Meta-population model for the North West Shelf Flatback Turtle Conservation Program

Flatback Futures – Update 4 – April 2020

The Northwest Shelf Flatback Turtle Conservation Program (NWSFTCP) is coordinated by the Department of Biodiversity, Conservation and Attractions (DBCA) in Western Australia. It has a 30-year contract to increase conservation and protection of the Northwest Shelf Flatback turtle population including:

a) surveying, monitoring and research

b) reducing interference to key breeding and feeding locations

c) establishing information and education programs

Key to the success of the program will be its ability to ensure effective linkages between research and conservation outcomes by integrating and planning research and activities for turtles and the community-at-large. Our four-year project (2018-2021) is undertaking a range of activities, including development of modelling approaches to support long-term adaptation planning.

Models can be used to help conservation managers evaluate management strategies for promoting long-term persistence of the flatback turtle (*Natator depressus*). The project team is developing a set of models, each with different strengths, to aid investigation of adaptation options.

Meta-population model description

The turtle population consists of a set of nesting sites. The number of juvenile (J) or adult (A) female turtles is estimated, and they are associated with the site where they hatched. Each year, juvenile and adult survival is s_J and s_A, and juveniles take, on average, ($1/p_{JA}$) years to reach sexual maturity.

A fraction b of adult females breed each year. Fraction ($1-f$) of these females will lay eggs at the same site they visited last time and fraction f use a new site - termed floaters (F). If there is sufficient space at their natal site (K available nests) then they return (R), otherwise those that miss out also become floaters in the model. Floaters choose among all sites with probabilities proportional to the nest availability, a. Floaters find a new nesting site with probability ϕ (Figure 1).

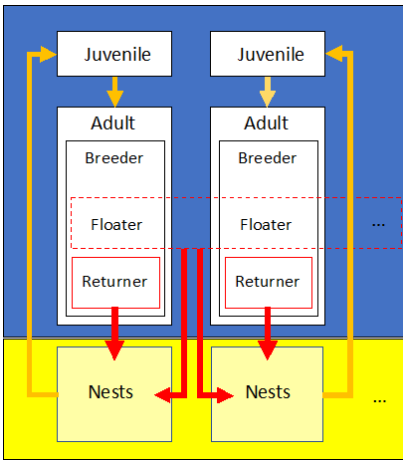

Figure 1: Metapopulation structure of the turtle population. White boxes depict animal states and orange arrows show possible annual state-transitions. Red-dashed box indicates breeding females that become floaters (because of local nest limitation), which then nest at a site other than where they were born. Red arrows show where females nest.

Successful breeders (*B*) each produce *C* clutches of *E* eggs, of which fraction *r* are female. These eggs survive to become juveniles with probability s_1, which is the product of state-dependent survival probabilities (e.g. egg, hatchling on beach, dispersing hatching).

The equations to the right describe the population dynamics of females associated with a site. Parameters may vary among sites due to environmental variation, or they may be altered by conservation activities. *t* is the year.

$$R_{t+1} = \min\{K, (1-f)bA_t\}$$

$$F_{t+1} = fbA_t + \max\{0, (1-f)bA_t - K\}$$

$$B_{t+1} = \min\left\{K, R_{t+1} + a\phi \sum F_{t+1}\right\}$$

$$J_{t+1} = CErS_1B_{t+1} + S_J\,(1-p_{JA})\,J_t$$

$$A_{t+1} = S_A A_t + S_J\,p_{JA}\,J_t$$

Currently, the model is implemented in Excel and it is very easy to use. Parameter values are entered into a spreadsheet, can be modified, and model predictions are quickly and automatically calculated.

Results

The model simulates turtle dynamics for nine monitored nesting sites: Thevenard, Barrow, Varanus, Montebellos, Rosemary, Dampier, Cape Lambert, Mundabullangana, and Port Hedland. Preliminary parameters were sourced from the literature (Table 1). Parameters with the highest uncertainty are associated with the survival of turtles during their first year. First year survival (s_1) was set so that populations were in weak decline.

Table 1: Parameter descriptions and base-line values

Parameter	Value	Description	Parameter	Value	Description
M	21 y	Age at maturity	*f*	0.05	Prob. nest elsewhere
p_{JA}	0.048	1/*M*	s_E	0.6	Egg survival
C	2.84	Clutches per year	s_H	0.5	Hatchling survival
E	48	Eggs per clutch	s_Y	0.2	Young hatchling survival
ϕ	0.8	Prob. floaters lay eggs	s_{J1}	0.15	Older hatchling survival
K	4-1067	Max. nests per site	s_1	0.009	= $s_E s_H s_Y s_{J1}$
b	0.4	Prob. females breed	s_J	0.88	Annual juvenile survival
r	0.5	Sex ratio (f:m)	s_A	0.92	Annual adult survival

As an example, the model is used to investigate the benefit of an intervention that increases egg survival from 60% to 70% at Mundabullangana and to 80% at Barrow. These protections still result in a very weak decline at Mundabullangana, but weak positive population growth at Barrow. The long-term rate of population decline is slowed, however, total population size is predicted to continue to decline even when such conservation efforts are sustained over 100 years (Figure 2).

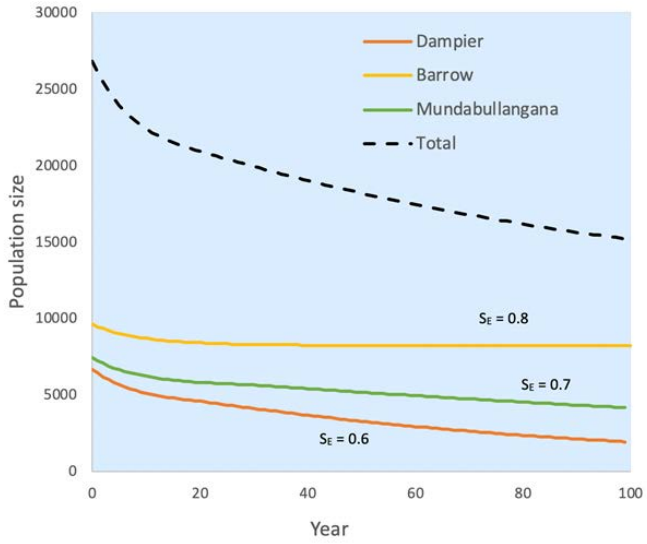

Figure2: Simulated long-term change in the population abundance of *N. depressus*. Numbers (adults + juveniles) are for three sites (coloured lines) and the total population size for the nine sites simulated (dashed line). Conservation activities result in an increase in egg survival at two of the larger nesting sites.

Future directions

Model parameter values (see Table 1) will be further refined using the latest available field data. Sensitivity analyses with respect to parameter uncertainty will also be performed. These analyses will identify which life-stages are best targeted and when, and what combination of conservation strategies are likely to be of benefit. The utility of reformulating the model into a spatially explicit and age-structured form will also be assessed.

Overall, these models contribute to the evidence base used to build productive partnerships and better target intervention, communication and engagement efforts.

Further information

The Flatback Futures project webpage features regular updates: https://research.csiro.au/teps/current-activities/mapping-and-monitoring- outcomes-and-developing-adaptation-pathways-for-the-northwest-shelf-flatback-turtle-conservation-program-western-australia/

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