Conservation through satellite telemetry: how accurate are state-space models and other Argos-derived datasets?

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Introduction:

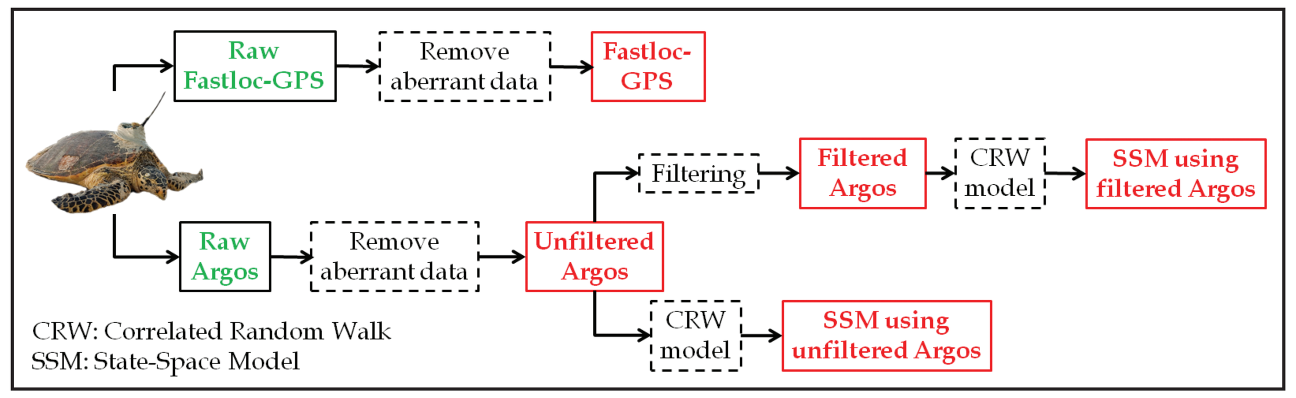
Satellite telemetry is the most common tool for wildlife tracking and home range estimation (Hays 2008). Two main technologies exist:

- Fastloc-GPS: very accurate (50 m.), but expensive,
- Argos: limited accuracy, cheaper.

State-Space Models (SSM) are widely used to overcome Argos' limited accuracy (Patterson et al. 2008): they consist in fitting Correlated Random Walk (CRW) models to Argos data to produce predicted locations (Jonsen et al. 2005). Few studies have yet tested the accuracy of those predicted data, especially for conservation purposes and the estimation of animals' home range (Patterson et al. 2010,). Such assessments are paramount to better understand animals habitat use and improve wildlife protection measures originally designed using raw or filtered Argos datasets. Here we used highly accurate Fastloc-GPS data to determine which Argos-derived dataset provides the best estimation of an animal's home range.

Methods:

Seven satellite tags recording Fastloc-GPS and Argos data were attached on adult female hawksbill sea turtles (*Eretmochelys imbricata*) in Groote Eylandt, Northern Australia. The figure below describes the procedure followed to obtain the five datasets (in red) we used for our analysis (CRW model developed by Breed et al. (2009)). The internesting (period between nesting events), migration and foraging phases were then isolated for each individual prior to further analysis.



The 50% fixed Kernel Density Estimation (KDE) method using least-squares cross-validation bandwidths was used to assess hawksbills' core area of activity. For the foraging period, each individual was treated separately as none foraged at the same location. Conversely individuals internesting locations were gathered (through random sampling and bootstrapping) to estimate the seven individuals' internesting area. Then we calculated the overlaying percentage between each Argos-derived home range and the Fastloc-GPS one along with the error ratio (=size of the Argos-derived area/size of the Fastloc-GPS area). Migratory corridors were compared by estimating the minimum distance between each Argos-derived location and the GPS track.

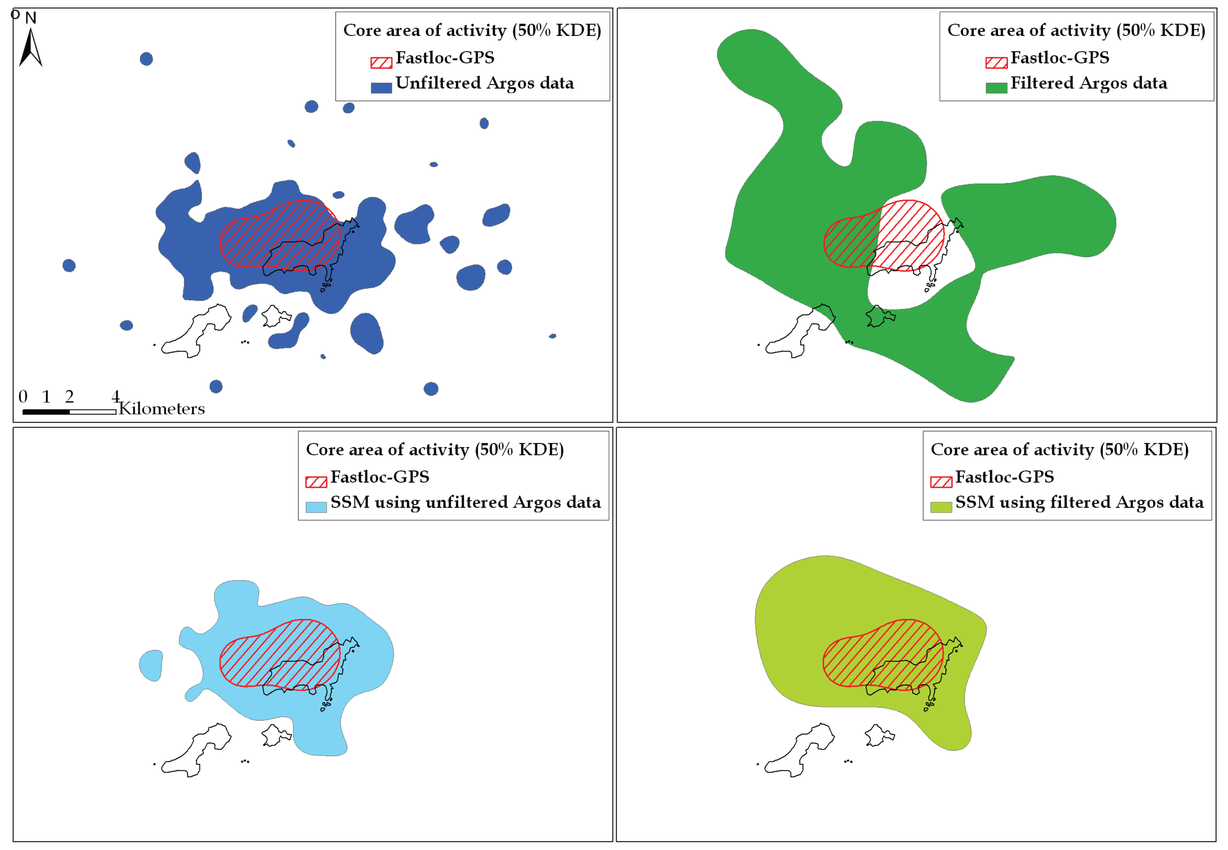


Figure 1: Comparison of Fastloc-GPS' core area of internesting activity (50% KDE) against all Argos-derived ones for all individuals

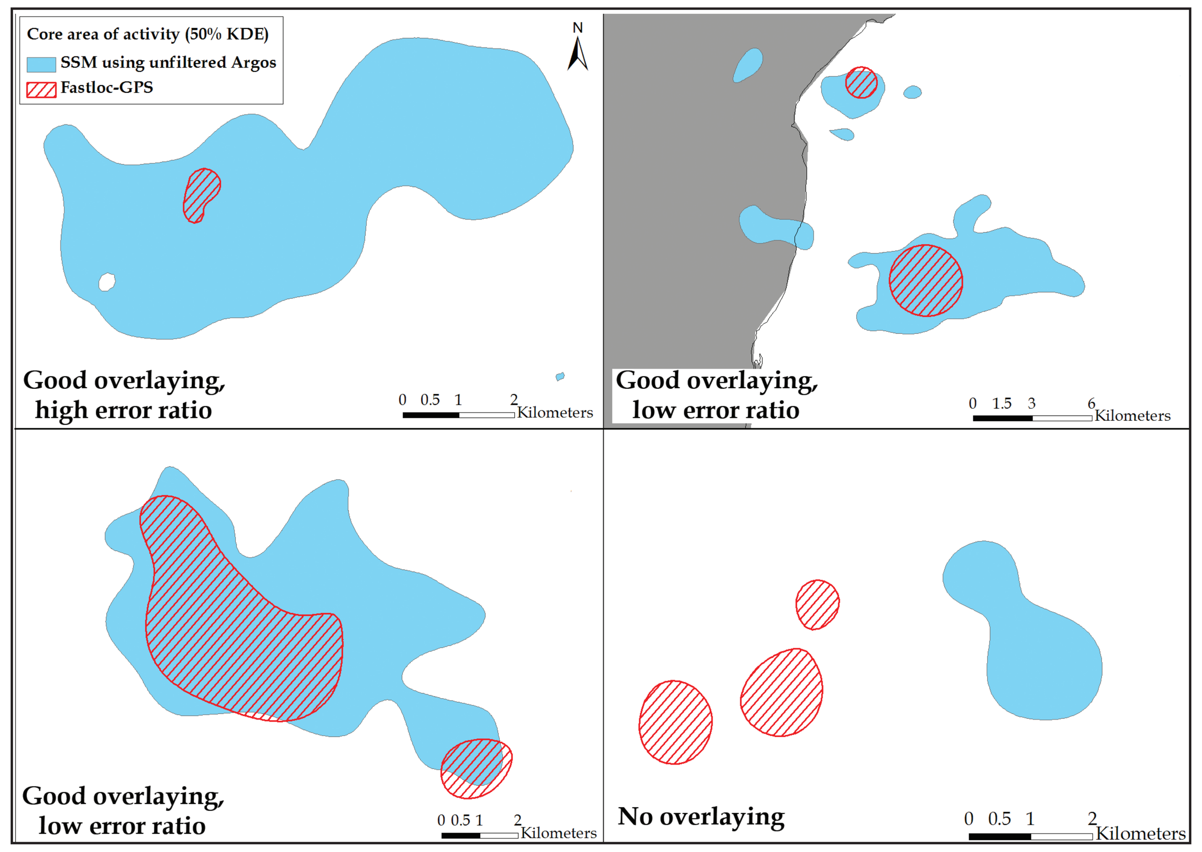


Figure 2: Comparison of Fastloc-GPS' core area of foraging activity (50% KDE) against the most accurate Argos-derived one (SSM using unfiltered Argos data) for four individuals

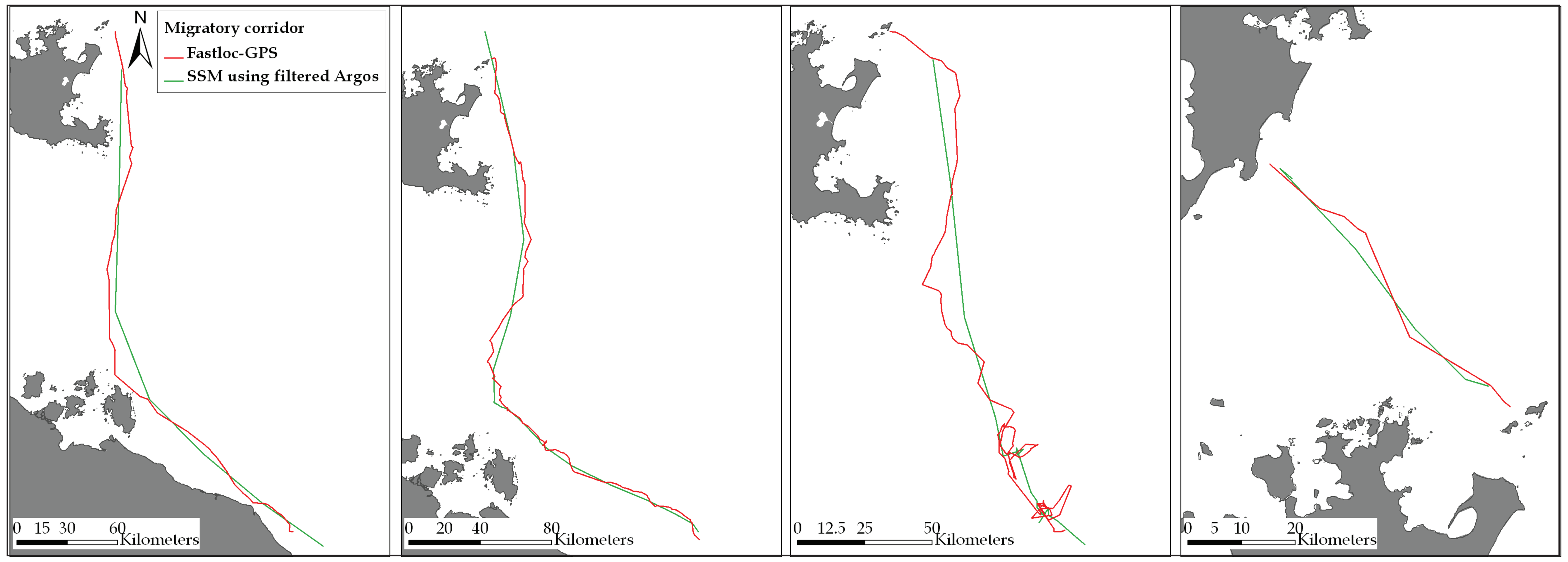


Figure 3: Comparison of migration tracks obtained using Fastloc-GPS data and the most accurate Argos-derived dataset (SSM using filtered Argos data) for four individuals

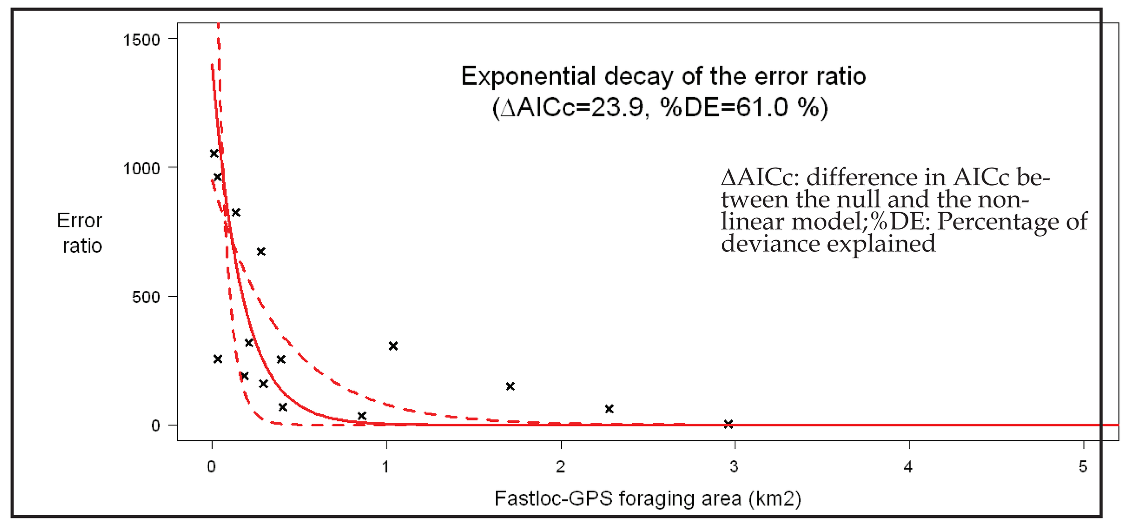


Figure 4: Relationship between the error ratio and the size of the Fastloc-GPS area. The red line has been obtained by reiteration of non-linear models using different values of starting parameters. Dashed lines represent the 2.5 and 97.5% confidence intervals.

Results:

Our seven hawksbill turtles spent little time at the surface (68.9±50.7 s), only transmitted 2.4±1.0 Argos locations per day and had a low proportion of location classes above zero (8.8±7.0 %).

All Argos-derived datasets overestimated hawksbills home range size (Figure 1 and 2). For both internesting and foraging periods, SSMs from unfiltered Argos data displayed the best results: they maximized the overlaying percentage while minimizing the error ratio (Table 1). Poor overlapping was observed for small sample size while the error ratio decreased exponentially with increasing GPS area sizes (Figure 4).

For the migration phase similar mean errors (≈3.0±3.4km) were obtained for the filtered Argos and the two SSM datasets. Nevertheless only SSMs using filtered Argos data minimized the mean maximum error (10.8±3.7km) (Table 1, Figure 3).

Table 1: Error associated with each Argos-derived datasets. The best approach for each phase is indicated in red

Phase	Method	Unfiltered Argos data	Filtered Argos data	SSM using unfiltered Argos	SSM using filtered Argos
INTERNESTING (50% KDE)	Error ratio/coverage	5.9 / 100%	7.6 / 37.5%	**3.2 / 100%**	4.1 / 100%
MIGRATION (error, in km)	Mean ± SD Mean max. ± SD	5.4±8.7 49.6±19.3	2.9±3.4 13.4±3.1	3.4±3.4 14.8±7.2	**3.1±3.3** **10.8±3.7**
FORAGING (50% KDE)	Mean ± SD (error ratio/coverage)	484.6±937.6/ 84.8±30.5%	289.8±651.5/ 77.4±32.2%	**326.0±747.6 / 84.2±37.2%**	393.9±950.3 / 59.0±42.3%

Conclusions:

Although experience is required to properly implement SSMs, they provide a noticeable improvement to Argos data and are freely available as supplements to many scientific journal articles. SSMs always performed better than Argos data, we therefore recommend their use to set up more efficient conservation measures (Table 1). Fastloc-GPS should nonetheless be preferred to Argos when studying animals known to have restricted home-ranges.

This study was carried out on seven marine animals having low transmission frequencies and more than 90% of poor Argos location classes (A and B). Collecting more data is consequently paramount as Argos transmission frequency and quality heavily influence SSMs performance (Nicholls & Robertson 2007).

Literature cited:

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