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Pacific Region

RECOVERY POTENTIAL ASSESSMENT FOR CHILCOTIN RIVER AND THOMPSON RIVER STEELHEAD TROUT (*ONCORHYNCHUS MYKISS*) DESIGNATABLE UNITS

Steelhead Trout image by Robert Basok.

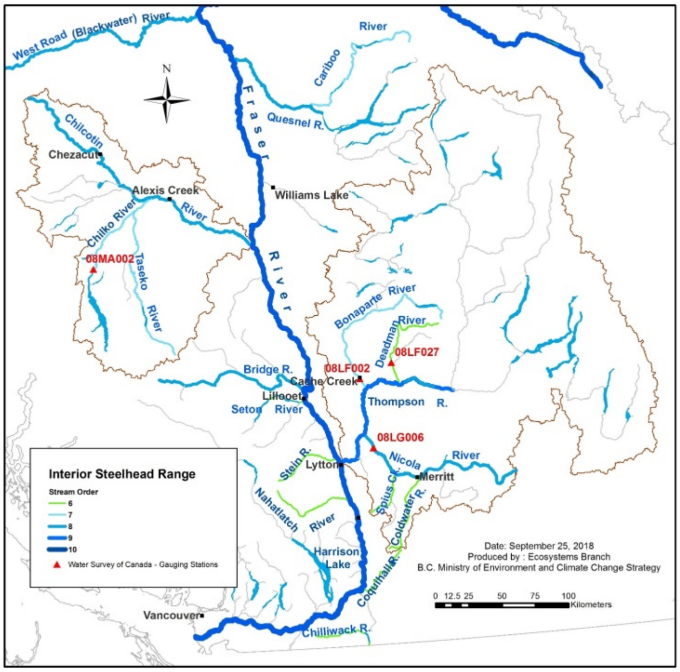

Figure 1. Major stock groups of Steelhead Trout in the Fraser River system, up stream of the Fraser Canyon. Produced by BC Ministry of Environment and Climate Change Strategy, Ecosystems Branch

Context:

The Chilcotin and Thompson River populations of Steelhead Trout (Oncorhynchus mykiss) were both assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in an Emergency Assessment in January 2018 based on population decline of 79% and 81% respectively over the last three generations.

Fisheries and Oceans Canada (DFO) Science Branch was asked to complete a modified Recovery Potential Assessment (RPA), based on the national RPA guidance, to provide science advice to inform a Ministerial opinion on imminent threat to survival as it relates to the Emergency Assessment and a potential Governor in Council (GIC) listing decision for the addition of Steelhead Trout to Schedule 1 of the Species at Risk Act *(SARA).*

This Science Advisory Report is from the September 20-21, 2018 regional peer review on Recovery *Potential Assessment – Chilcotin River and Thompson River Steelhead Trout (Oncorhynchus mykiss) Designatable Units. Additional publications from this Regional Peer Review will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.*

SUMMARY

- This Recovery Potential Assessment (RPA) focuses on the Chilcotin and Thompson River Designatable Units (DU) of Steelhead Trout. Both of these DUs were assessed as Endangered by COSEWIC in an emergency assessment in January 2018.
- The estimated number of mature fish that returned to fresh water from the sea in the fall of 2017 and spawned in the spring of 2018 was 150 for the Thompson DU and 77 for the Chilcotin DU. The estimated decline of Steelhead Trout spawners over the last three generations has been 79% (over 15 years) for the Thompson DU, and 81% (over 18 years) for the Chilcotin DU.
- Given the shortened timelines required for an emergency assessment, the advice in this RPA only addresses a subset of the elements required in a full RPA. Outstanding elements will be addressed in the future as the *Species at Risk Act* processes continue.
- Threats and limiting factors identified to be most relevant to the survival and recovery of Steelhead Trout include changes in the marine environment, fishing mortality, degradation of freshwater and marine habitats, predation and competition. General categories of threats and limiting factors were agreed to, however the rationale and scoring for level of impact, causal certainty, and threat risk had greater uncertainty and will require further input and evaluation.
- Recommended Distribution Target is to retain the present level of occupancy in freshwater habitats, thereby avoiding contraction of freshwater range. Five spatial sub-areas within the spawning and juvenile rearing areas of the Thompson DU, including the main stem are recommended and two spatial subdivisions are recommended within the Chilcotin DU. These distribution targets are consistent with current level of occupancy in freshwater habitats, and are believed to be sufficient to avoiding contraction of freshwater range.
- Recommended Abundance Recovery Target for Thompson Steelhead Trout DU is 938 spawners. This value, which also meets the distribution target, is the total escapement to the DU that results in a 95% probability that a minimum of 100 spawners returns to each of its five sub-areas in the same year.
- Recommended Abundance Recovery Target for Chilcotin Steelhead Trout DU is 562–744 spawners, using a length-standardized requirement of 1.8–2.4 spawners/km. This also meets the distribution target for the Chilcotin DU.
- Model simulations suggest increases in future abundances of both DUs are conditional on improvements in natural productivity. Exploitation rate (fishing mortality) reduction has the potential to lessen rates of decline if the most recent productivities observed continue in the future. However, eliminating exploitation alone will not result in population recovery.
- Uncertainties regarding the exploitation rate estimates, unaccounted for fixed rate terminal harvest, and variations in escapement were identified as having the potential to affect the estimated productivity of each population.
- For the Thompson DU, simulations estimate that if productivity levels from the most recent year persist (recruits/spawner), recovery is not expected regardless of exploitation rate. If productivities double (10 and 5-year time periods), the estimated recovery probability exceeds 47% for all exploitation rates. However, if the 1-year time period productivity doubles, recovery probability estimates are 12% or less under all exploitation rates.

- For the Chilcotin DU, simulations estimate that recovery probability is zero at all exploitation rates if productivity levels from the most recent year persist, but recovery probability exceeds 39% at all exploitation rates if productivity increases to 5-year mean level. If the 5- and 10- year mean productivities double (10 and 5-year time periods), the estimated recovery probability exceeds 74% at all exploitation rates.
- Given the declining and very low abundances of both the Thompson and Chilcotin Steelhead DUs, any harm will inhibit or delay potential recovery and potentially result in further declines in abundance. Allowable harm should not be permitted to exceed current levels and should be reduced to the maximum extent possible. Preventing and mitigating habitat destruction, restoring damaged habitat, and reducing exploitation rates, to the extent possible, are immediate actions that will increase the likelihood that allowable harm will not exceed current levels and promote recovery if productivity increases.

INTRODUCTION

Rationale for Recovery Potential Assessment

After the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses an aquatic species as Threatened, Endangered or Extirpated, Fisheries and Oceans Canada (DFO), as the responsible jurisdiction for aquatic species under the *Species at Risk Act* (SARA), undertakes a number of actions to support implementation of the Act. Many of these actions require scientific information on the current status of the species, threats to its survival and recovery, and the species' potential for recovery. Formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA) following the COSEWIC assessment. This timing allows for the consideration of peer-reviewed scientific analyses into SARA processes, including the decision whether or not to list a species on Schedule 1, and during recovery planning if the species is listed.

Oncorhynchus mykiss exhibits two broad life-history types: a lake- and stream-resident form known as freshwater or resident Rainbow Trout, and an anadromous (sea run) form known as Steelhead Trout. This RPA focuses on the Chilcotin and Thompson River Designatable Units (DU) of Steelhead Trout. Both DUs were assessed as Endangered by COSEWIC in an emergency assessment in January 2018 based on estimated population declines of 79% and 81% within three generations (15-18 years) respectively, inferred continuing decline, and a very small number of mature individuals (COSEWIC 2018).

To inform an imminent threat opinion and in anticipation of the need to inform a listing decision by Cabinet to add Steelhead Trout to Schedule 1 of the *Species at Risk Act* (SARA), DFO Science has been asked to undertake a modified RPA, based on the national RPA Guidance (DFO 2014a). Given the shortened timelines required for an emergency assessment, this advice only addresses a subset of the elements required in a full RPA (for example, Habitat elements were omitted, potential ecological impacts of identified threats were not explored, estimate of reduction in mortality rate expected from each mitigation measure was not provided, parameter values for population productivity and starting mortality were not recommended). Outstanding elements will be addressed in the future as the SARA processes continue. The advice in this RPA may be used to inform both scientific and socio-economic aspects of the potential listing decision, as well as development of a SARA recovery strategy and action plan if listed, and to support decision making with regards to the issuance of permits or agreements, and the formulation of exemptions and related conditions, as per sections 73, 74, 75, 77, 78 and 83(4) of SARA. It also provides information relevant to the reporting requirements of SARA section 55.

ASSESSMENT

Biology and Life History Parameters

In British Columbia, *O. mykiss* occurs as two ancestral lineages, referred to as “coastal” and “interior” *O. mykiss*. Freshwater-resident and anadromous life-history types or phenotypes are found within each lineage. Both resident Rainbow Trout and Steelhead Trout may occur in a single watershed, though the genetic differentiation between the two can vary greatly. The two can successfully interbreed; however, there is no information on this genetic relationship in the Thompson and Chilcotin River DUs. This RPA focuses on the Steelhead anadromous life-history type, not the freshwater resident Rainbow Trout.

Thompson and Chilcotin Steelhead Trout reside in the Fraser River drainage (Figure 1), and are descendants of the Interior *O. mykiss* lineage. Based on genetic data, Steelhead Trout in the Thompson and Chilcotin rivers are discrete from all other Canadian Steelhead Trout, and also differ from each other. Thus, Thompson River and Chilcotin River Steelhead Trout were assessed as two separate DUs or populations (COSEWIC 2018).

Juvenile Steelhead Trout typically spend 1–5 winters in freshwater before undergoing a smoltification process which allows them to live in the ocean. Smolts migrate to sea in the spring and typically spend two or three summers in the ocean before returning to spawn.

Following offshore ocean residence, Thompson and Chilcotin River Steelhead Trout undertake spawning migrations. They are generally classed as “summer-run” which, when applied to steelhead, means that the migration occurs in two stages; an initial stage from sea to freshwater overwintering areas and a second stage from overwintering areas to spawning sites. For Thompson and Chilcotin Steelhead Trout, the first stage occurs in the late summer and extends into autumn. This timing has evolved to facilitate upstream passage over seasonal migration barriers, located in the Fraser River, which become impassable after the onset of winter. Both Thompson and Chilcotin Steelhead Trout have to ascend a set of two seasonal barriers in the lower Fraser canyon (~180–210 river km upstream) while Chilcotin Steelhead Trout have to also ascend a third barrier further upstream (~320 km river km upstream). Consequently, Thompson and Chilcotin Steelhead Trout may exhibit different migration characteristics. Chilcotin Steelhead Trout may migrate earlier and may be faster on average at a given temperature while Thompson Steelhead Trout may migrate later and may be slower. In the lower Fraser River, there is overlap in run timing between Thompson and Chilcotin Steelhead Trout. The collective run timing also contains some smaller steelhead populations that also migrate to spawning and rearing streams upstream of the lower Fraser canyon, but would belong to different DUs. Upon entry into the tidal portion of the lower Fraser River, the collective run timing spans a duration of about 12 weeks, peaking on October 10 on average with Chilcotin Steelhead Trout typically dominating the early part of the run timing and Thompson Steelhead Trout typically dominating the middle and latter part (Figure 2).

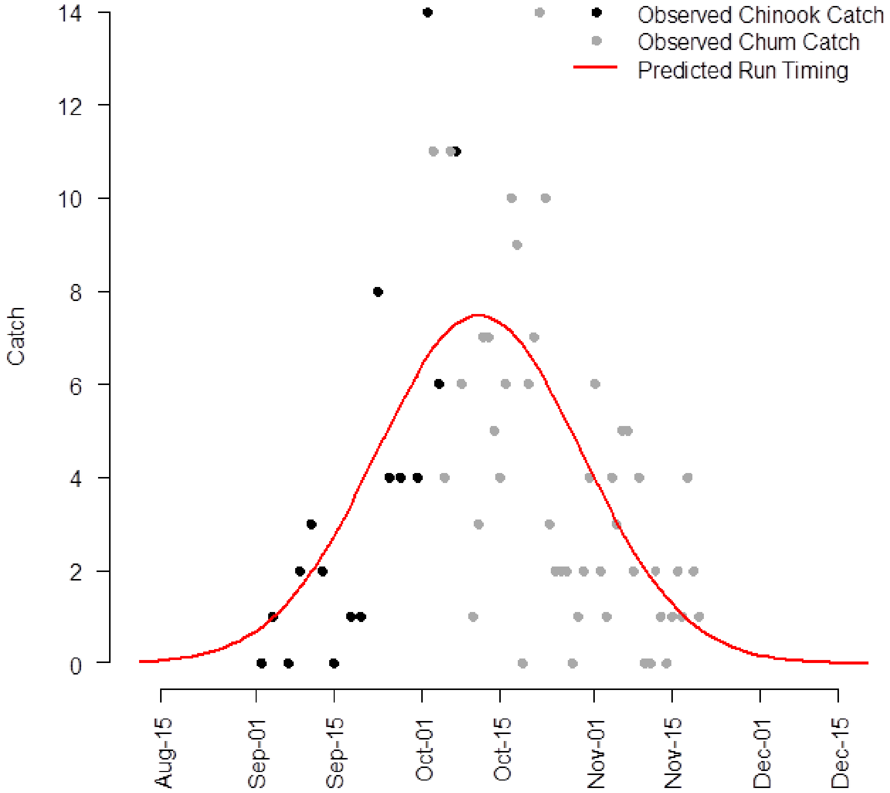

Figure 2. An illustration of the run timing of Chilcotin and Thompson Steelhead Trout in the lower Fraser River (data from gillnet test fisheries conducted in 1985). Black and gray points are the observations in 8" (Chinook) and 6.75" (Chum) mesh gillnet, respectively.

Unlike other species of Pacific Salmon, Steelhead Trout are iteroparous, with some (<10%) individuals surviving the return to the ocean, and then migrating back to freshwater to spawn in subsequent years. Typically, the returning individuals (<10%) spawn twice but some return to spawn for a third and rarely a fourth time.

Thompson River Steelhead Trout spawn in tributaries of the Thompson River. On average, 85% of adult Thompson River Steelhead Trout are five years old when they first spawn. Age data for Thompson River Steelhead Trout are available for all 36 brood years (1978–2018 with the exception of 2002–2004). For Thompson River Steelhead Trout, repeat spawning has averaged about 3% (i.e., 3% of total returning individuals will return to spawn again), which is a relatively low rate compared to other Steelhead Trout populations.

Data on age structure for the Chilcotin population are limited and based on only 10 brood years (1980–1982, 1984, 2011–2016). Chilcotin River Steelhead Trout are on average one year older than Thompson River fish due to the predominance of three year old smolts resulting from slower growth in the largely glacial watershed and a shorter growth season.

Thompson Steelhead Trout have distinguishing traits that include being unusually large and highly fecund with small eggs relative to other BC steelhead populations. After accounting for body size, Thompson Steelhead Trout are 15% more fecund than Chilcotin Steelhead Trout and 40% more fecund than coastal winter run Steelhead Trout in southern BC. However, a time series of the size of returning Thompson Steelhead Trout suggests a large decline in maximum size and fecundities from1979 and 1994, and a second decline between 2004 and 2009.

Abundance

The estimated number of mature fish that returned to fresh water from the sea in the fall of 2017 and spawned in the spring of 2018 was estimated to be 150 for the Thompson DU and 77 for the Chilcotin DU. The estimated decline of Steelhead Trout spawners over the last three generations has been 79% (over 15 years) for the Thompson DU, and 81% (over 18 years) for the Chilcotin DU (Figure 3). The average annual number of mature individuals returning to the Thompson and Chilcotin DUs over the last three years (2016–2018) has been the lowest ever observed.

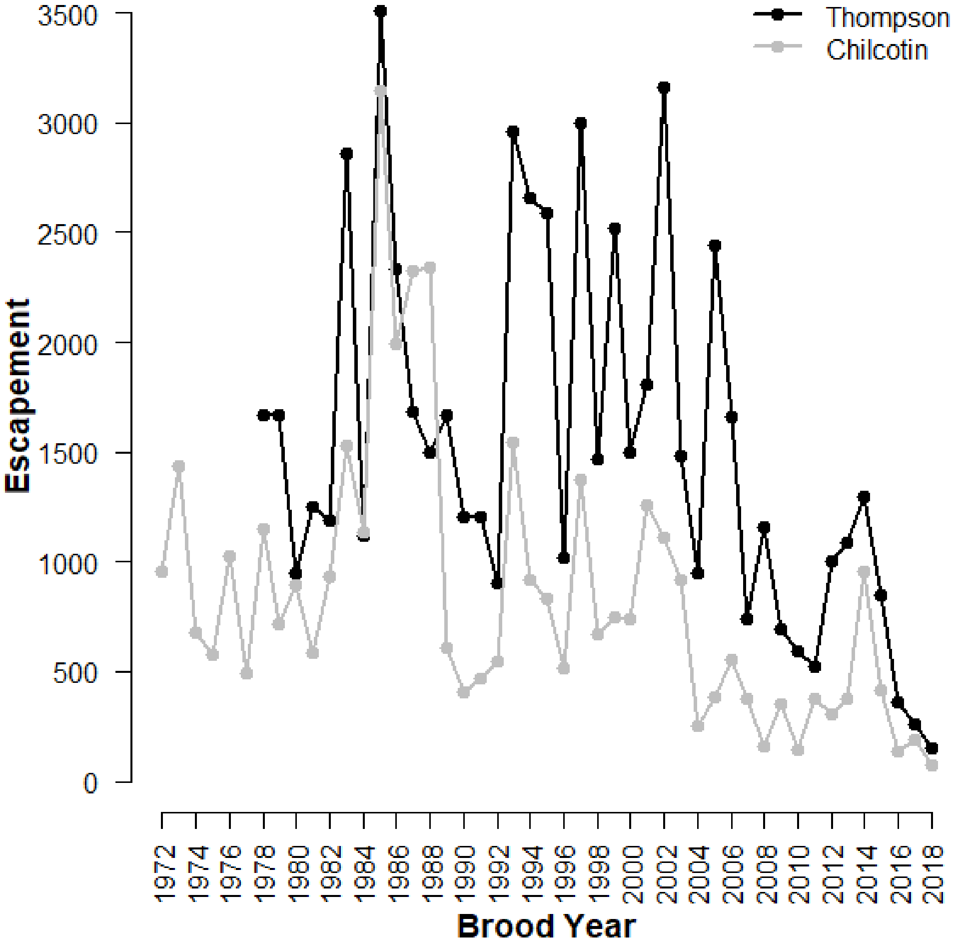

Figure 3: Annual escapement (spawner abundance) estimates for Steelhead Trout in Thompson and Chilcotin Designatable Units.

Habitat Requirements

Similar to other anadromous salmonids, Steelhead Trout require different habitats at varying stages of their life cycle. This includes freshwater spawning, rearing, over-wintering and smolt migration habitats, marine rearing and migration habitats, and the habitat requirements to return to the freshwater environment for spawning. A complete description and analysis of the habitat properties, functions, features, and attributes that Steelhead Trout need for successful completion of all life history stages and requirements was not explicitly addressed in this emergency RPA process but will be completed in future work, if required, as the SARA processes continue.

Residence

Under SARA, a residence is defined as a dwelling-place that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating (SARA section 2.1). Following DFO's *Guidelines for the Identification of Residence and Preparation of a Residence Statement for an Aquatic Species at Risk* (DFO 2015), spawning redds most closely match the criteria for a residence because they are constructed. Redds have a structural form and function of a nest, the female has invested energy in its creation, redds are essential for successful incubation and hatching of the eggs, and redds can contain hundreds to several thousand eggs from a single female Steelhead Trout.

Threats and Limiting Factors

Steelhead Trout are vulnerable to threats and limiting factors through all of their life stages, from egg to adult, in a variety of habitat types in both freshwater and marine environments within Canada and in the North Pacific. Threats are defined as any anthropogenic activity or process that has caused, is causing, or may cause harm, death, or behavioural changes to a species, or the destruction, degradation, and/or impairment of its habitat, to the extent that population-level effects occur (DFO 2014b). Limiting factors are non-anthropogenic factors that, within a range of natural variation, limit the abundance and distribution of a species. Limiting factors may be exacerbated by anthropogenic activities (DFO 2014b).

There is uncertainty regarding the degree to which threats and limiting factors impact various life stages of Steelhead Trout due to limited or inconclusive information currently available to definitively characterize them. General categories for both threats and limiting factors were agreed to, and there was general agreement with the proposed limiting factors scores provided that the table was considered preliminary. In contrast, consensus was not reached for inclusion of preliminary scores for the threats table. A preliminary threats table was therefore developed that does not include specific scoring (Appendix). Both tables will require further input and evaluation. Participants noted that scores for each of the categories may vary by life stage, area, and quality and quantity of data available.

Threats to Steelhead Trout include bycatch in commercial salmon fisheries (i.e., gillnet, purse seine and troll), recreational fisheries (directed and bycatch), Food, Social, Ceremonial (FSC) fisheries (directed and bycatch), science activities, pollution and physical habitat degradation. Regardless of uncertainties related to precision in quantifying the impact level of physical habitat degradation, actions which convert or degrade marine or freshwater habitat, increase sedimentation or alter water flow patterns from their natural range of variation have been observed to impact return migration and spawning, egg development and hatching, freshwater incubation, and freshwater rearing. Habitat related threats are known to have locally occurred, are currently occurring and are anticipated to continue and may have population level impacts on Steelhead Trout once scoped and quantified, but don’t appear to be the dominant factor.

Limiting factors to Steelhead Trout recovery include changing freshwater and ocean conditions, physical habitat degradation (including natural factors which increase sedimentation, alter water flow patterns and cause physical habitat degradation), native parasites and pathogens, predation, long migration routes which make them more susceptible to predation, competition, and the availability and amount of parr habitat. Broad scale changes in climate, over annual and decadal scales, are correlated with reduced trout and salmon survival in marine and fresh water environments. Although relationships between temperature and survival have been identified, the underlying causal mechanisms driving the relationships and the direct and indirect (e.g., food webs) impact to Steelhead Trout are poorly understood. Predation also contributes to Steelhead Trout mortality across all life stages in both freshwater and marine environments. Although a correlation between pinniped population growth and steelhead population decline was suggested, there was no consensus that there is a causal relationship between the two. Similarly the recommendation for a pinniped cull in the working paper was not supported and requires further investigation. There is a large degree of uncertainty in the level of impact predators such as pinnipeds and other marine and freshwater predators have on Steelhead Trout. Whether or not human activities have caused the variation in climate, competition, and predator effects to exceed the natural variation criteria of the limiting factor definition was not determined during the RPA. The role of human activities in influencing variation in these limiting factors will affect the likelihood of recovery by mitigation of these limiting factors.

Recovery Targets

For this assessment, the Thompson Steelhead Trout DU consists of five spatially separated sub-areas which include the main stem of the Thompson, Deadman, Bonaparte, Coldwater, Spius, and Lower Nicola rivers. The Chilcotin Steelhead Trout DU consists of two spatially-separated sub-areas which include the Chilko and Chilcotin rivers, and the Taseko River. The recommended distribution target for each of the DUs is to maintain spawning populations in each of these sub-areas. These distribution targets are consistent with current level of occupancy in freshwater habitats, and are believed to be sufficient to avoiding contraction of freshwater range.

The approach taken to use a direct estimate to recommend an abundance recovery target for the Thompson Steelhead Trout DU closely follows the approach used for interior Fraser Coho salmon. The recommended abundance recovery target for the Thompson Steelhead Trout DU is a total escapement that is predicted to result in a 95% chance of a minimum of 100 spawners returning to each of its five sub-areas in the same year. The most likely estimate for the Thompson DU was 938 spawners.

A direct estimate for a recommended abundance recovery target for the Chilcotin DU was not possible as there were only three years when escapement estimates were available for the two sub-areas. Alternatively, a benchmark was derived by multiplying the length-standardized Thompson DU requirement by the accessible stream length of the Chilcotin DU. A total abundance target of 938 spawners for the Thompson DU results in a length-standardized requirement of 1.8–2.4 spawners/km. The product of these values and accessible stream length for the Chilcotin DU (306 km) is a recovery target of 562–744 spawners for the Chilcotin DU.

The difference in abundance targets for Thompson and Chilcotin DUs is consistent with differences in their escapement early in the time series, which may reflect freshwater carrying capacities prior to major reductions in abundance. The ratio of Thompson/Chilcotin escapement over the first ten overlapping years of available data (1978–1987) is approximately 1.5. Using that ratio, the abundance target for the Chilcotin would be 629 spawners (928/1.5), which lies within the 562-744 estimated range.

Recommended abundance targets for Thompson and Chilcotin DUs are generally consistent but slightly above previous proposed conservation limits. Using a dual threshold approach, Johnston (2013) recommended a conservation concern threshold of 1187 and a limit reference point of 431 for the Thompson population aggregate. Johnston (2013) also recommended a conservation concern threshold of 763 and a limit reference point of 296 spawners for the Chilcotin population aggregate. Johnston's dual threshold recommendations span the range of conservation requirements identified in the RPA.

Trajectories of future escapement for each DU were simulated under three alternative productivity (i.e., recruits/spawner) scenarios. Under the first scenario future productivity was assumed to be the same as that observed over the last 10 years. Under the second scenario productivity was assumed to similar to that observed over the most recent 5 years and under the third scenario productivity was assumed to be the same as that estimated from the most recent year. Projections for each DU were initialized with the most recently observed escapement estimates (2013 to 2018) and the dynamics of each DU were simulated forward in time by randomly drawing from estimates of productivity contained within each of these recent time frames. It is noteworthy that the productivity of the Thompson DU continues to decline at the end of the time series, so this projection will overestimate productivity and consequently overestimate potential future recovery of the Thompson DU if the current decline continues (Figure 4).

Projections were simulated six generations into the future, which is 36 years for the Thompson DU (maximum age-at-return of six years), and 42 years for the Chilcotin DU (maximum age-at-return of seven years). A range of fixed exploitation rates from 0% to 25%, which span the range experienced in recent years, were simulated under each productivity scenario. The 0–25% is due to bycatch in salmon fisheries and through targeted sport fishing and does not include other sources of mortality. Finally, a second set of simulations were conducted based on a subjective 2-fold increase in productivity values relative to the baseline scenarios (i.e., a doubling in the log of productivity). Note that the scenario that assumes a doubling of productivity using the 10-year productivity is a 3.32x increase in productivity compared to those using the last brood year alone and may overestimate recovery potential.

For the Thompson DU, simulations estimate that under mean productivity levels for the 10, 5, and 1-year time periods, recovery is not expected (17% or less) regardless of exploitation rate. If mean 10 and 5-year Thompson DU productivities double, the estimated recovery probability exceeds 47% for all exploitation rates. For example, under this scenario, estimated probability of recovery is greater than 90% at double mean 10-year productivities, exceeds 50% for exploitation rates 20% or less under the 5-year time period, and is 12% or less under all exploitation rates for the 1-year time period (Table 1a). Therefore, simulations suggest that the population will continue to decline even in the absence of exploitation and an increase in productivity is critical to recover this population (either through direct intervention or by natural improvements in ocean conditions). Furthermore, it is unlikely that the recovery target can be achieved within 6 generations without additional improvement in productivity.

For the Chilcotin DU, simulations estimate that under mean productivity levels for the 10 and 5-year time periods that recovery probability exceeds 39% at all exploitation rates for the 5-year mean productivity and are 33% or less for 10-year mean productivity. If mean 10 and 5-year productivities doubles, the estimated recovery probability exceeds 74% at all exploitation rates. However, the estimated recovery probability for the 5-year mean productivity is 99%. Estimated recovery probability is zero at all exploitation rates and all productivity levels for the 1-year time period (Table 1b).

Because current mean productivity is the most likely scenario, preventing and mitigating habitat destruction and reducing exploitation below current levels of exploitation are immediate actions necessary to increase the likelihood that allowable harm will not exceed current levels and promote recovery if productivity increases.

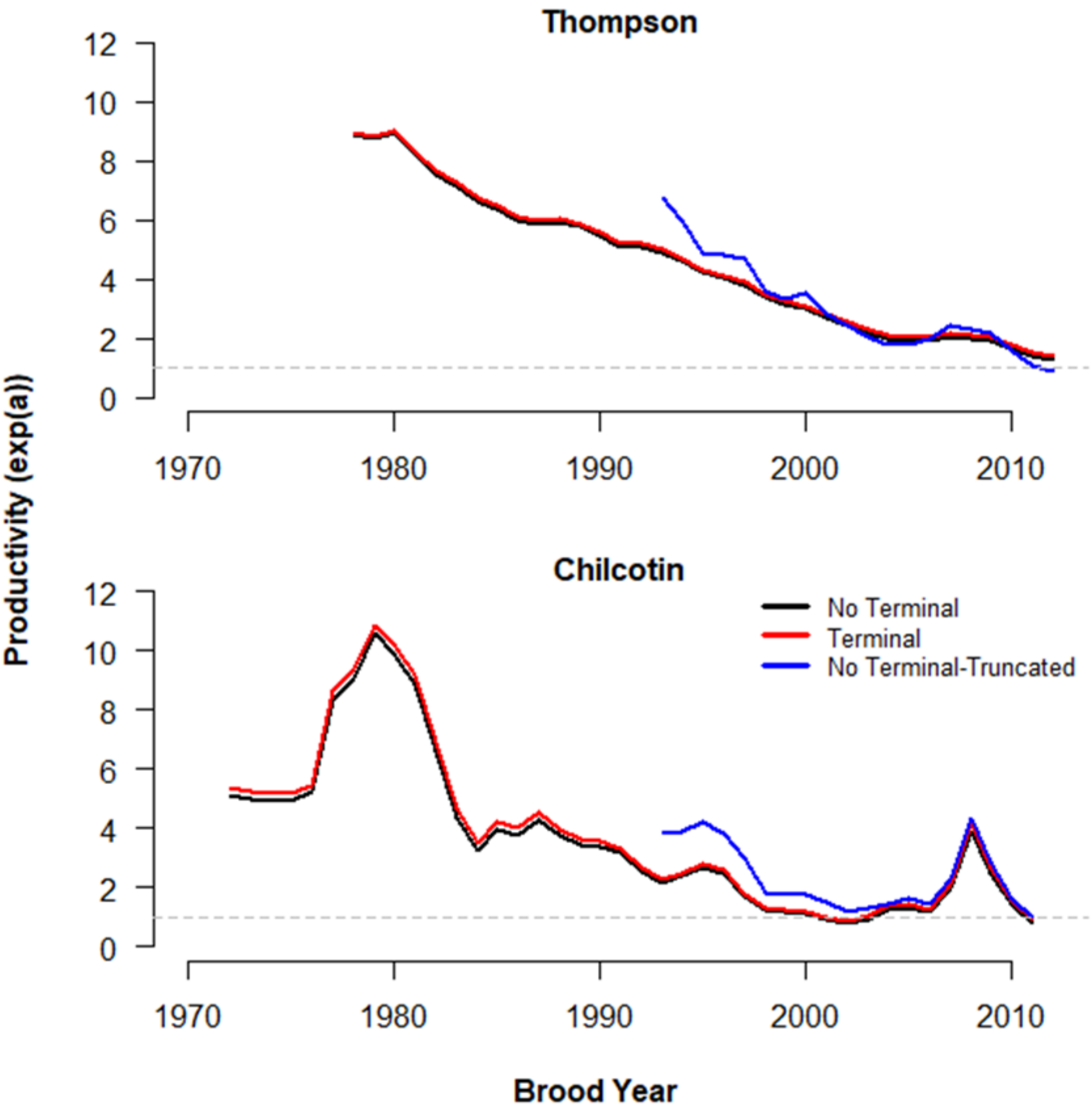

Figure 4. Comparison of estimated trends in productivity (recruits/spawner) based on 3 alternate recruitment reconstructions which do not (No Terminal) and do (Terminal) include estimates of terminal First Nations harvest, and the estimated trend based on a truncated reconstruction (1993-last available brood year) without terminal harvest (No Terminal-Truncated).

Table 1. Recovery statistics from the simulation model showing predicted mean change in the generationally-average abundance over the simulation period across trials (Mean Growth), the probability of positive population growth over the simulation (Probability of Growth), the probability of exceeding the recovery objective (938 for Thompson, 562 for Chilcotin), and the number of years required to meet the recovery objective assuming mean growth. Results are shown across the 3 productivity scenarios (based on last 10, 5, and 1 year of available estimates), without and with a doubling in the log of productivity (log Productivity Multiplier = 1 or 2, respectively), and over a range of exploitation rates.

a) Thompson

Years for Productivity Sample	log Productivity Multiplier	Exploitation Rate	Mean Growth	Probability of Growth	Probability of Recovering	Years to Recovery
10	1	0.00	155	0.81	0.17	NA
10	1	0.05	87	0.70	0.08	NA
10	1	0.10	12	0.49	0.03	NA
10	1	0.15	-67	0.31	0.01	NA
10	1	0.20	-144	0.17	0.01	NA
10	1	0.25	-227	0.08	0.00	NA
10	2	0.00	1,030	1.00	0.99	5
10	2	0.05	934	1.00	0.99	5
10	2	0.10	884	1.00	0.98	5
10	2	0.15	808	1.00	0.98	6
10	2	0.20	703	0.99	0.95	6
10	2	0.25	626	0.99	0.92	7
5	1	0.00	-30	0.41	0.02	NA
5	1	0.05	-101	0.27	0.01	NA
5	1	0.10	-167	0.14	0.01	NA
5	1	0.15	-235	0.08	0.00	NA
5	1	0.20	-305	0.03	0.00	NA
5	1	0.25	-370	0.01	0.00	NA
5	2	0.00	654	0.98	0.89	6
5	2	0.05	582	0.97	0.86	7
5	2	0.10	526	0.96	0.81	9
5	2	0.15	446	0.93	0.72	10
5	2	0.20	353	0.89	0.62	13
5	2	0.25	252	0.83	0.47	NA
1	1	0.00	-420	0.04	0.01	NA
1	1	0.05	-452	0.04	0.01	NA
1	1	0.10	-499	0.02	0.00	NA
1	1	0.15	-526	0.01	0.01	NA
1	1	0.20	-559	0.01	0.00	NA
1	1	0.25	-583	0.00	0.00	NA
1	2	0.00	-235	0.23	0.12	NA
1	2	0.05	-297	0.19	0.08	NA
1	2	0.10	-320	0.18	0.08	NA
1	2	0.15	-381	0.13	0.06	NA
1	2	0.20	-413	0.12	0.04	NA
1	2	0.25	-441	0.10	0.04	NA

b) Chilcotin

Years for Productivity Sample	log Productivity Multiplier	Exploitation Rate	Mean Growth	Probability of Growth	Probability of Recovering	Years to Recovery
10	1	0.00	160	0.88	0.33	NA
10	1	0.05	95	0.77	0.17	NA
10	1	0.10	37	0.58	0.09	NA
10	1	0.15	-24	0.39	0.02	NA
10	1	0.20	-78	0.21	0.01	NA
10	1	0.25	-136	0.06	0.00	NA
10	2	0.00	929	1.00	0.94	6
10	2	0.05	851	1.00	0.92	6
10	2	0.10	810	0.99	0.91	7
10	2	0.15	742	1.00	0.88	8
10	2	0.20	657	0.98	0.83	8
10	2	0.25	565	0.96	0.74	9
5	1	0.00	526	1.00	0.97	13
5	1	0.05	464	1.00	0.95	14
5	1	0.10	402	1.00	0.89	17
5	1	0.15	341	1.00	0.79	20
5	1	0.20	260	0.97	0.62	27
5	1	0.25	183	0.93	0.39	NA
5	2	0.00	1,599	1.00	0.99	4
5	2	0.05	1,544	1.00	0.99	4
5	2	0.10	1,487	1.00	0.99	4
5	2	0.15	1,409	1.00	0.99	4
5	2	0.20	1,355	1.00	0.99	5
5	2	0.25	1,274	1.00	0.99	5
1	1	0.00	-322	0.00	0.00	NA
1	1	0.05	-330	0.00	0.00	NA
1	1	0.10	-336	0.00	0.00	NA
1	1	0.15	-341	0.00	0.00	NA
1	1	0.20	-344	0.00	0.00	NA
1	1	0.25	-347	0.00	0.00	NA
1	2	0.00	-258	0.00	0.00	NA
1	2	0.05	-278	0.00	0.00	NA
1	2	0.10	-296	0.00	0.00	NA
1	2	0.15	-310	0.00	0.00	NA
1	2	0.20	-322	0.00	0.00	NA
1	2	0.25	-331	0.00	0.00	NA

Scenario for Mitigation of Threats and Alternatives to Activities

Increases in Steelhead Trout productivity (i.e., recruits/spawner), or reductions in exploitation can contribute to or reduce rates of future decline in some scenarios. However, eliminating exploitation alone will likely not result in population recovery. The mitigation measures below are considered preliminary and require significant further investigation and discussion to determine their effectiveness and feasibility.

1. Limit fishing mortality on adult Thompson and Chilcotin Steelhead Trout in fisheries where Steelhead Trout bycatch occurs, by limiting mixed species fishing opportunity to times and places when Steelhead Trout is not present, or to highly-monitored fisheries where the release mortality rate of Steelhead Trout is very low.

2. Implement closures of fisheries targeting adult Steelhead Trout in migratory, overwintering, and spawning habitats.
3. Maintain current freshwater range expansion of Steelhead Trout.
4. Maintain or improve freshwater habitats, including addressing water use issues.
5. Reduce potential competition for a limited pool of food resources in offshore marine areas by reducing the enhancement of Pink, Chum, and Sockeye populations originating from other nations. However, this mitigation is likely not feasible given there is no control over enhancement within other countries.
6. Reduce the trend in declining size of spawners, to increase fecundity to increase egg deposition in spawning habitat.

Allowable Harm Assessment

Currently, there are numerous anthropogenic threats and natural limiting factors contributing to the declines in Thompson and Chilcotin River Steelhead Trout. Fishing activities result in both direct mortality and indirect harm to the fish. In addition, the survival of steelhead is directly or indirectly impacted by predation, competition, physical habitat destruction, changing marine and/or freshwater conditions. Focusing on mitigation actions that are directly linked to human activities that impair production should receive priority.

In the absence of productivity improvement, simulations suggest that the most likely way to promote recovery or potentially stop the continued decline in escapement of the Thompson River Steelhead Trout population is to reduce or eliminate losses from fisheries where Steelhead Trout bycatch occurs and recreational or FSC fisheries which target Steelhead Trout. The benefits of reductions in exploitation rate depend on the future productivity scenario. If productivity remains at the most recent estimates (~1 or < 1) the population will decline even in the absence of harvest. Reducing exploitation rate under this scenario will slow the rate of decline, but achieving positive population growth or the recovery target will not be possible. However under other scenarios that assume productivity in the future will be higher than the most recent available estimate, reducing exploitation rate results in substantive improvements in recovery potential.

Given the very low numbers and decreasing trends in escapement for both the Thompson and Chilcotin river Steelhead Trout populations, every returning adult is valued and any harm will inhibit or delay potential for recovery. Allowable harm should not be permitted to exceed current levels and should be reduced to the maximum extent possible. Preventing and mitigating habitat destruction (i.e., through restoration initiatives, and ensure adequate water quantity) and reducing exploitation, are immediate actions that will increase the likelihood that allowable harm will not exceed current levels.

Sources of Uncertainty

- There is considerable uncertainty in exploitation rates which would lead to error in productivity and capacity trends of Thompson and Chilcotin DUs, and error in the extent of the impact of exploitation rates on recovery potential as determined by the simulations. Uncertainty in exploitation rates is caused by a variety of factors including:
    - The lack of reliable catch data for Steelhead Trout in salmon bycatch fisheries which leads to uncertainty in catchability adjustments used to estimate bycatch in each fishery.

  - Lack of data on the diversion rate for Steelhead Trout (Johnstone Strait vs. Juan de Fuca Strait).
  - Data to estimate run-timing parameters are available from the Albion test fishery only. Effort in this fishery is limited resulting in low catch of Steelhead Trout, especially in more recent years when returns have been much smaller and sampling occurs every second day. The low catch leads to uncertainty in run-timing.
  - As there is potential for bycatch of Steelhead Trout prior to reaching the Albion test fishery, the current model potentially underestimates the proportion of the run arriving during periods when these downstream fisheries result in substantive catch. This error would lead to an underestimate of the strength of the early part of the run.
  - The lack of reliable catch and effort data from First Nations terminal fisheries leads to uncertainty in the impact of these fisheries, which may be more important in recent years due to low pre-fishery returns.
- Uncertainty in current and future productivity estimates: The Kalman Filter approach to estimating time-varying Ricker stock-recruitment parameters used in this analysis is vulnerable to errors-in-variable and time series biases which can result in overestimates of productivity. The extent of this bias will depend on the amount of uncertainty in escapement data (errors-in-variables) and the extent to which escapements in one year are dependent on escapements from earlier years (time series bias, which depends on variation in exploitation rates and the extent of process error around the stock-recruitment curve). In the absence of reliable estimates of uncertainty in escapement, we are unable to accurately evaluate the extent of these biases.
- Uncertainty in age structure: Age structure is relatively well determined for the Thompson DU, but there are a limited number of years available to quantify age structure for the Chilcotin DU. This leads to greater uncertainty with respect to the recruitments assigned to each brood year, and hence greater uncertainty in the estimated productivity trend.
- Uncertainty in the assumed minimum population size required to maintain adequate genetic diversity in each DU and limit inbreeding depression (assumed to be 100 in this analysis per sub-area). Errors in this assumption could impact proposed abundance recovery targets.
- There is uncertainty about the causes for decline in productivity for Thompson and Chilcotin DUs. In addition to the degree of impact both threats and limiting factors have on various life stages of Steelhead Trout, including levels of pinniped predation and other sources of predation in freshwater and marine habitats. Furthermore there is uncertainty in quantifying the characteristics and limiting factors associated with Steelhead freshwater habitat. These uncertainties could lead to error in productivity and capacity trends of Thompson and Chilcotin DUs, and error in the extent of the impact of exploitation rates on recovery potential as determined by the simulations.

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SOURCES OF INFORMATION

This Science Advisory Report is from the September 20-21, 2018 regional peer review on Recovery Potential Assessment – Chilcotin River and Thompson River Steelhead Trout (*Oncorhynchus mykiss*) Designatable Units. Additional publications from this Regional Peer Review will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

COSEWIC. 2018. Technical Summaries and Supporting Information for Emergency Assessments Steelhead Trout *Oncorhynchus mykiss* (Thompson River and Chilcotin River populations). 26pp.

DFO. 2014a. Guidance for the Completion of Recovery Potential Assessments (RPA) for Aquatic Species at Risk.

DFO. 2014b. Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/013. (Erratum: June 2016)

DFO. 2015. Directive on the Application of Species at Risk Act Section 33 (Residence) to Aquatic Species at Risk. Species at Risk Program. Ottawa.

Johnston, N.T. 2013. Management reference points for the Thompson and Chilcotin late summer-run steelhead (*Oncorhynchus mykiss*) stock aggregates. Fisheries Project Report RD139, BC Fish and Wildlife Branch.

Pollard, S. 2013. The role of hatcheries in steelhead management for British Columbia—A summary and recommendations. Fish. Manage. Rep. 125. Prov. British Columbia.

APPENDIX – PRELIMINARY THREATS AND LIMITING FACTORS EVALUATION

This appendix identifies general categories of threats and limiting factors that were discussed during the peer review meeting for Chilcotin and Thompson River Steelhead Trout. These threats and limiting factors are intended to help inform a decision on imminent threat.

It should be noted that there were extended discussions on the degree of uncertainty associated with development of scores in the risk categories, to assess the overall threat risk. Due to limited time for more in-depth discussions, consensus on this threat assessment was not reached. The threats and limiting factors tables should therefore be considered preliminary and require significant further investigation and discussion.

Threats and Limiting Factors

Steelhead Trout are vulnerable to threats and limiting factors through all of their life stages, from egg to adult, in a variety of habitat types in both freshwater and marine environments within Canada and in the North Pacific. Threats are defined as any anthropogenic activity or process that has caused, is causing, or may cause harm, death, or behavioural changes to a species, or the destruction, degradation, and/or impairment of its habitat, to the extent that population-level effects occur. Limiting factors are non-anthropogenic factors that, within a range of natural variation, limit the abundance and distribution of a species. Limiting factors may be exacerbated by anthropogenic activities.

There is uncertainty regarding the degree of impact of threats and limiting factors on various life stages of Steelhead Trout because there is generally limited or inconclusive information currently available to adequately characterize them.

This threat assessment follows DFO's (2014) *Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk*, to the extent possible in the context of limited data and information on Steelhead Trout within Canadian waters. General categories of threats and limiting factors were agreed to, however the rationale and scoring for level of impact, causal certainty, and threat risk had greater uncertainty and will require further input and evaluation.

Threats

By-catch from Commercial Fisheries

There are no directed commercial fisheries for Steelhead Trout DUs in BC, but there is mortality from bycatch in inshore, and in-river salmon fisheries. Harvest impacts vary according to geographic region depending on where fisheries intercept adult Steelhead Trout during their marine residence (e.g., Johnston Strait, Area 29 [mouth of Fraser River], Area 21 [SW coast of Vancouver Island], Area 20 [Canadian side of Juan de Fuca Strait]), as well as by fishery type (e.g., gillnet, purse seine and troll bycatch).

Salmon fisheries occur in summer and fall and summer-run Steelhead Trout are susceptible to unintentional interceptions by virtue of the overlapping run timing of the species.

Exploitation rates of Thompson and Chilcotin Steelhead Trout due to bycatch in salmon fisheries and through targeted sport fishing were estimated from 7–26% (average of 18%) over the last 10 years (Bison 2016).

Simulations suggest that reducing bycatch of Steelhead Trout in salmon fisheries would lead to nominal levels of increased escapements for the Chilcotin DU, but that increased escapements to the Thompson DU may only occur reductions in exploitation coincide with increases in productivity.

Recreational Fisheries

In BC the freshwater sport fishery operates on a catch and release basis with respect to wild Steelhead Trout. Catch-and-release fisheries have been be subjected to closure for conservation reasons. In a few cases, such as the Thompson Steelhead Trout sport fishery, closures have been administered in-season to conserve Steelhead Trout populations, in terms of reducing fishing mortality and sub-lethal harm (Cooke et al. 2007), when abundance estimates are below predetermined limits. Gear type and timing of fisheries opening are also regulated to minimize catch-and-release mortality. Steelhead Trout are also intercepted in marine recreational fisheries and other fresh water fisheries that bycatch Steelhead Trout.

Food, Social, Ceremonial (FSC) Fisheries

This includes fishing mortality from First Nations Food, Social and Ceremonial (FSC) fisheries through bycatch in marine areas, the lower Fraser, and targeted Steelhead Trout fisheries as they stage in the Chilcotin, and Thompson main stems and as they enter tributary streams on their final spawning migrations. Effort in these fisheries have diminished and been curtailed due to declines in Steelhead Trout abundance and it is uncertain how much current targeted harvest and/or bycatch continues, thus the impact on steelhead recovery is unknown. Steelhead are also intercepted in the marine area FSC fisheries at unknown frequency, which use commercial gear types.

Science Activities

Adult mortality occurs from science activities in test fisheries (e.g., Albion test fishery and other stock assessment activities). Juvenile Steelhead Trout are also be captured and released during stock assessment activities in rearing streams during Chinook salmon mark-recapture studies and smolt traps on the lower Fraser and marine areas. Reducing exploitation rate and bycatch of Steelhead Trout may lead to slightly increased escapements for Thompson and Chilcotin Steelhead Trout. Fry and parr natural survival rates to the adult stage are generally very low; in the magnitude of 3–7% at 13% marine survival. Increased survival of either fry or parr would likely result in increased adult abundance.

Pollution

Pollution is associated with introduction of deleterious substances such as nutrients, and toxic chemicals, hormones and endocrine disrupters, from point and nonpoint sources from agricultural, mining, forestry, wastewater treatment, aquaculture other industry and urban activities. Pollution includes direct and indirect impacts to Thompson and Chilcotin Steelhead Trout in both marine and freshwater environments.

Environmental contaminants, including persistent organic pollutants (POPs) such as PBDEs and PCBs and biological pollutants, are likely to threaten the health of Steelhead Trout and negatively impact food webs based on studies in other salmonids. High contaminant burdens have been demonstrated in other Pacific salmonids, including Chinook, and are known to affect reproductive and immune function. Activities within the Georgia Basin, such as shipping, farming and industry also contribute pollutants and noise to the marine environment as a result of collisions, spills, boat traffic and direct water discharge.

However, threat risk is unknown as there is little data to guide the assessment of severity of this threat to Thompson and Chilcotin Steelhead Trout DUs.

Physical Habitat Degradation

Regardless of uncertainties related to precision in quantifying the impact level of physical habitat degradation, actions which convert or degrade habitat, increase sedimentation or alter water flow patterns from their natural range of variation have been observed to impact terminal migration and spawning, egg development and hatching, freshwater incubation, and freshwater rearing. Habitat related threats are known to have locally occurred, are currently occurring and anticipated to continue and may have population level impacts on Steelhead Trout once scoped and quantified.

Activities may include water extraction, riparian vegetation clearing and channel modification associated with livestock grazing, agriculture, forestry and urban development. These activities result in increased erosion, siltation, loss of riparian habitat, alter habitat structure or function (e.g., slope, drainage, loss of pool riffle run structure and channel destabilization), reduce water flow or increase water temperature. Increased sedimentation through forestry related activities including road construction and upslope harvesting can cover spawning redds, smother incubating eggs and reduce egg to fry survival (Levasseur et al. 2006). Increased sedimentation can also increase embeddedness of the river substrate and affect water quality parameters.

Changes in freshwater habitat in the Thompson or Chilcotin watersheds could lead to reduced smolt output and reduced spawner to adult recruit productivity. The Thompson watershed has greater physical habitat degradation due to water extraction and hydrograph alteration (lower summer flows, higher water temperatures), agricultural land clearing and cattle grazing (bank erosion, increased sedimentation), and forestry effects (sedimentation). While Chilcotin has had less physical habitat degradation, satellite photos suggest degradation and alterations to the watershed have occurred. However, overall, the severity of the freshwater habitat-based threats in the Thompson and Chilcotin Rivers is not quantified and we did not develop metrics for physical habitat conditions within the time limits to compare with productivity trends for both DUs. Standardized sampling of habitat characteristics in both Thompson and Chilcotin DUs is necessary in order to better understand the severity of freshwater habitat-based threats in these DUs.

Table A1. Threat assessment for Thompson and Chilcotin Steelhead Trout in Pacific Canadian waters.

Threat	DU	Likelihood of Occurrence	Level of Impact	Causal Certainty	Threat Risk	Threat Occurrence	Threat Frequency	Threat Extent
Bycatch in Commercial Fisheries	Thompson	Known	*	*	*	*	*	*
	Chilcotin	Known	*	*	*	*	*	*
Recreational Fisheries (Directed and Bycatch)	Thompson	Known	*	*	*	*	*	*
	Chilcotin	Known	*	*	*	*	*	*
Food, Social, Ceremonial (FSC) Fisheries (Directed and Bycatch)	Thompson	Known	*	*	*	*	*	*
	Chilcotin	Known	*	*	*	*	*	*
Science Activities	Thompson	Known	*	*	*	*	*	*
	Chilcotin	Known	*	*	*	*	*	*
Pollution	Thompson	Known	*	*	*	*	*	*
	Chilcotin	Known	*	*	*	*	*	*
Physical Habitat Degradation	Thompson	Known	*	*	*	*	*	*
	Chilcotin	Known	*	*	*	*	*	*

*Note – the six categories of risk assessment were discussed extensively; however, consensus on the final scorings was not achieved and consequently they are not presented. The threats table requires significant further investigation and discussion to achieve evidence-based scores for each of the threats.

Limiting Factors

Altered Ocean Conditions

Reduced marine survival (or smolt-adult survival) of Steelhead Trout and other salmonids is considered to be a key factor driving population declines since the early 1990s (Kendall et al. 2017). A number of studies have highlighted the broad scale influence of ocean climate variation, over annual and decadal scales, on salmon survival and abundance. Ocean temperatures have warmed an average of 0.5°C over the past two decades and have likely contributed to declining survival of salmon at different marine life stages.

The ocean environment and the prey field encountered by migrating salmon is far from static, but complex, dynamic and in flux over multiple spatial and temporal scales. Change in ocean conditions is being compounded by global climate change. Variations in marine survival of salmon often correspond with periods of alternating cold and warm ocean conditions. Altered ocean conditions affecting Steelhead Trout and salmon include both large-scale ocean and atmospheric events as well as more regional and local processes which ultimately influence and shape the composition and ‘quality’ of food webs salmon encounter. Coastal waters off the Pacific Northwest are influenced by atmospheric conditions not only in the North Pacific Ocean (as indexed by the Pacific Decadal Oscillation - PDO), but also in equatorial waters, especially during El Niño events. More regional effects include water temperature, and the timing and degree and coastal upwelling. These processes can change horizontal transport of water masses resulting in north-south shifts in the plankton and zooplankton community composition and their relative abundance, which in turn have been linked to variation in salmon growth and survival. While this is an oversimplification of complex dynamics, there is an emerging understanding of the integrative oceanographic factors and food web features which favour juvenile salmon growth and survival and the strong role they can play in stock productivity.

Altered freshwater conditions

Reduced instream flows due to climatic variation or trends can degrade freshwater rearing habitats. High water temperatures alter the rates of physiological processes in fish and variation that exceeds natural ranges creates stressful, sometimes lethal, conditions for juveniles. Groundwater is also essential for juveniles rearing in smaller rivers to avoid temperature extremes. Wildfires in combination with land use practices can increase sedimentation and exacerbate degradation of freshwater conditions. Intensity of altered freshwater conditions are localized to sub-areas of the Thompson DU. Altered freshwater conditions are less prevalent within the Chilcotin DU, but it was noted that recent major wildfire effects in the Chilcotin watershed are not well understood at this time.

Oceanic climate shifts can also affect freshwater conditions by altering snowpack, timing of runoff, groundwater accumulation (Cayan and Peterson 1989, 1996).

Predation

Predation contributes to Steelhead Trout mortality across all life stages in both freshwater and marine environments. Predation contributes to the mortality of Steelhead Trout and other salmon along the sea going migration routes of Thompson and Chilcotin Steelhead Trout (Thomas et al. 2017, Nelson et al. 2018). Berejikian et al. (2016) suggests that predation by Harbour Seals (*Phoca vitulina*) contributes to mortality of migrating juvenile Steelhead Trout off Washington State. Data are very limited, but Harbour seals have also been known to consume outmigrating smolts in one river estuary of the Strait of Georgia (Thomas et al. 2017). In other systems, seabirds have been identified as important predators of steelhead (Hostetter et al.

2011 and 2012); however this has not been assessed for the Fraser River system. Interestingly, susceptibility of steelhead smolts to bird predation has also been linked to condition and disease (Hostetter et al 2011 and 2012).

However, there is a large degree of uncertainty in the mortality rate and level of impact of predators such as pinnipeds on Steelhead Trout. There is further uncertainty regarding the impact of pinnipeds vs other predators or factors which may also contribute to Steelhead Trout declines, in addition to the extrapolation of localized pinniped predation to a coast wide impact. Uncertainty also arises because it is not clear whether in fact predation by any predator is compensatory or additive; that is there are no other factors or predators which would contribute to mortality if a particular predator was removed. Moreover, marine survival rates for steelhead suggest large decreases in survival during periods of low pinniped abundance, and for some stocks, periods of increasing marine survival under high pinniped abundance (Kendall et al. 2017).

Although the working paper demonstrated a strong negative correlation between pinniped population growth and steelhead population decline, there was not consensus that there is a causal relationship between the two. Similarly the recommendation for a pinniped cull in the working paper was not supported and requires further investigation. Furthermore, there is insufficient evidence fully understand the potential unintended ecosystem consequences of reducing pinniped predation.

Predation also occurs on Steelhead eggs, alevins and fry during freshwater incubation and rearing. Fish predators likely include but are not limited to Bull Trout (*Salvelinus confluentus*), whitefish, Cutthroat Trout (*Oncorhynchus clarkia*), juvenile Coho (*Oncorhynchus kisutch*) and Chinook (*Oncorhynchus tshawytscha*), Prickly Sculpin (*Cottus asper*) and Northern Pikeminnow (*Ptychocheilus oregonensis*). In the Nicola system, Northern Pikeminnow is likely the top predator on fry and parr. The mortality rates associated with freshwater predation have not been estimated.

Competition and reduced prey in the Ocean

Reduced prey availability resulting from higher levels of competition can increase foraging times and lead to higher mortality. Ruggerone and Irvine (2018) show that competition for prey species on which Steelhead Trout depend has increased due to increases in naturally and hatchery-produced Pink, Chum, and Sockeye salmon. The RPA results also suggest that increased competition may be reducing marine survival rates for Thompson and Chilcotin DUs.

Parasites or pathogens

Salmonids are hosts to a multitude of pathogens including viruses, bacteria, fungi, and parasites, which are a natural component of all ecosystems and not all infections cause disease. Pathogen transmission frequently occurs where host populations are concentrated.

In addition to pathogens and disease, harmful algal blooms sporadically can occur on an annual basis in BC waters, particularly within the Strait of Georgia. Harmful algal blooms have caused mortality in salmon by diminishing respiratory function. Blooms that may also coincide with the timing migration periods and may pose a threat to some salmonids (Cohen Commission 2012).

Table A2. Limiting Factor assessment for Thompson and Chilcotin Steelhead Trout in Pacific Canadian waters based on DFO 2014 guidance.

Limiting Factor	DU	Likelihood of Occurrence	Level of Impact	Causal Certainty	Threat Risk	Threat Occurrence	Threat Frequency	Threat Extent	Comments
Altered ocean conditions	Thompson	Known	Medium-High	Low (4)	Medium – High	Current/ Anticipatory	Continuous	Extensive	Altered ocean conditions affecting Steelhead Trout and salmon include cyclical oceanographic patterns associated with Pacific Decadal Oscillation (PDO) and underlying oceanographic trends or episodes that may be linked to global climate change. There is a high degree of uncertainty with this threat assessment.
	Chilcotin	Known	Medium-High	Low (4)	Medium – High	Current/ Anticipatory	Continuous	Extensive	
Altered freshwater conditions	Thompson	Known	Medium	Medium (3)	Medium	Current/ Anticipatory	Continuous	Extensive	Reduced instream flows, higher temperatures etc due to climatic variation or trends. Wildfires in combination with other processes can increase sedimentation and degradation of freshwater habitats. There is a high degree of uncertainty with this threat assessment.
	Chilcotin	Known	Medium	Medium (3)	Medium	Current/ Anticipatory	Continuous	Extensive	
Predation	Thompson	Known	Medium	Medium (3)	Medium	Historical/ Current/ Anticipatory	Continuous	Extensive	Predation contributes to Steelhead Trout mortality across all life stages in both freshwater and marine environments – but there is uncertainty with the level of impact of various at each life stage. There is a high degree of uncertainty with this threat assessment
	Chilcotin	Known	Medium	Medium (3)	Medium	Historical/ Current/ Anticipatory	Continuous	Extensive	
Competition	Thompson	Known	Low	Medium (3)	Low	Current/ Anticipatory	Continuous	Extensive	Pathogens including viruses, bacteria, fungi, and parasites, which are a natural component of all ecosystems, can negatively impact Steelhead Trout, but impact is unknown. There is a high degree of uncertainty with this threat assessment.
	Chilcotin	Known	Low	Medium (3)	Low	Current/ Anticipatory	Continuous	Extensive	

Limiting Factor	DU	Likelihood of Occurrence	Level of Impact	Causal Certainty	Threat Risk	Threat Occurrence	Threat Frequency	Threat Extent	Comments
Parasites or pathogens	Thompson	Unknown	Unknown	Very Low (5)	Unknown	Current/ Anticipatory	Continuous	Extensive	Pathogens including viruses, bacteria, fungi, and parasites, which are a natural component of all ecosystems, can negatively impact Steelhead Trout, but impact is unknown. There is a high degree of uncertainty with this threat assessment.
	Chilcotin	Unknown	Unknown	Very Low (5)	Unknown	Current/ Anticipatory	Continuous	Extensive	

Appendix References

Berejikian, B.A., Moore, M.E., and Jeffries, S.J. 2016. Predator-prey interactions between harbor seals and migrating steelhead trout smolts revealed by acoustic telemetry. Marine Ecology Progress Series 543: 21-35.

Bison, R. 2016. Fishing Mortality Trends for Thompson River Steelhead from 1991 to 2015. BC Ministry of Natural Resource Operations, Fish & Wildlife Branch, Kamloops, BC. 30 p.

Cayan, D.R. and D.H. Peterson. 1989. The influence of the North Pacific atmospheric circulation and streamflow in the west. In Aspects of Climate Variability in the Western Americas, D.H. Peterson, ed., Geophys. Monogr. 55, Amer. Geophys. Union, Washington DC, 375-397.

Cayan, D.R. and D.H. Peterson. 1996. Interannual climate variability and snowpack in the western United States. J. Clim. 9, 928-948.

Cohen Commission. 2012. The Uncertain Future of Fraser River Sockeye. Volume 1: The Sockeye Fishery. Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River. Final Report prepared by the Honourable Bruce I. Cohen, Commissioner. Public Works and Government Services Canada. 722 pp.

Cooke, S. J., and H. L. Schramm. 2007. "Catch-and-release science and its application to conservation and management of recreational fisheries." Fisheries Management and Ecology14.2:73-79.

DFO. 2014. Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/013. (Erratum: June 2016)

Hostetter N.J., A.F. Evans, D.D. Roby, K. Collis, M. Hawbecker, and B.P. Sandford. 2011. Relationship of External Fish Condition to Pathogen Prevalence and Out-Migration Survival in Juvenile Steelhead. Transactions of the American Fisheries Society 140(5):1158-1171.

Hostetter N.J., A.F. Evans, D.D. Roby, and K. Collis. 2012. Susceptibility of Juvenile Steelhead to Avian Predation: the Influence of Individual Fish Characteristics and River Conditions Transactions of the American Fisheries Society 141(6): 1586-1599

Kendall, N.W., Marston, G.W., and M.M. Klungle. 2017. Declining patterns of Pacific Northwest steelhead trout (*Oncorhynchus mykiss*) adult abundance and smolt survival in the ocean. Can. J. Fish. Aquat. Sci. 74:1275-1290

Levasseur, M., N.E. Bergeron, M.F. Lapointe, and F. Berube. 2006. Effects of silt and very fine sand dynamics in Atlantic salmon (*Salmo salar*) redds on embryo hatching success. Canadian Journal of Fisheries and Aquatic Sciences 63:1450-1459.

Nelson, B.W., Walters, C.J., Trites, A.W., and M.K. McAllister. 2018. Wild chinook salmon productivity is negatively related to seal density, and not related to hatchery releases in the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences, In Press.

Ruggerone, G.T., and J.R. Irvine. 2018. Numbers and biomass of natural- and hatchery-origin pink salmon, chum salmon, and sockeye salmon in the North Pacific ocean, 1925-2015. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 10:152-168.

Thomas, A.C., Nelson, B.W., Lance, M.M., Deagle, B.E., and Trites, A.W. 2017. Harbour seals target juvenile salmon of conservation concern. Canadian Journal of Fisheries and Aquatic Sciences 74(6): 907-921.

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