# Tables

Table 1.—State variables

|  |  |
| --- | --- |
| Symbol | Description |
| *Indices* | |
|  | Time |
|  | Age |
|  | Hatchery or natural origin |
|  | Years since spawning |
| *State variables* | |
|  | Embryo (; 5-8 days): period from fertilization to hatching |
|  | Free embryo (; 8-12 days days post hatch (dph)): period from hatching until the larval fish initiates feeding |
|  | Exogenously feeding larvae and age-0 (; 8-12 dph - June 1): period from full development of fin rays over the winter period until June 1 of the following year. |
|  | Juvenile (; age-1 to age-9): period of pallid sturgeon sexual immaturity, a fish can remain in this stage until age-9 |
|  | Spawning adult (;age-7 to age-41): this stage includes juvenile fish that have become sexually mature and are read to spawn and adult fish that have already spawned and are ready to spawn again |
|  | Post-spawn Adult (): a pallid sturgeon that has released its gametes, model assumes fish remain in this state until June the following year |
|  | Recrudescent adult (): a post-spawn pallid sturgeon, replenishing gametes, may remain in this state for up to 4 years post-spawn |
|  | Broodstock (B): sexually mature fish ready to spawn that are removed from the Missouri River System and used as a source of gametes to fertilize and produce offspring in a controlled hatchery environment. |
|  | Fingerlings (F): pallid sturgeon hatched in a hatchery setting and reared for 3–4 months and released back into the Missouri River System. |
|  | Yearlings (Y): pallid sturgeon hatched in a hatchery setting and reared for 10–12 months and released back into the Missouri River System. |

Table 2.—Demographic values, symbols, descriptions, and sources used in modeling population dynamics for upper and lower Missouri River Basin pallid sturgeon populations.

|  |  |  |  |
| --- | --- | --- | --- |
| Symbol | Description | Value | Source |
| *Survival* | | | |
|  | Probability an oocyte is fertilized and gamete produced | Varies | Calibrated to each basin such that population is in equilibrium |
|  | Probability an embryo survives and transitions to a free embryo | Varies | Calculated at initialization |
|  | Probability an free embryo survives and transitions to an exogenously feeding larvae | Varies | Calculated at initialization |
|  | probability exogenously feeding larvae survives and transitions to the juvenile stage | Varies | See Table 3.3 |
|  | probability juvenile fish survival and transition to adult stage | Varies | See Table 3.3 |
| *State transitions probabilities* | | | |
|  | Age-specific probability that a juvenile fish becomes sexually mature and transitions to the spawning stage | Varies | See Figure 3.4 |
|  | probability of a recrudescent adult returning to spawning stage given the years since last spawn | Varies | See Figure 3.5 |
|  | Maximum age | 41 | (Keenlyne et al. 1992) |
|  | Initial sex ratio of adult pallid sturgeon |  | (Steffensen et al. 2013b) |
| *Fecundity* | | | |
|  | Age specific female fecundity | Varies | See equation xxx and Figure 3.1 |
|  | Intercept for linear relationship of fecundity and fork length | -43678 | (Steffensen et al. 2013b) |
|  | slope term for relationship of fecundity and fork length | 72.70 | (Steffensen et al. 2013b) |
| *Growth* | | | |
|  | Average maximum fork length | 1683 | (Reynolds and Tyre 2011) a |
|  | Growth coefficient | 0.036 | (Reynolds and Tyre 2011) a |
|  | theoretical size at age-0 | -5.9 | (Reynolds and Tyre 2011)a |

a used data from Keenlyne and Jenkins (1993) to estimate parameters

# MATURITY FUNCTION R TO SP

yr<-seq(0,5,0.1)

b0<- 2 # value of 0.5

b1=2 # steepness

y<- b0+b1\*yr

p<- exp(y)/(1+exp(y))

p<-1/(1+exp(-b1\*(yr-b0)))

plot(yrs,p,type='l')

# MATURITY FUNCTION J TO A

yr<-seq(0,10,0.1)

# SOLVE FOR LOGISTIC GIVEN MID POINT AND 99% MATURE

fn<- function(b1, b0,high)

{

(1/(1+exp(-b1\*(high-b0))))-0.99

}

b0=7 # P=0.5

b1<-uniroot(fn, b0=b0,high=9,lower=0, upper=20)$root

p<-1/(1+exp(-b1\*(yr-b0)))

plot(yr,p,type='l')

Age=9

b0=7

k= log(99)/(Age-b0)# solve for K given mid point and age at 99%

Table 2.—Stage- and origin-specific initial abundance used in modeling population dynamics for upper and lower Missouri River Basin pallid sturgeon populations. Values reported as minimum, expected, and maximum values with corresponding sources.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Value | | |  |
| Stage | Basin | Origin | Minimum | Expected | Maximum | Source |
| Juvenile | Lower | Hatchery | 3750 | 4000 | 4250 | 1 |
|  |  | Natural | 0 | 500 | 1000 | 1 |
|  | Upper | Hatchery | 73439 | 97220 | 121025 | 2 |
|  |  | Natural | 0 | 500 | 1000 | 3 |
| Adult | Lower | Hatchery | 18000 | 21500 | 25000 | 1 |
|  |  | Natural | 0 | 500 | 1000 | 1 |
|  | Upper | Hatchery | 275 | 480 | 687 | 2 |
|  |  | Natural | 129 | 158 | 193 | 4 |

1 K. Steffensen personal communication

2 Rotella (2013)

3 Unknown; assumed to be similar abundances to lower basin

4 Braaten et al. (2009)

Table 3.—Stage- and origin-specific survival rates used in modeling population dynamics for upper and lower Missouri River Basin pallid sturgeon populations. Values reported as minimum, expected, and maximum values with corresponding sources.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Value | | |  |
| Basin | Survival | Minimum | Expected | Maximum | Source |
| Lower | S0 | 0.02 | 0.051 | 0.1 | 1 |
|  | S\_a = 1 | 0.60 | 0.686 | 0.75 | 1 |
|  | S\_a>=2 | 0.9 | 0.922 | 0.95 | 1 |
| Upper | Age-0 | 0.02 | 0.051 | 0.1 | 1a |
|  | Age-1 | 0.423 | 0.633 | 0.83 | 2b |
|  | Age-2 | 0.64 | 0.81 | 0.97 | 2b |
|  | Age-3 | 0.82 | 0.92 | 1 | 2b |
|  | Age-4+ | 0.71 | 0.82 | 0.94 | 2b |

1 Steffensen et al. (2013a)

2 Hadley and Rotella (2009)

a Age-0 survival estimates were unavailable, therefore lower basin estimates used.

b Survival values are average of values reported for RPMA1, RPMA2, and RPMA3.

# References

Braaten, P. J., D. B. Fuller, R. D. Lott, and G. R. Jordan. 2009. An estimate of the historic population size of adult pallid sturgeon in the upper Missouri River Basin, Montana and North Dakota. Journal of Applied Ichthyology 25:2-7.

Hadley, G. L., and J. Rotella. 2009. Upper basin pallid sturgeon survival estimation project.

Keenlyne, K. D., E. M. Grossman, and L. G. Jenkins. 1992. Fecundity of the Pallid Sturgeon. Transactions of the American Fisheries Society 121:139-140.

Keenlyne, K. D., and L. G. Jenkins. 1993. Age at sexual maturity of the pallid sturgeon. Transactions of the American Fisheries Society 122:393-396.

Reynolds, S., and A. J. Tyre. 2011. A life history model for pallid sturgeon. University of Nebraska-Lincoln.

Rotella, J. 2013. Upper basin palid sturgeon survival estimation project-2010 update. Pages 46 *in* U. b. p. s. w. group, editor.

Steffensen, K. D., M. A. Pegg, and G. Mestl. 2013a. Population prediction and viability model for pallid sturgeon (Scaphirhynchus albus, Forbes and Richardson, ) in the lower Missouri River. Journal of Applied Ichthyology 29:984-989.

Steffensen, K. D., M. A. Pegg, and G. E. Mestl. 2013b. Population characteristics of pallid sturgeon (Scaphirhynchus albus(Forbes & Richardson, )) in the Lower Missouri River. Journal of Applied Ichthyology 29:687-695.