



How Groundwater Can Affect the Survival Rate of Salmon Eggs



Salmon eggs recovered from a natural redd near hatch time. When they die eggs become opaque.

Why do salmon eggs die in redds?

Salmon spawn in rivers, releasing their eggs into a depression made in the gravel of the river bed to form a redd. It is known that many eggs die in redds, and this is usually attributed to an inadequate supply of oxygen, caused by infiltration of fine sediment into the streambed which reduces the flow of water to the eggs.

However, another factor may be involved since research shows that many eggs survive in the Newmills Burn, a degraded stream where spawning areas show a high content of fine sediment (<2mm; 23%), and that many die in the Gironck Burn, a near-pristine environment where the fine sediment fraction is low (12%).

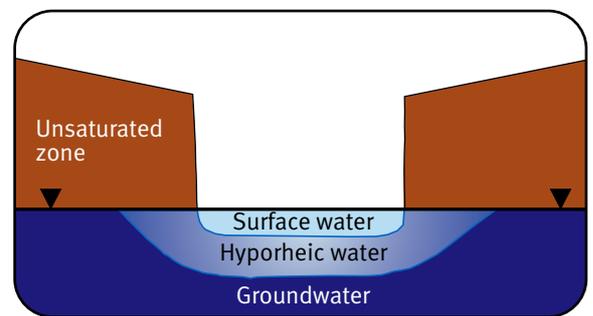
Groundwater in streams and rivers

Some rainwater finds its way to streams via surface routes. Other rainwater gets there via complex sub-surface pathways. This is groundwater. It contributes to stream flow all the time and drives flow when rainfall has been low. The chemical quality of groundwater is altered during passage through soils and rocks. Short-residence

groundwater passes to streams quickly and changes only in minor ways. However, some groundwater takes months or even years to reach streams.

Long- residence groundwater

Long-residence groundwater differs markedly from surface water. In particular, oxygen is removed by soil bacteria. The iron-stained springs and seeps often seen near stream banks occur where long-residence groundwater of low oxygen content becomes exposed to air.



Groundwater and surface water mix in the hyporheic zone.

The hyporheic zone

Upwelling groundwater mixes with surface water below the streambed in an area known as the hyporheic zone. Salmon lay their eggs in hyporheic gravels, at depths of 100 - 300 mm. The eggs are therefore at risk of exposure to groundwater. Exposure is potentially prolonged, since young salmon emerge from the hyporheic zone in late spring, several months after spawning has taken place.

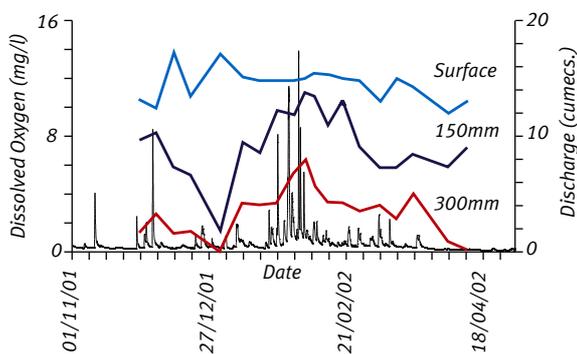
Tracking oxygen levels in redds

As part of an FRS collaborative research project, groundwater and oxygen levels were tracked over the winter and spring in simulated redds in locations used by spawning salmon. Eggs were placed in the redds to monitor mortality and development. Several redds were monitored in a near-natural stream, the Gironck Burn, and in the Newmills Burn, a degraded agricultural stream.



These studies showed that:

- oxygen levels were lower in hyporheic water than in stream water;
- levels were lower at greater depth in the hyporheic zone;
- levels varied widely over the period of egg incubation.



Oxygen levels vary with time and depth beneath the stream bed.

In the redd shown above, oxygen levels at 300mm depth approached zero during episodes of groundwater dominance associated with low stream flow. Hyporheic conditions were not noticeably worse in the degraded Newmills Burn than in the near-natural conditions of the Girnock Burn.

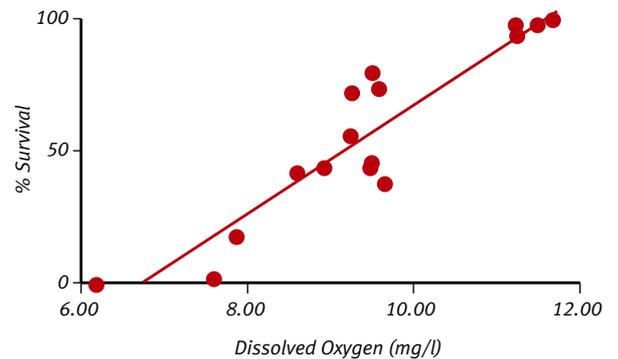
Oxygen levels in redds responded to the changing balance of groundwater and surface water in the hyporheic zone. Groundwater was dominant in the aftermath of floods or when surface water flow was reduced by severe frosts. During high flows, the contribution of surface water increased. However, even in redds that were only a metre apart, oxygen levels differed markedly in their response to all these types of change, emphasising the complexity of the mixing processes that occur in the hyporheic zone.

For further information see:

I.A. Malcolm, A.F. Youngson, C. Soulsby. 2003. Survival of salmonid eggs in gravel bed streams: effects of groundwater – surface water interactions. *River Research and Applications* **19**.

Egg mortality caused by low-oxygen groundwater

Low-oxygen groundwater kills salmon eggs. By hatching time, all the eggs in the most vulnerable redds had died. In redds where some eggs did survive, survival rate was dependent on the quality of the hyporheic environment. Survival rate was proportional to the average levels of oxygen that eggs experienced during their development. As a general guide, no eggs survived in redds where average oxygen levels were less than 7 mg.l^{-1}



Egg survival rate is proportional to average oxygen concentration.

Summary

- the hyporheic zone is an unseen but important component of stream habitat that is used by salmon for spawning.
- intrusion of long-residence groundwater into the hyporheic zone can kill salmon eggs.
- even in the best spawning streams, the hyporheic environment is a potential constraint on the survival of eggs.