Direct Mortality and System Capacity

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Species Information

Common Name: Westslope Cutthroat Trout, Athabasca Rainbow Trout
Genus: Oncorhynchus lewisi, Oncorhynchus mykiss

Stressor Details

Stressor Name: Direct Mortality
Units: Total Annual Mortality (%)
Metric: Natural, Entrainment, and Research Mortality
Scale: linear
Function Type: continuous
Vital Rate/Process: System Capacity

Life Stage & Context

Life Stages: Adults
Geography: Rocky Mountain foothills, Alberta
Season: year-round

Descriptions

Overview

> In the Joe model, direct mortality was separated into natural causes, entrainment and research and monitoring, although more variables can be added as required. Using these three mortality sources, the total annual mortality rate (A) can be calculated using the conditional rates of natural mortality (n), entrainment mortality (en) and research and monitoring mortality (r), by applying the following equation adapted from Ricker (1975):
>
> A=1-[(1-n)×(1-en)×(1-r)]
> The stressor-response curve for direct mortality (Figure 1) is based on the results from modelling using a modified version of the Bull Trout model of Post et al. (2003). Assuming a conditional mortality rate of 20% from natural causes (Post et al. 2003), a Bull Trout population shown to switch from growth overfishing to recruitment overfishing (assumed to occur at ½ of maximum system capacity) if the combined conditional rate of mortality from other sources exceeded 8% and extirpation was expected when additional mortality exceeded 12%. This model was modified for the assessment of Athabasca Rainbow Trout and Westslope Cutthroat Trout populations in Alberta foothills streams (Sullivan 2007) which assumed there was a conditional mortality rate of 35% from natural causes (Post et al. 2003; Sullivan 2007). An Athabasca Rainbow Trout or Westslope Cutthroat Trout population may be at high risk of extirpation if the combined conditional rate of mortality from other sources exceeds 15% (Figure 1). Similar to the Angling Effort (incidental angling mortality and illegal harvest) function, there is an assumption that there is a portion of fish in a population that are less vulnerable or invulnerable to direct mortality hence the system capacity does not reach zero. For all three species, the upper limit of direct mortality was not exceeded so the stressor-response curve does not have a flat-tail on the x-axis but this could be seen in the future if the threat of entrainment or research and monitoring increase.

Function Derivation

> mechanistic/theory-based relationships, empirical studies

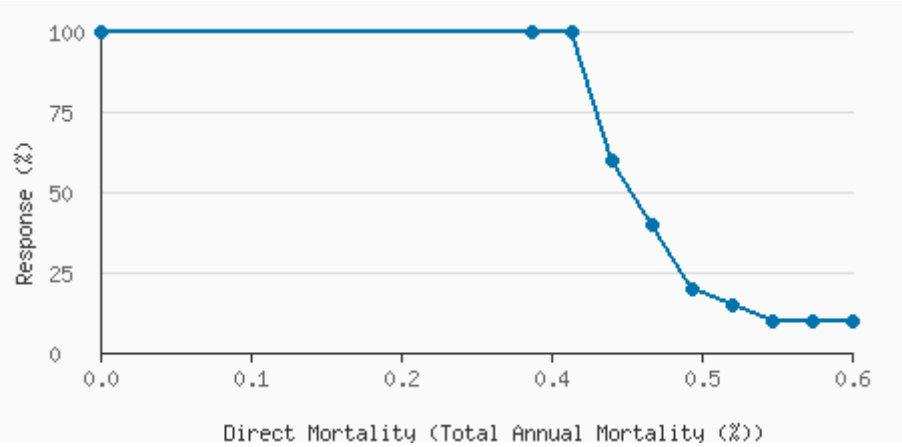
Transferability of Function

This function was developed and applied to Athabasca Rainbow Trout in Alberta foothills watersheds. The theoretical model behind the function was originally designed for Bull Trout but modified with inflection points to match Athabasca Rainbow Trout and Westslope Cutthroat Trout. The function should only be applied to other species if additional data is available to customize mortality rates.

Source of Stressor Data

a. Entrainment Mortality
Fish can become entrained in irrigation canal headworks and killed if not rescued before the canal is dewatered at the end of the irrigation season. Entrainment rates are expected to be variable between canals, however, there have been no recent studies to determine the total number of entrained fish and the overall effect on population sustainability. The primary data source to inform the potential severity of this threat is the Trout Unlimited Canada annual fish rescue program, which includes most but not all canal headworks within the current Bull Trout and Westslope Cutthroat Trout range. Typically, no or small numbers of entrained Bull Trout (

Stressor Response Data



?Direct Mortality (proportion)	Mean System Capacity (%)	SD	low.limit	up.limit	
0	100	0	0	100	
0.35	100	0	0	100	
0.3825	100	0	0	100	
0.415	60	0	0	100	
0.4475	40	0	0	100	
0.48	20	0	0	100	
0.5125	15	0	0	100	
0.545	10	0	0	100	
0.5775	10	0	0	100	
0.61	10	0	0	100	

Citations

AESRD - Alberta Environment and Sustainable Resource Development. 2013a. Standards for the ethical use of fishes in Alberta. 5 p.

AESRD - Alberta Environment and Sustainable Resource Development. 2013b. Standard for sampling of small streams in Alberta. 18 p.

AFMD - Alberta Fisheries Management Division. 2004. Electrofishing Policy Respecting Injuries to Fish. 3 p.

Clayton, T.B. 2001. Movements and status of Bull Trout (Salvelinus confluentus) in the Belly River, Alberta and Montana. Pages 141-145 in Brewin, M.K., A.J. Paul, and M. Monita, editors. Bull Trout II conference proceedings. Trout Unlimited Canada, Calgary, Alberta, Canada.

FERC - Federal Energy Regulatory Commission. 1995. Preliminary assessment of fish entrainment at hydropower projects, a report on studies and protective measures, volumes 1 and 2 (appendices). FERC Office of Hydropower Licensing, Washington, D.C. Paper No. DPR-10. June 1995 (volume 1) and December 1994 (volume 2).

Hatch Ltd. 2010. Alberta Utilities Commission update on Alberta's hydroelectric energy resources. Final report prepared for the Alberta Utilities Commission, 26 Feb 2010

Langford, M.T. 2016. Predicting the Hydraulic Influence of Hydropower Operations on Upstream Aquatic Habitat. A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Water Resources Engineering Department of Civil and Environmental Engineering. University of Alberta. 222 p.

Lindsay, E., L. Peterson, H. Tunna, J. Dubnyk, and T. Urquhart. 2015. Late Fall Fisheries Investigations in Irrigation Canals of Southern Alberta, 2014 Trout Unlimited Technical Report No. AB-037.

Ma, B., E. Parkinson, and D. Marmorek. 2012. Using single species population models of Bull Trout, Kokanee and Arctic Grayling to evaluate Site C passage alternatives. Site C Clean Energy Project Technical Data Report: Vol. 2, App. Q3, Attachment B.

Martins, E., L. Gutowsky, P. Harrison, D. Patterson, M. Power, D. Zhu, A. Leake, and S. Cooke. 2013. Forebay use and entrainment rates of resident adult fish in a large hydropower reservoir. Aquatic Biology 19: 253–263.

Post, J., C. Mushens, A. Paul, and M. Sullivan. 2003. Assessment of alternative harvest regulations for sustaining recreational fisheries: model development and application to Bull Trout. North American Journal of Fisheries Management 23:22–34.
Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, Bulletin 191. Ottawa, ON. 401 pp.

Salow, T and L. Hostettler. 2004. Movement and mortality patterns of adult adfluvial Bull Trout (Salvelinus confluentus) in the Boise River basin Idaho. U.S. Bureau of Reclamation, Denver, Colorado.

Sullivan, M. 2007. Modelling potential effects of angling on recovery of Westslope Cutthroat Trout (Oncorhynchus clarkii lewisi) in Alberta. Alberta Fish and Wildlife Division. 22 pp.

Underwood, K., and S. Cramer. 2007. Simulation of human effects on Bull Trout population dynamics in Rimrock Reservoir, Washington. American Fisheries Society Symposium 53:191-207.

USFWS - U.S. Fish and Wildlife Service. 2000. Revised section 7 programmatic consultation on issuance of section 10(a)(1)(A) scientific take permits and section 6(c)(1) exemption from take for Bull Trout (Salvelinus confluentus) (6007.2100). Memorandum from Acting Supervisor, Snake River Basin Office, Boise, Idaho, to Regional Director, Region 1, Portland, Oregon. February 14, 2000. 22 p.

USFWS - U.S. Fish and Wildlife Service. 2015. Recovery plan for the coterminous United States population of Bull Trout (Salvelinus confluentus). Portland, Oregon. xii + 179 pages