ISRP INDEPENDENT SCIENTIFIC REVIEW PANEL

FOR THE NORTHWEST POWER AND CONSERVATION COUNCIL PORTLAND · NWCOUNCIL.ORG/ISRP

Memorandum (ISRP 2023-4) **October 4, 2023**

To: Jeffery Allen, Chair, Northwest Power and Conservation Council

From: Richard Carmichael, ISRP Chair

Subject: 2023 Follow-up Review of Project #1990-077-00, *Development of Systemwide Predator Control* (Northern Pikeminnow Management Program)

Background

On September 5, 2023, the Northwest Power and Conservation Council asked the ISRP to review a cover letter and response memorandum (August 31, 2023) submitted by Pacific States Marine Fisheries Commission, Washington Department of Fish and Wildlife, and Oregon Department of Fish and Wildlife, as proponents, regarding Project #1990-077-00, *Development of Systemwide Predator Control* (referred hereafter as the Northern Pikeminnow Management Program [NPMP]). This project has been reviewed by the ISRP numerous times over the past 25 years, and this particular review dialogue originated in the Mainstem and Program Support Category Review (ISRP 2019-2, May 29, 2019), in which the ISRP recommended the project met scientific criteria with qualifications (i.e., conditions), and the Council requested a response to a number of those conditions. In 2020, the NPMP proponents provided an initial response to the ISRP. The 2020 response demonstrated that the NPMP agreed with the majority of the ISRP's recommendations and intended to explore actions to address them, but it was unclear how and when the recommendations would be addressed. Consequently, the ISRP requested that the three proponents respond collectively to the ISRP review and indicate how the recommended actions would be addressed (ISRP 2020-10). The NPMP's 2023 submittal is intended to address the conditions requested by the Council arising from the ISRP's 2020 response review of the project. The 2023 NPMP response focuses on the ISRP's 2020 requests regarding action implementation and adaptive management, and an explanation of how the condition on SMART objectives would be addressed in the future, as needed.

In our review below, we provide a recommendation and a brief summary of our findings followed by a point-by-point response to the proponents' response to show a record of our iterative dialogue.

ISRP Review Recommendation and Summary

ISRP Recommendation: Meets scientific review criteria, the conditions are satisfied

Response issues:

1. Action Implementation
The NPMP response satisfactorily addresses and adopts most of the ISRP recommendations from the 2020 review for improving the northern pikeminnow monitoring and suppression effort via the Sport Reward Fishery. The NPMP established partnerships with the Yakama Nation on stomach content DNA (scDNA) evaluation, and this information will be useful in developing future iterations of the monitoring program to help populate models evaluating smolt consumption rates. The NPMP reallocated funds ($313,000) from the Sport Reward Fishery program so staff could address many of the issues we raised in the 2020 review. This level of effort is acceptable if it is sustained in future years with a continued focus on these issues until they are fully addressed.

2. SMART Objectives
The proponents state that "No SMART objectives are included as there are no new activities proposed at this time. However, if we develop new work for the next review cycle, we will submit SMART objectives to cover the new and existing work." The ISRP still encourages the NPMP to recast current objectives where appropriate to meet SMART criteria for interim RM&E efforts developed within ongoing funded activities and document them in annual reports. This will facilitate development of quantitative desired outcomes with timelines, which will guide the project, inform the Council, and benefit future reviews.

3. Adaptive Management
The partners in the NPMP made substantial progress toward developing a formal adaptive management process. Future adaptive management assessments and NPMP proposals should reconcile differences in measures of abundance of pikeminnows and other predators and the objectives of the program. This could lead to program adjustments reducing the scope of the program to tailraces of dams and other areas of extremely high pikeminnow density where predation exerts a substantial risk to salmon. A fundamental component of the adaptive management system for the project could be to establish "stopping rules" based on established thresholds of pikeminnow abundance and consumption of juvenile salmon and steelhead.

Over the NPMP's 33-year history, the program has been unable to measure a direct response of salmon and steelhead to northern pikeminnow removal based on the sample design and analytical methods applied. Additionally, the proponents' recent study of John Day Reservoir only captured northern pikeminnow in the tailrace of McNary Dam, whereas indices of abundance of smallmouth bass and walleye increased in the sampled areas of the reservoir. If climate warming increases, consumption rates by non-native predatory fish, such as walleye and smallmouth bass, might exert greater predation pressure on salmon as a result of

population increases or higher metabolic rates. Moreover, climate change and competition with non-natives could diminish northern pikeminnow abundance as populations of non-native warmwater species increase. The NPMP has the opportunity to evolve and expand its existing evaluation of impacts of non-native predators, and perhaps explore more aggressive management actions for them than currently implemented.

Point-by-point Review Discussion: ISRP 2020 Requests, NPMP 2023 Response, and ISRP 2023 Comments

In this section, we excerpt the NPMP's 2023 memorandum section responding to our 2020 review requests and add our comments on the responses. The ISRP's 2020 requests, NPMP 2023 responses, and ISRP 2023 comments are organized below and distinguished by headings, font type, and indentation.

1.a ISRP 2020 Request: Use of a Barker Model

The NPMP response identifies several limitations of the available data, including: 1) small number of recaptures, the majority of which are dead fish, 2) <10% of recaptures are from PIT tag detectors, samples from bird colonies, and NPMP electrofishing, and 3) the large spatial scale of the project (i.e., sampling over the 750 km of the mainstem), which together make it unlikely that the Barker Model can be used effectively for estimating pikeminnow abundance.

The proponents will discuss application of the Barker Model with Dr. Mary Connor, who applied it in Murderer's Creek on the John Day River. They also intend to explore the Brownie Bird Band Recovery Model, which may be a better alternative because it is designed to use tag recoveries from dead animals. The Brownie Model may be able to provide estimates of annual natural mortality and exploitation, particularly in areas of low tag returns. The ISRP encourages the proponents to pursue these options, so the results can be used to improve and adjust the monitoring efforts and analyses. The NPMP should describe their evaluations of these models and basis for their selection or rejection of alternative approaches for analyzing mark-recapture data to supplement and potentially calibrate current metrics for pikeminnow populations.

> **NPMP 2023 Response: Mark/recapture Model, Actions and Implementation**
> NPMP biological monitoring and evaluation was initially developed to evaluate the effectiveness of the Sport Reward Fishery (SRF) and to monitor the Northern Pikeminnow population for signs of intra- and interspecies compensation using 'rapid assessment' techniques. These techniques included modeling predation reduction to juvenile salmonids through SRF exploitation of Northern Pikeminnow based on mark/recapture data and indices of abundance, consumption, and predation to monitor the Northern Pikeminnow population. An updated or improved mark/recapture (recovery) based population model was tested using RMark (RMark, Laake 2013). RMark is a combination of the documented Mark population estimate software (White and Burnham 1999) operating within the open source analytical software package R (R Core Team 2021). RMark contains numerous mark/recapture based population estimate models (e.g., Cormack-Jolly-Seber, Brownie Bird Band) with additional flexibility to customize

numerous additional parameters for specific systems. The biological monitoring and evaluation of NPMP was initially designed as a 'rapid assessment' framework so our interest in testing RMark was twofold. First, we assessed the functionality of RMark as an analytical interface 'rapid assessment' tool using NPMP data. Second, we tested the validity of a Brownie Bird Band mark/recovery population estimate with NPMP SRF data (Brownie 1985).

A subset of the 30-year NPMP mark/recapture dataset was chosen for an initial assessment using RMark. Specifically, mark/recovery data were incorporated from NPMP biological evaluation (indexing) sites in the area below Bonneville Dam from 2012 – 2021. Spatiotemporally subsampling the data was prioritized for this assessment step because that area has some of the most consistent and largest samples sizes. Additionally, that 10-year timeframe has mark/recapture data available in a hierarchical related database (Microsoft Access). Positive results from this initial assessment would help NPMP determine whether RMark could function as a potential 'rapid assessment' tool while also providing an opportunity to test the Brownie Bird Band population model with NPMP data.

The initial assessment of RMark as a tool to estimate Northern Pikeminnow population using mark/recovery data returned positive results. NPMP data can be incorporated relatively easily into RMark. Furthermore, RMark has flexibility to modify some parameters of the model which may allow NPMP additional options in updating population estimates in the future. Population estimates using the Brownie Bird Band model in RMark closely matched Lincoln-Peterson estimates for the same time period and area ($R^2 = 0.903$). In addition to population estimates, the Brownie Bird Band model also provides estimates of survivorship, natural mortality, and mortality from SRF. These additional parameters may provide information about the assumptions of compensation used in the predation reduction model as well as other programmatic assumptions. Additionally, the Brownie Bird Band model utilized recaptures from multiple years, giving NPMP additional information about mortality that was unavailable using the existing Lincoln-Peterson method. Paired with this modeling approach during the 2022 field season was a shift to exclusively using PIT tags for marking purposes. This can be seen as a substantial step towards enhancing mark/recovery models that utilize multiyear recaptures as external tags can cause additional stress and mortality, particularly in smaller fish.

Timeline

Future work could include further assessing the existing population estimates or mortality from fishing with existing estimates from additional reservoirs in the Columbia and Snake Rivers. This work is necessary to validate whether full incorporation of the Brownie Bird Band model would be functional at a program level. An additional step could involve incorporating Northern Pikeminnow size structure into the Brownie Bird Band model to further hone estimates of mortality or survival based on size (age) class which would allow for further examination of intraspecies compensation by size class. This work could take months to years, depending on the level of assessment and

incorporation into the existing NPMP biological monitoring and evaluation framework. Conducting this work using the existing level of funding and focus for the Northern Pikeminnow Management Program will be difficult. In 2023, the level of funding necessitated the suspension of marking efforts in order to continue biological evaluation efforts. While NPMP realizes the importance of continuing to pursue these population and predation modeling updates we implore the ISRP to recognize that our current funding does not contain space for monitoring and evaluation of the NPMP SRF while validating and updating the analytical approaches used.

ISRP 2023 Comments:

The objectives of the NPMP to evaluate the effectiveness of the Sport Reward Fishery (SRF) and to monitor the northern pikeminnow population for signs of intra- and interspecies compensation are critical for the continuation of this program, designed to reduce populations of a native fish species. These assessments and methodological improvements are essential to the success for a 33-year program.

The NPMP has carefully considered alternative models and software for analyzing mark-recapture data to estimate and calibrate current metrics for pikeminnow populations. Application of RMark and the models within it appears to be a promising direction for the Program. The ISRP is very encouraged that the NPMP was able to conduct an initial analysis of part of their data with the Brownie model using RMARK. Estimates using the Brownie Bird Band model in RMark closely matched Lincoln-Peterson estimates. The additional estimates of survivorship and mortality (both natural and from SRF) should be highly useful in evaluating the program and potential compensation. If the marking has shifted to exclusively using PIT tags, has the program estimated the rate of PIT tag shedding to adjust the recapture data?

The ISRP encourages the NPMP to continue their evaluation based on size structure, as suggested. Such analyses are likely to yield important results that can help understand population dynamics in response to the SRF and other important factors.

The ISRP commends the NPMP for improving the monitoring and evaluation program. Further assessment and possible transition to the new models should be a high priority for the NPMP and its adaptive decision-making process. Given the limited funding available to do this work, the ISRP wonders whether the NPMP might engage with university scientists who might be interested in analyzing the extensive dataset for a dissertation research project, for example. The program should consider whether the new assessments and need to transition to new models and capture methods are of greater importance than other ongoing work that could be delayed until future years.

1.b. & c. ISRP 2020 Request: Are the abundance estimators valid? How do the CPUE estimates align with a mark-recapture estimate?

The NPMP agrees that use of an alternative method for estimating pikeminnow abundance would allow them to evaluate the current CPUE approach. The NPMP proponents also indicate they will compare their CPUE estimates from boat electrofishing with CPUE estimates from the Sport Reward Fishery and annual tagging efforts to validate the current abundance index and examine its sensitivity to environmental conditions and specific types of thresholds. While the response indicates the proponents do not disagree with the recommendation, it only indicates they will use existing data from the Sport Reward Fishery Program for the comparisons. The proponents do not state that they plan to validate their current approach with a more robust estimate of pikeminnow abundance in the near future. The ISRP understands the value of using a standard protocol for long-term historical data, but such approaches require recalibration. If funds cannot be obtained or reallocated to validate their abundance estimate, the NPMP could reduce the additional funding burdens of validation by conducting the validation in one reservoir, or parts of several reservoirs (to achieve some replication) in a sound statistical approach, which might be more feasible.

NPMP 2023 Response: Northern Pikeminnow Abundance Estimators, Actions and Implementation

Abundance estimators were assessed using a subset of NPMP data from below Bonneville Dam from 2012 – 2021. The fisheries independent index of abundance (catch per unit effort scaled with reservoir subsection area) was compared to mark/recapture estimates of population using the Lincoln-Peterson based population model and with fisheries dependent Sport Reward Fishery (SRF) catch per unit effort (CPUE, number of fish caught per angler day). Historically, there was a strong relationship ($R^2 = 0.95$) between NPMP index of abundance and Lincoln-Peterson mark/recapture based population estimates (Ward et al. 1995). The recent analysis using data below Bonneville Dam demonstrated mixed results, generally showing weak to no relationships between the index of abundance and the Lincoln-Peterson population estimate. This analysis incorporated a longer timeseries of data than Ward et al. 1995 but using data that were collected every three years, limiting the size of the data set. The index of abundance was significantly, inversely related to SRF CPUE though the relationship was not as strong as the relationship between the index of abundance and the mark/recapture based population estimate from Ward et al. 1995 ($p = 0.02$, $R^2 = 0.44$). The inverse relationship supports the idea that SRF removals may be detected during biological monitoring and evaluation as a reduction in the index of abundance. Additionally, the spatial data provided with SRF CPUE is coarse including a more granular estimate of effort (angler days vs. number of seconds electrofished, per indexing site).

NPMP piloted more frequent fisheries independent sampling during early Spring 2023, below Bonneville Dam, to further assess the relationship between the fisheries independent index of abundance, mark/recapture population estimates, and SRF CPUE. As of this report, a preliminary field data set had been generated and NPMP was opportunistically adding additional sample days to this effort. Early Spring sampling

during 2023 was relatively unproductive, with a total of 18 tags deployed during 12 days of fisheries independent index of abundance sampling and no recaptures. It was likely that river conditions were not favorable during the initial 12 days of sampling as catch was higher in the same areas during the regular index of abundance sampling, five weeks later. Furthermore, the low early spring catch rates demonstrate the additional constraints to increasing sampling efforts necessary to assess abundance indicators. These constraints include temporal limitations related to optimal fishing conditions, aligning predator diet analysis with peak juvenile salmonid outmigration, complying with take permits issued by NOAA, and temperature restrictions due to the presence of Endangered Species Act (ESA) listed salmonids in the study area. The SRF was ongoing at the time of this response and could provide a potential source of recapture data however that fishery will not be closed until after this response is due.

Additionally, NPMP conducted a full spring indexing effort in the area below Bonneville Dam during 2023. This increased the sample frequency from every three years to two years. An additional year of sampling could be acquired in 2024 to provide four years of data that spans a five-year window (2020, 2021, 2023, 2024). Replication at this level may be more appropriate to assess the relationship between the index of abundance and mark/recapture based population estimates.

Timeline

The timeline for future work depends on NPMP priorities based on the information from the analyses presented in this response and the subsequent response from ISRP. Data from below Bonneville Dam did not show a strong relationship between the index of abundance and SRF based Lincoln-Peterson population estimates. However, the preliminary analyses were limited by the size of the data set. Recent fieldwork from 2023 will need to be expanded upon to build a larger dataset for a more thorough assessment of the relationship between NPMP index of abundance and SRF derived mark/recapture population estimates. Future steps could include assessing the relationship between the mark/recapture Brownie Bird Band model population estimate from 1a and the index of abundance. This would further validate whether an updated mark/recapture population estimate would also be supported by the long-term index of abundance. The spatiotemporal scope of the analysis between the index of abundance and SRF mark/recapture derived populations estimates could be expanded to assess whether there are differential patterns in other reservoirs or different time periods. To enhance the understanding of the relationship between fisheries independent indices of abundance and fisheries dependent population estimates, additional field sampling increasing the frequency and spatial extent of the data set could be implemented. Conducting work of this nature will be necessary should NPMP consider a change to the existing index of abundance or mark/recapture methods currently utilized. This is warranted given the low tag numbers during the 2023 pilot efforts. The timeline for these proposed additional actions could take months to years, depending on the scope of the analyses and resources available. While the current results suggest additional validation work should be conducted, the existing budget will severely restrict the progress of the necessary additional fieldwork and analyses.

ISRP 2023 Comments:

The ISRP appreciates the effort the NPMP has invested to validate and compare abundance estimates across datasets to address this condition about the validity of abundance estimators from the 2020 ISRP review. In their response, the NPMP compared their CPUE-based index of abundance with mark/recapture estimates using the Lincoln-Peterson based population model and the SRF CPUE. They found little or no relationship between the index of abundance and mark/recapture estimates. This finding has major implications for the validity of the large-scale monitoring of pikeminnow abundance.

The CPUE-based index of abundance of pikeminnow was inversely related to the angler CPUE, though the relationship was not very strong. The NPMP concludes that this relationship "supports the idea" that reduction in the index of abundance is an indication of the effectiveness of the angler catches to reduce pikeminnow populations. The description of these indirect measures of abundances and harvest does not clearly explain the logic that supports the idea that the inverse relationship demonstrates that the angler catches are effectively reducing pikeminnow populations. Unless the data indicate that abundances are decreasing within a season as catches increase, the ISRP cannot see how this conclusion accounts for other factors that influence pikeminnow population size. A much more robust method of determining whether the Sport Reward Fishery is effective is by estimating the removal-induced mortality relative to the natural mortality, which would require a reliable open population model.

The proponents' discussion of relationships between measures of abundance is confusing. It appears that the proponents developed an index of abundance based on NPMP boat electrofishing CPUE, a SRF CPUE based on reported catch, a NPMP mark/recapture estimate, and a mark/recapture estimate based on recaptures of marked fish returned in the SRF. Different descriptors were used for the NPMP estimates (e.g., fisheries-independent estimate).

The SRF CPUE estimate could be biased because remaining fish congregate in good habitat and anglers target them, keeping CPUE high even when the population is declining. A classic study of the collapse of sport fisheries for walleye-pike-lake trout in Alberta observed that because anglers target fish in known habitat hotspots, and remaining fish congregate there, then CPUE can remain high even as abundance declines, masking a collapse in sport fish populations (Post et al. 2002, Post 2013). It is possible that this might explain the negative relationship between the sport fishing CPUE and the abundance estimate. The critical finding is that the NPMP has not been able to validate that any CPUE is strongly correlated with their mark-recapture estimate of abundance. If this is the case, given the reliance on CPUE, it is a major problem for the program that must be resolved, and hence requires prompt attention.

The NPMP is considering an additional year of sampling in 2024 to provide four continuous years of data. These data will be useful for evaluating the relationship between the index of abundance and mark/recapture-based population estimates. The ISRP encourages the proponents to take advantage of this opportunity for their RM&E efforts.

The analyses of NPMP abundance estimates could provide crucial information about sampling biases and other, perhaps unrecognized, factors that account for differences in abundance estimates across methods. While the proponents argue that current data do not allow for a full analysis and that analytical work is beyond the scope of the existing program, future proposals should seek to develop explicit comparisons of these methods. This would be essential for right-sizing various aspects of the program, or adjusting the scope of activities to reflect local pikeminnow abundance and their likely predation impact on smolts.

The proponents indicate that they may be able to adopt a new modeling approach and obtain the necessary field data to support changes in the program, but the additional actions could take months to years, depending on the scope of the analyses and resources available. The proponents acknowledge that additional validation work should be conducted, but budget limitations will limit their progress. The ISRP encourages the partners in the program to give these efforts to improve the monitoring data high priority in their funding decisions. Additionally, future proposals could seek to develop explicit comparisons of these methods. Continued monitoring and implementation of a long-term bounty program for a native fish using methods or estimates that are questionable or could be strengthened substantially would be ill advised.

References

Post, J.R., M. Sullivan, S. Cox, N.P. Lester, C.J. Walters, E.A. Parkinson, A.J. Paul, L. Jackson, B.J. Shuter. 2002. Canada's recreational fisheries: the invisible collapse? Fisheries 27:6-17.

Post, J.R. 2013. Resilient recreational fisheries or prone to collapse? A decade of research on the science and management of recreational fisheries. Fisheries Ecology and Management 20:99-110.

1.d. ISRP 2020 Request: Use of bioenergetics model to estimate consumption

The NPMP agrees that a bioenergetic model would provide improved estimates of consumption and calibration of the current consumption indices. Additionally, a bioenergetics model could provide consumption estimates for walleye, for which peer-reviewed indices are not available. In a teleconference with the ISRP, the project staff indicated that they collect 1,200 samples per year for diet analysis. Most fish recovered in the diet samples are highly digested and degraded, so accurate data on mass are difficult to obtain. Therefore, the NPMP would need to collect additional fish samples to achieve quantitative estimates of diet. The proponents will explore use of eDNA and genetic analyses to better identify stomach contents and sensitivity of bioenergetic models to the parameters to determine where improvements are most likely.

The ISRP requests additional information about the consumption index currently used. To what factors is the index most sensitive (e.g., temperature, prey data, or other parameters)? What power analyses has the ODFW subproject conducted in the past, and how did they determine

that the current analyses are the best possible approach? The proponents' response indicates they currently do not have funds available to obtain the information required for the bioenergetic model and conduct this analysis. The co-managers need to consider the importance of better understanding the factors that determine the consumption of juvenile salmon and steelhead by pikeminnow and other non-native predators.

NPMP 2023 Response: Bioenergetics, Actions and Implementation

ODFW is in the process of evaluating a software based bioenergetics analytical tool as a means to assess the current index of consumption for Northern Pikeminnow and Smallmouth Bass as well as to explore a bioenergetics model for Walleye. This bioenergetics software could function as a 'rapid assessment' tool that provides NPMP the technical capacity to rapidly assess bioenergetic budgets for piscine predator species as well as the modularity to update the bioenergetics models as new data becomes available or biological or physical conditions change. This matches well with the premise of the existing NPMP biological monitoring and evaluation techniques designed as rapid assessment tools. The first step of this process involves determining whether the bioenergetics software tool, Fish Bioenergetics 4.0 (Deslauriers et al. 2017), is suited to NPMP diet and catch data. The limitations of sampling in time and space may have significant implications for bioenergetics modeling. NPMP biological evaluation sampling efforts cover a large area consisting of eight reservoirs, and the free-flowing area below Bonneville Dam. Despite a 30-year time series, sampling effort is limited to a two-day sampling period in reservoir sub-sections which are surveyed on a rotating basis over multiple years. If the software is functional within the bounds of the available data, the next steps will be to assess how the bioenergetics models in Fish Bioenergetics 4.0 relate to the existing indices of consumption for Northern Pikeminnow and Smallmouth Bass. Fish Bioenergetics 4.0 uses published biological parameters for numerous species of fish and the Wisconsin Bioenergetics modeling framework (Deslauriers et al. 2017) to calculate an energy budget for fishes. There is modularity within the program to allow users to customize numerous biological and physical parameters relative to the species and system of interest.

eDNA, Actions and Implementation

In general, analyses using eDNA (stomach content DNA or 'scDNA') samples are not yet at the point where information from this genetic tool can be easily incorporated into the index of consumption. ODFW NPMP staff have had conversations with internal experts on the technique and the consensus is the technology is in development but is not yet practical for the scale of this work. The financial burden would be substantial with per sample (fish) costs estimated at $70 - $120, depending on the extent of the genetic analysis to be conducted. Additionally, there would need to be modifications to the existing field sample collection methods that have not yet been developed for incorporation into the existing digestive content collection process. However, ODFW NPMP staff have engaged in a collaborative partnership with members of the Yakima Nation on a pilot project to assess field collection methods for scDNA. Dozens of samples were collected from Northern Pikeminnow, Smallmouth Bass, and Walleye in

NPMP evaluation and monitoring sites below Bonneville Dam in June 2023. This collection included establishing an initial field collection protocol and will be followed up with genetic analyses of the stomach contents obtained from the sampling efforts. These efforts are ongoing at the writing of this response.

Consumption Index, Actions and Implementation

The sensitivity of the Northern Pikeminnow index of consumption to the input parameters was assessed early in the development of the index and found to be most sensitive to changes in temperature (Ward et al. 1995, Peterson and Ward 1999). However, large changes in mean predator size with little change in temperature or a lack of salmonid diet items, could also have a substantial influence on the index of consumption calculation.

A formal power analysis was not conducted as part of this response. For many years, NPMP biological monitoring and evaluation has used standardized minimum indexing sampling effort of twelve, 15-minute electrofishing runs per night to obtain indexing data. Vigg and Burley 1989 demonstrated this level of sampling represented the inflection point past which little additional variability was explained by further sampling. Additionally, the currently used target of twelve runs per night was double the number of fishing runs used to validate many of the early relationships currently used in the biological evaluation and monitoring program (e.g., Zimmerman and Ward 1999). Additionally, there was a minimum sample size of six or more individual fish per reservoir sub-section (e.g., tailrace, mid-reservoir, forebay) per year for the calculation of the index of consumption (Ward et al. 1995). NPMP has focused on a consistent sampling effort that maximizes data collection without severely straining our existing resources. Numerous studies have demonstrated that the current level of sampling provides robust data used for statistical analyses across the broad monitoring and evaluation area along the Columbia and Snake Rivers (e.g., Vigg and Burley 1989, Ward et al. 1995, Beamesderfer et al. 1996, Zimmerman and Ward 1999).

Timeline

The timeline for continued bioenergetics work will include a preliminary assessment of the utility of Fish Bioenergetics 4.0 to be used with NPMP biological evaluation and monitoring data. This will be ongoing through November 2023. Additionally, should Fish Bioenergetics 4.0 be useful with NPMP data and resources permit, additional assessments will be conducted comparing the existing index of consumption and the bioenergetics models. ODFW NPMP staff will continue to work on these tasks, as resources permit, until the next ISRP review.

ISRP 2023 Comments:

It is encouraging that the NPMP is pursuing the latest tools in bioenergetics to see if they are applicable and useful, and that they have considered use of eDNA for investigating stomach contents (referred to as stomach content (scDNA) and application in their consumption index.

The proponents appear to have seriously considered the ISRP's input regarding bioenergetics modeling and evaluated several pathways for implementing these models in some form.

As the NPMP considers the application of bioenergetic models in the future, additional details on data requirements for modeling the population-level bioenergetics are needed. It is not clear how much stomach content data are needed to adequately parameterize a bioenergetics model. Can empty vs. full stomachs be a proxy for feeding, with an assessment of stomach contents for a small subset of fish to establish predation rates on salmon? Reliable estimates of predator abundance (by size class), their growth rates, and reliable diet composition will be required to determine how much energy they consume and what proportion are salmonids. These and other details should be included in future reports and proposals if the NPMP continues to consider use of bioenergetic models to better evaluate consumption.

The proponents rightly emphasize limitations in sampling and the ability to adequately assess stomach contents using scDNA (because of expenses outside the program budget). While the costs of such analyses are likely prohibitive at this time, we encourage the proponents to continue to follow development of this technique and possible cost-effective ways to employ it as costs of analyses decrease. Through work with the Yakama Nation and other partners, it may be possible to develop a "rapid assessment" protocol that allows for robust estimation of northern pikeminnow predation impact and its variation in time and space, but the ISRP cannot assess the strengths and weakness of this approach without additional details. Future work – perhaps with academic, tribal, and other partners – could develop this framework based on sampling data that are being accumulated as a part of joint efforts, and the work could be included in future proposals.

2a. ISRP 2020 Request: Can direct measures of colonial water bird predation be applied to northern pikeminnow and other piscivorous fishes?

The ISRP suggests three approaches to explore compensatory response of predators and salmonids: 1) analyses of compensatory versus additive mortality of smolts (similar to recent avian research: Payton et al. 2020, Haeseker et al. 2020), 2) measuring compensation of other predators that increase in abundance as pikeminnow decrease in abundance, and 3) using life cycle models to evaluate the effect of pikeminnow predation and control efforts on the full life cycle of salmon and steelhead.

To date, the NPMP has measured the effect of the Sport Reward Fishery on the abundance of larger predatory pikeminnow, but it has not measured the response of juvenile salmon to reductions in pikeminnow abundance. The ODFW M&E team indicates that it will work with Allan Evans and Quinn Payton from Real Time Research to determine if their approach is suitable for measuring compensatory mortality of pikeminnow. PIT tag recovery methods for avian predators and pikeminnow are substantially different. In terms of direct measures of consumption, the project staff indicated during the teleconference that they annually recover approximately 100 ingested smolts with PIT tags from 200,000 pikeminnows. The approach used

by Evans and Payton is possible with reservoir-specific data on juvenile salmon survival and pikeminnow abundance, but the ODFW subproject notes that their captures of pikeminnow are insufficient to calculate abundance indices in many years. Reservoir-scale measurements would be adequate to examine compensatory mortality, so the low number of captures within the three areas of each reservoir would not be a constraint. The subproject describes additional limitations on the amount of information available in a given year (e.g., yearly rotation of reservoirs sampled, inadequate samples for calculating consumption indices, collecting permit limitations). The ISRP recognizes that these limitations may affect the analysis, and we encourage the NPMP to explore the approaches used by the avian predation projects, which would allow the proponents to estimate the effect of pikeminnow on juvenile salmon survival.

NPMP 2023 Response: Modeling Predation, Actions and Implementation

ODFW NPMP staff initiated several conversations with members from Real Time Research, Allan Evans and Quinn Payton, to assess whether their approach can be applied to our data. Initial attempts at applying their methods were unfruitful. Modeling avian predation is facilitated by terrestrial deposition of consumed salmonid tags to known colony sites, which represent a large data source generally not available for fish predation. We attempted to use PIT tag recoveries from ingested smolts in the Pikeminnow delivered to the Sport Reward Fishery check-in stations to evaluate consumption. A preliminary examination suggests the predatory impact to PIT-tagged smolts entering the area where ingested PIT-tagged smolts are observed in harvested Pikeminnows is very low. In a given year on average around 100 ingested PIT-tagged smolt have been observed in Pikeminnow from harvests up to nearly 200,000 individuals system wide that could amount to less than 0.1% in a given year. ODFW NPMP has been piloting an alternative approach to detect tagged prey salmonids. Coded Wire Tags (CWT) are implanted in millions of juvenile salmonids per year. During 2022 and 2023, ODFW NPMP staff developed lab protocol to better detect CWT in digestive tract samples from Northern Pikeminnow. This was paired with field protocol to detect potential ingested CWT salmonids in whole Northern Pikeminnow. The initial phases of this work show promise as an additional source of tagged juvenile salmonids. This work is ongoing and the next steps include assessing the frequency of CWT from potential field detections during the lab processing phase.

Timeline

Currently, these efforts are of low priority for NPMP as the other ISRP related recommendations have been the focus of NPMP for the past two years, primarily because of the existing uncertainties around applying the methods used with avian predators. Future efforts could include establishing whether it's possible to quantify annual in-river predation of the populations of PIT-tagged smolts. There may be approaches to compare annual smolt survival rates in each reservoir with annual estimates of Pikeminnow predation in the same reservoir. A novel estimate of Pikeminnow predation rates is likely needed for this analysis. CWT may provide an alternative to the less frequently placed PIT tags as a source of data for an analysis like the one used for avian predators. Due to

the added challenges of developing the analytical approach, additional resources would be needed to pursue this recommendation in more detail.

ISRP 2023 Comments:

The NPMP is taking ISRP recommendations seriously, while prioritizing activities to available funding and resources. The NPMP has explored the use of the methods used in avian predation research in the Columbia River. The proponents attempted to use PIT tags recoveries from ingested smolts, which demonstrates that they are actively pursuing this potential approach. It is encouraging that the NPMP is evaluating use of coded wire tags (CWT) in addition to PIT tags to detect predation by pikeminnow on juvenile salmonids and develop more informative estimates of predation. Incorporation of CWT assessment in pikeminnow stomachs could be an important advance toward understanding pikeminnow impact on smolt mortality, and assessment data could then be incorporated into models like those developed by Real Time Research and Haeseker's research group.

Data thus far suggest the impact of pikeminnow predation on smolts is relatively low based on the few recovered PIT-tags in stomachs. The proponents report that the initial estimates from the PIT tag analysis indicate that predation rates are low, less than 0.1% of the migrating smolts. If future and expanded studies using CWT, scDNA, and PIT-tag recoveries continue to indicate such low rates of consumption, the proponents should consider a streamlined or targeted program at specific locations rather than throughout the entire mainstem Columbia River.

2b&c. ISRP 2020 Request: Proponents should perform analyses to evaluate trends in locations that exhibit potential localized compensation and work with avian researchers to determine if northern pikeminnow removal has prompted a compensatory effect in colonial waterbirds.

Collaboration with the avian predation projects could allow these projects to explore complex interactions between avian and fish predators of juvenile salmon and steelhead. The proponents state that obtaining information on localized compensatory responses of other predators, compensatory versus additive mortality of smolts, and use of the life cycle models could be new projects rather than efforts added to the existing Program. The response indicates that they will explore use of the CSS survival estimates, the pikeminnow CPUE, and the life cycle models, but it is unclear whether those analyses would become part of the existing NPMP. The proponents should consider soliciting the assistance of the multi-agency life cycle modeling workgroup chaired by NOAA to incorporate predation hypotheses into the models.

NPMP 2023 Response: Predatory Interactions, Actions and Implementation

NPMP staff have been participating in regional conversations among piscine, avian, and pinniped predation technical experts through the Columbia Basin Collaborative (CBC). CBC's broad goals are to improve salmonid populations in the region by incorporating a

multi-stakeholder process. The process has focused on bringing the numerous agencies, institutions, and entities involved with managing and using the resources of the Columbia River Basin into conversations about approaches to improve salmonid populations. While the CBC process has not explicitly detailed approaches to address interactions between avian and piscine predators of juvenile salmonids, that question was highlighted early in the CBC process and each subsequent meeting provides additional opportunities for conversation potentially leading to more comprehensive approaches to understanding and managing piscine, avian, and pinniped predation to salmonids.

While NPMP does not currently utilize CSS and life cycle models to assess compensatory responses, the proponents agree that explorations of piscine predation on juvenile salmonids, using CSS and life cycle models would be worth investigating. As NPMP has done with CBC participation, we will continue to pursue and foster collaborative relationships that may help improve our assessments of compensatory versus additive predatory responses. This work will proceed slowly and full incorporation into NPMP is unlikely at the current level of funding.

Compensatory Response, Actions and Implementation

ODFW NPMP modified the 2022 biological monitoring and evaluation field season to double the sampling effort in the John Day Reservoir. This additional sampling effort was intended to further assess trends in the index of abundance among Northern Pikeminnow, Smallmouth Bass, and Walleye as well as compare the trends in the indices of consumption and predation between Northern Pikeminnow and Smallmouth Bass. The John Day reservoir was chosen as the focal point for this work as it was central to the establishment of NPMP biological evaluation and monitoring methods more than 30 years ago, functioning as the 'model' reservoir for the program (e.g., Ward et al. 1995, Beamesderfer et al. 1996). There were several notable results from these efforts. First, relatively few Northern Pikeminnow were captured despite a doubling of the effort, suggesting that the spatial patterns in the distribution of Northern Pikeminnow or their abundance have changed in the John Day Reservoir. Northern Pikeminnow were only captured in the tailrace of the McNary Dam. Second, of the Northern Pikeminnow captured, none of them contained salmonids in their digestive tracts leading to a consumption index and predation index equaling zero. Third, the long-term patterns in the index of abundance among the three species suggests a decrease in Northern Pikeminnow abundance and a concurrent increase in Smallmouth Bass and Walleye abundance. These findings have been presented at NPMP Adaptive Management meetings and the exploration and meaning of these results are still in progress.

NPMP biological evaluation and monitoring reports include assessments in the trends of indices of abundance, consumption (Northern Pikeminnow and Smallmouth Bass only), and predation (Northern Pikeminnow and Smallmouth Bass only) within the paired river 'indexing' locations that are sampled on a three-year rotating schedule. In addition to these indices, fisheries metrics like Proportional Size Distribution and Relative Weight are measured for Northern Pikeminnow, Smallmouth Bass, and Walleye. These indices and fisheries metrics provide NPMP with some information about potential compensatory

responses within sub-areas of each reservoir (i.e., tailrace, mid-reservoir, and forebay). NPMP has historically tracked the trends in these fishery metrics as a means to assess potential compensatory predatory responses. More recently, NPMP staff have been conducting preliminary investigations into the relationships among these indices and metrics among Northern Pikeminnow, Smallmouth Bass, and Walleye. While there appear to be shifts in the index of abundance in some areas, relative to historical trends, additional work is underway to determine analytical approaches for the index data. With respect to 'localized' assessments into compensatory predatory responses, the existing three-year rotating sampling frequency, due to reduced financial resources, limits the utility of these data to assess for compensatory responses at a finer spatial or temporal scale. However, the proponents agree that further enhancing the data stream would improve our ability to examine the relationships in consumption among major piscine predators in the Columbia and Snake Rivers.

Timeline

Future work involves NPMP staff continuing to participate in regional discussions regarding salmonid population restoration through CBC meetings which are occurring on weekly to monthly cycles. These meetings will be ongoing for at least the next calendar year as the CBC develops regional recommendations for salmonid recovery. Our adaptive management meetings will remain a venue for the NPMP group to discuss trends in fisheries dependent and independent data to inform programmatic decisions about the future directions of the project.

ISRP 2023 Comments:

The shifts in abundance of northern pikeminnow, smallmouth bass, and walleye in John Day Reservoir are consistent with the concerns raised by the ISRP in the 2020 review. In the study of John Day Reservoir, northern pikeminnow were captured only in the tailrace of McNary Dam, whereas indices of smallmouth bass and walleye abundance increased. This trend is likely to continue as regional climate warms. It is encouraging that the NPMP is pursuing these trends and considering interspecies compensation. Evaluation of smolt predation by northern pikeminnow using CSS survival estimates and an integrated framework is a laudable goal, even if the analysis is restricted to certain portions of the northern pikeminnow range. Until the issues of generating useful data on survival, abundance, and consumption are addressed, it is unlikely that compensation among predators can be rigorously analyzed. The ISRP encourages the proponents to continue to explore these trends and consider the results in designing future program actions. The Sport Reward Fishery would not be necessary in reaches of the Columbia River where pikeminnow abundances are low and other predators create greater risk to juvenile salmonids. Using this information in the adaptive management framework outlined below can help the program meet new challenges from these non-native predators.

3. ISRP 2020 Request: Adaptive management

The NPMP response describes several major changes in their program over the last 25 years. They point out that these changes have been ad hoc adjustments based on perceived needs rather than an explicit adaptive management process. The program participants recently have evaluated the project more formally and have developed a list of key issues that require attention in the future. The co-managers agreed to "participate in a process to review, discuss, and adopt changes on a cooperative and collaborative basis" and held their first meeting in July 2020.

The ISRP strongly supports the development of an explicit, regularly scheduled, and formalized decision-making process for the collective efforts of the Sport Rewards Fishery and the monitoring component. These efforts have a common purpose but are managed separately. Identification of key questions, design of the types and distributions of ongoing actions, and allocation of funds and staff resources greatly influence the scientific soundness of the program. Development and implementation of a structured decision support system would greatly benefit the NPMP's efforts to increase survival of salmonids by reducing pikeminnow predation. Consequently, we recommend that the co-managers develop a formal adaptive management process for their collective pikeminnow control efforts and reassess the critical questions that should be addressed to make the program effective for improving recovery of salmon and steelhead in the Columbia River.

NPMP 2023 Response: Adaptive Management, Actions and Implementation

Project managers appreciate the additional ISRP input and have been utilizing a more formal process since receiving the ISRP comments. To engage in this adaptive management activity, both direct partner participants and higher-level supervisory managers from Pacific States Marine Fisheries Commission, Bonneville Power Administration, National Oceanic and Atmospheric Administration, Oregon Department of Fish and Wildlife, and Washington Department of Fish and Wildlife agreed to review, discuss, and adopt changes in a cooperative and ongoing collaborative process at a meeting on the future direction of the Pikeminnow Sport Reward Program in July, 2020. They were formally designated as the Pikeminnow Adaptive Management Committee (AMC) at the second meeting of the group on August 10, 2021.

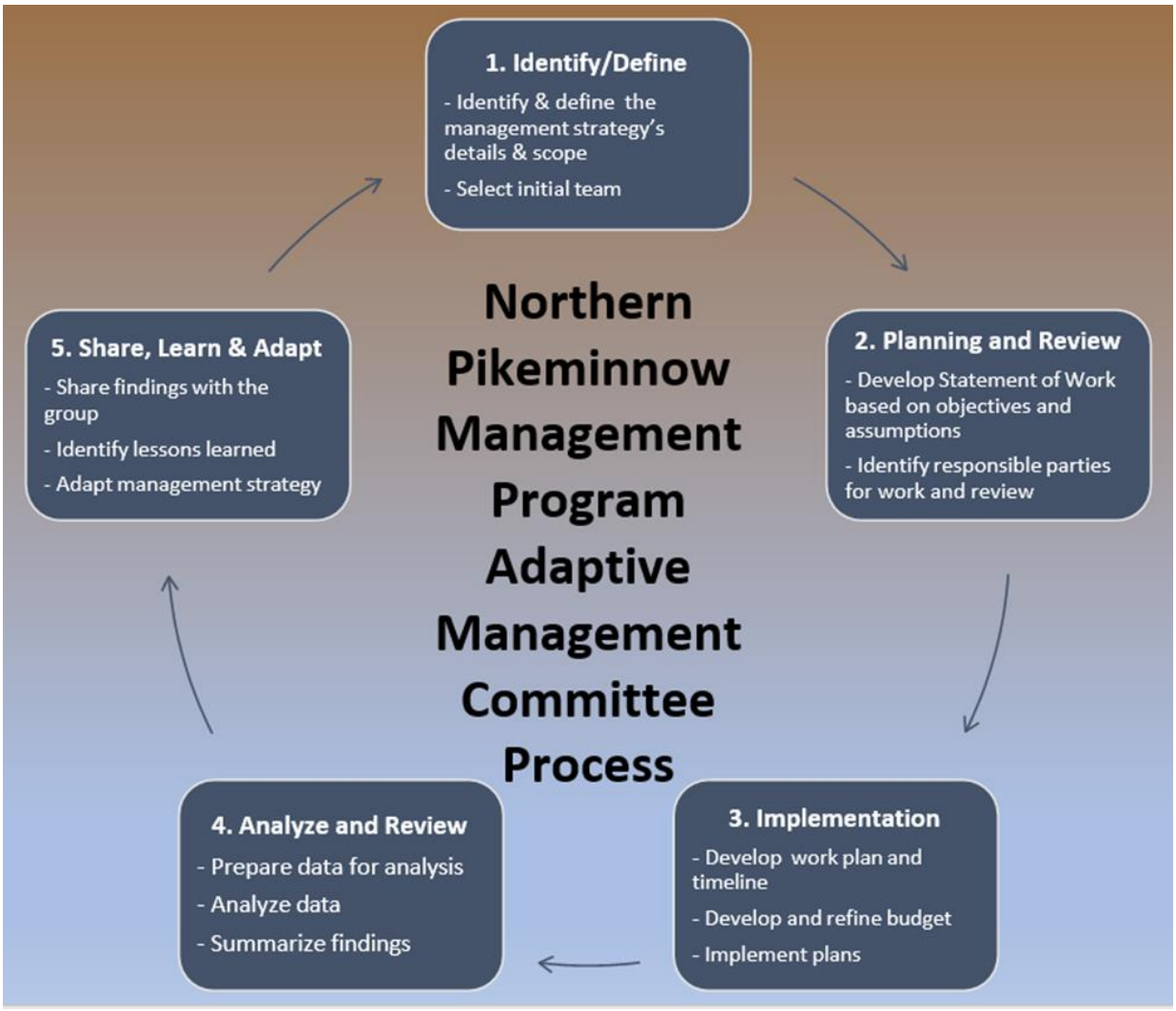
The group evaluates the future direction of the program each year. Management options and alternatives are also reviewed annually, and the group will continue to meet until consensus is reached on any changes. This more formal approach to adaptive management serves as a periodic review of the program on an annual basis. Our adaptive management process is detailed within Figure 1. Council staff's input during the development of the formalized adaptive management process was valuable, and the program proponents extend an open invitation to attend future meetings. Our fourth annual meeting of this group was on June 14, 2023. We intend to continue to identify key questions, design actions, and allocate funds and staff resources annually with this group. Examples of Adaptive Management activities to date include:

- Addressing NOAA fisheries concerns on the level of electrofishing conducted for

this program. The group was tasked with developing a plan in 2022 for addressing the BiOp concerns, as described by NOAA at two AMC meetings.

- Finalized the decision and implementation of "pit tag only" NPM tagging for ODFW M&E in 2022.
- Increased tier rewards for the 2022 season (after evaluation in 2021) to address declining participation.
- Developed an on-line registration APP for anglers that went online in 2023.
- Agreed upon tasks to be funded with potential program savings and consensus on prioritization in 2023.
- Developed a timeline and identified potential funding paths for maintaining and replacing aging infrastructure in 2023.

Figure 1. Steps of the adaptive management process.



ISRP 2023 Comments:

The ISRP is pleased that the NPMP partners have taken steps to begin the process of formal coordination among agencies and projects and developed a formal adaptive management process. This should lead to better planning, data, and analysis, which should lead to better decisions to improve the effectiveness of the project and the status of salmon and steelhead. This process will be critical for decisions about adopting new methods for population estimation and measures of consumption, capture alternatives, program actions and design, and budget reallocation. NPMP partners should develop timelines for implementing the formal adaptive management process and for important decisions regarding current high priority uncertainties. The ISRP encourages the proponents to continue to reallocate funds to support the new assessments and analyses described in this response. Documentation of meeting proposals, decisions, and outcomes is an essential part of accountability and will strengthen future proposals and reports, along with shaping the program to deal with rapidly changing conditions. This documentation should be included in annual reports, and the process for documenting and archiving meeting agendas, reports, decisions, and outcomes should be described in future documents.

A high priority need of the adaptive management process for the project could be to establish "stopping rules" based on established thresholds of pikeminnow abundance and consumption of juvenile salmon and steelhead. Such rules would ensure that 1) the pikeminnow suppression only occurs when the best available science indicates that returns of adult salmonids ultimately are negatively affected by the pikeminnow predation of juvenile salmonids monitored by the program and 2) populations of pikeminnow are not reduced to a point that their viability and benefits in the food web (including competition with non-native predators) are reduced to unacceptable levels. Continued suppression of northern pikeminnow, if not warranted, could negatively affect this species in the Columbia River Basin and inadvertently benefit non-native predators.

The ISRP is encouraged by the NPMP's new assessments and analyses described in this response, which should inform the adaptive management process. This monitoring, evaluation, and the adaptive management framework are critical to the program's ecological justification and success, given that the primary action of the program is a bounty system for northern pikeminnow, a fish species native to the Columbia River Basin.