Appendix C1: Ohio River Fish Species Life History Parameter Values

The tables in this appendix summarize the life history parameter values used by EPA to calculate age 1 equivalents, fishery yield, and production foregone from I&E data for the Ohio River case study.

Table C1-1: Bigmouth Buffalo Life History Parameters.

Stage Name	Natural Mortality (per stage)[a]	Fishing Mortality (per stage)[b]	Fraction Vulnerable to Fishery[c]	Weight (lbs)[d]
Eggs	2.87	0	0	0.0000000202[e]
Larvae	1.72	0	0	0.00214[f]
Age 0	2.98	0	0	0.00851[g]
Age 1+	0.548	0	0	1.14[g]
Age 2+	0.548	0	0	1.82[g]
Age 3+	0.548	0	0	2.63[g]
Age 4+	0.548	0	0	3.48[g]
Age 5+	0.548	0	0	4.64[g]
Age 6+	0.548	0	0	5.04[g]
Age 7+	0.548	0	0	11.1[g]
Age 8+	0.548	0	0	12.7[g]
Age 9+	0.548	0	0	16.8[g]
Age 10+	0.548	0	0	27.8[g]
Age 11+	0.548	0	0	28[g]
Age 12+	0.548	0	0	36.1[g]
Age 13+	0.548	0	0	36.2[f]
Age 14+	0.548	0	0	36.3[f]
Age 15+	0.548	0	0	36.5[f]

[a] Bartell and Campbell, 2000.
[b] Not a commercial or recreational species, thus no fishing mortality.
[c] Assumed.
[d] Weight calculated from length using the formula: $(2.399*10^{-6})*\text{Length(mm)}^{3.30} = \text{Weight(gm)}$ (Carlander, 1969).
[e] Kleinholz, 2000.
[f] Assumed based on Carlander, 1969.
[g] Carlander, 1969).

Table C1-2: Black Bullhead Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[e]	Weight (lbs)[f]
Eggs	2.3[a]	0	0	0.000000559[g]
Larvae	4.61[b]	0	0	0.000186[h]
Age 0+	1.39[b]	0	0	0.00132[i]
Age 1+	0.446[c]	0	0	0.0362[i]
Age 2+	0.446[c]	0	0	0.0797[i]
Age 3+	0.446[c]	0	0	0.137[i]
Age 4+	0.446[c]	0	0	0.233[i]
Age 5+	0.446[c]	0	0	0.402[i]
Age 6+	0.446[c]	0	0	0.679[i]
Age 7+	0.446[c]	0	0	0.753[i]
Age 8+	0.446[c]	0	0	0.815[i]
Age 9+	0.446[c]	0	0	0.823[j]

[a] Calculated from assumed survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from survival (PSEG, 1999c) for channel catfish (Geo-Marine Inc., 1978) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] Calculated from survival (PSEG, 1999c) for brown bullhead (Carlander, 1969) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[d] Not a commercial or recreational species, thus no fishing mortality.
[e] Assumed.
[f] Weight calculated from length using the formula: $(8.797*10^{-6})*\text{Length(mm)}^{3.060} = \text{Weight(gm)}$ (Froese and Pauly, 2001).
[g] Wang, 1986b.
[h] Assumed based on Wang, 1986b and Carlander, 1969.
[i] Carlander, 1969.
[j] Assumed based on Carlander, 1969.

Table C1-3: Black Crappie Life History Parameters.

Stage Name	Natural Mortality (per stage)[a]	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[c]	Weight (lbs)[d]
Eggs	1.8	0[b]	0	0.0000000179[e]
Larvae	0.498	0[b]	0	0.00000857[e]
Age 0	2.93	0[b]	0	0.012[f]
Age 1+	0.292	0.292[a]	0.5	0.128[f]
Age 2+	0.292	0.292[a]	1	0.193[f]
Age 3+	0.292	0.292[a]	1	0.427[f]
Age 4+	0.292	0.292[a]	1	0.651[f]
Age 5+	0.292	0.292[a]	1	0.888[f]
Age 6+	0.292	0.292[a]	1	0.925[f]
Age 7+	0.292	0.292[a]	1	0.972[g]
Age 8+	0.292	0.292[a]	1	1.08[f]
Age 9+	0.292	0.292[a]	1	1.26[f]

[a] Bartell and Campbell, 2000.
[b] Recreational species. Fraction vulnerable assumed.
[c] Assumed.
[d] Weight calculated from length using the formula: $(1.014*10^{-5})*\text{Length(mm)}^{3.066} = \text{Weight(gm)}$ (Froese and Pauly, 2001).
[e] Wang, 1986b.
[f] Carlander, 1977.
[g] Assumed based on Carlander, 1977.

Table C1-4: Bluegill Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[e]	Weight (lbs)[g]
Eggs	1.73[a]	0[e]	0	0.0000000108[h]
Larvae	0.576[a]	0[e]	0	0.00000156[h]
Age 0	4.62[a]	0[e]	0	0.00795[i]
Age 1+	0.39[b]	0[e]	0	0.00992[i]
Age 2+	0.151[c]	0[e]	0	0.032[i]
Age 3+	0.735[d]	0.735[f]	0.5	0.0594[i]
Age 4+	0.735[d]	0.735[f]	1	0.104[i]
Age 5+	0.735[d]	0.735[f]	1	0.189[i]
Age 6+	0.735[d]	0.735[f]	1	0.193[i]
Age 7+	0.735[d]	0.735[f]	1	0.209[i]
Age 8+	0.735[d]	0.735[f]	1	0.352[i]
Age 9+	0.735[d]	0.735[f]	1	0.393[i]

[a] Bartell and Campbell, 2000.
[b] Froese and Pauly, 2001.
[c] Calculated from survival (PSEG, 1999c) (Carlander, 1977) using the equation: (natural mortality) = -LN(survival)-(fishing mortality).
[d] Calculated from survival (PSEG, 1999c) (Carlander, 1977) using the equation: (natural mortality) = -LN(survival$^{1/2}$).
[e] Recreational species. Fraction vulnerable assumed.
[f] Calculated from survival (PSEG, 1999c) (Carlander, 1977) using the equation: (fishing mortality) = -LN(survival$^{1/2}$).
[g] Weight calculated from length using the formula: $(4.326*10^{-6})*\text{Length(mm)}^{3.209}$ = Weight(gm) (Froese and Pauly, 2001).
[h] Wang, 1986b.

Table C1-5: Bluntnose Minnow Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[d]	Weight (lbs)[e]
Eggs	2.3[a]	0	0	0.000000985[f]
Larvae	2.06[b]	0	0	0.000375[g]
Age 0	2.06[b]	0	0	0.00208[g]
Age 1+	1[c]	0	0	0.00585[g]
Age 2+	1[c]	0	0	0.0121[g]
Age 3+	1[c]	0	0	0.0143[f]

[a] Calculated from assumed survival(PSEG, 1999c) using the equation: (natural mortality) = -LN(survival)-(fishing mortality).
[b] Calculated from estimated survival using the equation: (natural mortality) = -LN(survival)-(fishing mortality).
[c] Froese and Pauly, 2001.
[d] Not a commercial or recreational species, thus no fishing mortality.
[e] Weight calculated from length using the formula: $(4.466*10^{-4})*\text{Length(mm)}^{2.34}$ = Weight(gm) (Froese and Pauly, 2001).
[f] Assumed based on Carlander, 1969.
[g] Carlander, 1969.

Table C1-6: Brown Bullhead Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[d]	Weight (lbs)[e]
Eggs	2.3[a]	0	0	0.0000000165[f]
Larvae	4.61[b]	0	0	0.0000192[f]
Age 0	1.39[b]	0	0	0.00246[g]
Age 1+	0.446[c]	0	0	0.0898[g]
Age 2+	0.446[c]	0	0	0.172[g]
Age 3+	0.446[c]	0	0	0.278[g]
Age 4+	0.446[c]	0	0	0.33[g]
Age 5+	0.446[c]	0	0	0.57[g]
Age 6+	0.446[c]	0	0	0.582[g]

[a] Calculated from assumed survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from survival (PSEG, 1999c) for channel catfish (Geo-Marine Inc., 1978) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] Calculated from survival (PSEG, 1999c) (Carlander, 1969) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[d] Not a commercial or recreational species, thus no fishing mortality.
[e] Weight calculated from length using the formula: $(7.491*10^{-6})*\text{Length(mm)}^{3.065} = \text{Weight(gm)}$ (Froese and Pauly, 2001).
[f] Assumed based on Carlander, 1969.
[g] Carlander, 1969.

Table C1-7: Channel Catfish Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[d]	Weight (lbs)[f]
Eggs	2.3[a]	0[d]	0	0.000000408[g]
Larvae	4.61[b]	0[d]	0	0.0000191[g]
Age 0	1.39[b]	0[d]	0	0.00987[h]
Age 1+	0.41[c]	0.41[e]	0.5	0.0554[h]
Age 2+	0.41[c]	0.41[e]	1	0.189[h]
Age 3+	0.41[c]	0.41[e]	1	0.436[h]
Age 4+	0.41[c]	0.41[e]	1	0.71[h]
Age 5+	0.41[c]	0.41[e]	1	1.22[h]
Age 6+	0.41[c]	0.41[e]	1	1.55[h]
Age 7+	0.41[c]	0.41[e]	1	2.27[h]
Age 8+	0.41[c]	0.41[e]	1	2.66[h]
Age 9+	0.41[c]	0.41[e]	1	3.41[h]
Age 10+	0.41[c]	0.41[e]	1	5.59[h]
Age 11+	0.41[c]	0.41[e]	1	5.81[i]
Age 12+	0.41[c]	0.41[e]	1	5.92[h]

[a] Calculated from assumed survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from survival (PSEG, 1999c) (Geo-Marine Inc., 1978) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] Calculated from survival(PSEG, 1999c) (Miller, 1966) using the equation: (natural mortality) = -LN($survival^{1/2}$).
[d] (Salia et al., 1997) Hake.
[e] Calculated from survival (PSEG, 1999c) (Miller, 1966) using the equation: (fishing mortality) = -LN($survival^{1/2}$).
[f] Weight calculated from length using the formula: $(2.945*10^{-6})*Length(mm)^{3.133}$ = Weight(gm) (Froese and Pauly, 2001).
[g] (Wang, 1986b).
[h] (Carlander, 1969).
[i] Assumed based on (Carlander, 1969).

Table C1-8: Common Carp Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[d]	Weight (lbs)[e]
Eggs	2.3[a]	0	0	0.000000143[f]
Larvae	4.61[b]	0	0	0.0000118[f]
Age 0	1.39[b]	0	0	0.0225[g]
Age 1+	0.26[c]	0	0	0.79[g]
Age 2+	0.26[c]	0	0	1.21[g]
Age 3+	0.26[c]	0	0	1.81[g]
Age 4+	0.26[c]	0	0	5.13[g]
Age 5+	0.26[c]	0	0	5.52[h]
Age 6+	0.26[c]	0	0	5.82[h]
Age 7+	0.26[c]	0	0	6.76[g]
Age 8+	0.26[c]	0	0	8.17[g]
Age 9+	0.26[c]	0	0	8.55[h]
Age 10+	0.26[c]	0	0	8.94[h]
Age 11+	0.26[c]	0	0	9.76[h]
Age 12+	0.26[c]	0	0	10.2[h]
Age 13+	0.26[c]	0	0	10.6[h]
Age 14+	0.26[c]	0	0	11.1[h]
Age 15+	0.26[c]	0	0	11.5[h]
Age 16+	0.26[c]	0	0	12[h]
Age 17+	0.26[c]	0	0	12.5[h]

[a] Calculated from assumed survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from survival (PSEG, 1999c) (Geo-Marine Inc., 1978) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] (Froese and Pauly, 2001).
[d] Not a commercial or recreational species, thus no fishing mortality.
[e] Weight calculated from length using the formula: $(1.095*10^{-5})*\text{Length(mm)}^{3.025}$ = Weight(gm) (Froese and Pauly, 2001).
[f] (Wang, 1986b).
[g] (Carlander, 1969).
[h] Assumed based on (Carlander, 1969).

Table C1-9: Emerald Shiner Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[e]	Weight (lbs)[f]
Eggs	2.3[a]	0	0	0.000000252[e]
Larvae	2.3[b]	0	0	0.0016[e]
Age 0	1.39[b]	0	0	0.0135[g]
Age 1+	0.916[b]	0	0	0.026[g]
Age 2+	1.1[c]	0	0	0.0478[g]
Age 3+	1.1[c]	0	0	0.106[g]

[a] Calculated from assumed survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from survival (PSEG, 1999c) (Geo-Marine Inc., 1978) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] (Froese and Pauly, 2001).
[d] Not a commercial or recreational species, thus no fishing mortality.
[e] Assumed.
[f] Weight calculated from length using the formula: $(1.144*10^{-4})*\text{Length(mm)}^{2.92} = \text{Weight(gm)}$ (Fuchs, 1967).
[g] (Trautman, 1981).

Table C1-10: Freshwater Drum Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[d]	Weight (lbs)
Eggs	2.3[a]	0	0	0.0000011[e]
Larvae	6.13[b]	0	0	0.00000295[b]
Age 0	2.3[b]	0	0	0.0166[b]
Age 1+	0.31[c]	0	0	0.05[f]
Age 2+	0.31[c]	0	0	0.206[f]
Age 3+	0.31[c]	0	0	0.438[f]
Age 4+	0.31[c]	0	0	0.638[f]
Age 5+	0.31[c]	0	0	0.794[f]
Age 6+	0.31[c]	0	0	0.95[f]
Age 7+	0.31[c]	0	0	1.09[f]
Age 8+	0.31[c]	0	0	1.26[f]
Age 9+	0.31[c]	0	0	1.44[f]
Age 10+	0.31[c]	0	0	1.6[f]
Age 11+	0.31[c]	0	0	1.78[f]
Age 12+	0.31[c]	0	0	2[f]

[a] Calculated from assumed survival(PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] (Bartell and Campbell, 2000).
[c] (Froese and Pauly, 2001).
[d] Not a commercial or recreational species, thus no fishing mortality.
[e] Assumed based on (Bartell and Campbell, 2000).
[f] (Scott and Crossman, 1973). Average of males and females.

Table C1-11: Gizzard Shad Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[c]	Fraction Vulnerable to Fishery[c]	Weight (lbs)[d]
Eggs	2.3[a]	0	0	0.0000000118[e]
Larvae	2.3[b]	0	0	0.0000335[e]
Age 0	3.69[b]	0	0	0.0276[f]
Age 1+	0.916[b]	0	0	0.322[f]
Age 2+	0.916[b]	0	0	0.666[f]
Age 3+	0.916[b]	0	0	2.92[f]
Age 4+	0.916[b]	0	0	3.66[f]
Age 5+	0.916[b]	0	0	4.57[f]
Age 6+	0.916[b]	0	0	4.72[g]

[a] Calculated from assumed survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from survival (PSEG, 1999c) (Geo-Marine Inc., 1978) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] Not a commercial or recreational species, thus no fishing mortality.
[d] Weight calculated from length using the formula: $(1.291*10^{-5})*\text{Length(mm)}^{3.071}$ = Weight(gm) (Froese and Pauly, 2001).
[e] (Wallus et al., 1990).
[f] (Carlander, 1969).
[g] Assumed based on (Carlander, 1969).

Table C1-12: Golden Redhorse Life History Parameters.

Stage Name	Natural Mortality (per stage)[a]	Fishing Mortality (per stage)[b]	Fraction Vulnerable to Fishery[b]	Weight (lbs)[c]
Eggs	2.3	0	0	0.0000000308[d]
Larvae	2.3	0	0	0.0000037[d]
Age 0	2.99	0	0	0.0267[e]
Age 1+	0.548	0	0	0.0521[e]
Age 2+	0.548	0	0	0.18[e]
Age 3+	0.548	0	0	0.493[e]
Age 4+	0.548	0	0	0.653[e]
Age 5+	0.548	0	0	0.916[e]
Age 6+	0.548	0	0	2.78[e]
Age 7+	0.548	0	0	3.07[e]

[a] (Bartell and Campbell, 2000). Shorthead redhorse.
[b] Not a commercial or recreational species, thus no fishing mortality.
[c] Weight calculated from length using the formula: $(1.398*10^{-5})*\text{Length(mm)}^{2.975}$=Weight(gm) (Froese and Pauly, 2001).
[d] Assumed based on Carlander (1969).
[e] (Carlander, 1969).

Table C1-13: Logperch Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[d]	Weight (lbs)[e]
Eggs	2.3[a]	0	0	0.00000000309[f]
Larvae	1.95[b]	0	0	0.000276[d]
Age 0	1.95[b]	0	0	0.00345[f]
Age 1+	0.7[c]	0	0	0.0128[f]
Age 2+	0.7[c]	0	0	0.0274[f]
Age 3+	0.7[c]	0	0	0.0443[f]

[a] Calculated from assumed survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from estimated survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] (Froese and Pauly, 2001).
[d] Not a commercial or recreational species, thus no fishing mortality.
[e] Weight calculated from length using the formula: $(5.240*10^{-7})*\text{Length(mm)}^{3.641}$ = Weight(gm) (Carlander, 1997).
[f] (Carlander, 1997).

Table C1-14: Longear Sunfish Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[d]	Weight (lbs)[f]
Eggs	1.71[a]	0[d]	0	0.00000000736[g]
Larvae	0.687[b]	0[d]	0	0.000000994[g]
Age 0+	0.687[b]	0[d]	0	0.000878[h]
Age 1+	1.61[a]	0[d]	0	0.00666[h]
Age 2+	1.61[a]	0[d]	0	0.0271[h]
Age 3+	1.5[c]	1.5[e]	0.5	0.0593[h]
Age 4+	1.5[c]	1.5[e]	1	0.0754[h]
Age 5+	1.5[c]	1.5[e]	1	0.142[h]
Age 6+	1.5[c]	1.5[e]	1	0.18[h]
Age 7+	1.5[c]	1.5[e]	1	0.214[h]
Age 8+	1.5[c]	1.5[e]	1	0.232[h]

[a] Calculated from survival for pumpkinseed (Carlander, 1977) using the equation: (natural mortality) = -LN(survival) -(fishing mortality).
[b] Calculated from estimated survival(PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] Calculated from survival for pumpkinseed (Carlander, 1977) using the equation: (natural mortality) = -LN($\text{survival}^{1/2}$).
[d] Assumed.
[e] Calculated from survival for pumpkinseed (Carlander, 1977) using the equation: (fishing mortality) = -LN($\text{survival}^{1/2}$).
[f] Weight calculated from length using the formula: $(3.337*10^{-6})*\text{Length(mm)}^{3.262}$ = Weight(gm) (Froese and Pauly, 2001). Pumpkinseed.
[g] (Wang, 1986b).
[h] (Carlander, 1977).

Table C1-15: Muskellunge Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[f]	Weight (lbs)[g]
Eggs	1.08[a]	0[e]	0	0.000000205[h]
Larvae	5.49[b]	0[e]	0	0.0133[i]
Age 0	5.49[b]	0[e]	0	0.0451[h]
Age 1+	0.15[c]	0[e]	0	0.365[h]
Age 2+	0.15[c]	0[e]	0	1.1[h]
Age 3+	0.15[c]	0[e]	0	1.53[h]
Age 4+	0.15[c]	0[e]	0	2.72[h]
Age 5+	0.15[c]	0[e]	0	6.19[h]
Age 6+	0.15[c]	0[e]	0	7.02[h]
Age 7+	0.15[c]	0[e]	0	8.92[h]
Age 8+	0.15[c]	0[e]	0	12.3[h]
Age 9+	0.15[c]	0[e]	0	13.9[h]
Age 10+	0.075[d]	0.075[d]	0.5	16.6[h]
Age 11+	0.075[d]	0.075[d]	1	19[h]
Age 12+	0.075[d]	0.075[d]	1	24.2[h]
Age 13+	0.075[d]	0.075[d]	1	25.3[h]
Age 14+	0.075[d]	0.075[d]	1	30[h]
Age 15+	0.075[d]	0.075[d]	1	32.4[h]
Age 16+	0.075[d]	0.075[d]	1	34.3[h]
Age 17+	0.075[d]	0.075[d]	1	45.6[h]
Age 18+	0.075[d]	0.075[d]	1	45.8[i]
Age 19+	0.075[d]	0.075[d]	1	47.7[h]
Age 20+	0.075[d]	0.075[d]	1	48.8[i]
Age 21+	0.075[d]	0.075[d]	1	48.9[i]
Age 22+	0.075[d]	0.075[d]	1	49[i]
Age 23+	0.075[d]	0.075[d]	1	49.1[i]
Age 24+	0.075[d]	0.075[d]	1	49.2[i]
Age 25+	0.075[d]	0.075[d]	1	49.3[i]
Age 26+	0.075[d]	0.075[d]	1	49.4[i]
Age 27+	0.075[d]	0.075[d]	1	49.4[i]

[a] Calculated from survival (Carlander, 1969) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from estimated survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] (Froese and Pauly, 2001).
[d] (Froese and Pauly, 2001), assuming half of mortality was natural and half was fishing.
[e] Assumed.
[f] (Pennsylvania, 1999).
[g] Weight calculated from length using the formula: $(5.590*10^{-6})*\text{Length(mm)}^{3.016} = \text{Weight(gm)}$ (Froese and Pauly, 2001).
[h] (Carlander, 1969).
[i] Assumed based on (Carlander, 1969).

Table C1-16: Paddlefish Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[e]	Weight (lbs)[f]
Eggs	2.3[a]	0[e]	0	0.00000361[g]
Larvae	3.23[b]	0[e]	0	0.0000816[h]
Age 0	3.23[b]	0[e]	0	0.0578[h]
Age 1+	0.57[c]	0[e]	0	0.453[g]
Age 2+	0.285[d]	0.285[d]	0.5	7.1[g]
Age 3+	0.285[d]	0.285[d]	1	16.3[g]
Age 4+	0.285[d]	0.285[d]	1	27.4[g]
Age 5+	0.285[d]	0.285[d]	1	31.6[g]
Age 6+	0.285[d]	0.285[d]	1	37.3[g]
Age 7+	0.285[d]	0.285[d]	1	41.6[g]
Age 8+	0.285[d]	0.285[d]	1	43.7[g]
Age 9+	0.285[d]	0.285[d]	1	49.2[g]
Age 10+	0.285[d]	0.285[d]	1	51.9[g]
Age 11+	0.285[d]	0.285[d]	1	54.6[g]
Age 12+	0.285[d]	0.285[d]	1	60.6[g]
Age 13+	0.285[d]	0.285[d]	1	63.5[g]
Age 14+	0.285[d]	0.285[d]	1	68.1[g]
Age 15+	0.285[d]	0.285[d]	1	72.7[g]
Age 16+	0.285[d]	0.285[d]	1	75.5[h]
Age 17+	0.285[d]	0.285[d]	1	80.8[h]
Age 18+	0.285[d]	0.285[d]	1	82.6[h]
Age 19+	0.285[d]	0.285[d]	1	85.4[g]
Age 20+	0.285[d]	0.285[d]	1	87.9[g]
Age 21+	0.285[d]	0.285[d]	1	96.2[h]
Age 22+	0.285[d]	0.285[d]	1	102[g]

[a] Calculated from assumed survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from estimated survival (PSEG, 1999c) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] (Froese and Pauly, 2001). Mississippi paddlefish.
[d] (Froese and Pauly, 2001). Mississippi paddlefish. Assumed half of mortality was natural and half was fishing.
[e] Assumed.
[f] Weight calculated from length using the formula: $(5.226*10^{-5})*\text{Length(mm)}^{2.85} = \text{Weight(gm)}$ (Froese and Pauly, 2001).
[g] (Carlander, 1969).
[h] Assumed based on (Carlander, 1969).

Table C1-17: Rainbow Smelt Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[c]	Weight (lbs)[e]
Eggs	3.32[a]	0[c]	0	0.0000000115[f]
Larvae	2.65[a]	0[c]	0	0.00000233[f]
Age 1+	0.72[b]	0[c]	0	0.0195[g]
Age 2+	0.72[b]	0[c]	0	0.041[h]
Age 3+	0.72[b]	0[d]	0	0.177[h]
Age 4+	0.72[b]	0[d]	0	0.338[i]
Age 5+	0.72[b]	0[d]	0	0.537[i]
Age 6+	0.72[b]	0[d]	0	0.597[j]

[a] Calculated from survival (Carlander, 1969) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] (Froese and Pauly, 2001).
[c] Assumed.
[d] (Stone & Webster Engineering Corporation, 1977).
[e] Weight calculated from length using the formula: $(5.23*10^{-6})*\text{Length(mm)}^{3.114}$ = Weight(gm) (Froese and Pauly, 2001).
[f] (Able and Fahay, 1998).
[g] Assumed based on (Able and Fahay, 1998) and (Scott and Scott, 1988).
[h] (Scott and Scott, 1988).
[i] Assumed based on (Scott and Scott, 1988).
[j] Assumed to be 5.6 cm less than maximum reported length (Froese and Pauly, 2001).

Table C1-18: River Carpsucker Life History Parameters.

Stage Name	Natural Mortality (per stage)[a]	Fishing Mortality (per stage)[b]	Fraction Vulnerable to Fishery[b]	Weight (lbs)[c]
Eggs	2.05	0	0	0.0000000135[d]
Larvae	2.56	0	0	0.00000198[d]
Age 0+	2.3	0	0	0.000145[e]
Age 1+	0.548	0	0	0.0447[e]
Age 2+	0.548	0	0	0.249[e]
Age 3+	0.548	0	0	0.305[e]
Age 4+	0.548	0	0	0.609[e]
Age 5+	0.548	0	0	0.823[e]
Age 6+	0.548	0	0	0.929[e]

[a] (Bartell and Campbell, 2000).
[b] Not a commercial or recreational species, thus no fishing mortality.
[c] Weight calculated from length using the formula: $(6.13*10^{-6})*\text{Length(mm)}^{3.099}$ = Weight(gm) (Froese and Pauly, 2001).
[d] Assumed based on Carlander (1969).
[e] (Carlander, 1969).

Table C1-19: Sauger Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[c]	Fraction Vulnerable to Fishery[c]	Weight (lbs)[d]
Eggs	1.05[a]	0	0	0.0000000179[c]
Larvae	3.55[b]	0	0	0.000163[e]
Age 0+	1.62[b]	0	0	0.0341[f]
Age 1+	0.23[b]	0.05	0.5	0.505[f]
Age 2+	0.23[b]	0.05	1	1.03[f]
Age 3+	0.23[b]	0.05	1	1.53[f]
Age 4+	0.23[b]	0.05	1	2.19[f]
Age 5+	0.23[b]	0.05	1	2.27[f]
Age 6+	0.23[b]	0.05	1	3.82[f]
Age 7+	0.23[b]	0.05	1	4.65[f]
Age 8+	0.23[b]	0.05	1	4.8[f]

[a] Calculated from survival for walleye (Carlander, 1997) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] (Bartell and Campbell, 2000).
[c] Recreational species. Fraction vulnerable assumed.
[d] Weight calculated from length using the formula: $(8.137*10^{-6})*\text{Length(mm)}^{3.058}$ = Weight(gm) (Froese and Pauly, 2001).
[e] (Carlander, 1997). Walleye.
[f] (Carlander, 1997).

Table C1-20: Skipjack Herring Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[d]	Weight (lbs)[e]
Eggs	2.3[a]	0	0	0.00000242[f]
Larvae	4.25[b]	0	0	0.000381[f]
Age 0+	4.25[b]	0	0	0.0572[f]
Age 1+	0.7[c]	0	0	0.301[g]
Age 2+	0.7[c]	0	0	0.833[g]
Age 3+	0.7[c]	0	0	1.74[h]

[a] Calculated from assumed survival using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] Calculated from estimated survival using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] (Froese and Pauly, 2001). Alewife.
[d] Not a commercial or recreational species, thus no fishing mortality.
[e] Assumed.
[e] Weight calculated from length using the formula: $(7.565*10^{-5})*\text{Length(mm)}^{2.690}$ = Weight(gm) (Froese and Pauly, 2001).
[f] (Wallus et al., 1990).
[g] Assumed based on (Wallus et al., 1990) and (Trautman, 1981).
[h] (Trautman, 1981).

Table C1-21: Smallmouth Bass Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[d]	Weight (lbs)[f]
Eggs	1.9[a]	0[d]	0	0.000000331[g]
Larvae	2.7[b]	0[d]	0	0.0000198[g]
Age 0+	0.446[a]	0[d]	0	0.0169[c]
Age 1+	0.86[c]	0.23[c]	0.5	0.202[c]
Age 2+	1.17[c]	0.322[e]	1	0.518[c]
Age 3+	0.755[c]	0.208[e]	1	0.733[c]
Age 4+	1.05[c]	0.288[e]	1	1.04[c]
Age 5+	0.867[c]	0.238[e]	1	1.44[c]
Age 6+	0.867[c]	0.238[e]	1	2.24[c]
Age 7+	0.867[c]	0.238[e]	1	2.56[h]
Age 8+	0.867[c]	0.238[e]	1	2.92[h]
Age 9+	0.867[c]	0.238[e]	1	3.3[c]

[a] Calculated from survival (Carlander, 1977) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] (Bartell and Campbell, 2000).
[c] (Carlander, 1977).
[d] Recreational species. Fraction vulnerable assumed.
[e] (Carlander, 1977), assuming that 27.5% of natural mortality was fishing mortality.
[f] Weight calculated from length using the formula: $(2.494*10^{-5})*\text{Length(mm)}^{2.917}$ = Weight(gm) (Froese and Pauly, 2001).
[g] (Wang, 1986b).
[h] Assumed based on (Carlander, 1977).

Table C1-22: Striped Bass Life History Parameters.

Stage Name	Natural Mortality (per stage)[a]	Fishing Mortality (per stage)[a]	Fraction Vulnerable to Fishery[a]	Weight (lbs)[b]
Eggs	1.39	0	0	0.000022[b]
Yolksac larvae	2.22	0	0	0.097[c]
Post-yolksac larvae	5.11	0	0	0.194[c]
Juvenile 1	2.28	0	0	0.291[c]
Juvenile 2	1	0	0	0.388[c]
Age 1+	1.1	0	0	0.485[a]
Age 2+	0.15	0.31	0.06	2.06[a]
Age 3+	0.15	0.31	0.2	3.31[a]
Age 4+	0.15	0.31	0.63	4.93[a]
Age 5+	0.15	0.31	0.94	6.5[a]
Age 6+	0.15	0.31	1	8.58[a]
Age 7+	0.15	0.31	0.9	12.3[a]
Age 8+	0.15	0.31	0.9	14.3[a]
Age 9+	0.15	0.31	0.9	16.1[a]
Age 10+	0.15	0.31	0.9	18.8[a]
Age 11+	0.15	0.31	0.9	19.6[a]
Age 12+	0.15	0.31	0.9	22.4[a]
Age 13+	0.15	0.31	0.9	27[a]
Age 14+	0.15	0.31	0.9	34.6[a]
Age 15+	0.15	0.31	0.9	41.5[a]

[a] (PSEG, 1999c).
[b] Assumed.
[c] Assumed based on (PSEG, 1999c).

Table C1-23: Sucker Life History Parameters.

Stage Name	Natural Mortality (per stage)[a]	Fishing Mortality (per stage)[b]	Fraction Vulnerable to Fishery[b]	Weight (lbs)[c]
Eggs	2.05	0	0	0.0000000135[d]
Larvae	2.56	0	0	0.00000198[d]
Age 0+	2.3	0	0	0.000145[e]
Age 1+	0.548	0	0	0.0447[e]
Age 2+	0.548	0	0	0.249[e]
Age 3+	0.548	0	0	0.305[e]
Age 4+	0.548	0	0	0.609[e]
Age 5+	0.548	0	0	0.823[e]
Age 6+	0.548	0	0	0.929[e]

[a] (Bartell and Campbell, 2000).
[b] Not a commercial or recreational species, thus no fishing mortality.
[c] Weight calculated from length using the formula: $(6.130*10^{-5})*\text{Length(mm)}^{3.099} = \text{Weight(gm)}$ (Froese and Pauly, 2001). River carpsucker.
[d] Assumed based on (Carlander, 1969).
[e] (Carlander, 1969).

Table C1-24: Walleye Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[c]	Weight (lbs)[e]
Eggs	1.05[a]	0[c]	0	0.00000000506[f]
Larvae	3.55[b]	0[c]	0	0.0000768[g]
Age 0+	1.93[b]	0[c]	0	0.03[g]
Age 1+	0.0474[b]	0.6[d]	0.5	0.328[g]
Age 2+	0.0474[b]	0.6[d]	1	0.907[g]
Age 3+	0.0474[b]	0.6[d]	1	1.77[g]
Age 4+	0.0474[b]	0.6[d]	1	2.35[g]
Age 5+	0.0474[b]	0.6[d]	1	3.37[g]
Age 6+	0.0474[b]	0.6[d]	1	3.97[g]
Age 7+	0.0474[b]	0.6[d]	1	4.66[f]
Age 8+	0.0474[b]	0.6[d]	1	5.58[g]

[a] Calculated from survival (Carlander, 1997) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[b] (Bartell and Campbell, 2000).
[c] Recreational species. Fraction vulnerable assumed.
[d] (McDermot and Rose, 2000).
[e] Weight calculated from length using the formula: $(2.296*10^{-6})*\text{Length(mm)}^{3.23} = \text{Weight(gm)}$ (Froese and Pauly, 2001).
[f] Assumed based on (Carlander, 1997).
[g] (Carlander, 1997).

Table C1-25: White Bass Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)[d]	Fraction Vulnerable to Fishery[e]	Weight (lbs)
Eggs	2.3[a]	0	0	0.0000000266[f]
Larvae	4.61[b]	0	0	0.00000174[g]
Age 0+	1.39[b]	0	0	0.174[h]
Age 1+	0.42[c]	0	0	0.467[h]
Age 2+	0.42[c]	0.7	0.5	0.644[h]
Age 3+	0.42[c]	0.7	1	1.02[h]
Age 4+	0.42[c]	0.7	1	1.16[h]
Age 5+	0.42[c]	0.7	1	1.26[h]
Age 6+	0.42[c]	0.7	1	1.66[h]
Age 7+	0.42[c]	0.7	1	1.68[i]

[a] Calculated from assumed survival using the equation: (natural mortality) = -LN(survival)-(fishing mortality).
[b] Calculated from survival (Geo-Marine Inc., 1978) using the equation: (natural mortality) = -LN(survival)-(fishing mortality).
[c] (Froese and Pauly, 2001).
[d] (McDermot and Rose, 2000).
[e] Recreational species. Fraction vulnerable assumed.
[f] Calculated from assumed length of 1 mm using the formula: $(1.206*10^{-5})*\text{Length(mm)}^{3.132} = \text{Weight(gm)}$ (Van Oosten, 1942).
[g] Calculated from length of 3.8 mm (Carlander, 1997) using the formula: $(1.206*10^{-5})*\text{Length(mm)}^{3.132} = \text{Weight(gm)}$ (Van Oosten, 1942).
[h] (Carlander, 1997).
[i] Assumed based on (Carlander, 1997).

Table C1-26: Yellow Perch Life History Parameters.

Stage Name	Natural Mortality (per stage)	Fishing Mortality (per stage)	Fraction Vulnerable to Fishery[g]	Weight (lbs)[h]
Eggs	2.75[a]	0[e]	0	0.0000000274[i]
Larvae	1.79[b]	0[e]	0	0.00171[j]
Age 0+	1.79[b]	0[e]	0	0.01[j]
Age 1+	2.41[c]	0[e]	0	0.051[j]
Age 2+	1.35[c]	0[e]	0	0.137[j]
Age 3+	1.2[c]	0[e]	0	0.23[j]
Age 4+	1.24[c]	0[e]	0	0.347[j]
Age 5+	1.31[c]	0[e]	0	0.46[j]
Age 6+	1.77[c]	0[e]	0	0.617[j]
Age 7+	1.83[d]	0.7[f]	0.5	0.763[j]
Age 8+	1.83[d]	0.7[f]	1	0.92[j]
Age 9+	1.83[d]	0.7[f]	1	1.15[k]
Age 10+	1.83[d]	0.7[f]	1	1.17[j]

[a] (PSEG, 1999c). White perch.
[b] Calculated from estimated survival using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[c] Calculated from survival (Carlander, 1997) using the equation: (natural mortality) = -LN(survival) - (fishing mortality).
[d] Calculated from survival (Carlander, 1997) using the equation: (natural mortality) = -LN(survival) - (fishing mortality), and subtracting known fishing mortality (McDermot and Rose, 2000).
[e] Assumed based on landings data. See Chapter C6.
[f] (McDermot and Rose, 2000).
[g] Recreational species. Fraction vulnerable assumed.
[h] Weight calculated from length using the formula: $(1.710*10^{-5})*\text{Length(mm)}^{3.015} = \text{Weight(gm)}$ (Froese and Pauly, 2001).
[i] (Wang and Kernehan, 1979).
[j] (Carlander, 1997).
[k] Assumed based on (Carlander, 1997).