

TROUT FISHERY PUBLICATION REVIEWS

Fish Entrainment into the Bow River Carseland Irrigation Headwaters Canal

The Publication Review:

Entrainment of fish in irrigation canals has been considered a major source of mortality for some fish populations. However, the magnitude of fish loss from entrainment is usually not evaluated from a broader perspective of its impact on the source fish population. This published abstract and the more detailed research project report commissioned for the Government of Alberta (GoA) address sport fish entrainment on the Bow River Irrigation District headwaters diversion canal at Carseland. The project was completed in 2003 but also used data from previous years when the Bow River fish populations were at their highest in many years. A subsequent decline in the Bow River Rainbow Trout population of 43% was reported over a 10-year period from 2003 to 2013⁽³⁾ has heightened the fishing community's interest in fish entrainment as a possible cause for the Bow River fish population decline.

This review of the University of Calgary research reports could be considered limited but the online reference to the document will allow for further investigation by those individuals who wish to broaden their knowledge base. The discussion within the publication gives direction that should be considered in the interpretation of fish entrainment and consideration of what research is needed to fill in the gaps. **It is not the intention of this review to present an opinion but rather to highlight the pertinent information that relates to the Alberta sport fishery.**

Fish Entrainment into Irrigation Canals: An Analytical Approach and Application to the Bow River, Alberta, Canada

John R. Post, Brett T. van Poorten, Trevor Rhodes, Paul Askey, Andrew Paul

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Abstract

The Carseland Canal on the Bow River, Alberta, diverted water at a rate of 1.4–37.7 m³/s during the 2003 irrigation season. We estimated daily entrainment rates of rainbow trout *Oncorhynchus mykiss*, brown trout *Salmo trutta*, and mountain whitefish *Prosopium williamsoni* throughout the diversion season using population assessments of fish in the Bow River and the irrigation canal coupled to an estimate of the evacuation rate of intentionally entrained fish. Total entrainment during the irrigation season was estimated at 3,996 rainbow trout, 664 brown trout, and 2,352 mountain whitefish. Large fish (>150 mm fork length [FL]) made up 42.0% of the total number of entrained rainbow trout, 17.0% of entrained brown trout, and 0.5% of entrained mountain whitefish, representing 1.1, 0.8, and 0.3% of the total mortality observed in these Bow River populations. Earlier estimates of canal losses based on fall rescues of fish suggest that entrainment varies annually and that the 2003 estimates were low for rainbow trout and brown trout and high for mountain whitefish. We also identified 11 additional species that were either entrained or resident in the system within the canal and associated settling pond.

Magnitude and Temporal Variability of Entrainment at the Carseland-Bow River Headworks Canal

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University of Calgary., October 2004

Background:

The study commissioned by Alberta Environment and Parks in 2003 was designed to quantitatively determine total annual entrainment for rainbow trout, brown trout, and mountain whitefish (target species) in the Bow River Irrigation District Headwaters Canal at Carseland. Estimated entrainment was then put into context of the density of target species in the Bow River so that an estimate of the proportional loss of these fish to the canal could be determined. In addition, the entrainment of non-target fish species was assessed throughout the irrigation season. The overall study had three field components. The first was in the Bow River, which involved marking fish and assessing the abundance and size structure of river populations. The second component was in the Carseland Canal and involved catching target and non-target species throughout the upper 10-km reach of the canal. The final component involved the Trout Unlimited Canada Fish Rescue, which took place in the Carseland Canal at the end of the irrigation season.

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Data Collection & Analysis:

River Fish Population: Bow River fish population estimates for the three target species of rainbow trout, brown trout, and mountain whitefish were assessed using boat-mounted electro-fishing techniques over three time periods in 2003 (May, July, and September) at eight separate 2 km long locations along the river.

Canal Entrainment: The study areas comprised the upper 10 km section of the canal and an estimation of the evacuation rate of fish through this section of the canal using the gill nets capture technique. An estimated catchability was calculated on the probability of capturing white suckers, rather than the target species because there were insufficient numbers of target species in the canal. Catch-per-unit effort (CPUE) of the three target species was calculated based on the number of fish from each species caught with gill nets at night over 10-day intervals throughout the irrigation season from mid-April to mid-October. Total entrainment throughout the irrigation season was calculated from point estimates of fish abundance and the evacuation rate of fish through the canal.

Fish Rescue: The canal headwork was closed on October 10. At that time, a temporary earthen dam was put in place at the 11-km mark in the canal. The fish rescue was conducted by Trout Unlimited Canada. Once fish were caught, sorted into species and measured before being returned to the Bow River. Target species were also examined for tags or fin clips. Fish Rescue Efficiency was estimated as the proportion of the fish present in the upper 10 km of the canal that were captured by the fish rescue team.

Impact of Canal-Induced Mortality on Bow River Target Species: Using a population model based on previously existing data on the Bow River populations, an estimate of the proportion of the total annual mortality was attributed to entrainment in the Carseland Canal.

RESULTS

Seasonal timing of entrainment: Most fish of all three target species are primarily entrained in the later part of the diversion period. Rainbow trout are the earliest of the three target species to have large numbers become entrained. 79% of all rainbow trout entrainment in the Carseland Canal can be prevented by blocking fish entry into the canal after July 2. Over 80% of all brown trout and mountain whitefish entrainment can be prevented if access to the canal by fish can be blocked after August 11 and August 21, respectively.

Annual entrainment of target species: Target fish ≥ 150 mm was consistently below half of all entrained target species in the canal (Table 1). Total annual entrainment of Rainbow Trout was estimated to be 1,683 for fish greater than 150 mm. Brown trout had an annual entrainment for larger fish of 116. The annual entrainment for mountain whitefish ≥ 150 mm was 430. Therefore, entrainment for larger fish accounted for only 42.1%, 17.4%, and 0.5% of all rainbow trout, brown trout, and mountain whitefish, respectively (Table 1).

Table 1: Estimated Entrainment of Rainbow Trout, Brown Trout, and Mountain Whitefish for all fish of each and for large species (>150 mm) and small (<150 mm) fish of each species

Species	Estimated Entrainment		
	Total	Large Fish (≥ 150 mm)	Small Fish (< 150 mm)
Rainbow Trout	3,996	1,683 (42.1%)	2,313 (57.9%)
Brown Trout	664	116 (17.4%)	549 (82.6%)
Mountain Whitefish	93,850	430 (0.5%)	93,420 (99.5%)

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The Reports Discussion:

- The Carseland Canal entrains large numbers of fish every year. The three target species alone constituted an estimated loss of 98,510 fish of all sizes from the Bow River in 2003. Entrainment of all other species in the Carseland Canal may be between 139,977 and 1,444,928 fish. While this is a large number of fish, the impact of loss to the canal on the total population abundance of the three target species is relatively low. **Our results for fish greater than 150 mm indicate that mortality due to entrainment in the canal accounts for only 0.6%, 0.5%, and 0.3% of all sources of annual mortality for rainbow trout, brown trout, and mountain whitefish, respectively. These results are similar to findings on other irrigation canals.**
- The annual Trout Unlimited Canada fish rescue on the Carseland Canal provides a useful source of information for examining the relative change in species composition and size structure of entrained fish between years. However, **our results indicate that although fish rescue is extremely efficient at capturing fish, the number of fish rescued each year is a small proportion of the total estimated entrainment. In 2003, the fish rescue volunteers recovered 9,455 of all sizes of the three target species out of 98,510 estimated to have been entrained throughout the diversion period. This represents only 9.6% of the estimated entrained target fish.**
- **The public perception of the problem is that a large proportion of the Bow River sport fish population is being lost to entrainment into canals such as the Carseland Canal. However, our findings indicate that for fish larger than 150 mm, the proportional loss of populations in the Bow River is low.** We estimate that in 2003, the total entrainment of all sizes of the three target species to be over 95,000 fish. This may have a substantial effect on the total productivity of the Bow River sport fishery, both through loss of catchable-sized fish and potential loss in recruitment. However, given that the Carseland Canal has been operational for many decades and the persistence of target populations, the entrainment of fish into the canal has not led to population collapse despite the number of fish being entrained each year.
- **The current study demonstrates that more than 80% of the total entrainment of the target species occurs in the second half of the diversion period. The use of a fish exclusion device for only the second half of the irrigation season could substantially reduce the entrainment of the target species.** It should be noted, however, that target species are not the only species lost into the canal, and there may be substantial entrainment of other species in the first half of the diversion period. Notable examples based on net catches are white and longnose suckers.

Reference:

1. John R. Post, Brett T. van Poorten, Trevor Rhodes, Paul Askey & Andrew Paul (2006) Fish Entrainment into Irrigation Canals: An Analytical Approach and Application to the Bow River, Alberta, Canada, *North American Journal of Fisheries Management*, 26:4, 875-887, DOI: [10.1577/M05-047.1](https://doi.org/10.1577/M05-047.1)
2. Van Poorten, Brett & Post, John. (2004). Magnitude and temporal variability of entrainment at the Carseland-Bow River headworks canal. https://www.researchgate.net/publication/310828092_Magnitude_and_temporal_variability_of_entrapment_at_the_Carseland-Bow_River_headworks_canal
3. Christopher L. Cahill, Stephanie Mogensen, Kyle L. Wilson, Ariane Cantin, R. Nilo Sinnatamby, Andrew J. Paul, Paul Christensen, Jessica R. Reilly, Linda Winkel, Anne Farineau, and John R. Post (2018). Multiple challenges confront a high-effort inland recreational fishery in decline. *Canadian Journal of Fisheries and Aquatic Sciences*. <https://doi.org/10.1139/cjfas-2018-0086>