

BioVeL – Biodiversity Virtual e-Laboratory

Workflow Documentation

Orcinus orca (Killer whale) demography and population viability analysis (PVA) workflow for local execution

Augustus 2014

Capacities Programme of Framework 7: EC e-Infrastructure Programme – e-Science Environments - INFRA-2011-1.2.1

Grant Agreement No: Project Co-ordinator: Project Homepage: Duration of Project: Start Date: End Date:



283359 Mr Alex Hardisty http://www.biovel.eu 36 months Sept 2011 Aug 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: <u>https://wiki.biovel.eu/x/BIBp</u>
- By using the BioVeL community discussion Forum on our website, <u>www.biovel.eu</u>. If you have questions go to the Forum by clicking the grey button shown below and post your help request or question there.

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Discussions	mail A Subscribe via rss	🛡 🕝 🛓 Matth	ias 0 +	BioVeL's Meetings
Q, Looking	for something?	Popular Last replied by:	Search	Functioning & Valuation Web Service and Workflows," Budapest, Hungary, Jun 6-7, 2013 • European Biodiversity Informatics Conference, Italy, September 3-6, 2013
<u>=</u>	 posted in Data Refinement Workflow (DRW) By: Alex ⊙ 3 weeks ago Training in DRW posted in Data Refinement Workflow (DRW) By: Kennet Lundin ⊙ more than a month ago 	Peter Last replied by:	0	BioVeL Third Annual Meeting and General Assembly, Budapest, Hungary, September 30-October 4, 2013 BioVeL at Conferences
	masks to choose posted in Ecological Niche Modelling (ENM) By: Sonja Leidenberger	Last replied by:	ovanni	 INTECOL 2013 London, UK, August 18-23, Booth E3 Feed Entries

By emailing to support@biovel.eu

2. Input files for tutorial

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

2.1 Input data

To download click here in the file:

Orcinus orca input data:

- NRKW_R or SRKW_R
- <u>VR_combined</u>

The following files are needed in order to get some necessary results to run (a second workflow), Interaction between killer whale population dynamics and Chinook salmon abundance workflow.

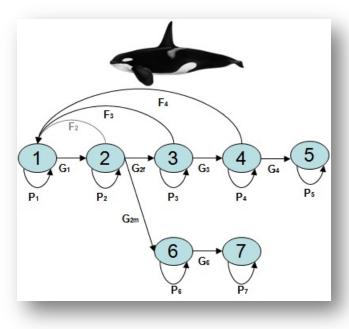
Chinook input data:

- <u>Chinook Ab Definitions R</u> or <u>Chinook Ab Defs FI R</u>
- <u>ChinookAbundance_Data_R</u> or <u>ChinookAbundance_FI_R</u>

<u>NRKW_R</u> or <u>SRKW_R</u>: 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 \geq 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.

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10		1973		9 5.5	NA	Juv									
11		1973			4 NA	Male									
12		1973		0.5	1100	0 Female									
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VR_combined



The stage-structured life cycle of resident killer whales with seven life stages:

- (1) calves; (Calf)
- (2) juveniles; (**Juv**)
- (3) young reproductive females; (F1)
- (4) old reproductive females; (F2)
- (5) post-reproductive females; (F3)
- (6) young mature males; and (M1)
- (7) old mature males (M2).

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.

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	0,75	1	1	0,993055556	1	1	1	0,970238095	1	0,785714286	1	1	1	1	0,15	0,23684
	0	0,857142857	1	0,992647059	1	1	1	0,882051282	1	0,875	0,761904762	1	1	1	0,095238095	0,1647
	1	1	1	0,985078053	1	1	1	1	0,857142857	1	1	1	1	0,974358974	0,05	0,0869
į,	1	1	1	0,973611111				0,948412698	1	0,857142857		0,948412698	1	0,897435897	0,25	0,148
5	0,75	0,983333333	0,94444444	0,980298637	1	0,991656667	1	0,987179487		0,957380952	1	1				0,1443
1	1	1	1	0,941024029	1	0,99	1	1	1	0,9125	1	0,94444444	- 1	0,909863946	0,111111111	0,1176
3	0,833333333	0,95	0,951020408	0,972566097	0,875	1	0,952380952	0,990384615	1	0,623809524	1	1	1	0,958874459	0,222222222	0,0925
ľ.	1	1	1	0,960858294	1	1	1	0,969387755	1	0,967320261	0,857142857	1	0,772727273	0,995192308	0,1	0,1621
0	1	0,857142857	1	0,966741871	1	1	0,875	0,988095238	1	0,824242424	0,833333333	1	0,9	0,985294118	0,181818182	0,0877
1	1	0,875	1	0,969385027	1	0,966356024	0,915714286	0,985714286	0,625	0,71484375	1	0,99905643	0,9	0,914393939	0,166666667	0,1152
2	NA	0,846153846	0,94375	0,970779221	1	0,989472728	1	0,985185185	1	0,939068101	1	0,999029514	0,777777778	0,818796992	0	0,2062
3	1	1	0,94047619	0,941666667	0,9	0,989256037	0,953703704	0,977460317	1	0,873809523	1	0,932962301	0,666666667	0,8	0,083333333	0,1202
4	0,333333333	1	1	0,983004386	0,955	0,970654319	0,808333333	0,979259259	1	0,689618332	1	0,97963928	0,928571429	0,773148148	0,12	0,1130
5	0,666666667	0,666666667	1	0,922341721	1	0,97	0,857142857	0,9666666667	1	0,875	0,9	0,941666667	0,571428571	0,819607843	0,12	0,0774
6	0,666566667	0,875	1	0,969405594	0,975	0,986749049	1	1	1	1	1	0,989015278	1	0,9375	0,170212766	0,1156
7	1	0,9	1	0,97092803	1	1	1	1	0,8	1	1	0,94444444	0,8	0,941176471	0	0,1186
8	0,833333333	1	1	0,994565217	1	1	1	1	0,77777778	0,9375	1	1	1	1	0,22727272727	0,0780
9	1	0,971428571	1	0,979707792	1	1	1	0,986111111	1	0,875	1	1	1	1	0,043478261	0,2015
0	0,714285714	0,875	0,785714286	0,94407994	1	0,969009158	1	0,981481481	0,875	0,75	1	0,997693316	1	0,921052632	0,166666667	0,1975
1	0,3333333333	0,933333333	1	0,973996887	0,954545455	0,983470866	0,928571429	1	1	1	0,96875	0,942875078	1	0,98245614	0,125	0,2179
2	1	0,846153846	0,971428571	0,9841536	1	0,972785639	1	1			1	0,916666667	1	0,975	0,052631579	0,1586
3	0,3333333333	0,764705882	1	0,996875	0,96959697	0,993197279	0,975	0,988888889	0,833333333	0,75	1	0,96969697	1	0,825396825	0	0,1770
4	1	1	1	0,978250916	1	0,992592593			0,916666667		1	0,962121212	0,666666667	0,789473584	0,055555556	0,1443
5	0,833333333	0,923076923	1	0,976678475	1	0,970899471	1	0,996732026	0,833333333	1	0,9375	0,981818182	0,6	0,979166667	0,263157895	0,1505
6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,052631579	0,1139
7																
8																
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4	+ H VR comb	ined 12								1141						

<u>Chinook_Ab_Definitions_R</u>: Table that contains Chinook abundance definitions by stock aggregate, abundance type (TR: Terminal Run; OA: Ocean Abundance), time lag (5YA: 5-year running average), and hypothesis (SR: Southern Resident Killer Whale; NR: Northern Resident Killer Whale) and abundance ID. See below information about hypothesis.

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A	В	С	D	E	F	G	Н	1	J
1 TimeSeries	Stock	Ab.Type	lag	SR_Hyp	NR_Hyp	Ab_ID			
2 FE_TR_0	Fraser Early (Spring and Summer)	Terminal run		0 1a	2b	1			
3 FE_TR_1	Fraser Early (Spring and Summer)	Terminal run		1 1a	2b	1			
4 FE_TR_2	Fraser Early (Spring and Summer)	Terminal run		2 1a	2b	1			
5 FE_TR_5YA	Fraser Early (Spring and Summer)	Terminal run	5YA	1a	2b	1			
6 FE2_TR_0	Fraser Early (Spring)	Terminal run		0 1a	2b	1			
7 FE2_TR_1	Fraser Early (Spring)	Terminal run		1 1a	2b	1			
8 FE2_TR_2	Fraser Early (Spring)	Terminal run		2 1a	2b	1			
9 FE2_TR_5YA	Fraser Early (Spring)	Terminal run	5YA	1a	2b	1			
LO FE3_TR_O	Fraser Early (Summer)	Terminal run		0 1a	2b	1			
L1 FE3_TR_1	Fraser Early (Summer)	Terminal run		1 1a	2b	1			
12 FE3_TR_2	Fraser Early (Summer)	Terminal run		2 1a	2b	1			
13 FE3_TR_5YA	Fraser Early (Summer)	Terminal run	5YA	1a	2b	1			
L4 PS_TR_0	Puget Sound (Summer and Fall)	Terminal run		0 1a	2b	1			
15 PS_TR_1	Puget Sound (Summer and Fall)	Terminal run		1 1a	2b	1			
16 PS_TR_2	Puget Sound (Summer and Fall)	Terminal run		2 1a	2b	1			
17 PS_TR_5YA	Puget Sound (Summer and Fall)	Terminal run	5YA	1a	2b	1			
18 FEPS_TR_0	Fraser Early + Puget Sound	Terminal run		0 1a	2b	1			
19 FEPS_TR_1	Fraser Early + Puget Sound	Terminal run		1 1a	2b	1			
0 FEPS_TR_2	Fraser Early + Puget Sound	Terminal run		2 1a	2b	1			
1 FEPS TR 5YA	Fraser Early + Puget Sound	Terminal run	5YA	1 a	2b	1			

<u>Chinook Ab Defs FI R:</u> Table used to define fishery impacts (FI) on Chinook abundance by stock aggregate, time lag (5YA: 5-year running average), and hypothesis (SR: Southern Resident Killer Whale; NR: Northern Resident Killer Whale) and abundance ID. FI represent ocean catch of specific Chinook stocks or stock aggregates. See below information about hypothesis.

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1	TimeSeries	Stock	Ab.Type	lag	SR_Hyp	NR_Hyp	Ab_ID					
2	FE_FI_0	Fraser Early	Ocean Catch	0	NA	1b		3				
3	FE_FI_1	Fraser Early	Ocean Catch	1	NA	1b		3				
4	FE_FI_2	Fraser Early	Ocean Catch	2	NA	1b		3				
5	FE_FI_5YA	Fraser Early	Ocean Catch	5YA	NA	1b		3				
6	PS_FI_0	Puget Sound	Ocean Catch	0	2a	1b		3				
7	PS_FI_1	Puget Sound	Ocean Catch	1	2a	1b		3				
8	PS_FI_2	Puget Sound	Ocean Catch	2	2a	1b		3				
9	PS_FI_5YA	Puget Sound	Ocean Catch	5YA	2a	1b		3				
10	COLf_FI_0	Columbia Fall (UpRiver Brights+ Tule)	Ocean Catch	0	2a	1b		3				
11	COLf_FI_1	Columbia Fall (UpRiver Brights+ Tule)	Ocean Catch	1	2a	1b		3				
12	COLf_FI_2	Columbia Fall (UpRiver Brights+ Tule)	Ocean Catch	2	2a	1b		3				
13	COLf_FI_5YA	Columbia Fall (UpRiver Brights+ Tule)	Ocean Catch	5YA	2a	1b		3				
14	COLs_FI_0	Columbia Spring/Summer	Ocean Catch	0	2a	NA		3				
15	COLs_FI_1	Columbia Spring/Summer	Ocean Catch	1	2a	NA		3				
16	COLs_FI_2	Columbia Spring/Summer	Ocean Catch	2	2a	NA		3				
17	COLs_FI_5YA	Columbia Spring/Summer	Ocean Catch	5YA	2a	NA		3				
18	ALL1b_FI_0	Fraser Early+Puget Sound+Columbia Fall	Ocean Catch	0	NA	1b		3				
19	ALL1b_FI_1	Fraser Early+Puget Sound+Columbia Fall	Ocean Catch	1	NA	1b		3				
20	ALL1b_FI_2	Fraser Early+Puget Sound+Columbia Fall	Ocean Catch	2	NA	1b		3				
	ALL1b FI 5YA	Fraser Early+Puget Sound+Columbia Fall	Ocean Catch	5YA	NA	1b		3				► []

<u>ChinookAbundance_Data_R</u>: Table showing the time series of abundance (TR or OA) of all stocks and stock aggregates by time lag used in the analysis.

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1	985	136405	112697	8264	992	31 657	10 4	8496	38371	4285	8 70695	64201	44270	56372,	5 252880	229833	216003	229204	399285	342530	298544	328435	183104	1319
1	986	160271	136405	11269	1165	37 738	05 6	5710	48496	5223	86466	70595	64201	64303,	8 235049	262880	229833	232209	395320	399285	342530	348746	182545	1831
1	987	144071	160271	13640	5 1272	17 701	57 7	3805	65710	5930	8 73914	86466	70695	67909,	225725	235049	262880	233898	369796	395320	399285	361115	99673	1825
1	988	149717	144071	16027	1406	32 620	85 7	0157	73805	6405	87632	73914	85466	76581,	5 229522	225725	235049	236602	379239	369796	395320	377234	54401	996
1	989	117553	149717	14407	1416	03 540	99 6	2085	70157	6517	63454	87632	73914	76432,	258029	229522	225725	242241	375582	379239	369796	383844	79699	544
1	990	152585	117553	14971	1448	39 576	33 5	4099	62085	6355	94952	63454	87632	81283,	5 244442	258029	229522	238553	397027	375582	379239	383393	182657	796
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6 1	995	157329	161964	12090	5 1424	86 777	32 8	8741	65565	6781	79597	73223	55340	74671,	8 150858	143298	122234	147553	318187	305262	243139	290039	67026	1112
5 1	996	216402	157329	16196	1 1600	57 845	19 7	7732	88741	7463	131883	79597	73223	85425,	158474	160858	143298	145362	384876	318187	305262	305419	65141	670
5 1	997	233918	216402	15732	1781	868 40	27 8	4519	77732	8067	147091	131883	79597	97426,	8 155835	168474	160858	152140	399753	384876	318187	330243	157189	651
7 1	998	204354	233918	21640	1947	95 671	75 8	6827	84519	8099	137189	147091	131883	113796,	5 186992	165835	168474	165091	391356	399753	384876	359887	271502	1571
8 1	999	154677	204364	23391	1933	38 478	67 6	7175	85827	7282	106810	137189	147091	12051	203005	185992	165835	177033	357683	391356	399753	370371	196182	2715
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<u>ChinookAbundance_FI_R:</u> Table showing the time series of Fishery Impacts of all stocks by time lag used in the analysis.

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1994	143415,3846	40701,03608	105727,974	109947,8902	147110,52	172536,69	177534,46	210118,788	112173,61	169846,23	188672,71	174286,468	17587,83	25878,19	29169,84	30772,04	402699,5146	383083,9551	47193
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3 2004	102062,3203	98515,43072	157207,8517	90919,68998	138251,53	144897,73	132711,42	141653,634	316611,31	318555,4	311202,92	233408,855	61704,34	52515,69	57117,27	42946,758	556925,1603	561968,5607	601122
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8 2009	77755,46914	100799,0989	95395,90874	131279,058	147824,47	161020,6	214294,67	175525,132	141249,75	129674,29	114271,32	174203,914	33788,63	26359,22	41446,68	43858,116	366839,6991	391493,9889	423962
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2.1 Related publications

- Vélez-Espino, L.A., John K.B. Ford, Eric Ward, Chuck K. Parken, Larrie LaVoy, Ken Balcomb, M. Bradley Hanson, Dawn. P. Noren, Graeme Ellis, Tom Cooney, and Rishi Sharma. 2013. Sensitivity of resident Killer Whale population dynamics to Chinook salmon abundance. Completion Report, Pacific Salmon Commission, Southern Boundary Restoration and Enhancement Fund, Vancouver BC. 191 p.
- Vélez-Espino, L.A., Ford, J.K.B., Araujo, H.A., Ellis, G., Parken, C.K, & Balcomb, K. Comparative demography and viability of northeast Pacific resident killer whale populations at risk. Can. Tech. Rep. Fish. Aquat. Sci. 3084: vi + 56 p.
- Vélez-Espino, L.A., John K.B. Ford, H. Andres Araujo, Graeme Ellis, Charles K. Parken and Rishi Sharma. *In Press.* Relative importance of Chinook salmon abundance on resident killer whale population growth and viability. Aquatic Conservation: Marine and Freshwater Ecosystems.

3. Tutorial: Killer Whale (Orcinus orca) Demography Workflow for portal execution

The Orcinus orca (Killer whale) demography and population viability analysis (PVA) workflow provides an environment to calculate a two-sex stage-structured matrix with no density dependence and to (i) quantify the differences in demographic rates between *Orcinus orca* population that explain population growth; (ii) to determine the relative influence vital rates on expected population growth; and, (iii) to generate projections of population size at various time horizons.

This workflow performs the following analyses:

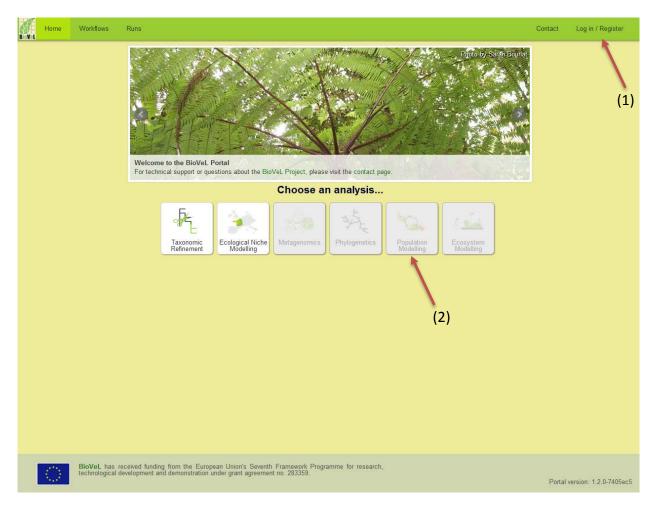
- Vital rates estimation and probability distributions
- Construction of Birth-flow Matrix Model
- Eigen analysis
- Elasticity analysis (deterministic and stochastic)
- Damping time
- Stable stage distributions
- IID projection matrices representing discrete time periods
- Retrospective perturbation analysis
- Stochastic population growth from IID matrices and vital rate probability distributions
- Projections of population size

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 northeastern 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 prev abundance levels and availability, particularly Chinook salmon (Oncorhvnchus 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.

In your browser (preferably Firefox or Chrome) navigate to the <u>BioVeL Portal</u> page (<u>http://portal.biovel.eu</u>/) 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 *Orcinus orca* (Killer whale) demography and population viability analysis (PVA) (1) you can also directly run the workflow using the 'Run workflow' button at the bottom-right (2).

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Your private workfloas Only visible to BioVeL, members Only visible to registered users Public workflows Filter by uploader Marka Bakazar-Vargas (you) Robert Haines Finn Bacal Sarah Bourlat	Matrix Population Model analysis v12 The Matrix Population Models Workflow provides an environment to perform several analyses on a stage-matrix with no density dependence: - Eigen analyses - Generation time (T), - Net reproductive rate (Ro); - Transient Dynamics; - Bootstrap of observed census transitions	Population Modelling
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On the resulting page click on the 'Run Workflow' button at the top (1).

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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. *Orcinus orca* D&PVA run1).

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3.1 Input Ports

3.1.1 DATA

<u>Chinook Ab Definitions</u>: it's a .csv file. Chinook abundance definitions by stock aggregate, abundance type (TR:Terminal Run; OA: Ocean Abundance), time lag (5YA: 5-year running average), and hypothesis (SR: Southern Resident Killer Whale; NR: Northern Resident Killer Whale) and abundance ID. See below information about hypothesis.

e.g.: Chinook_Ab_Definitions_R.csv

To open the file. Click in Browse (1), a window dialog appears and the user selects the file e.g. Chinook_Ab_Definitions_R.csv, (2) and then clicks the Open button (3). Repeat this action for all the input DATA.

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<u>ChinookAbundance Data</u>: it's a .csv file. Time series of abundance (TR or OA) of all stocks and stock aggregates by time lag used in the analysis.

e.g.: ChinookAbundance_Data_R.csv.

To open the file. Click in choose file, a window dialog appears and the user selects the file e.g. ChinookAbundance_Data_R.csv and then clicks the Open button.

<u>KWDataFile:</u> 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.

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e.g.: SRKW_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.

<u>*VR* combined:</u> Time series of vital rates (fecundity and survival by life stage) for both populations

e.g.: VR_combined.csv

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).

BetaQ_SR ()		
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<u>BetaQ</u> SR: defines if the simple regressions should be run with a Beta: YES or Linear model: NO.

e.g.: YES

EndYear: Last year to be considered in the analysis.

e.g.: 2011

ENVIR: Type of environmental stochasticity used for projection of population size. Two types available: IID (identically and independently distributed) or VR Random (vital rates as random variables). For IID, various matrices are generated from vital rates representative of discrete time periods specified by the user (see "Study_period_year_x"). These matrices are drawn randomly for projections. For VR_Random, vital rates are randomly drawn from their probability distributions parameterized with mean and variances from the entire study time period (see Output Port "Stats_by_Category").

e.g.: IID

NREPS: Number of replications for projections of population size

e.g.: 5000.

<u>p.val:</u> p- value for the regression.

e.g.: 0.05

<u>percIncr</u>: Percentage increment of Chinook abundance (0.1 = 10%).

e.g.: 0.1

population: It is the name of the analyzed population.

e.g.: SRKW

<u>Sims</u>: 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.

e.g.: 10000

Standr Data: Use standardized data? YES or NO

e.g.: NO

StartYear: First year to be considered in the analysis.

e.g.: 1987

<u>Variant</u>: Using direct perturbations, two computational variants of the elasticity of interactions were explored. Variant 1 (equation 5) completely represents a direct perturbation process whereas variant 2 (equation 6) is a combination of vital rate elasticity and direct perturbation:

$$\varepsilon \left(x_{Chinook \to v_i} \right)_{DP, \text{variant 1}} = \frac{\Delta \lambda}{\Delta x_{Chinook}} = \frac{\left(\left(\lambda_{after} / \lambda_{before} \right) - 1 \right)}{\left(\left(x_{Chinook, after} / x_{Chinook, before} \right) - 1 \right)}$$

$$\varepsilon \left(x_{Chinook \to v_i} \right)_{DP, \text{variant } 2} = \varepsilon \left(v_i \right) \frac{\Delta v_i}{\Delta x_{Chinook}} = \varepsilon \left(v_i \right) \frac{\left(\left(v_{i,after} / v_{i,before} \right) - 1 \right)}{\left(\left(x_{Chinook,after} / x_{Chinook,before} \right) - 1 \right)}$$

The term $x_{Chinook, before}$ is the Chinook abundance from a particular stock corresponding to the mean value of the interacting vital rate, $x_{Chinook, after}$ represents the simulated value of Chinook abundance that is used to explore the effect of changes in Chinook abundance (e.g. through changes in harvest rates) on RKW population growth rates. Thus, λ_{before} and λ_{after} represent the population growth rate before and after a perturbation on the vital rate(s) corresponding to a given change in Chinook abundance as per beta regressions, where ($v_{i,after}$) is the vital rate value after the perturbation. For more information see Velez-Espino et al. (Aquatic Conservation: Marine and

Freshwater Ecosystems, In press)

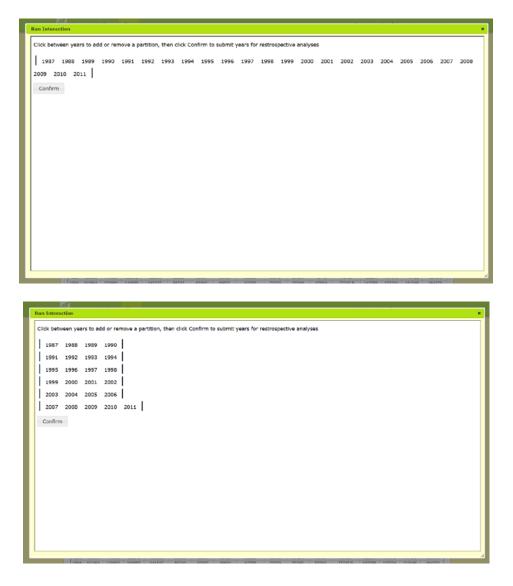
e.g.: 2

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 <u>Sims</u> and <u>NREPS</u> to carry out the analyses.

3.2. Dialogue

<u>Years for retrospective analysis:</u> Set the sets for the study period manually. Click after the desired year.

In this tutorial, click every 4 year, (e.g. 1987 1988 1989 1999). Click between 1990 and 1991, repeat the process. The last period will be for 5 years.



Run Interaction	×
Complete	
1987 1988 1989 1990	
1991 1992 1993 1994	
1995 1996 1997 1998	
1999 2000 2001 2002	
2003 2004 2005 2006	
2007 2008 2009 2010 2011	
Confirm	

3.2.1 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 PostWorkspace, a zip file that is needed to run the second workflow: Interaction between killer whale population dynamics and Chinook salmon abundance workflow.

Run was successfully created.			
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Category: Population Modelling	Finished at: 20 Aug 2014 13:39:57 UTC		
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zipFile () (application/2p)		(1)	 Download value

3.3 Results

Zip File

Abundance Regressions Population Start year-End year (csv): Statistics from beta regressions between Chinook abundance and killer whale vital rates.

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7 YoungRFem	SF_TR_1	1	0,295742509	19,32310136	6,55E-06	0,003546335	2a								
8 YoungRFem	SF_TR_SYA	5YA	0,301777258	18,66445244	8,47E-06	0,003203134	Za								
9 YoungRFem	KLF_TR_SYA	5YA	0,169533764	17,57058797	3,31E-05	0,026041431	2a								
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11 OldRFem	WCVI_TR_1	1	0,306575374	11,08824465	2,31E-05	0,002952616	2a								
12 OldRFem	WCVI_TR_5YA	5YA	0,378423439	8,476269861	3,81E-05	0,000821015	2a								
13 OldRFem	PS_OA_SYA	5YA	0,349930844	5,904452461	9,56E-05	0,001094931	2a								
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15 OldRFem	WCVI_OA_1	1	0,387340193	11,70142527	2,65E-05	0,000533126	2a								
16 OldRFem	WCVI_OA_5YA	5YA	0,42133783	10,14100036	3,82E-05	0,000267739	2a								
17 OldRFem	FL_OA_5YA	5YA	0,145787907	8,307570787	4,67E-05	0,033779642	2a								
18 OldRFern	OC_OA_SYA	5YA	0,248749495	9,343975841	4,81E-05	0,006525056	2a								
19 OldRFern	ALL2a_OA_1	1	0,221903505	9,239381935	9,858-06	0,01015127	2a								
20 OldRFem	ALL2a_OA_5YA	5YA	0,523126812	3,726432132	1,89E-05	2,66E-05	2a								
21 OldRFem	CW_OA_5YA	5YA	0,331933103	5,475050779	8,74E-06	0,001528385	2a								
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23 PostRFem				5,417500939		0,028190488									
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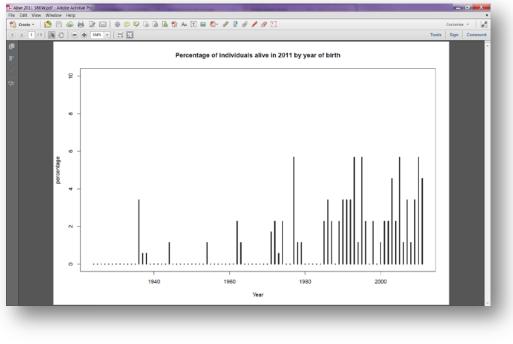
Abundance Regressions SRKW 1987-2011

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

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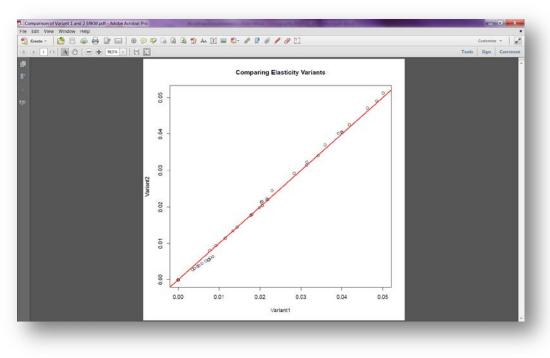
Alive 2011 SRKW.csv

Alive End Year Population (pdf): Graphical output for "Alive End Year Population"



Alive 2011 SRKW.pdf

Comparison of Variant 1 and 2 Population (pdf): Plot showing the relationship between the two computational variants of the elasticity of interactions



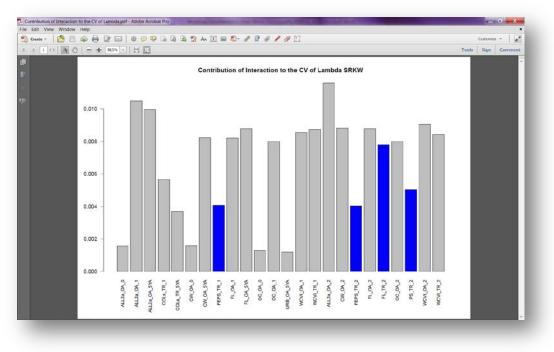
Comparison of Variant 1 and 2 SRKW

Contribution of Interaction to the CV of Lambda (csv): This file shows the proportion of the CV in population growth due to specific interactions between Chinook salmon stocks and abundance type and killer whale vital rates as explained by retrospective perturbation analysis.

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Contribution of Interaction to the CV of Lambda (csv)

Contribution of Interaction to the CV of Lambda (pdf): Graphical representation of Contribution of Interaction to the CV of Lambda (csv)



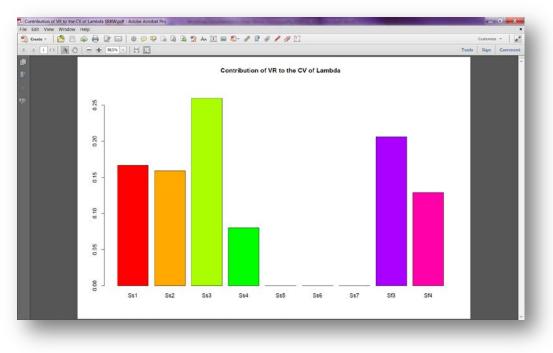
Contribution of Interaction to the CV of Lambda (pdf)

Contribution of VR to the CV of Lambda Population (.cvs): Results of retrospective perturbation analysis showing the contribution of past (observed) vital rate variation to the coefficient of variation of population growth rate (details in Vélez-Espino et al. 2013) e.g.: Contribution of VR to the CV of Lambda SRKW

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Contribution of VR to the CV of Lambda Population (cvs)

Contribution of VR to the CV of Lambda Population (pdf): Graphical representation of "Contribution_of_VR_to_CV_of_Lambda.csv".



Contribution of VR to the CV of Lambda Population (pdf)

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

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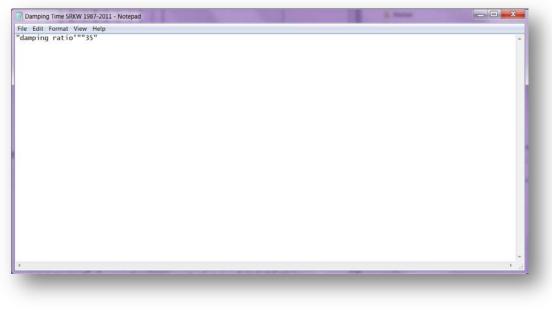
Counts and Proportions T0 Population Start year-End year (csv)

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

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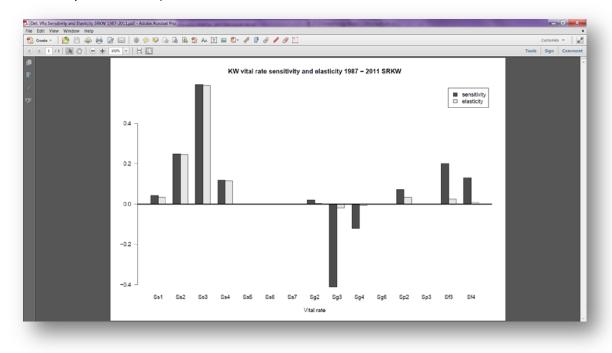
Counts by Year SRKW 1987-2011

Damping Time Population Start year-End year (txt): Damping time (*t*) is defined as $r = \ln(z)/\ln(\rho)$, where ρ is the damping ratio and z is the number of times the contribution of λ_1 (dominant eigenvalue) becomes as great as that of λ_2 (subdominant eigenvalue). Damping times at z = 10 were used to define minimum time horizons for projections of population size.



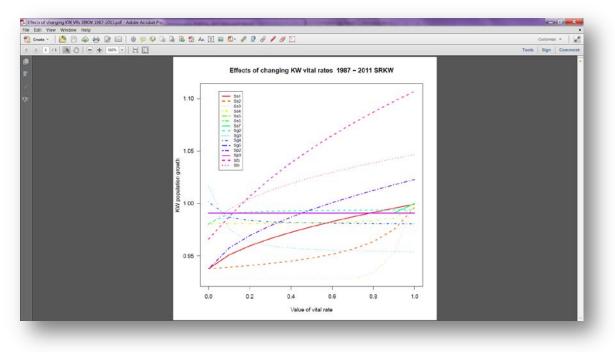
Damping Time SRKW 1987-2011

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

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)



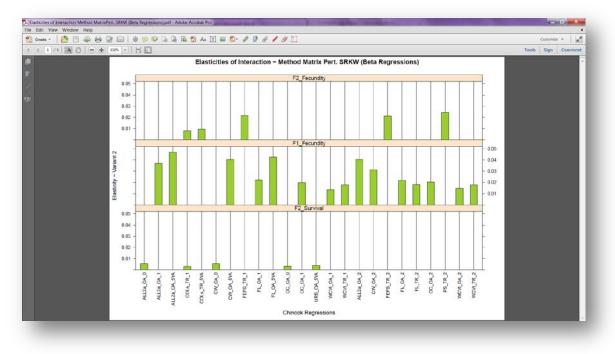
Effects of changing KW VRs SRKW 1987-2011

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.

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Eigen Analysis (opens in excel)

Elasticities of Interaction Method MatrixPert. Population (Type of Regressions) (pdf): This plot shows the elasticities (as determined by variant 2) of all significant interactions (as determined by beta regressions) between Chinook stock/abundance type/lag and killer whale vital rates



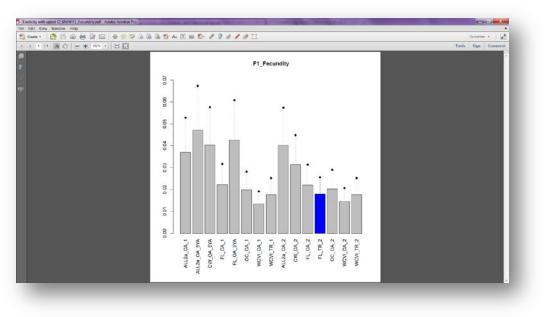
Elasticities of Interaction Method MatrixPert. SRKW (Beta Regressions)

Elasticity of Interactions Population (csv): This file shows the beta regression statistics and the value of variables involved in the direct perturbations used to compute the elasticities of all significant interactions.

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Elasticity of Interactions SRKW

Elasticity with upper CI Population Stage_Vital rate (pdf): These plots show the mean upper 95% confidence limit of elasticities of interactions by population (SRKW or NRKW) and vital rate. Interactions characterizing strong hypotheses 1a or 1b are highlighted in blue for SRKW and in green for NRKW. For example, using the 1987-2011 killer whale data, three vital rates exhibited significant interactions with Chinook salmon stocks: F1_Fecundity, F2_Fecundity, and F2_Survival.



Elasticity with upper CI SRKW F1_Fecundity

IID Matrices Population (csv): Projection matrices produced by discrete time periods within the study period (see Input Port "ENVIR"). Each of these matrices represents population dynamics for discrete temporal strata. Default is six time periods (see Input Ports "Study_period_year_x"). These matrices are used for projections of population size if ENVIR is set to "IID"

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IID Matrices SRKW

lambda from IID and VR random Population (csv): Stochastic population growth rate computed from IID matrices and from vital rates as random variables (see Input Port "ENVIR")

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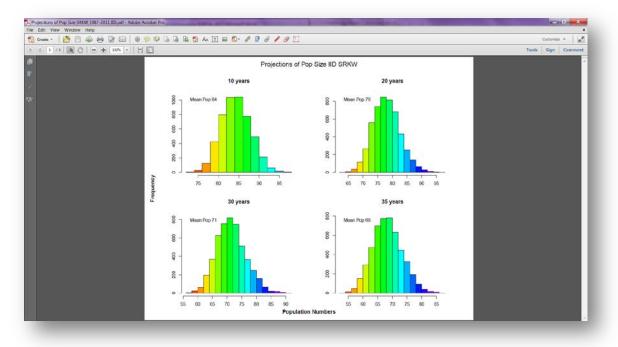
lambda from IID and VR random SRKW

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).

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MeanMatrix SRKW

Projections of Pop Size Population Start year – End year IID (pdf): Graphical output showing frequency distributions for projections of population size at the four time horizons specified in Input Ports "Time_horizons_x". Along with stochastic population growth "Lambda_from_IID_and_VR_random", these outputs are the components of the analysis showing expected future population dynamics. Therefore, these two outputs can be seen as components of a PVA



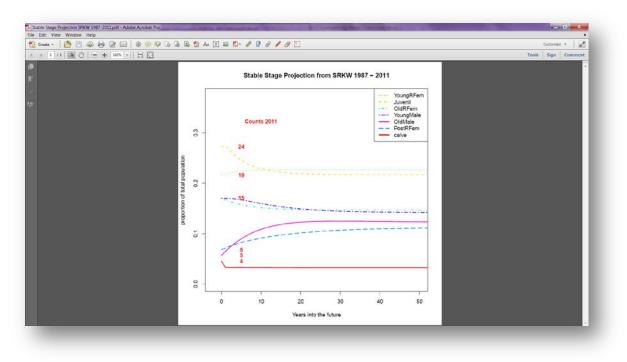
Projections of Pop Size SRKW 1987-2011 IID

SimpleRegModels Population (Type of Regressions) (csv): Statistics for all significant regressions (beta or linear) between killer whale vital rates and Chinook salmon stocks. The list of regressions includes vital rates not contributing directly to population growth such as survival of males and post-reproductive females.

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SimpleRegModels SRKW (Beta Regressions)

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



Stable Stage Projection SRKW 1987-2011

Stable State Values Population Start year – End year (csv): Long-term projections of population size by life stage based on transient dynamics.

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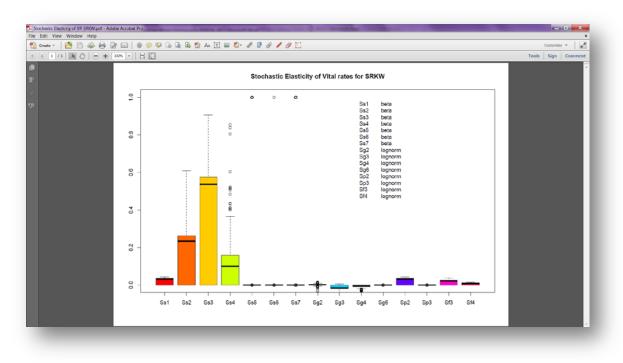
Stable State Values SRKW 1987-2011

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").

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Stochastic Elasticity of VR Population (pdf): Graphical output for stochastic elasticities of vital rates based on "Stochastic_Vital_rates"



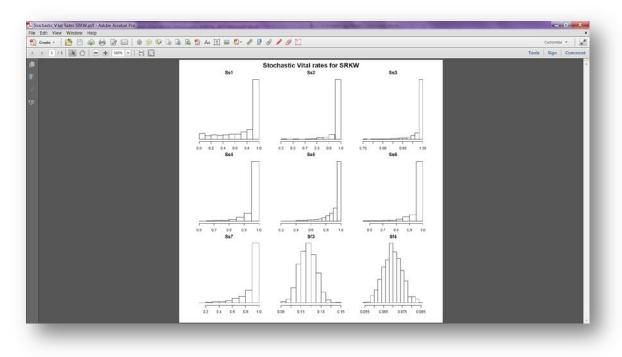
Stochastic Elasticity of VR SRKW

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

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Stochastic Elasticity Stats SRKW

Stochastic Vital Rates Population (pdf): Graphical output for vital rate probability distributions. Beta distribution used for survival; lognormal distribution used for fecundity.



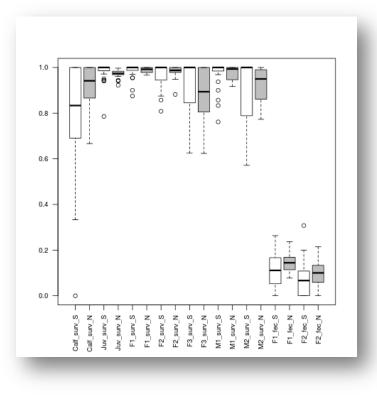
Stochastic Vital Rates SRKW

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

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	A	В	С	D	E	F	G	н	1	J	К	L	M	N	0
ľ		Calf_Survival	Juvenile_Survival	F1_Survival	F2_Survival	F3_Survival	M1_Survival	M2_Survival	F1_Fecundity	F2_Fecundity					
ľ	1987	0,75	1	1	1	1	1	1	0,15	0,057142857					
	1988	0	1	1	1	1	0,761904762	1	0,095238095	0					
	1989	1	1	1	1	0,857142857	1	1	0,05	0,055555556					
	1990	1	1	1	1	1	1	1	0,25	0					
	1991	0,75	0,944444444	1	1	1	1	0,95	0,1	0,108108108					
	1992	1	1	1	1	1	1	1	0,111111111	0,05					
	1993	0,833333333	0,951020408	0,875	0,952380952	1	1	1	0,222222222	0,095238095					
	1994	1	1	1	1	1	0,857142857	0,772727273	0,1	0					
	1995	1	1	1	0,875	1	0,833333333	0,9	0,181818182	0,114285714					
	1996	1	1	1	0,915714286	0,625	1	0,9	0,166666667	0,066666667					
	1997	NA	0,94375	1	1	1	1	0,77777778	0	0					
	1998	1	0,94047619	0,9	0,953703704	1	1	0,666666667	0,083333333	0					
	1999	0,3333333333	1	0,955	0,808333333	1	1	0,928571429	0,12	0					
	2000	0,666666667	1	1	0,857142857	1	0,9	0,571428571	0,12	0					
	2001	0,666666667	1	0,975	1	1	1	1	0,170212766	0					
	2002	1	1	1	1	0,8	1	0,8	0	0,08					
	2003	0,833333333	1	1	1	0,77777778	1	1	0,227272727	0,076923077					
	2004	1	1	1	1	1	1	1	0,043478261	0,076923077					
1	2005	0,714285714	0,785714286	1	1	0,875	1	1	0,166666667	0,307692308					
	2006	0,333333333	1	0,954545455	0,928571429	1	0,96875	1	0,125	0					
	2007	1	0,971428571	1	1	0,75	1	1	0,052631579	0,125					
	2008	0,333333333	1	0,96969697	0,975	0,833333333	1	1	0	0,125					
	2009	1	1	1		0,916666667		0,666666667	0,055555556	0,129032258					
1	0010	0.0000000000	SRKW 1987 / 😒 /				A 4447		111						

Vital rates estimates SRKW 1987-2011

VR_combined (.png): Box plot with the survival and fecundity probabilities of each stage.



VR_combined

PostWorkspace (zip file): An R Workspace that transfers values from the main workflow to the post-processing workflow. This file must be provided as an input to the post-processing workflow (Orcinus orca (Killer whale) interaction with Chinook (Oncorhynchus tshawytscha) workflow) in order for it to have access to values generated in the main workflow.

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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