Determining the egg-to-fry survival of Gerrard rainbow trout at their primary spawning grounds

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Executive Summary
A preliminary field study conducted in spring 2007 to measure egg-to-fry survival of Gerrard rainbow trout at their primary spawning grounds documented a decrease in survival with distance downstream from Gerrard bridge. Furthermore none of the eggs planted in the lower gravels – an area frequently used by Gerrard's for spawning – survived. The egg containers from this area had a distinctive reddish brown stain suggesting that low dissolved oxygen groundwater may be responsible for the total mortality. However, interpretation of the results is confounded by a number of factors. Further work is required to determine the spatial pattern of egg-to-fry survival at Gerrard and identify the factors responsible for any differences in mortality.
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Background

Gerrard rainbow trout are a morphologically (Keeley et al. 2005) and genetically distinct (Keeley et al. 2007) population of rainbow trout (*Oncorhynchus mykiss*) from Kootenay Lake that due to a primarily piscivorous diet can reach a weight of 30 lbs (Irvine 1978). Gerrards are popular among anglers – the population in Kootenay Lake supports an economically important sport-fishery (Andrusak 2005) – and for almost a century now eggs have been stripped from spawning females and incubated in hatcheries for stocking in other waters (Irvine 1978).

Their name is derived from the old town site of Gerrard which is located beside a 500 m section of the Lardeau River where the majority of Gerrard's spawn (Hartman and Galbraith 1970). Despite the site's importance for the sustainability of the population, and despite many years of Gerrard egg incubation in hatcheries, the egg-to-fry survival of Gerrard rainbow trout at their primary spawning grounds has never been determined.

A preliminary field study conducted in spring 2007 and funded by the Freshwater Fisheries Society of BC (FFSBC) demonstrated the feasibility of assessing egg-to-fry survival at Gerrard by planting out eggs from the Kootenay Trout Hatchery (KTH) in small perforated containers. The survival varied from 0 to 80% and was consistent with an increase in mortality when moving in a downstream direction. Furthermore, the plastic caps on the eggs containers recovered from the reach with no egg survival exhibited a distinctive reddish-brown staining suggesting that low dissolved oxygen groundwater may be responsible for the high level of mortality.

Knowledge about the levels and spatial distribution of egg-to-fry survival at Gerrard are important for 1) ensuring the long-term survival of this unique population, 2) calculating required escapement, 3) modelling population dynamics, 4) determining whether fry habitat is a limiting factor, 5) monitoring long-term changes in the gravels, and 6) informing the introduction of additional gravels.
Figure 1. Hartman and Galbraith’s (1970) scheme for dividing the Gerrard spawning gravels into discrete areas. Reproduced from Hartman and Galbraith (1970).
Preliminary study

Methods
On March 29th 2007, water-hardened green eggs from three female Gerrard's were driven from the KTH and planted out at Gerrard in perforated stainless steel containers (Baxter and McPhail 1999; Dumas and Marty 2006). Each container contained 30 eggs from just one of the three females. The containers themselves were buried in the gravels at a depth of approximately 30 cm in clusters of three containers – with each female represented by one container. Five clusters were planted out in each of spawning areas S-E and S-D (Figure 1) to give a total of 900 eggs in 30 containers in 10 clusters in two spawning areas. The water depth, mean column water velocity and water velocity 20 cm above bottom were measured for each of the clusters prior to excavation (Keeley and Slaney 1996; Thorley and Bowers 2006). The distance of each cluster from Gerrard bridge and the south bank was also recorded.

Due to concerns that the survival of the eggs had been compromised by the low water temperatures at planting out the experiment was terminated prematurely. The majority of the containers were recovered in May 2007 when the surviving eggs were at the eyed stage.

Results
Egg survival was analysed using a generalized (binomial) additive mixed model (GAMM) with container as a random effect and a smoother on site (Pinheiro and Bates 2002). There were no significant differences in survival between females. The proportion of eggs surviving in each container by cluster are plotted in Figure 2.
Estimating the egg-to-fry survival of Gerrard rainbow trout

Figure 2. Survival to eyed egg stage by cluster. Clusters are ordered by increasing distance downstream from Gerrard bridge. Clusters 1-5 are located in spawning gravels S-E and clusters 1-6 in S-D. The solid line represents the predicted values for the GAMM.

Eggs containers recovered from the most downstream spawning gravels exhibited a distinctive reddish brown staining (Figure 3).

Figure 3. The plastic end caps of three containers demonstrating no stain, partial staining and complete staining (from left to right).
Discussion

The results are consistent with a decrease in egg survival with distance downstream, however, their interpretation is confounded by the order of artificial redd construction and planting out. Redds were constructed and eggs planted out by moving sequentially downstream. Although every effort was made to standardise redd construction and planting out it is possible that either procedure was systematically biased by time. Steelhead eggs are increasingly sensitive to shock after water-hardening, reaching an LD10 of 6 cm after 7 hours of incubation at 10°C (Jensen and Alderdice 1989). Furthermore, a logger at Gerrard recorded the water temperature to be around 2°C in the main channel. Rainbow trout eggs incubated at 2°C have significantly lower survival rates than those incubated at 4 or 7°C (Stonecypher et al. 1994).

Alternatively, the results may indicate the actual pattern of egg survival at Gerrard. If representative, the results should be cause for concern as they indicate that eggs laid in one of the main spawning areas used by Gerrard rainbow trout (Hartman and Galbraith 1970, Thorley 2006) have zero survival. Furthermore the reddish brown staining on the egg containers (Wallace 2007) suggests that low dissolved oxygen groundwater could be responsible (Baxter and McPhail 1999, Malcolm et al. 2003, Youngson et al. 2004). Further work is required.

Proposed study

Outline

In order to determine the levels and spatial distribution of egg survival a follow-up study should:

1) Plant out water-hardened green eggs in mid-April when water temperatures have risen to 4°C but before spawning has fully commenced or water levels have risen too high.
2) Separate the eggs from each female to model inter-female variation.
3) Use temperature loggers to record the temperatures experienced by eggs from fertilization, through transportation and development in the gravels, to emergence.
4) Incubate a sample of eggs in the hatchery to control for the effect of transportation.
5) Incubate a sample of eggs instream but above the substrate to control for the effect of burial in the gravels.
6) Randomise the order of artificial redd construction and planting out to prevent confounding with any spatial variation in survival.
7) Increase the number of clusters to at least 20 to allow greater resolution of spatial differences.
8) Within a cluster, plant out containers at a depth of 20 and 30 cm to assess the importance of depth.
9) Use at least two different types of container to allow modelling of container-effects.

Budget
The costs of the proposed project are expected to be just under $10,000. A detailed budget is currently being prepared. The project could be funded by multiple sponsors.

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Literature


