Figure S1: Examples of GEPAT/GEMACO instructions on E-SURGE.

In addition to the matrix description, we provide here details of the practical implementation for the best model in the form of the GEPAT/GEMACO instructions. These are the interfaces of E-SURGE that are used to constrain multi-event models (Choquet et al. 2009).

In the model definition (MDL) of E-SURGE, ",” distinguish two categories; ":" lumps two categories; "+" means interactions; "+" refers to additive effects; "&" is used to constrain two parameters to be identical. "f" (from) is the effect of state of departure; "t" is for time effect as a discrete effect; "a" is for age effect (actually "time since first capture") and "g" is for group effect (group 1 is adult females captured, group 2 is young females captured during their first wintering, group 3 is young females captured during their first breeding season, group 4 is adult males captured, group 5 is young males captured during their first wintering, group 6 is young males captured during their first breeding season). Shortcuts can be used to associate a definition to a given name in order to simplify the formulas.

We used the shortcut "adult" defined as

\[ g(1)\&g(4)\&g(2).a(3:13)\&g(3).a(2:13)\&g(5).a(3:13)\&g(6).a(2:13)\]

We used the shortcut "young" defined as

\[ g(2).a(1:2)\&g(3).a(1)\&g(5).a(1:2)\&g(6).a(1)\]

1. The modeling of the initial state is done through GEPAT and GEMACO as follow:

**GEPAT instruction:**

\[ p \quad * \quad - \quad - \quad - \quad - \]

**GEPAT instruction:**

\[ t(1:2:13,2:2:14) \]

2. The modeling of the movement-transition probabilities ($\Psi^n_i$) is done through GEPAT and GEMACO as follow:

**GEPAT instruction:**

\[
\begin{array}{cccccccc}
  y & - & * & - & - & - & - & - \\
  - & y & - & * & - & - & - & - \\
  y & - & * & - & - & - & - & - \\
  - & y & - & * & - & - & - & - \\
  - & - & - & - & - & * & - & - \\
  - & - & - & - & - & - & * & - \\
  - & - & - & - & - & - & - & * \\
\end{array}
\]

**GEMACO instruction:**

\[ f(2\ 4).t(2:2:12).g(1\ 2\ 3,4\ 5\ 6)+f(1\ 3).t(1:2:13)+f(2\ 4).t(1:2:13).g(1\ 2\ 3,4\ 5\ 6)+f(1\ 3).t(2:2:12).\[\text{adult+young}\] \]
3. The modeling of the survival probabilities ($\Phi_{st}$) is done through GEPAT and GEMACO as follow:

GEPAT instruction:

\[
\begin{array}{cccccc}
  & s & - & - & - & - \\
 s & - & - & - & - & - \\
 - & - & s & - & - & - \\
 - & - & - & s & - & - \\
 - & - & - & - & - & - \\
 - & - & - & - & - & - \\
\end{array}
\]

GEMACO instruction:

[adult+young]+t(1:2:13,2:2:12)

4. The modeling of the recapture probabilities ($P_{st}$) and the dead recovery probabilities ($D_{st}$ called $R_{st}$ in the material and method section) is done through GEPAT and GEMACO as follow:

GEPAT instruction:

\[
\begin{array}{cccccc}
  & * & p & - & - & - \\
 * & p & - & - & - & - \\
 * & - & p & - & - & - \\
 * & - & - & d & - & - \\
 * & - & - & - & d & - \\
 * & - & - & - & - & - \\
\end{array}
\]

GEMACO instruction:

The first occasion of capture (named "firste") is also part of the matrix and was constant and set to 1 since the capture probability equals 1. The next occasions (events of recapture/resighting/recoveries) are specified by "nexte".

firste+nexte.[f(1 2).t(3:2:13),t+l(1 2 3 4 5 6)]+f(3 4).t(3,5,7,9,11,13)+f(1 2,3 4).t(2,4,6,8,10,12,14)+f(5 6).t(2:2:14,3:2:13)]

Reference