Study Proposal for BPA-funded Basin Assessments

Project Title: **Protocol for Monitoring Trajectories of Bull Trout Populations Using Demographic Parameters in a Probabilistic Framework**

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Justification and Background

There is a demonstrated need to monitor native salmonid species' population trends for various management, conservation, and legal concerns. Despite this need there exists no established framework for objectively and consistently determining the status of a population. The fundamental approach of this project is to develop a strategy for Viable Population Maintenance in which mathematical methods are used for quantifying population trends in bull trout, *Salvelinus confluentus*. Population status will be assessed by continually updating short-term (5-15 years) projections of population trajectories using monitoring data entered in appropriate stochastic demographic models. These predictions will then be examined for trends resulting in more accurate determination of population status. Such an approach is much more statistically and legally defensible than traditional population viability assessment (PVA) predictions for long-term probability of persistence. Monitoring of native fishes should be an iterative process, where existing data and expert opinion can be used to develop an initial model which can then be used to better define which demographic parameters should be monitored and allow for testing, validation, and, if necessary, modification of model assumptions to provide the most sensitive and realistic measure of population health.

Bull trout have undergone serious reductions throughout their range (Rieman et al. 1997). These declines have resulted in bull trout being listed as threatened under the Endangered Species Act (ESA). Existing and planned conservation efforts, especially BPA-funded mitigation being planned and implemented by many different administrative entities, requires a comprehensive protocol for monitoring and determining status of bull trout populations. Presently, there is no statistically rigorous or standardized methodologies for monitoring bull trout populations throughout their range, thus there are no accepted methodologies that allow for objective assessments of population "health" or recovery. To facilitate better communication between state and federal management agencies, a collaboratively developed comprehensive monitoring strategy is needed to ensure consistent and scientifically valid criteria are used for assessing the status of salmonid populations.

Monitoring Design Development

To develop a Viable Population Maintenance strategy, a spatially explicit stochastic demographic population model will first be developed for bull trout. The model will use a series of sub-models to incorporate complex features such as density dependence, community interactions, spatial differences in juvenile rearing and emigration, spatial variability in habitat condition, migration through habitats, alternate spawning, etc. The model will then be used to test for elasticity and sensitivity of life history components as to their effect on the population, and to determine what demographic parameters are influential to population dynamics, and thus meaningful for monitoring. Regional and spatial differences in populations and habitat characteristics will then be incorporated in a spatially explicit GIS framework to provide a flexible model that could then be re-parameterized for a variety of resident trout species.

The development of a spatially explicit stochastic demographic model will greatly aid in planning, monitoring and assessing conservation strategies for bull trout, and other native fish, in different drainages. First, this type of model will identify critical features of the monitoring design such as what variables should be monitored and at what frequency and spatial arrangement they should be estimated, based on each variable's influence on a population. . Thus monitoring design strategies may be flexible, but still most appropriate for specific populations or spatial scales. The model will also help determine how demographic parameters, and data collected to estimate those parameters, relate to population health through model-based inference. Spatial structure of populations and the environment will also be incorporated to explore the potential effects of metapopulation structure and variable habitat conditions on local, regional, and overall population health.

By coupling the model to statistically efficient monitoring of ecologically relevant variables a population's status will be determined in the most cost-effective and statistically rigorous fashion, given the relatively fixed budget for monitoring. In addition, as monitoring information is collected through time, the model would be refined through adaptive updating of demographic sub-models, data requirements, parameter estimations, and predictions of the population trajectory over time. The result will be a continual reduction in the uncertainty of predicted population trajectories. Model simulations will estimate the health of populations at various time scales (short, medium, long), while allowing for incorporation of known stochastic effects on salmonid populations. Stochasticity has been demonstrated in the past to complicate monitoring efforts based on abundance or habitat alone (House 1995; Ham and Pearsons 2000). The efficacy of proposed management options for particular populations may also be evaluated using model simulations (Caswell 2000).

Assessing trends in populations by using continually updated short-term (5-15 years) predictions of population trajectories will allow managers to determine whether a particular population is moving towards recovery or extinction, or functioning as a stable population at a pre-determined desired level. Using this type of assessment should result in a more statistically quantifiable technique for measuring local, regional, and overall population health. Our use of short-term prediction time frames will be much more statistically defensible than traditional PVA. PVA, as it is often implemented, has shortfalls that we may avoid by using short-term predictions. First, our protocol does not require projecting far beyond the range of existing data, to either very low or very high population levels. Such projections assume a stability of process at unobserved densities that are unjustified in light of the growing awareness of impacts of Allee effects in natural populations (Dennis 2002). Second, the compounding of error that occurs when simulations are projected for long time periods (Berlinsky 1976) can be avoided. Lastly, long-term simulations typically assume biotic communities remain constant, but community changes can greatly affect bull trout populations, as has been documented in Flathead Lake. Community shifts, such as those that occurred in Flathead Lake, are difficult to anticipate and by restricting model predictions to shorter time periods we can reduce this potential error.

Due to the stochastic nature of salmonid populations, much of our effort will focus on reducing the uncertainties inherent within any monitoring program. Uncertainties in monitoring can originate through sampling error, model identification, and parameter estimates, as well as process variation. These uncertainties will be quantified to determine what effects they have on final estimates of population trajectories. Explicit identification and quantification of these uncertainties will give credibility to population estimates. We will employ new statistical techniques, using generalized mixed model estimation using smoothed simulated composite likelihood being developed by Drs. Lele and Taper, to partition these sources of variation and estimate model parameters.

Model analyses of collected data that are incorporated into a structured decision framework, ideally with predetermined recovery levels, will lead to a more objective method for evaluating population status and facilitate better communication between agencies. These decision models must be statistically, scientifically, and legally defensible for utilization in making status determinations for species under ESA. Using a common sampling and analysis protocol will ensure that all involved interests will be communicating within a common framework. Levels defining population status indices at which a population may be considered secure or recovered should be established “a priori”. This would ensure that management agencies have established “recovery” goals that define conservation success prior to implementation of a particular conservation project or development of a monitoring program. Most importantly this work will provide a framework for better communication between management and regulatory agencies on the status of listed species and for decisions concerning listing and de-listing.

Our models will initially be developed using the spatial and temporal aspects of bull trout life histories in the Flathead drainage above Flathead Lake. We plan to incorporate habitat covariates known to influence survivals within and between each life-stage. Initial development and parameterization for our models will be aided by an existing Ecosystem Diagnosis and Treatment model (EDT) (Lestelle et al. 1996) that is presently being parameterized for bull trout. The Flathead Subbasin Planning process will not use EDT as the basis for the Assessment throughout the basin, but will consider using EDT on a small subset of streams on which substantial data sets have been compiled. We propose focusing on the Coal and Big Creek drainages, where bull trout have responded differently and an additional “pristine stream” for comparison. This strategy would allow for an affordable, small-scale trial of the EDT model. This EDT model also incorporates population life-stages, habitat covariates that affect each life-stage, and spatial use of habitats by life-stage over time, but is being developed to assess influences of habitat on populations as a tool to direct habitat mitigation efforts. Characterizing life histories followed by bull trout populations and summarizing, consolidating, and organizing habitat and fish monitoring data are tasks that must be done for both the EDT model and our efforts. Incorporating expert opinion about habitat effects on, and demographic parameter estimates for, bull trout populations will be important components for both the EDT and our models. We assume that these tasks will be completed for a generalized EDT model for bull trout prior to initiation of our project. We will apply existing site-specific bull trout life history and habitat relationship data collected from Flathead basin streams to validate and help calibrate the EDT model for bull trout within the Flathead basin. In addition, information about life stage-specific habitat effects and demographic estimates used within the EDT model will be used as initial hypotheses about factors affecting bull trout populations. As our understanding of demographic processes and the amount of data collected increase over time, these initial hypotheses will be refined to reflect the empirical effects of habitat factors on the bull trout population in the Flathead System.

This effort will extend the EDT framework, which currently provides a static assessment of habitat quality, to allow prediction of population trends using population dynamics. The EDT model is based largely on expert opinion about habitat effects on fish populations. Our procedures will smoothly and increasingly augment expert opinion used in developing “rule curves” for the EDT bull trout model with hard data derived from population monitoring over time. In addition, our model will explicitly incorporate the dynamics of the monitored population so users can evaluate effects of various parameters on model results. The incorporation of site-specific population dynamics information will allow for better predictions of future population levels and better assessments of how habitat and management actions influence populations.

We will collaborate with staff from Montana Fish, Wildlife and Parks, the Salish and Kootenai Tribes of Montana, British Columbia Ministry of Environment, and the Fish and Wildlife Service to provide them with assessments of the EDT model for the Flathead drainage and help them refine their bull trout monitoring program for use in their on-going BPA-funded basin planning and assessment process. This effort will include feedback from field personnel and managers to assure that the recommended protocol is implementable, given existing constraints on personnel and funding for monitoring. While we do not anticipate that we will have time to complete a thorough basin-wide EDT assessment prior to the first iteration of basin planning for the Flathead basin, due to current time constraints on that process, we believe we can make a few EDT assessments for local bull trout populations that might help with their planning effort. We also plan to collaborate with Idaho Department of Fish and Game, the Kootenai Tribe of Idaho, British Columbia Ministry of Environment, and the Fish and Wildlife Service to help them assess bull trout populations in the Kootenai River drainage. We believe that our collaboration will: (1) allow for the potential to use either the EDT, or our modification of EDT, assessment in subsequent efforts to restore bull trout populations in both the Flathead and Kootenai basins; (2) allow for an objective evaluation of the efficacy of currently planned restoration efforts in both basins; (3) help develop and refine existing monitoring programs for bull trout that should be more efficient; and (4) allow for more objective evaluations of the status and trends in bull trout populations in those basins, fostering better communication among agencies responsible for managing and conserving this species. We will explore the potential for applying our model to other native species, particularly westslope cutthroat trout, in these two basins. As time permits, we will collaborate with other researchers in the Kootenai River basin in their efforts to model populations of white sturgeon and burbot.

Throughout the project Drs. Subhash Lele and V.P. Godambe, statisticians at the forefront of sampling design and evidential theory, will brought in for consultation. Dr. Lele in an expert in parameter estimation from time-series data with sampling error, process variation, and model uncertainty. Dr. Godambe will consult on matters of sampling design and statistical inference.

References

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Appendix 1. Budget - Protocol for monitoring trajectories of native salmonid populations using demographic parameters in a probabilistic framework.

Personnel	
2 years Ph.D student stipend	$32,000
Benefits (2%)	640
Tuition and Fees	8,000
4 months PI salary	22,000
Benefits (25%)	5,500
Contracted Services	
Statistical Consulting	15,000
Dr. Subhash Lele; Department of Mathematics, University of Alberta	
Dr. V.P. Godambe; Statistics and Actuarial Science, University of Waterloo, Faculty of Mathematics	
Supplies/ Expendables	
GIS Monitor	2,141
Printer	1,479
Publication Costs	750
Miscellaneous	500
Office Supplies	
Travel	1,500
2-person, per-diem, mileage, lodging- National Meeting	
2-person, per-diem, mileage, lodging- National Meeting	
Subtotal	$89,510
Overhead	
0.26	$23,273
Total Requested	**$112,783**