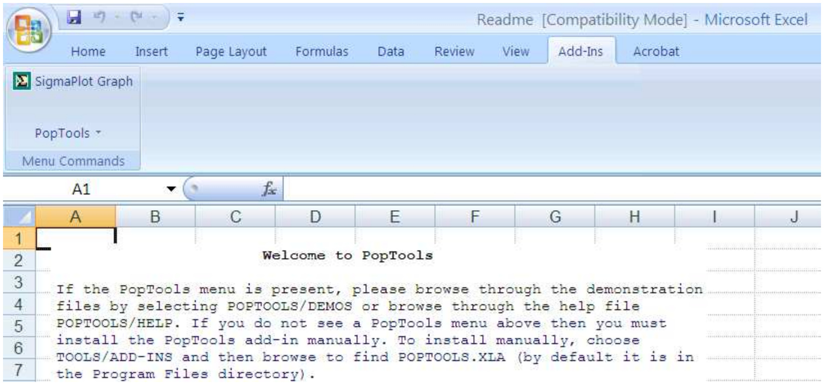
Name: KEY Email: ______________________________ MARS 6920_Spring 2010

1) *Introduction: Upload PopTools (http://www.cse.csiro.au/poptools/download.htm)*

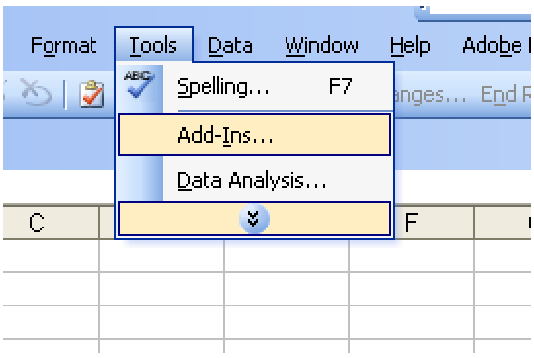
- *Install Add-in and activate the module in Excel*
- *Add-in will start automatically, if using MS Excel 2007:*

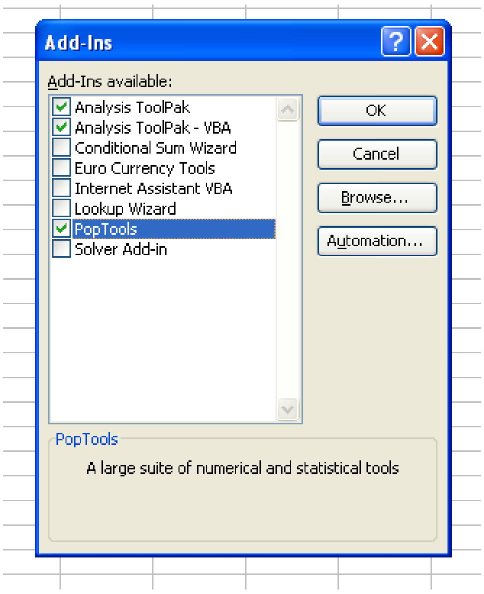



- *Otherwise, you may need to activate "Add-In" in Excel 1997*

  *(Go to Tools -> Add-Ins)*

- *Activate PopTools*
- *Read the intro provided in the: Welcome to PopTools*



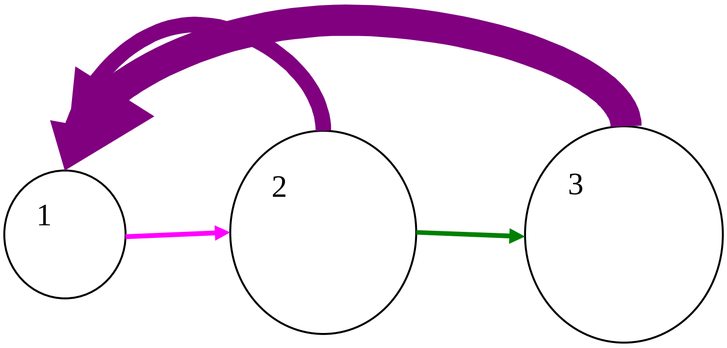

- *Read the demo provided online: http://www.cse.csiro.au/poptools/matrices.htm*

2) *Data Analysis: Type the matrix you created in the previous hw into an Excel sheet and use PopTools to analyze the data.*

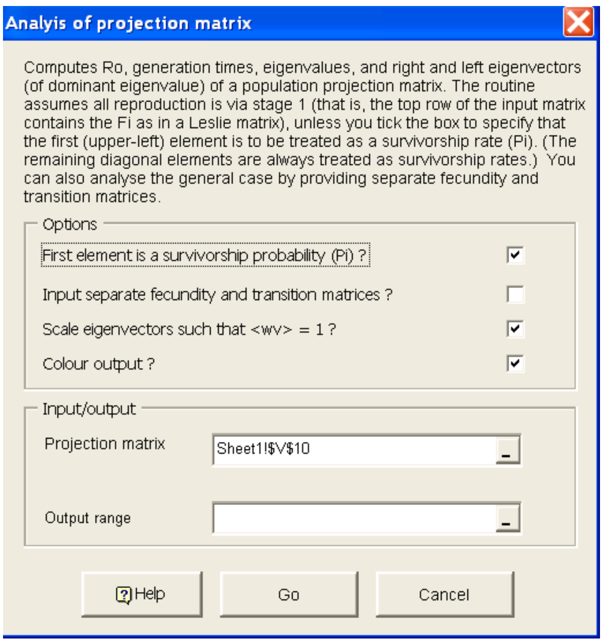
| | | |
|---|---|---|
| ***0.0*** | ***2.0*** | ***4.0*** |
| ***0.6*** | ***0.0*** | ***0.0*** |
| ***0.0*** | ***0.6*** | ***0.0*** |

- *Using the following menu selection, draw a life cycle diagram:*

  *PopTools -> Matrix Tools -> Draw Life Cycle (check out the various options)*




- *Use PopTools to analyse these data: PopTools -> Matrix Tools -> Basic Analysis*
- *Use these default settings:*




- *First element is a survivorship*
- *DO NOT input fecundity and transitions matrices separately (all data in same matrix)*
- *Scale eigenvectors to*
- *Color output is NICE*

*NOTE: Make sure you highlight at least four blank columns where results will go. Otherwise, the PopTools program will give you error message.*

Name: KEY Email: ___________________________ MARS 6920_Spring 2010

- *Report the Population Lambda using PopTools.* $\lambda$ = **1.48**

- *How does this value compare to the "equilibrium" Lambda you calculated using the matrix projections in the last hw?*

The two lambda values calculated from hw 5 are larger (2.40) and smaller (1.05) than the "equilibrium" lambda from PopTools.

- *Why do the values from the projections from the last homework for time steps 0-1 and 1-2 differ from the Lambda value you calculated with PopTools?*

The larger and smaller lambda values are caused by the transient (short-lived) fluctuations in the population size during the first few generations. These are caused by the fact that the starting population structure was different from the equilibrium population structure we end up with.

Basically, the rate of growth was not the same as it would be at equilibrium, once the size structure equilibrates (the proportions of the various age classes do not change). Nevertheless, the lambda of the population does stabilize at 1.48.

- *Write down the two population growth formulations (discrete time / continuous time) if there is no density dependence (i.e. no carrying capacity).* **Use a calculator to calculate the instantaneous population growth rate ( r ) from the Lambda value above.**

DISCRETE=linear

$Nt = No * R^{t}$

CONTINUOUS=exponential

$Nt = No * e^{rt}$

Note: LAMBDA = R

R= N(t+1) / N(t) = 1.48 r: =intrinsic rate of growth = (birth rate – death rate)

$Nt = No (lambda)^{t} = No*e^{rt}$ Remove No from both sides of the equation (divide by No)

$(lambda)^{t} = e^{rt}$ Simplify by assuming we are dealing with one time step (t=1)

$Lambda = e^{r}$ Take the ln of both sides

Ln (lambda) = r

Ln (1.48) = 0.39 = r

- *Calculate the elasticity of the demographic parameters with PoopTools and enter the values in grid below (Use: PopTools -> Matrix Tools -> Matrix Elasticity) Check that the elasticities add to 1 (circle one):* (**YES** / No)

| | | |
|---|---|---|
| 0 | 0.225 | 0.183 |
| **0.408** | 0 | 0 |
| 0 | 0.183 | 0 |

*What is the most elastic demographic parameter?* **Survival from age 1 to age 2 (BOLD)**

- *Based on this result, would the population growth increase faster if we protected (decreased mortality) of age 2 or of age 3 individuals? Explain your answer:*

To obtain the highest population level response (growth in Lambda), we should protect age 2 individuals because their survivorship elasticity (0.183) is much larger than the survivorship elasticity of age 3 individuals (0). If you go to the Leslie Matrix shown above, you will see that S(age 2) = 0.6, and S(age 3) = 0. This may seem counterintuitive, because age 3 individuals reproduce more, yet age 3 survivorship will give us the best return, if we increase the probability that age 2 individuals will make it to age 3.

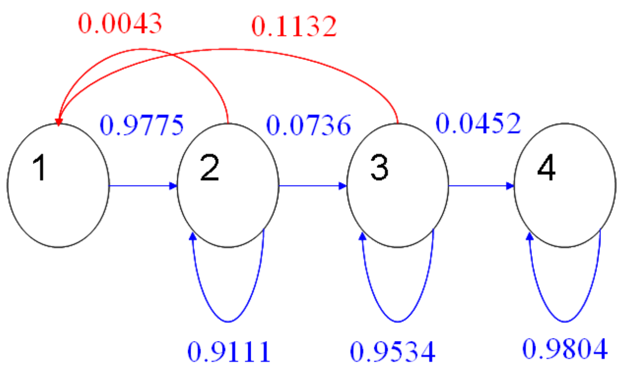
3) *Finally, enter these demographic data into a Leslie Matrix and use PopTools to calculate the following: Lambda, r, age-specific reproductive value, age-specific population structure (% of individuals), elasticities of the demographic parameters*

Check out the values are pasted below, obtained from the 'basic analysis' menu, as described on page 1.

| | | | |
|---|---|---|---|
| Eigenvalues | | Eigenvectors (R&L) | |
| Real | Imaginary | Age/stage struct | Reprod val |
| 1.475178901 | 0 | 63.6% | 0.642073165 |
| -0.737589451 | -0.657354237 | 25.9% | 1.57862131 |
| -0.737589451 | 0.657354237 | 10.5% | 1.741004199 |
| r | 0.388779271 | (rate of increase) | |
| Ro | 2.64 | (expected number of replacements) | |
| T | 2.496992481 | (generation time - time for increase of Ro) | |
| mu1 | 2.545454545 | (mean age of parents of offspring of a cohort) | |
| N (fundamental matrix) | | | |
| 1 | 0 | 0 | |
| 0.6 | 1 | 0 | |
| 0.36 | 0.6 | 1 | |
| R (expected lifetime production) | | | |
| 2.64 | 4.4 | 4 | |

Name: KEY Email: ______________________________ MARS 6920_Spring 2010

***Killer Whales:*** *Age First Reproduction: 13, Maximum Age: 60*




*Use the diagram above to figure out these age-specific demographic rates:*

| Age Class | Annual Survivorship Rate | Annual Mortality Rate |
|---|---|---|
| 1 | **0.9775**<br><br>**(all move into age class 2)** | 1-0.9775 = **0.0225** |
| 2 | 0.0736+0.9111=**0.9847**<br><br>**(move into age class 3 or stay)** | 1-0.9847 = **0.0153** |
| 3 | 0.0452+0.9534=**0.9986**<br><br>**(move into age class 4 or stay)** | 1-0.9986 = **0.0014** |
| 4 | **0.9804**<br><br>**(stay in age class 4)** | 1-0.9804 = **0.0196** |

*Using the life cycle above answer these questions:*

- *What age class should have the highest reproductive value? Explain*

Age 3 because they have the highest reproductive rate: because these individuals produce more offspring on average (0.1132) than age 2 individuals (0.0043). Moreover, they have a high survivorship rate, so they will have future reproduction. Remember that reproductive value involves current reproduction + future reproduction (discounted by the probability of getting to that age).

The reasons for higher fecundity at older age (more mature individuals) makes sense because as the whales become older and larger, perhaps they can provide better for their calves… or perhaps they have more experience. Another consideration is that first-born mammals (especially cetaceans and pinnipeds) inherit the pollutant loads from their mothers, so they often have lower weights and may have lower survivorships.

- *What should be the reproductive value of age 4 whales? Explain*

Their reproductive value is 0 because they do not reproduce at that age – or in the future.

- *What could be the role of these older whales – if they do not get to breed anymore, but still live for many years?*

Older female killer / pilot whales play an important role in the 'culture' of the pods, which are organized as matrilineal lineages. Older females may act as "granmas" nursing the young communally and may also serve as the pod's memory of foraging grounds / migratory routes.

- *Why do age 1 whales have a higher reproductive value than age 4 whales, if neither age class reproduces? Explain.*

Assuming age 1 whales survive, they will reproduce in the future. Remember that their reproductive value equals current reproduction + future reproduction. The current reproduction is 0 for both ages 1 and 4, but age 1 individuals have a higher potential for future reproduction, whereas age 4 individuals have no potential for future reproduction.

*Enter these demographic data into excel and use PopTools to calculate the following: Lambda, r, age-specific reproductive value, age-specific population structure (% of individuals), elasticities of the demographic parameters. Copy and paste output from PopTools below. Explain which demographic parameters are the most / least elastic.*

| **Eigenvalues** | | **Eigenvectors (R&L)** | |
|---|---|---|---|
| **Real** | **Imaginary** | **Age/stage structure** | **Reproductive value** |
| 1.025441326 | 0 | 3.7% | 1.1416316 |
| 0.9804 | 0 | 31.6% | 1.1976228 |
| 0.834222976 | 0 | 32.3% | 1.793869 |
| 0.004835698 | 0 | 32.4% | -0 |
| **r** | 0.025123081 | (rate of increase) | |
| **Ro** | 2.013144018 | (expected number of replacements) | |
| **T** | 27.85079093 | (generation time - time for increase of Ro) | |
| **mu1** | 33.20383049 | (mean age of parents of offspring of a cohort) | |
| **N (fundamental matrix)** | | | |
| 1 | 0 | 0 | 0 |
| 10.99550056 | 11.24859393 | 0 | 0 |
| 17.36628415 | 17.76601959 | 21.45922747 | 0 |
| 40.04877773 | 40.97061661 | 49.4876062 | 51.020408 |
| R (expected lifetime production) | | | |
| 2.013144018 | 2.059482372 | 2.429184549 | 0 |

**Table 1**: Results from PopTools Basic Analysis of Leslie matrix created from the killer whale life cycle.

The population is growing, as evidenced by the Lambda = first real eigenvalue =1.025 (r = 0.025).

Name: KEY Email: ______________________________ MARS 6920_Spring 2010

| | |
|---|---|
| λ | 1.025441326 |
| r | 0.025123081 |

The stable population structure shows the following relative age class composition:

| Elasticities | | | |
|---|---|---|---|
| 0 | 0.001513103 | 0.040695 | 0 |
| 0.042208255 | 0.336325827 | 0 | 0 |
| 0 | 0.040695151 | **0.538563** | 0 |
| 0 | 0 | -0 | **-0** |

| Age/stage structure | Reproductive value |
|---|---|
| 3.7% | 27.6% |
| 31.6% | 29.0% |
| 32.3% | 43.4% |
| 32.4% | 0.0% |

The elasticities - which add to 1 - are as follows:

| | | | |
|---|---|---|---|
| 0 | 0.001513 | 0.040695 | 0 |
| 0.042208 | 0.336326 | 0 | 0 |
| 0 | 0.040695 | 0.538563 | 0 |
| 0 | 0 | -0 | -0 |

**The survivorship of age 3 (from age 3 to age 3) is the most elastic parameter (elasticity = 0.5385)**

**The survivorship of age 4 (from age 4 to age 4) is the most inelastic parameter (elasticity = 0)**

**The transition from age 3 to age 4 is the most inelastic parameter (elasticity = 0)**

*To finish the assignment, try changing the rates in the population matrix to get the population to go from growth (Lambda > 1) to decline (Lambda < 1). Using the elasticity results from PopTools, first change the most "elastic" parameter and figure out how much you need to change it to get the population to* *decline. Then, change the most "inelastic" parameter. Try through trial-and-error, try to get as close as you can to Lambda = 1 (so the population would not decline).*

*Report the starting parameter values (in the original matrix) and the ending parameter values (the ones you uses to get to Lambda = 1). Also report the final Lambda values.*

**Most Elastic Parameter:**

lambda: 0.9941
start parameter: 0.9534
end parameter: 0.8900

decrease by 0.0634 or 6.6%

**Least Elastic Parameter:**

lambda: 1.000
start parameter: 0.0043
end parameter: 0.0270

increase by 0.0227 or 527%

A much greater (proportional) change in the inelastic parameter is needed to compensate for a smaller (proportional) change in a highly elastic parameter.