

**INTERGENERATIONAL EFFECTS: FRESHWATER MIGRATION
EXPERIENCE OF ADULT SOCKEYE SALMON (*ONCORHYNCHUS
NERKA*) AND OFFSPRING FITNESS.**

Patterson, D.A.
Fisheries and Oceans Canada
Cooperative Resource Management Institute
School of Resource and Environmental Management
Simon Fraser University
Burnaby B.C.
V5A 1S6
Pattersond@dfo-mpo.gc.ca

J.S. Macdonald¹, E.A. MacIsaac¹ and A.P. Farrell²

¹ Fisheries and Oceans Canada
Cooperative Resource Management Institute
School of Resource and Environmental Management
Simon Fraser University

² Department of Biological Sciences
Simon Fraser University

EXTENDED ABSTRACT ONLY – DO NOT CITE

Introduction

Semelparous sockeye salmon (*Oncorhynchus nerka*) have a single opportunity to allocate a finite supply of energy into the contrasting demands of a long stressful migration and reproduction. Our research explores the evidence, mechanisms, and implications of adult migration experience affecting offspring fitness at the individual and population level. Individual sockeye salmon from four Fraser River populations (Early Stuart Horsefly, Gates and Weaver) with different spawning migration distances were examined for physiological condition and gamete quality looking for evidence of intergenerational effects, such as interannual variation in gonad investment, and individual and population

level variation in gamete viability. To elucidate some of the mechanisms responsible we correlated reproductive investment and success to migration conditions as well as directly manipulating the migration environment to recreate an intergenerational effect. The implications of these effects in regards to changes in the relative offspring survival and phenotype were explored.

Evidence

At the population level there is evidence of large interannual differences in gonadal investment as evidenced by interannual variation in both fecundity and egg sizes at the spawning grounds. There is a weak association between low gonadal investment and extreme migration difficulties in long distance migrating populations. For example, the years 1999 and 1997 had extremely high discharge levels, based on 90 years of historic data (Macdonald, 2000), during the period which Early Stuart sockeye migrated through the Fraser River and they had two of the lowest gonad masses recorded.

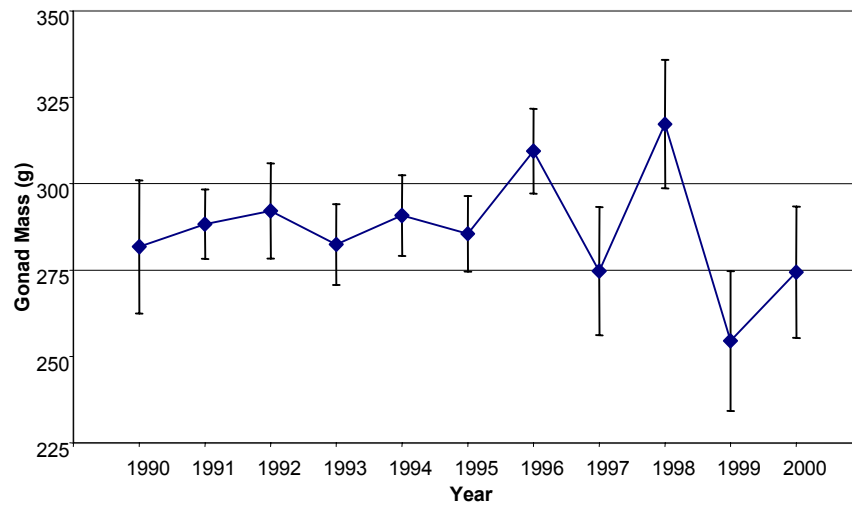


Figure 1: Interannual variation in gonad mass of Early Stuart sockeye salmon. Values represent the mean gonad mass of 50-150 females sampled at the spawning grounds, error bars +/- 95% C.I. and all values are standardized to an overall mean length.

There were significant differences in survival to eyed stage between broodlines generated from a total of 96 females and 39 males. To generate these full-sib and half-sib broodlines each female was crossed with a minimum of 3 males and each male was crossed with minimum of 5 females. There was no evidence of interaction between specific male and female combinations but there was more variability in offspring survival based on maternal rather than paternal gamete origin.

Mechanisms

The 3 longer distance migrating populations had lower survival and greater variation in offspring survival than the shortest distance migrating population (Weaver). This was more dramatic in years of harsh migration conditions. This is consistent with the hypothesis that migration experience adversely effects gamete quality. However, more long term monitoring is required to separate population effects from interannual variability in migration conditions.

Early Stuart sockeye salmon were intercepted near the beginning of their freshwater migration and forced to swim under no flow or a moderate flow environment. The manipulation of the flow environment resulted in differential reproductive success between the two groups. Contrary to our expectations exercised females achieved greater reproductive success than non-exercised females. We also explored the mechanisms behind the differential survival by correlating parental condition to gamete viability. The physiological condition of the adult female was not related to viability of eggs produced. In fact unspawned moribund or fresh dead unspawned females also produced viable offspring. A simple mechanistic link between parental condition and gamete viability remains elusive.

Implications

Previous research has already shown that adverse migration conditions are associated with high en route losses (Macdonald, 2000) and high pre-spawn mortalities on the spawning grounds (Gilhousen, 1990). We found that in years with high pre-spawn mortality the deposited egg to fry survival rates were low. The connection between harsh migration conditions, using high pre-spawning mortality as a surrogate for difficult migration experience, and egg to fry survival has consequences to future recruitment estimates that has hitherto been ignored.

When external conditions select against different adult phenotypes, such as egg size or quality, then the fitness of the individual surviving offspring may be compromised. We found that egg size was not correlated to egg embryonic survival *per se*, but was directly related to fry size at emergence. This will likely confer post emergent survival advantages. There is also an interaction between gamete quality and incubation environment. Eggs from different mothers that were fertilized and incubated under both optimal and sub-optimal (high) temperature had similar survival rates under optimal conditions but at high temperatures survival rates varied with maternal origin.

Conclusions

Parental origin has a significant influence on survival of wild sockeye salmon embryos. Migration conditions experienced by parents influences gonad investment, leads to differential reproductive success, and will shape the individual offspring phenotype. We are beginning to understand that adverse environmental conditions experienced by migrating adult sockeye salmon have implications beyond the simple reduction in the numbers of eggs successfully deposited (the current method for forecasting future returns).

References

- Gilhausen, P. 1990. Prespawning mortalities of sockeye salmon in the Fraser River system and possible casual factors. Int. Pac. Salmon. Fish. Comm. Bull. No. 26. 58 p.
- Macdonald, J.S. 2000. Mortality during the migration of Fraser River sockeye salmon (*Oncorhynchus nerka*): a study of the effect of ocean and river environmental conditions in 1997. Can. Tech. Rep. Fish. Aquat. Sci. 2315: 120 p.