Estimation of Transformer Out-migration Mortality with Acoustic Micro-transmitters

C. Michael Wagner[2], Taylor F. Haas[2], Travis R. Brenden[2], Christopher M. Holbrook[3], Scott Miehls[3], Daniel Deng[4]

[2] Department of Integrative Biology, Michigan State University, 203 Natural Sciences Building, East Lansing, Michigan 48824

[3] USGS Hammond Bay Biological Station, 11188 Ray Rd., Millersburg, MI, 49759

[4] USDOE, Pacific Northwest National Laboratory, 902 Battelle Blvd, Richland, WA 99354

August 2021

ABSTRACT:

There currently are no empirical estimates of survival for newly transformed sea lampreys exiting natal tributaries in the Great Lakes basin, and scant descriptions of out-migration behavior. There is, however, substantial interest in ascertaining whether variation in out-migration survival can be associated with characteristics of river systems that regulate rates of mortality (e.g., distance traveled, predator abundance), and thereby the recruitment of parasites to the lakes. The principle impediment to investigating mortality during the transformer stage is methodological – the absence of a telemetry transmitter small enough to function in transformers without substantially impairing survival and swim performance. We tested the performance of a new micro-transmitter, the Eel-Lamprey Acoustic Transmitter (ELAT) designed for use with JSATS acoustic receivers, in newly transformed sea lamprey. In a laboratory study, we examined the effect of surgical implantation of an ELAT transmitter on survival, wound healing, and two measures of swim performance. Survival analysis (Cox-Proportional Hazard) suggests tag implantation rendered transformers 7.4 times more likely to die (vs. untagged animals) during the first 32 days post-implantation, with the majority of that mortality experienced in the first four days post-surgery. However, overall survival for 61 days was high (71% tagged, 85% untagged), and after 32 days survival was comparable between the two groups. The condition of the surgical wound rapidly improved between the first (Day 4) and second (Day 20) assessments. In burst-swim tests, tagged animals exhibited a 22% reduction in maximum burst swim velocity (vs control, ANOVA, P=0.003), whereas time to exhaustion when swimming against a 4 cm/sec flow was not different between tagged and untagged fish (ANOVA, P=0.32).

Swim performance measures were unrelated to body size; however, in the burst swim test, maximum burst swim speeds were significantly related to the wound healing score (linear regression, $P=0.007$). Overall, outcomes and performance in animals implanted with the ELAT transmitter were comparable to previous studies with similar sized PIT tags. We conclude the ELAT transmitter meets the current standards for use in field studies of transformer movement and fate. In a subsequent field study, we examined the timing and extent of downstream movements in 56 transformers implanted with active ELAT transmitters in the White River, Michigan. The field study area encompassed single-thread river channel, river-wetland complexes, and a drowned river mouth lake. During tag-drag tests, detection ranges for the transmitters averaged 32 m, ranging to 78 m. Performance in animals was slightly improved to an average detection range of 48 m. Ninety-six percent of transformers were detected on at least one receiver. Transformers exhibited nocturnal movement, commencing downstream transits near nautical twilight, or ~60 min after darkness (Rayleigh Test, $P=0.01$), and tending to move on nights with higher discharge (mixed effect logistic regression, $P=0.009$). Ground speed was significantly reduced in river/wetland complexes and the drowned river mouth lake vs. the single-thread channel, commensurate with changes in average water velocity, suggesting the animal drifts (vs. active swimming). Survival probabilities between receivers, and across habitat types, were modeled with a Cormack-Jolly-Seber (CJS) mark-recapture analysis using a Bayesian framework. The results were consistent with a substantial reduction in both survival probability and detection performance in the wide and structurally complex areas of the stream (river-wetland complexes), and the drowned river mouth (vs the single-thread river). However, given the short duration of the transmitter’s battery (~30 days), we have less confidence in the survival estimates for the lower reach of the study area, when transmitter’s may have ceased transmission prior to passing the lower receivers. Subsequent simulation studies using the CJS model were performed to estimate the necessary sample size to achieve high confidence in mortality estimates, and to compare a single release site vs. staggered releases moving downstream, to compensate for the battery life. Results indicate a sample size of 250 individuals substantially improves confidence in the morality estimates, with limited benefit for larger samples. Further, the simulations support the use of a staggered release study design to maximize detections. Finally, additional simulations that varied parameter estimates determined the empirical mortality estimates fell within the 95% High Posterior Density Intervals, despite the low sample size. However, new studies with a larger sample size are necessary to generate habitat-specific estimates of mortality for use in population models.