Refresher on the questions we must address:

2. Expand on STRYKE method analysis and how it differs from other fish strike methods.

STRYKE is an open-source software application developed by Kleinschmidt to perform entrainment risk assessments. STRYKE is an individual based model (IBM), which follows the fate of a population of fish as they migrate past a hydroelectric project. Movement and survival are simulated with Monte Carlo methods. The software is written in Python 3.7.x and utilizes Networkx[[1]](#footnote-1) to simulate routes of passage and Numpy[[2]](#footnote-2) and Scipy for pseudo-random probability distribution draws. Kleinschmidt has validated STRYKE with the USFWS Turbine Blade Strike Model or TBSM[[3]](#footnote-3). STRYKE is scalable, such that it is possible to model complex movement through multiple facilities.

Fish move through a hydroelectric project where passage routes can be described with a network. For this assessment, we assume simulated fishes will move downstream as they approach the projects. If fish survive their current node, they can move to the next one. If there is more than one node available at their current location, then Monte-Carlo role of the dice and *a priori* determined transition probabilities control their movement. The simulation ends for a fish when it arrives at the last node in the network or dies.

For fish passing via entrainment, individuals are exposed to turbine blade strike, which is modeled with the Franke et al. (1997) equations. For fish that pass via passage structures or spill, mortality is assessed with a roll of the dice using survival metrics determined *a priori*, sourced from similar studies, or from expert opinion. The Franke et al. (1997) equations calculate the probability a fish of a given length will get struck by a turbine runner blade. With these equations, if we know how long a given fish is, the amount of discharge through the turbine, the type of turbine, how many blades, and how fast it is rotating, then we can calculate with certainty the probability of being struck. Therefore, the only morphometric parameter needed to assess blade strike is length. All other input parameters are sourced from technical drawings of the facility.

STRYKE also has built in convenience functions that conduct hydrologic analyses to determine flow scenarios, sample from the EPRI (1997) entrainment database to determine entrainment rates, and summary functions that aggregate thousands of simulations and calculate a suite of summary statistics.

3. Expand on the use of Monte Carlo simulations for creating more robust confidence intervals for the turbine survival estimates.

With Monte Carlo methods we can follow the fate of thousands of individual fish. We will describe fish lengths with an empirical distribution (most likely lognormal) describing fish within the river system being studied. All fish are oriented as downstream migrants and all fish start within the forebay. Once in the forebay, it is possible to model movement through bypass, spill, or unit entrainment routes with passage rates determined *a priori*. If a fish is entrained, we then calculate the probability it will be struck by a turbine runner. If the Monte Carlo seed value drawn from a uniform probability distribution is greater than the probability of being struck, the modeled fish survives entrainment. The survival rates calculated from a single simulation are rarely reported as they are not robust. Rather, results of thousands of simulations at a range of flows, operating conditions, and fish lengths, are often aggregated and described with a probability distribution. For that, we use the beta distribution, which is limited to the unit interval [0, 1), to describe whole project survival rates.

5. Expand on use of logistic regression and extrapolation that will be used to create turbine survival rates of Alden turbine.

A logistic regression allows us to express the change in the log odds (probability) of an event occurring as a function of the change in a suite of predictor variables. For this assessment our dependent variable is the probability of surviving entrainment through the Alden turbine, while predictor variables include fish length and turbine parameters. If the data is applicable, and if a regression equation is found to be significant, it is possible to express survival probability as a function of fish length and unit size.

1. <https://networkx.github.io/> [↑](#footnote-ref-1)
2. <https://numpy.org/> [↑](#footnote-ref-2)
3. <https://www.fws.gov/northeast/fisheries/fishpassageengineering.html> [↑](#footnote-ref-3)