Snake River White Sturgeon Model, v. 1.6 August 2004 **Selina Heppell, Oregon State University**

This sheet is designed to allow the user the ability to manipulate various input parameters to compare management strategies for a given set of life history parameters, shown on the "Vital Rates" sheet. The output on this sheet is generated by models on the various other sheets in this workbook. The red numbers are the variables that can be manipulated. The F9 key will re-calculate the formulas, but keep in mind that due to the large amount of data being calculated, this process may take several minutes depending on processor speed. All worksheets are locked except for this one, to avoid unintentional alterations of the program. Contact selina.heppell@oregonstate.edu for password or if bugs are detected.

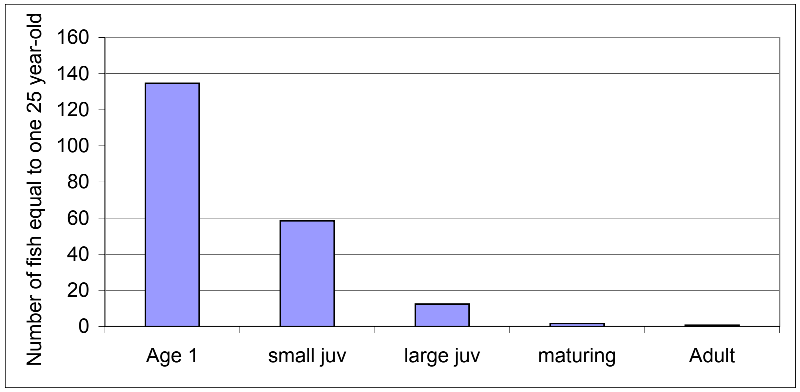
This model is a female only, deterministic matrix based on the age specific information on the worksheet called "vital rates". Age-length, length weight, and fecundity equations are based on data presented in the Tuell-Everett report (2002) and DeVore(1995)

This chart represents the "adult equivalents" (AE) or, the number of 1 year olds or juveniles that would need to be produced to replace one female of the age you specify. This is based on the reproductive value of the fish. This information can be used to
a) compare the relative "risks" of different mortality sources that kill individuals of particular age/size classes, using a common currency of adult value
b) determine the number of individuals that must be generated (i.e., hatchery production) or saved to mitigate for the loss of an adult of a particular age.

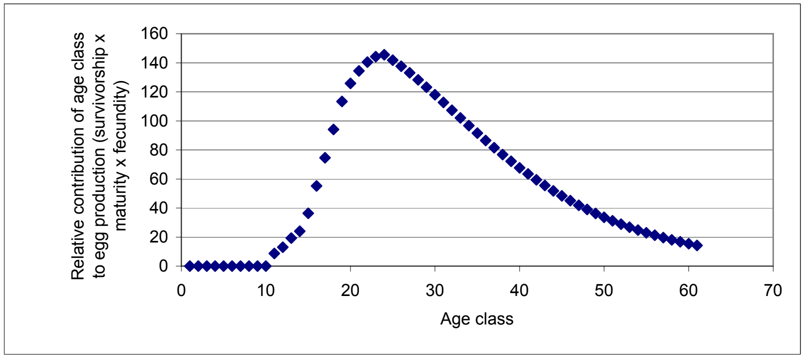
Because the AE are dependent on the vital rates used in the model, which may be very uncertain, and are based on a population at stable age distribution, these results should be compared qualitatively.

The example shown is the calculated equivalents for a 25 year-old female.

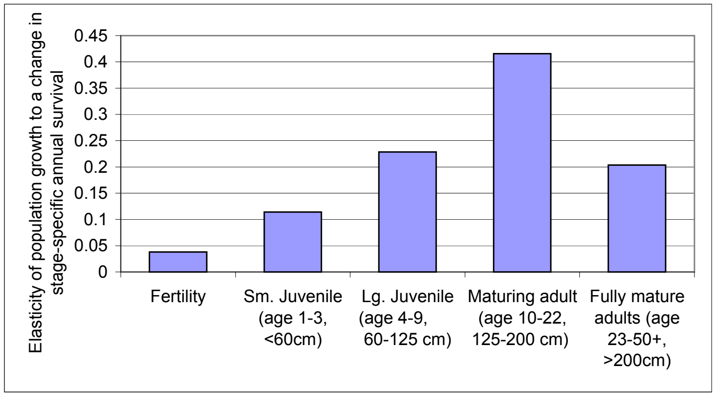
Age of fish you would like to calculate equivalents for:
25
size: 215.9415



This next chart represents the contribution of each age class to egg production. For each age class it is determined by the proportion of females within each age class, as well as their fecundity. Although older female fish produce more eggs, there are fewer of them in the total population, so their contribution decreases.



Elasticity Analysis -
In this graph, each bar represents the proportional contribution of the survival rates in each age class to the population growth rate, lambda. Management objectives can influence specific age classes; for this population, a proportional change in the survival rates of fish in the Maturing Adults stage would have the greatest effect on lambda.



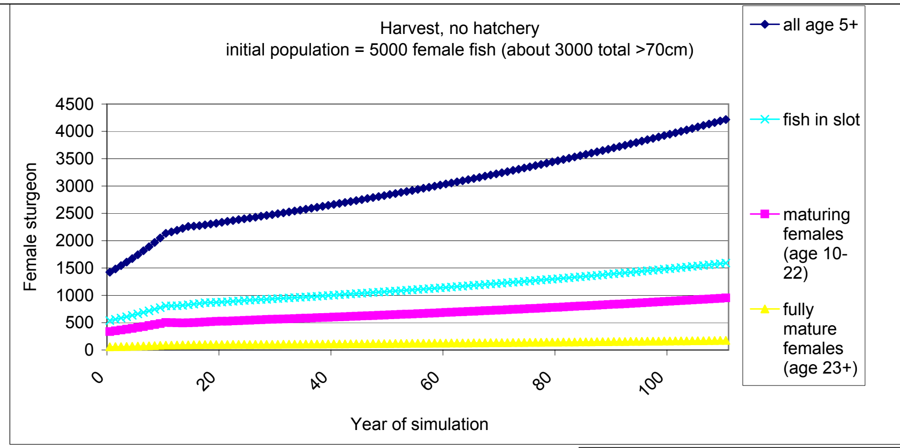
This model is designed to calculate various life table metrics with a range of harvest values, with and without hatchery input. To run this program, you will need an Excel add-in called "PopTools", written by which is available through the CSIRO Website (www.csiro.au).

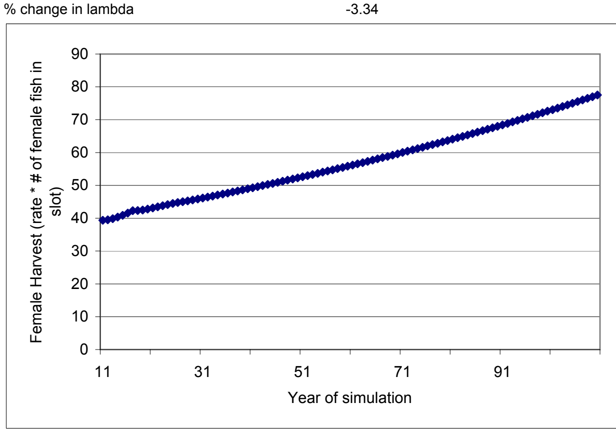
There are several parameters that can be manipulated to simulate harvest, including bycatch mortality. On subsequent worksheets, a time series of the age distribution is simulated deteriminstically and stochastically, with harvest starting in year 10 and an initial population (year 0) of 10,000 fish (both sexes) that is at a stable age distribution (= about 3000 fish >=75 cm, age 5).

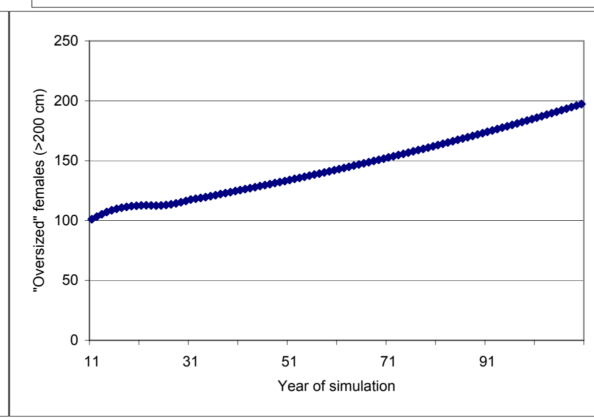
The harvest level shown is in terms of female fish. The total harvest will depend on the sex ratio in the slot limit.

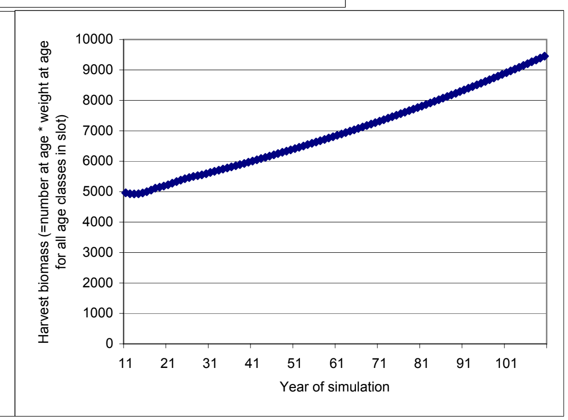
There is no density-dependent compensation in the model, so the population growth rate must decrease with added harvest. The population growth rate for this population has not been determined. In the model, the growth rate "Lambda" is a deterministic, exponential rate of increase that is largely dependent on unknown parameters for average survival of eggs to age 1. Because this survival rate is uncertain, it is important to use this model to compare *changes* in lambda, rather than the rates themselves. Likewise, the number of fish that can be harvested without causing a population decline will not be accurate until this survival rate can be determined.

Initial population	5000			
Wild egg survival (average)	0.0008			
YOY survival to age 1	0.5000			
Proportion of adult females to hatchery	0.00			
Hatchery egg survival	0.00			
Hatchery sex ratio	0.00			
Harvest				
min size	110.00	min age	8	
max size	180.00	max age	18	
rate (F)	0.05			
release mortality - oversize	0.02	"Oversize"	200	
release mortality - undersize	0.02	age	21	
release fertility reduction	0.10			
		% per year change		
lambda without harvest	1.0413966	4.139659		
lambda with harvest	1.0065852	0.658522		
change in lambda	-0.03			
% change in lambda	-3.34			









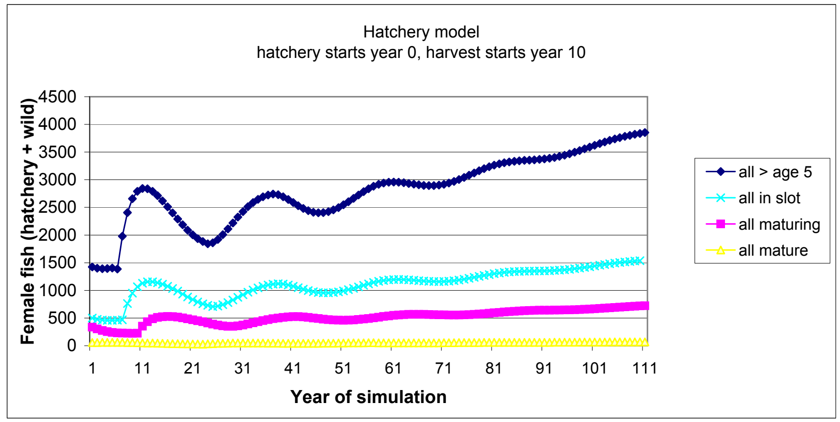
Now we add a hatchery. A constant proportion of wild and hatchery-born females are stripped in the hatchery each year, then returned to the river. Note that this means an increasing number of female fish are stripped each year if the population is increasing. The hatchery in this model rears larvae to age 1. Upon release, the model keeps track of the hatchery and wild population separately (female only).

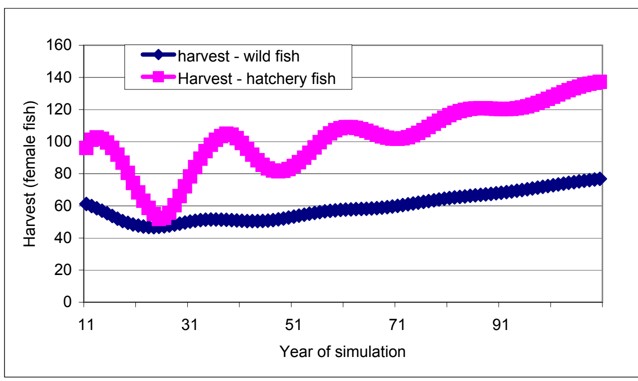
Parameters to specify include the age classes of fish used as broodstock, survival rate of their eggs to age 1 in the hatchery (default is 10x natural survival rate), and a multiplier for the survival rate of hatchery-born juveniles after release. This multiplier allows you to specify a decreased annual survival rate for ages 1-3 years (e.g., a multiplier of 0.9 says that hatchery-born juveniles have a 10% lower survival rate than wild fish of the same age), the same survival rate as wild fish (hjs=1.0) or an increased survival rate (hjs>1.0), which might occur if hatchery-reared fish are larger than wild juveniles of the same age. After age 3, hatchery and wild fish have the same survival rates.

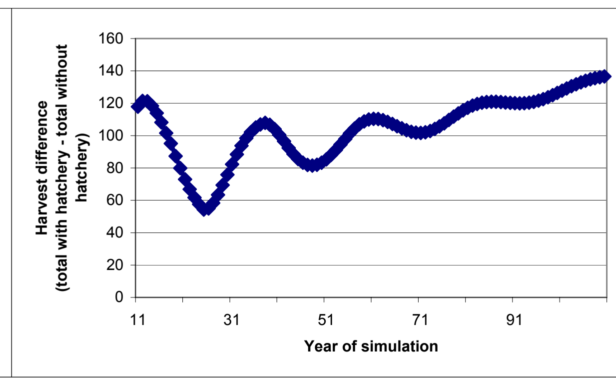
With a hatchery in place, there could be regulations and hatchery fish tagging or marking that restricts harvest to hatchery fish. You can specify the proportion of harvest that is hatchery-born - if "proportion F hatchery fish" = 1.0, all harvest mortality is directed at hatchery fish only.

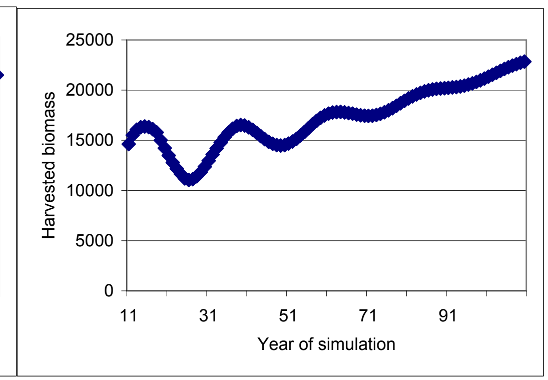
Wild egg survival (average)	0.0008		
YOY survival to age 1	0.5000		
Minimum age of females to hatchery	18.0000		
Maximum age of females to hatchery	30.0000		
Proportion of adult females to hatchery	0.0100		
Survival rate of hatchery broodstock	same as wild		
Hatchery egg survival rate to YOY	0.0500		
Hatchery-bred small juvenile survival multiplier	0.9000	age 1-3	
Harvest			
min size	110.00	min age	8
max size	180.00	max age	18
rate (F)	0.30		
prop F hatchery fish	0.50		
release mortality - oversize	0.02		
release mortality - undersize	0.02		
release fertility reduction	0.10	min age	10

lambda without harvest **1.0414**
Lambda with harvest, no hatchery **1.0066**
lambda with hatchery + harvest **1.0061**

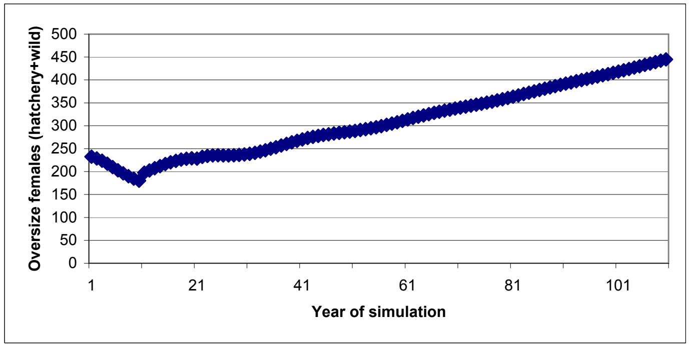


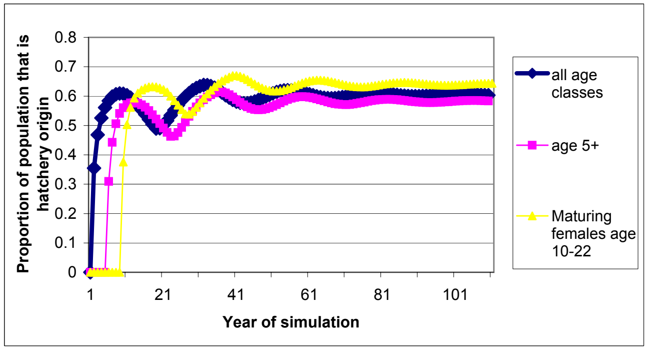






If harvest is restricted to hatchery fish, there will be fewer fish available for harvest until the hatchery population "catches up"


Oversize females (hatchery+wild)
500
450
400
350
300
250
200
150
100
50
0
1
21
41
61
81
101
Year of simulation


Proportion of population that is hatchery origin
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
21
41
61
81
101
Year of simulation
all age classes
age 5+
Maturing females age 10-22