Individual Based Modeling of Green Turtle Spatial Dynamics in the Southwest Indian Ocean
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Introduction
Southwest Indian Ocean (SWIO) represents a noteworthy region to study green turtle Chelonia mydas spatial ecology. Indeed, spatial complexity of the region and presence of numerous nesting sites (mostly islands) as well as vast nesting areas (mostly East-Africa and Madagascar) is a unique opportunity to understand the role of space in turtle ecology. For more than twenty years now, a number of effective studies have been conducted locally in major areas. Due to recent progress in wildlife tracking, movements of marine turtles between those sites are starting to be well-documented. Here, we propose an original approach to integrate this knowledge using a spatially explicit individual-based model.

Material and Methods
Individual-based modeling
Individual-based or agent-based models (IBM) generally refer to models that infer the global dynamic of a system by modeling and simulating the constituents of that system. In ecology, IBMs are models that derive the properties of ecological systems from the properties of the individuals constituting these systems. This “bottom-up” approach allows the understanding of unexplained properties at population scale from a good knowledge of what is happening at individual scale. We used the publicly available platform NetLogo to implement the model.

Objectives
The main objective of the model is to study the influence of SWIO topology on the reproductive potential of green turtle rookeries. As a matter of fact, spatial arrangement of nesting and feeding areas affects population viability. Proximity and accessibility of feeding sites is likely to favor reproduction by reducing the cost of the migration. On the other side overpopulated feeding sites might delay reproduction event through food competition. Thus, population reproductive potential and therefore viability may be a resulting balance between the accessibility of the sites and the number of individuals that share this site.

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Inductive potential and therefore viability may be a resulting balance between the cost of the migration. On the other side overpopulated feeding sites might delay reproduction event through food competition. Thus, population reproductive potential and therefore viability may be a resulting balance between the accessibility of the sites and the number of individuals that share this site.

Results
With a few number of simulated scenarios, the model already exhibits interesting patterns regarding reproductive potential of green turtle rookeries in the SWIO. Under moderate site depletion, an island (e.g. Tromelin) located far from the feeding sites areas generally displayed a lower reproductive potential while islands (e.g. Mayotte, Glorieuses) closely surrounded by numerous feeding areas displayed a higher reproductive potential. This can easily be explained, the migration cost being higher when turtles have to swim long distances. Indeed, lowering the energetic expenditure due to migration tends to homogenize rookeries reproductive potentials. Remarkably increasing the impact of individuals on feeding site quality also tends to reduce these differences. This is mainly because turtles from remote nesting islands make use of less frequented feeding sites. So our model suggests that longer reproductive migration can be compensated by a lower frequentation of the feeding areas. Further simulations should confirm these results and guide us in our understanding of the influence of the SWIO spatial topology on green turtles population.

Discussions
Also this model showed very intuitive results, further investigation is needed at this stage to gain confidence in the results. Exploiting this model to its best requires a sensitivity analysis in particular to energetic parameters. Moreover, more individual variability could easily be implemented. We also plan to run more simulations under different case scenarios (e.g. altering local feeding sites quality). Oceanographic and environmental variables also play for sure an important role in the spatial dynamic of the green turtle in the SWIO and could be integrated.