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RECOVERY POTENTIAL ASSESSMENT FOR WESTSLOPE CUTTHROAT TROUT, *ONCORHYNCHUS CLARKII LEWISI*, SASKATCHEWAN-NELSON RIVER POPULATIONS (DU 1)

Westslope Cutthroat Trout, Oncorhynchus clarkii lewisi*.*
Photo credit: J. R. Tomelleri

Figure 1. Distribution of Westslope Cutthroat Trout in Alberta.

Context:

The status of Westslope Cutthroat Trout (WCT, Oncorhynchus clarkii lewisi*) in Canada was initially assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Threatened in designatable unit (DU) 1 (Saskatchewan-Nelson River populations) and Special Concern in DU 2 (Pacific populations) in May 2005 and November 2006. The status was assessed and confirmed in November 2016. The Saskatchewan-Nelson River populations of WCT are currently listed as Threatened on Schedule 1 of the Species at Risk Act (SARA) and a proposed Recovery Strategy and Action Plan has been developed (DFO 2019).*

A species Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) Science to provide the information and scientific advice required to meet the various requirements of the SARA, such as the authorization to carry out activities that would otherwise violate the SARA, as well as the development of recovery strategies. An RPA was conducted following the initial assessment of WCT in 2009. In light of the November 2016 assessment by COSEWIC, DFO Science has been asked to undertake a partial RPA to provide advice on life history parameters, recovery targets, and allowable harm. This advice may be used to update the existing recovery strategy and action plan and inform other aspects of decision-making in regard to the SARA.

SUMMARY

- Life history data for genetically pure, stream resident populations of Westslope Cutthroat Trout (WCT) in Alberta were compiled to generate a population model.
- Modelling was used to estimate the impacts of anthropogenic harm to WCT populations, estimate recovery targets for abundance and habitat, and estimate potential recovery timeframes.
- Under most model scenarios, WCT populations were most sensitive to perturbations to the juvenile stage (survival, growth, or habitat) regardless of the assumptions of density-independence, density-dependence, or periodic harm. This indicates that impacts to this portion of the lifecycle, such as fishing mortality or habitat alterations, may be the most detrimental to the population as a whole. As well, improvements to aspects of the juvenile stage may provide the greatest stimulus for population recovery.
- However, the exception to this occurred when an extreme surplus (> 10 times the amount required to support the stage-specific population size) in juvenile habitat or adult habitat existed. With an extreme surplus in juvenile habitat, small perturbations to juvenile habitat did not have much impact on stable adult density; however, perturbations to adult or spawning/YOY (young-of-year) habitat did impact adult density. With an extreme surplus in adult habitat, perturbations to adult habitat did not significantly affect adult density; however, juvenile habitat become even more important.
- Population viability analysis (PVA) was used to assess the minimum viable population (MVP) as a measure of an abundance recovery target. To achieve a 99% persistence probability over 100 years, adult (> 138 mm) population sizes of ~ 1,600, 3,000, and 4,200 were required assuming a frequency of catastrophic events (> 50% decline in population size) of 5%, 10%, and 15% per generation.
- The minimum amount of habitat required to support a population abundance of MVP (i.e., minimum area for population viability) was estimated to be ~ 21, 30, and 37 river km for the respective catastrophe rates based on the upper confidence interval of estimates.
- Recovery time, defined as the time taken to reach MVP from an initial population of 10% of MVP, ranged from 27–33 years across simulations.

BACKGROUND

The status of Westslope Cutthroat Trout (WCT; *Oncorhynchus clarkii lewisi*) was re-assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in November 2016. Populations in designatable unit (DU) 1 (Saskatchewan-Nelson River populations) were assessed as Threatened and populations in DU 2 (Pacific populations) were assessed as Special Concern (COSEWIC 2016). The primary threats to DU 1 populations include habitat loss, overharvesting, and the introduction of, and hybridization with, non-native species such as Rainbow Trout (*O. mykiss*) and other cutthroat trout sub-species (i.e., Yellowstone Trout (*O. c. bouvieri*)) which have been widely distributed in Alberta through stocking (COSEWIC 2016).

The *Species at Risk Act* (SARA) mandates the development of strategies for the protection and recovery of species that are at risk of extinction or extirpation from Canada. In response, Fisheries and Oceans Canada (DFO) has developed the recovery potential assessment (RPA; DFO 2007a,b) as a means of providing information and scientific advice. There are three components to each RPA - an assessment of species status, the scope for recovery, and scenarios for mitigation and alternatives to activities. A partial RPA was conducted for DU 1 WCT to provide advice on life history parameters, recovery targets, and the impact of harm.

This advice may be used to update the existing recovery strategy and action plan and inform other aspects of decision-making in regard to the SARA.

This RPA focuses on genetically pure WCT in Alberta (Figure 1) and is a summary of the conclusions and advice from a Canadian Science Advisory Secretariat (CSAS) peer-review meeting that occurred on December 17, 2019. The research document which used population modelling to assess the impacts of anthropogenic harm, recovery targets for abundance and habitat, and project recovery time frames (van der Lee and Koops 2020) provides an in-depth account of the information summarized below.

ASSESSMENT

The analysis consisted of four parts:

1. Information on vital rates were compiled to build projection matrices representing genetically pure, stream resident WCT that incorporate environmental stochasticity and density-dependence.

With these projection matrices:

2. The impacts of anthropogenic harm to a WCT population was assessed with three methods: deterministic elasticity analysis of population growth (λ) rate assuming density-independence; deterministic elasticity analysis of population abundance (N) assuming density-dependence; and simulation analysis used to assess the effects of periodic harm.
3. Population viability analysis was conducted to estimate recovery targets for abundance (minimum viable population, MVP) and habitat (minimum area for population viability, MAPV; i.e., the amount of suitable habitat required to support the MVP).
4. Simulation analysis was performed to project recovery timeframes from low density to recovery targets.

Impact of Harm

The impact of anthropogenic harm to populations of WCT was assessed using three methods: a density-independent elasticity analysis to determine the impact of changes to vital rates on population growth; a density-dependent elasticity analysis to determine the impact of changes to vital rates on stable population density; and stochastic simulation analysis to determine the impact of periodic harm (e.g., harm occurring once every 1, 2, 5, or 10 years).

Elasticities are deterministic estimates of the effects of proportional changes to matrix elements to population level metrics such as population growth rate or density. Elasticities are useful as they allow for assessment of how impactful changes to vital rates and other model parameters are to a population and because they represent proportional changes, their values are directly comparable. They are preferable to simulation analyses because of the speed they can be estimated allowing for many more perturbations to be examined than with simulations. Elasticities are limited, however, as they represent permanent changes and assume all other model parameters remain unchanged. Therefore, simulation analysis was used to examine the effects of transient or periodic harm to a population.

Across analyses, under most simulation scenarios, WCT populations were most sensitive to perturbations to aspects of the juvenile stage, including survival rate, juvenile somatic growth rate, and habitat quantity. This indicates that impacts to this portion of the lifecycle, such as fishing mortality or habitat alterations, may be the most detrimental to the population as a whole. As well, improvements to aspects of the juvenile stage may provide the greatest stimulus for population recovery. The exceptions to this were under conditions of surplus juvenile habitat or surplus adult habitat; here “surplus” represents > 10 times the amount of habitat required to support the stage-specific population size. With surplus juvenile habitat there was no impact of small proportional changes to the amount of juvenile habitat available. In this scenario adult population size was most affected by changes to juvenile survival as there was ample habitat for juveniles to fill. As well, the effects of habitat restoration affecting nursery or adult habitat were approximately equal on increasing adult density. When there was surplus adult habitat, changes to adult survival had the greatest effect on adult density; although, the juvenile survival rate elasticity was also large. In this scenario reductions to adult mortality, such as greater limitation on fishing, would have the greatest impact on stable adult density.

Simulation analysis was used to assess the impacts of periodic harm (Figure 2). The results were largely consistent with the elasticity analyses. The analysis, however, demonstrates the non-linear effects of harm as the magnitude of harm becomes large (i.e., > 30%). As well the results reveal that there was little impact of even large amounts of harm to the YOY stage when the frequency of harm was ≥ 5 years. This has important implications when assessing the potential effects of, for example, whirling disease.

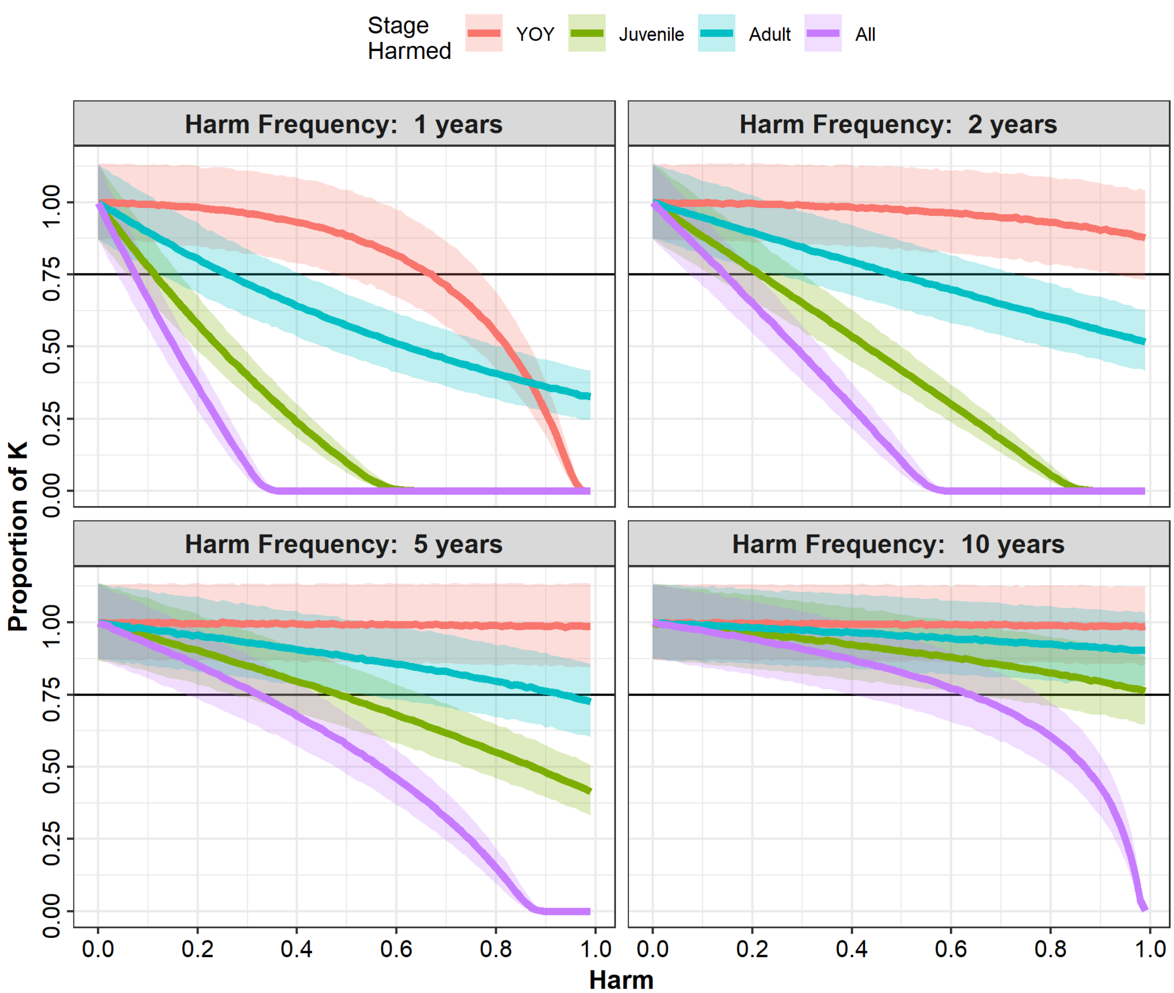

Figure 2. Results from harm simulation analysis where harm is applied at different frequencies to specific life-stages. The x-axis represent the proportional harm (e.g., annual mortality) applied to the life-stage and the y-axis represents the proportional decrease in adult density over a 100 year simulation. The solid lines represent the mean impact and the surrounding ribbons represent 95% confidence intervals. The reference line indicates a 25% decline from initial density.

Recovery Targets

Potential recovery targets for WCT were identified based on demographic sustainability. Demographic sustainability is related to the concept of a MVP which was defined as the minimum adult population size that results in a desired probability of persistence over 100 years (~ 15 generations for WCT). MVP was estimated using simulation analysis which incorporated environmental stochasticity and density-dependence. In choosing recovery targets, the risks associated with extinction probability must be balanced with the costs associated with an increased target (increased recovery effort, longer time to recovery, etc.). Recovery target values were estimated for a 5% and 1% risks of extinction using simulation criteria of populations affected by a 5%, 10% or, 15% per generation catastrophe rate, where a catastrophe is a stochastic population decline of > 50%, with a quasi-extinction threshold of 25 adult females. Results indicated that to achieve a 99% likelihood of persistence over 100 years, adult population sizes of ~ 1,600, 3,000, and 4,200 were required for catastrophe rates of 5%, 10% and 15% per generation, respectively.

The quantity of habitat required to support an MVP sized population was estimated with use of a fitted relationship between stream length and abundance from Alberta populations of WCT (van der Lee and Koops 2020), where mean abundance (N):

$$N_{>153mm} = (7.55 + 0.0023 stream\ length)^2 \qquad (1)$$

Solving for the stream lengths that resulted in adult abundances equal to MVP and using the upper confidence intervals gave estimates of ~ 21, 30 and 37 river km of habitat required to support MVP sized adult populations assuming catastrophe rates of 5%, 10%, and 15% per generation, respectively.

Recovery Time

Recovery timeframes were investigated with use of simulations analysis with simulations following the same protocols as MVP simulations. Initial abundance was set to 10% of MVP and the time taken for the population to reach MVP size recorded. Simulation replicates resulted in a distribution of recovery times. Recovery time was estimated as the 95th percentile of simulations; therefore 95% of simulations experience recovery by the recovery time estimate. Across all catastrophe rates and persistence probabilities recovery times ranged from 27 to 33 years.

Sources of Uncertainty

There were a number of uncertainties in the parameterization of the model due to wide variation in empirical estimates of survival rate and length-specific fecundity. The majority of parameters included in the population model were taken from Janowicz et al. (2018) as the study provided a variety of measures specific to stream resident WCT occupying high elevation headwater streams in Alberta, which were the target of this modelling exercise. While Janowicz et al. (2018) provides important information towards parameterizing the model, it should be noted that the data were collected from 2002–2004 when a legal harvest of WCT > 35 cm was permitted and genetic methods were not able to determine genetic purity at today's standards. As such, four of the six streams sampled by Janowicz et al. (2018) do not meet the current 99% requirement for WCT.

Additional aspects of the model that likely influence the results include the manner in which density-dependence was included, specifically the estimate of maximum population growth rate. This value was unknown and if allowed to be greater would likely increase population resilience and lead to smaller estimates of MVP and MAPV. Therefore the estimates reported may be conservative. As well, the WCT population were modelled as single isolated populations with no migration among them. Allowing for migration would also increase population persistence and lead to lower estimates of MVP and MAPV. Finally, the frequency of catastrophic events for WCT was unknown and had significant impacts on estimates of MVP. Results were presented for multiple rates of catastrophes, however, which scenario is most appropriate is not clear. Best practices may be to use the most conservative estimates (i.e., 15%/generation).

LIST OF MEETING PARTICIPANTS

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SOURCES OF INFORMATION

This Science Advisory Report is from the December 17, 2019 meeting on Recovery Potential Assessment – Westslope Cutthroat Trout, *Oncorhynchus clarkii lewisi*, Saskatchewan-Nelson River Populations (DU1). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2016. COSEWIC assessment and status report on the Westslope Cutthroat Trout Oncorhynchus clarkii lewisi, Saskatchewan-Nelson River populations, Pacific populations, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. xvi + 83 p.

DFO. 2007a. Documenting Habitat Use of Species at Risk and Quantifying Habitat Quality. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/038.

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DFO. 2019. Recovery Strategy and Action Plan for the Alberta populations of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa, ON. vii + 60 p. + Part 2.

Janowicz, M.E., Zatachowski, W., Rybczyk, A., Dalton, S., Fernandes, E., and Fontoura, N.F. 2018. Age, growth and reproductive biology of threatened Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* inhabiting small mountain streams. J. Fish. Biol. 93: 874–886.

van der Lee, A.S., and Koops, M.A. 2020. Recovery Potential Modelling of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada (Saskatchewan-Nelson River populations). DFO Can. Sci. Advis. Sec. Res. Doc. 2020/046. v + 26 p.

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Aussi disponible en français :

*MPO. 2020. Évaluation du potentiel de rétablissement pour la truite fardée versant de l'ouest (*Oncorhynchus clarkii lewisi*) : populations de la rivière Saskatchewan et du fleuve Nelson (UD 1). Secr. can. de consult. sci. du MPO, Avis sci. 2020/052.*