ADDENDUM TO:

BAYESIAN ASSESSMENTS OF SOUTHERN HEMISPHERE HUMPBACK WHALE BREEDING SUB-STOCKS C1 AND C3, INCLUDING ALLOWANCE FOR INTERCHANGE ON THE BREEDING GROUNDS

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ABSTRACT

This Addendum adds results for the ***Migrant*** and ***Tourist*** models to those reported for the ***Sabbatical*** and ***Resident*** models in the original paper. Results for the C1 sub-stock are hardly affected, but recovery is slightly less advanced for the C3 sub-stock.

INTRODUCTION

SC/F09/SH3 presented Bayesian stock assessment results for Southern Hemisphere humpback whale breeding sub-stocks C1 and C3 using two models, one which allowed for interchange on the breeding ground – the ***Sabbatical*** model (allows for interchange on the breeding ground) and the ***Resident*** model (no interchange). Here results are presented for two further models – the ***Migrant*** model and the ***Tourist*** model – both of which have been described conceptually in Butterworth and Johnston (2009).

The only difference between the ***Sabbatical*** model and the ***Migrant*** model is that in the latter, when a whale from one sub-stock happens to move to the breeding area for the other sub-stock in a particular year, it "stays" there, losing memory of its origins and behaving in the future exactly as do other members of that other sub-stock. Thus, it has the same probability (now denoted by β) as those other members of moving back in any particular year to the first-mentioned sub-stock.

The ***Tourist*** model is an adaptation of the ***Resident*** model where whales from one breeding sub-stock, in addition to returning to their own breeding area each year, have a probability (denoted by γ) of also visiting the breeding area for the other sub-stock that same year. Given that same season recaptures are ignored (for reasons of non-independence) in the assessments conducted (and further that no same season recaptures in different breeding grounds have as yet been observed), the ***Tourist*** model in its simplest form becomes equivalent to the ***Sabbatical*** model for the analysis method used. This is because spending some time in the other breeding area during the breeding season makes it less likely that a whale will be photographed in its own breeding area, so that the same equations apply as for the ***Sabbatical*** model. The variant of the ***Tourist*** model implemented here is therefore a somewhat extreme one which might be termed the "***Photogenic Tourist***" model. It assumes that photographs in each breeding area are taken only at the time all the "tourists" of the year from the other sub-stock are present as well. This is not put forward as a realistic scenario, but rather as a "bounding case" which renders the results of the ***Tourist*** model as different as possible from those of the ***Sabbatical*** model.

The Table below lists the core changes to the ***Sabbatical*** model in order to parametrize the ***Migrant*** and ***Tourist*** models, where the parameter defining the annual exchange (or related) probability is changed from α for the ***Sabbatical*** model to β for the ***Migrant*** model, and to γ for the ***Tourist*** model.

Sabbatical	***Migrant***	***Tourist***
α	β	γ
	But Equations 1 and 2 change to: $N_{y+1}^{B,C1} = N_y^{B,C1} + r^{C1}N_y^{B,C1}\left(1-(\frac{N_y^{B,C1}}{K^{C1}})^{\mu}\right) - C_y^{C1} - \beta^{C1}N_y^{B,C1} + \beta^{C3}N_y^{B,C3}$ and $N_{y+1}^{B,C3} = N_y^{B,C3} + r^{C3}N_y^{B,C3}\left(1-(\frac{N_y^{B,C3}}{K^{C3}})^{\mu}\right) - C_y^{C3} - \beta^{C3}N_y^{B,C3} + \beta^{C1}N_y^{B,C1}$	But Equation 15 and 16 change: $1-\gamma \rightarrow 1$ $\gamma \rightarrow \gamma$

Note that for the ***Migrant*** model, there is one less estimable parameter, because long-term equilibrium in the absence of exploitation requires migration rates to balance so that $\beta^{C1}K^{C1} = \beta^{C3}K^{C3}$. Thus only the β^{C1} parameter is estimated, with this last relationship then determining β^{C3}.

The catches from the breeding grounds are split between the C1 and C3 sub-stocks as for the ***Sabbatical*** model.

RESULTS

The Bayesian ***Tourist*** and ***Migrant*** model results are reported in Tables A1a and A1b respectively. Figures A1 and A2 illustrate the ***Tourist*** model C1 and C3 population trajectories, and Figures A3 and A4 illustrate those for the ***Migrant*** model. Figures A5a and b compare the posterior median C1 and C3 population trends estimated by the ***Sabbatical***, ***Resident***, ***Tourist*** and ***Migrant*** models.

DISCUSSION

Figure 5 provides perhaps the best summary of the implications of the alternative exchange models for the size and status of the C1 and C3 sub-stocks. There is little difference in results for the first amongst the four models considered. For C3 on the other hand, the ***Resident*** model suggests the fastest recovery; the results for the ***Sabbatical*** and (***Photogenic***) ***Tourist*** models are only marginally different, and the ***Migrant*** model suggests the slowest recovery.

REFERENCE

Butterworth, D.S. and Johnston, S.J. 2009. Report on discussions on modelling studies of possible interchange between the C1 and C3 breeding substocks of Southern Hemisphere humpback whales, Cape Town, December 2008. IWC document SC/F09/SH1.

Table A1a: ***Tourist*** model assessment results (posterior medians with 5th and 95th percentiles in parenthesis).

	BS C1	**BS C3**
***r* prior**	**U[0, 0.106]**	**Post BS(A)**
Historic catch	**Feeding grounds split proportional to abundance**	**Feeding grounds split proportional to abundance**
Recent abundance	**5965 (2003)**	**None**
Trend information	**Cape Vidal and aircraft SPUE trend data only**	**None**
Capture-recapture Data	**“All” photo-ID data**	**“All” photo-ID data***
r	0.090 [0.064; 0.104]	0.067 [0.027; 0.090]
K	8087 [7163; 9258]	10719 [9199; 14648]
γ	0.031 [0.003; 0.104]	0.019 [0.001; 0.068]
N_{min}	376 [258; 863]	2143 [838; 4772]
N_{2006}	7183 [5880; 8049]	10031 [7883; 12491]
η_{2006}	7119 [6083; 7858]	10012 [8032; 12512]
N_{min}/K	0.047 [0.033; 0.096]	0.197 [0.088; 0.356]
N_{2006}/K	0.898 [0.710; 0.979]	0.984 [0.641; 1.000]
N_{2020}/K	0.996 [0.960; 1.000]	0.998 [0.796; 1.000]
N_{2040}/K	1.000 [0.999; 1.000]	1.000 [0.934; 1.000]

Table A1b ***Migrant*** model assessment results (posterior medians with 5th and 95th percentiles in parenthesis).

	BS C1	**BS C3**
***r* prior**	**U[0, 0.106]**	**Post BS(A)**
Historic catch	**Feeding grounds split proportional to abundance**	**Feeding grounds split proportional to abundance**
Recent abundance	**5965 (2003)**	**None**
Trend information	**Cape Vidal and aircraft SPUE trend data only**	**None**
Capture-recapture data	**“All” photo-ID data**	**“All” photo-ID data**
r	0.068 [0.025; 0.096]	0.070 [0.030; 0.091]
K	7929 [5913; 9865]	11052 [9506; 14832]
β	0.017 [0.003; 0.063]	0.012 [0.002; 0.043]
N_{min}	337 [250; 901]	1731 [843; 4248]
N_{2006}	6590 [5292; 7674]	9933 [8301; 11834]
η_{2006}	6605 [5325; 7676]	9917 [8308; 11789]
N_{min}/K	0.044 [0.031; 0.108]	0.157 [0.089; 0.307]
N_{2006}/K	0.861 [0.620; 0.973]	0.933 [0.638; 0.994]
N_{2020}/K	0.984 P0.884; 0.999]	0.989 [0.842; 0.999]
N_{2040}/K	0.999 [0.971; 1.000]	0.999 [0.960; 1.000]

Figure A1a: ***Tourist*** model fit to C1 trend data (Cape Vidal and aircraft SPUE), as well as the recent abundance estimate (2003). The model trajectory is the Bayesian posterior median values of η_y^{C1}, the whales in the C1 breeding grounds. The vertical line shows 2006.

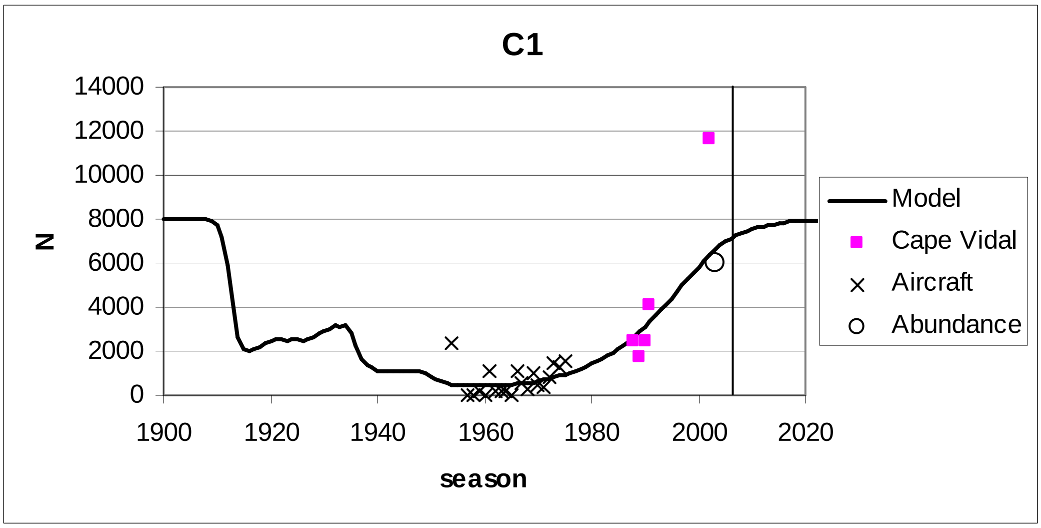

Figure A1b: ***Tourist*** model C1 population (N_y^{C1}) trajectories, showing the median and 95% probability envelopes. The vertical line shows 2006.

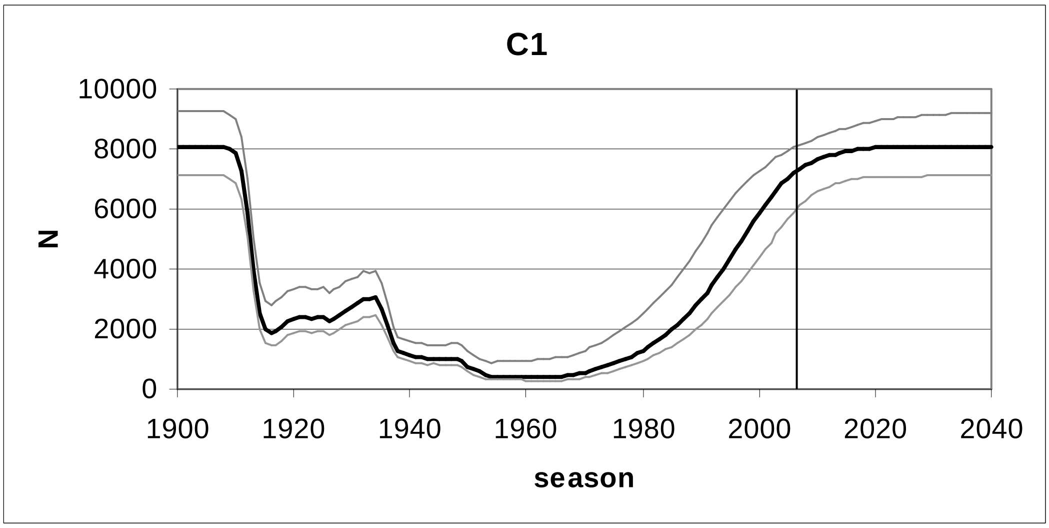

Figure A2a: ***Tourist*** model trajectories of is the Bayesian posterior median values of η_y^{C3}, the whales in C3 breeding grounds. The vertical line shows 2006. The squares show the upper and lower abundance estimates from Cerchio *et al*. (2008a) for comparative purposes – these estimates are not used in fitting the model because the capture-recapture data underlying them are used instead.

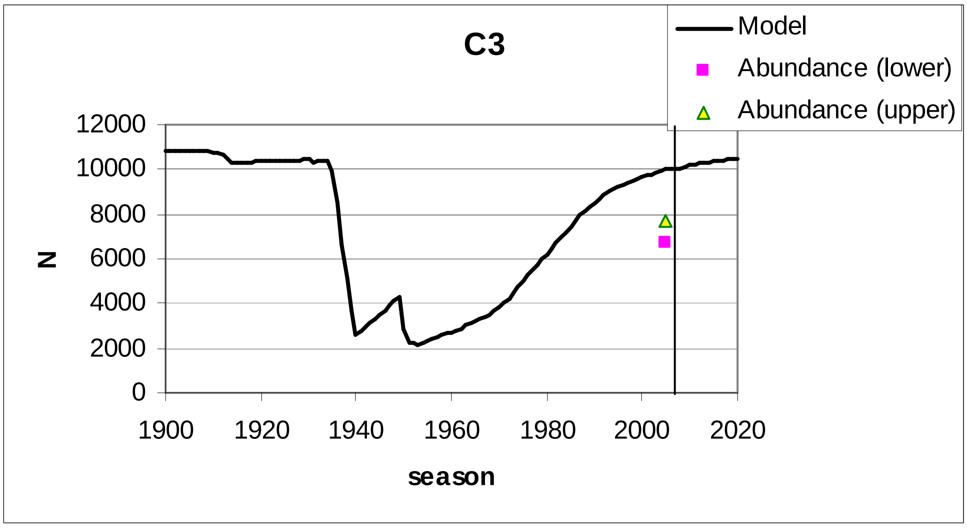

Figure A2b: Tourist model C3 population (N_y^{C3}) trajectories, showing the median and 95% probability envelopes. The vertical line shows 2006.

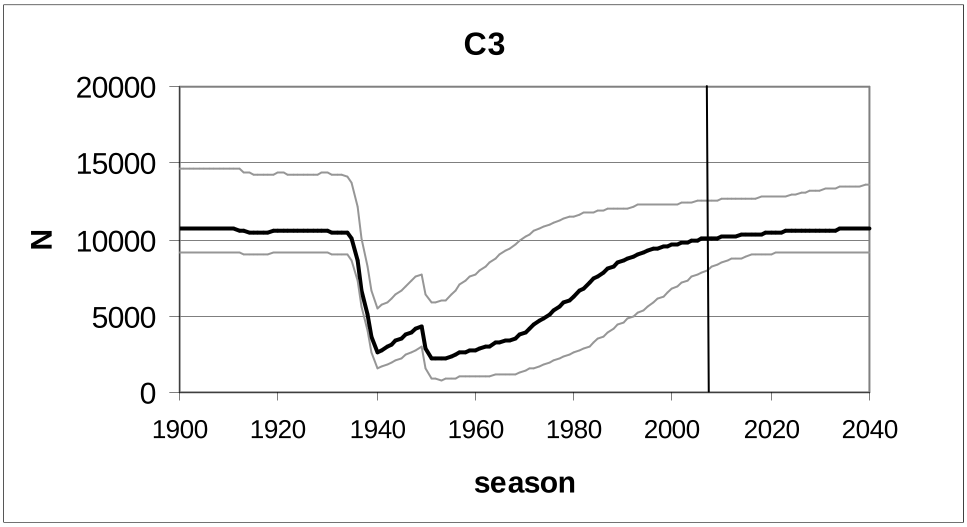

Figure A3a: ***Migrant*** model fit to C1 trend data (Cape Vidal and aircraft SPUE), as well as the recent abundance estimate (2003). The model trajectory is the Bayesian posterior median values of η_y^{C1}, the whales in the C1 breeding grounds. The vertical line shows 2006.

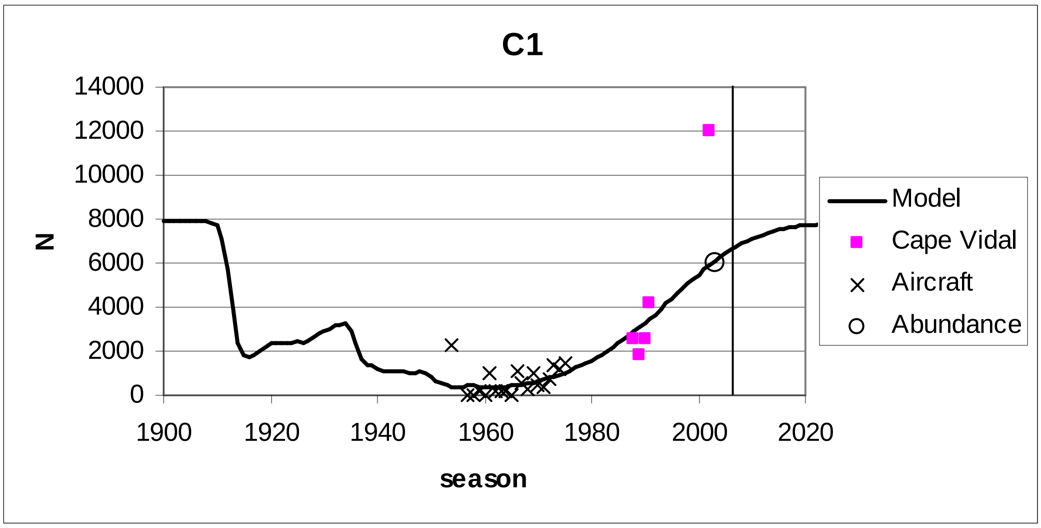

Figure A3b: ***Migrant*** model C1 population (N_y^{C1}) trajectories, showing the median and 95% probability envelopes. The vertical line shows 2006.

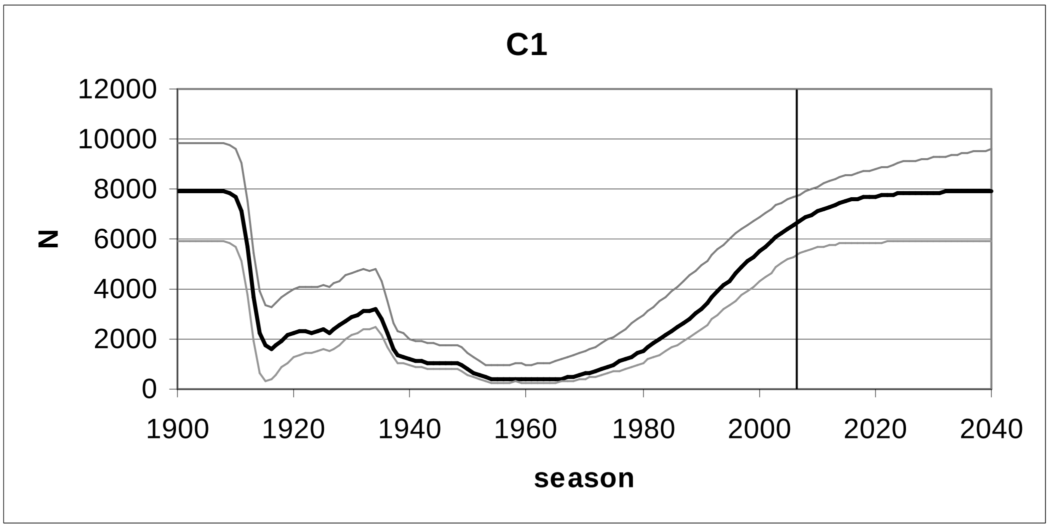

Figure A4a: ***Migrant*** model trajectories of is the Bayesian posterior median values of η_y^{C3}, the whales in C3 breeding grounds. The vertical line shows 2006. The squares show the upper and lower abundance estimates from Cerchio *et al*. (2008a) for comparative purposes – these estimates are not used in fitting the model because the capture-recapture data underlying them are used instead.

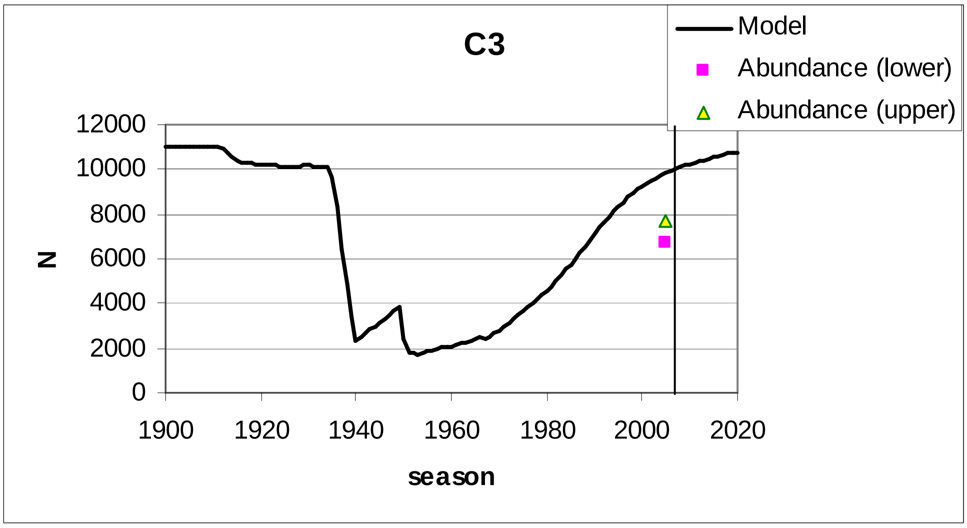

Figure A4b: ***Migrant*** model C3 population (N_y^{C3}) trajectories, showing the median and 95% probability envelopes. The vertical line shows 2006.

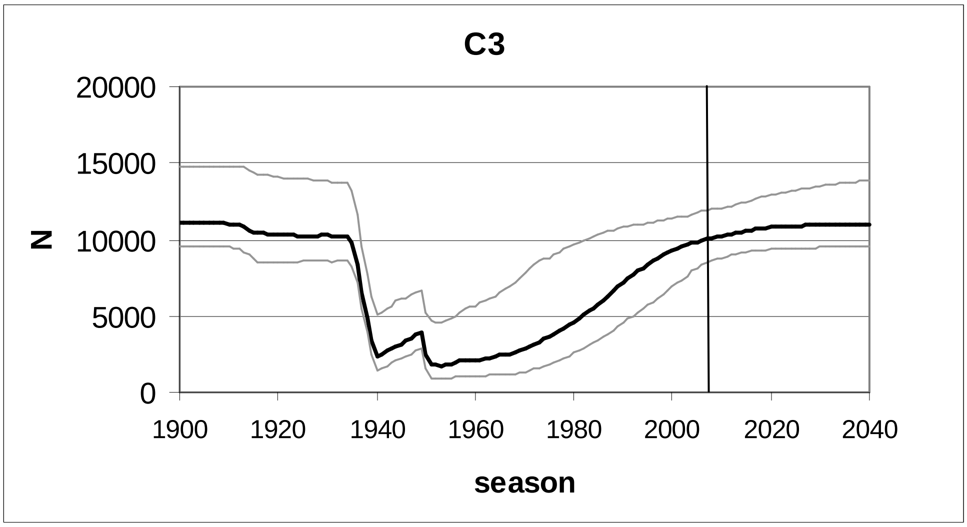

Figure A5a: Comparison between the ***Sabbatical***, ***Resident, Tourist*** and ***Migrant*** model fits of C1 population trajectories (the Bayesian posterior medians of N_y^{C1} are shown).

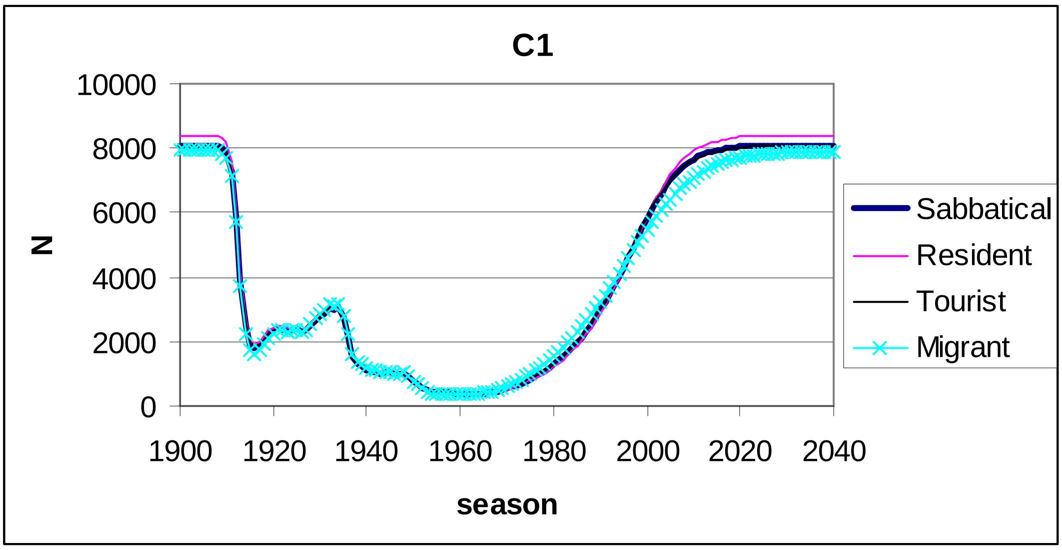

Figure A5b: Comparison between the ***Sabbatical***, ***Resident***, ***Tourist*** and ***Migrant*** model fits of C3 population trajectories (the Bayesian posterior medians of N_y^{C3} are shown).