FINAL

SUMMARY REPORT

Peer Review of the Science Informing the Upper San Joaquin River Basin Storage Investigation

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December 4, 2015

Prepared for:

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Reclamation Order No. R15PB00396
Amec Foster Wheeler Project No. 32106C014

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Executive Summary

The Upper San Joaquin River Basin Storage Investigation (Investigation or USJRBSI) is a feasibility study by the Bureau of Reclamation (Reclamation or USBR), in cooperation with the California Department of Water Resources (DWR). The purpose of the Investigation is to determine the type and extent of federal interest in a potential project to expand water storage capacity in the Upper San Joaquin River watershed to: (1) improve water supply reliability and flexibility of the water management system for agricultural, municipal, industrial, and environmental uses; and (2) enhance water temperature and flow conditions in the San Joaquin River downstream from the Friant Dam for salmon and other native fish. The Final Feasibility Report presents the results of planning, engineering, environmental, social, economic, and financial studies of potential benefits and effects of alternative plans, and is a companion document to the Final Environmental Impact Statements (EIS), published under separate cover.

A peer review of the use of this modeling to estimate benefits to fish habitat, which was completed as part of feasibility study, was required. The purpose of this review is to provide a formal, independent, external scientific peer review of whether the conclusions and results based on the EDT model presented in the Feasibility Report and EIS are appropriate and whether the model is appropriate for this use. Four peer reviewers with experience with fish habitat, river planning, and river and fish habitat modeling were selected.

While offering many caveats on the use of models in general and EDT specifically, reviewers generally agreed that the application of EDT to evaluate relative differences in fish performance in the San Joaquin River resulting from habitat changes was appropriate. However, each reviewer qualified their conclusions with a number of observations and suggestions. All reviewers wanted to see more detailed assumptions and additional documentation of model inputs and assumptions. Three of the four reviewers emphasized that EDT was best used for relative comparisons of potential fish performance between scenarios rather than absolute comparison of fish abundance. Each reviewer identified one or more specific items that would benefit from additional clarification or explanation. While all reviewers felt there were limitations associated with the EDT results and that evaluating its use was hampered by lack of detail about assumptions and inputs, there was general agreement that the analysis was an appropriate use of the EDT model.

1.0 Background

The Upper San Joaquin River Basin Storage Investigation (Investigation or USJRBSI) is a feasibility study by the Bureau of Reclamation (Reclamation or USBR), in cooperation with the California Department of Water Resources (DWR). The purpose of the Investigation is to determine the type and extent of federal interest in a potential project to expand water storage capacity in the Upper San Joaquin River watershed to: (1) improve water supply reliability and flexibility of the water management system for agricultural, municipal, industrial, and environmental uses; and (2) enhance water temperature and flow conditions in the San Joaquin River downstream from the Friant Dam for salmon and other native fish. The Final Feasibility Report presents the results of planning, engineering, environmental, social, economic, and financial studies of potential benefits and effects of alternative plans, and is a companion document to the Final Environmental Impact Statements (EIS), published under separate cover. Both the Feasibility Report and the Final EIS have been provided.

The Investigation is one of five surface water storage studies recommended in the CALFED Bay-Delta Program (CALFED) Programmatic Environmental Impact Statement/Report (PEIS/R) Record of Decision (ROD) of August 2000. Progress and results of the Investigation have been documented in a series of interim reports, culminating in this Final Feasibility Report and accompanying Final EIS. Preliminary studies in support of the CALFED PEIS/R considered more than 50 surface water storage locations throughout California and recommended more detailed study of the five locations identified in the CALFED Programmatic ROD. The Final EIS, accompanying the Final Feasibility Report, tiers to the CALFED PEIS/R.

In particular, Reclamation is performing the Investigation to determine if there is a federal interest in pursuing construction of a Dam upstream of the current Friant Dam on the San Joaquin River. A parallel yet separate process, the San Joaquin River Restoration Program (SJRRP), is focused on restoring a naturally reproducing population of spring run Chinook salmon to the San Joaquin River. The SJRRP has applied a number of tools to analyze various options for improving habitat to facilitate reintroduction of salmon, including the Ecosystem Diagnosis and Treatment (EDT) tool. EDT has been used in the SJRRP to compare the alternative restoration and management options in terms of potential spring-run Chinook performance. EDT was chosen for the SJRRP after a review of salmonid habitat models and because of its history of useful application to similar programs in the Pacific Northwest (SJRRP 2008). Because of its ongoing application to the SJRRP, the inclusion of the SJRRP in the No Action Alternative for the Investigation, and intent to quantify fish habitat enhancement beyond the No Action Alternative consistent with the primary planning objectives and purpose and need, the Investigation choose to use EDT to evaluate the effects of the Investigation alternatives on spring run Chinook salmon.

The application of EDT in the Investigation is documented in detail in the Modeling Appendix to the Final EIS, which has been provided. This material is the focus of the peer review, along with its use in the Feasibility Report and EIS. Additionally, during preparation of the Feasibility Study and EIS, Reclamation received comments from the public and other government agencies regarding the application of certain information to derive benefits associated with the Investigation. This agency and public feedback has been provided.

A peer review of the use of this modeling to estimate benefits to fish habitat, which was completed as part of the feasibility study, was required. The purpose of this review is to provide a formal, independent, external scientific peer review of whether the conclusions and results based on the EDT model presented in the Feasibility Report and EIS are appropriate and whether the model is appropriate for this use. Evaluation of the EDT model within the general context of habitat modeling is outside the scope of this review. This review is focused solely on the utilization of EDT in its application to quantify the benefits as proposed within the Investigation feasibility study and EIS.

2.0 Peer Reviewers

The peer reviewers reviewed the materials provided (see Appendix A for a list of materials provided). The selection of peer reviewers followed the guidance provided in the Office of Management and Budget's *Final Information Quality Bulletin on Peer Review* (OMB Bulletin; December 16, 2004) to ensure scientific integrity of the peer review. Appropriate expertise and an appropriate balance of that expertise was identified for this peer review panel during the process of identifying potential reviewers. Panelists with expertise in fish habitat modeling and river modeling were essential for this peer review. All peer reviewers were provided the language from the OMB Bulletin (2004) with regard to independence and conflicts of interest and any potential issues were identified and evaluated during the selection of the panelists, both with respect to both Reclamation and the report under peer review. To maintain the independence and objectivity of the peer review, a number was randomly assigned to each peer reviewer and all references in this report are to that number.

The four peer reviewers all have experience with fish habitat, river planning, river and fish habitat modeling, and with peer reviews of scientific publications. The reviewers are all independent of Reclamation and have no conflicts of interest. The resumes for the peer reviewers are presented in Appendix C and the reviewers consist of:

- Wesley Daniel, PhD from Michigan State University;
- James Gore, PhD from University of Tampa;
- Peter McHugh, PhD from Utah State University; and
- Joseph Wheaton, PhD from Utah State University.

3.0 Summary of Peer Reviewer Responses

The peer reviewers considered and responded to the Charge to the Reviewers, a total of two questions, with respect to the documents provided (see Appendix A). The following section provides brief synopses of their responses to each question, with their full responses provided in Appendix B. Comments received from Reclamation during review of the draft summary report and the individual memos are provided in Appendix D, along with a summary of any revisions made as a result of those comments.

Question 1

Is displaying results for the EDT model in terms of fish abundance to compare future population outcomes amongst alternatives a recognized suitable application of the EDT model?

- Reviewer 1: Yes, but with some caveats. These caveats pertain to (a) the delivery/presentation of abundance-based results; (b) the assumptions associated with abundance at equilibrium (*Neq)* as an output; and (c) a lack of detail about the *Neq* calculations.
    - (a) Because EDT is not a population simulation model, it is important that any display of abundance metrics be plainly labeled as being (*i*) a mathematical re-arrangement of *C* and *P* parameters, (*ii*) an equilibrium construct, and (*iii*) subject to particular assumptions to be meaningful (described further below).
    - (b) Computing *Neq* from EDT outputs necessitates that a number of assumptions are either explicitly or implicitly made, yet few of these are stated anywhere in the SJRRP/Investigation's EDT documentation.
    - (c) Although the conceptual basis of *Neq* is explained in the documents provided, there are aspects of its derivation/calculation that remain elusive.
- Reviewer 2: The EDT model results include the productivity, capacity and equilibrium abundance for the fall run Chinook salmon. The equilibrium abundance is steady-state abundance and capacity is a theoretical maximum abundance supported by suitable habitat. EDT has been described as a habitat model, and habitat models are not good at predicting absolute numbers like species abundance. EDT results should be displayed as a relative fish abundance.
- Reviewer 3: In my experience, attempting to predict fish abundance, based upon empirical data to calibrate a model of future abundance is fraught with many dangers. Most commonly, since not all environmental influences can be predicted by any model, it becomes difficult to place narrow error margins around existing data. A useful predictor of a population response is an habitat quality index in which the response is known within

acceptable limits and beyond which there is certainty of loss of quality habitat (as a surrogate of abundance and productivity) and resulting lost productivity, without placing a numerical value on that loss. That is, the “currency” for making the decision is not based upon fish productivity [although it is certainly used to calibrate the model], but instead upon a range of acceptable losses of habitat quality and quantity, below which “significant ecological harm” is likely to occur; the extent of that harm being immaterial to the decision.

- Reviewer 4: No, EDT is not an appropriate tool for forecasting population outcomes in absolute abundance estimates between alternatives. Tables 5-9, 5-10 and Figures 5-5 through 5-9 in the modelling appendix are a reasonable way to display and convey the EDT findings. However, in Figure 5-11 and Tables 5-11 through 5-14, absolute estimates are provided. This is of course what the model spits out and is a useful relative metric for inter-comparison between scenarios. However, I find it worrying that no +/- estimates are provided with each of these abundance calculations. I don’t have a problem with using EDT to explore potential impacts of different design scenarios. I do, however, worry that EDT (as with any model) is only capable of doing so much and way too much stock is put in this single model. Comparing a plurality of competing models and forecasts from fundamentally different perspectives is a safer way of tip-toeing into the dangerous business of forecasting population responses. The easiest way to explore the fundamental uncertainty is to not put all your eggs in one modelling basket and explore the outputs of a variety of different models formulated in different ways and see if they paint a convergent picture or divergent picture.

Question 2

Have the assumptions and uncertainties associated with utilizing a habitat model for the intended purpose been appropriately characterized?

- Reviewer 1: This question is difficult to answer, owing to the fact that many details (e.g., habitat inputs) of the San Joaquin River application of EDT are not documented and/or are inaccessible to reviewers. In sum, the level of uncertainty surrounding the Investigation’s use of EDT to guide the selection of action alternatives is unknown but arguably high. With respect to the assumptions portion of Question 2, my response is a mixed ‘yes and no’. Many assumptions associated with the specific application of EDT to the San Joaquin River have are plainly stated in the Modeling Appendix, while general assumptions are provided in published literature. Yet, there are a number of other assumptions that were made but were not stated, some of which are possibly quite influential in determining modelling results/interpretation; several examples are included in Appendix B. Similar to this EDT application’s treatment of assumptions, there were notable limitations to its consideration of input/output uncertainty. Arguably, these are limitations associated with the broader EDT framework and not its specific application to the SJRRP/Investigation context. EDT is a deterministic model and thus is not equipped to integrate uncertainty in model inputs (e.g., variability in measurements), assumptions (see above), and/or model structure (i.e., quantitative rules linking survival factor values to environmental conditions) into outputs.

- Reviewer 2: The Public Comments and Responses (Chapter 35) section did a good job clarifying some of the assumptions and uncertainties associated with EDT model, but the main text did not. There is a need for complete transparency in the EDT modeling process and recognition that there is a potentially false sense of precision. There is no attempt to show how well the model fits empirical data or use of performance measures. Several of the responses in Chapter 35 did not fully answer the questions raised. Additional clarification is needed in the text to fully support some of the statements.

- Reviewer 3: The assumptions of the model seem to be reasonable. I question the use of the prediction, based upon historical flows, to make management decisions.

- Reviewer 4: Generally, no. With regards to the 'assumptions…. been appropriately characterized' part of the question, I would say that the authors have done a good job of explaining the EDT model and transparently outlining the assumptions behind the model itself as well as the assumptions behind specific parametrizations to represent specific scenarios in individual simulations. It was hard to find some of these specifics in the EIS. With regards to the 'uncertainties associated with utilizing a habitat model' being appropriately characterized, I would say the authors made a reasonable attempt to characterize many of these and specifically to address concerns raised in previous reviews. However, they focus on a narrow class of parametric uncertainties and a limited sensitivity analysis and it does not adequately convey to the reader the actual uncertainty in the outputs. Finally, the 'intended purpose' part of the question is what is driving most of my 'no' response. The authors did a reasonable attempt at using a tool like EDT for the purpose of exploring part of the potential impacts of FSH-10 through FSH-17. My criticism is that too much stock is put in this one tool and there are other ways to explore those impacts and represent the uncertainty other than just relying on EDT.

Other Comments

- Reviewer 1: Upon examining the life stage-specific results in Tables 5-15 through 5-18 and in the appendix to the modeling appendix (i.e., 'EDT Productivity and Capacity Effects by Life Stage for Action Alternatives and Sensitivity Analyses'), I was struck by the fact that nearly all the benefits realized across the action alternatives occur for the spawning/egg-incubation stages primarily and that the costs/benefits for other life stages (especially parr and smolt) results are essentially nil. Given the shift in temperature during spawning/incubation (a 1-2 degree reduction) this seems implausible. In fact, given that mean temperatures (Figure 4-13, pages 4-56) range 2-3 degrees warmer and that peak spring flows are more muted (Figure 4-15, pages 4-58) during the spring outmigration for all action alternatives than the no action alternative, one might expect to see more of a capacity/ productivity response here (e.g., due to lower turbidity and increased metabolic demand/activity of non-native predators). A review of the stage-specific results illustrates that the model formulation places an overwhelming emphasis on the spawning/incubation stages and that parr/smolt stages are unresponsive to change. Although this may be intentional given an understanding of the biology of the San Joaquin River system, it seems inconsistent with assumptions about the freshwater biology of Chinook salmon elsewhere and the life history and limiting factor expectations for a San Joaquin River spring Chinook salmon population. Regardless, this observation underscores the need for Reclamation and/or EDT developers to more convincingly display that they fully understand model behavior/sensitivity.

- Reviewer 2: None.

- Reviewer 3: Ultimately, the simulation will rely upon historical flow records to predict the distribution and abundance of Chinook salmon. This may be appropriate to “test” the simulation; however, the appropriateness of the simulation going forward, considering potential changes as a result of climate change and impacts on flow records, may not make it an appropriate model without adjustments to the predictive protocols and some of the choices made within the simulation. However, the existence of discontinuous connections between high quality habitat patches must be taken into account as a “normal” condition and may yield predictions that label these as “infrequent events.” I suggest that the investigators consider an even lower flow situation that reflects this potential new flow scheme, as agricultural demands only increase if low flow / drought conditions continue or become the new “historical” condition. A large number of simulations predict dramatic reductions in flow and loss of freshwater fish species (up to 37% losses from the Sacramento River, in some scenarios) by 2070 if these climate-change induced changes in river flow patterns in the Sierra Nevada continue.

- Reviewer 4: While EDT is an interesting model for exploring various habitat restoration scenarios and has been used effectively in the Pacific Northwest in an exploratory manner to inform complex decisions about restoration and the management of anadromous salmonids, it is just one way to look at an extremely complicated problem. The remit for this review and the overall presentation of the EIS reads like a narrowly considered list of checkboxes considered in isolation of each other without any meaningful integration of the complicated interaction between all the many pieces being considered. Just as EDT itself attempts to simplify conceptually and quantitatively represent a multi-faceted process into a digestible output, I recognize that an EIS is a blunt tool for considering and forecasting the impacts a proposed action may have. EDT is more appropriate as a planning tool then the sole determinant of whether or not there will be impacts from a proposed project.

4.0 Conclusions and Recommendations

Reviewers generally agreed that the application of EDT was appropriate and valuable for evaluating relative differences in fish performance in the San Joaquin River resulting from habitat changes. Each reviewer, however, qualified that conclusion with a number of caveats, observations, and suggestions. All four reviewers wanted to see more detailed assumptions and additional documentation of model inputs and assumptions. Three of the four reviewers emphasized that EDT is only appropriately used for relative comparisons of potential fish performance between scenarios rather than absolute comparison of fish abundance. While all reviewers felt there were limitations associated with the EDT results and that evaluating its use was hampered by lack of detail about assumptions and inputs, there was general agreement that the analysis was an appropriate use of the EDT model.

Specific suggestions from reviewers include:

1. Confine results to the relative comparison of alternatives and avoid absolute comparisons of fish performance.
2. While some assumptions are explicitly stated, others are not and are relevant for interpreting results.
    a. *Neq* is only meaningful under equilibrium conditions.
    b. *Neq* as a performance metric assumes there will be no harvest impacts on the re-introduced spring run Chinook salmon. Provide more details about why harvest was not included in the analysis.
    c. Clarify mathematical details of final calculation of *Neq* to avoid misinterpretations.
    d. Clarify the use of survival factors.
    e. Explicitly state that no template condition was used, although this is common in other EDT analyses.
    f. Provide more details on the use of the Beverton-Holt production function
3. Include more information about model inputs (i.e., habitat, temperature, stream flow) and whether based on field data or expert opinion.
4. Expand model documentation to better address uncertainties in the model.
5. Include error bars to assist in correct interpretation of results.
6. Consider the implications of future flow conditions on project impacts including the impacts of climate change on San Joaquin flow.
7. Add results of any analyses (quantitative or qualitative) of the potential impacts of the project on other fish species besides the spring run Chinook salmon.
8. Overall results of the analysis could be strengthened by the use of other habitat or fish population models in addition to EDT.

APPENDIX A

Charge to the Reviewers and List of Documents Provided

Peer Review of the Science Informing the Upper San Joaquin River Basin Storage Investigation

U.S. Bureau of Reclamation

Charge to the Peer Reviewers
Of the Use of Fish Habitat Modeling in the Upper San Joaquin River Basin Storage Investigation

September 2015

Charge to Reviewers

The focus of the peer review is whether the conclusions and results based on the EDT model presented in the Feasibility Report and EIS are appropriate and whether the model is appropriate for this use.

A peer review of the use of this modeling to estimate benefits to fish habitat, which was completed as part of feasibility study, is required. Evaluation of the EDT model within the general context of habitat modeling is outside the scope of this review. This review is focused solely on the utilization of EDT in its application to quantify the benefits as proposed within the Investigation feasibility study and EIS. Peer reviewers are asked to provide responses to the two questions below regarding the fish habitat modeling.

Question 1: Is displaying results for the EDT model in terms of fish abundance to compare future population outcomes amongst alternatives a recognized suitable application of the EDT model?

Question 2: Have the assumptions and uncertainties associated with utilizing a habitat model for the intended purpose been appropriately characterized?

Charge to the Peer Reviewers
Of the Use of Fish Habitat Modeling in the Upper San Joaquin River Basin Storage Investigation
September 2015

Documents Provided

Public comments on EDT use in the Upper San Juan River Basin Storage Investigation Draft Environmental Impact Statement (Extracted from Chapter 35 of the Final EIS). 2015.

Reclamation. 2015a. Environmental Impact Statement: Modeling Appendix CalSim II Operations Attachment (Upper San Joaquin River Basin Storage Investigation) Regional Director's Final. US Department of Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

Reclamation. 2015b. Environmental Impact Statement: Modeling Appendix EDT Productivity and Capacity Effects by Life Stage for Action Alternatives and Sensitivity Analyses (Upper San Joaquin River Basin Storage Investigation) Regional Director's Final. US Department of Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

Reclamation. 2015c. Environmental Impact Statement: Modeling Appendix Modeling Results Supporting Chapter 5 – Fisheries and Aquatic Ecosystems Attachment (Upper San Joaquin River Basin Storage Investigation) Regional Director's Final. US Department of Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

Reclamation. 2015d. Environmental Impact Statement: Modeling Appendix (Upper San Joaquin River Basin Storage Investigation) Regional Director's Final. US Department of Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

Reclamation. 2015e. Environmental Impact Statement - Upper San Joaquin River Basin Storage Investigation - Regional Director's Final. US Department of Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

Reclamation. 2015f. Feasibility Report - Upper San Joaquin River Basin Storage Investigation - Regional Director's Final. US Department of Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

SJRRP. 2008. *Quantitative fisheries model selection recommendation process*. (Draft Technical Memorandum). Sacramento, CA: San Joaquin River Restoration Program.

Additional information is available at http://www.restoresjr.net/. Another EDT reference that may be useful (and is more recent than the other SJRRP EDT reports) is the March 2014 Technical Report: Analysis of Fish Benefits of Reach 2B Alternatives of the San Joaquin River (attached and available online at http://www.restoresjr.net/download/data-reporting/data-reporting2014/Final_Reach2B_EDT_201403_ADA.pdf).

APPENDIX B

Complete Individual Memoranda

Peer Review of the Science Informing the Upper San Joaquin River Basin Storage Investigation

U.S. Bureau of Reclamation

Individual Memorandum
Peer Review of the Use of Fish Habitat Modeling in the Upper San Joaquin River Basin Storage Investigation

Reviewer 1 – 23 October 2015

Choosing among alternatives with potentially varying levels of impact on aquatic biota is a central challenge to river management. This challenge is compounded by a diversity of species and life histories, many of which are uniquely adapted to specific hydrologic conditions. By synthesizing available information about fish populations, their environment (habitat), and fish–habitat relationships, the Ecosystem Diagnosis and Treatment (EDT) model boils this task down to a manageable problem, offering a means to pursue decision making in a technically rigorous manner. Accordingly, EDT has greatly assisted planners and restoration practitioners in the pursuit of salmonid habitat restoration throughout the Pacific Northwest. However, EDT's offer of tractability is gained by making modeling compromises (e.g., EDT is a wholly deterministic model) and assumptions (reviewed in Blair et al. 2009), some with unknown veracity, that can influence model results (e.g., Steel et al. 2009, McElhany et al. 2010). The use of EDT to guide the San Joaquin River Restoration Program (SJRRP), and more specifically the BOR's Storage Investigation, is not exempt from these realities. It is with this balanced perspective in mind that I approached my reviewing assignment. Thus, I acknowledge the merits of using EDT in the SJRRP/Investigation's decision-making context but also identify several issues that may bear upon the strength of inference that should be drawn from results relative to the Investigation.

1. Is displaying results for the EDT model in terms of fish abundance to compare future population outcomes amongst alternatives a recognized suitable application of the EDT model?

The answer to this question is a qualified 'Yes'. Based on my limited knowledge of specific EDT applications, the abundance at equilibrium (*Neq*) is a standard output produced by the model. See, for example, EDT applications in the Lower/Mid-Columbia (e.g., White Salmon River; Allen and Connolly 2005) and Upper Columbia (e.g., Okanogan; Colville Tribes 2013). Further, *Neq* is a population metric that flows naturally from the primary parameters computed during an EDT run, given the model's underlying population biology assumptions (i.e., that the salmon life cycle can be approximated by a series of stage-specific Beverton-Holt spawner-recruit functions); thus, *Neq* in concept is simply a mathematical transformation of productivity (*P*) and capacity (*C*) parameters (e.g., Hilborn and Walters 1992). For these reasons, displaying results in terms of *Neq* for the SJRRP/Investigation is consistent with established EDT precedent, EDT documentation (e.g., Blair et al. 2009), and the model's theoretical underpinnings.

The 'qualified' part of the affirmative response to this question relates to a few key issues pertaining to (a) the delivery/presentation of abundance-based results, (b) the assumptions associated with *Neq* as an output, and (c) a lack of detail about the 'guts' of *Neq* calculations. I elaborate on each of these points below:

(a) Because EDT is not a population simulation model, it is important that any display of abundance metrics be plainly labeled as being (*i*) a mathematical re-arrangement of *C* and *P* parameters, (*ii*) an equilibrium construct, and (*iii*) subject to particular assumptions to be meaningful (described further below). Doing so may help to minimize confusion among readers/reviewers, which comments on the draft EIS suggest was an issue in the past. Additionally, the Investigation's treatment of *Neq* results (and *C* and *P* for that matter) should focus strictly on relative differences across modelling scenarios (e.g., as in Figures 5-5 to 5-9 in BOR 2015a), given the range of data and assumption uncertainties required to generate *Neq* predictions; the Investigation's EDT analysts largely adhered to this suggestion, but there are still a few instances where 'abundance' was presented in terms of absolute fish (e.g., Figure 5-11 in BOR 2015a). Keeping differences in relative terms not only makes sense for an application attempting to select among alternatives, but also helps avoid the pitfalls of implying a greater degree of confidence in model outputs than is perhaps warranted (i.e., given the range of uncertainties reviewed under the Question 2 response, below).

(b) Computing *Neq* from EDT outputs necessitates that a number of assumptions are either explicitly or implicitly made, yet few of these are stated anywhere in the SJRRP/Investigation's EDT documentation. Perhaps the most obvious of these is that *Neq* is a number that is only meaningful under equilibrium conditions. Is it reasonable to assume that the conditions present today (or assumed under each EDT parameterization) will persist into the future? See my response to Question 2 for more on this subject. Beyond equilibrium, the display of *Neq* as a performance metric assumes that there will be no harvest impacts on the re-introduced spring Chinook population. This assumption is potentially important because (*i*) it is likely that some harvest will occur and (*ii*) the relationship between a particular harvest level and realized abundance will vary across different scenarios characterized by different capacity and productivity parameters. While assumptions such as these may be characterized elsewhere (i.e., in non-SJRRP/Investigation EDT documents), they have contextual meaning relevant to this specific EDT application and should probably be acknowledged.

(c) Although the conceptual basis of *Neq* is explained in BOR (2015a), there are aspects of its derivation/calculation that remain elusive. In particular, whereas deriving a single *Neq* value for a scenario requires the productivity and capacity parameters for different life history types and trajectories to be integrated into a set of single synoptic population values, the mathematical details underlying this final calculation are somewhat unclear and potentially flawed. The clearest explanation for this integration, which is essentially a weighted average across trajectories, can be found in Blair et al. (2009). As worded, however, one is led to believe that dead end trajectories (i.e., with *Neq* fated to 0/extinction) do not influence the final integrated *Neq* estimate ('*Trajectories with productivity less than 1.0 do not have an NEQ value and hence are not included in the weighting…*'; Blair et al. 2009). Is this indeed the case? If so, there appears to be potential for positive bias in *Neq* calculations, as it is plausible that some trajectories cannot achieve replacement for some scenarios. This observation may simply be a misinterpretation of EDT documentation on my part, but if it is not it may have implications for the present EDT application.

2. Have the assumptions and uncertainties associated with utilizing a habitat model for the intended purpose been appropriately characterized?

This question is difficult to answer, owing to the fact that many details (e.g., habitat inputs) of the San Joaquin River application of EDT are not documented and/or are inaccessible to reviewers. For example, in the Modelling Appendix (Chapter 5, pages 5-11 of BOR 2015a), the user is referred to Lestelle (2005) in order to gain insight on precisely how seasonal temperature and flow data–*the two primary environmental attributes of interest to the Investigation*–were transformed into monthly survival reductions. Yet, all that is provided in Lestelle (2005) is a conceptual illustration of a temporal rating process that must be carefully tailored to a specific system, both in terms of timing and magnitude of survival factor reductions. Further, while the Investigation leans heavily on an existing EDT application (i.e., the version developed for the SJRRP), the specifics of this borrowed parameterization are not documented in detail anywhere either. ICF (2014) provides what is perhaps the best description of the habitat inputs for the (adopted) SJRRP EDT model, but these descriptions are incomplete and cover only what was changed relative to earlier EDT runs. All of this is further confounded by the fact that language in 'Exhibit F: EDT Proof of Concept' of the SJRRP's Fisheries Management Plan (SJRRP 2010) plainly states that the first-cut SJRRP EDT parameterization was a rough, somewhat unreliable one at best ('…*the results are valuable as an illustration of model capabilities, but should not be considered useful estimates at this time*…'). While this may owe in part to EDT's proprietary status, this scenario casts doubt on the reliability and rigor of the specific SJRRP/Investigation application. The relative influence of field data vs. expert opinion on modeled outcomes (baseline or scenarios), for example, cannot be assessed if their presence in input data sets is unknown. In sum, the level of uncertainty surrounding the Investigation's use of EDT to guide the selection of action alternatives is unknown but arguably high.

<u>Characterization of model assumptions</u>

With respect to the assumptions portion of Question 2, my response is a mixed 'yes and no'. For example, many of EDT's general assumptions (i.e., associated with the model generally, independent of the SJRRP/Investigation application) have been articulated in other SJRRP documents or other model documentation (e.g., Blair et al. 2009). Many other assumptions associated with the specific application of EDT to the San Joaquin River have are plainly stated in the Modeling Appendix. For example, assumptions were made about other river management/restoration actions (e.g., floodplain restoration, gravel augmentation, etc.—the 'minimum restoration scenario' was assumed) that may occur coincidental to the simulated action alternatives in order to keep the focus on the Investigation's flow/temperature management emphasis. Yet, there are a number of other assumptions that were made but were not bluntly stated as such, some of which are possibly quite influential in determining modelling results/interpretation. Consider the following examples, each of which is likely to have a substantial influence on EDT predictions of productivity, capacity, and *Neq*:

(A1.) *All three outmigrant life history strategies (fry, parr, smolt) are assumed to be equally probable (Table 5-5, BOR 2015a)*. Although a modeling decision such as this makes some sense in the absence of concrete population data, it seems unlikely that three life history trajectories are equally likely, particularly across the range of environmental conditions (flow, temperature) under consideration. For example, Beckman et al. (2007) observe plasticity in outmigration preparedness due to variation in growth and phenology, both of which vary across action alternatives. It is possible that the EDT juvenile component's apparent sensitivity to action alternatives is wrapped up in this assumption. A relatively high (33%) fry outmigrant fraction combined with a relatively high fry SAR (0.6-1.7%, contrast this with *yearling* Chinook SARs in the Columbia Basin, which are typically <2%, e.g., McCann et al. 2014) might mean that the parr/smolt stages would have to suffer catastrophically before an effect of an action alternative would be detected.

(A2.) *By interpreting results in terms of Neq, the EDT application inherently assumes that equilibrium conditions apply to the SJRRP/Investigation context*. Although this assumption underlies many stock-recruitment analyses, e.g., fitting spawner-recruit curves, etc., such analyses are typically accompanied by some sort of assessment of its validity (e.g., Hilborn and Walters 1992). Using a Beverton-Holt stock-recruit function to infer habitat condition/potential within the SJRRP/Investigation context invokes the need for some open consideration of this issue. The intense drought conditions that have plagued the Central Valley for the recent decade in combination with a large restoration program with a defined trajectory suggest the SJRRP area is just about as far from an equilibrium system as one can get for Chinook salmon. If the interpretation is simply that the EDT Beverton-Holt curves/parameters under a different scenario are achieved in an instant and there is really no temporal/equilibrium context, then this should be openly stated.

(A3.) *The EDT model, in the process of rolling up survival factors across different habitat variables, makes untested (or undocumented) assumptions that are likely to profoundly affect the outcome of specific model applications.* Firstly, all survival factors are assumed to operate independently and are equally weighted (i.e., $P_s = F_1F_2 \ldots F_pP_{base}$) within a given life stage (e.g., Blair et al. 2009). Thus, it is plausible that a survival factor reduction due to, for example, increased turbidity can influence life-stage survival to the same extent as something that's arguably more detrimental (e.g., extreme temperatures). Further, EDT's assumes some 'synergy' for *F*s within some Level 2 categories, which is treated with a synergistic parameter of unknown origin. Whereas the origin/assumptions of the 0.37 exponent are not clear, McElhany et al. (2010) has shown it to be an influential parameter in a recent sensitivity analysis of EDT.

(A4.) *A 'template' (or benchmark) condition is implicitly assumed for the Investigation's EDT application.* However, the origin/basis for the template condition, a requirement for establishing survival and capacity benchmarks (i.e, P_0 and MD_s in Blair et al. 2009) for all scenarios to reference, was not specified in any Investigation-related documents. Assumedly it is similar to what was described conceptually in SJRRP (2010) and ICF (2014), but neither of these documents contains much in the way of specifics. Given that the analysis emphasizes relative differences across scenarios, the Investigation's outcomes and conclusions may be fairly insensitive to Template formulation, however it would be good for readers to know the extent to which it falls within the realm of biological plausibility for Chinook salmon (e.g., benchmarked against something like the Parken et al. [2006] watershed area-based approach).

information about the adult age structure/maturation schedule, nor adult fecundity, was provided in the documents. Was something adopted from Central Valley fall Chinook salmon? Was it assumed to apply equally to all outmigrant life history categories? Although this may seem like a minor detail, past investigations have found adult age structure to be an extremely influential model input (Steel et al. 2009).

<u>Characterization of model uncertainty</u>

Similar to this EDT application's treatment of assumptions, there were notable limitations to its consideration of input/output uncertainty. Arguably, these are limitations associated with the broader EDT framework and not its specific application to the SJRRP/Investigation context. EDT is a deterministic model and thus is not equipped to integrate uncertainty in model inputs (e.g., variability in measurements), assumptions (see above), and/or model structure (i.e., quantitative rules linking survival factor values to environmental conditions) into outputs (Blair et al. 2009). However, recent independent reviews of the model's sensitivity have revealed a high degree of uncertainty in outputs relative to variation in inputs (Steel et al. 2009; McElhany et al. 2010), concluding that 'EDT…predictions lack the precision needed for many management applications…'. These findings seem particularly germane to the Investigation's use of this model given that the action alternatives, in most instances, differ in *Neq* by 10s of fish. Although public comments on the DEIS also raised this issue, it was not addressed during the preparation of the final EIS.

Additionally, while some might argue that ignoring uncertainty is justified because managers cannot process (or make decisions in the face of) it anyway, forging ahead with a model like EDT without acknowledging/addressing input/output uncertainty and model sensitivity is inconsistent with sound modelling practice. Further, it is at odds with the promising developments highlighted in Blair et al. (2009), which include: (1) a weight-of-evidence ('level of proof', LOP) scoring approach that accompanies the preparation of habitat variable inputs, and (2) an approach towards conducting EDT model runs at a variety of plausible levels for input variables (the 'WDFW approach' in Blair et al. 2009). Although a 'stochastic EDT' that provides prediction intervals may be a thing of the future, the present application could be strengthened greatly from a combination of new sensitivity analyses (at least for the key inputs that are uncertain and/or influential) and some contextual treatment relative to published sensitivity analyses (i.e., Steel et al. 2009 and McElhany et al. 2010) and/or efforts to validate the model (e.g., Rawding 2004). While acknowledging weaknesses/limitations, incorporating this context will also strengthen the utility of the SJRRP/Investigation's application of EDT, as those past investigations also highlight EDT's strengths.

Lastly, within the context of uncertainty, I close my review with two minor points on model sensitivity/uncertainty:

(1) The Modelling Appendix entitled 'EDT Sensitivity Analysis' should potentially be relabeled something more like 'Analysis of Sensitivity to Restoration Formulation' (or something like this). As currently labelled, it implies something akin to a thorough sensitivity analysis, whereas it is really only focused on a narrow (albeit important) set of input assumptions.

(2) Upon examining the life stage-specific results in the provided in Tables 5-15 through 5-18 and in the appendix to the modeling appendix (i.e., 'EDT Productivity and Capacity Effects by Life Stage for Action Alternatives and Sensitivity Analyses', BOR 2015b), I was struck by the fact that nearly all the benefits realized across the action alternatives occur for the spawning/egg-incubation stages primarily and that the costs/benefits for other life stages (especially parr and smolt) results are essentially nil. Given the shift in temperature during spawning/incubation (a 1-2 degree reduction) this seems implausible. In fact, given that mean temperatures (Figure 4-13, pages 4-56 in BOR 2015c) range 2-3 degrees warmer and that peak spring flows are more muted (Figure 4-15, pages 4-58 in BOR 2015c) during the spring outmigration for all action alternatives than the no action alternative, one might expect to see more of a capacity/ productivity response here (e.g., due to lower turbidity and increased metabolic demand/activity of non-native predators; e.g., Gregory and Levings 1998 and Peterson and Kitchell 2001). Or perhaps there's a commensurate and compensating growth response for Chinook salmon? Either way, a review of the stage-specific results illustrates that the model formulation places an overwhelming emphasis on the spawning/incubation stages and that parr/smolt stages are unresponsive to change. Although this may be intentional given an understanding of the biology of the SJR system, it seems inconsistent with assumptions about the freshwater biology of Chinook salmon elsewhere and the life history and limiting factor expectations for a SJR spring Chinook salmon population. Regardless, this observation underscores the need for the BOR and/or EDT developers to more convincingly display that they fully understand model behavior/sensitivity.

References

Allen, M.B., and P.J. Connolly. 2005. Assessment of White Salmon watershed using the ecosystem diagnosis and treatment methodology (EDT). Final Report prepared for Yakama Nation, Toppenish, WA.

Beckman, B. R., B. Gadberry, P. Parkins, K. A. Cooper, and K. D. Arkush. 2007. State-dependent life history plasticity in Sacramento River winter-run chinook salmon (*Oncorhynchus tshawytscha*): interactions among photoperiod and growth modulate smolting and early male maturation. Canadian Journal of Fisheries and Aquatic Sciences 64(2):256-271.

Blair, G.R., L.C. Lestelle, and L.E. Mobrand. 2009. The Ecosystem Diagnosis and Treatment Model: a tool for assessing salmonid performance potential based on habitat conditions. American Fisheries Society Symposium 71:289-309.

Bureau of Reclamation (BOR). 2015a. Environmental Impact Statement Modeling Appendix. Sacramento, California. 252 pp.

Bureau of Reclamation (BOR). 2015b. EDT Productivity and Capacity Effects by Life Stage for Action Alternatives and Sensitivity Analyses. Sacramento, California. 33 pp.

Bureau of Reclamation (BOR). 2015c. Upper San Joaquin River Basin Storage Investigation. Regional Director's Final Feasibility Report. Sacramento, California. 402 pp.

Colville Confederated Tribes. 2013. OBMEP/EDT Habitat Status and Trends Report for the 2009 Monitoring Cycle: Okanogan Summer/Fall Chinook. December. (ICF 220.13.) Omak, WA. Prepared by ICF International, Seattle, WA. 642 pp.

Gregory, R. S., and C. D. Levings. 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. Transactions of the American Fisheries Society 127(2):275-285.

Hilborn, R. C., and C. J. Walters. 1992. Quantitative fisheries stock assessment. New York, New York: Chapman and Hall.

ICF International. 2014. Revised Final Technical Report: Analysis of Fish Benefit for Reach 2B Alternatives of the San Joaquin River. March. (ICF 00787.11.) Sacramento, CA. Prepared for U.S. Department of the Interior, Sacramento, CA.

Lestelle, L.C. 2005. Guidelines for rating level 2 environmental attributes in Ecosystem Diagnosis and Treatment (EDT). Mobrand, Jones, and Stokes. 143 pp.

McElhany, P., E.A. Steel, K. Avery, N. Yoder, C. Busack, and B. Thompson. 2010. Dealing with uncertainty in ecosystem models: lessons from a complex salmon model. Ecological Applications 20(2):465-482.

Parken C.K., McNicol R.E., and Irvine J.R. 2006. Habitat Based Methods to Estimate Escapement Goals for Chinook Salmon Stocks in British Columbia, 2004. Research Document 2006/083. Ottawa, ON: Canadian Science Advisory Secretariat, 74 pp.

Petersen, J. H., and J. F. Kitchell. 2001. Climate regimes and water temperature changes in the Columbia River: bioenergetic implications for predators of juvenile salmon. Canadian Journal of Fisheries and Aquatic Sciences 58(9):1831-1841.

Rawding, D. 2004. Comparison of spawner-recruit data with estimates of EDT spawner-recruit performance. WDFW, Vancouver, Washington. 20 pp.

San Joaquin River Restoration Program (SJRRP). 2010. Exhibit F: EDT Proof of Concept. Appendix to the SJRRP Fisheries Management Plan. Sacramento, California. 28 pp.

Steel, E.A. and 12 co-authors. 2009. Making the best use of modeled data: multiple approaches to sensitivity analysis of a fish-habitat model. Fisheries 34:330-339.

Individual Memorandum
Peer Review of the Use of Fish Habitat Modeling in the Upper San Joaquin River Basin Storage Investigation

Reviewer 2 – 23 October 2015

1. Is displaying results for the EDT model in terms of fish abundance to compare future population outcomes amongst alternatives a recognized suitable application of the EDT model?

The Ecosystem Diagnosis and Treatment (EDT) model results include the productivity, capacity and equilibrium abundance for the fall run Chinook salmon. The equilibrium abundance is steady-state abundance and capacity is a theoretical maximum abundance supported by suitable habitat. EDT has been described as a habitat model, and habitat models are not good at predicting absolute numbers like species abundance (Boyce et al. 2015). Abundance of a population may be influenced by factors not directly related to suitable habitat, and without building this information into the model the results may be compromised. Based on the underlying Beverton-Holt density-dependent model (1957) that is at the heart of the population estimates and the products from the EDT model, results can be displayed as a relative abundance. Beverton-Holt provides a discrete-time of population model or expected number (n_{t+1}) of individuals in generation (t+1). The "relative" portion is important and should be added to the EDT model results since the model has been found to be best at comparative measure of fish performance (LCFRB 2010, McElhany et al. 2010).

A recent study in the lower Columbia River from the Lower Columbia Fish Recovery Board's (LCFRB) 2010 Recovery Plan compared EDT modeled populations verse empirical fish abundance data. That study suggested that EDT results were within the range of empirical observations, and differences could be explained by typical sources of variation and error. However, the study suggested that EDT was not sufficient for modeling absolute numbers of abundance. The results are best for comparing relative magnitudes between scenarios. I would also note the LCFRB made a point that the use of EDT was best not for "numbers of fish abundance and productivity for a population." The study's findings suggest that it is better used to determine the influences of habitat on various life cycles and identification of restoration and preservation benefits of specific habitat attributes (LCFRB Volume VI, Chapter 6 Application of the EDT model 2010).

A sensitivity analysis was conduct on three EDT modeled salmon populations; East Fork Lewis River fall Chinook, Germany Creek Coho, and West Fork Washougal River mainstem steelhead all from the lower Columbia River, WA (McElhany et al. 2010). The findings of the analyses showed that EDT model performed well for relative population results since slightly different input values had the potential to produce quite different results. The authors warn that these results test precision of the model not accuracy.

Both of these papers suggest that the results from the EDT population predictions are best for comparative purposes and not absolute values. Displaying the results as a relative fish abundance is a suitable application of the EDT model.

2. Have the assumptions and uncertainties associated with utilizing a habitat model for the intended purpose been appropriately characterized?

I feel that the Upper San Joaquin River Basin Storage Investigation (USJRBSI) report's Public Comments and Responses (Chapter 35) section did a good job clarifying some of the assumptions and uncertainties associated with EDT model. The main text did not describe very well all of the assumptions and uncertainties about the EDT model. There is a need for complete transparency in the EDT modeling process and recognition that there is a potentially false sense of precision. The report makes the statement that the use of habitat models like EDT in predicting populations is potentially problematic (page 286, Chapter 2 Alternatives USJRBSI report), but does not provide any additional evidence to the contrary. There is no attempt to show how well the model fits empirical data or use of performance measures (McElhany et al. 2010).

When reviewing the EDT related comments on the USJRBSI DEIS and the Public Comments and Responses (Chapter 35 USJRBSI report), several of the responses still lacked clear information to support the statements in the report. Below are several points about assumptions and uncertainties associated with the EDT model not fully addressed in the USJRBSI report's Public Comments and Responses.

1) I do not believe that the fact that the EDT does not perform like a population model (Mobrand et al. 1997) has been clearly addressed. The underlying Beverton-Holt density-dependent model (1957) has numerous assumptions as part of it that were not provided in USJRBSI report. There is a real danger in population assessments of using average behaviors predicted by a model. Management groups' concerns over its use and lack of built-in uncertainty in the model are made to prevent depensation dynamics. There are too many peer-reviewed documents that address EDT's use as a relative model of habitat to ignore this fact. I would address this point more directly.

2) The concern over conducting the EDT modeling on only the spring-run Chinook was not fully addressed. By ignoring the fall-run Chinook, the population estimates are inaccurate. It was clearly laid-out that the "an accurate smolt-to-adult return (SAR) cannot be estimated and used in the model because there is not a current Chinook population", (page 280 Chapter 5 Plan Evaluation, Comparison, and Selection USJRBSI Report). This is a big caveat that most of that data was created by professional judgment, or based on other region's populations. This also brings into question why other species were not also modeled. If the Chinook spring-run population were modeled with no upper San Joaquin River population data, why not the fall-run Chinook salmon, steelhead, or white sturgeon? I know there are established EDT habitat rules for the Chinook salmon and steelhead (Lestelle et al. 2004).

3) The lack of measurements of the model's fit or performance (McElhany et al. 2010) was not addressed. McElhany and others (2010) demonstrated that slight changes in the input values could change the results. So, a post-hoc assessment could provide additional information

about differences between scenarios. I would think a performance assessment would strength the results of the study, and potentially reduce concerns.

References

Beverton, R.J., and Holt, S.J. 1957. On the dynamics of exploited fish populations. Fisheries Investment Series 2. Vol. 19. U.K. Ministry of Agriculture and Fisheries, London.

Boyce, M. S., C. J. Johnson, E. H. Merrill, S. E. Nielsen, E. J. Solberg, and V. van Moorter. 2015. Can habitat selection predict abundance? Journal of Animal Ecology 84: 11/1365-2656.12359

Lestelle, L.C., Mobrand, L.E., and McConnaha, W.E. 2004 .Information Structure of Ecosystem Diagnosis and Treatment (EDT) and Habitat Rating Rules for Chinook Salmon, Coho Salmon, and Steelhead Trout. Mobrand Biometrics, Inc.

Lower Columbia Fish Recovery Board. 2010. Recovery Plan http://www.lcfrb.gen.wa.us/#!library/c1tqm, Volume VI, Chapter 6 Application of the EDT model.

McElhany, P.E., Steel, A., Avery, K., Yoder, N., Busack, C. and Thompson, B. 2010. Dealing with uncertainty in ecosystem models: lessons from a complex salmon model.Ecological Applications 20(2): 465-482

Mobrand, L.E., Lichatowich, J.A., Lestelle, L.C., and Vogel, T.S. 1997. An approach to describing ecosystem performance ``through the eyes of salmon'' Canadian Journal of Fisheries and Aquatic Sciences. 54: 2964-297

Individual Memorandum
Peer Review of the Use of Fish Habitat Modeling in the Upper San Joaquin River Basin Storage Investigation

Reviewer 3 - 26 October 2015

1. Is displaying results for the EDT model in terms of fish abundance to compare future population outcomes amongst alternatives a recognized suitable application of the EDT model?

In my experience, attempting to predict fish abundance, based upon empirical data to calibrate a model of future abundance is fraught with many dangers. Most commonly, since not all environmental influences can be predicted by any model, it becomes difficult to place narrow error margins around existing data. That is, the error limits around the calibration data are so wide that they are compounded so that the abundance predictions have confidence intervals plus or minus five-times the mean predicted abundance. The best management decision models I have encountered place the decisions upon availability of high quality habitat and the gains or losses of that habitat, above or below a designated break point, are used as the deciding factors (Gore and Nestler 1988). Response to loss of habitat over a long period of time is not necessarily a linear or predictable condition. The more useful predictor is an habitat quality index in which the response is known within acceptable limits and beyond which there is certainty of loss of quality habitat (as a surrogate of abundance and productivity) and resulting lost productivity, without placing a numerical value on that loss. That is, the “currency” for making the decision is not based upon fish productivity [although it is certainly used to calibrate the model], but instead upon a range of acceptable losses of habitat quality and quantity, below which “significant ecological harm” is likely to occur; the extent of that harm being immaterial to the decision.

As important, if flows are manipulated to maximize the amount and location of the highest quality habitat, the model would also appear to predict the greatest abundance and productivity of Chinook salmon. Has this been tested? That is, is there a point at which habitat is saturated and increasing the amount of that habitat no longer supports concomitant increases in productivity?

2. Have the assumptions and uncertainties associated with utilizing a habitat model for the intended purpose been appropriately characterized?

The assumptions of the model seem to be reasonable. I only question the use of the prediction, based upon historical flows, to make management decisions. I have this vision of a water-user employing some expert to count fish and exclaiming that the model predicted a certain amount of productivity or abundance and declaring that the actual number from the count was, in fact 10% higher and, therefore, the flows should be diverted for consumer use. In fact, the number of errors around the predicted abundances may be so wide that the “+10%” is within those limits. It easier to predict the proportionate gain or loss of high quality habitat and the transition value (say, 20% habitat loss) as the “significant harm” threshold.

Additional Comments

"The EDT model conditions do not include the Critical-Low water year types because, in those very infrequent years …" the population would not be supported due to discontinuous flows. It appears that the alternative would be to truck fish upstream and downstream around these discontinuities. All of the analyses were conducted on flows between 1980 and 2003, an historically "typical" period of record [at least, with reference to flow records in the region prior to 1980]. However, these simulated flows do not take into account the possibility that those historical records are no longer the "normal" for the region and that the Critical-Low water years may be the most appropriate flows to be analyzing into the future.

Ultimately, the simulation will rely upon historical flow records to predict the distribution and abundance of Chinook salmon. This may be appropriate to "test" the simulation; however, the appropriateness of the simulation going forward, considering potential changes as a result of climate change and impacts on flow records, may not make it an appropriate model without adjustments to the predictive protocols and some of the choices made within the simulation. Recent research suggests that large-scale climatic oscillations (AMO, PDO, and ENSO), while continuing, are not influencing continental weather patterns in the manner that has been recorded over the past one hundred years. In some areas, additional flooding might be expected. However, it appears that historically low and high flow decadal weather patterns will now be much drier. As a result, the critical low-flow simulation may be the most appropriate to predict future distributions of Chinook salmon. However, the existence of discontinuous connections between high quality habitat patches must be taken into account as a "normal" condition and may yield predictions that label these as "infrequent events." I suggest that the investigators consider an even lower flow situation that reflects this potential new flow scheme. These are likely to become impoverished as agricultural demands only increase if low flow / drought conditions continue or become the new "historical" condition. This comment is emphasized by a large number of simulations (for example, Maurer 2007 and Xenopoulos et al. 2005) which predict dramatic reductions in flow and loss of freshwater fish species (up to 37% losses from the Sacramento River, in some scenarios) by 2070 if these climate-change induced changes in river flow patterns in the Sierra Nevada continue.

References

Gore, J.A., and J.M. Nestler. 1988. Instream flow studies in perspective. *Regulated Rivers: Research and Management* 2: 93-101.

Maurer, E. 2007. Uncertainty in hydrologic impacts of climate change in the Sierra Nevada, California, under two emissions scenarios. Climate Change 82: 309-325.e managers.

Xenopoulos, M.A., D.M. Lodge, J. Alcamo, M. Märker, K. Schulze, and D.P. Van Vuuren. 2005. Scenarios of freshwater fish extinctions from climate change and water withdrawal. Global Change Biology 11: 1557-1564.

Individual Memorandum
Peer Review of the Use of Fish Habitat Modeling in the Upper San Joaquin River Basin Storage Investigation

Reviewer 4 – 3 November 2015

1. Is displaying results for the EDT model in terms of fish abundance to compare future population outcomes amongst alternatives a recognized suitable application of the EDT model?

In my opinion, and (caveat) limited exposure with EDT, no - EDT is not an appropriate tool for forecasting population outcomes in absolute abundance estimates between alternatives. I am confused as to what value answering this narrow question provides. I presume this question is targeted at Tables 5-9, 5-10 and Figures 5-5 through 5-9 in the modelling appendix? In those tables and figures, the authors are careful to present abundance differences between scenarios in percent difference terms. That seems a reasonable way to display and convey the EDT findings. However, in Figure 5-11 and Tables 5-11 through 5-14, absolute estimates are provided. This is of course what the model spits out and is a useful relative metric for inter-comparison between scenarios. However, I find it worrying that no +/- estimates are provided with each of these abundance calculations.

There are many different variants of the phrase 'all models are wrong, some are useful'. I don't have a problem with using EDT to explore potential impacts of different design scenarios. However, as with any model, it comes down to what purpose those results are put to and how they are interpreted that ultimately is far more important. While the authors have done a reasonable job of chasing down extremely specific concerns, in Chapter 35 of the EIS, I was worried by the spirit of the response to the broader concerns raised. I don't share many of the reviewer comments' blanket dismissal of EDT and concern over it having any utility in this context. I do, however, worry that EDT (as with any model) is only capable of doing so much and way too much stock is put in this single model. Comparing a plurality of competing models and forecasts from fundamentally different perspectives is a safer way of tip-toeing into the dangerous business of forecasting population responses. The bigger issue is this is an area where the science is highly uncertain (not to say it is useless) and there are too many knobs to make accurate predictions. While adding additional model analyses is not a task taken lightly (significant costs and time are involved), the over reliance on one model here is worrying. When that over reliance is combined with, in my opinion, an inadequate representation of the uncertainty in the output, it makes it difficult to judge to what extent the model is capable of addressing the question at hand – namely will the proposed action negatively impact fisheries. The short answer is we don't really know and if you put error bars on your estimates it may conservatively suggest the outputs are nearly useless. Yes, one model seemed to suggest negligible impacts or benefits under a range of scenarios. That doesn't mean it is right.

While there is a long section under the heading of 'EDT Sensitivity Analysis' from 5-47 to 5-63, it explores sensitivity to only some of the input parameters (primarily those associated with how different design alternatives impact input parameters and water years). I fully admit that there are varying degrees to which sensitivity analyses can be done and many folks have differing opinions as to what a sensitivity analysis is (Beven and Binley 1992; Zak and Beven 1999; Zapert et al. 1998). I also believe that what the authors did to explore the sensitivity of the EDT output to *some* of the driving factors in the model is reasonable. However, a sensitivity analysis only explores parametric uncertainty within a specific model and does nothing to explore the bigger underlying structural uncertainties in the model itself. The easiest way to explore that more fundamental uncertainty is to not put all your eggs in one modelling basket and explore the outputs of a variety of different models formulated in different ways and see if they paint a convergent picture or divergent picture. This was notionally addressed in 35-64 to 35-65 in a somewhat reasonable, but sort of dismissive, tone. I sympathize with the individuals tasked with preparing this analysis. They can only do what they can do with the tools they had at hand, and EDT was no doubt a useful tool for giving some insights into the process. Does it give the answer demanded by the EIS process? I am not sure it does.

2. Have the assumptions and uncertainties associated with utilizing a habitat model for the intended purpose been appropriately characterized?

In a word - no. As I discussed in the response above, there seems to be either confusion over what uncertainty is or at least too narrow of a perspective (with respect to EDT portion of EIS) explored. Various lexicons for uncertainty exist that can shed light on this productively (e.g. Rotmans and Van Asselt 2001; Van Asselt 2000; Van Asselt and Rotmans 2002) and have been used productively in climate change forecasting. This question requires deconstructing to properly consider my ‘no’ response:

With regards to the ‘assumptions…. been appropriately characterized’ part of the question, I would say that the authors have done a good job of explaining the EDT model and transparently outlining the assumptions behind the model itself as well as the assumptions behind specific parametrizations to represent specific scenarios in individual simulations. The EIS is such a behemoth and its organization a nightmare, it may be hard to find specific aspects of these, but what was done is reasonable.

With regards to the ‘uncertainties associated with utilizing a habitat model’ being appropriately characterized, I would say the authors made a reasonable attempt to characterize many of these and specifically to address concerns raised in previous reviews. However, they focus on a narrow class of parametric uncertainties and a limited sensitivity analysis to explore these and I don’t feel that it adequately conveys to the reader, and whomever may sign off on this EIS, the actual uncertainty in the outputs. I fully admit that my suggestion of putting some +/- error bars on quantities the model outputs is an easy thing to say, a harder thing to do, and will in many cases paint too conservatively uncertain of a picture. However, that is your burden. I don’t feel the risks in believing the outputs of a single model, which suggest impacts are negligible, have been adequately contextualized.

Finally, with regards to the vague ‘intended purpose’ part of the model question, I really take issue with this and this is what is driving most of my ‘no’ response. To be fair to the vague group of ‘authors’ for this little piece of the EIS, aside from some of the cans of worms I suggest above, what they did was a reasonable attempt to use a tool like EDT for the purpose of exploring part of the potential impacts of FSH-10 through FSH-17. My criticism is that too much stock is put in this one tool and there are other ways to explore those impacts and represent the uncertainty other than just relying on EDT.

Additional Comments

In over a decade of providing scientific peer reviews for public agencies, this is, by far, one of the most peculiar and narrow reviews I've ever been asked to do. I knew nothing about the proposed Upper San Joaquin River Basin Storage project, nor this EIS prior to the request. After wading through well over 4000 pages of information from the BOR, and over 150 pages of comments from other interested parties (with their recognized biases, expertise and remits), and my own literature review, I feel qualified to provide the above answers to the specific questions. Prior to the review, I would say I had a superficial understanding of EDT, but a more in-depth familiarity with anadromous salmonid life cycle modeling in general and extensive experience in fish habitat modeling, assessment and restoration.

This entire review process reeks of a narrow-laser focus on what are probably the wrong questions without any scope for the reviewers to evaluate some more basic or fundamental questions with regards to the fish habitat modelling work. I recognize that is not the job of the scientists you ask to pass judgement on the overall project and I am in way seeking a pulpit to do that. However, a fair thing to ask of your reviewers is to comment as to whether the information presented is used appropriately to address specific concerns or justify an action or inaction. For example, it is clear from the external comments already received and the responses in Chapter 35 of the EIS (pp 35-61 to 35-70) that the methodological choice of using EDT solely to evaluate the environmental consequences and benefits was seen by multiple people as questionable. Instead of taking that to heart, the authors appear to have defended that choice. This is unfortunate. In my opinion it is the difference between an appropriate use of EDT versus potentially inappropriate by giving it too much weight.

The remit to the reviewers reads like a request for some scientific experts to whitewash and give a stamp of approval on some hyper-specific detail of a massively complicated and tremendously interconnected project. Namely, you seem to be not wanting us to comment on whether or not something other than EDT should have or could have been used (even to augment), and instead want us to just say everything is fine. While EDT is an interesting model for exploring various habitat restoration scenarios and has been used effectively in the Pacific Northwest in an exploratory manner to inform complex decisions about restoration and the management of anadromous salmonids, it is just one way to look at an extremely complicated problem. The remit for this review and the overall presentation of the EIS reads like a narrowly considered list of checkboxes considered in isolation of each other without any meaningful integration of the complicated interaction between all the many pieces being considered. Just as EDT itself attempts to simplify conceptually and quantitatively represent a multi-faceted process into a digestible output, I recognize that an EIS is a blunt tool for considering and forecasting the impacts a proposed action may have.

I must admit, I took offense, professionally, to the instructions: 'Evaluation of the EDT model within the general context of habitat modeling is outside the scope of this review. This review is focused solely on the utilization of EDT in its application to quantify the benefits as proposed within the Investigation feasibility study and EIS.'

I find it very misleading to be asked to complete a review on 'the use of fish habitat modeling', without being given the freedom to judge the model used to make this evaluation or at least the broader context of the purposes to which it is being put. As a developer myself of models that can easily be misused, misapplied, abused, taken out of context and otherwise put to purposes for which they were never intended, I wish to make it clear that I don't have any issue per se with the EDT modeling approach and find it a very creative way to try to better understand a complicated problem. However, I would like to highlight this phrase from Mobrand et al. (1997), the original EDT paper:

> "The performance measure we propose and the conceptual framework from which it is derived constitute **a model for understanding and for learning, not a tool for short-term prediction**. It is an indicator of how favorable the environment is (or might become) for salmon to persist and abound, **not a predictor of how many will return and when**. Such predictors are unreliable, and consequently, performance measures based on short-term abundance responses are poor guides to decision making (Lichatowich and Cramer 1979). Instead, we must use our understanding of the system (i.e., the conceptual framework) to make decisions and take actions that increase or decrease the likelihood of returning salmon in greater numbers."

Finally, I must admit I am frustrated by my review above as I fear there is little constructive advice that comes out of it to improve the product or the process. Both are flawed. This review took an inordinate amount of time to wade through a lot of EIS material to provide what is ultimately an unsatisfying answer to two questions. In retrospect, I should have declined to review this.

References Cited

Beven, K. and Binley, A.M., 1992. The future of distributed models: model calibration and uncertainty prediction. Hydrological Processes, 6: 279-298.

Mobrand, L.E., Lichatowich, J.A., Lestelle, L.C. and Vogel, T.S., 1997. An approach to describing ecosystem performance "through the eyes of salmon". Canadian Journal of Fisheries and Aquatic Sciences, 54: 2964-2973.

Rotmans, J. and Van Asselt, M.B.A., 2001. Uncertainty Management in Integrated Assessment Modeling: Towards a Pluralistic Approach. Environmental Monitoring and Assessment, 69(2): 101 - 130.

Van Asselt, M.B.A., 2000. Perspectives on uncertainty and risk: The PRIMA approach to decision support. Ph.D. Thesis, Kluwer Academics Publishers, Dordrecht, The Netherlands, 452 pp.

Van Asselt, M.B.A. and Rotmans, J., 2002. Uncertainty in integrated assessment modelling – From positivism to pluralism. Climatic Change, 54(1-2): 75-105.

Zak, S.K. and Beven, K.J., 1999. Equifinality, sensitivity and predictive uncertainty in the estimation of critical loads. The Science of the Total Environment, 236: 191-214.

Zapert, R., Gaertner, P.S. and Filar, J.A., 1998. Uncertainty propagation within an integrated model of climate change. Energy Economics, 20: 571-598.

APPENDIX C

Reviewer's Resumes (Alphabetical)

Peer Review of the Science Informing the Upper San Joaquin River Basin Storage Investigation

U.S. Bureau of Reclamation

Curriculum Vitae

Wesley M. Daniel

Michigan State University
Department Fisheries and Wildlife
East Lansing, Michigan 48823
Cell: 225-953-2935
Work: 517-432-3102
Email: Danielwe@MSU.edu

EDUCATION

2012 Doctor of Philosophy in biological sciences; minor in fisheries science from Louisiana State University, Department of Biological Sciences & Department of Renewable Natural Resources. Baton Rouge, Louisiana

Dissertation: Modeling Effects of Instream Variables, Land Use, and Life History Attributes On Community Structure of Freshwater Mussels in Louisiana Streams

Kenneth M. Brown (chair), William Kelso (co-chair), Michael Kaller, Richard Stevens

2008 Master of Science in biology from University of Louisville, Department of Biology. Louisville, Kentucky

Thesis: Impact of Urbanization Across an Indirect Anthropogenic Gradient in Metro Louisville, KY: A Current and Historical Prospective.

Jeff Jack (chair), Margaret Carrerio (co-chair), William Alexander, Phillip Lienesch

2003 Bachelor of Science in biology from Western Kentucky University, Department of Biology. Bowling Green, Kentucky

CURRENT POST-DOCTORAL EXPERIENCE

2012 Research Associate, Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI.

ACADEMIC AWARDS AND HONORS

2011 Louisiana State University Graduate School Dissertation Fellowship Award

Freshwater Mollusk Conservation Society: Honorable Mention Best Student Presentation

Freshwater Mollusk Conservation Society: Student Travel Award

Louisiana State University Biograds Travel Award

2010 Louisiana State University Biograds Research Award

2009 Louisiana State University Biograds Travel Award

2008 American Fisheries Society Award (Kentucky Chapter): Best Student Paper Presentation

Louisiana State University Biograds Research Award

2006 Beechmont Garden Club Conservation Award

University of Louisville Biology Graduate Student Presentation Award

2005 Furnish Graduate Student Award for Excellence in Teaching of Biology

2004 Clay Memorial Biology Scholarship

GRANTS

Funded Grants

2015 Gulf Coast Prairie Landscape Conservation Cooperative
Co-Principal Investigator -$59,915
"Strategic coordination of Quadrula spp. Research and Conservation" -Dana M. Infante and Wesley M. Daniel (Michigan State University)

2013 Northeast Climate Science Center
Collaborator- $199,881
"A decision support mapper for conserving stream fish habitats of the NECSC region" -Craig Paukert (University of Missouri, USGS), Dana M. Infante (Michigan State University), Jana Stewart (USGS), Jodi Whittier (University of Missouri), Tyler Wagner (Pennsylvania State University, USGS)

2011 Louisiana Department of Wildlife and Fisheries, Environmental Education Grant
Principal Investigator - $959
"Is dispersal limitation leading to the extinction of an endangered aquatic species in Louisiana?" -Wesley Daniel and Kenneth Brown (Louisiana State University)

2010 Louisiana Department of Wildlife and Fisheries, State Wildlife Grant
Co-Principal Investigator and dissertation research - $28,098
"Using quantitative sampling, electro-shocking, and shell sectioning to determine the abundance, age distribution, and host fish of an endangered mussel, the inflated heelsplitter, in the Amite River" -Kenneth Brown and Wesley Daniel (Louisiana State University)

2009 Louisiana Department of Wildlife and Fisheries, Environmental Education Grant
Principal Investigator - $1,000
"Does competition structure mussel communities in Louisiana?" -Wesley Daniel and Kenneth Brown (Louisiana State University)

2008 Louisiana Department of Wildlife and Fisheries, Environmental Education Grant
Principal Investigator - $1,000
"Diversity and abundance of freshwater mussels (Unionida) in the Atchafalaya basin" -Wesley Daniel and Kenneth Brown (Louisiana State University)

2007 Louisiana Department of Wildlife and Fisheries, State Wildlife Grant
Collaborator and dissertation research - $105,000
"Predicting the diversity and risk of extinction of Louisiana freshwater mussels from water quality, landscape scale factors and host fish communities" -Kenneth Brown (Louisiana State University)

2006 Louisville Metro Sewer District, Conservation Grant
Collaborator and thesis research - $30,000
"Impacts of land use change on aquatic food webs and fish communities"- Jeffery Jack (University of Louisville)

Grants – approved, but not funded

2008 National Oceanic and Atmospheric Administration, Pontchartrain Conservation
Co-Principal Investigator - $87,384
"Mussel species of concern in the Pontchartrain Basin: Documenting existing diversity and delineating threats" - Kenneth Brown and Wesley Daniel (Louisiana State University)

PUBLICATIONS

2015 Robert M. Hughes, Felipe Amezcua, David Chambers, Wesley M. Daniel, et al. Position paper and American Fisheries Society policy statement on mining and oil gas extraction. *In press* Fisheries

Wesley M. Daniel, Michael D. Kaller, and Jeff Jack. 2015. Nitrogen stable isotopes as an alternative for assessing mountaintop removal mining's impact on headwater streams. Fundamental Applied Limnology 186:193-202

Wesley M. Daniel, Dana M. Infante, Robert M. Hughes, Peter C. Esselman, Yin-Phan Tsang, Daniel Wieferich, Kyle Herreman, Arthur R. Cooper, Lizhu Wang, William W. Taylor. 2015. Characterizing coal and mineral mines as a regional source of stress to stream fish assemblages. Ecological Indicators 50:50-61.

2014 Wesley M. Daniel, Kenneth M. Brown, and Michael Kaller. 2014. A tiered aquatic life unit bioassessment model for Gulf of Mexico coastal streams. Fisheries Management & Ecology 21:491-502.

Wesley M. Daniel and Kenneth M. Brown. 2014. The role of life history and behavior in explaining mussel distributions. Hydrobiologia 734:57-68

Kenneth M. Brown, and Wesley M. Daniel. 2014. The population ecology of the threatened inflated heelsplitter, *Potamilus inflatus*, in the Amite River, Louisiana. American Midland Naturalist 171:328-339.

2013 Wesley Daniel and Kenneth M. Brown. 2013. Multifactorial model of habitat, host fish, and landscape effects on Louisiana freshwater mussels. Freshwater Science 32: 193-203.

2012 Kenneth M. Brown and Wesley Daniel. 2012. Mussel mortality from a toxic spill in the Pearl River, Louisiana. Ellipsaria 14: 28-31.

Wesley Daniel and Kenneth M. Brown. 2012. Growth Curves for *Margaritifera hembeli* from shell sectioning similar to mark and recapture estimates. Ellipsaria 14: 25-27.

Wesley M. Daniel and Kenneth M. Brown. 2012. Reproductive biology and host fishes of four unionids from the Lake Ponchartrain basin, Louisiana. Walkerana, Journal of the Freshwater Mollusk Conservation Society 15:1.

2010 Kenneth M. Brown, Wesley Daniel, and Gerry George . 2010. The effect of Hurricane Katrina on the mussel assemblage of the Pearl River, Louisiana. Aquatic Ecology 44: 223-231.

Kenneth M. Brown, Gerry George, and Wesley Daniel. 2010. Urbanization and a threatened freshwater mussel: evidence from landscape scale studies. Hydrobiologia 655:189-196.

Manuscripts in review

Fragmentation of conterminous U.S. streams by large dams. Arthur Cooper, Dana M. Infante, Wesley M. Daniel, Lizhu Wang, Kevin E. Wehrly, Travis O. Brenden. *In review* Landscape Ecology

REPORTS

2014 Wesley M. Daniel and Dana Infante. National Fish Habitat Partnership (NFHP), 2015 National Inland Fish Habitat assessment: Annual Update to the NFHP Science and Data Committee.

2013 Wesley M. Daniel and Dana Infante. National Fish Habitat Partnership (NFHP), 2015 National Inland Fish Habitat assessment: Updates on new data sources and analytical techniques to the NFHP Science and Data Committee.

2012 Kenneth Brown and Wesley M. Daniel. Using quantitative sampling, electro-shocking, and shell sectioning to determine the abundance, age distribution, and host fish of an endangered mussel, the inflated heelsplitter, in the Amite River. Final Report prepared for Louisiana State Wildlife Grant, Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

Wesley M. Daniel and Kenneth Brown. Is dispersal limitation leading to the extinction of an endangered aquatic species in Louisiana? Final Report prepared for Environmental Education Grant, Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

2011 Tony R. Brady, Cedric Doolittle, Gary Vitrano, and Wesley M. Daniel. Freshwater mussel survey of the West Pearl River in response to the chemical release from the Temple Island Paper Mill. US Fish and Wildlife Service, Natchitoches, LA

2010 Wesley M. Daniel and Kenneth Brown. Does competition structure mussel communities in Louisiana? Final Report prepared for Environmental Education Grant, Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

Kenneth Brown, Bill Kelso and Wesley M. Daniel. The role of local, regional and fish assemblages in determining mussel assemblages in the Florida Parishes. Final Report for Louisiana State Wildlife Grant for Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

2009 Wesley M. Daniel and Kenneth Brown. Diversity and abundance of freshwater mussels (Unionida) in the Atchafalaya basin. Final Report prepared for Environmental Education Grant, Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

PRESENTATIONS

2015 Wesley M. Daniel, Arthur Cooper, Pete Badra, Dana Infante Michigan's fluvial habitat suitability for 11 listed unionids. Invited Presentation American Malacological Society, Kellogg Biological Station, MI

Wesley M. Daniel, Jared Ross, Dana M. Infante, Kyle Herreman. Assessing Alaska's river systems for improved management and conservation of fish habitats and the fisheries they support. Invited Presentation American Fisheries Society, Portland, OR

Wesley M. Daniel, Dana M. Infante, Kyle Herreman, Arthur Cooper, Yin-Phan Tsang, William W. Taylor. 2015 assessment of the Nation's fluvial fish habitats: Promoting conservation of fish habitats throughout the conterminous United States. Invited Presentation American Fisheries Society, Portland, OR

Ralph W. Tingley III, Dana M. Infante, Wesley Daniel, Yin-Phan Tsang and Kyle Herreman. Assessing Hawaii's stream habitats: Incorporation of an ecological classification of streams for improved conservation opportunities. Invited Presentation American Fisheries Society, Portland, OR

Dana M. Infante, Wesley M. Daniel, Yin Phan Tsang, Daniel Wieferich. Improving opportunities for conserving streams through national data layers and a common spatial framework: Advances in large-scale ecological investigations of aquatic systems. Invited Presentation American Fisheries Society, Portland, OR

Dana M. Infante, William W. Taylor, Wesley M. Daniel, and Yin Phan Tsang. Evaluating Inland Fisheries over Large Regions: Using a Landscape Approach to Enhance Conservation Opportunities. Invited Presentation American Fisheries Society, Portland, OR

Wesley M. Daniel, Nick Sievert, Dana M. Infante, Craig Paukert, Jana Stewart, Jodi Whittier, Tyler Wagner, Kyle Herreman, and Yin-Phan Tsang. A decision support mapper for conserving stream fish habitats of the NE CSC region. Invited Presentation Midwest Fish and Wildlife Conference, Indianapolis, IN

Wesley M. Daniel, Kay McGraw, Dana M. Infante, Gary Whelan. Working towards a large-scale assessment of mollusks: improving conservation of freshwater snails and mussels nationally. Freshwater Mollusk Conservation Society, St. Charles, MO

Wesley M. Daniel, Arthur Cooper, Pete Badra, Dana Infante. Predicting statewide habitat suitability for 11 of Michigan's listed unionids. Freshwater Mollusk Conservation Society, St. Charles, MO

Wesley M. Daniel, Nick Sievert, Dana M. Infante, Craig Paukert, Jana Stewart, Jodi Whittier, Tyler Wagner, Kyle Herreman, and Yin-Phan Tsang. FISHTAIL: A decision support mapper for conserving stream fish habitats of the NE CSC region. Invited Presentation NE CSC Spring seminar series

Dana Infante & Wesley M. Daniel. National inland assessment of fish habitat for the National Fish Habitat Partnership. Great Lakes' Nearshore Assessment Conference Call. Great Lakes Basin Fish Habitat Partnership

2014 Wesley M. Daniel, Jared Ross, Dana M. Infante, Christopher Estes. Influence of catchment-scale landscape factors on fishes of southeast Alaska: Determining condition of fluvial fish habitat for the National Fish Habitat Partnership 2015 assessment. Alaska American Fisheries Society/ American Water Resources Association, Juneau, AK.

Wesley M. Daniel, Dana Infante, Lizhu Wang, Kyle Herreman, Arthur Cooper, Daniel Wieferich, Jared Ross, Ralph Tingley, Yin-Phan Tsang. 2015 national assessment of fluvial fish habitats: Improving opportunities for conservation and management. American Fisheries Society, Quebec City, PQ

Dana M. Infante, Wesley M. Daniel, Joe Nohner, and William W. Taylor. Enhancing a National View of River Condition for Improved Management and Conservation of Fluvial Fish Habitats. American Fisheries Society, Quebec City, PQ

Michelle D. Staudinger, Evan Grant, Brian Irwin, Richard Kraus, Wes Daniel, and Jana Stewart. Climate impacts on fish and fish habitats: Case studies from the Northeast Climate Science Center. American Fisheries Society, Quebec City, PQ

Dana Infante, Wesley M. Daniel, Kyle Herreman, Janet Hsiao. National assessment of fluvial habitats: Developing data and approaches to protect and restore rivers nationally. Restore America's Estuaries, Washington D.C.

Wesley M. Daniel, Dana Infante, Arthur Cooper. National Scale Assessment of Fish Habitat: Update on Data, Analytical Plan and Proposed Products for 2015. National Fish Habitat Partnership

Damon Kruger, Dana Infante, Wesley M. Daniel. North East Climate Science Center project outline. NECSC science and data committee

2013 Wesley M. Daniel, Dana M. Infante, , Robert Hughes, Peter C. Esselman, Yin-Phan Tsang, Daniel Wieferich, Arthur R. Cooper, Kyle Herreman, Lizhu Wang, and William W. Taylor. Fish Community Threshold Response Associated with Coal and Mineral Mines in Catchments. American Fisheries Society, Little Rock, AR

Kyle Herreman, Jared Ross, Dana Infante, Wesley Daniel. Catchment creation and data attribution for stream reaches in southern Alaska: Generating data to facilitate stream research and management. American Fisheries Society, Little Rock, AR

Damon Krueger, Dana Infante, Wesley Daniel. Assessment of Columbia River Salmonid populations using a landscape approach: An application for the National Fish Habitat partnership. American Fisheries Society, Little Rock, AR

Kenneth Brown and Wesley M. Daniel. What is the role of habitat, life history and host fish in determining distributions of Louisiana mussels? American Fisheries Society, Little Rock, AR

Wesley M. Daniel, Dana M. Infante, Lizhu Wang, Yin-Phan Tsang, Arthur R. Cooper, Daniel Wieferich, Kyle Herreman, and Peter C. Esselman. Fish Habitat Conservation at a National Scale: Biases, Trends, and Future Directions. Invited Presentation Society of Freshwater Science, Jacksonville, FL

2012 Wesley M. Daniel and Kenneth M. Brown. Life History and Behavioral Adaptations of Unionid Mussels Along a River Gradient. Freshwater Mollusk Conservation Society, Guntersville, AL

Kenneth M. Brown and Wesley M. Daniel. Can an opportunistic Mussel become endangered? The case of the Inflated Heelsplitter in the Amite River. Freshwater Mollusk Conservation Society, Guntersville, AL

Wesley M. Daniel. A Tiered Aquatic Life Unit (TALU) bioassessment model based on fishes and unionid mussels in Gulf of Mexico coastal streams. Invited Presentation Michigan State University, Fisheries and Wildlife Seminar Series

2011 Wesley M. Daniel, Kenneth Brown, William Kelso, and Gerald George. Reproductive biology and host fishes of 4 unionids from Pontchartrain Basin, Louisiana. Freshwater Mollusk Conservation Society, Louisville, KY

Wesley M. Daniel, Kenneth Brown, William Kelso, and Mike Kaller. Modeling the distribution and diversity of southeastern Louisiana freshwater mussels. Freshwater Mollusk Conservation Society, Louisville, KY

Wesley M. Daniel, Kenneth Brown. LSU Benthic Ecology Lab: research in Louisiana's estuaries and rivers. Louisiana State University, Biological Sciences Department, Biological Summer Camp "BIOS"

2010 Wesley M. Daniel, Kenneth Brown, William Kelso, and Mike Kaller. Modeling factors that determine Unionid mussel abundance, distribution and diversity in Louisiana coastal plain rivers. North American Benthological Society, 2010 Santa Fe, NM

Wesley M. Daniel, Kenneth Brown. LSU Benthic Ecology Lab. Louisiana State University, Biological Sciences Department, Biological Summer Camp "BIOS"

2009 Wesley M. Daniel and Kenneth Brown. The role of fish hosts, local and landscape factors in determines unionid abundance, diversity, and community composition in

Louisiana coastal plan rivers. Freshwater Mollusk Conservation Society, Baltimore, MD

2008 Wesley M. Daniel and Jeff Jack. Wilson Creek restoration and response in food web and fish community structure. Louisiana State University Graduate Student Organization Biosymposium, Baton Rouge, LA

Wesley M. Daniel and Jeff Jack Impacts of urbanization on aquatic food webs and fish community structure across an urban -rural gradient in metro Louisville, Kentucky (USA). Kentucky Fisheries Society, Mammoth Cave National Park, KY

2007 Wesley M. Daniel, Jeff Jack, Margaret Carreiro. Impacts of urbanization on aquatic food webs across an urban -rural gradient in metro Louisville, Kentucky (USA). Current and historical perspectives. Bulletin of the North American Benthological Society 23(1):738, Columbia, South Carolina

Wesley M. Daniel, Jeff Jack, Margaret Carreiro. Evidence of Stream Food Web Alterations Due to Land-use Change Across Metro Louisville, Kentucky (USA). University of Louisville Research Symposium 2008, Louisville, KY

2006 Wesley M. Daniel, Jeff Jack, Margaret Carreiro Stream Food Web Alterations Due to Land-use Change. North American Benthological Society, Anchorage, Alaska

2005 Wesley M. Daniel and Jeffery Jack. Impacts of urbanization on aquatic food webs along an anthropogenic gradient in Louisville metro area: Current and Historical perspectives. University of Kentucky Spring Research Symposium, 2005

Wesley M. Daniel, Jeffery Jack, Randall Kelley, and William Pearson. Fish community responses to stream restoration. Bulletin of the North American Benthological Society 22(1):359, New Orleans, Louisiana

Jeff Jack and Wesley M. Daniel. Structural responses of a Stream community to a channel relocation using a natural channel design approach. Bulletin of the North American Benthological Society 22(1):248. New Orleans, Louisiana

2004 Wesley Daniel, Jeffrey Jack, and Randall Kelley. An assessment of restoration of streams draining coal mine valley fills. Bulletin of the North American Benthological Society 21(1): 539, Vancouver, British Columbia

David Word, Jeff Jack, and Wesley M. Daniel. Structural and function assessment of stream relocation. Bulletin of the North American Benthological Society 21(1): 513, Vancouver, British Columbia

2003 Wesley Daniel and Phillip Lienesch. Effects of dams on fish upstream of reservoirs. Kentucky Academy of Science, Bowling Green, KY

STUDENT PROJECT MENTOR

I assisted mentoring several underrepresented undergraduate interns from the Howard Hughes Medical institute and Louisiana Biological Research Network. I helped each student in develop of an individual research project, conducting their field/lab research, assisted with data analyses and development of their project presentation.

2012 Zach Goodnow and Wesley M. Daniel. Response of Unionidae mussels to flood conditions

2010 Gilias Taylor, Wesley M. Daniel, and Kenneth Brown. Age determination and comparison of the life span of freshwater mussels (Unionidae) using annual growth rings. Louisiana Research Network Symposium,

Curvelle Lewis, Wesley M. Daniel, and Kenneth Brown. Comparison of mark recapture verses thin sectioning techniques to age Unionidae mussel species. Annual Biomedical Research Conference for Minority Students

2009 Rayon Golding, Wesley M. Daniel, and Kenneth Brown. Testing the functional morphology of freshwater mussel shells. Louisiana Research Network Symposium

JOURNAL REVIEWER

Freshwater Science

American Malacological Bulletin

Transactions of the American Fisheries Society

Wetlands

Limnologica

COURSE INSTRUCTION

Michigan State University, Department of Fisheries and Wildlife

2015 Hydrology, Guest Lecture
Lectured on how hydrologic conductivity can influence downstream function of a catchment. Dr. Dana Infante, instructor of record.

Louisiana State University, Biological Sciences Department

2011 Principles of Ecology Lab, Teaching Assistant
Responsible for two laboratory sections for approximately 30 students in fall semester. Class included numerous field trips and in class exercises. Oversaw the development of a new mark and recapture lab under the direction of Dr. Barry Aronhime, instructor of record.

2010 Introductory Biology Lecture for majors, Section Instructor
Responsible for in class assistance including questions and weekly reviews for 750 students in the spring semester under direction of Dr. William Wischusen, instructor of record.

2007 Introductory Biology Lab for majors, Teaching Assistant
Responsible for two laboratory sections for approximately 30 students each in the fall semester under direction of Dr. William Wischusen, instructor of record.

University of Louisville, Biology Department

2004-2006 Fundamentals of Introductory Biology lab, Lead Teaching Assistant
Responsible for three laboratory sections of approximately 30 non-major students and training of new teaching assistants under direction of Dr. Arnold J. Karpoff, instructor of record.

DEPARTMENT, COMMUNITY, or PROFESSIONAL SERVICE

2015 Michigan State University, Department of Fisheries and Wildlife Symposium Judge.
Judged student presentation as part of Fish and Wildlife Graduate Student Research Symposium

2014 Interviews with the following media groups about Mining Paper in Ecological Indicators:

1. Public radio international interview 12/1/14

2. The Speaker (Columbia) http://thespeaker.co/even-single-mine-can-damage-fish-habitats-miles-downstream-study/

3. Canadian Institute of Mining 12/12/14

4. Fish Sens Magazine- http://magazine.fishsens.com/mines-make-bad-neighbors-fish-streams-afar-new-large-scale-study-shows.htm

5. AZO Cleantech- http://www.azocleantech.com/news.aspx?newsID=21076

6. Mississippi River Basin Policy Analysis- https://plus.google.com/101473675488333674529/posts/Wcp1XY42QsF

7. Science Newsline- http://www.sciencenewsline.com/summary/2014112518480010.html

8. Science daily- http://www.sciencedaily.com/releases/2014/11/141125111851.htm

9. Iowa Environmental Focus- http://iowaenvironmentalfocus.org/2014/11/25/study-mining-can-affect-fish-habitats-miles-downstream/

10. Phs.org- http://phys.org/news/2014-11-fish-habitats-downstream.html

11. Courier Journal newspaper- http://www.courier-journal.com/story/watchdog-earth/2014/12/01/mining-pollution-destroys-fish-habitat-far-downstream/19734155/

Fisheries consultant for I.M. Systems Group, Rockville, MD

Michigan State University, Department of Fisheries and Wildlife Search Committee Member. Assisted in the development of a job description, review all applications and interview candidates for Research Technologist II position.

Michigan State University, Department of Fisheries and Wildlife Symposium Judge. Judged student presentation as part of Fish and Wildlife Graduate Student Research Symposium

2013 Michigan State University, Department of Fisheries and Wildlife Symposium Judge. Judged student presentation as part of Fish and Wildlife Graduate Student Research Symposium

2012 Malacology Expert for Louisiana Wildlife Action Plans
At the request of the Louisiana Department of Wildlife and Fisheries, I assisted with state wildlife action plans assessments for state listed mollusk species.

2011 Malacology Expert for Pearl River, LA Fish Kill
After a paper mill spill, the Louisiana Department of Wildlife and Fisheries and US Fish and Wildlife asked for assistance in surveying and identification of mussel assemblages impacted by the spill. Responsibilities included leading the field survey, assisting with data analysis and preparation of final reports for the state and federal government agencies.

Louisiana State University, Biological Sciences Department, Biological Summer Camp Graduate Mentor
Mentored approximately 35 incoming freshmen biology students by introducing them to lab course work, held sessions to teach study skills, presented dissertation work and lead group study sessions.

2010 Louisiana State University, Biological Sciences Department, Biological Summer Camp “BIOS” Graduate Mentor
Mentored approximately 35 incoming freshmen biology students by introducing them to lab course work, held sessions to teach study skills, presented dissertation work and lead group study sessions.

2008-2011 Graduate Association Merchandise Commissioner
Coordinated, supervised, and developed products for fundraising to support graduate student travel awards and department activities.

2007 University of Louisville, Biology Department Graduate Association Fundraising Committee
Assisted with developing and planning innovative fundraising strategies to fund graduate student travel awards.

2006-2007 Graduate Association Seminar, Chair
Lead the planning and recruitment of recognized leaders in various fields of biology for the department’s seminar series.

2006 Kentucky Aquatic Resource Education Workshop
Workshop for local landowners and stakeholders to informed about local aquatic fauna.

2005 Louisville Champions for Children- Middle School Connection Volunteer
Conferences with seventh grade students to focus on career explorations.

2003-2007 Kentucky Water Watch, Warren County
Helped collect water samples as part of Water Watch program.

PROFESSIONAL SOCIETY SERVICE

2015 Moderated National Fish Habitat symposium at American Fisheries Society, Portland, OR

Gastropod Distribution and Status Committee, Freshwater Mollusk Conservation Society

2013 Technical Advisory Group, Bristol Bay, Alaska mining assessment, American Fisheries Society

2010-current Mussel Status and Distribution Committee, Freshwater Mollusk Conservation Society

2006-2010 Propagation and Restoration Committee, Freshwater Mollusk Conservation Society

PROFESSIONAL AFFILIATIONS

Freshwater Mollusk Conservation Society

American Fisheries Society

Society for Freshwater Science

American Malacological Society

CURRICULUM VITA

James A. Gore

Current Position: **Dean, College of Natural and Health Sciences**
Professor of Biology
University of Tampa
401 W. Kennedy Blvd.
Tampa, FL 33606-1490

EDUCATION:

B.A. (Zoology; Minor: Botany) University of Colorado (1971)
(Senior Research: A computer model of evapotranspiration rates and water availability in the Colorado alpine tundra.)

M.A. (Zoology; Minor: Geology) University of Montana (1976)
(Thesis: In-stream flow requirements of benthic macroinvertebrates in a prairie river.)

Ph.D. (Zoology; Minor: Hydrology) University of Montana (1981)
(Dissertation: Trophic ecology of mayflies (*Ephemeroptera*) in natural and laboratory streams.)

Areas of Specialization

Aquatic ecology/Hydrology/Conservation. Hydrodynamic and hydraulic change as an influence on the distribution of aquatic biota. Habitat modeling and instream flow requirements of aquatic biota as a means of regulated river management. Human impacts (primarily from energy development technologies) upon running water ecosystems, with emphasis on benthic macroinvertebrates. Habitat restoration for lotic ecosystems. Impacts and flow management of hydroelectric facilities, particularly peaking hydropower. Ecology of arid and semi-arid rivers of southern Africa. Distribution of Chironomids as indicators of the ecological integrity of wetland ecosystems. Bioassessment of lotic ecosystems using GIS filters to pick reference sites and conditions combined with physical and biological metrics to create a numerical stream classification system. Water quality and biotic distributions related to coal mine and other petroleum development technologies. Biology and ecology of invertebrates, especially aquatic insects and solpugids [Solifugidae] (sun spiders).

Professional Experience

Professor of Environmental Science (2004-2009), University of South Florida St Petersburg

- **Interim Dean** (2006-2008), College of Arts and Sciences, University of South Florida St Petersburg
- **Chair** (2004 – 2007), Environmental Science, Policy and Geography, University of South Florida St Petersburg [Tenured 2004]

Associate Professor/Professor (1996 – 2004), **Director**, Graduate Program in Environmental Science, **Chair**, Department of Environmental and Health Sciences, Columbus State University, Columbus, GA [Tenured 1998]

Adjunct Professor (1989-Present), Dept. of Biology, Tennessee Tech Univ., Cookeville, TN

Senior Scientist/Director (1994-1996) Environmental Protection Division, The Conservancy of Southwest Florida, Naples, FL

Eminent Scholar Chair in Environmental Sciences (1992-1994) Center for Environmental Research and Service, Troy State University, Troy, AL

- **While** at Troy State University, **also** served as:
- Executive Director (1992 - 1993) Choctawhatchee-Pea Rivers Watershed Management Authority, Troy, Alabama

Professor and Director of Research (1990-1992) The Center for Field Biology, Austin Peay State Univ., Clarksville, TN

Associate Professor/Assistant Professor (1981-1990) [Tenured 1986] Faculty of Biological Science, University of Tulsa, Tulsa, OK

While on the Faculty of the University of Tulsa, **also** served as:

- Visiting Professor (1989) Freshwater Research Unit, Dept. of Zoology, University of Cape Town, South Africa (**Fulbright Fellowship**)
- Guest Faculty (Summer, 1988) Univ. of Oklahoma, Biological Station, Lake Texoma - taught Reservoir and Tailwater Ecology
- Research Ecologist (1986-1988) [Water Quality Modeling Group], U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS (Sabbatical from Univ. Of Tulsa, 1986-1987, IPA assignment and research grant)
- Guest Professor (Summer, 1985) Zoologisches Institut der Universitat (T.H.), Karlsruhe, West Germany

Research Associate (1980-1981) Tennessee Cooperative Fisheries Research Unit, Tennessee Tech. Univ., Cookeville, TN (**Post-Doc)**

While working on Master's and Doctoral Degrees

- Research Aquatic Biologist (1978-1980) Water Resources Research Institute, University of Wyoming, Laramie, WY
- Instructor (1976-1978) Dept. of Zoology, University of Montana, Missoula, MT
- Research Assistant (1974-1976) Dept. of Geology, Univ. of Montana, Missoula, MT

Military Service: U.S. Navy (1971-1974) [Operational Electronics/Avionics]
Vietnam (1972-1973)

Professional Memberships

American Association for the Advancement of Science
American Fisheries Society
American Institute of Biological Sciences
American Society of Naturalists
North American Benthological Society
  (Executive Committee, 1986-1987)
  (Chair, Technical Issues Committee, 1986-1988; member, 1986 - Present)
Phi Gamma Kappa
  (Vice-President, 1985-1986)
Sigma Xi
Southern African Society of Aquatic Scientists
New Zealand Limnological Society
Phi Beta Delta (Honor Society for International Scholars)

Honors/Awards

FULBRIGHT SENIOR RESEARCH FELLOWSHIP - Council for the International Exchange of Scholars - Freshwater Research Unit, Univ. of Cape Town, South Africa - regulated river management projects - Jan 1989 - Sept 1989

U.S. Dept. of Energy/Assoc. of Western Universities Faculty Research Participation Award - Laramie Energy Technology Center, Univ. of Wyoming - toxicology research - Summer, 1983

Assoc. of Western Universities/ U.S. Dept. of Energy Fellowship - Western Research Institute, Univ. of Wyoming - toxicology of treated synfuel effluents - Summer, 1984.

Columbus State University – Faculty Research and Scholarship Award – 2000
Columbus State University – Faculty Research and Scholarship Award – 2004

Listed:	Who's Who in the South and Southwest	[Marquis] (1985, 1996, 1999-2000)
	Who's Who in Science and Engineering	[Marquis] (1989, 1995-1998, 2003-2017)
	Who's Who in America	[Marquis] (1992, 1998-2017)
	Who's Who in Medicine and Health Care	[Marquis] (1999-2003)
	Who's Who Environmental Registry	[Citation Press] (1992)
	American Men and Women of Science	(1992)
	Who's Who in the World	[Marquis] (1995-2017)
	Men of Achievement	[Melrose, UK] (1996)
	Int. Directory of Distinguished Leadership	[Amer. Biog. Inst.] (1996)
	International Who’s Who of Professionals	[2000]
	Who’s Who in America’s Teachers	[2003-2006]
	Who’s Who in American Education	[Marquis] (2004-2014)

Lifetime Achievement Award – August 2015 - International Society For River Science

Publications in Refereed Journals

[most influential (i.e., most cited) are in **bold**]

Lamouroux N., **Gore J.A.**, Lepori F. & Statzner B. (2015) The ecological restoration of large rivers needs science-based, predictive tools meeting public expectations: an introduction to the Rhône project. *Freshwater Biology* DOI:10.1111/fwb.12553

Casper, A.F., B. Dixon, J. Earls, and **J.A. Gore.** 2011. Linking a spatially explicit watershed model (SWAT) with an in-stream fish habitat model (PHABSIM): A case study of setting minimum flows and levels from a low gradient, sub-tropical river. *River Research and Applications* 27: 269-282.

Kelly, M.H., and **J. A. Gore**. 2008. Florida river flow patterns and the Atlantic Multidecadal Oscillation. *River Research and Applications* 24: 598-616.

Addison, D.S., **J.A. Gore**, J. Ryder, and K. Worley. 2002. Tracking post-nesting movements of loggerhead turtles (*Caretta caretta*) with sonic and radio telemetry on the southwest coast of Florida, USA. *Marine Biology* 141: 201-205.

Gore, J.A., J.B. Layzer, and J. Mead. 2001. Macroinvertebrate instream flow studies after 20 years: a role in stream and river restoration. *Regulated Rivers* 17: 527-542.

Gore, J.A. 2001. Models of Habitat Use and Availability to Evaluate Anthropogenic Changes in Channel Geometry. Pp 27-36 *in:* J. Dorava (ed.) **American Geophysical Union Monograph** *Geomorphic Processes and Riverine Habitat*. Water Science and Application, Volume 4.

Schuller, D., H. Brunken-Winkler, P. Busch, M. Förster, P. Janiesch, R. v. Lemm, R. Niegringhaus, H. Straßer, and **J.A. Gore**. 2000. Sustainable land use in an agriculturally misused landscape in northwest Germany through ecotechnological restoration by a "Patch-Network-Concept." *Ecological Engineering.*

Timchenko, V., O. Oksiyuk, and **J.A. Gore**. 2000. A model for ecosystem state and water quality management in the Dnieper River delta. *Ecological Engineering* 16: 119-125.

Statzner, B**., J.A. Gore**, and V.H. Resh. 1998. Monte Carlo simulation of benthic macroinvertebrate populations: Estimates using random, stratified, and gradient sampling. *J.N. Am. Benthol. Soc.* 17: 324-337.

Gore, J.A., D.J. Crawford, and D.S. Addison. 1998. An analysis of artificial riffles and enhancement of benthic community diversity by Physical Habitat Simulation (PHABSIM) and direct observation. *Regulated Rivers* 14: 69-77.

Gore, J.A., and S.W. Hamilton. 1996. A comparison of flow-related habitat evaluations downstream of low-head weirs on small and large fluvial ecosystems. *Regulated Rivers* 12: 459-469.

Gore, J.A., and F.D. Shields, Jr. 1995. Can large rivers be restored? *BioScience* 45: 142-152.

Gore, J.A., Niemela, S., Statzner, B., and V.H. Resh. 1994. Near substrate hydraulic conditions under artificial floods from peaking hydropower operation: disturbance intensity and duration. *Regulated Rivers* 9: 15-34.

Niemela S., J.B. Layzer, and **J.A. Gore**. 1993. An improved radiotelemetry method for determining use of microhabitats by fishes. *Rivers* 4: 30-35.

Gore, J.A., J.M. King, and K.C.D. Hamman. 1991. Application of the Instream flow incremental methodology (IFIM) to southern African rivers. I. Protecting endemic fish of the Olifants River. *Water SA* 17: 225-234.

Gelwick, F.P., and **J.A. Gore**. 1990. Fishes of Battle Branch, Delaware County, in northeastern Oklahoma. *Proceedings of the Oklahoma Academy of Science* 70: 13-18.

Gore, J.A., J.R. Kelly, and J.D. Yount. 1990. Application of ecological theory to determining the recovery potential of disturbed lotic ecosystems: Research needs and priorities. *Environmental Management* 14: 755-762.

Gore, J.A., and A.M. Milner. 1990. Island biogeographic theory: can it be used to predict lotic recovery rates? *Environmental Management* 14: 737-753.

Gore, J.A., and R.M. Bryant, Jr. 1990. Temporal shifts in physical habitat of the crayfish, *Orconectes neglectus* (Faxon). *Hydrobiologia* 199: 131-142.

Gore, J.A. 1989. Case histories of instream flow analyses for permitting and environmental impact assessments in the United States. *South African Journal of Aquatic Sciences* 15: 194-208. (INVITED PAPER)

Gore, J.A. 1989. Setting priorities for minimum flow assessments in Southern Africa. *South African Journal of Science* 85: 614-615.

Layzer, J.B., T.J. Nehus, W. Pennington, **J.A. Gore**, and J.M. Nestler. 1989. Seasonal variation in the composition of the drift below a peaking hydro-electric project. *Regulated Rivers* 3: 29-34.

Gore, J.A., J.M. Nestler, and J.B. Layzer. 1989. Instream flow predictions and management options for biota affected by peaking hydropower releases. *Regulated Rivers* 3: 35-48.

Statzner, B., J.A. Gore, and V.H. Resh. 1988. Hydraulic stream ecology: observed patterns and potential applications. *Journal of the North American Benthological Society* 7: 307-360.

Gore, J.A., and J.M. Nestler. 1988. Instream flow studies in perspective. *Regulated Rivers* 2: 93-101.

Gore, J.A., and R.M. Bryant, Jr. 1986. Changes in fish and macroinvertebrate assemblages along the impounded Arkansas River. *Journal of Freshwater Ecology* 3: 333-345.

Gore, J.A., and W.A. Swartley. 1985. Distribution of mayfly nymphs in relation to water quality of streams draining coal surface-mined areas on the Cumberland Plateau. *American Fisheries Society, Special Publication, Water Quality Section*, pp. 59-73.

Gore, J.A. 1984. Comment: Potential errors in P/R measurements by the methods of Pavletic, Matonickin, Stilinovic, and Habdija. *Hydrobiologia* 118: 213-214.

Gore, J.A. 1983. The distribution of desmognathine larvae (Amphibia: Plethodontidae) in coal surface mine impacted streams of the Cumberland Plateau, USA. *Journal of Freshwater Ecology* 2: 12-23.

Gore, J.A 1982. Benthic invertebrate colonization: source distance effects on community composition. *Hydrobiologia* 94: 183-194.

Gore, J.A., and R.D. Judy, Jr. 1981. Predictive models of benthic macroinvertebrate density for use in instream flow studies and regulated flow management. *Canadian Journal of Fisheries and Aquatic Science* 38: 1363-1370.

Gore, J.A., and L.S. Johnson. 1981. Restoration of surface mined rivers in the Northern Great Plains. *Water Spectrum* 13: 31-38.

Gore, J.A. 1980. Ordinational analysis of benthic communities upstream and downstream of a prairie storage reservoir. *Hydrobiologia* 69: 33-44.

Gore, J.A., and B.S. Cushing. 1980. Observations on temporary foraging areas and burrows of the sun spider, *Ammotrechula penninsulana* (Banks) (Arachnida: Solpugida). *Southwestern Naturalist* 25: 95-102.

Gore, J.A. 1979. Patterns of initial benthic recolonization of a reclaimed coal strip-mined river channel. *Canadian Journal of Zoology* 57: 2429-2439.

Gore, J.A. 1978. A technique for predicting the in-stream flow requirements of benthic macroinvertebrates. *Freshwater Biology* 8: 141-151.

Gore, J.A. 1977. Reservoir manipulations and benthic macroinvertebrates in a prairie river. *Hydrobiologia* 55: 113-123.

Gore, J.A., D.S. Addison, S.C. Nichols, D.W. Ceilley, and P.A. Stansly (Submitted) The distribution of larval midge (Diptera: Chironomidae) assemblages in isolated wetlands of south Florida. *Amer. Midl. Nat.*

Gore, J.A., and W.F. McTernan. (Submitted) Composition and macroinvertebrate toxicity of synfuel effluent waters. *Arch. Environ. Contam. Toxicol.*

Manuscripts in Review

Addison, D.S., J.A. Gore, E. Odgaard, and D. Cassill. An assessment of long-term fecundity and hatchling production in a population of loggerhead turtles (*Caretta caretta*) from a nesting beach in Southwest Florida, USA. *Journal of Herpetology*

Manuscripts in Preparation

Gore, J.A., V.H. Resh, and B. Statzner. Physical habitat shifts in final instars of *Hydropsyche angustipennis* (Curtis).

Gore, J.A., J.H. O'Keeffe, and A.A. Fouts. Application of the instream flow incremental methodology (IFIM) to southern African rivers. II. Prediction of relative abundances of fish and benthos at minimum flows.

Gore, J.A., and J.M. King. Application of the instream flow incremental methodology (IFIM) to southern African rivers. III. IFIM evaluations of flows to restore ecosystem integrity.

Gore, J.A., and P.M. Jones. Distribution of Chironomidae in the mainstem Chattahoochee River and cumulative impacts of a combination of low and high-head impoundments.

Olson, J.R., J.A. Gore, and M. Barbour. A GIS-based method for choosing candidate reference streams in the ecoregions of Georgia: Comparisons with *best professional judgement.*

Gore, J.A., W.S. Birkhead, D.L. Hughes, S.L. Nichols, and T.W. Roever. Recovery and colonization dynamics of macroinvertebrates and fish in newly created habitat after sediment remediation from manufactured gas processing waste in the Oconee River.

Gore, J.A. Balancing reservoir releases, electric power demands, and instream biotic habitat in the Roanoke River system. [Invited by Transactions of the American Fisheries Society]

Professional Presentations

Vietnam War Colloquium. Columbus, GA (Fort Bennting). 2013. **INVITED TALK:** Reflections of an Environmental Scientist in Vietnam.

FMCS Workshop on Environmental Flows, Athens, GA. 2012. **INVITED PLENARY TALK:** How much water does a healthy mollusk need? Water abstraction, mollusk conservation and the science and practice environmental flows.

Southeast Regional Sea Turtle Meeting, Jekyll Island, GA. 2012. Presented Paper: Making More Turtles One Season at a Time - Insights from Ten Reproductive Cycles by a Very Persistent Loggerhead Turtle.

The conservation and management of rivers: 20 years on. 2011. York, UK. Presented Paper: Defining 'significant harm' for the evaluation of minimum flows and levels in subtropical Florida rivers.

North American Benthological Society/American Society of Limnology and Oceanography Joint Meeting: 2010. Santa Fe, NM. Special Symposium on Global Climate Change. **INVITED TALK:** Application of the Atlantic Multidecadal Oscillation (AMO) as a surrogate for the initial phases of climate change: Shifts in community composition and management decision for Southeastern, USA, rivers.

North American Benthological Society. 2009. Grand Rapids, MI. Presented Paper: Analysis of the effectiveness of an urban stormwater best management practice on Weracoba Creek, Georgia, using the rapid bioassessment protocol.

Environmental Flows—Water for People and Nature in the Southeast. Southeastern Environmental Flows Partnership (SEFlows). 2008. Athens, GA. Presented Paper: Accounting for Long-term Oscillations in Flow Regimes for Management of Rivers of the Southeast.

Weracoba Creek Water Quality Improvement Workshops. 2008. Columbus, GA. **INVITED TALK**: An analysis of the effect of the BMP on Weracoba Creek macroinvertebrates using the Rapid Bioassessment Protocol.

North American Benthological Society. 2008. Salt Lake City, UT. Presented Paper: The Atlantic Multidecadal Oscillation (AMO) as a surrogate for climate change in the southeastern United States.

North American Benthological Society. 2008. Salt Lake City, UT. Poster: A surrogate model for future regional climate change: The current affects of the Atlantic Multidecadal Oscillation and its influence on the ecohydrology of Great Lakes and New England rivers.

North American Benthological Society. 2008. Salt Lake City, UT. Paleoreconstruction of tree island hydroperiods using fossilized invertebrate remains. (Charlotte C. Svoboda, J.A. Gore, J.M. Smoak and Binhe Gu.)

Homeland Security Medical Executive Course (HLSMEC) / Defense Medical Readiness Training Institute's (DMRTI). 2008. Jacksonville, FL. **INVITED TALK:** Water Security in an All-Hazards Incident.

North American Benthological Society. 2007. Columbia, South Carolina. Presented Paper: Evaluating the Efficacy of Water Quality Sampling Strategies: Blending Sensor Technology, Robotics, and Geospatial Analysis Reveals Important Reach-Scale (10-100m) Environmental Heterogeneity in Rivers

4th North American Reservoir Symposium. Balancing Fisheries Management and Water Uses for Impounded River System. 2007. Atlanta, GA, **INVITED TALK**: Balancing reservoir releases, electric power demands, and instream biotic habitat in the Roanoke River system.

Homeland Security Medical Executive Course. 2007. Reno, NV. **INVITED TALK:** Water Security in a CBRNE Incident.

Environmental Monitoring and Assessment Program. Great River Ecosystems Reference Condition Workshop. 2006. Cincinnati, OH. **INVITED TALK**: The use of a GIS-based system to recreate historical/reference conditions of large rivers in Florida.

Tenth International Symposium on Regulated Streams. 2006. Stirling, Scotland. **PLENARY PAPER**: Florida river flow patterns and the Atlantic Multidecadal Oscillation (AMO).

Tenth International Symposium on Regulated Streams. 2006. Stirling, Scotland. Presented Paper: The Atlantic Multidecadal Oscillation (AMO) and its influences on instream flow analysis and management decisions: Examples from Florida, USA, rivers.

25th Annual Symposium on Sea Turtle Conservation and Biology. 2005. Savannah, GA. An assessment of long-term fecundity, philopatry, and the "luck-of-the-draw" of loggerhead turtles (*Caretta caretta*) on a nesting beach in Southwest Florida, U.S.A. (with David S. Addison)

American Geophysical Union/North American Benthological Society. 2005. New Orleans, LA. Special Session: Geological and Biological Perspectives in Stream Restoration: **INVITED PAPER**: Computer applications to river and stream restoration : some case studies and recommendations.

South Florida Water Management District. Kissimmee, Florida. 2005. Kissimmee Chain of Lakes Long Term Management Plan and Conceptual Ecosystem Model evaluation. **INVITED TALK**: Macroinvertebrates.

North American Benthological Society. 2004. Vancouver, BC. Presented Paper: Speculation on habitat loss and community change in rivers impacted by long-term flow Increases from proposed coal bed methane production in the Northern Great Plains.

North American Benthological Society. 2004. Vancouver, BC. Presented Paper: Stream reference conditions using discriminating invertebrate indices for ecoregions of Georgia. (with Duncan Hughes)

North American Benthological Society. 2004. Vancouver, BC. Presented Paper: Taxonomic Resolution: Cost v. Benefits (with Jodi Williams)

North American Benthological Society. 2004. Vancouver, BC. Presented Paper: Should mean catchment slope be added as a metric to the Rapid Bioassessment Protocol? (with George Williams)

North American Benthological Society. 2004. Vancouver, BC. Presented Paper: The effects of nutrients on macroinvertebrates in Georgia. (with P. Michele Brossett)

11th International Petroleum Environmental Conference. 2004. Albuquerque, NM. **INVITED PAPER**: Changes in community structure after habitat loss and potential changes in water quality in Northern Great Plains Rivers impacted by long-term flow increases resulting from CBM production.

Instream Flow Science and Management in Western Washington: Developing a Comprehensive, Ecosystem-Based Approach. 2003. Seattle, WA. **INVITED PAPER**: Effects of streamflows on aquatic and riparian biota (excluding salmonids).

Southeast Chapter, Society for Environmental Toxicology and Chemistry. 2003. Columbus, GA. **KEYNOTE TALK**. The Georgia Ecoregions Project - Assessing Stream Ecosystem Integrity from NPS Pollution: Is there a linkage to TMDL's?

Ninth International Conference on River Research and Applications. 2003. Albury, NSW, Australia. Presented Paper: Recovery and colonization dynamics of macroinvertebrates and fish in newly created habitat after sediment remediation from manufactured gas processing waste in the Oconee River, Georgia, USA.

Colloquium Series. 2003. University of South Florida St. Petersburg. Environmental Science, Policy, and Geography. **INVITED SPEAKER**: Minimum flow assessments in central Florida Rivers: first attempts and new considerations.

10th International Petroleum Environmental Conference. 2003. Houston, TX. **INVITED PAPER**: Potential habitat loss and population bottlenecks created by increased flows from CBM operation.

International Association for Sediment Water Science (**IASWS**) Ninth International Symposium, Banff, CANADA. 2002. Recovery and structure of aquatic communities after MGP sediment remediation and habitat rehabilitation.

North American Benthological Society. 2002. Pittsburgh, PA. Presented Paper: Recovery and structure of benthic communities after MGP sediment remediation and habitat rehabilitation.

9th International Petroleum Environmental Conference. 2002. Albuquerque, NM. **INVITED PAPER**: Analysis of habitat loss for target biota in rivers impacted by long-term flow increases resulting from CBM production in the Powder River basin.

Georgia Water & Pollution Control Association. 2002. Dalton, GA. **INVITED PAPER**: The Georgia Ecoregions Project: Assessing nonpoint source impacts in reference and impaired streams.

North American Benthological Society. 2001. LaCrosse, WI. Using GIS and landuse data to select candidate reference sites for stream bioassessment.

North American Benthological Society. 2001. LaCrosse, WI. Macroinvertebrate bioassessment detects the impacts of three years of drought in the catchment of the middle Chattahoochee River.

Atlanta Constorium for Research in the Earth Sciences. 2001. Atlanta, Ga. **INVITED LECTURE**: Ecohydrological models for use in regulated river management and stream restoration.

Murray-Darling Freshwater Research Center. 2001. Albury, NSW, Australia. **INVITED LECTURE**: Instream flows, politics, and engineers?

Water Environment Federation. WEFTEC. 2001. Atlanta, GA. WERF: Technology and Watershed Assessment: Application to Reasonable Assurance Determinations in Columbus, Georgia. Presented Paper: Macroinvertebrates survey and biotic indices.

SEMP Ecosytem Management Program. 2001. Columbus, GA. **INVITED LECTURE**: The Georgia Ecoregions Project.

Gas Technology Institute. GTI's 14th International Conference on Site Remediation Technologies & Environmental Management in the Utility Industry. 2001. Orlando, FL. Presented Paper: Recovery and structure of benthic and fish communities after habitat rehabilitation: Athens, Georgia, MGP excavations.

Eighth International Symposium on Regulated Streams. 2000. Toulouse, France. **INVITED PAPER**: Macroinvertebrate instream flow studies after 20 years: a role in stream and river restoration.

Georgia Chapter, American Fisheries Society. 1999. Tifton, GA. **INVITED PRESENTATION**: Is there value in using benthic macroinvertebrates in in-stream flow decisions

19th Annual Symposium on Sea Turtle Biology and Conservation. 1999. South Padre Island, TX. Presented Paper: Early post-nesting movements of loggerhead turtles (*Caretta caretta*) on the southwest coast of Florida.

International Conference on Modeling for the Twenty-First Century, Predicting Plant and Animal Occurrences: Issues of Scale and Accuracy. 1999. Snowbird, UT. **INVITED PAPER**: Macroinvertebrates in instream flow management: issues of density, diversity, and taxonomic scale.

WERF Workshop to Develop Research Framework to Assess Ecosystem Effects Relative to the Scale and Dynamics of Large River System. 1999. Chicago, IL. **INVITED PAPER**: Summary report: US EPA Large Rivers Science Advisors workshop in Baltimore.

Cooperative Research Center for Freshwater Ecology, Albury, NSW Australia. 1998. **INVITED WORKSHOP** (full day): The future of stream and river rehabilitation and restoration.

Department of Biology, Monash University, Caulfield East, VIC Australia. 1998. **INVITED WORKSHOP** (full day): The future of stream and river rehabilitation and restoration.

North American Benthological Society. 1998. Prince Edward Island, Canada. **INVITED PRESENTATION:** Large River Restoration: Lessons yet to be learned.

Workshop on Instream Flow Assessments. 1997: T.G. Masaryk Institute of Hydrology; Prague, Czech Republic. **INVITED PRESENTATION**: Field analysis and PHABSIM application of macroinvertebrate habitat suitability criteria. [Funded by the United States Department of State]

Seventh International Symposium on Regulated Streams (SISORS III). 1997. Chattanooga, TN. Presented Paper: Macroinvertebrates in instream flow studies: What are the appropriate targets for management?

North American Benthological Society. 1996. Kalispell, MT. Presented Paper: Longitudinal shifts in high quality macroinvertebrate habitat as flows fluctuate across an artificial riffle.

Ecohydraulics 2000. 1996. Quebec City, Quebec. Presented Paper: An analysis of artificial riffles and enhancement of benthic community diversity by Physical Habitat Simulation (PHABSIM) and direct observation.

American Water Resources Association. 1996. Syracuse, New York. **INVITED KEYNOTE PAPER**: Blending biological and physical considerations in riverine restorations.

North American Benthological Society. 1995. Keystone, CO. **INVITED PAPER**: The use of benthic macroinvertebrate community diversity as a "target species" in instream flow assessments. (invited as organizer/chair of Technical Information Workshop on applications of benthos in instream flow studies)

Symposium on Water Quality: Freshwater Quality: Defining the Indefinable? 1995. Stirling, Scotland. **INVITED PLENARY PAPER**: Current interpretations of the term 'freshwater quality': a non-European perspective.

Symposium on Remedial Strategies in Regulated Rivers. 1995. Lycksele, Sweden. **INVITED PLENARY PAPER**: Flow-related habitat requirements as a component of remediation in regulated rivers.

North American Benthological Society. 1994. Orlando, FL. **INVITED PAPER**: Using physical habitat models to aid in the design, placement and timing of instream habitat structures.

American Power Conference. 1994. Chicago, IL. **INVITED PAPER**: New methods for instream flow assessments related to hydropower development.

International Conference on Sustaining the Ecological Integrity of Large Floodplain Rivers. 1994. La Crosse, WI. **INVITED PAPER**: Managed floods on floodplain rivers: is hydraulic disturbance offset by ecological benefit?

Sixth International Symposium on Regulated Streams (SISORS II). 1994. Ceske Budejovice, Czech Republic. Presented Paper: Habitat partitioning among co-existing darter species (Percidae) in parallel catchments. Implications for instream flow analysis using target fish species.

Sixth International Symposium on Regulated Streams (SISORS II). 1994. Ceske Budejovice, Czech Republic. Presented Paper: Disturbance risk as a measure of habitat suitability for benthos below a peaking hydropower project.

First IAHR Symposium on Habitat Hydraulics. 1994. Trondheim, Norway. Presented Paper: Combining colonization rates and hydraulic criteria for prediction of restoration success in streams and rivers.

Symposium on Aquatic Habitat Restoration in Northern Ecosystems. 1994. Girdwood, AK. **INVITED PAPER**: The science of restoration: facts and fiction.

Symposium on Aquatic Habitat Restoration in Northern Ecosystems. 1994. Girdwood, AK. **INVITED PAPER**: Applying island biogeographic theory to river and stream restoration.

Fifth Symposium on The Natural History of Lower Tennessee and Cumberland River Valleys. 1993. Land Between The Lakes, Tennessee. Presented Paper: Best management practices for improving water quality in the West Sandy Creek watershed, Henry County, Tennessee.

New Zealand Limnological Society. 1993. Wellington, New Zealand. **INVITED SPECIAL WORKSHOP**: Stream and River Restoration. [Conducted two days of 8-hour sessions].

National Institute of Water and Atmospheric Research. 1993. Hamilton, New Zealand. **INVITED PAPER**: Problems associated with the management of endangered species and river ecosystems in developing nations.

Riparian Habitat Protection and Reconstruction Workshop. 1993. Clarksville, TN. **INVITED PAPER**: Habitat enhancement using instream sediment control structures.

Ecological Society of America. 1993. Madison, WI. **INVITED PAPER**: Ecological considerations in the design of restoration projects on large rivers.

Association for Integrative Studies. 1993. Detroit, MI. Presented Paper: An approach to the development of interdisciplinary graduate programs in environmental analysis and management.

North American Benthological Society. 1992. Louisville, KY. Presented Paper: Use of physical habitat models to predict relative abundances of benthos downstream of multiple impoundments in the Buffalo River (eastern Cape Province), South Africa.

Auburn University. Dept. of Biology/Coop. Fish. Res. Unit. 1992. Auburn, AL. **INVITED SEMINAR**: Southeastern streams and the hydrodynamics associated with macroinvertebrate populations; plus IFIM.

International Environmental Dredging Symposium. 1992. Buffalo, NY. **INVITED PLENARY PAPER**: Predicting enhancement and recovery times after placement of habitat structures for fish and benthos in erosional zones.

Phi Beta Kappa Symposium on Development and the Environment. 1992. Tulsa, OK. **INVITED PAPER**: Water resource management in southern Africa: ecosystem stability and human consumption.

University of New Orleans. Dept. of Biology. 1991. **INVITED SEMINAR**: Application of physical habitat models for conserving endangered aquatic fauna in southern Africa.

Louisiana Nature and Science Center. 1991. New Orleans, LA. **THE ANNUAL FREEPORT-MCMORAN LECTURE**: A biologist's view of South Africa.

North American Benthological Society. 1991. Santa Fe, NM. Presented Paper: Near-substrate hydraulic conditions under artificial flood conditions.

Hancock Biological Station. 1991. Murray, KY. Summer seminar series. **INVITED SEMINAR**: Conserving endangered aquatic biota in southern Africa through application of physical habitat models.

United States Environmental Protection Agency. National Workshop: Water Quality-Based Approach for Point Source and NPS Controls. 1991. Chicago, IL. **INVITED PAPER**: Application of tools for ecological restoration - predictive modeling.

Fifth International Symposium on Regulated Streams. 1991. Flathead Biological Station, MT. Presented Paper: Use of physical habitat models to predict relative abundances of biota downstream of multiple impoundments in the Buffalo River (eastern Cape Province), South Africa.

East Tennessee State University, Dept. of Biology. 1991. Johnson City, TN. **INVITED SEMINAR**: Application of habitat models in the management of endangered aquatic fauna of southern Africa.

Tennessee Tech University, Dept. of Biology. 1991. Cookeville, TN. **INVITED SEMINAR**: Application of habitat models for protecting endangered aquatic fauna in southern African rivers.

Seventh Annual Scientific Symposium of the Ohio River Basin Consortium. 1991. Murray State University, Murray, KY. Presented Paper: Special considerations in the development of predictions of ecological effects from modification of peaking hydropower operations.

Center for Field Biology. 1990. Third Annual Symposium, The Natural History of Lower Tennessee and Cumberland River Valleys. Land-Between-The-Lakes, TN. **INVITED PAPER**: The affect of varying flow rates on colonization rates and the ability to predict recovery from disturbance in lotic ecosystems.

Symposium on River and Stream Management. 1990. Indiana Dept. Env. Mgmt./Indiana Wildlife Society. Muncie, IN. **INVITED PAPER**: The role of instream flow studies in regulated river management.

North American Benthological Society. 1990. Blacksburg, VA. Presented Paper: *Hippopotamus amphibius*, a "benthic" indicator for flow-related habitat in southern Africa.

Wetlands Delineation Workshop (Tennessee Div. of Water Poll. Contr./US EPA) 1990. Tech Aqua Biol. Stn., TN. **INVITED PAPER**: An overview of stream restoration practices.

International Conference on the Conservation and Management of Rivers. 1990. Univ. of York, Peterborough, UK. Presented Paper: A non-traditional application of instream flow techniques for conserving habitat of biota in the Sabie River of southern Africa.

International Conference on the Conservation and Management of Rivers. 1990. Univ. of York, Peterborough, UK. Presented Paper: The use of instream flow techniques for evaluating freshwater mussel habitats and predicting flow-related loss of mussel beds.

Freshwater Research Unit, University of Cape Town, South Africa. 1989. **INVITED SEMINAR**: Techniques for predicting minimum flow requirements in lotic ecosystems: application of the physical habitat simulation (PHABSIM).

Department of Water Affairs, Pretoria, South Africa. 1989. **INVITED SEMINAR**: A survey of instream flow techniques, the computer simulation PHABSIM, and possible applications to southern Africa rivers.

Institute for Freshwater Research/J.L.B. Smith Institute of Ichthyology/Department of Zoology, Rhodes University, Grahamstown, South Africa. 1989. **INVITED SEMINARS**: (1) Theory and field techniques in instream flow analysis. (2) Are lotic organisms adapted to flow?

North American Benthological Society. 1989. Guelph, Ontario. Presented Paper: Application of ecological theory to determining the recovery potential of disturbed lotic ecosystems: research needs and priorities.

Symposium on Water: Laws and Management. 1989. Cape Town, South Africa. **INVITED PAPER**: Case histories of instream flow assessments to meet U.S. regulatory requirements.

Zoology Department/University of Cape Town. 1989. Cape Town, South Africa. **INVITED COLLOQUIUM**: Are lotic organisms adapted to flow and what are the implications to ecological theory?

Department of Zoology/Department of Botany/Institute of Natural Resources, University of Natal, Pietermaritzburg, South Africa. 1989. **INVITED SEMINAR**: Development and application of minimum flows to riverine ecosystems.

American Fisheries Society. 1989. Ann. Mtg. Anchorage, AK. Presented Paper: Altering physical habitat simulations to account for responses of rainbow trout and banded sculpin to peaking hydroelectric discharges.

Fourth South African National Hydrological Symposium. 1989. Pretoria. Presented Paper: Application of the revised physical habitat simulation (PHABSIM II) to minimum flow evaluations of South African rivers.

U.S. Fish and Wildlife Service, National Conf. on Instream Flow and Restoration Techniques. 1988. Atlanta, GA. **INVITED PAPER**: Case history study of the application of IFIM techniques to river restoration.

North American Benthological Society. 1988. Tuscaloosa, AL. Presented Paper: Changes in larval chironomid habitat with distance from peaking hydropower operations.

Fourth International Symposium on Regulated Streams. 1988. Loughborough, England. **INVITED KEYNOTE PAPER**: Instream flow predictions and management options for biota affected by peaking-power hydroelectric operations.

Fourth International Symposium on Regulated Streams. 1988. Loughborough, England. Presented Paper: Benthic macroinvertebrate communities below a hydropower dam, Caney Fork River, Tennessee, USA.

Fourth International Symposium on Regulated Streams. 1988. Loughborough, England. Presented Paper: Seasonal variation in the composition of the drift below a peaking hydroelectric project.

Texas Instream Flow Workshop. 1988. San Marcos, TX. **INVITED PAPER**: Techniques and limitations of instream flow models for peaking hydropower impacts. [Invited as participant on National Expert Panel]

U.S. Environmental Protection Agency. National Symposium: Recovery of lotic ecosystems following disturbance: theory and application. 1988. Duluth, MN. **INVITED PAPER**: Island biogeographic and predicting lotic community recovery rates and pathways.

U.S. Environmental Protection Agency. National Symposium: Recovery of lotic ecosystems after disturbance: theory and application. 1988. Duluth, MN. **INVITED PAPER**: Summary and synthesis of research needs and application to EPA regulatory functions.

Sixth Annual Fisheries and Limnology Colloquium. 1987. Land-Between-The-Lakes, Kentucky. **INVITED PAPER**: Research needs for instream flow assessments.

National Science Foundation. Workshop on Prairie Stream Ecology. 1987. Univ. of Oklahoma, Biol. Stn., Lake Texoma, OK. **INVITED PAPER**: Applied hydraulics in stream research.

North American Benthological Society. 1987. Orono., ME. **INVITED PLENARY SESSION PAPER**: Physical habitat simulations for benthos applied to stream management.

American Fisheries Society, Warmwater Fish. Div. Workshop on application of instream flow methodologies to warmwater fisheries. 1987. Tech Aqua Biol. Stn., TN. **INVITED PAPER**: Macroinvertebrate instream flow studies: needs and levels of precision.

American Fisheries Society, Warmwater Fish. Div. Workshop on application of instream flow methodologies to warmwater fisheries. 1987. Tech Aqua Biol. Stn., TN. Presented Paper: Problems in applying IFIM to warmwater river ecosystems.

Waterways Experiment Station. 1986. Vicksburg, MS. **INVITED SEMINAR**: Modifications and alternatives for instream flow models predicating the effects of flow alterations on benthic invertebrates.

North American Benthological Society. 1986. Lawrence, KS. Presented Paper: Stream hydraulics as a determinant of microhabitat shifts in the crayfish, *Orconectes neglectus* (Faxon).

Fifth International Symposium on Trichoptera. 1986. Lyon, France. Presented Paper: Physical habitat characteristics and microdistribution of final instars of *Hydropsyche angustipennis* (Curtis).

European Entomological Congress. 1986. Amsterdam, The Netherlands. Presented Paper: Microdistribution of *Aphelocheirus* in relationship to physical characteristics of the stream reaches.

Workshop on Environmental Aspects of Local Flood-Protection Projects. 1986. Waterways Experiment Station, Vicksburg, MS. Presented Paper: The physical habitat simulation (PHABSIM) system: overview and potential application to local flood-protection projects.

North American Benthological Society. 1985. Corvallis, OR. Presented Paper: Diet and habitat preference of four co-existing darter species in an Ozark stream.

Third International Symposium on Regulated Streams. 1985. Edmonton, Alberta. **INVITED PLENARY SESSION PAPER**: Development and application of macroinvertebrate instream flow models for regulated flow management.

North American Benthological Society. 1984. Raleigh, NC. Presented Paper: Comparison of toxicity of treated condensate from underground coal gasification to *Daphnia* and selected mayfly species.

Univ. of Texas-Dallas, Environ. Sci. Colloquium. 1984. Dallas, TX. **INVITED PAPER**: Composition and toxicity of synfuel effluents to *Daphnia* and selected mayfly species.

North American Benthological Society. 1983. LaCrosse, WI. Presented Paper: Distribution of benthic macroinvertebrates along the impounded Arkansas River.

American Fisheries Society. 1983. Ann. Mtg. Milwaukee, WI. **INVITED PAPER**: Distribution of mayfly nymphs in relation to water quality of streams draining coal surface-mined areas on the Cumberland Plateau.

North American Benthological Society. 1982. Ann Arbor, MI. Presented Paper: Effects of metals and other strip mine pollutants on benthic communities in the New River drainage, Tennessee.

North American Benthological Society. 1981. Provo, UT. **INVITED PAPER**: Macroinvertebrate instream flow habitat preferenda: a component of regulated flow management in the Rocky Mountains.

Ann. Mtg., South. Div., Amer. Fish. Soc. and Southeastern Assoc. Fish. Wildl. Agencies. 1981. Tulsa, OK. Presented Paper: Chironomid communities as indicators of water quality affected by acid mine drainage.

American Society of Limnology and Oceanography. 1980. Los Angeles, CA. **INVITED PAPER**: Colonization theory applied to benthic stream ecosystems.

North American Benthological Society. 1980. Savannah, GA. **INVITED PAPER**: Models of biotic recovery in strip mined river channels.

American Fisheries Society, CO-WY Chapter. 1979. Laramie, WY. Presented Paper: Fisheries recolonization of a channel of the Tongue River reclaimed after coal strip mining.

First International Symposium on Regulated Streams. 1979. Erie, PA. **INVITED PAPER**: An ordinational analysis of benthic communities influenced by a prairie irrigation reservoir.

North American Benthological Society. 1979. Erie, PA. Presented Paper: Trends in recolonization and diversity of benthos in a reclaimed coal strip-mined river.

National Symposium on Strategies for Fish and Wildlife Mitigation (The Mitigation Symposium). 1979. Fort Collins, CO. Presented Paper: Biotic recovery of reclaimed channels after coal strip mining.

North American Benthological Society. 1978. Winnipeg, Manitoba. Presented Paper: A dendrogram analysis of long-term effects of channelization on stream benthos.

American Society of Limnology and Oceanography. 1977. San Francisco, CA. Presented Paper: In-stream flow requirements of benthic macroinvertebrates as a means of minimum flow recommendations.

North American Benthological Society. 1976. LaCrosse, WI. Presented Paper: Effects of temporary massive flow reductions on benthic invertebrates of a prairie river.

Fort Union Coal Field Symposium. 1975. Billings, MT. Presented Paper: Fall-winter distribution of benthic macroinvertebrates in the Tongue River, Montana.

Books/Chapters

[most influential (i.e., most cited) are in **bold**]

Gore, J. A., and J. Banning. 2016. Discharge Measurements and Streamflow Analysis. pp. 51-77 *in*: F.R. Hauer and G.A. Lamberti (eds.) *Methods in Stream Ecology*. (3^{nd} Edition). Academic Press, San Diego, CA.

Gore, J.A., J. Banning, and A.F. Casper. 2015. River Resource Management and the Effects of Changing Landscapes and Climate. *In*: D.J. Gilvear, M.T. Greenwood, M.C. Thoms, and P.J. Wood (eds.) *River Science: Research Applications for the 21st Century*. John Wiley and Sons, Chichester. (IN PRESS)

Hughes, D.L, P.M. Brossett**, J.A. Gore**, and J.R. Olson (eds.) 2010. ***Rapid Bioassessment of Stream Health.*** Taylor & Francis Group/CRC Press, Boca Raton, FL.

Chapter 1: **Introduction** *James A. Gore, Duncan L. Hughes, Michele P. Brossett, and Amanda M. Herrit*

Chapter 3: **Rapid Bioassessment Materials and Methods** *Michele P. Brossett, Duncan L. Hughes, John R. Olson, and James A. Gore*

Chapter 4: **Candidate Reference Conditions.** *John R. Olson, Duncan L. Hughes, James A. Gore, P. Michele Brossett*

Chapter 5: **Development of Ecoregional and Sub-ecoregional Reference Conditions.** *Duncan L. Hughes, John R. Olson, P. Michele Brossett, and James A. Gore*

Chapter 6: **A Numerical Index of Stream Health.** *Amanda M. Harrit, Duncan L. Hughes, James A. Gore, and P. Michele Brossett*

Chapter 7: **The Effect of Sample Size on Rapid Bioassessment Scores.** *Uttam Rai, James A. Gore, Duncan L. Hughes and P. Michele Brossett*

Chapter 8: **Taxonomic Resolution and Cost Effectiveness of Rapid Bioassessment.** *Jodi A. Williams, James A. Gore, and P. Michele Brossett*

Chapter 9: **Quality Assurance / Quality Control: What Does It Reveal About the Reliability of the Rapid Bioassessment Protocol?** *Tracy J. Ferring, James A. Gore, and Duncan L. Hughes*

Chapter 10: **The Use of Rapid Bioassessment to Assess the Success of Stormwater Treatment Technologies (BMPs) in Urban Streams.** *Erik Oij, James Banning and James A. Gore*

Chapter 11: **Implementation of the Rapid Bioassessment Protocol.** *Michele P. Brossett, Duncan L. Hughes, Michele de la Rosa and James A. Gore*

Gore, J.A., and J. Mead. 2008. The Benefits and Dangers of Ecohydrological Models to Water Resource Management Decisions. Pp. 112 – 137. *In:* D. Harper, M. Zalewski, and N. Pacini (eds.) *Ecohydrology: Processes, Models and Case Studies. An approach to the sustainable management of water resources.* CABI Publ., London.

Gore, J.A., J. Mead, T. Penczak, L. Higler and J. Kemp. 2008. Processes Influencing Aquatic Fauna. Pp. 62- 87. *In:* D. Harper, M. Zalewski, and N. Pacini (eds.) *Ecohydrology: Processes, Models and Case Studies. An approach to the sustainable management of water resources.* CABI Publ., London.

Gore, J. A. 2006. Discharge Measurements and Streamflow Analysis. pp. 51-77 *in*: F.R. Hauer and G.A. Lamberti (eds.) *Methods in Stream Ecology*. (2nd Edition). Academic Press, San Diego, CA.

Gore, J.A. 2005. Water Regime Fluctuations – methods and assessment. *In:* G. Ziglio, M. Siligardi, and G. Flaim (eds.) *Biological Monitoring of Rivers: Applications and Perspectives.* John Wiley & Sons, London.

Gore, J.A. 2004. A experiência de reuperaçã e restauro de cursos de água nos Estados Unidos. Pp. 497-516 *in*: I. Moreira, G. Saraiva, and F. Nunes Correia (eds.) *Gestão ambiental de sistemas fluviais. Aplicação à bacia hidrográfica do rio Sado.* ISA Press, Lisboa (Lisbon), Portugal.

Gore, J.A. 2002. Endangered Species. *In:* B.A. Stewart and T. Howell (eds.) *The Encyclopeida of Water Science*. Marcel Dekker, Inc., New York.

Gore, J.A. 1997. "Water Quality" in the United States: Evolving perspectives and public perception. pp. 69-85 *in:* P.J. Boon and D.L. Howell (eds.) *Freshwater Quality: Defining the Indefinable?* HMSO, The Stationery Office, Edinburgh.

Gore, J.A. 1996. Forward. *in*: A.Brookes and F.D. Shields, Jr. (eds.) *River Channel Restoration*. Wiley, Chichester.

Gore, J.A. 1996. Discharge measurements and Streamflow Analysis. Pp.53-74 *in*: F.R. Hauer and G. A. Lamberti (eds.) *Methods in Stream Ecology*, Academic Press, San Diego.

Gore, J.A. 1996. Responses of Aquatic Biota to Hydrological Change. pp. 209-230 *in*: P. Calow and G.E. Petts (eds.) *River Biota. Diversity and Dynamics*. Blackwell Sci., Publ., Oxford.

Gore, J.A., F.L. Bryant, and D.J. Crawford. 1995. River and Stream Restoration. pp. 245 - 275 *in*: J. Cairns, Jr. (ed.) *Rehabilitating Damaged Ecosystems. Second Edition.* Lewis Publ., Chelsea, MI.

Gore, J.A. 1994. Perturbations and Biological Impacts: Hydrological Change. pp. 33 - 54 *in*: P. Calow and G.E. Petts (eds.) *The Rivers Handbook*. Vol 2. Blackwell Sci., Publ., Oxford.

Davies, B.R., M. Thoms, K.F. Walker, J.H. O'Keeffe, and **J.A. Gore**. 1994. Arid and semi-arid-land river ecosystems: perspectives on ecological functioning, and problems of their management and conservation. pp. 484 - 511 *in*: P. Calow and G.E. Petts (eds.) *The Rivers Handbook*. Vol. 2. Blackwell Sci., Oxford.

Gore, J.A., J.B. Layzer, and I.A. Russell. 1992. Non-traditional applications of instream flow techniques for conserving habitat of biota in the Sabie River of southern Africa. pp. 161-177 *in*: P.J. Boon, G.E. Petts, and P. Calow. (Eds.) *River Conservation and Management*, Wiley, NY.

Gore, J.A., and G.E. Petts. (Eds.) 1989. ***ALTERNATIVES IN REGULATED RIVER MANAGEMENT***. CRC Press, Inc., Boca Raton, FL. 345 pp.

Gore, J.A. 1989. Models for predicting benthic macroinvertebrate habitat suitability under regulated flows. pp. 253-265 *in*: J.A. Gore and G.E. Petts (eds.) *Alternatives in Regulated River Management*, CRC Press, Inc., Boca Raton, FL.

Gore, J.A., and F.L. Bryant. 1988. River and stream restoration. Pp. 23-38 *in*: John Cairns, Jr. (ed.) *Rehabilitating Damaged Ecosystems, Vol. I*, CRC Press, Inc., Boca Raton, FL.

Gore, J.A. 1987. Development and application of macroinvertebrate instream flow models for regulated flow management. p. 99-115. *in*: J.F. Craig and J.B. Kemper (eds.) *Regulated Streams: Advances in Ecology*, Plenum Press, NY.

Gore, J.A. (Ed.) 1985. ***THE RESTORATION OF RIVERS AND STREAMS***. *Theory and Experience*. Butterworth Publ., Inc., Boston, MA. 280 pp.
[2nd printing - 1987]

Gore, J.A. (Ed.) 1989. *ВОССТАНОВЛЕНИЕ ИОХРАНА МАЛЫХ РЕК. ТЕОРИЯ ИЛРАКТИКА*. Moscow, USSR.

Gore, J.A. 1985. Mechanisms of colonization and habitat enhancement for benthic macroinvertebrates in restored river channels. pp. 81-101 *in*: J.A. Gore (ed.) *The Restoration of Rivers and Streams*, Butterworth, Publ., Inc., Boston, MA.

Gore, J.A. (Ed.) (In Preparation) (Under Contract) **THE RESTORATION OF RIVERS AND STREAMS. NEW VISIONS.** Chapman & Hall, London.

Technical Reports

Kneib, R.T., **J. A. Gore**, J.J. Anderson, M. Lorang, J. Nestler, and J. Van Sickle. 2012. Report of the 2012 Delta Science Program Independent Review Panel (IRP) on the Long-term Operations Opinions (LOO) Annual Review. Delta Science Program, Sacramento, CA. (61 pp,)

Kneib, R.T., J.J. Anderson**, J. A. Gore**, M. Lorang, and J. Van Sickle. 2011. Report of the 2011 Independent Review Panel (IRP) on the Implementation of Reasonable and Prudent Alternative (RPA) Actions Affecting the Operations Criteria And Plan (OCAP) for State/Federal Water Operations. Delta Science Program, Sacramento, CA. (45 pp,)

Gore, J.A., M.de la Rosa, T. J. Ferring, U. K. Rai, P. M. Brossett. 2007. *An Analysis of a Numerical Index of Health of Wadeable Streams in Georgia Using a Multimetric Index for Benthic Macroinvertebrates and a Recommendation for a Framework to Incorporate Bioassessment Protocols into the Regulatory Process*. Ecoregion Reference Site Project – Phase IV. United States Environmental Protection Agency, Clean Water Act, Section 319(h) FY 01-Element 9, Georgia Department of Natural Resources, Atlanta, GA (345 pp.)

Gore, J.A. 2005. Roanoke River Instream Flow Study. Clover Power Station. Dominion Electric, Richmond, VA (185 pp).

Gore, J.A. 2005. Kissimmee Chain of Lakes Long Term Management Plan and Conceptual Ecosystem Model evaluation. Chapter 4. Macroinvertebrates. South Florida Water Management District, West Palm, FL.

Gore, J.A., A. Middleton, D.L. Hughes, U. Rai, P. Michele Brossett. 2005. *A Numerical Index of Health of Wadeable Streams in Georgia using a Multimetric Index for Benthic Macroinvertebrates.* . Georgia Department of Natural Resources, Atlanta, GA (332 pp.)

Gore, J.A., J.R. Olson, D.L. Hughes, M. Brossett. 2004. *Reference Conditions for Wadeable Streams in Georgia with a Multimetric Index for the Bioassessment and Discrimination of Reference and Impaired Streams.* Georgia Department of Natural Resources, Atlanta, GA (625 pp.)

Gore, J.A., C. Dahm, C. Klimas. 2002. A Review of "Upper Peace River:An Analysis of Minimum Flows and Levels", Southwest Florida Management District, Brooksville, FL.

Gore, J.A. 1998. Instream flow studies and habitat suitability - criteria for macroinvertebrates. Pp. 14-16. *In*: S. Blažková, C. Stalnaker, and O. Novický (eds.) *Hydroecological Modelling : Research, Practice, Legislation and Decision-Making*. Occ. Non-Per. Publ., USGS MESC, Fort Collins, Co./T.G. Masaryk Water Research Inst., Prague, Czech Republic.

Gore, J.A. 1997. Introduction: Application of ecological theory to aquatic habitat restoration. Pp. 17-22 *in*: K. Koski and W.J. Hauser (eds.) *Aquatic Habitat Restoration in Northern Ecosystems*. U.S. Environmental Protection Agency/American Fisheries Society, Special

Publication, Washington, DC/Bethesda, MD.

Gore, J.A. 1997. Application of a hydraulic habitat approach to restoration. Pp. 27-34 *in*: K. Koski and W.J. Hauser (eds.) *Aquatic Habitat Restoration in Northern Ecosystems*. U.S. Environmental Protection Agency/American Fisheries Society, Special Publication, Washington, DC/Bethesda, MD.

Finley, M.R., **J.A. Gore**, and S.W. Hamilton. 1992. Proposed best management practices for improving water quality in the West Sandy watershed. Tennessee Dept. of Environ. and Conserv., Contr. C-92-0081.

Gore, J.A., and M. Piehler. 1992. The development of guidelines for use of statistical tools in terrestrial monitoring. pp. 217-220 *in*: R. Graves and R. Bisson (eds.) *Fourth Annual Ecological Quality Assurance Workshop*, U.S. Environmental Protection Agency, EPA-600/R-92/097.

Gore, J.A. 1991. Application of tools for ecological restoration: predictive modeling. pp. 42-44 *in*: Tetra Tech Inc. (ed.) *Workshop on the Water Quality-based Approach for Point Source and Nonpoint Source Controls*. U.S. Environmental Protection Agency, Office of Water. EPA 503/9-92-001.

Gore, J.A., J.M. Nestler, and J.B. Layzer. 1990. Habitat factors in tailwaters with emphasis on peaking hydropower. U.S. Army Engineers, Waterways Experiment Station, Tech. Rpt. EL-90-2.

Nestler, J.M., **J.A. Gore**, L.T. Curtis, and J.L. Martin. 1988. Prediction of effects on brown and rainbow trout of turbine uprating in the Cumberland River downstream of Wolf Creek Dam, Kentucky. U.S. Army Engineers, Waterways Experiment Station, Misc. Paper EL-88-10.

Gore, J.A. 1983. Summary report: Toxicity tests of coal gasification process waters to the cladoceran *Daphnia magna* and the mayfly *Ephemerella doddsi*. U.S. Dept. of Energy/Univ. of Wyoming Res. Corp., 40 pp.

Wichers, D.L., L.S. Johnson, T.A. Wesche, and **J.A. Gore**. 1982. Two techniques for locating and sampling brown trout microhabitat under complete ice cover. Water Resources Series No. 83, Wyoming WRRI, Univ of Wyoming, 48 pp.

Johnson, L.S., D.L. Wichers, T.A. Wesche, and **J.A. Gore**. 1982. Instream salmonid habitat exclusion by ice-cover. Water Resources Series No. 84, Wyoming WRRI, Univ. of Wyoming, 92 pp.

Gore, J.A., and L.S. Johnson. 1980. Establishment of biotic and hydrologic stability in a reclaimed coal strip-mined river channel. Rocky Mtn. Inst. Energy and Environ. 135pp.

Bovee, K.D., **J.A. Gore**, and A.J. Silverman. 1978. Field testing and evaluation of a methodology to measure "in-stream" values in the Tongue River, Northern Great Plains (NGP) region. U.S. Environmental Protection Agency, EPA-908/4-78-004a. 465 pp.

Stansly, P.A., **J.A. Gore**, D.W. Ceilley, D.S. Addison, M.B. Main. (IN PRESS) Inventory of freshwater macroinvertebrates for the South Florida Water Management District Isolated Wetlands Monitoring Program. SFWMD Tech. Rpt.

Sharber, J., J.M. Nestler**, J.A. Gore**, and L.T. Curtis. (In Preparation) Effects of hydropower uprate on trout habitat in the Obey River, Tennessee. U.S. Army Engineers, Waterways Experiment Station, Misc. Paper.

<u>Proceedings Publications</u>

[most influential (i.e., most cited) are in **bold**]

Gore, J.A. 2002. Preliminary Analysis of Habitat Loss for Target Biota in Rivers Impacted by Long-Term Flow Increases from CBM Production. *In:* Proc. of 9th Int. Petroleum Environmental Conference, *http://ipec.utulsa.edu/ipec/Conf2002/gore_121.pdf*

Gore, J.A., D.J. Crawford, and D.S. Addison. 1996. An analysis of artificial riffles and enhancement of benthic community diversity by Physical Habitat Simulation (PHABSIM) and direct observation. pp. B643-B653 *in*: M. Leclerc, H. Capra, S. Valentine, A. Boudreault, and Y. Côté (eds.) *Proc. 2nd International Symposium on Habitat Hydraulics*, INRS-Eau, Québec.

Gore, J.A. 1996. Blending biological and physical considerations in riverine restorations. pp. 509-518 *in*: P.E. Black and J.J. McDonnell (eds.) Proc. AWRA Symposium, *Watershed Restoration Management*, American Water Resources Association, Huntsville, AL.

Gore, J.A. 1992. Predicting enhancement value and recovery times after placement of habitat structures for fish and benthos in erosional zones. *Proc. 1992 Int. Environmental Dredging Symposium.*

Gore, J.A. 1990. Predicting recovery of stream ecosystems from disturbance: the potential for application of colonization theory and hydraulic stream ecology. *Proc. 3rd Ann. Symp. Natural History of Lower Tennessee and Cumberland River Valleys*, pp. 21-31.

Gore, J.A. and J.M King. 1989. Application of the revised physical habitat simulation (PHABSIM II) to minimum flow evaluations of South African rivers. pp. 289-296. in: S. Kenzle and H. Maaran (eds.) *Proc. Fourth South African Nat. Hydrological Symp.* Univ. of Pretoria.

Gore, J.A. 1983. Considerations of size-related flow preferences among benthic macroinvertebrates for use in instream flow studies and regulated flow management. pp. 389-397 *in*: H.I. Shuval. (ed.) Developments in Ecology and Environmental Quality, Vol. II, Balaban Int. Publ., Jerusalem.

Summers, P.B., Jr., and J.A. Gore. 1981. Chironomid communities as indicators of water quality affected by acid mine drainage. *Proc. Southeast. Assoc. Fish. Wildl. Agencies* 35: 474-486.

Gore, J.A. and L.S. Johnson. 1979. Biotic recovery of reclaimed channels after coal strip mining. *Proc. The Mitigation Symposium,* Rocky Mtn. For. Range Exp. Stn., Gen. Tech. Rpt. TM-65: 239-244.

Gore, J.A. 1975. Fall-winter distribution of benthic macroinvertebrates in the Tongue River, Montana. *Proc. Ft. Union Coal Field Symp*. 2: 212-225.

Other Publications

Gore, J.A. and L.S. Johnson. 1980. Baseline survey: Powder River and Willow Creek. Macroinvertebrates and suspended sediment. Wyoming WRRI report to Wyoming Minerals Corporation. 16pp.

Gore, J.A., J.D. Hughes, Jr., and W.A. Swartley. 1981. Benthic macroinvertebrates of low order streams of coal surface mining areas of the Cumberland Plateau; Kentucky, Tennessee, and Alabama. Tennessee Coop. Fish. Res. Unit report to U.S. Dept. of Interior, Office of Surface Mining. 375 pp.

Gore, J.A., J.D. Hughes, Jr., and W.A. Swartley. 1981. A survey of benthic macroinvertebrates of streams of coal surface mining areas of the Cumberland Plateau in Tennessee. Tennessee Coop. Fish. Res. Unit report to U.S. Geological Survey.

Gore, J.A. 1985. A ripple of hope. The ebb and flow of the Arkansas River. *Univ. of Tulsa Annual (1984-85):* 78-83.

Gore, J.A. 1985. *Book Review:* REGULATED RIVERS by Lillehammer and Saltveit. *Bull. N. Amer. Benthol. Soc*. 2: 148-150.

Gore, J.A. 1987. Regulated river management/models & a review of regulated research in the United States. Int. Newsletter on Regulated Stream Limnology 8: 27-34.

Yount, J.D., J.A. Gore, and J.R. Kelly. 1990. Application of ecological theory to determining the recovery potential of disturbed lotic ecosystems: research needs and priorities. *Bull. Ecol. Soc. Amer.*

Gore, J.A. 1992. *Book Review:* RIVER PROJECTS AND CONSERVATION by Gardiner. *J.N. Amer. Benthol. Soc.* 11: 336-338.

Gore, J.A. 1992. *Book Review*: BATTLE AGAINST EXTINCTION: NATIVE FISH MANAGEMENT IN THE AMERICAN SOUTHWEST by Minckley and Deacon. *Quarterly Review of Biology* 67: 542-543.

Division of Environmental Protection, The Conservancy. 1995. A Conservation Guide to the Ecosystems of Southwest Florida. The Conservancy of Southwest Florida, Naples, FL.

Gore, J.A. 1997. ESRI Conservation Program: GIS Stories from the field. *The Conservancy, Inc.* http://www.conservationgis.org/ctsp/consinc/consinc.html.

Gore, J.A. 1999. *Book Review.* ELEMENTS OF PHYSICAL HYDROLOGY by Hornberger, et al. *Journal of the North American Benthological Society* 18: 143-145.

Gore, J.A. 2000. *Book Review*. INSTREAM FLOW PROTECTION. SEEKING A BALANCE IN WESTERN WATER USE by Gillilan and Brown. *Aquatic Conservation*

Gore, J.A. 2001. *Book Review.* RESTORING STREAMS IN CITES by Ann L. Riley. *Rivers*

Turner, B.G., C.J. Arnett, J.A. Gore, and M.J. Boner. 2001. Sound Science TMDL's. *Progress* (Water Environment Research Foundation, *WERF Newsletter*.

Addison, D., **J.A. Gore,** and E. Odgaard. 2012. Making more turtles one season at a time – Insights from 28 years of loggerhead nesting at Keewaydin Island, Florida. *Florida Environmental Outreach* 3: 10-12.

Gore, J.A. (Submitted) A computer examination of trout habitat on the Eerste River. *The Piscator* (INVITED by editor)

Resh, V.H., B. Statzner, and J.A. Gore. (In Preparation) Authorship, instantaneous growth rates, and fried eel. (to be submitted to: Journal of Irreproducible Results)

Funded Research Proposals/Contracts

"Minimum Flows and Levels Analysis, Appilachicola Tributaries" 2014-Present. Northwest Florida Water Management District.

St Marks and Wakulla Rivers 2014-2015 $30,000

"Minimum Flows and Levels Analysis: Impacts of the Atlantic Multidecadal Oscillation (AMO), future water withdrawals, and climate change" 2003-Present. Southwest Florida Water Management District. [$1,279,323]

Anclote River PHABSIM Analysis. 2003-2005. $30,000.
Peace River minimum flow analysis. 2003-2005. $45,000.
Weeki Wachee PHABSIM Analysis. 2003-2005. $30,000.
Braden River PHABSIM Analysis. 2004-2005. $30,000.
Myakka River PHABSIM Analysis. 2004-2005. $24,323.
Upper Hillsborough River PHABSIM Analysis. 2004-2006. $30,000.
Buckhorn Springs Analysis. 2004-2006. $40,000.
Lithia Springs Analysis. 2004-2006. $30,000.
Alafia and Middle Peace Rivers PHABSIM Analysis. 2005. $16,500.
Hillsborough River Invertebrate Community Identification. 2005. $8,500.
Alafia River-Lithia Springs Modeling Runs – PHABSIM. 2005-2006. $10,000.
Little Manatee River PHABSIM Analysis. 2005-2008. $30,000.
Manatee River PHABSIM Analysis. 2005-2009. $35,000.
Rainbow River PHABSIM Analysis. 2005-2009. $35,000.
Rainbow River Macroinvertebrate & Fish Assessments. 2005-2006. $40,000.
Silver River PHABSIM Modeling Runs. 2007-2008. $30,000.
Withlacoochee River PHABSIM Modeling Runs. 2007-2009. $60,000.
Additional runs Upper Hillsborough River PHABISM Analysis. 2008. $5,000.
Brooker Creek PHABSIM Modeling Runs. 2008-2010. $30,000.
Gum Springs PHABSIM Modeling Runs. 2008-2010. $30,000.
Pithlachascotee River PHABSIM Modeling Runs. 2008-2010. $30,000.
Gum Springs Diversion for Testing "Significant Harm" 2009-2019. $400,000
Upper Peace River PHABSIM Modeling Runs. 2009-2011. $25,000
Gum Springs Bypass Study. 2009-2019. $750,000
Gum Springs Macroinvertebrate Study. 2011-2015. $160,000
Prairie Creek PHABSIM Field and Modeling Runs. 2010-2015. $25,000
Shell Creek PHABSIM Field and Modeling Modeling Runs. 2011-2015. $25,000
Cypress Creek PHABSIM Modeling Runs. 2011-2015. $25,000

"Development of Models of Hydraulic Depth and Time of Travel, Staunton River, at Clover Power House" 2008. Dominion Electric/Dominion Resources. $5,000.

“Site selection and physical habitat analysis of the Northern Withlacoochee River.” 2007-2008. Florida Wildlife Conservation Commission. ($35,000)

“Interfacing SWAT and PHABSIM: A potential GIS-based Water Resource Management Tool” 2006-2007. [with Barnali Dixon] U.S. Environmental Protection Agency. [C-SPACE project] ($183,811).

“Analysis of the impacts of stormwater treatment BMP’s on macroinvertebrates in an urban stream, Weracoba Creek” 2005-2007. U.S. Environmental Protection Agency [CWA §319(h)]. ($20,000)

“Sample Reallocation Analysis” 2004. U.S. Environmental Protection Agency (Section 319(h))/Georgia Department of Natural Resources. ($107,715)

“The design of a stream restoration effort for Dry Creek, Early County, Georgia, as part of a mitigation banking project” 2003-2004. Kolomoki Plantation, Consolidated Resources, LLC/James Butler, Inc. ($18,000)

“Roanoke River Instream Flow Study. Clover Power Station. 2002-2005. Old Dominion/Virginia Power ($150,000)

“Recovery of fish and benthic macroinvertebrate communities after dredging PAH contaminated sediments on the Oconee and Ocmulgee Rivers in Georgia.” 2001 – 2003. Georgia Power/Electric Power Research Institute (EPRI). ($80,000)

Georgia Ecoregions Project. U.S. Environmental Protection Agency (Section 319(h))/Georgia Department of Natural Resources. (**$1,334,667**) as:

> **Phase II -** “Distribution and characterization of reference stream sites for bioassessment in Georgia” 2000-2002. ($417,667)
>
> **Phase III -** “Development of a numerical index (biocriteria for water quality) for the major ecoregions and subecoregions of the state of Georgia” 2001– 2003. ($417,000)
>
> **Phase IV -** “Validation of numerical index and recommendations for application of macroinvertebrate biocriteria for the state of Georgia” 2003– 2005. ($500,000)

"Recovery of fish and macroinvertebrate communities in restored wetlands of the western Everglades" 2000-2001. Laurel Foundation/Florida Game and Freshwater Fish Commission. ($20,000)

"Recreation support services - Middle Chattahoochee Hydroelectric Project" 1999-2000. CH2M Hill ($8,000)

"Fish and mussel surveys - Middle Chattahoochee Hydroelectric Project" 1999. "CH2M Hill. ($8000)

"An analysis of temporal changes in wetland macroinvertebrate communities in hydric pine flatwoods of south Florida". 1997-1998. South Florida Water Management District. ($13,101)

"The distribution of fish and macroinvertebrates in the Chattahoochee watershed near Columbus, Georgia, as they are affected by CSO treatment technology and changes in land use". 1997-1999. Columbus Water Works, Water Environment Research Foundation, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, Georgia Environmental Protection Division, Alabama Department of Environmental Management, Georgia Power. ($100,000)

"Analysis of the composition and distribution of midge (Diptera: Chironomidae) assemblages in isolated wetlands in South Florida." 1996-1997. South Florida Water Management District. ($10,000)

"Water quality study of West Point Lake, Georgia" 1996-1997. West Point Lake Development Authority ($20,000)

"The hydrology and ecology of the Clam Bay basin and mangrove ecosystem" funded through:

> "Analysis of the Clam Bay ecosystem. Phase I - historical records and data analysis." 1995. Bay Colony Assoc. ($10,000)
>
> "Water quality analysis of canals and estuarine areas on Marco Island" 1995-1996. Marco Island Civic Association. ($6,000)
>
> "Water quality analysis of Vanderbilt Lagoon and the southern end of Water Turkey Bay" 1996-1997. Vanderbilt Beach Property Owners Association and Wiggins Pass Conservancy ($5,000)

"Nutrient analysis of waters in Moorings Bay, Seagate, and Clam Bay ecosystems." 1995-1996. Save The Bays Assoc., Inc. ($5,000)

"PHABSIM analysis of stream restoration structures on the Little Missouri River, Arkansas, before and after construction of reregulation weirs." 1991-1992. U.S. Army Engineers, Waterways Experiment Station. ($124,000)

"GIS support and training" 1995-1996. CTSP Program - Hewlett Packard/Environmental Systems Research Institute/Smithsonian Institution. (awarded complete GIS system [hardware and software] plus training) (approximate value: $75,000) (submitted with Christine Ramsey)

"GIS analysis of environmentally sensitive areas, seagrass beds, and manatee protection zones in waterways in Collier County, Florida" 1994-1995. Marine Trades Assoc. ($5,000)

"Evaluation of the success of Best Management Practices to control nonpoint source pollution in the Double Bridges Creek watershed." 1993 - 1994. Wiregrass RC&D (U.S. Soil Conservation Service) ($15,000)

"Nonpoint source water pollution reduction planning process: West Sandy watershed." 1991-1996. Tennessee Dept. of Environment and Conservation. ($200,000) (co'PI with Mack T. Finley and S.W. Hamilton)

"Distribution and assessment of restoration potential of endangered mussel fauna in Shoal Creek, Tennessee and Alabama." 1991-1992. U.S. Fish and Wildlife Service, Tennessee Wildlife Resources Agency ($15,000) (renewed 1992-1993 [$30,000]; renewed 1993-1994 [$30,000])

"Minimum flow requirements to maintain faunal diversity on the Sabie and Letaba Rivers in Kruger National Park." 1991. CSIR/FRD and Univ. of the Witwatersrand, Pretoria, South Africa. ($10,000)

"Analysis of benthic invertebrate and fish communities associated with potential groundwater and surface water contamination by creosote plant effluent." 1990. U.S. Geological Survey, Nashville Office. ($5,000)

"Hydraulic influences on colonization rate in disturbed streams: can they be used to predict recovery?" 1990. Univ. of Tulsa, Faculty Summer Fellowship ($4,500)

"Testing instream flow methodologies to resolve water resource issues in South Africa." 1988-1989. Council for International Exchange of Scholars**.** **(FULBRIGHT SENIOR RESEARCH FELLOWSHIP)** ($29,035 + travel and expenses)

"Assessment of hydropower uprates on the Obey River downstream of Dale Hollow Dam, Tennessee." 1987. U.S. Army Engineers, Nashville, District. ($40,000)

"Assessment of hydropower uprates on the Cumberland River downstream of Wolf Creek Dam, Kentucky." 1987. U.S. Army Engineers, Nashville, District ($80,000)

"Development of a method for predicting the effects of peaking hydropower releases on fish and benthos." 1986-1988. U.S. Army Engineers ($360,000; including 1 year IPA assignment to Waterways Experiment Station [1986-1987]) [Project extended, 1988-1989; $160,000; co-PI with James B. Layzer, Tennessee Tech University; renewed, 1989-1990; $75,000]

"Changes in darter assemblage structure with changes in hydraulic parameters as a test of the river continuum concept." 1986. Univ. of Tulsa, Faculty Development Summer Fellowship ($2,500)

"Comparison of techniques for predicting densities of aquatic invertebrates." 1985-1986. Federal Republic of Germany, Academy of Science; Univ. of Karlsruhe; Univ. of Tulsa ($35,000) (with V.H. Resh and B. Statzner)

"Maintenance of macroinvertebrate habitat for fish food production: implications to regulated flow management." 1985. Univ. of Tulsa, Summer Fac. Fellowship ($2,400)

"A test of instream flow theory for macroinvertebrates by the use of colonization of artificial substrates in natural and experimental streams." 1982-83. Council for the International Exchange of Scholars. **(FULBRIGHT AWARD)** (Full maintenance and travel for one year to the Hebrew University of Jerusalem, Israel)

"Cumulative effects of a series of storage impoundments on benthic communities of the Arkansas River." 1982. Univ. of Tulsa, Summer Faculty Fellowship. ($3,000)

"Distribution and microhabitat requirements of *Mudalia potosiensis* (Mesogastropoda: Pleuroceridae), a stream dwelling snail." 1981. Univ. of Tulsa, Faculty Res. Suppl. ($350)

"Survey and habitat description of aquatic biota in the Cheyenne river and tributaries near uranium mine site, Edgemont, SD." 1980-81. Tennessee Valley Authority ($6,500)

"Evaluation of limnological parameters of Fremont, Willow, and Half-Moon Lakes as related to *Mysis* production." 1980-81. U. S. Dept. of Interior, Office of Water Resources and Technology. ($19,365)

"Benthic invertebrate baseline studies from previously coal mined areas in Tennessee." 1980-81. U.S. Geological Survey. ($18,000)

"Benthic invertebrate distributions in low order streams potentially impacted by coal surface mining on the Cumberland Plateau." 1980-1981. U.S. Dept. of the Interior, Office of Surface Mining, Knoxville. ($36,000)

"Cumulative effects of a series of storage and run-of-river impoundments on aquatic communities." 1980-1981. OWRT. (Requested: $45,022; Approved but canceled after federal dissolution of OWRT).

"Determination of instream flow requirements of benthic macroinvertebrates in the Tongue River upstream of the reservoir." 1980. AMAX foundation ($1,500)

"Determination of instream flow requirements of brown trout using radio-isotopes." Year II. Salmonid winter flow studies. 1979-1980. Office of Water Resources and Technology (OWRT), Wyoming Game and Fish Commission, and Wyoming State Engineer Office. (Requested: $36,000; Funded: $31,000)

"Determination of effective methods of restoration of hydrologic and biotic balance of a reclaimed coal strip-mined river." 1979. Rocky Mountain Inst. of Energy and Environment, Industrial Fund. ($12,500)

"Baseline impact study (macroinvertebrates and suspended sediment). Powder River and Willow Creek. *In situ* uranium mining." 1979-1980. Wyoming Mineral Corporation. ($8,700)

"Recolonization of a reclaimed stream channel after coal strip mining." 1978-79. Peter Kiewit Sons, Mining District Office and Big Horn Mine Corp., Sheridan, WY ($24,000)

"Forage area, home-range, and population density of Solpugidae in Organ Pipe Cactus National Monument, Arizona." 1978. Sigma Xi. (Requested: $750; Funded: $350)

Masters and Doctoral Committees

(Director) **Lora S. Johnson** (MS 1980, Univ. of Wyoming) "Tracking movement and identification of instream flow needs of brown trout (*Salmo trutta*) by use of radio-isotopes." **[Senior Ecologist, US EPA, Cincinnati, OH]**

(Member) **Deborah Contreras** (MS 1984, University of Tulsa) "Environmental and genetic differences in *Pectis papposa* over an altitudinal gradient in the Providence Mountains, California." **[US Army]**

(Director) **Richard B. Smith** (MS 1984, University of Tulsa) "Impacts of a multiple level release reservoir on macroinvertebrate communities of the Little River, Oklahoma."
[Director of Environmental Services, Indian Nations Council of Governments, Tulsa, OK]

(Director) **Richard M. Bryant, Jr.** (MS 1984, University of Tulsa) "Seasonal and successional patterns of macroinvertebrates in a three year-old man-made marsh."
[PhD, Oklahoma State Univ.; Director of Water Quality Services, Williams Assoc., Tulsa, OK]

(Member) **James Bergman** (MS 1984, University of Tulsa) "Water quality analysis of an EPA SuperFund site: Tar Creek, Oklahoma"

(Director) **Franklin L. Bryant** (MS 1986, University of Tulsa) "Habitat partitioning and diet overlap of coexisting darter species (Percidae) in Fourteen Mile Creek, Cherokee County, Oklahoma."
[Senior Ecologist, Ohio EPA]

(Director) **Francis I.P. Gelwick** (MS 1987, University of Tulsa) "Longitudinal and temporal patterns of riffle and pool fish assemblages in an Ozark stream, Delaware County, Oklahoma."
[Faculty, Texas A&M University]

(Director) **William A. Swartley** (MS 1987, Tennessee Tech Univ.) "Development of a biotic index for heavy metal contamination from surface coal mining in the New River, Tennessee."
[Directory of Hydrology Division, North Carolina Dept of Forestry]

(Member) **Scott Niemela** (MS 1989, Tennessee Tech Univ.) "Influence of peaking hydroelectric discharges on habitat selection and movement patterns of rainbow trout (*Oncorhynchus mykiss*)."

(Director) **Arlesa A. Fouts** (MS 1990, University of Tulsa) "Assessment of instream flow requirements of the benthic macroinvertebrates of the Olifants River, western Cape Province, South Africa."
[Faculty, University of Texas]

(Director) **Jimmy Smith** (MS 1993, Austin Peay State University) "Analysis of placement of reregulation weirs on habitat structure and availability for selected fish species downstream of a peaking hydropower project."

(Member) **Mark Hartman** (MS 1994, Tennessee Tech Univ.) "Habitat relationships among larval fish in Shoal Creek, Tennessee and Alabama"

(Member) **Tim Nehus** (MS 1995, Tennessee Tech Univ.) "Changes in drift patterns of benthic macroinvertebrates downstream of a peaking hydropower facility on the Caney Fork River, Tennessee)

(Member) **Nicolas Lamouroux** (PhD 1997, Université Claude Bernard - Lyon I - FRANCE) "Hydraulique statistique et prediction de caracteristiques du peuplement piscicole: Modeles pour l'ecosysteme fluvial" **[CNRS, Lyon]**

(Director) **Henry Leon Griffith III** (MS 1998, Columbus State University) "Analysis of hydric pine ephemeral pool macroinvertebrate and crustacean assemblages along a temporal and spatial gradient from a hypothesized colonial source."

(Member) **Pierre Sagnes** (PhD 1998 Université Claude Bernard - Lyon I - FRANCE) "Morphométrie, potentiel hydrodynamique et utilisation de l'habitat par les poissons: une nouvelle approche écomorphologique." **[Faculty, University of Lyon]**

(Director) **Margaret Ann Berg** (MS 2001, Columbus State University) "Temporal differances in nest mortality and hatchling survival of loggerhead sea turtles, *Caretta caretta*, over 13 years of record.

(Director) **Page Jones** (MS 2001, Columbus State University) "Cumulative impacts of run of river dams on the distribution of benthic macroinvertebrates in the middle Chattahoochee River."
[Faculty, University of Arkansas]

(Director) **John Olson** (MS 2001, Columbus Sate University) "GIS characterization and analysis reference streams for bioassessment in Georgia"
[Faculty, Utah State University]

(Member) **Theodor Roever** (MS 2002, Columbus State University) "Development of a fish index of biotic integrity for the middle Chattahoochee River catchment"

(Member) **Jonathan Neufeldt** (MS 2003, Columbus State University) "Terrestrial range and habitat use of gopher frogs (*Rana capito*) at Fort Benning, Georgia" **[USFWS, Fort Benning, GA]**

(Director) **Jodi Williams** (MS 2004, Columbus State University) "Effect of taxonomic precision and accuracy in rapid bioassessment scores for Georgia ecoregions"

(Director) **Jennifer Lang** (MS 2004, Columbus State University) "Distribution of benthic macroinvertebrates in urbanized tributaries of the Chattahoochee River."
[Instructor, Columbus Technical College]

(Director) **Marcie Parrish** (MS 2005, Columbus State University "An analysis of agricultural and resort land-use patterns on benthic macroinvertebrate communities in tributaries of the Chattahoochee River."
[Ecologist, Joe Jones Ecological Research Center, Univ. of Georgia]

(Director) **Michele Brossett** (MS 2005, Columbus State University) "Ecoregional differences in nutrient concentrations and macroinvertebrate distributions in determination of reference streams in Georgia"
[Senior Ecologist, Georgia Department of Natural Resources]

(Director) **Duncan Hughes** (MS 2006, Columbus State University) "Development of reference conditions of wadeable streams in the major ecoregions and subecoregions of Georgia"
[Faculty, North Georgia College]

(Director) **Tracy Ferring** (MS 2006, Columbus State University) "Analysis of QA/QC protocols and value of data to the development of reference criteria in the Georgia Ecoregions project."
[Ecologist, Florida Fish and Wildlife Conservation Commission]

(Director) **Amanda Middleton** (MS 2006, Columbus State University) "A numerical index for classifying wadeable streams in Georgia and their correlation with EPA's aquatic life use stages"

(Director) **Uttam Rai** (MS 2006, Columbus State University) "The effect of sample size on rapid bioassessment scores and management efficiency"
[Senior taxonomist, Rhithron Assoc., Missoula, MT]

(Director) **Salini Pillai** (MS 2007, Columbus State University) "Ecoregional differences between blackwater and clear water streams in determination of reference conditions in Georgia"

(Member) **Jason Hood** (MS 2007, University of Florida) "Hydrological analysis of flood patterns on the Rainbow River"
[Director, Water Quality Division, SWFWMD]

(Member) **Steffen Schweitzer (**PhD 2007, EAWAG (Swiss Federal Institute for Environmental Science and Technology). "An integrative model to predict the hydraulic, morphological and ecological consequences of river rehabilitation"

(Member) **George Kish (**PhD 2008, University of South Florida) Undetermined: Focus on restoration of riparian vegetation in urban river ecosystems.

(Director) **James Banning** (MS 2009) "Examination of BMP applications (settling-pond valves for erosion control) for stormwater runoff in an urban stream, Roaring Branch"
[Research Assistant, University of Tampa]

(Director) **Mike Sears** (MS 2010) "Differences in diet and health among bluegill sunfish feeding in mainsteam areas and spring vent areas, Rainbow River, Florida"
[Ecologist, Maine Department of Natural Resources]

(Member) **Laura Hadeed** (Honors 2010) "Sacred healing and ceremonial healing practices among two North Native American nations: the Wind River Shoshone and the Seneca of the Iroquois"

(Director) **Charlotte Clayton** (MS 2011) "Utilizing macroinvertebrate fossils to recreate historic hydroperiods on tree islands in the Everglades"

(Director) **Erik Oij** (MS 2011) "Examination of off-site BMP applications for stormwater runoff in an urban stream, Weracoba Creek"

(Member) **Jennifer Jackson** (MS 2011) **"**An Evaluation of Roost Selection Preferences by Bats in Georgia Bridges."
[Biologist, Idaho Department of Wildlife]

(Director) **Renee Duffey** (MS 2012) **"**A Multi-scale Approach for Characterizing Habitat Selection of Tidal Creek Fish in Charlotte Harbor, Florida"
[GIS Coordinator, Florida Wildlife Conservation Commission]

<u>Technical Consulting</u>

JOURNAL REFEREE

Proc. Oklahoma Academy of Science (1982 - 86)
Ecology (1982 - 83, 1996)
Hydrobiologia (1982, 1984 - 87, 1989, 1991 - 92, 1994, 1997, 1999, 2001-02)
Ecological Monographs (1982, 1996)
Journal of Freshwater Ecology (1983 - 85, 1990)
Canadian Journal of Fisheries and Aquatic Science (1984 - 86, 1988, 1991, 1998, 2000)
Freshwater Invertebrate Biology (1985)
Journal of the North American Benthological Society (1986, 1988 - 91, 1993-95, 1998-2000, 2003, 2006-2007)
American Midland Naturalist (1986)
River Research and Applications (formerly Regulated Rivers (1986 - 2008)
Proc. Southeastern Assoc. Fish Wildl. Agencies (1987)
Proc. Pennsylvania Academy of Science (1987)
Rivers (1988 - 2001)
Transactions of the American Fisheries Society (1990, 1998, 2000)
Aquatic Conservation (1992 - 1994, 1997, 1999)
North American Journal of Fisheries Management (1992)
Copeia (1992)
Bulletin of Marine Science (1994)
Canadian Journal of Zoology (1994)
Wetlands (1995, 1997)
Limnology & Oceanography (1996)
Journal of Restoration Ecology (1997)
Freshwater Biology (1998, 2006-2008)
New Zealand Journal of Marine and Freshwater Research (1998)
Marine and Freshwater Research (Australia) (1999)
Ecological Engineering (1999)
Basic and Applied Ecology (2001)
Archiv für Hydrobiologie (2001)
Journal of Animal Ecology (2003)

PROCEEDINGS REFEREE:

Floodplain River Symposium (1990)
Fifth International Symposium on River Sedimentation (1991)
International Riprap Workshop (1993)

BOOK/CHAPTER REFEREE:

STREAM ECOLOGY: The testing of ecological theory in stream ecosystems. Plenum Press, NY. (1982)

THE ECOLOGY OF AQUATIC INSECTS by V.H. Resh and D.M. Rosenberg. Praeger Press, NY. (1983)

HYDROLOGY FOR AQUATIC BIOLOGISTS by Nancy Gordon (1990)
[Wiley, NY]
[reviews of chapters/software]

RIVER CONSERVATION AND MANAGEMENT by Boone, Petts, and Calow (1990) [Wiley, NY]

THE RIVER HANDBOOK by Calow and Petts (1992)
[Wiley, NY]

DYNAMICS OF SHALLOW LAKE COMMUNITIES by Marten Scheffer (1995)
[Chapman & Hall, London]

ECOLOGY AND MANAGEMENT OF STREAMS IN RIVERS IN THE PACIFIC NORTHWEST COAST ECOREGION by R.J. Naiman and R.E. Bilby (1997)
[Univ. of Washington Press]

THE MEMOIRS OF DR. ALBERT PATRICK BLAIR by Peggy S.M. Hill (2007)
[Univ. of Oklahoma Press]

CONSULTANT BIOLOGIST/HYDROLOGIST

1981 - 1989. Macroinvertebrate surveys of Cheyenne River and Cottonwood Creek, Edgemont, SD, and Marquez Canyon, NM. Tennessee Valley Authority. Abandoned uranium mine program.

1982. TESTIMONY. Hearing: Requirements for macroinvertebrate studies for low-head hydroelectric permits. State of Washington, Div. of Fisheries.

1983. (reclamation evaluations). Office of the Solicitor, U.S. Dept. of Interior, Office of

Surface Mining

1984. (evaluation of instream flow studies). Swedish State Power Board. Villingby, Sweden.

1985. Technical Review: second draft - Oklahoma state water quality standards - Oklahoma State Water Resources Board

1986 - 1992. Associate Editor. International Newsletter on Regulated Stream Limnology.

1988. Consultant/participant - Draft writing of EPA National Ecosystems Research Plan: Surface Waters (especially, proposed needs and projects for cause and effect relationships in habitat alteration and model development of risk assessment for habitat alteration) - U.S. Environmental Protection Agency, Office of Environmental Processes and Effects Research

1989. 1) Institute of Hydrology, Wallingford, Oxfordshire, UK
2) Department of Water Affairs, Pretoria, South Africa
3) National Parks Board, Kruger National Park, Skukuza, South Africa

1991. Manuscript Referee:

U.S. Fish and Wildlife Service, National Ecology Research Center

"Benthic macroinvertebrate microhabitat requirements and trophic structure in southeastern streams: a literature synthesis."

"Use of benthic macroinvertebrates in the development of impact assessment methods for southeastern rivers."

INVITED GROUP LEADER: Fourth Ecological QA Workshop, EPA, Cincinnati, Ohio. Responsible for development of documents on statistical tools for terrestrial monitoring program.

Program Committee - Ohio River Basin Consortium annual meeting

1992. 1) U.S. District Attorney, U.S. Highway Department
2) Wright Brothers Construction, Johnson City, TN

1992 - 1994 Trustee: Board of Trustees, Alabama Forever Wild Land Trust

1993. 1) National Institute for Water and Atmospheric Research, Hamilton, New Zealand
2) Carolina Power & Light
3) Standing Rock Sioux Nation, South Dakota

4) Friends of the Locust Fork River (Alabama)

1994. 1) South Carolina Electric & Gas Company
2) Mid South Area National Sedimentation Laboratory (part of program review team)

1995. 1) Texas Parks and Wildlife Department, Texas Water Development Board, Texas Natural Resource Conservation Commission - Instream Flow Task Force of the Ecological Water Needs Technical Advisory Committee
2) USDA - Agricultural Research Service - Atlanta, GA - Regional Vision Development Conference
3) City of Hendersonville, NC - instream flow reservations on the Mills River and tributaries
4) Virginia Power & Light - instream flow reservations for relicensing of hydropower facilities on the Roanoke River in North Carolina and Virginia.

1996. 1) City of Gatlinberg and City of Sevierville, TN - minimum flow evaluations for the Pigeon River
2) Bureau of Reclamation - review of proposals for research on controlled flood releases downstream of Glen Canyon Dam, Arizona
3) Virginia Water Resources Research Center - review of proposals for research sponsored by the U.S. Geological Survey
4) Nantahala Power and Light (North Carolina) - evaluation of instream flow studies of hydropower relicensing
5) U.S. Environmental Protection Agency - National peer review panel - Risk Management Plan for Ecosystem Restoration in Watersheds
6) South Florida Water Management District - macroinvertebrate surveys in isolated wetlands project - specifically taxonomic identification and analysis of distribution of chironomid larvae

1997. 1) City of Gatlinberg and City of Sevierville, TN - minimum flow evaluations for the Pigeon River
2) South Florida Water Management District - macroinvertebrate surveys in isolated wetlands project - specifically taxonomic identification and analysis of distribution of chironomid larvae
3) Virginia Power & Light - instream flow reservations for relicensing of hydropower facilities on the Roanoke River in North Carolina and Virginia.

1998. 1) Virginia Power & Light - instream flow reservations for relicensing of hydropower facilities on the Roanoke River in North Carolina and Virginia.

1999. 1) Virginia Power & Light - instream flow reservations for relicensing of hydropower facilities on the Roanoke River in North Carolina and Virginia.

2000. 1) Virginia Power & Light - instream flow reservations for relicensing of hydropower facilities on the Roanoke River in North Carolina and Virginia.
2) Nantahala Power & Light – time series analysis of habitat availability and bottlenecks on Queens Creek and South Yadkin River

2001. 1) Virginia Power & Light - instream flow reservations for relicensing of hydropower facilities on the Roanoke River in North Carolina and Virginia.
2) Nantahala Power & Light – time series analysis of habitat availability and bottlenecks on Queens Creek and South Yadkin River
3) Upper Chattahoochee River Keeper – instream flow analysis of water withdrawal by Georgia Power at Plant Wansley

2002. 1) U.S. Environmental Protection Agency. National Center for Environmental Research. Peer Review Panel. Proposal reviews for: *Futures: Ecosystem Assessment and Effects* – Washington, DC.
2) Wyoming Outdoor Council. Review: Draft Environmental Impact Statement for the Powder River Coalbed Methane.
3) Expert Panel Member. Pacific Rivers Council. Regional Conservation Plan for Rivers of the Southeast. Chattanooga, TN.
4) CALFED Bay-Delta Program's Ecosystem Restoration Program. Proposal reviews.
5) Southwest Florida Water Management District. Peer review committee on minimum flow analysis of the Upper Peace River. (committee chair)

2003. 1) Southwest Florida Water Management District. IFIM and PHABSIM workshop for SWFMD and Florida Wildlife and Fisheries Conservation Commission personnel
2) Earthjustice Legal Defense Fund, Denver, Colorado. Affidavit regarding potential impacts on riverine ecosystems from Coal Bed Methane development in the Northern Great Plains.

2004. 1) Columbus State University, Columbus, GA. Analysis of data collection from Georgia Ecoregions project.

2005. 1) Columbus State University, Columbus, GA. Analysis of data collection from Georgia Ecoregions project.
2) Tennessee Tech University, Cookeville, TN. External reviewer (state-mandated) – Doctoral program in Environmental Science

2008. 1) Florida Sea Grant Strategic Plan workshop – invited panelist – climate change

1994 - 1996 Collier County, Florida, Environmental Advisory Board (appointed by County Commission)

1995 - 1996 Collier County, Florida, Citizens Advisory Council - Evaluation and Appraisal Report on the Collier County Growth Management Plan - (appointed by County Commission) - Future Land Use element subcommittee

1996 - 1997 Member, Science and Technology Council - The Naples Institute - [a public policy institute affiliated with Mt. Ida College, Newton, Massachusetts]

1997 - Present **Member, Working Group for Technical Guidance on Large Rivers,** U.S. Environmental Protection Agency

2006-2009 **Host / Organizer** – First Triennial Symposium for the International Society of River Science – meeting in St Petersburg, FL

PROPOSAL REFEREE:

National Science Foundation (1987, 1989 - 90, 1996, 1998, 2000, 2002, 2003 [3])
- Ecology Section (1987, 1989 - 90, 1996, 1998, 2000, 2002)
- Hydrology Section (2000, 2002, 2003)
- Geology and Paleontology Section (2003)

United States-Israel Binational Science Foundation (1987, 1992, 1994)
National Environment Research Council (Great Britain) (1990, 1998-2001, 2003, 2006)
National Geographic Society (1992)
National Fish and Wildlife Foundation (2009)
Foundation for Research and Development (FRD) - South Africa (1993)
U.S. Dept. of Interior, Bureau of Reclamation (1996)
U.S. Environmental Protection Agency (1997, 2000, 2001)
Water Environment Research Federation (2002)
U.S. Army Engineers – Waterways Experiment Station (2003)
Earthwatch, Institute (2004)
Delta Science Council (2015)

1987 - 1991. Panelist/Site Visitor. National Research Council.

1988 - 2002. Board of Editors:

(1) *Regulated Rivers: Research & Management* (Wiley)

(2) *Rivers: Studies in the Science, Environmental Policy, and Law of Instream Flow* (Allen Press). [Ceased publication in 2002]

2003 – Present. Regional Editor [Americas] *River Research and Applications* (Wiley) [formerly: *Regulated Rivers: Research & Management*]

1989 - 1992. Member: Advisory board for ANNUAL EDITIONS: Environment (89/90, 90/91, 91/92, 92/93) [Dushkin Publishing Grp., Guilford, CT]

1993 - 1994: Steering Committee/Scientific Committee: International Symposium on Hydraulic Habitat (sponsored by the International Association for Hydraulic Research) - Trondheim, Norway

1995-1996: Steering Committee/Scientific Committee: Biohydrology - 2000 (sponsored by the International Association for Hydraulic Research) - Quebec City, Quebec

1995-1997: Organizing Committee: Seventh International Symposium on Regulated Streams - Chattanooga, TN.

Scientific Committee: National Conference on Management of Landscapes Disturbed by Channel Incision (Sponsored by USDA National Sedimentation Lab and US Army Corps of Engineers), Oxford, MS.

1999-2000: Scientific Advisory Panel: Water Environment Research Foundation. Project 98-HHE-6, "Assessment of Ecosystem Effects Relative to the Scale and Dynamics of Large River Systems"

1999-2001: Advisory Panel on watershed restoration - State of North Carolina, Department of Forestry.

Invited Panelist: U.S. EPA and Water Environment Federation Workshop: Assessment of Ecosystem Effects Relative to the Scale and Dynamics of Large Rivers

2008: Strategic Plan (2009-2013) Florida Sea Grant (FSG) Program. Invited workshop participant.

1999-Present Scientific Advisory Board – United Nations/UNESCO – International Hydrology Program (IHP) – section on ecohydrology

2006-Present Board of Directors – International Society for River Science

2010-Present Delta Science Program – Analysis of the collapse of the Sacramento River Fishery – Sponsored by the National Marine Fisheries Service and the US Fish and Wildlife Service

Pete McHugh

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EDUCATION

Ph.D. in Aquatic Ecology, Utah State University, Logan, Utah. 2006.

Thesis Title: "A multi-scale assessment of brown trout (*Salmo trutta*) – cutthroat trout (*Oncorhynchus clarkii utah*) interactions in Bonneville Basin streams", Advisor: Dr. Phaedra Budy.

M.S. in Fisheries Biology, Utah State University, Logan, Utah. 2003.

Thesis Title: "A model-based approach to assessing the potential response of Chinook salmon to habitat improvements", Advisor: Dr. Phaedra Budy.

B.S. in Fisheries Management (*summa cum laude*), The Ohio State University. Columbus, Ohio. 1999.

PROFESSIONAL EXPERIENCE

Researcher, Utah State University / Eco Logical Research. Logan, UT. Development and application of population models to assess the benefits of habitat restoration for threatened salmon and steelhead populations; analysis of relationships between stream salmonids and physical habitat conditions; development of spatial statistical models for network-scale analysis of fish–habitat relationships. *Supervisor: Nick Bouwes. Feb 2015-Present.*

Salmon Fishery Policy Analyst, Washington Department of Fish and Wildlife. Olympia, WA. Operation and maintenance of a multi-jurisdiction, multi-stock salmon population and fishery simulation model (the Fishery Regulation Assessment Model, FRAM); collaboration with modeling staff in interagency fishery management forums associated with the Pacific Fishery Management Council and The Pacific Salmon Commission (WA representative on the PSC-Chinook Technical Committee); general stock assessment, analysis, programming (Visual BASIC .NET, R), and modeling tasks associated with Pacific salmon species and the commercial and recreational fisheries in which they are exploited. *Supervisor: Angelika Hagen-Breaux. 2012-2015.*

Project Leader, Oregon Department of Fish and Wildlife. Clackamas, OR. Led field studies on the impacts of predation by fishes on salmonids in the mainstem Columbia River; fish sampling, data analysis, and report preparation; project administration (recruiting and supervising 4 permanent and 12 seasonal staff; budgeting; etc.); inter-agency coordination (USACE, WDFW, PSMFC, USGS) on collaborative research contracts. *Supervisor: Christine Mallette. 2011.*

Postdoctoral Research Fellow, University of Canterbury. Christchurch, New Zealand. Investigated effects of hydrology and stream habitat characteristics on food-web structure in New Zealand high-country streams; designed and implemented field studies to quantify the effects of flooding and drying (natural and simulated) on fish and invertebrate communities; co-advised and provided statistical programming support to graduate students; assisted with the administration of a large (15+ students) freshwater ecology research group. *Supervisor: Angus McIntosh. 2009-2011.*

Fish & Wildlife Biologist, Washington Department of Fish and Wildlife. Olympia, WA. Development of monitoring plans and analysis of sampling results associated with recreational salmon fisheries in Puget Sound; development of statistical analysis programs (in R) for processing, illustrating, and summarizing fishery data; provided technical support to policy staff in state–tribal and trans-boundary (WA representative on the PSC-Fraser River Panel Tech. Committee) and salmon fishery management forums; prepared technical reports, memoranda, and presentations. *Supervisor: Laurie Peterson. 2007-2009.*

Fish Population Biologist, State of the Salmon/Wild Salmon Center. Portland, OR. Developed and programmed an analysis framework for the first IUCN-based range-wide and population-level status assessment for an exploited salmon species (sockeye); created comprehensive, range-wide databases containing salmon escapement data for sites monitored around the Pacific Rim; performed life cycle, population viability, and stock status analyses using modeling approaches; prepared grant proposals and technical publications. *Supervisor: Pete Rand. 2007.*

Fishery Biologist, The Fish Passage Center. Portland, OR. Provided analytical support for long-term and in-season management-related investigations on the effects of the Federal Columbia River Power System dams on the survival and/or migration of juvenile and adult Chinook salmon; managed and analyzed large (>100K records) datasets; prepared technical memoranda to brief decision makers (i.e. dam operations during migration season) as well as detailed project reports. *Supervisor: Michele DeHart. 2006-2007.*

PROFESSIONAL EXPERIENCE (CONTINUED)

Research Technician, Aquatic Ecology Lab, Ohio State University. Columbus, OH. Performed lab and field work for a doctoral research project on mechanisms controlling recruitment of Lake Erie fishes; collected, identified, and quantified zooplankton samples; collected and quantified larval fish samples; analyzed larval fish diets. *Supervisors: Stuart Ludsin and Roy Stein. 1997-1999 (academic year).*

Research Technician, Idaho Department of Fish and Game. Nampa, ID. Assisted with fieldwork for a steelhead trout recovery study; conducted snorkel surveys in remote Idaho streams; collected juvenile steelhead using multiple sampling methods; assisted with a large-scale PIT-tagging program. *Supervisor: Alan Byrne. 1998 (summer).*

Hatchery Technician, Wyoming Trout Ranch. Cody, WY. Performed daily duties associated with the maintenance and operation of a private trout hatchery and pond management company; estimated daily rations to achieve desired growth goals; managed fish waste and water quality; installed pond aeration systems. *Supervisor: 1997 (spring/summer).*

TEACHING AND MENTORING EXPERIENCE

TEACHING AND SEMINAR COORDINATION

University of Canterbury: Freshwater Ecosystems (BIOL375, *co-instructed*), 2009-2010; Freshwater Ecology Graduate Seminar (BIOL472; *co-led*), 2009-2010.
Utah State University: Biodiversity Conservation (AWER1200), 2005; Directed Readings in Ecology (AWER 6900), 2004; Ecology Center Seminar Series, graduate committee chair, 2004-2006.
University of Idaho: Fish Ecology (FISH314, *teaching assistant*), 2000.

GUEST LECTURES

Portland State University: Lecture title: "Models and Pacific salmon management in the Pacific Northwest" (Course: Limnology and Aquatic Ecology), 2013.
Oregon State University: Lecture title: "Evaluating the effects of mitigation measures on imperiled Snake River Chinook salmon: the Comparative Survival Study" (Course: Fish & Wildlife Seminar), 2006.

GRADUATE COMMITTEES

Helen Warburton, Ph.D., University of Canterbury (*July 2015*)
Simon Howard, Ph.D., University of Canterbury (*December 2014*)

PEER-REVIEWED PUBLICATIONS

1) **McHugh, P.A.**, R.M. Thompson, H.S. Greig, H.J. Warburton, and A.R. McIntosh. 2015. Habitat size influences food web structure in drying streams. Ecography 38:700-712.
2) Al-Chokhachy, R.A., S. Moran, P.A. McHugh, S. Bernall, W. Fredenberg. And J.M. DosSantos. 2015. Consequences of actively managing a small bull trout population in a fragmented landscape. Transactions of the American Fisheries Society 144:515-531.
3) White, R.S., **P.A. McHugh**, C.N. Glover, and A.R. McIntosh. 2015. Multiple environmental stressors increase the realised niche breadth of a forest-dwelling fish. Ecography 38:154-162.
4) Jellyman, P.G., **P. McHugh**, and A.R. McIntosh. 2014. Increases in disturbance and reductions in habitat size interact to suppress predator body size. Global Change Biology. 20: 1550-1558.
5) Budy, P., G.P. Thiede, J. Lobon-Cervia, G. Gonzalez Fernandez, **P. McHugh,** A.McIntosh, L. Asbjorn Vollestad, E. Becares, and P. Jellyman. 2013. Limitation and facilitation of one of the world's most invasive fish: an intercontinental comparison. Ecology 94:356-367.
6) Rand, P.S., M. Goslin, M.R. Gross, J.R. Irvine, X. Augerot, **P.A. McHugh**, and V.F. Bugaev. 2012. Global assessment of extinction risk to populations of sockeye salmon. PLOS ONE 7(4):e34065.
7) **McHugh, P.**, A.R. McIntosh, S.W. Howard, and P. Budy. 2012. Niche flexibility and trout-galaxiid co-occurrence in a hydrologically diverse riverine landscape. Biological Invasions 14:2393-2406.
8) McIntosh, A., **P.A. McHugh**, and P. Budy. 2011. Brown Trout, Chapter 24, In: Handbook of Global Freshwater Invasive Species (a summary of the current state of knowledge of 30 of the most notable global invasive freshwater species). Earthscan Press.

PEER-REVIEWED PUBLICATIONS (CONTINUTED)

9) Woodford, D.J., T.A. Cochrane, **P.A. McHugh**, and A.R. McIntosh. 2011. Modelling spatial exclusion of a vulnerable native fish by introduced trout in rivers using landscape features: a new tool for conservation management. Aquatic Conservation: Marine and Freshwater Ecosystems. 21:484-49.
10) **McHugh, P.**, A.R. McIntosh, and P.G. Jellyman. 2010. Dual influences of ecosystem size and disturbance on food chain length in streams. Ecology Letters. 13:881-890.
11) McIntosh, A.R., **P.A McHugh**, N.R. Dunn, J.M. Goodman, S.W. Howard, P.G. Jellyman, L.K. O'Brien, P. Nyström, and D.J. Woodford. 2010. The impact of salmonids on galaxiid fishes in New Zealand. New Zealand Journal of Ecology. 34:195-206.
12) P. Budy, G.P. Thiede, **P. McHugh**, E.S. Hansen, and J. Wood. 2008. Exploring the relative influence of biotic interactions and environmental conditions on the abundance and distribution of exotic brown trout (*Salmo trutta*) in a high mountain stream. Ecology of Freshwater Fish. 17:554-566.
13) **McHugh, P.**, P. Budy, E. VanDyke, and G.P. Thiede. 2008. Trophic relationships between exotic brown trout (*Salmo trutta*) and native Bonneville cutthroat trout (*Oncorhynchus clarkii utah*) in a northern Utah river. Environmental Biology of Fishes 81:63-75.
14) Budy, P., G.P. Thiede, and **P. McHugh**. 2007. A quantification of the vital rates, abundance, and status of a critical population of endemic cutthroat trout. North American Journal of Fisheries Management 27:593-604.
15) **McHugh, P.**, and P. Budy. 2006. Experimental effects of exotic brown trout (*Salmo trutta*) on the individual- and population-level performance of native Bonneville cutthroat trout (*Oncorhynchus clarkii utah*). Transactions of the American Fisheries Society 135:1441-1455.
16) **McHugh, P.**, and P. Budy. 2005. An experimental evaluation of competitive and thermal effects on brown trout (*Salmo trutta*) and Bonneville cutthroat trout (*Oncorhynchus clarkii utah*) performance along an altitudinal gradient. Canadian Journal of Fisheries and Aquatic Sciences 62:2784-2795.
17) **McHugh, P.**, and P. Budy. 2005. A comparison of visual versus measurement-based techniques for quantifying cobble embeddedness and fine-sediment levels in salmonid-bearing streams. North American Journal of Fisheries Management 25:1208-1214.
18) **McHugh, P.**, P. Budy, and H. Schaller. 2004. A model-based assessment of the potential response of Snake River spring/summer Chinook salmon to habitat improvements. Transactions of the American Fisheries Society 133:622-638.
19) **McHugh, P.**, and P. Budy. 2004. Patterns of spawning habitat selection and suitability for two populations of spring Chinook salmon, with an evaluation of generic versus site-specific suitability criteria. Transactions of the American Fisheries Society 133:89-97.

MANUSCRIPTS IN PRESS, REVIEW, OR PREPARATION

1) White, R.S., **P.A. McHugh**, C.N. Glover, and A.R. McIntosh. *In Press*. Trap-shyness subsidence is a threshold function of mark-recapture interval in brown mudfish populations. Submitted to: Journal of Fish Biology (Accepted July 2015).
2) White, R., C. Glover, **P. McHugh**, and A.R. McIntosh. *In Review*. Metabolic trade-offs drive distribution and abundance in extremophile forest fish. Submitted to: PLOS ONE (April 2015).
3) McIntosh, A.R., **P.A. McHugh**, M.J. Plank, P.G. Jellyman, H.J. Warburton, H.S. Greig, and P. Nyström. *In Preparation*. Capacity to support predators scales with habitat size. Target journal: Ecology Letters.
4) Greig, H.S., A.R. McIntosh, and **P.A. McHugh**. In *Preparation*. Influence of habitat size on the structure and stability of stream food webs. Target journal: Global Change Biology.

SELECTED TECHNICAL REPORTS

1) **McHugh, P**, A. Hagen-Breaux, and L. LaVoy. 2013. Incorporating recent empirical information on sublegal encounters into FRAM modeling. Report to Pacific Fishery Management Council, Portland, Oregon. 21 pp.
2) **McHugh, P.A.**, C. Mallette, L.E. Rinearson, E.S. Van Dyke, and M.H. Weaver. 2012. Smallmouth bass abundance and dietary habits at three mainstem Columbia River dams: are forebay and tailrace environments 'hotspots' of salmonid predation? DOE/BPA Project 200871800. Portland, Oregon. 33 pp.
3) Weaver, M.H., E. Tinus, M. Gardner, C. Mallette, **P.A. McHugh**. 2012. Development of a system-wide predator control program: fisheries evaluation. Oregon Dept. of Fish and Wildlife, Contract Number DE-B1719-94BI24514. 2011 Annual Report to the Bonneville Power Administration, Portland, Oregon. 36 pp.
4) **McHugh, P.**, M. Baltzell, and L. Peterson. 2009. Marine Area 7 (San Juan Islands) mark-selective recreational Chinook fishery, February 1-29, 2008 Post-season report. Washington Department of Fish and Wildlife. Olympia, Washington. 48 pp. (*12 other co-authored fishery reports are at* http://wdfw.wa.gov/fish/selective/techniques/technical_documents.htm).
5) Conrad, R. and **P. McHugh**. 2008. Assessment of two methods for estimating total Chinook salmon encounters in Puget Sound/Strait of Juan de Fuca mark-selective Chinook fisheries. Northwest Fishery Resource Bulletin. Manuscript Series Report No. 2.
6) WDFW (**P. McHugh** and 7 co-authors). 2008. A multi-year review of the Marine Areas 8-1 and 8-2 mark-selective Chinook fishery, 2005-2007. Washington Department of Fish and Wildlife. Olympia, Washington. 145 pp.
7) Comparative Survival Study Oversight Committee and Fish Passage Center (14 co-authors, including **P. McHugh**). 2007. Comparative Survival Study of PIT-tagged spring/summer Chinook salmon and steelhead in the Columbia River Basin: Ten-year retrospective analyses report. DOE/BPA Project 199602000. Portland, Oregon. 674 pp.
8) Berggren, T., **P. McHugh**, P. Wilson, H. Schaller, C. Petrosky, E. Weber, and R. Boyce. 2006. Comparative survival study of PIT-tagged spring/summer Chinook salmon and summer steelhead. DOE/BPA Project 199602000. Portland, Oregon. 179 pp.

PAPERS PRESENTED

1) *Using spatial autocorrelation to improve network-scale models of salmonid abundance.* American Fisheries Society, Portland, OR (2015)
2) *Variation in terrestrial invertebrate contributions to salmonid production in the John Day River Basin*. American Fisheries Society, Portland, OR (2015)
3) *Individual and environmental factors influencing survival for exploited populations of northern pikeminnow in the Columbia and Snake rivers*. American Fisheries Society, Seattle, WA (2011)
4) *Food-web structure-flow relationships in intermittent Canterbury streams*. New Zealand Freshwater Sciences Society, Christchurch, New Zealand (2010)
5) *Variation in food-web structure along inverse size gradients in temperate alluvial streams*. North American Benthological Society, Santa Fe, NM (2010)
6) *The impacts of non-native trout on galaxiid fishes in New Zealand*. Western Division of the American Fisheries Society, Salt Lake City, UT (2010)
7) *Hydrology and food webs.* Department Seminar, University of Canterbury, School of Biological Sciences, Christchurch, New Zealand (2010)
8) *Biotic and abiotic drivers of galaxiid–salmonid trophic relationships in upper Waimakariri River tributaries: new insight from stable isotope analysis*. New Zealand Freshwater Sciences Society, Whangarei, New Zealand (2009)
9) *Contrasting emigrant life-history characteristics between wild stream-type Chinook salmon populations in the John Day and Snake River basins.* American Fisheries Society (OR Chapter), Portland, OR (2007)

PAPERS PRESENTED (CONTINUED)

10) *An experimental assessment of the multi-scale effects of exotic brown trout on native Bonneville cutthroat trout*. American Fisheries Society, Anchorage, AK (2005)
11) *An experimental evaluation of altitudinal species-zonation patterns in montane streams: do abiotic or biotic factors determine the distribution of native and nonnative trout in Utah, USA, rivers?* VI International Congress on the Biology of Fish, Manaus, Brazil (August 2004)
12) *Evidence for competition between introduced brown trout and native Bonneville cutthroat trout in the Logan River, Utah*. American Fisheries Society (Western Division), Salt Lake City, UT (2004)
13) *Evaluating the demographic effects of disease on cutthroat trout in the Logan River, Utah: a PVA approach*. American Fisheries Society, Quebec, Canada (2003)
14) *A model-based assessment of the potential response of selected Snake River spring/summer Chinook salmon populations to habitat improvements.* Invited presentation, U.S. Fish and Wildlife Service Columbia River Fisheries Program Office, Vancouver, WA (2002)
15) *An assessment of Snake River spring/summer Chinook salmon spawning habitat suitability using logistic regression techniques*. American Fisheries Society (ID/Bonn. chapters), Pocatello, ID (2002)
16) *A model-based approach to assessing the potential response of selected Snake River spring/summer Chinook salmon populations to spawning and rearing habitat improvements*. American Fisheries Society, Phoenix, AZ (2001)

GRANTS AND AWARDS

Project Grant ($159,855) for project entitled *Washington Age Database*, U.S. Section Pacific Salmon Commission, 2013 and 2014 (with Brodie Cox, Lance Campbell, and Mick Morbitzer).

Research Grant (NZ$20,820) for project entitled *Fish in the Forest: Ecophysiological determinants of mudfish distributions in the forests of Westland National Park*, Brian Mason Scientific and Technical Trust, 2011 (with Angus McIntosh, Chris Glover, and Richard White).

Research Support (NZ$5,000) for supervised undergraduate project entitled *Assessing the effects of hydrologic disturbance on the structure of stream food webs*, University of Canterbury, 2009.

USU Spring Runoff Conference, Best Poster Presentation Award ($250), 2006.

Research Support ($1,200), Utah State University Ecology Center, 2005.

VI International Congress on the Biology of Fish, Fish Ecology Symposium, Best Presentation. 2004.

Graduate Mentor Award, Utah State Univ., Dept. of AWER, 2004.

Community-University Initiative Grant ($12,000), Utah State University, 2004 (with Phaedra Budy).

Quinney Doctoral Fellowship ($36,000), The Quinney Foundation, 2002.

American Fisheries Society/Sea Grant, Outstanding Presentation Award ($1,000), 2001.

SERVICE, OUTREACH, AND PROFESSIONAL SOCIETY AFFILIATION

Reviewer for journals: Aquatic Conservation-Marine and Freshwater Ecosystems, Canadian Journal of Fisheries and Aquatic Sciences, Ecology of Freshwater Fish, Fisheries, Journal of Applied Ecology, Journal of Fish Biology, New Zealand Journal of Marine and Freshwater Research, North American Journal of Fisheries Management, PLOS ONE, Restoration Ecology, and Transactions of the American Fisheries Society.

Professional society activity: American Fisheries Society (2000-present), former secretary of the Utah State University sub-unit of the AFS; Continuing Ed Coordinator AFS Annual Meeting (Portland, OR, 2015); New Zealand Freshwater Sciences Society (2009-2011), organizer for 2010 meeting field trips.

Outreach and public service: volunteer docent for the Kennedy Creek Salmon Watch, Mason County, WA (2008); staffed Washington Department of Fish and Wildlife kids fishing events at the Puyallup Fair (2007), and Klineline Ponds (2012); outreach/extension with the Utah Coop. Fish and Wildlife Research Unit (2002-2005), inclusive of activities/presentations at Stokes Nature Center (2003), Bear River Celebration (2002-4), Common Ground (2002-2004), Trout Unlimited/Cache Anglers (2004-2005).

REFERENCES

(1) Phaedra Budy, Unit Leader and Professor
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Utah State University
Logan, UT 84322
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(2) Angus McIntosh, Professor and Mackenzie Foundation Chair in Freshwater Ecology
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University of Canterbury
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Updated February 6, 2015

STATEMENT OF RESEARCH INTERESTS

I am an ecogeomorphologist and I am fascinated by rivers and streams and the biota that occupy and alter the habitat shaped by such systems. I have strong applied interests in the restoration and the management of watersheds and their rivers and have worked extensively at the interface between environmental policy, practice and science. I strive to find practical outlets for my research and in particular take the technological and methodological developments we work on and package them into tools and frameworks of use to both practitioners and researchers. Some of the hot applied topics my lab (ET-AL) has been working on lately include:

- Developing 'cheap and cheerful' restoration and monitoring approaches
  - Using beaver as a restoration tool
  - Using $_{HD}$LWD (high density large woody debris) to restore dynamic, self-sustaining, complex habitats to recover salmonid fish populations
- Developing multi-scalar monitoring protocols (see CHaMP and Big Rivers Monitoring Protocol)
- Pioneering new analytical tools to help the community deal with a new era of big data (see: GCD, ZCloud Tools, MBES Tools, BRAT)

There are three broad themes in which most of the research I pursue fits into:

1. Linking Fluvial Geomorphology & Ecohydraulics
2. Monitoring and Adapting to Change
3. Scenario Model Development

See http://www.joewheaton.org/Home/research for more information.

EDUCATION

University of Southampton, Southampton, United Kingdom
Ph.D. Degree in Geography — *Received:* June 2008

University of California at Davis, Davis, CA, USA
M.S. Degree in Hydrologic Sciences — *Received*: June 2003

University of California at Davis, Davis, CA, USA
B.S. Degree in Hydrology — *Received*: June 2002

WORK EXPERIENCE

PROFESSIONAL ACADEMIC EXPERIENCE

Assistant Professor, August 2009 to Present
Utah State University, Department of Watershed Sciences, *Logan, UT, USA*
Related USU Affiliations:
Director of *Ecogeomorphology & Topographic Analysis Lab*
Director of Fluvial Habitats Center
Co-Director of *Intermountain Center for River Rehabilitation & Restoration*
Water Faculty Member of *USU Water Initiative*
Faculty member of *Ecology Center*

Honorary Lecturer in Physical Geography, Jan 2009 – Present
Aberystwyth University, Institute of Geography & Earth Sciences, *Aberystwyth, Wales, UK*

Research Assistant Professor, August 2008 - July 2009
Idaho State University, Department of Geosciences, *Pocatello, ID, USA*

Lecturer in Physical Geography, January 2006 - August 2008
Aberystwyth University, Institute of Geography & Earth Sciences, *Aberystwyth, Wales, UK*

Ph.D. Student, 2003- 2008
University of Southampton School of Geography, *Southampton, Hampshire, UK*
Research Projects:
Uncertainty from Morphological Sediment Budgeting in Rivers (PhD Thesis)
MORPHED (object oriented Cellular Automaton Slope and River) Model
International River Restoration Survey
Supervisors: Stephen E. Darby, Ph.D., *Senior Lecturer in Geography*
David A. Sear, Ph.D., *Reader in Geography*
Mike Acreman, Ph.D., *Centre for Ecology and Hydrology*
Douglas Booker, Ph.D., *Centre for Ecology and Hydrology*

Research Assistantship, 2001-2003 (full time summers; half-time school year)
U.C. Davis Watershed Hydrology & Geomorphology Laboratory, *Davis, CA, USA*
Research Projects:
SHIRA – Developed Spawning Habitat Integrated Rehabilitation Approach as a holistic, science-based framework for reach-scale rehabilitation of salmonid spawning habitat on regulated rivers (Master's Thesis)
Mokelumne River – Design and implementation of two separate spawning bed enhancement projects using SHIRA approach. Included modeling, design development, construction observation, field work and monitoring
Bear Creek – Topographic surveying & post project monitoring of restoration
Dry Creek – Revisiting "velocity-reversal hypothesis"
Clear Creek – Topographic surveying & post project monitoring of dam removal
Cosumnes River - Coordinated aerial topographic surveys & set ground control
Supervisor: Gregory B. Pasternack, Ph.D.; *Assistant Professor of Hydrology*

OTHER PROFESSIONAL EXPERIENCE

Associate Consultant, November 2008 to 2012
CH2M HILL, Water Group, *Boise, ID, USA*
Responsibilities:

Conduct senior reviews of restoration project design and monitoring

Sub-Consultant, 2001-2003 (part-time)
Jennifer Chandler Landscape Architect, *Napa, CA, USA*
Responsibilities:

Design and preparation of erosion control plans, grading and drainage plans, regulatory applications and technical reports for restoration, agricultural and residential projects

Provide professional drafting services and field reconnaissance

Civil Engineering Technician, 1997-2000 (full-time)
Bartelt Engineering, *Napa, CA, USA*
Responsibilities:

Project Manager of various projects which included field engineering, preparation and design of plans, construction observation and conducting meetings and maintaining correspondence with clients, other consultants, contractors and regulatory agencies

Preparation of improvement plans, design calculations, regulatory applications and technical reports for residential, agricultural, commercial, and industrial projects

Agricultural Projects Coordinator (primarily erosion control for hillside vineyards)

Company CAD Manager and Network Administrator

Civil Engineering Intern, 1995-1996 (full-time summers)
County of Napa Public Works Department, *Napa, CA, USA*
Responsibilities:

Drafting, surveying, writing legal descriptions, preparing departmental presentations and inspecting flood control channel network

RESEARCH

SCHOLARLY CONTRIBUTIONS

PEER-REVIEWED RESEARCH PUBLICATIONS

See Also:

Researcher Gate Profile: https://www.researchgate.net/profile/Joseph_Wheaton
ResearcherID Profile: F-1965-2010: http://www.researcherid.com/rid/F-1965-2010

*Wheaton Graduate Student
**Wheaton Graduate advisee
†Wheaton's PhD or MS Supervisor
‡ Wheaton Post-Doc

1. 2015. Kasprak* A, Wheaton JM, Ashmore PE, Hensleigh JH, & Peirce S. The Relationship Between Particle Travel Distance and Channel Morphology: Results from Physical Models of Braided Rivers. JGR Earth Surface. DOI: 10.1002/2014JF003310.

2. 2014. Camp R* and Wheaton JM. Streamlining Field Data Collection with Mobile Apps. EOS. 95 (49): 453-454. DOI: 10.1002/2014EO490001.

3. 2014. Jackson JR, Pasternack GB, and Wheaton JM. Virtual manipulation of topography to test potential pool-riffle maintenance mechanisms. Geomorphology. DOI:10.1016/j.geomorph.2014.10.016.

4. 2014. Hough-Snee N*, Roper BB, Wheaton JM and Lokteff RL*. Riparian Vegetation Communities of the American Pacific Northwest are Tied to Multi-Scale Environmental Filters. River Research & Applications. DOI: 10.1002/rra.2815.

5. 2014. Bangen SG*, Wheaton JM, Bouwes N, Jordan C, Volk C and Ward M. Crew variability in topographic surveys for monitoring wadeable streams: a case study from the Columbia River Basin. Earth Surface Processes and Land Forms. DOI: 10.1002/esp.3600.

6. 2014. Pollock, M., Beechie T , Wheaton JM, Jordan C, Bouwes N, Weber N, and Volk C. Using Beaver Dams to Restore Incised Stream Ecosystems. Bioscience. DOI: 10.1093/biosci/biu036.

7. 2014. Tang C‡, Dong C, Crosby BT, Piechota TC, Thomas C and Wheaton JM. Is the PDO or AMO the climate driver of soil moisture in the Salmon River Basin, Idaho? Global and Planetary Change. DOI: 10.1016/j.gloplacha.2014.05.008.

8. 2014. Bangen SG*, Wheaton JM, Bouwes N, Bouwes B, and Jordan C. A methodological intercomparison of topographic survey techniques for characterizing wadeable streams and rivers. Geomorphology. DOI: 10.1016/j.geomorph.2013.10.0100.010.

9. 2013. Hough-Snee N*, Roper BB, Wheaton JM, Budy P, Lokteff RL. Riparian vegetation communities change rapidly following passive restoration at a northern Utah stream. Ecological Engineering 58: 371-377.7. DOI: 10.1016/j.ecoleng.2013.07.042.

10. 2013. Lokteff RL*, Roper B and Wheaton JM. Do beaver dams impede the movement of trout? Transactions of American Fisheries Society. DOI: 10.1080/00028487.2013.797497.

11. 2013. Wheaton JM, Brasington J, Darby SE, Sear DA, Vericat D‡., and Kasprak A*. Morphodynamic signatures of braiding mechanisms as expressed through change in sediment storage in a gravel-bed river. Journal of Geophysical Research - Earth Surface. DOI: 10.1002/jgrf.20060.

12. 2013. Manners RB**, Schmidt J and Wheaton JM. Multi-scalar model for the determination of spatially explicit riparian vegetation roughness. Journal of Geophysical Research - Earth Surface. 118: 1-19. DOI: 10.1029/2011JF002188.

13. 2012. Pollock M, Wheaton JM, Bouwes N and Jordan CE. Working with Beaver to Restore Salmon Habitat in the Bridge Creek Intensively Monitored Watershed: Design Rationale and Hypotheses. US Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-20: NOAA Northwest Fisheries Science Center, Seattle, WA, 47 pp.

14. 2012. Erwin SO**, Schmidt JC, Wheaton JM and Wilcock PR. Closing a sediment budget for a reconfigured reach of the Provo River, Utah, United States. Water Resources Research. 48: WR10512. DOI: 10.1029/2011WR011035.

15. 2012. Tang C, Crosby BT, Wheaton JM and Piechota TC. Assessing streamflow sensitivity to climate changes in the Salmon River Basin, Idaho. Global and Planetary Change. 88-89: 32-44. DOI: 10.1016/j.gloplacha.2012.03.002.

16. 2012. Wheaton JM, Garrard C, Whitehead K and Volk C. A Simple, Interactive GIS Tool for Transforming Assumed Total Station Surveys to Real World Coordinates - The CHaMP Transformation Tool. Computers & Geosciences. 42: 28-36. DOI: 10.1016/j.cageo.2012.02.003.

17. 2011. Wheaton JM, Gibbins C, Wainwright J, McElroy B and Larsen L. Preface: Multiscale Feedbacks in Ecogeomorphology. Geomorphology. 126(3-4): 265-268. DOI: 10.1016/j.geomorph.2011.01.002.

18. 2010. Wheaton JM, Brasington J, Darby SE† and Sear D†. Accounting for Uncertainty in DEMs from Repeat Topographic Surveys: Improved Sediment Budgets. Earth Surface Processes and Landforms. 35(2): 135-156. DOI: 10.1002/esp.1886.2009.

19. 2010. Wheaton JM, Brasington J, Darby SE†, Merz JE, Pasternack GB†, Sear DA† and Vericat D‡. Linking Geomorphic Changes to Salmonid Habitat at a Scale Relevant to Fish. River Research and Applications. 25: 469-486. DOI: 10.1002/rra.1305.

20. 2009. Vericat, D‡, Brasington, J, Wheaton, JM and Cowie M. Accuracy Assessment of Aerial Photographs Acquired using Lighter-Than-Air Blimps: Low-Cost Tools for Monitoring Fluvial Systems. *River Research and Applications*. DOI: 10.1002/rra.1198.

21. 2008. Sear, DA, Wheaton, JM and Darby, SE. Uncertain restoration of gravel-bed rivers and the role of geomorphology. In: Habersack, H, Piegay, H and Rinaldi, M (Editors), *Gravel-Bed Rivers VI: From Process Understanding to River Restoration*. Elseiver, pp. 739-760. DOI: 10.1016/S0928-2025(07)11162-7.

22. 2008. Wheaton, JM, Darby, SE† and Sear, DA†. The Scope of Uncertainties in River Restoration. In: Darby, SE and Sear, DA (Editors), *River Restoration: Managing the Uncertainty in Restoring Physical Habitat.* John Wiley and Sons, Chichester, U.K., pp. 21-39. DOI: 10.1002/9780470867082.ch3.

23. 2006. MacWilliams, ML Jr., Wheaton, JM, Pasternack, GB†, Street, RL and Kitanidis, PK. Flow convergence and routing hypothesis for pool-riffle maintenance in alluvial rivers, *Water Resources Research*, 42, W10427. DOI: 10.1029/2005WR004391.

24. 2006. Pasternack, GB†, Gilbert, AT, Wheaton, JM and Buckland, EM. Error Propagation for Velocity and Shear Stress Prediction: Using 2D Models For Environmental Management. *Journal of Hydrology*. 328 (1-2): 227-241. DOI: 10.1016/j.jhydrol.2005.12.003.

25. 2006. Wheaton, JM, Darby, SE†, Sear, DA† and Milne, JA. Does scientific conjecture accurately describe restoration practice? Insight from an International River Restoration Survey. *Area*. 38(2): 128-142. DOI: 10.1111/j.1475-4762.2006.00685.x.

26. 2006. Merz, JE, Pasternack, GB† and Wheaton, JM. Sediment budget for salmonid spawning habitat rehabilitation in a regulated river. *Geomorphology*. 76(1-2): 207-228. DOI: 10.1016/j.geomorph.2005.11.004.

27. 2004. Wheaton, JM, Pasternack, GB†, and Merz, JE. Spawning Habitat Rehabilitation - I. Conceptual Approach and Methods, *International Journal of River Basin Management*. 2(1): 3-20. DOI: 10.1080/15715124.2004.9635218.

28. 2004. Wheaton, JM, Pasternack, GB†, and Merz, JE. Spawning Habitat Rehabilitation - II. Using Hypothesis Testing and Development in Design, Mokelumne River, California, U.S.A., *International Journal of River Basin Management.* 2(1): 21-37. DOI: 10.1080/15715124.2004.9635219.

29. 2004. Merz JE, Setka JD, Pasternack GB† and Wheaton JM. Predicting benefits of spawning-habitat rehabilitation to salmonid (Oncorhynchus spp.) fry production in a regulated California river. *Canadian Journal of Fisheries and Aquatic Sciences*. 61(8): 1433-1446. DOI: 10.1139/f04-077.

PEER REVIEWED RESEARCH PUBLICATIONS IN PRESS, REVISION OR REVIEW

*Wheaton Graduate Student	†Wheaton's PhD or MS Supervisor
**Wheaton Graduate advisee	‡ Wheaton Post-Doc

1. In Revision. Wheaton JM, Fryirs K, Brierley G, Bangen S, Bouwes N, and O'Brien G. Geomorphic Mapping and Taxonomy of Riverscapes. For submission to Geomorphology.

2. In Revision. Hough-Snee N*, Laub B, Merritt DM, Long L, Nackley LL, Roper BB, and Wheaton JM. Multi-scale environmental filters and niche partitioning govern the distributions of riparian vegetation guilds. Submitted to Ecosphere. Preprint available at: DOI: 10.7287/peerj.preprints.653v1.

3. In Review. Schaffrath K, Belmont P and Wheaton JM. Landscape-scale geomorphic change detection: Quantifying spatially-variable uncertainty and circumventing legacy data issues. Submitted to: ISPRS Journal of Photogrammetry and Remote Sensing.

4. In Review - 2015. Majerova M, Neilson BT, Schmadel NM, Wheaton JM, and Snow C. Impacts of beaver dams on hydrologic and temperature regimes. Hydrology and Earth Systems Science Discussions, 12: 839-878. DOI: 10.5194/hessd-12-839-2015.

5. In Revision. Macfarlane WW‡ , Wheaton JM, Jensen M*, Bouwes N, Hough-Snee N*, and Shivick J. Modeling the capacity of riverscapes to support beaver dams. Submitted to: Ecohydrology.

6. In Revision. Wheaton JM, Bennett S, Bouwes N and Camp R*. Adapting Adaptive Management for Testing the Effectiveness of Stream Restoration: An Intensively Monitored Watershed Example. Submitted to Fisheries.

7. In Review. Passalacqua P, Belmont P, Staley D, Simley J, Arrowsmith JR, Bodee C, Crosby C, DeLongg S, Glenn N, Kelly S, Lague D, Sangireddy H, Schaffrath K, Tarboton D, Wasklewicz T, Wheaton J. Analyzing high resolution topography for advancing the understanding of mass and energy transfer through landscapes: A review. Submitted to Earth Science Reviews.

PEER REVIEWED RESEARCH PUBLICATIONS IN PREP

1. In Prep. Wheaton JM, Bouwes N, DeMurichy K‡ , Jordan C, Pollock M, Volk C, Weber N, The Ecogeomorphic Response of an Incised Channel to Beaver Dams. For submission to Earth Surface Processes and Landforms.

2. In Prep. Wheaton JM and Vericat D. The morphologic approach and novel instrumentation as keys to estimate bedload yield. For submission to edited volume for Gravel Bed Rivers 8.

3. In Prep. Fryirs K, Wheaton JM, Brierley G, Macfarlane W‡ , Whitehead K, and Volk C. A Quantitative Approach to Measurement of Valley Confinement. For submission to Water Resources Research.

4. In Prep. Wheaton JM, Brierley G. Is there an appetite for Cheap & Cheerful Recipes For Rivers? For submission to Science.

5. In Prep. Camp R*, Wheaton JM, Bennett S, and Bouwes N. Short Term Effectiveness of Cheap and Cheerful Restoration Using High Density Large Woody Debris. For submission to River Research and Applications? or Environmental Management?

6. In Prep. Camp R*, Wheaton JM, Bennett S, O'Brien G,and Bouwes N. Using River Styles to Prioritize $_{HD}$LWD Restoration for Steelhead Habitat in a Washington Stream . For submission to Journal of Applied Geography? or Similar.

7. In Prep. Camp R*, Wheaton JM, Bennett S, O'Brien G,and Bouwes N. Viability of a Cheap and Cheerful Restoration Monitoring Method. For submission to Environmental Management? or Similar.

8. In Prep. Camp R*, Wheaton JM, Weber N, Bennett S, Bouwes N and Hough-Snee N*. Determining Functional Structure of Winter Concealment Locations for Steelhead (Oncorhynchus Mykiss).

9. In Prep. Kasprak A*, Wheaton JM, Brasington J, and Hafen K‡. A simplified framework for modeling braided river morphodynamics. For submission to: Journal of Geophysical Research: Earth Surface or

10. In Prep. Bangen S‡, Wheaton JM, Hensleigh J‡, and Bailey P. Pragmatic Error Modeling of Digital Elevation Models from Topographic Surveys using Fuzzy Inference Systems. For submission to ESPL.

11. In Prep. Bangen S‡, Wheaton JM, Baiely P, Brierley G., Bouwes N, and O'Brien G. Derivation of Fluvial Geomorphic Units from Topography. For submission to Earth Surface Dynamics.

12. In Prep. Hensleigh J‡, Wheaton JM and others? Guidelines for Developing DEM Error Models Using Fuzzy Inference Systems. -For submission to ESPL?

13. In Prep. Wheaton JM, Bailey PE, Hensleigh J‡, Reimer M., Garrard C, Grams PE, and Schmidt J. Geomorphic Change Detection Software. For submission to Geomorphology.

14. In Prep. Portugal E‡, Bangen SG*, Wheaton JM, Faux R and Bouwes N. The Critical Importance of Using Breaklines in Digital Elevation Models of Rivers and Streams. For submission to Geomorphology.

15. In Prep. Wheaton JM, Bennett SN, Bouwes N and Camp R*. Designing Cheap and Effective Stream Restoration Projects - An Example of System Wide Woody Addition Treatment. For submission to: Restoration Ecology.

16. In Prep. Scott ML, Perkins D, Wheaton JM and Macfarlane WW‡. Big River Monitoring Protocol for Large, Remote, Canyon-bound Rivers. For submission to: River Research and Applications.

17. In Prep. Lokteff R*, Wheaton JM and Roper BB. Hierarchically Related Habitat Characteristics in the Habitat Use of Three Trout Species. For submission to: Ecohydrology.

18. In Prep. Dittbrenner B, Hough-Snee N, et al. Engineering streams with North American beaver (Castor canadensis): benefits, trade-offs, and concerns across the American West. For submission to Restoration Ecology.

19. In Prep. Hough-Snee N*, MacFarlane WW, Wheaton JM, Blankenau J, Deters H. Managing North American beaver (Castor canadensis) in urban settings: an adaptive management plan from Park City, Utah's urban-wildland interface. For submission to Ecology & Society.

20. In Prep. Hough-Snee N*, Wheaton JM, Bouwes N, Roper BB, Kasprak AK*, Camp RJ*, Rossi R*. Factors controlling wood distributions within targeted subbasins of the Columbia River Watershed. For submission to Water Resources Research.

21. In Prep. Kasprak AK*,, Hough-Snee N*, Beechie T, Bouwes N, Brierley G, Camp R*, Fryirs K, Imaki H, Jensen M*, O'Brien G, and Wheaton JM. Choosing the Right Tool for the Job: Comparing Stream Channel Classification Frameworks. For submission to Water Resources Research.

22. In Prep. Hough-Snee N*, Wheaton JM. Estimating instream wood in two basins targeted for salmon habitat restoration: models for predictive inference in Washington and Oregon, USA. For submission to River Research & Applications.

SELECTED ORAL PRESENTATIONS

1. 2015. *Invited Talk:* Wheaton JM. Optimizing the use of beaver in restoration and water quality improvement. Stream Restoration Planning Committee. Utah Division of Wildlife Resources. Salt Lake City, UT.

2. 2014. *Invited Keynote Talk:* Wheaton JM. Trends and Challenges in Geomorphic Change Detection. Australia and New Zealand Geomorpholgy Group Annual Conference. Queensland, Australia.

3. 2014. *Invited Webinar:* Wheaton JM. What Role Might Beaver Play in Restoring The West? Utah State Forestry Extension Webinar.

4. 2014. *Invited Talk:* Wheaton JM. Integrated Geomorphic Assessment and Life Cycle Modelling. Upper Columbia River Watersheds Technical Review Team, Levenworth, Washington.

5. 2014. *Invited Talk*: Wheaton JM. Departmental Seminar – Unverstiat de Lleida – Department of Environment and Soil Sciences, Lledia, Catalunya, Spain.

6. 2014. *Invited Talk*: Wheaton JM. How do you account for fish habitat with a total station. 2014 CHaMP Camp. Cove, OR.

7. 2014. *Invited Talk*: Wheaton JM. What can a Rodent Teach us About Restoring Streams? Departmental Seminar – Boise State University Department of Geosciences. Boise, ID.

8. 2014. *Invited Talk*: Wheaton JM. Addressing Key Management Questions - Planning, Prioritization and Implementation. CHaMP & ISEMP State of the Science Workshop: Bonneville Power Administration. Portland, OR.

9. 2013. *Invited Talk*: Wheaton JM. Harnessing DEMs for Quantifying Fish Habitat. CHaMP 2013 Post Season Workshop. Boise, ID.

10. 2013. *Invited Talk*: Wheaton JM. Derivation of Geomorphic Units from Topography. Fall Meeting AGU. EOS Transactions, San Francisco, CA.

11. 2013. *Invited Webinar*: Wheaton JM. Geomorphic Change Detection: Harnessing Repeat Topographic Surveys. CUAHSI Cybersminar Series on Multidisciplinary Approaches to Investigating River Processes.

12. 2013. *Invited Talk*: Wheaton JM. Beaver: Restoration liaison between riparian and upland systems. Restoring the West Conference, Logan, Utah.

13. 2013. *Invited Webinar*: Wheaton JM. Cheap and Cheerful Stream & Riparian Restoration- With Beaver? Webinar to National Riparian Service Team.

14. 2013. *Invited Talk*: Wheaton JM. Conservation & Restoration Opportunities through Partnering With Beaver. Presentation to Utah Division of Wildlife Resources: Salt Lake City, UT.

15. 2013. *Invited Talk*: Wheaton JM. Beaver - Nuisance or Restoration Partner, Presentation to Swanner Ecocenter: Park City, UT.

16. 2013. *Invited Talk*: Wheaton JM. Partnering With Beaver In Restoration, Presentation to Beaver & Wetlands Workshop: Santa Fe, NM.

17. 2013. *Invited Talk:* Wheaton JM. Cheap and Cheerful Stream Restoration & Monitoring - The Example of Partnering With Beaver In Riparian Restoration, Presentation to Utah Riparian Team: Salt Lake City, UT.

18. 2013. *Invited Seminar:* Wheaton JM. Recent Developments in Geomorphic Change Detection, University of Oregon, 1st Annual American Society of Photogrammetry & Remote Sensing Lecture: Eugene, OR.

19. 2013. *Invited Talk:* Wheaton JM – Can beaver aggrade streams to the point of floodplain reconnection and recovery? River Restoration Northwest Annual Symposium 2013: Skamania, WA.

20. 2013. *Invited Talk:* Wheaton JM and Snyder N. What do fish care about hydrogeomorphology? – A Survey of the Latest Techniques at a Full Range of Spatial Scales, Diadromous Species Restoration Research Network 2013 Science Meeting: Orono, Maine.

21. 2012. Wheaton JM, Bennett S, Bouwes N, and Camp R. Cheap and Cheerful Stream Restoration? An Example of System Wide Woody Addition Treatment, Fall Meeting AGU. EOS Transactions, San Francisco, CA.

22. 2012. *Invited Seminar:* Wheaton JM. Cheap and Cheerful Stream Restoration and Monitoring, University of Montana Department of Geosciences Colloquium. Missoula, Montana.

23. 2012. *Invited Talk*: Wheaton JM, Consolati F, Bouwes N, Pollock M, Jordan C and Volk C. Can beaver aggrade streams to the point of floodplain reconnection and recovery?, Society of Wetland Scientists Pacific Northwest Chapter 2012 Regional Conference, Boise, ID.

24. 2012. *Talk:* Wheaton JM, Consolati F, Bouwes N, Pollock M, Jordan C and Volk C. Can beaver aggrade streams to the point of floodplain reconnection and recovery? Canadian Geophysical Union. Banff, Canada.

25. 2012. *Invited Lecture/Workshop*: Wheaton JM and Pasternack G. Near Census Assessment of Fluvial Form, Process, Change and Associated Ecosystem Services., 2012 Annual Lecture Series - US Bureau of Reclamation Sedimentation & River Hydraulics GroupDenver, CO.

26. 2011. *Invited Talk*: Wheaton JM and Bangen SG*. Crew Variability in Topographic Data. Columbia Habitat Monitoring Program Post Pilot Season Workshop. NOAA: Portland, OR.

27. 2011. *Invited Talk*: Wheaton JM, Bangen SG*, and Portugal E. Topographic Survey Comparisons. Columbia Habitat Monitoring Program Post Pilot Season Workshop. NOAA: Portland, OR.

28. 2011. *Invited Seminar:* Wheaton JM. The Role of an Undiscriminating Rodent in Driving Landscape Change and Stream Dynamics, Watershed Sciences Departmental Seminar, Logan, Utah.

29. 2010. *Invited Talk*: Wheaton JM. Hydrographs & Bar Building – Using Morphological Sediment Budgeting to Test Hypotheses about Flow Release Designs, Invited Talk, Sediment Workshop, Trinity River Restoration Program, Weaverville, CA.

30. 2010. *Invited Talk*: Wheaton JM. Use of Airborne and Ground-based LiDaR in Geomorphic Change Detection, Invited Talk, AGU Fall Meeting, San Francisco, CA, pp. EP44B-06.

31. 2010. *Invited Talk*: Wheaton JM. 'Meaningful change detection and sediment budgeting from repeat topographic data'. Invited Workshop Leader, NSF-Sponsored Workshop on 'New Tools in Process-Based Analysis of Lidar Topographic Data'.

32. 2009. *Invited Seminar:* Wheaton JM. Challenges and Opportunities in Morphological Sediment Budgeting. Invited Seminar, Geology Department, Utah State University.

33. 2009. *Invited Talk*: Wheaton JM., Clayton, S., and Butler, J. Designing and Monitoring Restoration Projects with Uncertainty. Invited Talk, US Bureau of Reclamation, Boise, ID.

34. 2009. *Invited Talk*: Wheaton JM. Design Hypothesis Testing in Restoration: Examples from River Habitat Restoration Invited Guest Lecture, Restoration Course, Center for Ecohydraulic Research, University of Idaho.

35. 2009. *Invited Talk*: Wheaton JM. Coming to Grips with Uncertainty in Restoration Science and Practice. Spring Runoff Conference, Logan, UT.

36. 2008. Wheaton JM. Uncertainty in Ecosystem Restoration: Examples from River Restoration. Invited Seminar, Department of Biological Sciences, Idaho State University.

37. 2008. Wheaton JM, Brasington J, Darby SE†, Sear D† and Vericat D. Beyond the gross reach-scale sediment budget – using repeat topographic surveys for mechanistic geomorphic interpretation, British Society for Geomorphology Annual Meeting, Exeter, UK.

38. 2008. Wheaton JM, Vericat D, Brasington J, Darby S†, Sear D†, Pasternack GB†. Linking Morphological Sediment Budgeting to Salmonid Ecohydraulics, BHS Meeting: Ecohydraulics at Scales Relevant to Organisms, Loughborough.

39. 2005. Wheaton, JM. Assessing the Significance of Geomorphic Uncertainties in River Restoration, *Annual School of Geography Post Graduate Conference*, Southampton, UK.

40. 2004. Wheaton, JM, Pasternack, GB†, and Merz, JE. Use of habitat heterogeneity in salmonid spawning habitat rehabilitation design, *Fifth International Symposium on Ecohydraulics: Aquatic Habitats: Analysis and Restoration*, Madrid, Spain, pp. 791-796.

41. 2004. Wheaton, JM, Sear, DA†, and Darby, SE†. Uncertain Notions of `Natural' Targets in River Restoration. Joint International Geomorphology Conference: Glasgow, UK.

42. 2004. Wheaton, JM. Uncertainties in River Restoration, *Annual School of Geography Post Graduate Conference*, Southampton, UK.

43. 2003. Wheaton, JM, Spawning Habitat Rehabilitation in Regulated Rivers – Exit Seminar. At: University of California at Davis Hydrologic Sciences Seminar Series, Davis, CA.

44. 2003. Wheaton, JM, Pasternack, GB† and Merz, JE. Salmonid Spawning Habitat Rehabilitation in Regulated Rivers. At: The Restoration Toolbox: Joint Regional Conference of Society for Ecological Restoration and Society of Wetland Scientists, Portland, OR.

45. 2001. Wheaton, JM. Utilizing 2-D Hydrodynamic Models as Design Tools for Salmonid Spawning Gravel Enhancement Projects. Invited Lecture, At: U.C. Davis Extension- Instream Habitat Improvement for Regulated Rivers Course, Davis, CA.

THESES

2008. Wheaton JM. *Uncertainty in Morphological Sediment Budgeting of Rivers*. PhD Thesis, University of Southampton, Southampton, 412 pp.

2004. Wheaton, JM. *The Significance of Ecohydraulic and Geomorphic Uncertainties in River Restoration*. Unpublished Mini-thesis submitted in partial fulfillment for the transfer from Master of Philosophy (MPhil) to Doctor of Philosophy (PhD) Thesis, University of Southampton, Southampton, U.K., 80 pp.

2003. Wheaton, JM Rehabilitation of Spawning Habitat. *M.S. Thesis* University of California at Davis, Hydrologic Sciences: Davis, CA, 223 pp.

NON-REFEREED PUBLICATIONS

*Wheaton Graduate Student	†Wheaton's PhD or MS Supervisor
**Wheaton Graduate advisee	‡ Wheaton Post-Doc
♠ Wheaton Contributing Author	NOTE: see here for downloads.

1. O'Brien G, Wheaton JM and Bouwes N. 2015. Synthesis & Recommendations from Middle Fork John Day River Styles - Leveraging the River Styles Framework in Tributary Habitat Management for the Columbia River Basin. Fluvial Habitats Center, Utah State University, Prepared for Eco Logical Research and Bonneville Power Administration, Logan, UT, 20 pp. DOI: 10.13140/2.1.3937.3129.

2. O'Brien G and Wheaton JM. 2015. River Styles Report for the Middle Fork John Day Watershed, Oregon. Ecogeomorphology and Topographic Analysis Lab, Utah State University, Prepared for Eco Logical Research and the Bonneville Power Administration, Logan, UT, 207 pp. DOI: 10.13140/2.1.3251.2329

3. Wheaton JM and Macfarlane WW. 2014. The Utah Beaver Restoration Assessment Tool: A Decision Support & Planning Tool – Manager Brief, Ecogeomorphology and Topographic Analysis Lab, Utah State University, Prepared for Utah Division of Wildlife Resources, Logan, UT, 16 pp.

4. Macfarlane WW, Wheaton JM, and Jensen ML. 2014. The Beaver Restoration Assessment Tool: A Decision Support & Planning Tool for Utah. Ecogeomorphology and Topographic Analysis Lab, Utah State University, Prepared for Utah Division of Wildlife Resources, Logan, Utah, 142 pp.

5. 2013. Wheaton JM. Scoping Study and Recommendations for an Adaptive Beaver Management Plan. Prepared for Park City Municipal Corporation. Logan, Utah, 30 pp. DOI: 10.6084/m9.figshare.903648.

6. 2013. MacFarlane WW and Wheaton JM. Modeling the Capacity of Riverscapes to Support Dam-Building Beaver - Case Study: Escalante River Watershed, Final Report Prepared for Grand Canyon Trust and the Walton Family Foundation, Logan, UT, 79 pp.

7. 2012. CHaMP (Columbia Habitat Monitoring Program)♠. Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program, Prepared by the Integrated

Status and Effectiveness Monitoring Program and published by Terraqua, Inc., Wauconda, WA, 188 pp.

8. 2012. Wheaton JM, Bennett S, Bouwes N, and Camp R. Asotin Creek Intensively Monitored Watershed: Restoration Plan for North Fork Asotin, South Fork Asotin and Charlie Creeks, Eco Logical Research, Inc., Prepared for Snake River Salmon Recovery Board. Logan, UT, 125 pp.

9. 2012. Bangen SG* and Wheaton JM. CHaMP Crew Variability: Influence on Topographic Surfaces & Derived Metrics, Report to Eco Logical Research, Inc. and the Columbia Habitat Monitoring Program, Logan, Utah, 79 pp.

10. 2012. Scott ML, Perkins DL and Wheaton JM. Final Report: Big River Protocol Development – A Prototype Warranty Project, USGS, Fort Collins, CO, 198 pp.

11. 2012. Manners RB**, Schmidt JC, Grams P, Ralston B, Davis P and Wheaton JM. Predicting and detecting changes to riparian vegetation communities along the large rivers of the Colorado Plateau as a result of climate change, Final Report Prepared for Grand Canyon Research and Monitoring Center, Flagstaff, Arizona by Utah State University Geomorphology Lab, Logan, UT, 55 pp.

12. 2011. Ward MB, Nelle P and Walker SM (Eds)♠. CHaMP: 2011 Pilot Year Lessons Learned Project Synthesis Report. Bonneville Power Administration: Portland, OR, 95 pp.

13. 2011. DeMeurichy K, Wheaton JM, Welsh S* and Consolati F*. Bridge Creek IMW Topographic and Aerial Photography Surveys: 2010-2011 Deliverables. Ecogeomorphology and Topographic Analysis Lab, Utah State University, Prepared for Eco Logical Research and NOAA, Logan, Utah, 59 pp.

14. 2011. Pollock M, Wheaton JM, Bouwes N and Jordan CE. *Working with Beaver to Restore Salmon Habitat in the Bridge Creek Intensively Monitored Watershed: Design Rationale and Hypotheses, Interim Report*, NOAA Northwest Fisheries Science Center, Seattle, WA, 63 pp.

15. 2011. Kilham N‡, Schmidt JC and Wheaton JM. Analysis of Historical Longitudinal Profiles of the Colorado River Downstream From Glen Canyon Dam, 1965-2009: Draft Final Report, Intermountain Center for River Restoration and Rehabilitation, Logan, Utah.

16. 2011. Lokteff RL*, DeMeurichy KD, and Wheaton JM. High Resolution Mapping of Instream Habitat: Pilot Study using Ground-based LiDaR in Logan River Watershed. Ecogeomorphology and Topographic Analysis Lab, USU, Prepared for US Forest Service, Logan, Utah, 28 pp.

17. 2011. Bangen S*, Wheaton JM and DeMeurichy KD. Methodological Intercomparison of Topographic & Aerial Photographic Habitat Survey Techniques. Ecogeomorphology and Topographic Analysis Lab, Utah State University, Prepared for Eco Logical Research and NOAA, Logan, Utah, 33 pp.

18. 2007. Gee JHR, Keirle I, Wheaton JM and Wootton RJ. *A Monitoring Strategy for the Afon Teifi Restoration Project*. CCW Contract Science Report No: 773, Countryside Council for Wales, Bangor, 45 pp.

19. 2005. Wheaton, JM. *Salmon! In Sulphur Creek?* Acorn Soupe Scoop Newsletter (Spring): 1, 2 & 5.

20. 2005. Wheaton, JM. *Review of River Restoration Motives and Objectives*. Unpublished Review, Southampton, U.K.

21. 2003. Wheaton, JM. *A Review of Averaging and Upscaling in Hydrology*. Davis, CA, U.C. Davis Department of Land, Air and Water Resources: 10.

22. 2002. Wheaton, JM and Pasternack, GB. *The Integrated Design Approach to Designing In-Stream Spawning Habitat Enhancement Projects: A Case Study on the Mokelumne River (Draft Final Report Presented to East Bay Municipal Utility District)*. University of California at Davis, Watershed Hydrology & Geomorphology Laboratory. Davis, CA.

EXTRAMURAL RESEARCH GRANTS AWARDED

1. Utah Department of Natural Resources, 2014-2015. "Basin Creek Demonstration Beaver Project: Design, Monitoring and Adaptive Management" *Utah Division of Wildlife Resources*, Awarded $38,000 (PI)
2. Idaho Power Company, 2014. "Mapping Roughness from Multibeam SONAR Data" *Water Resources & Engineering*, Awarded $10,000 (PI)
3. US Geological Survey, 2015. "Surveying with a Camera: Rapid Topographic Surveys with Digital Images Using Structure-From-Motion", *USGS Grand Canyon Monitoring & Research Center,* Awarded $43,757 (PI)
4. *US EPA, 2015. "EPA Star Fellowship for Nathanial W. Hough-Snee" *US Environmental Protection Agency*, Awarded $34,000 (PhD Supervisor; PI – Nate Hough-Snee)
5. Utah Department of Natural Resources, 2014. "Development & Application of the Beaver Restoration Assessment Tool for State of Utah" *Utah Division of Wildlife Resources*, Awarded $40,000 (PI)
6. Utah Department of Natural Resources, 2014. "Home Creek Demonstration Beaver Restoration Project: Design, Monitoring & Adaptive Management" *Utah Division of Wildlife Resources*, Awarded $32,000 (PI)
7. Idaho Power Company, 2014. "Mapping Roughness from Multibeam SONAR Data" *Water Resources & Engineering*, Awarded $24,000 (PI)
8. Grand Canyon Trust, 2014. "Updating Economic Valuation of Ecosystem Services Provided by Beaver for Escalante with BRAT", Awarded $5,000 (PI)
9. Idaho Power Company, 2013. "Multi-Beam SONAR Change Detection" *Water Resources & Engineering*, Awarded $40,000 (PI)
10. *National Science Foundation, 2012-2015. "The Sensitivity of Braided Rivers to Sediment Supply" *Geomorphology and Landuse Dynamics*, Awarded $270,770 (PI)
11. *National Science Foundation, 2012-2015. "Collaborative Proposal: Development of Integrated Airborne and Ground-Based LiDaR Tools for the Earth Sciences" *Geoinformatics Program*, Awarded $100,599 (PI)
12. *NOAA, 2011-2013. "Linking Fisheries, beaver, geomorphic and physical habitat monitoring data to better understand the effectiveness of restoration efforts in Bridge Creek' *NOAA National Marine Fisheries Service Fish Ecology Division,* Awarded $60,000 (PI)
13. US Geological Survey, 2010-2011. "Dynamism and Persistence of Eddy Sand Bars in Grand Canyon ', *USGS Grand Canyon Monitoring & Research Center,* Awarded $47,240 (PI)
14. Grand Canyon Trust, 2012. "Pilot Study: Testing the Beaver Restoration Assessment Tool – Assessing the Greatest Potential for Restoration', Awarded $30,000 (PI)
15. Eco Logical Research, Inc., 2009-2015. "Stream Restoration Evaluation Projects" ISEMP Program, Awarded $690,800 (PI)
16. National Park Service, 2011-2012. "Assessment of Indicator Sites & Quantifying Short-Term Effects of High Flows on Riparian Vegetation along the Yampa & Green Rivers" *Rocky Mountain CESU, Dinosaur National Monument,* Awarded $80,000 (PI)
17. Eco Logical Research, Inc., 2012. "Remote Sensing of Fish Habitat Support" *ISEMP Program*, Awarded $85,000 (PI)
18. US Geological Survey, 2010-2011. "Compile, evaluate and synthesize existing geomorphic data for the Colorado River Corridor,' *USGS Grand Canyon Monitoring & Research Center,* Awarded $116,000 (PI)

19. Eco Logical Research, Inc. / NOAA, 2009-2015. “Improving Monitoring Protocols for Watersheds in the Columbia Basin” *ISEMP, CHaMP & IMW Programs*, Awarded $1,682,425 (PI)
20. *US Geological Survey, 2009-2011 “Use of Terrestrial Laser Scanning to Support Big River Protocol Development” *CESU Agreement*, Awarded $58,000 (PI)
21. US Geological Survey, 2009-2010. “Compile, evaluate and synthesize existing geomorphic data for the Colorado River Corridor,’ *USGS Grand Canyon Monitoring & Research Center,* Awarded $97,855 (PI)
22. USDA Forest Service, 2009-2010 “Comparison of traditional versus ground-based LiDaR in-stream habitat assessments” *Challenge Cost Share Program*, Awarded $45,000 (PI)
23. University Research Fund, 2006 – 2008 “Use of Terrestrial Laser Scanning to Test and Refine Landscape Evolution Models” *University of Wales Aberystwyth*, Awarded £5,700 (Principal Investigator)
24. *Horton Research Grant, 2005 – 2006 “Uncertainties in River Restoration”, *American Geophysical Union*, Awarded $10,000 US (Principal Investigator)

*Competitive

TEACHING

COURSES TAUGHT

Utah State University, 2009 to Present

Instructor for WATS 4930/6920 – Advanced GIS & Spatial Analyses (3 cr.)
Instructor for WATS 4931*/6921 – GIS Research Projects (2 cr.; * Capstone)
Instructor for WATS 6840 – Fluvial Hydraulics & Ecohydraulics (3 cr.)
Instructor for WATS 6860 - 'Partnering with Beaver in Restoration Design' (1 cr.)
Instructor for WATS 6900 Special Topic Short Courses on River Restoration

- 'River Styles' (2 cr.)
- 'Restoration Monitoring: Geomorphic Change Detection' (1 cr.)
- WATS 6915 'GIS Fundamentals' (1 cr.)

Co-Instructor for WATS 6900 Special Topic Short Courses on River Restoration

- 'Geomorphology & Sediment Transport in Channel Design' (2 cr.)
- 'Watershed Science Graduate Induction Field Course' (1 cr.)

Idaho State University, 2008 to 2009

Instructor for GEOL 100 – The Dynamic Earth (4 cr.)
Instructor for GEOL 210 – Earth in Space and Time (3 cr.)
Instructor for GEOL 599 – Tools in Geomorphology (3 cr.)

Aberystwyth University, 2005 to 2008

Instructor for EA20110 - Environmental Management
Instructor for GG30220 - Modelling In Fluvial Geomorphology
Staff for GG22110 - Level 2 Geography Tutorial
Staff for GG38110 - Level 3 Geography Tutorial
Staff for GG39130 - Geography Dissertation
Staff for GG21920 - Geography Science Fieldwork (New Zealand Field Trip)
Staff for EAM1920 - Geomorphological Approaches To River Basin Management

SUPERVISIONS

CURRENT GRADUATE STUDENTS

1. Rebecca Rossi, Fall 2014 to Present, *MS in Watershed Sciences,* Topic: 'Surveying with a Camera: Rapid Topographic Surveys with Digital Images Using Structure-From-Motion'; Study Area: Grand Canyon, AZ; Funding: USGS
2. Martha Jensen, Fall 2014 to Present, *MS in Watershed Sciences,* Topic: TBD; Study Area: TBD; Funding: ELR
3. Daniel Hamill, Spring 2015 to Present, *MS in Watershed Sciences,* Topic: 'Mapping Habitat and Bathymetry from Inexpensive Fish Finders'; Study Area: Glenn Canyon, AZ, Funding: USGS
4. Nate Hough-Snee, Fall 2012 to Present, *PhD in Ecology,* Topic: 'Ecogeomoprphic riparian feedbacks of beaver activity'; Study Areas: Bear River Range, UT, Others TBD; Funding: USEPA UDWR
5. Alan Kasprak, Fall 2010 to Present, *PhD in Watershed Sciences,* Topic: 'Influence of flood magnitude and frequency on morphology of braided streams'; Study Areas: John Day Watershed, OR; Rees River, NZ; & River Feshie, UK; Funding: NSF, NOAA & ELR; ICRRR & USU Start-up Initially
6. David Sutherland, Fall 2013 to Present, *PhD in Physical Geography – University of Southampton (co-supervised with David Sear)*, Topic: 'Large Woody Debris Dynamics'; Study Areas: Asotin Watershed, WA, & Tucannon Watershed, WA; Funding: ELR.

PAST GRADUATE STUDENTS

1. Reid Camp, 2013-2014*, *MS in Watershed Sciences,* Topic: 'Effectiveness of $_{HD}$LWD (High-Density Large Woody Debris) restoration at creating improved steelhead habitat'; Study Area: Asotin Creek Intensively Monitored Watershed, WA; Funding: ELR.
2. Florence Consolati, Fall 2011 to 2014*, *MS in Watershed Sciences,* Topic: 'Linking fisheries, beaver, geomorphic and physical habitat monitoring data to better understand the effectiveness of restoration efforts in Bridge Creek'; Study Area: Bridge Creek, John Day, OR; Funding: NOAA
3. James Hensleigh, Fall 2011 to Spring 2013, *MS in Watershed Sciences*, Topic: 'Geomorphic Change Detection with Multi-Beam SONAR'; Study Area: Hells Canyon, ID; Funding: Idaho Power
4. Ryan Lokteff, Fall 2010 to Fall 2013, *MS in Watershed Sciences*, Topic: 'Role of habitat heterogeneity in explaining Bonneville cutthroat trout distributions', Study Areas: Temple Fork & Spawn Creek, UT; Funding: USFS RMRS
5. Sara Bangen, Fall 2010 to Fall 2012, *MS in Watershed Sciences*, Topic: 'Improving Salmonid Habitat Monitoring Protocols in the Columbia Basin'; Study Area: Lemhi River Watershed, ID; Funding: Eco Logical Research, Inc.
6. Sonya Welsh, Fall 2009 to Spring 2012, *MS in Watershed Sciences*, Topic: 'Beaver Dam Failure and Abandonment. Complexity lost?'; Study Areas: Bridge Creek, John Day, OR; Funding: NOAA & ELR

* Defended

CURRENT GRADUATE STUDENT COMMITTEES

1. Rebecca Downard - PhD in Ecology Watershed Sciences (Supervisor: Karin Kettenring)
2. Michael Kohl – PhD in Ecology Wildland Resources (Supervisor: Dan McNaulty)
3. Kerry Riley - PhD in Geology (Supervisor: Tammy Rittenhour)
4. Keelin Schaffrath - PhD in Watershed Sciences (Supervisor: Patrick Belmont)
5. Noah Schmadel – PhD in Civil Engineering (Supervisor: Beth Nielson)
6. David Iles – PhD in Ecology Wildland Resources (Supervisor: Dave Koons)
7. Erica Hansen – MS in Wildland Resources (Supervisor: Nickey Frey)
8. Jarod Raithel – PhD in Ecology in Wildland Resources (Supervisor: Lise Aubry)
9. Sara Kelly – PhD in Watershed Sciences (Supervisor: Patrick Belmont)
10. Monica Blanchard – MS in Watershed Sciences (Supervisor: Nick Bouwes)

PAST GRADUATE STUDENT COMMITTEES

1. Ryan Belmore -2011. PhD in Stream Ecology at Idaho State University (Supervisor: Colden Baxter)
2. Danny White -2011. MS in Bioregional Planning (Plan B) at Utah State University (Supervisor: Richard Toth)
3. Marshall Baillie – 2012. MS in Watershed Sciences (Plan B) (Supervisor: Jack Schmidt)
4. Rachel Van Horne – 2012. MS in Watershed Sciences (Supervisor: Brett Roper)
5. Ericka Hegeman – 2012. MS in Ecology (Supervisor: Scott Miller)
6. Justin Stout – 2012. MS in Watershed Sciences (Supervisor: Patrick Belmont)
7. Tracy Bowerman – 2012. PhD in Aquatic Ecology (Supervisor: Phaedra Budy)
8. Shannon Clemens – 2012. MS in Civil Engineering (Supervisor: Mac McKee)
9. Susannah Erwin - 2012. PhD in Watershed Sciences (Supervisor: Jack Schmidt)
10. Rebecca Manners – 2013. PhD in Watershed Sciences (Supervisor: Jack Schmidt)
11. Steve Fortney – 2013. MS in Watershed Sciences (Supervisor: Jack Schmidt)
12. Michael Soufront – 2013. MS in Watershed Sciences (Supervisor: Patrick Belmont)
13. Eric Wall – 2014. MS in Watershed Sciences (Supervisor: Nick Bouwes)

POSTDOCTORAL RESEARCHERS

1. Steve Bennett, 2013 to Present, Senior Research Scientist, Restoration Ecologist, ETAL, Utah *State University*
2. Carl Saunders, 2013 to Present, Research Scientist, Aquatic Ecologist, ETAL, Utah *State University*
3. Nicole Czarnomski, 2011 to 2012, 'Compile, evaluate and synthesize existing geomorphic data for the Colorado River Corridor', *Intermountain Center for River Rehabilitation and Restoration*
4. Nina Kilham, 2010 to 2011, 'Compile, evaluate and synthesize existing geomorphic data for the Colorado River Corridor', *USGS Grand Canyon Monitoring & Research Center,* Co-Supervised with Jack Schmidt, Now at MacWilliams & Associates.
5. Chunling Tang, 2009 to 2010, Hydrologic Modeling of Salmon Basin, Idaho-EPSCoR Grant, *Idaho State University,* Co-Supervised with Benjamin Crosby, Now at EPA.
6. Damia Vericat, 2006 to 2008, Terrestrial Laser Scanning of Fluvial Environments, Centre for Catchment & Coastal Research Grant, Aberystwyth University, Co-Supervised with James

Brasington. Now Juan de la Cierva Postdoctoral Fellow at Forest Technology Centre of Catalonia, Spain

POSTGRADUATE RESEARCHERS SUPERVISED AT USU

1. Gary O'Brien, 2012 to Present, Research Associate, Fluvial Geomorphologist, ETAL, Utah *State University*
2. James Hensleigh, 2012 to Present, Research Associate, Geospatial Programmer & Analyst, ETAL, Utah *State University*
3. Sara Bangen, 2012 to Present, Research Associate, Habitat Analyst, ETAL, Utah *State University*
4. Wally MacFarlane, 2012 to Present, Research Associate, Photogrammetrist & GIS Analyst, ETAL, Utah *State University*
5. Kenny DeMeurichy, 2009 to Present, Surveyor and Terrestrial Laser Scanning Analyst, ETAL, Utah *State University*
6. Chris Garrard, 2009 to 2011, GIS Programmer for RSGIS Lab, Supervised on GCD & CTT Projects

SERVICE

WORKING GROUP AFFILIATIONS & SERVICE

USGS Powell Center Working Group on High Resolution Topography (2014 – Present): *Invited*. Serve on working group tasked with i) reviewing the state of the art & creating a scientific agenda for HRT in the earth sciences, ii) providing guidelines to others on use of HRT

Logan River Task Force (2014 – Present): *Invited*. This task force was formed at the request of the Logan City Mayor following concerns surrounding a recent Emergency Watershed Protection project on the Logan River. The task force is charged with coming up with a vision and guidance for how the Logan River should be managed in the future.

NCALM Steering Committee (2012 – 2015): *Invited.* Serve on the NSF-funded National Center for Airborne Laser Mapping's steering committee. Our primary duties are to provide direction to NCALM and review and make recommendations for the NCALM Seed Grant Proposals.

TRRP Independent Technical Panel (2012-2013): *Invited.* Serve on an independent technical panel to review the Trinity River Restoration Program's Science Advisory Board activities and recommendations.

Stream Restoration Decision Analysis & Design Guidance, 2010 - Present. Collaboration of National Center for Earth Surface Dynamics, Intermountain Center for River Rehabilitation and Restoration, US Army Corps of Engineers

Trinity River Restoration Program Sediment Workshop Invited Participant, 2010

Community Surface Dynamics Modeling System – Terrestrial Working Group, 2009 to Present

Reduced Complexity Modeling in Fluvial Geomorphology – Working Group, 2007 to 2008. Organized through: British Society for Geomorphology

Individuals & Environmental Change: eScience for Sustainable Systems – Working Group, 2008. Working Group on Agent-Based Modeling

EDITORIAL & REVIEWER SERVICE

Guest Editor, 2009-2010

- *Geomorphology (journal):* Special Issue on 'Multi-Scale Feedbacks in Ecogeomorphology'

Panelist, 2009

- *National Science Foundation, Cyber-Enabled Discovery and Innovation Program*

Proposal Reviewer, 2005- Present

- *National Science Foundation, United States Geological Survey, California Bay-Delta Authority, & United States Fish and Wildlife Service*

Ad-hoc Journal Reviewer, 2003- Present

- *Multiple journals including: Water Resources Research, Earth Surface Processes and Landforms, Geomorphology, JGR Earth Surface, River Research & Applications, Fisheries, Freshwater Biology, Hydrological Processes, Environmental Management, Journal of the American Water Resources Association, International Journal of River Basin Management, Compass, American Society of Agricultural Engineers, San Francisco Estuary and Watershed Science Journal*

INVITED/SOLICITED WORKSHOPS ORGANIZED

1. River Restoration Northwest, Feb 2015, 'Geomorphic Change Detection for Restoration Monitoring', Skamania, Washington.
2. Australia New Zealand Geomorphology Group, Dec 2014. 'Geomorphic Change Detection', Brisbane, Australia.
3. Klamath Watershed Council, Oct 2014. ' Partnering with Beaver in Restoration', Chilloquin, OR.
4. Fluvial Habitats Center, Feb 2014. 'Multibeam Echo Sounding in Rivers Summit', Logan, UT
5. Utah Natural Resource Conservation Service, Aug 2013. – 'Working with Beaver in Restoration' Short course, Logan, UT.
6. Wilburforce & Grand Canyon Trust, April 2013. – 'Beaver Restoration Assessment Tool', Logan, UT.
7. Kansas Water Office (March 2013) – 'Geomorphic Change Detection Workshop', Lawrence, KS.
8. River Restoration Northwest Annual Symposium. Feb 2013. – 'Working with Beaver in Restoration' Short course, Skamania, WA.
9. Utah Watersheds Coordinating Council, Oct 2012. – 'Partnering with Beaver in Restoration', Logan, UT.
10. US Army Corps of Engineers, May 2012. – 'Geomorphic Change Detection Workshop', Kansas City, MO.
11. US Bureau of Reclamation (April 2012) – '2012 Annual Lecture Series – Near Census Assessment of Fluvial Form, Process, Change & Associated Ecosystem Services', Denver, CO.
12. US Geologic Survey Grand Canyon Monitoring Research Center (May 2011) – 'Geomorphic Change Detection Workshop', Flagstaff, AZ.
13. NSF LiDaR Workshop on 'New Tools in Process-Based Analysis of LiDaR Topographic Data' (July 2010) – 'Geomorphic Change Detection Workshop', Boulder, CO.
14. Idaho Power (Nov 2010) – 'Geomorphic Change Detection Workshop', Boise, ID.

CONFERENCE SESSIONS CONVENED

1. Session Convener, *American Geophysical Union Fall 2012 Conference* -> Convened session titled 'Quantifying Hillslope and Fluvial Processes through Change Detection using High-Resolution Topography'

2. Session Convener, *American Geophysical Union Fall 2008 Conference ->* Convened session titled 'Multiscale Feedbacks in Ecogeomorphology'

NEWS COVERAGE, INTERVIEWS AND OUTREACH

1. KRCL Radio Active, Aug 2014. 'Beavers: Nature's Engineer', Park City, UT.
2. KCPW Explore Utah Science, July 2014. – 'Beaver Dam Mapping App Now Available for Citizen Scientists', Salt Lake City, UT.
3. Utah State Today – University News, May 2014 – 'River Restoration? Leave it to Beavers say USU Scientists', Logan, UT.
4. Balcerak, E. 2013. How do braided river dynamics affect sediment storage? Eos, Transactions American Geophysical Union. 94:212-212. DOI: 10.1002/2013EO230018.

COMMITTEE SERVICE

UTAH STATE UNIVERSITY SERVICE

Departmental Service & Administration

GIS Minor Adviser (2012 - Present)
Watershed Sciences Graduate Affairs & Selection Committee (2009-Present)
Watershed Sciences Graduate Program Review Committee (2010-2011)

College Service & Administration

Search Committee (2013). Member for search for Department Head in Watershed Sciences.

Search Committee (2012-2013). Member for search for Landscape Ecologist & Assistant Unit Leader in USGS Utah Cooperative Fish & Wildlife Unit.

Search Committee (2011-2012). Search was for an Assistant Professor, with emphases on human-environment geography and geospatial analysis for use in bioregional planning in Department of Environment & Society.

College of Natural Resources Graduate Affairs Committee (2010-Present). I serve on this committee with colleagues from across the College of Natural Resources and we are primarily responsible for making sure that the College graduation ceremonies run smoothly.

Ad-Hoc Espresso Course Curriculum Development Committee (2011-2012)

University Service & Administration

Water Initiative Spring Runoff Conference – Organizing Committee (2012)
USU Facilities – Moab Master Plan Committee (2011)

IDAHO STATE UNIVERSITY SERVICE

Faculty Board (2008-2009)

ABERYSTWYTH UNIVERSITY SERVICE

Scientific Steering Committee for Centre for Catchment and Coastal Research (2006-2008)
Computer Unit Liaison (2006-2008)
Web site Coordinator (2006-2008)
IES Network Administrator (2006-2008)
Blackboard Advisor (2006-2008)
IGES Newsletter Editor (2006-2008)
Undergraduate Recruitment Committee (2006-2008)
Manage & procure CCCR Computational Resources (2006-2008)

AWARDS & RECOGNITIONS

Large Grants Award, 2014, *Utah State University Office of Research & Graduate Studies*
Large Grants Award, 2013, *Utah State University Office of Research & Graduate Studies*
Overseas Research Studentship, 2003-2006, *Academic Universities U.K.*
Citation In Recognition of Outstanding Undergraduate Accomplishment in Hydrology, 2002 *University of California at Davis Hydrology Department*
LAWR Opportunity Fund, 2002, *University of California at Davis Department of Land, Air and Water Resources*
CGA Scholarship, 2000 & 2001, *California Groundwater Association*
ECA Scholarship, 2000, *Engineering Contractors Association*

PROFESSIONAL CERTIFICATIONS OR LICENSES

Accredited River Styler Status, 2014, *Macquarie University*
American Institute of Hydrology, 2003, *Certified Hydrologist in Training (HIT)*
CPESC #2594, 2003, *Certified Professional in Erosion and Sediment Control*, *Inc.*

PROFESSIONAL MEMBERSHIPS

American Association of Geographers, Since 2007, *Professional Member*
American Fisheries Society, Since 2011, *Professional Member*
American Geophysical Union, Since 2001, *Member, Hydrology Section and Earth & Planetary Surface Processes Focus Group*
British Society for Geomorphology, Since 2003, *Member*
International Erosion Control Association, 1998 – 2008, *Associate Member*
Geologic Society of America, Since 2010, *Professional Member*

APPENDIX D

Comment Response Matrix

Peer Review of the Science Informing the Upper San Joaquin River Basin Storage Investigation

U.S. Bureau of Reclamation

Comment #	The comment refers to: Reviewer	Page	Document Text Referenced	Name of Commenter	Office of Commenter	Comment	Action Taken to Address the Comment
			Comment Response Matrix **Individual Memos, Peer Review of the Science Informing the Upper San Joaquin River Basin Storage Investigation**				
1	Summary Report	All	Summary Report - All	Chip McConnaha Ryan Murdock	ICF MWH	The Summary Report does not state what in our opinion is the most salient fact of the review: the reviewers agreed that EDT was an appropriate tool for the comparison and had no major concerns with its application, notwithstanding their numerous caveats and suggestions, most of which are fine. The Summary Report focuses on the caveats and suggestions and really doesn't characterize the overall conclusions that could be drawn from the review. This in our opinion is a major shortcoming that should be addressed. For your consideration, and to crystalize our comments, we have attached a marked up version of the Summary Report that better captures the reviews and actually provides some concrete recommendations that could improve the analysis. SEE SPECIFIC SUGGESTED EDITS IN THE SUMMARY REPORT SHOWN IN TRACK CHANGES.	Reviewed suggested changes and completed revisions.
2	Summary Report	ii and 7	"Overall, all reviewers…."	Chip McConnaha	ICF	I saw nothing in the peer reviews that indicated that reviewers felt that EDT was not an appropriate tool for comparing habitat conditions in the EIS or that it had been mis-applied in the analysis. I believe this is a highly significant outcome of the review that needs to be emphasized for the sake of the EIS. The original wording of this paragraph only captured the qualifications and caveats of the reviewers (important as they are) and left considerable doubt as to the overall significance of the review.	Revised summary
3	Summary Report	1	"Because EDT was readily available…"	Chip McConnaha	ICF	Previous wording makes it sound like no one could think of anything better so they used EDT.	Revised text
4	Summary Report	6	"...explore those impacts and represent the uncertainty other than just relying on EDT."	Ryan Murdock	MWH	EDT was not the only source of information used in evaluating the fisheries and aquatic resources impacts.	
5	Summary Report	7	4.0 Conclusions and Recommendations	Chip McConnaha	ICF	This is just a restatement of the previous conclusions paragraph so my previous comments apply. I also provide a few concrete recommendations that I took from the review.	Revised text
6	Summary Report	7		Ryan Murdock	MWH	Other fish species were evaluated, but were not evaluated quantitatively through EDT modeling	Added recommendation
7	1	1	"Thus, I acknowledge the merits of using EDT in the SJRRP/Investigations decision-making context but also identify several issues that may bear upon the strength of interence that should be drawn from results relative to the Investigation."	Chip McConnaha Ryan Murdock	ICF MWH	This affirms the validity of the approach and the analysis while providing caveats and suggestions. Suggest including this statement in the Summary Report	Similar summary included in final report.
8	1	1	"…displying results in terms of Neq for the SJRRP/Investigation is consistent with established EDT precedent, EDT documentation…and the model's theoretical underpinnings."	Chip McConnaha	ICF	Reviewer correctly characterizes the nature of EDT, how it works and the relationship between C, P and Neq.	No revisions
9	1	2	Reviewer stresses that relative comparisons are more appropriate than absolute comparisons between scenarios. Notes that we were not consistent in our use of relative comparisons.	Chip McConnaha	ICF	Agree - revisions could be made to use relative comparisons exclusively when comparing across alternatives and providing adequate explanation of the basic metrics that underlie the percent changes.	Added specific recommendation to final report.
10	1	2	The display of Neq assumes there will be no harvest.	Chip McConnaha	ICF	We did not assume there would be no harvest; we simply did not use harvest in the analysis. Harvest is not a habitat parameter specific to the project area and was turned off for this analysis. Harvest rates on spring-run Chinook are subject to a myriad of issues outside the domain of this analysis and the proposed project. We do not recommend changing this, though we could clarify the decisions to not include harvest impacts.	Added recommendation to include more detail about why harvest was not included.

Comment #	The comment refers to: Reviewer	Page	Document Text Referenced	Name of Commenter	Office of Commenter	Comment	Action Taken to Address the Comment
11	1	2	By excluding trajectories with Neq<1, EDT could have a positive bias	Chip McConnaha	ICF	Mathematically trajectory with productivity <1 has an Neq of 0; a characteristic of the Beverton-Holt function. Productivity is survival at very low abundance (density-independent survival). At low abundance it is assumed the population will occupy life history trajectories that are sustainable (i.e., productivity >1). The capacity parameter is maximum number of fish supported by the habitat and includes all trajectories (a simple average of trajectory capacity). We assume at higher abundances fish would begin to occupy less optimal trajectories, therefore a capacity that is sensitive to all trajectories seems a reasonable approximation of habitat potential. The assessment was careful to use a consistent method to evaluate all alternatives. If there is a bias to this method we do not believe it would differ across the alternatives. No change is recommended here but perhaps a better discussion of trajectories in EDT is warranted.	Added recommendation to clarify discussion.
12	1	3	Asserts that the lack of clarity in documentation may be due to the proprietary nature of EDT.	Chip McConnaha	ICF	Not true. EDT is developed and maintained by ICF but all code is publically published (Microsoft Codeplex site) and we have attempted to document all assumptions and data in numerous reports. If perhaps we have been unclear in our explanations that lack of clarity has nothing to do with any proprietary aspects of EDT.	No changes. Already recommendations added regarding clarifying specific assumptions.
13	1	3	Model assumes that all three life history strategies are equally probable.	Chip McConnaha	ICF	Not true. EDT evaluates the relative efficacy of different life histories against the underlying spatial and temporal distributions of habitat. Life histories do not have equal likelihood of survival under given conditions, although their success can shift in response to water year, for example. The results show clearly that the conclusion from EDT is that there are important differences in potential survival of different life histories. We assume that this would be reflected in the selection of actual life histories in a San Joaquin population.	This was the reviewer's interpretation of the material provided. Minor edit to the reviewers statement. Clarification provided by reviewer: Table 5-5 indicates that fry, spring parr, and yearling life history trajectories arise with equal probability (33%) at the outset. Whether or not they perform equally is a different question. I was referring to the former case, which should be affect the overall population productivity...I suggest adding a citation to Table 5-5 under A-1 so that this is more clear.
14	1	4	A Template condition is assumed in the Investigations analysis	Chip McConnaha	ICF	Not true. A template condition is often used in an EDT analysis as a basis for diagnosing habitat and establishing spatial restoration priorities. However, in the Investigations, EDT was only used to compare alternatives and no diagnosis was performed and no Template condition was used. No change.	Added recommendation in final report to explicitly state that no template condition was used. Minor edit to reviewer's statement. Clarification from reviewer: Maybe this is just semantics-related confusion on my part, but the origin/basis for stage specific capacity/ productivity under 'current conditions' implicitly ties to some specification of a benchmark condition.
15	1	4	Survival factors are equally weighted as are environmental factors	Chip McConnaha	ICF	Not true. The effect of environmental factors is not equal in EDT but is determined by the slope of survival rating curve. In his example, the slope of the turbidity rating curve is low indicating a low effect on life stage survival whereas the slope of the temperature is steep indicating an important effect on survival. Clearly these slopes are important and are a key factor in the model performance. Similarly the 0.37 exponent referred to is a shaping factor that can control overall model sensitivity. It is not an input factor. I recommend no change in response to this comment.	Added recommendation to clarify discussion regarding survival factors. Clarification from reviewer: What was meant here is that each F (not the slope underlying its calculation) is equally weighted. Contrast this with a case in which turbidity as a factor is relatively unimportant (irrespective of slope/value) compared to temperature; here, you might have a weight scalar/multiplier that reflected this assumption., e.g., (1*F1)(1*F2)...(1*Fp) [case 1] (w1*F1)(w2*F2)...(wp*Fp) [case 2] The match could come in many forms, but the basic idea is that each factor (regardless of the F value) is assumed to be weighted equally, which may not be the best approach. If indeed the relative weights of different factors are built into the slopes of the Fis, then published EDT documentation is slightly misleading in this respect (i.e., it suggests all Fis range between 0 and 1)...

Comment #	The comment refers to: Reviewer	Page	Document Text Referenced	Name of Commenter	Office of Commenter	Comment	Action Taken to Address the Comment
16	1	5	Should provide greater treatment of sensitivity	Chip McConnaha	ICF	Agree; However, we should acknowledge the purpose of the sensitivity analysis relative to the need to evaluate storage alternatives. A sensitivity analysis would highlight what is already known - reintroducing spring-run Chinook to the San Joaquin River is very uncertain and population performance will likely not follow predictions.	Added recommendation to address uncertainity in the model.
17	1	6	Reviewer questions results indicating sensitivity of change on spawning/incubation relative to parr/smolt stages	Chip McConnaha	ICF	EDT assesses the effects of environmental change on fish populations by juxtaposing a life history (life stages, location and duration) on the environment and then test these conditions using a set of habitat rating relationships. Spawning and incubations life stages are particularly sensitive to temperature which is a major limiting factor in the SJR and a key outcome of the different operations strategies. In the most successful life histories, juveniles leave the system relatively early and so moderate exposure to high temperatures. Eggs are stuck though and are stongly affected by the timing and extent of high temperatures.	No change to reviewer memo or summary report.
18	2	2	"There is no attempt to show how well the model fits empirical data or use of performance measures (McElhaney et al 2010).	Chip McConnaha	ICF	EDT results have been successfully validated against empirical results on several occassions. Reviewers were provided with the analysis by WDFW (Rawding) and examples from other watersheds could have been provided. Given that there are no salmon returning to the project area (and no spring chinook in the SJR) validation against empirical data was not possible. This argues for the emphasis on relative rather than absolute comparisons as all reviewers stressed.	The reviewer acknowledged these previous efforts in his answer to Question 1. No change to reviewer's memo or summary report.
19	2	2	Reviewer questions why only spring Chinook were modeled.	Chip McConnaha Ryan Murdock	ICF MWH	Restoration of spring Chinook is the focus of the SJRRP and previous EDT modeling to support that program. The Investigation followed the SJRRP analysis and so also focused on spring Chinook. Modeling fall chinook and steelhead would be relatively straight forward. Sturgeon would be a greater challenge. Other fish species were evaluated, but were not evaluated quantitatively through EDT modeling	Added recommendation to include a summary of evaluations from other species, even if not done through EDT.
20	2	2	The reviewer (again citing McElhaney) questions the "lack of measurements of the model's fit or performance…"	Chip McConnaha	ICF	See response above. There are no data in the study are or the SJR against which to measure fitness. However, there are many examples from other basins leading to confidence in the underlying biological framework.	Already addressed through recommendations added from reviewer 1.
21	3	1	Under the first question, the reviewer provides an interesting philosophical discussion. Not sure how it specifically pertains to the analysis.	Chip McConnaha	ICF	Interesting, but no response is required. The reviewer might be confused with a need to validate the model versus an assessment of habitat potential.	No changes.
22	3	1	:... if flows are manipulated to maximize the amount and location of the highest quality habitat, the model would also appear to predict the greatest abundance and productivity of Chinook salmon. Has this been tested? That is, is there a point at which habitat is saturated and increasing the amount of that habitat no longer supports concomitant increases in productivity?"	Greg Blair	ICF	Manipulating flows to increase the amount of available habitat at critical periods when capacity is constraining abundance will increase capacity results in EDT. The assessment for the San Joaquin has shown that not enough fish are available to occupy the constructed habitat because of previous constraints on population productivity and capacity. This concept has been evaluated and tested in several watersheds.	No changes.
23	3	1	While stating that the assumption of the model seem reasonable, reviewer questions the use of historical flows to project future conditions.	Chip McConnaha	ICF	Probably valid concern given expectations of climate change. Has nothing to do specifically with the application of EDT but rather pertains to the entire analytical framework.	Added recommendation to consider climate change and changing flow conditions.
24	4	1	The reviewer did not like the question and answered "no" to the narrow question of whether EDT was appropriate to compute fish abundance. However, he was generally supportive of the use of EDT to make relative comparisons (recognizing all other caveats he had about the use of multiple models). See last comment below.	Chip McConnaha	ICF	Agree. See previous responses.	No changes.
25	4	1	Reviewer was concerned about over reliance on a single modeling approach to evaluate alternatives and stressed the value of using multiple models.	Chip McConnaha	ICF	Agree, but it would require a much greater effort by all parties than has been done in the SJR to date.	No changes.

Comment #	The comment refers to: Reviewer	Page	Document Text Referenced	Name of Commenter	Office of Commenter	Comment	Action Taken to Address the Comment
26	4	2	Reviewer's conclustions are effectively summarized in the last sentence: "…aside from some of the cans of worms I suggest above, what they [the EIS authors] did was a reasonable attempt to use a tool like EDT for the purpose of exploring part of the potential impacts of FSH-1- through FSH-17. My criticism is that too much stock is put in this one tool and there are other ways to explore those impacts and represent uncertainty other than just relying on EDT."	Chip McConnaha Ryan Murdock	ICF MWH	A broader analysis using multiple biological modeling approaches would certainly strengthen the analysis and potentially provide greater comfort in the results. This is unlikely to be possible for the EIS. EDT was not the only source of information used in evaluating the fisheries and aquatic resources impacts.	Added recommendation to include information on the other analyses/evaluations completed.