BioVeL – Biodiversity Virtual e-Laboratory

Workflow Documentation

Killer whale demography workflow
Portal execution

September 2014

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1. Sources of help

You can obtain help with using BioVeL workflows and services from 3 places:

1) From the BioVeL documentation website, here: https://wiki.biovel.eu/x/BIBp
2) By using the BioVeL community discussion Forum on our website, www.biovel.eu. If you have questions go to the Forum by clicking the grey button shown below and post your help request or question there.

By emailing to support@biovel.eu
2. Input files for tutorial

The workflow accepts input data in a .csv, comma delimited. The examples input files for the tutorial are available and described below. In this tutorial, two input files are used.

2.1 Input data

To download click here on the file name or they can be downloaded at myExperiment (http://www.myexperiment.org/packs/667.html):

*Orcinus orca* input data:
- **NRKW_R** or **SRKW_R**
- **VR combined**

**NRKW_R** or **SRKW_R**: The input data (a .csv-file) has to have the format of a table containing the *Orcinus orca* demographic data with the columns named: Year, Age, Count, Offspring and Cat1. Each year, the number of individuals per age and the number of offspring per age reproductive female category are counted (females ≥ 10 years old). IF A Female category does not have offspring equals to 0. For the called column, Cat1; Ages 1 to 9 belongs to Juv (Juveniles) and 10 to 88 (this tutorial) belongs to Female or Male. Juv and Male categories must have a NA offspring.
The stage-structured life cycle of resident killer whales with seven life stages: (1) calves; (2) juveniles; (3) young reproductive females; (4) old reproductive females; (5) post-reproductive females; (6) young mature males; and (7) old mature males. Fi represent fertility; Gi represent stage transition probabilities, with female and male juvenile-to-adult transitions indicated as G2f and G2m, respectively; and, Pi represent the probability of surviving and remaining in stage i.

The input data (a .csv-file) has to have the format of a table containing the survival and fecundity rates per stage, per year, per population of the Orcinus Orca. E.g. Calf_surv_S = 0.75 will the survival value of the first year (in this case 1987) of the SRKW calves stage.
2.1 Related publications


3. Tutorial:

This workflow analyses the demography and population growth of resident killer whale populations. Originally created for comparative studies of North-eastern Pacific populations at risk, Southern Resident Killer Whales (SRKW) and the Northern Resident Killer Whales (NRKW), the workflow can be used for other killer whale populations or cetaceans counting with census data and life cycles that can be represented using the matrix models described in this document.

This workflow performs the following analyses:

• Vital rates estimation and probability distributions
• Construction of Birth-flow Matrix Model
• Eigen analysis
• Elasticity analysis (deterministic and stochastic)
• Damping time

This tutorial explains the type of input data needed to run the workflow. The corresponding analysis use data from two distinct *O. orca* populations in Canada, Southern Resident Killer Whales (SRKW) and the Northern Resident Killer Whales (NRKW).

Two distinct populations of resident killer whales (*Orcinus orca*) in the north-eastern Pacific Ocean have been identified in Canada and the U.S. as being of conservation concern. The Southern Resident Killer Whale (SRKW) population is currently listed as endangered under the U.S. Endangered Species Act on the grounds of its small population size and vulnerability to demographic stochasticity and catastrophic events such as oil spills (NMFS 2008). In Canada, under the Species At Risk Act (COSEWIC 2008), SRKW is listed as endangered due to its small and declining population size while the Northern Resident Killer Whale (NRKW) population is listed as threatened due to its small population size. The major threats identified for these two populations are nutritional stress associated with prey abundance levels and availability, particularly Chinook salmon (*Oncorhynchus tshawytscha*) (COSEWIC 2008, Ford et al. 2010a, 2010b), pollution and contaminants, and disturbances from vessels and sound (COSEWIC 2008, NMFS 2008). An important difference in the population-size trajectories of these two populations is that, in spite of their home range overlap and potential access to similar resources, SRKW has remained at a population size of less than 100 individuals for the last four decades with an average of 85 individuals in the last decade. NRKW population size has been generally increasing for the last four decades with 268 individuals at the end of 2011.
Killer whale demography workflow

In your browser (preferably Firefox or Chrome) navigate to the BioVeL Portal page (http://portal.biovel.eu/) and log in with your username and password (1). You will need to register if you have not already done so.

Choose the Population Modelling analysis and click, this will show you a list of relevant analysis:

On the resulting page choose the workflow Killer whale demography (1) you can also directly run the workflow using the 'Run workflow' button at the bottom-right (2).

On the resulting page click on the 'Run Workflow' button at the top (1).
Killer whale demography workflow

On the next page you can edit the name of the workflow run to make it easier for you to identify it later (e.g. *Killer whale demography_1*).
Killer whale demography workflow

3.1 Input Ports

3.1.1 Data

**KWDataFile**: it’s a .csv file. Population File. This is a .csv file with the census data (i.e., counts) by age and group (juvenile, male or female) for the study population. For animals of uncertain year of death, amortized partial values were used. For instance, an animal with probable death over a span of two years was counted as 0.5 for the first year and 0.0 for the second year. Here, two files can be used as input: SRKW_R.csv or NRKW_R.csv

To open the file, Click in choose file, a window dialog appears and the user selects the file e.g. SRKW_R.csv and then clicks the Open button.
**Killer whale demography workflow**

**VR_combined**: Time series of vital rates (fecundity and survival by life stage) for both populations. To open the file, Click in choose file, a window dialog appears and the user selects the file e.g. VR_combined.csv and then clicks the Open button.

### 3.1.2 Parameters

To determine the parameters, type in each box the value of the variable (1).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EndYear</strong></td>
<td>Last year to be considered in the analysis.</td>
<td>e.g.: 2011</td>
</tr>
<tr>
<td><strong>Population</strong></td>
<td>It is the name of the analysed population.</td>
<td>e.g.: SRKW</td>
</tr>
<tr>
<td><strong>Sims</strong></td>
<td>Number of simulations that are used for generation of stochastic vital rate elasticities. This input indicates the number of stochastic matrices generated from randomly drawn vital rates. After computing population growth and elasticities for each of these matrices, a bootstrap is used to compute stochastic population growth and mean elasticities and their 95% confidence intervals.</td>
<td>e.g.: 10000</td>
</tr>
<tr>
<td><strong>Standr_Data</strong></td>
<td>Use standardized data? YES or NO</td>
<td>e.g.: NO</td>
</tr>
</tbody>
</table>
**Killer whale demography workflow**

**StartYear:** First year to be considered in the analysis.

  e.g.: 1987

After the user has filled out the input ports and has clicked the **Start Run**, the workflow performs the analysis. To complete all the analysis may take few minutes, depends on the number of **Sims** to carry out the analyses.

### 3.3 Outputs

Once the analyses are finished, the user can download all the results by clicking Download value button (1). Numerical and graph results will be download as a zip file that can be save by the user. The numerical results are .csv files than can be opened with Excel and the plot files are .PDF files. A second result is the PostWorkspace, a zip file that is needed to run the second workflow: Exploration of fishing scenarios workflow.
3.3.1 Results

**Alive End Year Population (csv):** Percentage of individuals alive in the last year of the study by year of birth. The sum of percentages for the selected time period indicates the number of individuals born during the study and alive the last year.

![Alive 2011 SRKW.csv](Alive 2011 SRKW.csv)

**Alive End Year Population (pdf):** Graphical output for “Alive End Year Population”

![Alive 2011 SRKW.pdf](Alive 2011 SRKW.pdf)
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Counts and Proportions T0 Population Start year-End year (csv): Number of individuals and relative proportion by stage in the last year of the selected time period. These proportions are used to represent initial conditions for projections.

Counts and Proportions T0 Population Start year-End year (csv)

Counts by Year Population Start year-End year (csv): Number of individuals by life stage (calves, juveniles, young reproductive females, old reproductive females, post-reproductive females, young mature males, and old mature males) and year through the selected time period. Last column represents total population size.

Counts by Year SRKW 1987-2011
Damping Time Population Start year-End year (txt): Damping time ($\tau$) is defined as $\tau = \ln(z)/\ln(\rho)$, where $\rho$ is the damping ratio and $z$ is the number of times the contribution of $\lambda_1$ (dominant eigenvalue) becomes as great as that of $\lambda_2$ (subdominant eigenvalue). Damping times at $z = 10$ were used to define minimum time horizons for projections of population size.

Damping Time SRKW 1987-2011

Det. VRs Sensitivity and Elasticity Population Start year-End year (pdf): Graphical output for sensitivities and elasticities of vital rates (survival, fecundity and stage transition probabilities)

Det. VRs Sensitivity and Elasticity SRKW 1987-2011
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Effects of changing KW VRs Population Start year-End year (pdf): Graphical output showing the response of population growth rate to hypothetical vital rate values ranging from 0.0 to 1.0. Some of these values could be biologically unfeasible (e.g., a fecundity rate of 1.0 would indicate every year all females in the stage produce a viable calf).

![Graphical output showing the response of population growth rate to hypothetical vital rate values ranging from 0.0 to 1.0. Some of these values could be biologically unfeasible (e.g., a fecundity rate of 1.0 would indicate every year all females in the stage produce a viable calf).]

Effects of changing KW VRs SRKW 1987-2011

Eigen Analysis (txt): Dominant eigenvalue (asymptotic population growth rate), stable stage distribution, sensitivities, elasticities, reproductive value, and damping ratio based on mean matrix of selected population.

![Eigen Analysis (txt): Dominant eigenvalue (asymptotic population growth rate), stable stage distribution, sensitivities, elasticities, reproductive value, and damping ratio based on mean matrix of selected population.]

Eigen Analysis (opens in excel)
**Killer whale demography workflow**

**MeanMatrix Population (csv):** Two-sex, stage structured matrix based on mean vital rate (survival and fecundity) values for the selected time period. A birth-flow matrix model is used with seven life stages and fixed transition probabilities based on stage duration (details in Vélez-Espino et al. 2014).

<table>
<thead>
<tr>
<th>Stage</th>
<th>Birth Rate</th>
<th>Survival Rate</th>
<th>Fecundity Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackal</td>
<td>0.05050505</td>
<td>0.65065065</td>
<td>0.05050505</td>
</tr>
<tr>
<td>Offspring</td>
<td>0.01010101</td>
<td>0.99099099</td>
<td>0.01010101</td>
</tr>
<tr>
<td>Adult</td>
<td>0.00000000</td>
<td>0.99999999</td>
<td>0.00000000</td>
</tr>
<tr>
<td>Elderly</td>
<td>0.00000000</td>
<td>0.99999999</td>
<td>0.00000000</td>
</tr>
</tbody>
</table>

**Stable Stage Projection SRKW 1987-2011**

Stable Stage Projection Population Start year – End year (pdf): Graphical output showing the change in stage composition with time towards stable stage distribution. Initial values correspond to counts and proportions in the last year of the study.
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**Stable State Values Population Start year – End year (csv):** Long-term projections of population size by life stage based on transient dynamics.

**Note:** If the user used ≥ 1850 Sims, you need to open the file as follows:
1. Open excel (versions 2007 onwards)
2. Go to Data tab
3. Click on From text (red oval)
4. Open the Folder where the file *Stable State Values SRKW 1987-2011.csv* is.

6. Follow three steps to open the file
   a. Text import wizard: step 1:
      i. Choose Delimited
      ii. File origin: MS DOS (PC-8)
      iii. Click next
b. Text import wizard: step 2:
   i. Choose Coma delimited
   ii. Click next

c. Text import wizard: step 3:
   i. Click in Advance (red oval) and the Advance Text Import Settings window appears.
   ii. Decimal separator: decimal numbers must be separated by a period, red oval).
   iii. Thousands separator: choose empty space (red oval).
   iv. Click ok
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7. Click in Finish.

8. Import Data window appears, asking Where do you want to put the data, choose Existing worksheet.
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Stable State Values SRKW 1987-2011

Stats by Category Population Start year – End year (csv): Mean and variance of vital rates (survival and fecundity) by life stage. Mean and variance generated from annual values during the selected time period are used to generate vital rate probability distributions (see “Stochastic_Vital_rates”).

Stats by Category SRKW 1987-2011
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Stochastic Elasticity of VR Population (pdf): Graphical output for stochastic elasticities of vital rates based on “Stochastic_Vital_rates”

![Stochastic Elasticity of VR SRKW](image1)

Stochastic Elasticity Stats Population (csv): Mean, median, minimum, maximum, and 95% confidence limits of stochastic elasticities of vital rates.

![Stochastic Elasticity Stats SRKW](image2)
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Stochastic Vital Rates SRKW

Vital rates estimates Population Start year – End year (csv): Vital rate (survival and fecundity) values by year and life stage through the selected time period

Vital rates estimates SRKW 1987-2011
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**VR_combined (.png)**: Box plot with the survival and fecundity probabilities of each stage.
4. References

This workflow was created using and based on Packages ‘popbio’ in R. (Stubben & Milligan 2007; Stubben, Milligan & Nantel 2011), lattice and betareg.


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10:1143-1153.


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