# Methods

## Model Validation

Turbine entrainment survival estimates were validated against existing empirical data and the USFWS Turbine Blade Strike Model (TBSM) using a tabular approach. In 1992, researchers conducted turbine blade strike balloon tag survival studies at Townsend Dam, where they tagged and released largemouth bass and rainbow trout ranging in size from 76 mm to 356 mm. Balloon tag studies allow researchers to recover test specimens and directly assess their condition. Recently, the USFWS developed the TBSM to support desktop entrainment evaluations. The TBSM simulates a population of fish and utilizes Franke et. al. (1997) equations to estimate survival through turbines as well as total station survival.

We also validated our yearly entrainment estimate (# of entrained fish) against empirical entrainment data collected at Townsend in 1992. The EPRI entrainment database lists the number of hours of sampled per month, the amount of water sampled (Mft3) and the total number of fish captured. This information afforded two expansion methods, one based on flow and the other on hours. With the EPRI entrainment database, we derived seasonal entrainment rates (average) fish/Mft3. With seasonal entrainment rates, we expanded to seasonal fish estimates by multiplying the seasonal entrainment rate to a daily discharge measurement for the 50% exceedance discharge year (1978) and simply summed across the year. With measures of hours sampled and fish captured, we calculated a monthly estimate of fish/hour. Which allows us to expand on the number of hours available per month. Since the project operates 24/7, we expanded fish/hour by the total number of hours within a month, and then summed across all months.

# Results

## Model Validation

The 1992 survival studies estimated high survival rates for the smaller size classes of Largemouth Bass and Rainbow Trout (Table XX). Interestingly, survival of large rainbow trout cohort was larger than the large largemouth bass cohort even though Trout were larger. Rainbow Trout were absent from the 2021 Impoundment Survey (cite), and were not modeled in the 2022 effort. However, large fish were present in the 2022 desktop entrainment exercise, including Walleye and other important sport fish. The TBSM estimates that the expected survival rates for the small Largemouth Bass cohort (3 – 5 inches) should be 98.1%. With lengths sampled from the EPRI entrainment database, Stryke estimates survival of the Fall cohort (simulated between 0.26 ft and 0.41 ft) to be 99.9% (98.8 – 100.0). The EPRI entrainment database does not have a seasonal cohort of Largemouth Bass that approximates the large Largemouth Bass cohort used in the 1992 balloon tag study. The closest EPRI derived Largemouth Bass seasonal cohort size range to the small Rainbow Trout cohort occurred in spring, which ranged between 0.22 ft – 0.67 ft. The TBSM estimates survival of fish within this range to be 97.4% while Stryke estimates survival within this size range to be 99.8% (97.8 – 1.0).

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| --- | --- | --- | --- |
| Species | Min (ft) | Max (ft) | Immediate Survival |
| largemouth bass | 0.25 | 0.42 | 1.000 |
| largemouth bass | 0.67 | 0.75 | 0.860 |
| rainbow trout | 0.42 | 0.50 | 0.944 |
| rainbow trout | 1.08 | 1.17 | 0.919 |

Table XX contains the expansion by hours and stryke estimates of entrained organisms. For the majority of species, empirical results are well approximated by regionally defined entrainment rates. Notable exceptions are Gizzard Shad, Emerald Shiner, and Green Sunfish.

|  |  |  |
| --- | --- | --- |
| species | Stryke | Expansion By Hour |
| Bluegill | 1,306 | 1,967 |
| Bluntnose Minnow | 436 | 67 |
| Channel Catfish | 9,046 | 2,304 |
| Common Carp | 230 | 739 |
| Emerald Shiner | 2,006 | 59 |
| Freshwater Drum | 6,056 | 6,671 |
| Gizzard Shad | 630,934 | 4,280,915 |
| Golden Redhorse | 985 |  |
| Green Sunfish | 1,348 | 92 |
| Johnny Darter | 350 |  |
| Largemouth Bass | 1,368 | 320 |
| Logperch | 994 | 191 |
| Muskellunge | 676 | 13 |
| Northern Hogsucker | 628 | 188 |
| Pumpkinseed | 1,297 | 342 |
| River Chub | 440 | 21 |
| Rock Bass | 3,246 | 182 |
| Sauger | 3,157 | 6,333 |
| Smallmouth Bass | 2,571 | 322 |
| Smallmouth Redhorse | 808 |  |
| Spotfin Shiner | 635 | 36 |
| Walleye | 6,308 | 567 |
| Yellow Perch | 3,369 | 92 |