

Response to Funding Recommendation 200723600

4 October 2006

Mark Walker
Director of Public Affairs
Northwest Power & Conservation Council
851 SW 6th Avenue, Suite 1100
Portland, Oregon 97204-1348

Dear Mr. Walker:

Please find enclosed my response to reviews of proposal 200723600 and to the draft funding decision by Council. Our proposal received glowing reviews from the Independent Scientific Review Panel (ISRP), being rated as “fundable”. While many projects received that rating, few received as strong an endorsement as 200723600. This review was followed by an unfavorable review by the Mainstem Review Team (MSRT). It is fair to describe review as incomplete, factually inaccurate, and not in compliance with the the instructions given to the MSRT. As far as we have been able to determine, participants in the MSRT review who had conflicts of interest (in the sense of being associated, directly or indirectly, with competing proposals) did NOT recuse themselves when our proposal was considered. I stress the inappropriateness of the MSRT review, because it appears to be the primary basis for denial of funding. I have attached a more detailed response to the MSRT review and a response to the ISRP as well. The latter clarifies a few minor points that raised question for the ISRP.

We respectfully request that the Council re-consider their decision not to fund 200723600.

Very truly yours,

David Jay
Associate Professor

Response to MSRT Review Comments
Columbia River Fish and Wildlife Program Proposal 200723600
Project Title: Strategic Adaptation of the Federal Columbia River Power System to Climate Variability and Change

Project Abstract:

This project brings together a group of leading coastal, hydrologic and climate scientists to tackle an urgent problem – strategic adaptation of the Federal Columbia River Power System (FCRPS) to increase survival of endangered juvenile salmonids during their seaward migration, in the face of competing demands for water, flow variability, and adverse climate change. Management of the FCRPS to simultaneously improve juvenile salmonid survival, maintain power production, and provide summer water supply requires advances on several fronts. We seek to improve both the strategic (annual) and tactical (seasonal) responses of the FCRPS through the following innovations:

1. *Conduct hydrologic modeling to identify management strategies that support increased survival of juvenile salmonids: Produce flow and water temperature data/models for the Columbia basin above Bonneville Dam and a flow model for the Willamette River. Construct systems operations models of the entire reservoir system to identify strategies that optimize water delivery to meet multiple demands and in response to changing flows associated with both climate variability and change.*
2. *Define remote-sensing based habitat metrics and stock specific survival: Define the river-estuary and plume response to climate and coastal forcing in terms of juvenile salmonid habitat metrics and stock-specific survival, through use of remote sensing, data-driven models, and climate analyses.*
3. *Assess economic consequences of climate-related changes in hydropower system operation: Define the economic costs and benefits associated with future management scenarios, including changes in power pricing, effects of changing salmon abundance, and altered flood risk.*
4. *Define and evaluate future management scenarios: Define management scenarios that: a) are based on integrated water-resources/economic modeling and climate analyses, b) can be evaluated in terms of remotely sensed habitat metrics, stock-specific survival and economic costs/benefits, and c) can lead to improved survival of juvenile salmonids in likely current and future climate scenarios.*

These innovative tools will deliver functional management strategies over the next three to eight years. A Project Advisory Board (PAB) that includes Action Agency, tribal government and FCRPS staff, and external scientists will be formed to help ensure productive application of our results. The proposed work will be tightly coordinated with and contribute to ongoing projects carried out by NOAA-Fisheries and other groups, but it is the only project that develops the hydrologic models and remote sensing tools to deal with climate fluctuations and future climate. It is arguably also the only project that brings together investigators familiar with the entire system, from its upper reaches to the continental shelf, to devise strategies for its future hydrosystem management. Finally, we believe that the combination of remote sensing and hydrologic/economic modeling developed here is the most cost-effective way to develop management options in response to climate fluctuations and climate change, and to forecast and then observe the consequences (economic and for juvenile salmonid survival) of the decisions implemented.

Reviews:

The ISRP Review

A highly favorable review was received from the Independent Scientific Review Panel (ISRP), along with their highest overall rating (fundable); see Attachment 1 for the full text of the ISRP review and Attachment 2 for a technical response to both the ISRP and MSRT reviews. The first paragraph of the ISRP review states:

The region must begin to face the certainty of climate change and its effects on regional economies and salmonid recovery. This project addresses the critical need of adaptively managing the hydropower system to meet the demands of salmon survival and power production under conditions imposed by climate variability and long-term climate change. A stellar group of scientists, experienced with research in the Columbia Basin, have joined together to undertake the project. Importantly, they are planning to form an advisory group of river managers to help guide the work. This will increase the chances that the work will be relevant to hydrosystem operations and that it will be used to inform management decisions.

This ISRP review is the clearest indication available within the project evaluation system of the relevance, urgency, and high technical merit of the proposal.

The MSRT Review

The proposal was dismissed with a superficial review and a “do not fund” rating by the Mainstem Review Team (MSRT). The entire text of the MSRT review is:

“There is an economic analyses contained in this proposal that would be suited for an IEAB review. The hydrologic model appears to be a reinvention of the wheel. The aspect of looking at climate change is on the mark and is included in the Council's work plan to include in power planning in the near future. The proposal will rely on a one dimensional temperature model and a new reservoir operations model that are not consistent with what the regional managers have agreed with.”

This review has a number of major shortcomings:

- 1) It fails to recognize the scope and importance of the project: The MSRT completely review fails to recognize the scope, importance and innovative nature of the project and its contribution to addressing “Focal Themes” identified in the February 2006 Northwest Power and Conservation Council (NPCC) *Research Plan*. By providing climate analyses, economic, hydrologic and water resources models, remote sensing habitat metrics of the coastal ocean, stock-specific survival estimates, and future management scenarios, the project would provide an integrated means to develop strategies for and assess consequences of future hydropower operations, addressing trade-offs throughout the entire system from the headwaters to the ocean. For the first time, it will provide hydrologic and water resources models that integrate into one integral model modules for the Upper Columbia, Snake and Willamette River Basins. The proposed combination of water resources and economic modeling, climate

analyses and habitat metrics (the latter largely based on remote sensing and climate indices) are arguably the only possible means to both develop hydropower operation strategies and measure outcomes with respect to juvenile salmon habitat and economic consequences.

The experience, qualifications and publishing records of the principal investigators were not mentioned by the MSRT, despite the fact that this was a major plus for the project in the ISRP review.

Major components of the program are not even mentioned by the MSRT review, specifically: a) the remote sensing analysis of habitat metrics, b) the climate analyses and stock-specific survival metrics, c) the development of future management scenarios, d) the water resources modeling, and e) the Project Advisory Board (PAB) that will help insure the relevance of the tools and scientific understanding developed by the project.

Pages 14 and 15 of the proposal text summarize the relationship of the proposed work to the NOAA FCRPS *Biological Opinion* and connections to existing and proposed projects. This discussion will not be repeated here. However, unless the MSRT specifically refutes these relationships, then it is not procedurally correct (as discussed below) to give the project the “Do not fund” rating it received.

The February 2006 Northwest Power and Conservation Council (NPCC) *Research Plan* was not available at the time our proposal was written. Nonetheless, our project addresses a number of questions, themes and uncertainties discussed in the report. “Focal Themes and Critical Uncertainties” from the *Research Plan* are summarized in Appendix 2b of the MSRT May 5, 2006 *Draft Report*. The proposal addresses the following “Focal Research Themes” as listed in Appendix 2b:

- Hydrosystem (parts 1 and 5): The proposal includes development of habitat metrics that measure impacts of FCRPS operations, and models mainstem water temperature down to Bonneville Dam.
- Tributary and mainstem habitat (part 3): The proposal will both develop estuary habitat metrics (our definition of “estuary” includes the freshwater tidal regime mentioned here) and predict outcomes of possible future management scenarios.
- The estuary: The proposal includes development of estuarine habitat metrics that will measure impacts of FCRPS management on estuarine habitat, and includes these impacts in its optimization analyses.
- The ocean (parts 1 to 3): The stock-specific survival estimates, climate analyses and remote sensing habitat metrics to be developed address important aspects of management of the FCRPS with respect to coastal and ocean impacts.
- Population structure and density (parts 1 and 4): Coastal and estuarine habitats are strongly affected by hydropower operation. Thus, to the extent that population structure and density are affected by coastal and estuarine habitats, this project is needed to examine historic changes, test scenarios and measure outcomes.
- Effects of climate change on fish and wildlife (all three parts): The MSRT review acknowledges that the proposed climate analyses are “on the mark” without acknowl-

edging that we are, therefore, addressing a focal research theme. Had the MSRT acknowledged this, then a “Do not fund” rating would not have been a possible outcome.

- Monitoring and evaluation: (part 3). Analyses of historical changes from remote sensing data and climate indices are part of the proposal.

As discussed in the next paragraphs, the fact that the proposal addresses these issues should have prevented it from receiving a “Do not fund” rating.

2) There are serious procedural flaws in the MSRT review: there are at least three major flaws in the MSRT review procedure as applied to the proposal:

- Failure to follow established procedures: The review produced by the MSRT does not meet the standards stated in Appendices 3 and 4 of the *Draft Review*. Specifically, a “Do not fund” rating is defined as follows in Appendix 4:

*“Do not fund - These projects are either technically inadequate or do not address a need within an appropriate guidance document. * These projects may be inappropriate for BPA funding.”*

[The footnote defines guidance documents, including the NOAA *FCRPS Biological Opinion* and the February 2006 Northwest Power and Conservation Council (NPCC) *Research Plan*.]

The ISRP review has emphasized the technical merit of proposal, the MSRT review does not meaningfully address technical merit, and (as discussed above) the project directly addresses needs defined within guidance documents such as the NOAA *FCRPS Biological Opinion* and the NPCC *Research Plan*. Moreover, the ISRP has explicitly stated that the project meets immediate and critical needs: *“The sponsors address the critical problem of strategically managing the hydropower system to enhance salmon survival under conditions of climate change. This problem is undoubtedly one the region will have to deal with now and in the future. There is, thus, an immediate need to develop scientifically valid ways to address the problem.”* Since the proposal does not meet either of the criteria for a “Do not fund” rating, it cannot, within the rules under which the MSRT is operating, receive such a rating. Given the high technical merit of the proposal (described in the ISRP review), its relevance, and the definition of the “High priority” category (*“The project addresses a specific need within an appropriate guidance document.”*), the project should be given at least a “High priority” rating in the MSRT review. The proposal may also meet the requirements for a “Core Program” rating.

- Technical expertise: Since major program elements are not even mentioned in the review, it is not evident that the MSRT review team has the technical expertise to judge an interdisciplinary research proposal involving remote sensing, hydrologic/water resources modeling, climate analyses and economic analyses. Yet this judgment of technical merit is part of the analysis required by Appendices 3 and 4 of the MSRT *Draft Review*.

- Conflict of interest: the MSRT Review process has at least the appearance of conflict of interest embedded in it. State and federal agencies are, in many cases, judging their own proposals, and there is no stated process by which individual agency members are excluded from deliberations on their own and closely competing proposals. On this basis also, it seems more appropriate that the merit of this project be judged from ISRP review, which is free from potential and actual conflicts of interest.

3) The MSRT review of technical aspects of the proposal is inaccurate and incomplete:

- Alleged redundancy: The review alleges that the hydrologic modeling outlined in the proposal is a “reinvention of the wheel”. This is simply incorrect. PI Lettenmaier, in addition to having served on the ISRP, has been an active and central participant in the most recent NWPCC climate change study (included as an appendix M to the 5th *Power Plan*¹) and is involved in proposed future work with the NPCC in collaboration with the Climate Impacts Group at the University of Washington. There are key differences between these approaches and those outlined in the proposal. The current modeling approach in the NWPCC is based on the GENESYS simulation model. Unlike the hydrologic models outlined in our proposal, this tool does not currently include a water resources optimization component and does not include an integrated model of the entire Columbia River basin water resources system, including detailed treatments of the Willamette and Snake river basins as components of the system. It also lacks connections between conditions in the coastal ocean and reservoir operations, which is a central component of the modeling framework we propose. Simulation models like GENESYS (and other current operational models), are generally inadequate for the purpose of identifying specific changes in the Columbia’s management policies that would respond effectively to hydrologic changes associated with climate change. The rebalancing of flood control and reservoir refill on a system wide basis is one area of proposed work that cannot be addressed with existing models.
- Adequacy of existing models: An assumption implied by the review is that, if the proposed models are different from what some unidentified managers have agreed to use for other purposes, then they are not appropriate to the task at hand. It seems more appropriate to turn this argument around and ask whether the current models are adequate to identify appropriate management responses to hydrologic and oceanographic changes affecting the basin. We have argued that currently available approaches are not adequate for future management, an argument that is corroborated by the ISRP review. Rather than “reinventing the wheel” as the review suggests, the approach outlined in our proposal would effectively support and extend existing efforts within the NPCC by providing access to new and more effective planning and analysis tools.
- Role of economic models: Even the MSRT review acknowledges that the economic modeling would be a valuable contribution. The MSRT review neglects, however, the point that this economic modeling cannot take place in isolation. It needs to be com-

¹ <http://www.nwcouncil.org/energy/powerplan/plan/Default.htm>

bined with water resources optimization models, climate analyses, and analyses of the coastal ocean via remote sensing, as we have proposed. Without these other analyses (which are unique to the proposal and do not duplicate any other efforts) to generate scenarios, the economic modeling would be largely sterile.

- Neglect of large parts of the proposal: Proposed work related to climate-based stock-specific survival estimates, development of remote-sensing based habitat metrics for the estuary and coastal ocean, formation of the Project Advisory Board, and the unprecedented integral analysis of the entire system from the headwaters to the coastal ocean are not even acknowledged by the review.

In summary, the proposal appears to have been judged in a cursory and inaccurate manner based on a few of its components. The resulting, off-hand comments do not constitute an accurate, complete or competent review of the proposal.

Attachment 1: Project Review by Independent Scientific Review Panel (ISRP)

From: www.nwcouncil.org/library/isrp/isrp2006-4.htm

200723600 - Strategic Adaptation of the Federal Columbia River Power System to Climate Variability and Change

Sponsor: Portland State University

Province: Mainstem/Systemwide **Subbasin:** Systemwide

Budgets: FY07: \$490,430 FY08: \$491,812 FY09: \$477,808

Short description: The FCRPS must respond to climate variations and change. The project sponsors will develop much-needed hydrologic and economic models, remotely-sensed habitat metrics, and scientific understanding of FCRPS impacts on juvenile salmonids in the river, estuary and plume.

Recommendation: Fundable

The region must begin to face the certainty of climate change and its effects on regional economies and salmonid recovery. This project addresses the critical need of adaptively managing the hydropower system to meet the demands of salmon survival and power production under conditions imposed by climate variability and long-term climate change. A stellar group of scientists, experienced with research in the Columbia Basin, have joined together to undertake the project. Importantly, they are planning to form an advisory group of river managers to help guide the work. This will increase the chances that the work will be relevant to hydrosystem operations and that it will be used to inform management decisions.

Technical and scientific background: The sponsors address the critical problem of strategically managing the hydropower system to enhance salmon survival under conditions of climate change. This problem is undoubtedly one the region will have to deal with now and in the future. There is, thus, an immediate need to develop scientifically valid ways to address the problem. The overall objective of building models that allow for predictions of the effects of different hydrosystem operation scenarios on early ocean survival of anadromous salmonids is admirable. The very large scale of this integrated effort is probably unique. The decision support tools that are the ultimate goal of the project will assist in developing annual hydrosystem strategies as well as in-season adjustments in operations to improve early ocean survival. The payoff for this proposal could be quite significant.

Rationale and significance to subbasin plans and regional programs: The proposed work is broadly consistent with the FCRPS Biological Opinion, the 4 H's report, and to specific recommendations in the ISRP's Retrospective Report. The sponsors did not point out relationships to the subbasin plans, specially the estuary plan.

Relationships to other projects: The project is related to two ongoing NOAA-Fisheries estuary and plume projects, an National Science Foundation project, a US Army Corp of Engineers estuarine project, and a University of Washington climate impacts project. The sponsors propose to use information obtained by these projects for their work. Collaboration will be facilitated because a number of the sponsors are also investigators on these other projects.

Objectives: The proposal contains very ambitious, but potentially valuable, objectives. The combination of efforts to model both the physical, biological, and economic aspects of climate changes on hydrosystem operations in an integrated fashion is an excellent idea. Few other projects have ever adopted such a big picture approach. The objectives are clearly defined and explicitly identify the steps and tasks needed to develop this complex model.

Tasks (work elements) and methods: Methods for modeling the flow, plume characteristics, temperature, and nutrients/productivity are described in detail. The investigators have extensive experience conducting the kind of research outlined in this proposal and have published their work in respected peer-reviewed journals. That the "plume habitat metrics" for smolts have not yet been determined (p. 18) could be a problem if satisfactory measures of plume characteristics that can be clearly related to salmon performance are not found. The elements of Objective 3 - economic analyses - describe mostly what will be done, but not how they will be done (contrast this with the description of the physical modeling tasks).

Monitoring and evaluation: The proposal identifies an innovative means of monitoring and evaluating progress - the formation of a Project Advisory Board composed of managers and scientists. If it works, this could be an effective way of monitoring progress on large scale, multi-species projects such as this one. The proposal ties with other projects with more explicit monitoring objectives such as NOAA-Fisheries estuary project.

Facilities, equipment, and personnel: The investigators are highly competent, have received funding for and conducted extensive research on the Columbia River estuary and ocean, and have stellar records of publication. The facilities are adequate to conduct this work.

Information transfer: The proposal does not go into much detail with regard to information transfer. In part 1, Section 1 there is a mention of web postings of models, images, and habitat metrics. The Project Advisory Board will apparently be a means of transferring information to FCRPS managers. The investigators all have long publication track records, so there will surely be peer-reviewed papers.

Benefits to focal and non-focal species: This project could have very large benefits for focal species if tools to assist hydrosystem operators to optimize reservoir releases for fish survival and economic considerations are developed. The ability of the models to forecast decadal climate and ocean condition changes make the benefits of this project long-term. There is little discussion of the effects of the reservoir optimization scenarios on non-focal species (e.g., shad and other introduced game fishes). The proposal seems to be oriented toward spring migrants which raises the question of how hydropower system changes favoring spring outmigrants will influence other species, both resident (e.g., white sturgeon), migrant (e.g., fall chinook), and other native species.

Attachment 2: Technical Response to ISRP and MSRT Review Comments Proposal 200723600

Prepared by Alan Hamlet, Dennis Lettenmaier and David A. Jay

7/14/06

Introduction

The separate reviews of our proposal from the ISRP (which gave the proposal the highest rating) and MSRT (which recommended that the project not be funded) are strikingly at odds with each other and might present to a neutral observer a confusing picture of the proposal and its research objectives. In fact, the MSRT review did not conform to professional standards for a peer review of this kind, or to the standards set for MSRT reviews (see main text). Despite the disparity between the quality and scope of the two reviews, we have attempted to respond in detail to the comments we have received, and to address the issues raised in each of the reviews. Our hope is that a more balanced view of the proposal will result.

Response to the MSRT Review

We believe the MSRT review of our proposal to be inadequate and to not corresponding to acceptable professional standards. The entirety of the text provided as review comments is:

“There is an economic analyses contained in this proposal that would be suited for an IEAB review. The hydrologic model appears to be a reinvention of the wheel. The aspect of looking at climate change is on the mark and is included in the Council's work plan to include in power planning in the near future. The proposal will rely on a one dimensional temperature model and a new reservoir operations model that are not consistent with what the regional managers have agreed with.”

We were greatly dismayed by the review's cursory format, its extremely limited scope and specificity, its speculative nature, and its factually inaccurate underlying assumptions. A highly subjective, three sentence dismissal of a proposal of this nature, addressing only a few aspects of the proposed study in the most cursory manner, does not correspond with minimal professional standards and raises many concerns with regard to validity of the review. That said the review raises a number of issues that are central the proposal's rationale and objectives which we believe are factually inaccurate and/or misleading and should not be allowed to stand unchallenged.

In particular, the review makes the blanket statement that the hydrologic modeling outlined in the proposal is a “reinvention of the wheel”, and implies that the proposed research is redundant with existing work in progress to address climate change within the Northwest Power and Conservation Council (NWPCC). Neither is an accurate portrayal. Dr. Lettenmaier and his staff (including Alan Hamlet) have been active and central participants in the most recent NWPCC climate change study (included as an appendix M to the 5th Power Plan ²) and proposed future work with the PNPCC in collaboration with the Climate Impacts Group at the University of Washington. We can speak with some authority on the strengths and limitations of the current modeling approaches available within the NWPCC, and the key differences between these approaches and those outlined in the proposal. The current modeling approach in the NWPCC is based on the

² <http://www.nwcouncil.org/energy/powerplan/plan/Default.htm>

GENESYS simulation model. Unlike the hydrologic models outlined in our proposal, this tool does not currently include an optimization component and is not integrated with the reservoir operations in the Snake basin. It also lacks any direct connections between conditions in the coastal ocean and reservoir operations, which is a central component of the modeling framework we propose. As we discuss in the proposal, simulation models like GENESYS (or other simulation models used operationally in the basin), while potentially useful for identifying areas of concern associated with climate change in the context of current management practices, are generally inadequate for the purpose of identifying specific changes in the Columbia's management policies that would respond effectively to hydrologic changes associated with climate change. The rebalancing of flood control and reservoir refill on a system wide basis is one aspect of this problem discussed in the proposal that presents formidable systems engineering problems that cannot be solved effectively using simulation approaches.

A crucial assumption underlying the statements made in the review is that if the proposed models are inconsistent with what some managers (who are not identified) have agreed upon for other purposes, then they are not appropriate to the task at hand. It seems more appropriate to turn this argument around and ask whether the models that are currently used for other purposes are adequate to identify appropriate management responses to hydrologic and oceanographic changes affecting the basin. We have argued in the proposal that currently available approaches are not adequate for this purpose, an argument that is corroborated by the ISRP review.

We conclude that the planning tools that are currently available to the NWPCC staff (which we acknowledge are currently being used to good effect to understand the key issues in the basin associated with warming) are not a replacement for the tools outlined in the proposal, and neither are the proposed methods a "reinvention of the wheel". Rather we have proposed the construction of new tools that we believe are essential to the process of moving "beyond the damage report" and towards an effective and well-conceived adaptive response to regional warming and uncertain oceanographic changes affecting the Columbia basin. Rather than reinventing the wheel as the review suggests, the approach outlined in our proposal would effectively support and extend existing efforts within the NWPCC by providing access to new and more effective planning tools.

Response to the ISRP Review

As noted in the introduction, the ISRP review is generally supportive of the research objectives and approach outlined in the proposal, giving the highest available rating of "fundable". Several important issues are raised in the discussion, however, to which we would like to respond and provide additional clarification.

"Information transfer: The proposal does not go into much detail with regard to information transfer. In part 1, Section 1 there is a mention of web postings of models, images, and habitat metrics. The Project Advisory Board will apparently be a means of transferring information to FCRPS managers."

As the reviewer notes, we did not provide a great deal of information about information transfer in the proposal (partly because of constraints on length). The proposal refers to availability of the models on line, and as the reviewer notes, the approaches would be described in detail in journal

articles or reports. As with all federally funded research, public access to tools and data would occur as needed. We also had in mind that other groups (e.g. the NWPCC) would have access to the models after a certain level of development had been achieved during the project, and would eventually begin to exercise (and presumably improve and adapt) them to better serve their own needs. The details regarding such a transfer would need to be decided at a later date, and (as the reviewer suggests) this would be one component of the ongoing interaction between the research team and the Project Advisory Board. It is our intention to use this interaction to ensure that the tools and approaches developed remain consistent with the guidance provided by the Project Advisory Board throughout the life of the project.

“Benefits to focal and non-focal species: This project could have very large benefits for focal species if tools to assist hydrosystem operators to optimize reservoir releases for fish survival and economic considerations are developed. The ability of the models to forecast decadal climate and ocean condition changes make the benefits of this project long-term. There is little discussion of the effects of the reservoir optimization scenarios on non-focal species (e.g., shad and other introduced game fishes). The proposal seems to be oriented toward spring migrants which raises the question of how hydropower system changes favoring spring outmigrants will influence other species, both resident (e.g., white sturgeon), migrant (e.g., fall chinook), and other native species.”

This is an important point, and one that we broadly allude to at one point in the proposal, but do not address in great detail. We have argued that warming is likely to disrupt the balance between traditional water management objectives (e.g. flood control, hydropower production, irrigation) and management objectives to protect and enhance juvenile and adult salmon survival in the basin (particularly instream flow and water temperature). The reviewer correctly notes, however, that the climate disruption has the potential to extend to management conflicts associated with operations intended to preserve and enhance different species as well, and that important trade-offs between focal and non-focal fisheries may also emerge as unintended outcomes of system optimization. Although we do not discuss this in the proposal in great detail, the issues associated with Canada’s protection of resident fisheries in man-made lakes has already been identified as a potential conflict with instream flow augmentation in the lower basin that would be exacerbated by warming and associated streamflow timing shifts. Although the proposal stresses the optimization of reservoir operations to benefit salmon, the overall approach is quite flexible and permits the inclusion of other objectives (such as those associated with non-focal species) as an extension of the optimization methods developed. Using these approaches, an objective and well-defined balance between management actions designed to benefit different fish species can potentially be developed to guide reservoir operations. One benefit of the methods proposed is that including additional objectives in the optimization model is relatively easy, and does not require historic management experience to identify effective approaches, provided appropriate impact metrics can be