel adjacent to the conveyance canal as another pilot location for broodstock collection.

The original program consisted of both subyearling (normal and accelerated groups) and yearling releases. Subyearlings were transferred to Turtle Rock Fish Hatchery for acclimation in May. These fish were released in June after about 30 days of acclimation on Columbia River water. The goal of this program was to release 1,620,000 subyearling summer Chinook Salmon (810,000 normal and 810,000 accelerated subyearlings) into the Columbia River at 40 fish per pound. Targets for fork length and weight were 112 mm (CV = 9.0) and 11.4 g, respectively. Over 50% of both subyearling groups were tagged with CWTs. In 2010, the subyearling program was converted to a 400,000-yearling program.

The goal of the yearling program was to release 200,000 summer Chinook Salmon smolts into the Columbia River from Turtle Rock Fish Hatchery at 10 fish per pound. Targets for fork length coefficient of variation (CV) and weight were 9.0 and 45.4 g, respectively. Beginning with the 2006 brood year, yearling summer Chinook Salmon were acclimated at both Turtle Rock Fish Hatchery and the Chelan River net pens. With the conversion of the subyearling program to a yearling program and the reduction of the NNI component to 176,000, the goal was to release 576,000 yearling summer Chinook Salmon smolts. Beginning in 2012, with brood year 2010, yearlings are acclimated overwinter at the Chelan Falls Acclimation Facility on Chelan River water. In 2022, the production target was revised to 535,283 yearling smolts at 13 fish per pound. The targets for fork length CV was 9.0.

Over 90% of yearling summer Chinook Salmon have been tagged with CWTs and all are ad-clipped. In addition, juvenile summer Chinook Salmon were PIT tagged within each of the circular and standard raceways.

Key Results

Key results from analyses conducted on Chelan Falls summer Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 4.3 and summarized below to facilitate interpretation. Because the Chelan Falls summer Chinook Salmon program is not a conservation program, it's a segregated program, it does not require the evaluation of all M&E objectives. However, we do track the trend in total spawners, natural-origin spawners, and hatchery-origin spawners within the Chelan River. In addition, we track stray rates, genetic composition, release numbers and sizes at release, and contribution to harvest.

Abundance of total spawners, natural-origin spawners, and hatchery-origin spawners increased in the Chelan River over the period 2000 to 2018.

Based on genetic evaluations, the Chelan Falls summer Chinook Salmon program did not appear to affect genetic diversity or population structure of summer Chinook Salmon in the Upper Columbia River basin. Measures of genetic diversity (allelic richness, heterozygosity, linkage disequilibrium, and effective number of breeders) showed little differentiation between baseline and contemporary collections. Although not significant, there was an indication that genetic drift and homogenization among stocks has occurred over time. Overall, there is little evidence for neutral genetic divergence between contemporary and baseline samples.

Because hatchery-origin fish are collected for broodstock, we were unable to compare fecundities between natural- and hatchery-origin fish. The fecundity metrics for hatchery-origin fish were significantly affected by fish size and weight.

Since 2015, the period when only Chelan Falls summer Chinook Salmon returned, fish from the program strayed into populations outside the Upper Columbia River basin but did not make up more than 5% of the recipient population. They also strayed into non-target spawning areas within the Upper Columbia basin but did not exceed the threshold of 10% of the recipient spawning aggregate. Few Chelan Falls summer Chinook Salmon contributed to the Wenatchee, Entiat, Methow, and Okanogan escapements and to the fall Chinook Salmon escapement on the Hanford Reach. Based on brood year analysis (2010-2016), on average, about 7.4% of the brood year returns strayed into non-target spawning areas. In contrast, on average, about 38.3% of the brood year returns strayed into non-target hatcheries.

Since 2010, the Chelan Falls summer Chinook Salmon program met its release goal of 576,000 (±10%) in 6 of the 8 brood years. Two brood year releases were below the release goal. Likewise, for brood years 2010-2017, the program met the FPP target in 7 of the 8 brood years. On the other hand, the program was less successful in meeting the CV target for length. For brood years 2010-2017, the CV target was met in 0 of the 8 brood years. Chelan Falls summer Chinook Salmon exhibited near-isometric growth with a mean condition factor of 1.09.

Since its initiation, the Chelan Falls summer Chinook Salmon program produced fish that have contributed to ocean and freshwater (tribal, commercial, and recreational) fisheries. For brood years 2010-2016, the average percent of the brood year return harvested was 70.4% (range 64.8-78.7), with most fish captured in the ocean (25-45% of the fish harvested; mean = 35%) and tribal (24-39% of the fish harvested; mean = 34%) fisheries.

Table 4.3. Summary of monitoring and evaluation results for Chelan Falls Summer Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	No Target: The Chelan Falls program is not a conservation program and therefore there is no requirement to compare total spawners with reference populations.	Total number of spawners within the Chelan River have increased over time (2000-2018).
1.2 Natural-Origin Spawners (NOS)	No Target: The Chelan Falls program is not a conservation program and therefore there is no requirement to compare NOS with reference populations.	
1.3 Natural-Origin Recruits (NOR)	No Target: The Chelan Falls program is not a conservation program and therefore there is no requirement to compare NOR with reference populations.	
1.4 Adjusted Productivity (NRR)	No Target: The Chelan Falls program is not a conservation program and therefore there is no requirement to compare natural-origin productivity with reference populations.	
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	No Target: The Chelan Falls program is not a conservation program and therefore there are no estimates of juvenile productivity.	
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	No Target: The Chelan Falls program is not a conservation program and therefore there is no comparison of NRR to NRR.	
3.2 HRR ≥ Target	No Target: The Chelan Falls program is not a conservation program and therefore has no HRR target.	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	No Target: The Chelan Falls program is not a conservation program and therefore has no PNI or pHOS targets.	
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	No Target: The Chelan Falls program is not a conservation program and therefore has no migration timing targets.	

M&E Objective	Findings	Comments
5.2 Spawn timing	No Target: The Chelan Falls program is not a conservation program and therefore has no spawn timing targets.	
5.3 Spawn distribution	No Target: The Chelan Falls program is not a conservation program and therefore has no spawning distribution targets.	Since 2013, both natural- and hatchery-origin fish spawn within the Chelan tailrace, Columbia tailrace, habitat channel, and habitat pools. A higher proportion of natural-origin fish spawn in the Chelan and Columbia tailraces, which a higher proportion of hatchery-origin fish spawn in the habitat channel and habitat pool.
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: Annual brood year donor stray percentage for hatchery-origin Chelan Falls summer Chinook Salmon are unknown.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: Since 2015 (period when only Chelan Falls fish returned), the Chelan Falls summer Chinook Salmon Program did not exceed the 5% out of basin stray rate target.	A small number of Chelan Falls summer Chinook Salmon have been detected in the Umatilla River, at Lower Granite Dam on the Snake River, and in Sand Hollow Creek.
6.3 Return Year Recipient Stray Targets (Within Basin)	Met: Since 2015 (period when only Chelan Falls fish returned), the Chelan Falls summer Chinook Salmon Program did not exceed the 10% in-basin stray rate target.	A small number of Chelan Falls summer Chinook Salmon have been detected in the Wenatchee, Methow, Okanogan, and Entiat rivers and on the Hanford Reach. On average, they have made up less than 2.1% of the spawning escapements in those streams.
6.4 Brood Year Recipient Stray Rates	No Target: For brood years 2010-2016, the mean recipient stray percentage for the Wenatchee River summer Chinook Salmon program was 7.4% (range 1.2-26.3%).	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Met: The AMOVA tests indicated that there was no significant differences (P > 0.05) in allele frequencies between baseline and contemporary collections and no difference in average expected heterozygosity among baseline and contemporary collections.	
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences (P < 0.05) in the number of locus pairs in linkage	Weaker linkage disequilibrium existed within hatchery contemporary collections than within baseline natural collections.

M&E Objective	Findings	Comments
	disequilibrium in comparisons of baseline and contemporary collections.	
7.3 Population Genetics (Genetic Distance)	Met: Contemporary hatchery-origin adults were not significantly different from natural-adults ($P > 0.05$); however, there was some evidence of homogenization among stocks.	
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: There was no clear pattern in baseline versus contemporary N_b (effective number of breeders) to census size (N); however, N was not available for several baseline populations.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	No Target: The Chelan Falls program is not a conservation program and therefore has no age at maturity targets.	
8.2 Phenotype Similarity (Size at Maturity)	No Target: The Chelan Falls program is not a conservation program and therefore has no size at maturity targets.	
8.3 Phenotype Similarity (Size and Fecundity)	No Target: The Chelan Falls program collects hatchery-origin fish and therefore there are no comparisons between natural- and hatchery-origin fish.	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 2010-2017, the target of 576,000 (±10%) was met 6 of the 8 brood years; two brood-year releases were less than the target.	
9.2 Size-at-release (FPP)	Met: For brood years 2010-2017, the target of 10-22 FPP and 13 FPP (±10%) was met in 7 of 8 brood years; one brood-year release was less than the target.	
9.3 Size-at-release (CV)	Not Met: For brood years 2010-2017, the CV target of <9.0 was met in 0 of 8 brood years. All releases exceeded the target.	Changes in feed, FPP, and other unknown factors may have affected the CVs.
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: For brood years 2010-2016, the average percent of the brood year return harvested was 70.4% (range 64.8-78.7), with most fish captured in the ocean (25-45% of the fish harvested) and tribal (24-39% of the fish harvested) fisheries.	

4.4 Wells Hatchery Summer Chinook Salmon Program

Introduction

The Wells Hatchery summer Chinook Salmon program is composed by the production of 320,000 yearling and 484,000 subyearling summer Chinook Salmon for compensation for lost spawning habitat as a result of the construction of Wells Dam (i.e., inundation compensation). Each of these two program components are segregated, and adult fish are intended to supplement various harvest opportunities before returning to the hatchery where they serve as broodstock for continuation of this or other programs or are distributed to Tribes for ceremonial or subsistence purposes. Adult fish from the Wells Hatchery summer Chinook Salmon program that are recovered at nontarget hatcheries or on spawning grounds are considered strays.

Broodstock for both components of the program are collected from the Wells Hatchery Volunteer Channel beginning as early as 15 June and concluding by 31 August. The program uses primarily hatchery-origin broodstock but may include up to ten percent natural-origin broodstock.

Spawning, incubation, and rearing for both components of the program occurs at Wells Hatchery. The entirety of both components of the program is marked with an adipose fin clip and tagged with a coded wire tag. The subyearling component is released in May. Beginning in brood year 1998 until brood year 2011, the target for size at release of the subyearling program was 20 fish per pound (FPP). From brood year 2012 on, the target for size at release was 50 FPP. The yearling component is released in April, and its target for size at release is 10 FPP.

Key Results

Key results from analyses conducted on Wells Hatchery summer Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 4.4 and summarized below to facilitate interpretation. Because the Wells Hatchery summer Chinook Salmon program is a segregated program and not a safety-net or conservation program, not all of the monitoring and evaluation objectives are applicable. Therefore, only some of the monitoring and evaluation objectives for this program have been evaluated.

In general, Wells Hatchery summer Chinook Salmon were successful in returning to the Wells Hatchery Volunteer Channel. Although returning adults have been recovered in the course of spawning surveys in several Columbia River tributaries and the Hanford Reach, the proportion of Wells Hatchery summer Chinook Salmon recovered within recipient spawning aggregates exceeded five percent of the spawning population only in the Methow River in 1997, 2001, 2002, 2009, and 2020, in the Okanogan River in 2000 and 2001, and in the Entiat River in 2001 and 2002.

Release group size for both program components were at or above the target more often than not. The average subyearling weight at release was consistently below the desired level, but CVs of both program components and the average weight of the yearling component achieved the Program goals in most years.

Approximately two thirds of both subyearling and yearling Wells Hatchery summer Chinook Salmon were harvested in tribal, commercial, or recreational fisheries.

Table 4.4. Summary of monitoring and evaluation results for Wells Hatchery Summer Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	No Target: The Wells Hatchery programs are not conservation programs and therefore there is no requirement to compare total spawners with reference populations.	
1.2 Natural-Origin Spawners (NOS)	No Target: The Wells Hatchery programs are not conservation programs and therefore there is no requirement to compare NOS with reference populations.	
1.3 Natural-Origin Recruits (NOR)	No Target: The Wells Hatchery programs are not conservation programs and therefore there is no requirement to compare NOR with reference populations.	
1.4 Adjusted Productivity (NRR)	The Wells Hatchery programs are not conservation programs and therefore there is no requirement to compare natural-origin productivity with reference populations.	
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	No Target: The Wells Hatchery programs are not conservation programs and therefore there is no estimate of juvenile productivity.	
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	No Target: The Wells Hatchery programs are not conservation programs and therefore there is no comparison of HRR to NRR.	
3.2 HRR ≥ Target	No Target: The Wells Hatchery programs are not conservation programs and therefore have no HRR target.	
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	No Target: The Wells Hatchery programs are not conservation programs and therefore have no PNI or pHOS targets.	
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		

M&E Objective	Findings	Comments
5.1 Migration timing	NA: Not analyzed for the Wells summer Chinook Salmon programs.	
5.2 Spawn timing	NA: Not analyzed for the Wells summer Chinook Salmon programs.	
5.3 Spawn distribution	NA: Not analyzed for the Wells summer Chinook Salmon programs.	
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: For brood years 1992-2017, annual donor stray percentage for Wells Hatchery summer Chinook Salmon ranged from 1.7-19.3% (mean = 6.8%) to non-target streams and hatcheries.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: From 1997-2020, Wells Hatchery summer Chinook Salmon never comprised more than five percent of a summer Chinook Salmon spawning aggregate outside of the Upper Columbia.	A small number of Wells Hatchery summer Chinook Salmon have been detected in the Klickitat and Snake River basins, and in Sand Hollow Creek.
6.3 Return Year Recipient Stray Targets (Within Basin)	Met: From 1997-2020, Wells Hatchery summer Chinook Salmon comprised more than 10 percent of a summer Chinook Salmon spawning aggregate in the Methow River in 2001 and 2002.	A small number of Wells Hatchery summer Chinook Salmon have been detected in the Wenatchee, Methow, Okanogan, and Entiat rivers, and on the Hanford Reach. On average, they have made up less than five percent of the spawning escapements in those streams.
6.4 Brood Year Recipient Stray Rates	NA: Not analyzed for the Wells summer Chinook Salmon programs.	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		
7.1 Population Genetics (Allele Frequency)	Met: The AMOVA tests indicated that there was no significant differences ($P > 0.05$) in allele frequencies between baseline and contemporary collections and no difference in average expected heterozygosity among baseline and contemporary collections.	
7.2 Population Genetics (Linkage Disequilibrium)	Not Met: Mann-Whitney tests indicated significant differences ($P < 0.05$) in the number of locus pairs in linkage disequilibrium in comparisons of baseline and contemporary collections.	Weaker linkage disequilibrium existed within hatchery contemporary collections than within baseline natural collections.
7.3 Population Genetics (Genetic Distance)	Met: Contemporary hatchery-origin adults were not significantly different from natural-adults ($P > 0.05$); however, there was some evidence of homogenization among stocks.	

M&E Objective	Findings	Comments
7.4 Population Genetics (Effective Spawning Population)	Inconclusive: There was no clear pattern in baseline versus contemporary Nb (effective number of breeders) to census size (N); however, N was not available for several baseline populations.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not specifically analyzed for the Wells summer Chinook Salmon programs.	
8.2 Phenotype Similarity (Size at Maturity)	Not specifically analyzed for the Wells summer Chinook Salmon programs.	Within return years, natural-origin fish taken as broodstock generally have a greater mean fork length than hatchery-origin broodstock of the same sex and age, although sample sizes of natural-origin fish within these categories are often too small to allow for meaningful comparisons for all sex, age, and origin groupings.
8.3 Phenotype Similarity (Size and Fecundity)	For the Wells summer Chinook Salmon program, there was no significant difference in fecundity and egg characteristics between natural-origin and hatchery-origin summer Chinook Salmon taken as broodstock (P = 0.43).	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: For brood years 1992-2017, the Wells Yearling summer Chinook Salmon program met the release target in 19 brood years, exceeded it in six, and did not achieve it on one. Met: for brood years 1993-2017, the Wells Subyearling summer Chinook Salmon program met the release target in 15 brood years, exceeded it once, and did not achieve it in nine.	The Wells Yearling summer Chinook Salmon release target is 320,000 (±10%). For all brood years, the average release group was 336,186. The Wells Subyearling summer Chinook Salmon release target is 484,000 (±10%). For all brood years, the average release group was 426,461.
9.2 Size-at-release (FPP)	Met: For brood years 1997-2017, the target of 10 FPP (±10%) was met in 15 of 21 years. Not Met: for brood years 1998-2017, the Wells Subyearling summer Chinook Salmon program met the release target in two of 20 years.	For the Wells Subyearling summer Chinook Salmon Program, the target size-at-release was 20 FPP (±10%) from 1998-2011, and 50 FPP (±10%) from 2012-2017.
9.3 Size-at-release (CV)	Met: For brood years 1997-2017, the Wells Yearling summer Chinook Salmon program met the CV at release target of in 13 of 21 years. Met: for brood years 1998-2017, the Wells Subyearling summer Chinook program	For the Wells Yearling summer Chinook Salmon Program, the target size-at-release CV was <9.0 for brood years 1997-2011, and <7.0 for brood years 2012-2017. For the Wells Subyearling summer Chinook Salmon Program, the target size-at-release CV was <9.0 for brood years

M&E Objective	Findings	Comments
	met the CV at release target in 15 of 20 years.	1998-2011, and <7.0 for brood years 2012-2017.
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: For brood years from 2004-2012, an average of 67.6% of the Wells Hatchery yearling program and 67.3% of the Wells Hatchery subyearlings were harvested.	Both subyearling and yearling summer Chinook Salmon released at Wells Hatchery were taken in Tribal, ocean, commercial, and recreational fisheries.

SECTION 5: FALL CHINOOK SALMON

5.1 Fall Chinook Salmon Program

Introduction

Grant PUD produces and releases 5.6 million subyearling fall Chinook Salmon smolts from Priest Rapids Hatchery (PRH) as part of its mitigation for the construction and operation of Priest Rapids and Wanapum dams. The mitigation is the result of three components: inundation of historic spawning habitat (5,000,000), annual losses of fish that migrate through the project (325,543), and flow fluctuation impacts in the Hanford Reach (273,961). In addition to meeting mitigation requirements, the hatchery program has two objectives; to augment harvest and minimize negative impacts to naturally spawning fall Chinook Salmon in the Hanford Reach. The PRH is located at the top end of the Hanford Reach on the east bank of the Columbia River immediately downstream of Priest Rapids Dam. The Washington Department of Fish & Wildlife (WDFW) operates PRH which is owned by the Grant PUD. Funding for operations and maintenance is provided by both the Grant PUD and the U.S. Army Corps of Engineers (USACE).

PRH also produces fish for other programs. PRH produces and releases 1.7 million subyearling smolts on-site for the USACE John Day Mitigation. An additional 4.1 million eyed eggs are targeted to provide fish for the USACE John Day Mitigation released at Ringold Springs Hatchery (RSH) located at the lower portion of the Hanford Reach. The eggs for the RSH program are first transferred to Bonneville Hatchery for marking and ultimately ~3.7 million subyearlings are transported to, acclimated, and released as subyearling smolts from RSH. In recent years, PRH has accommodated egg-takes for fall Chinook Salmon programs managed by either Yakama Nation (YN) or Umatilla Tribe as well as the WDFW's Salmon in the Classroom program and to support various research projects.

Key Results

Key results from analyses conducted on fall Chinook Salmon are presented as findings and comments by M&E Plan objective in Table 5.1 and summarized below to facilitate interpretation.

We evaluated whether the Priest Rapids Hatchery program was meeting the dual goals of harvest augmentation and minimizing negative impacts to the naturally spawning population in the Hanford Reach of the Columbia River. We compared adult escapement to the Hanford Reach and the peak abundance of redds before (the period for evaluation was: 1948–1984 for redds; 1964–1984 for escapement) and during (1985–2018 for both redds and escapement) the full supplementation program. The mean peak redd count, adult natural-origin escapement, and total adult escapement to the Hanford Reach were significantly larger during supplementation than the pre-supplementation period ($P < 0.001$). During the supplementation period, we compared return rates for hatchery-origin fish (HRR) to those of natural-origin fish (NRR) between 1993 and 2018; these values included adult fish that contributed to harvest. The mean HRR (16.7) was significantly larger ($P < 0.001$) and over five times greater than the mean NRR (3.1). The proportion of hatchery-origin fish on the spawning grounds did not affect the density-corrected freshwater productivity of the natural-origin population for brood years 1979-2009. There were significant increases in the number of redds and adults after supplementation was started and pHOS appeared to have little effect on density-corrected juvenile productivity. Reference streams were not available for comparisons and multiple changes to flows occurred between the before and after periods.

Prior to 2012, the Priest Rapids Hatchery generally failed to achieve the recommended PNI for the program (target = 0.67). Since implementing various partnerships and practices, the program exceeded the PNI goal in each of the last five years and since 2012 has averaged 0.72.

Hatchery- and natural-origin Chinook Salmon carcasses were well distributed throughout the Hanford Reach and the proportion of hatchery-origin carcasses generally matched that of natural-origin.

Run timing was evaluated using PIT-tag detections of adults ascending Bonneville Dam between 2010 and 2018. Spawn time was evaluated by comparing the proportion of hatchery- and natural-origin carcasses that were collected at different times after spawning between 2012 and 2018. Run times were similar between hatchery- and natural-origin fish; no significant differences were detected between natural- and hatchery-origin adults arriving at Bonneville Dam at 10th, 50th, or 90th percentile of the day of year. In contrast, there were significant differences detected between natural- and hatchery-origin fish for the recovery timing of female carcasses at the 10th, 50th, and 90th percentile with natural-origin fish recovery day of year being later at all percentiles than their hatchery-origin counterpart. However, the time differences were typically 2-4 days. The similarity of run and spawn timing of hatchery- and natural-origin salmon suggests that these factors are unlikely to contribute to large differences in natural production if they exist.

For return years 1999 to 2018, hatchery-origin fall Chinook Salmon from the Priest Rapids Hatchery Program did not exceed the out-of-basin stray target of 5% or the in-basin recipient stray target of 10%.

Fall Chinook Salmon, represented by collections from the Hanford Reach spawning grounds and Priest Rapids Hatchery, showed little differentiation among baseline and contemporary populations for measures of genetic diversity (allelic richness, heterozygosity, linkage disequilibrium, and effective number of breeders), suggesting that the hatchery has not led to a decrease in genetic diversity. The patterns observed in the Hanford fall Chinook Salmon suggest little population differentiation between baseline and contemporary collections, which is most likely due to the large number of broodstock used.

Carcasses surveys were used to characterize differences in age-at-maturity, size-at-age, and sex ratio between hatchery- and natural-origin adult fall Chinook Salmon in the Hanford Reach of the Columbia River during brood years 2007–2013. A shift to younger adult fish was observed in hatchery-origin fish in both males and females. A significant difference ($P < 0.01$) in the relative frequencies of males and females was observed between natural-and hatchery-origin carcasses recovered in the Hanford Reach for all brood years; the M:F ratios of hatchery-origin fish were lower than natural-origin males. Hatchery-origin fish were slightly larger than natural-origin at age 3 but not significantly ($P = 0.14$) and natural-origin fish were significantly ($P < 0.01$) larger than hatchery-origin fish at ages 4 and 5 regardless of fish sex.

Releases from 2014-2018 were within 10% of the release number target and ranged from 5,374,566 to 6,129,355 (target = 5,599,504). The mean annual weight of fish was between 49–52 FPP (target = 50 FPP) and the coefficient of variation was <10 mm (target ≤ 10 mm) for all years (annual range = 6.1-8.4 mm).

The Priest Rapids Hatchery fall Chinook Salmon program contributed to robust harvest. The percent of brood year harvested averaged 52.5% for brood years 2004–2012.

Table 5.1. Summary of monitoring and evaluation results for Fall Chinook Salmon by monitoring objective.

M&E Objective	Findings	Comments
1.0 Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.		
1.1 Total Spawners	Met: The mean number of redds counted during the treatment period (1985–2018) was 3.9 times greater and significantly more numerous than in the pre-period (1948–1984; P < 0.01).	BACI analyses were not possible because suitable reference streams were not available. Many management changes occurred during the period of evaluation and isolating hatchery effects was not possible.
1.2 Natural-Origin Spawners (NOS)	Met: The mean abundance of natural-origin spawners during the treatment period was 65,785 (SD = 44,484) and was 2.5 times greater than that observed during the pre-period.	BACI analyses were not possible because suitable reference streams were not available. Many management changes occurred during the period of evaluation and isolating hatchery effects was not possible.
1.3 Natural-Origin Recruits (NOR)	Met: The number of NORs exceeded 60,000 in each of the last 10 BYs 2006-2015 (range: 66,326-526,972).	BACI analyses were not possible because suitable reference streams were not available. Many management changes occurred during the period of evaluation and isolating hatchery effects was not possible. Data presented here are from the Priest Rapids Hatchery annual M&E Report (Pearsons and Richards 2022).
1.4 Adjusted Productivity (NRR)	Met: The NRR exceeded 1.0 in 8 of 10 BYs from 2006-2015 (range: 0.36-7.87).	BACI analyses were not possible because suitable reference streams were not available. Many management changes occurred during the period of evaluation and isolating hatchery effects was not possible. Data presented here are from the Priest Rapids Hatchery annual M&E Report (Pearsons and Richards 2022).
2.0 Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.		
2.1 pHOS on Juvenile Productivity (smolts/spawner)	Met: The density-corrected relationship between pHOS and juvenile productivity was not significantly different from zero.	Reference comparisons were not available.
3.0 Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.		
3.1 HRR > NRR	Met: From BY 1993–2012, the mean HRR for the Hanford Reach was 16.7 and significantly larger than the NRR, 3.1 (P < 0.01).	

M&E Objective	Findings	Comments
3.2 HRR ≥ Target	Met: Target = 5.3; HRR > 5.3 in 9 of 10 BYs from 2006-2015 and ranged from 1.15-63.05.	Data presented here are from the Priest Rapids Hatchery annual M&E Report (Pearsons and Richards 2022)
4.0 Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.		
4.1 PNI and pHOS	Met: The Hatchery Programs contributing spawners to the Hanford Reach exceeded the PNI goal in each of the last 5 years and between 2012-2018 averaged 0.72.	
5.0 Determine if the migration timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.		
5.1 Migration timing	Met: Run times were similar between hatchery- and natural-origin fish; no significant differences for adults arriving at Bonneville Dam at the 10th percentile ($P = 0.16$), 50th percentile ($P = 0.53$), or 90th percentile ($P = 0.07$) of the day of year.	
5.2 Spawn timing	Not Met: There were significant differences between the carcass recovery timing of hatchery- and natural-origin female carcasses at the 10th percentile ($P < 0.01$), 50th percentile ($P < 0.01$), and 90th percentile ($P = 0.05$) with natural-origin fish recovery day of year being later at all percentiles than their hatchery-origin counterparts.	The difference between hatchery- and natural-origin female carcass recovery time was 2-4 days.
5.3 Spawn distribution	Met: The spawning locations of hatchery- and natural-origin Chinook Salmon as indexed by carcasses were similar in the Hanford Reach.	
6.0 Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.		
6.1 Donor Stray Rates	No Target: The annual donor stray percentage for hatchery-origin Priest Rapids Hatchery fall Chinook Salmon was less than 1%.	
6.2 Return Year Recipient Stray Targets (Out of Basin)	Met: The Priest Rapids Program did not exceed the out-of-basin recipient stray target of 5%.	
6.3 Return Year Recipient Stray Targets (Within Basin)	Met: The Priest Rapids Program did not exceed the in-basin recipient stray target of 10%.	
7.0 Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.		

M&E Objective	Findings	Comments
7.1 Population Genetics (Allele Frequency)	Met: Measures of genetic diversity (allelic richness, heterozygosity, linkage disequilibrium, and effective number of breeders) showed little differentiation among baseline and contemporary populations for fall Chinook Salmon, suggesting that hatchery programs have not led to a decrease in genetic diversity.	
8.0 Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.		
8.1 Phenotype Similarity (Age at Maturity)	Not Met: a shift to younger adult fish was observed in hatchery-origin fish in both males and females. Most adult natural-origin males and females were age 4; there were increases in age 3 fish for both hatchery-origin males and females, and the majority of hatchery-origin males returned at age 3.	
8.2 Phenotype Similarity (Size at Maturity)	Inconclusive: Hatchery-origin fish were slightly larger than natural-origin fish at age 3 but not significantly ($P = 0.14$). Natural origin fish were significantly larger ($P < 0.01$) than hatchery-origin fish at ages 4 and 5 regardless of fish sex.	
8.3 Phenotype Similarity (Size and Fecundity)	Inconclusive: Fecundity, individual egg weights, and total egg mass increased significantly with fork length ($P < 0.01$). There were significant differences ($P < 0.05$) between hatchery- and natural-origin fish for fecundity and individual egg weight, although each was confounded by significant interactions between fork length and origin. There was no significant difference ($P = 0.33$) in total egg mass between hatchery- and natural-origin fish.	
9.0 Determine if hatchery fish were released at the programmed size and number.		
9.1 Release Numbers	Met: Target = 5,599,504; Releases from 2014–2018 were within the ±10% target.	
9.2 Size-at-release (FPP)	Met: Target = 50 fpp; mean annual weight was 49-52 fpp.	
9.3 Size-at-release (CV)	Met: Target ≤ 10 mm CV; annual range = 6.1–8.4 mm.	
10.0 Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.		
10.1 Harvest Contribution	Met: The percent of brood year harvested averaged 52.5% for brood years 2004-2012.	

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