

High T (mid-to-late gestation) females with successful pregnancies in our study had significantly higher T3 and lower GC concentrations, as well as a substantially higher T3/GC ratio over time, compared to High T unsuccessful pregnancies (Figs 3 and 4). This indicates that successfully pregnant females arrived in the Salish Sea in significantly better nutritional condition, and remained so compared to UPg females that experienced pregnancy loss some time after mid-pregnancy. West et al [25] similarly found significantly higher total T3 concentrations among adult females in successful compared to unsuccessful pregnancies at all stages of gestation among captive dolphins.

Only 4 detected pregnancies between 2011–2013 resulted in live births when Fraser River Chinook and early spring Columbia River Chinook runs were both exceedingly low. Just one of those births occurred in 2013, when both FRC and CRC abundances were at their lowest, and that animal died almost immediately post-partum. By contrast, there were up to 9 early gestation (Low T) and 5 mid to late gestation (High T) unsuccessful pregnancies detected during that same 3 year period, with almost half of these early-term and one of the mid to late term unsuccessful pregnancies occurring in 2013. That trend reversed in 2014, with relatively high CRC returns and early onset of FRC returns in 2014 and 2015 (S1 Fig, Appendix) that was followed by 8 new births between December of 2014 and October 2015; however, up to 6 unsuccessful pregnancies still occurred that year, five of which occurred early in gestation (Low T Upg).

High T UPg samples were either from late spontaneous abortions (also known as intrauterine fetal demise), or undocumented perinatal or neonatal deaths where the infant disappeared prior to first observation. The lack of observed perinatal or neonatal deaths when most successful births during our study were observed within 2 weeks of parturition (Table 1), led us to estimate that a substantial portion of the High T UPg samples represented late spontaneous abortions. Although the negative effect of these later reproductive losses on SRKW population growth is roughly the same, infection from a failed or incomplete abortion likely poses a greater risk of removing a reproductive female from the breeding population. At least one SRKW stranding was confirmed to be a pregnant female with infection from a retained fetus listed as the cause of maternal death (J32, December 2014).

Reproductive loss among women during the well-documented 1945 Dutch Famine may exemplify the kinds of impacts expected in response to severe nutritional stress among SRKWs, since: both humans and SRKWs have relatively long interbirth intervals (gestation length and extended lactation amenorrhea), starvation was acute and the Dutch Famine outcomes were not biased by interventions from modern health care [44,47,48]. The Nazis closed off the borders of Holland between October 1944 and May 1945, causing massive starvation over a 5–8 month period, with good food conditions before and after. There was a one-third decline in the expected number of births among confirmed pregnant woman during the under-nutrition period. Conceptions during the hunger period were very low. However, women who conceived during the hunger period had higher rates of abortion, premature and stillbirths, neonatal mortality and malformation. Nutrition had its greatest impact on birth weight and length for mothers experiencing hunger during their second half of gestation, when the fetus is growing most rapidly [47].

Many of the unsuccessful pregnancies in our study were based on single genotyped samples, and it is possible that pregnancy failure rates could be somewhat overestimated. For example, we cannot rule out that some portion of the singleton Low T samples were actually from post-ovulatory luteal phase females that did not produce a detectable conception. Some low T samples could also be from pseudo-pregnancies, although those are rare, have only been reported in captivity [49], and could be an artifact of captive husbandry where males and females are housed separately. It is unlikely that any post-ovulatory luteal phase samples were misclassified