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# Effects of inter-FAD distances on the movements of tuna in an array of FADs: an empirical modeling approach

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IPNLF FOR ONE-BY-ONE FISHERS

OBSERVATOIRE DES ÉCOSYSTÈMES PÉLAGIQUES TROPICAUX EXPLOITÉS

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# Goal of the project

- To assess the effects of different densities of floating objects on tuna behavior

# Objective of the study

- To develop and fit a model of tuna movements in arrays of FADs based on real data:
  - Active tracking of tuna (<2000's)
  - Passive tracking of tuna with coded tags and acoustic receivers (>2000's)

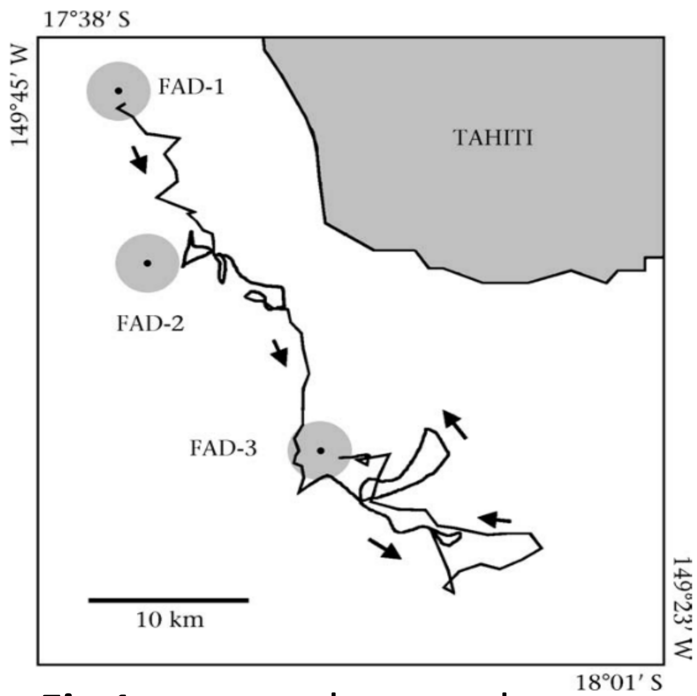
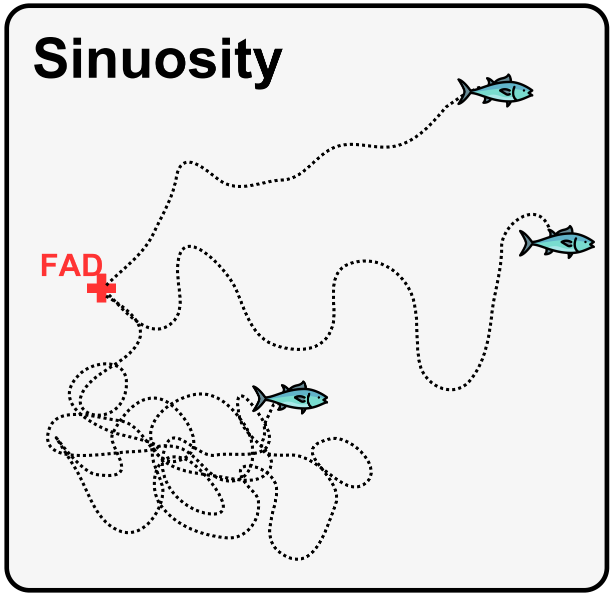
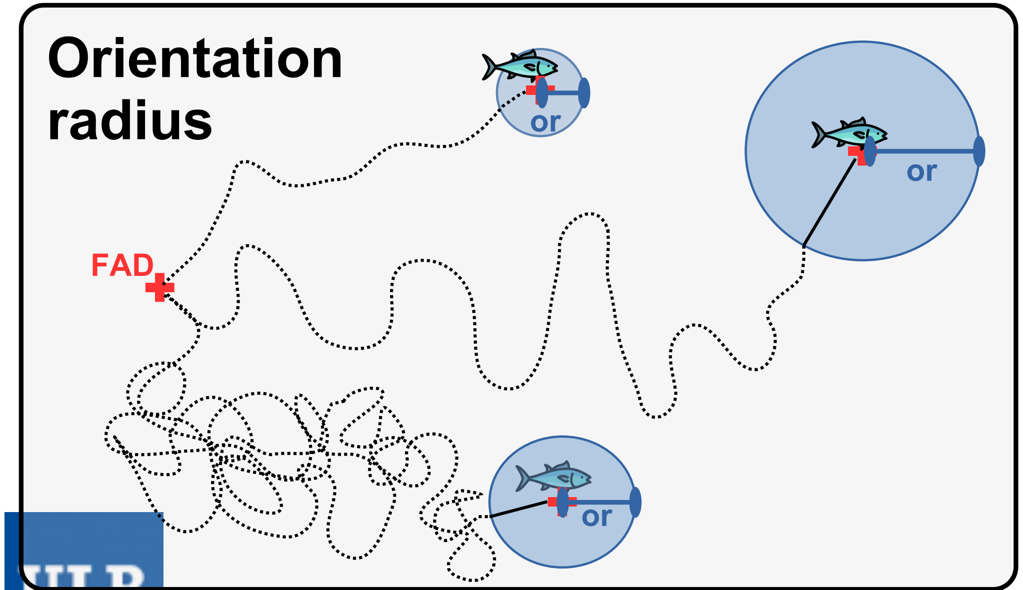



**Fig 1**: tuna path example (Girard et al. 2004)

# A simple model based on the sinuosity and the orientation radius




Correlated Random Walk model (Girard et al. 2004)

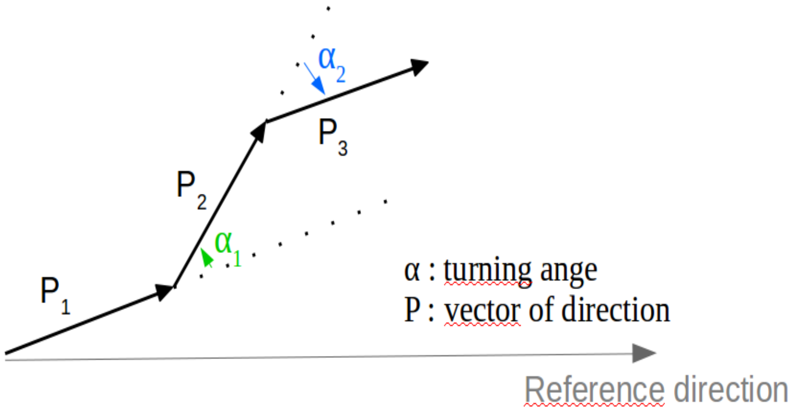



**Fig 2**: Diagram of a Correlated Random Walk.

$$N(0,\sigma) \rightarrow \alpha$$

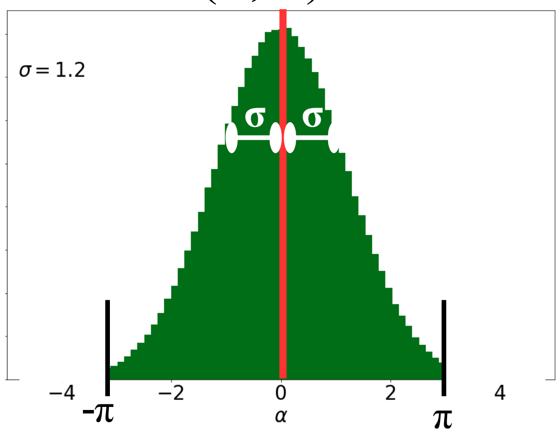



**Fig 3**: Normal distribution of the turning angle, only define between [-π, π]

# 2 options for a same model

**" PERSISTENT MODEL"**

Common rules

**" DIEL MODEL"**

→Tuna have a random search motion
→ When a tuna is

- close enough to a FAD to be able to detect it (orientation radius) and

PERSISTENT MODEL:
- the FAD detected is different from the previously visited FAD,

DIEL MODEL:
- It is day time

the individual goes straight towards the FAD.
→ When the FAD is reached the tuna gets back to a random search motion.

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# Fitting the models with passive tracking data

**CAT = Continuous Absence Time**: time that tuna spend out of FAD (between 2 associations)
This parameter represents an output of the movement of tunas in an array of FADs (sinuosity and orientation radius to FADs)

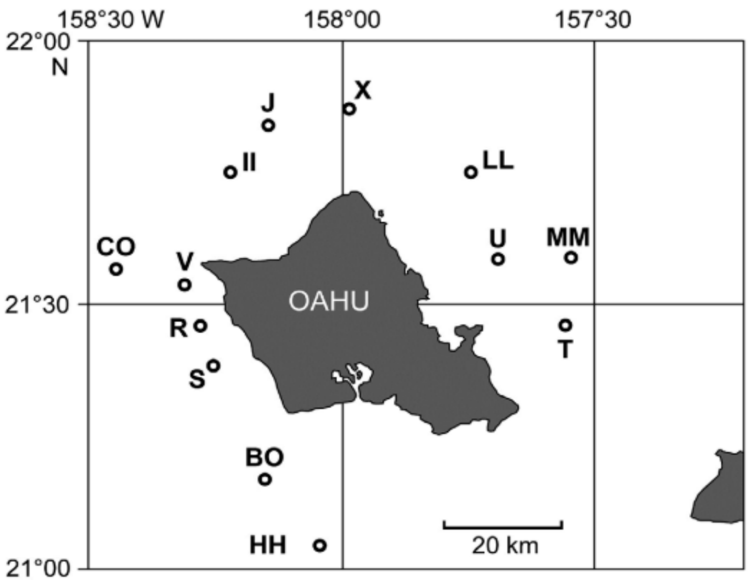



**Fig 1**: FADs around the island of Oahu (Hawaii) (Robert et *al.* 2013).

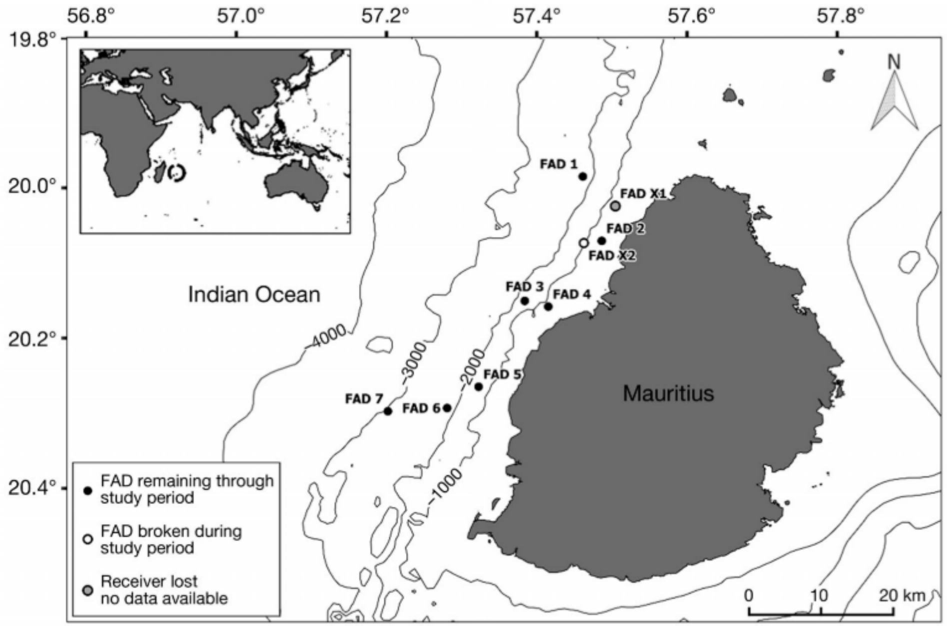
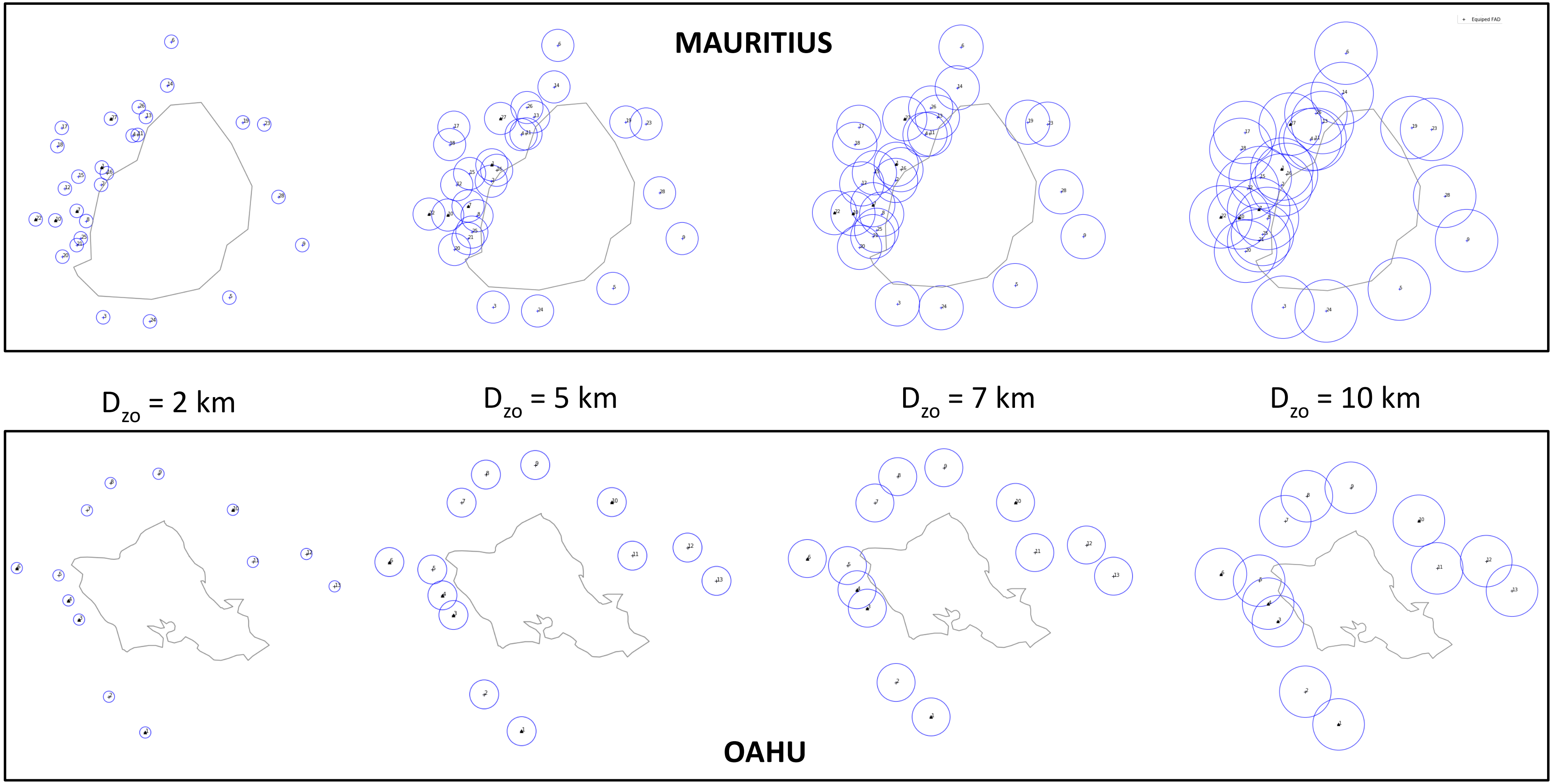



**Fig 2**: Instrumented FAD array off the coast of Mauritius (Rodriguez et *al.* 2017)

# Orientation radius – Modelled environment



# Sinuosity

The sinuosity parameter c is linked to the turning angles as follows: $$c = \exp\left(\frac{-\sigma}{2}\right)$$

(Where sigma is the standard deviation of the distribution of turning angles)

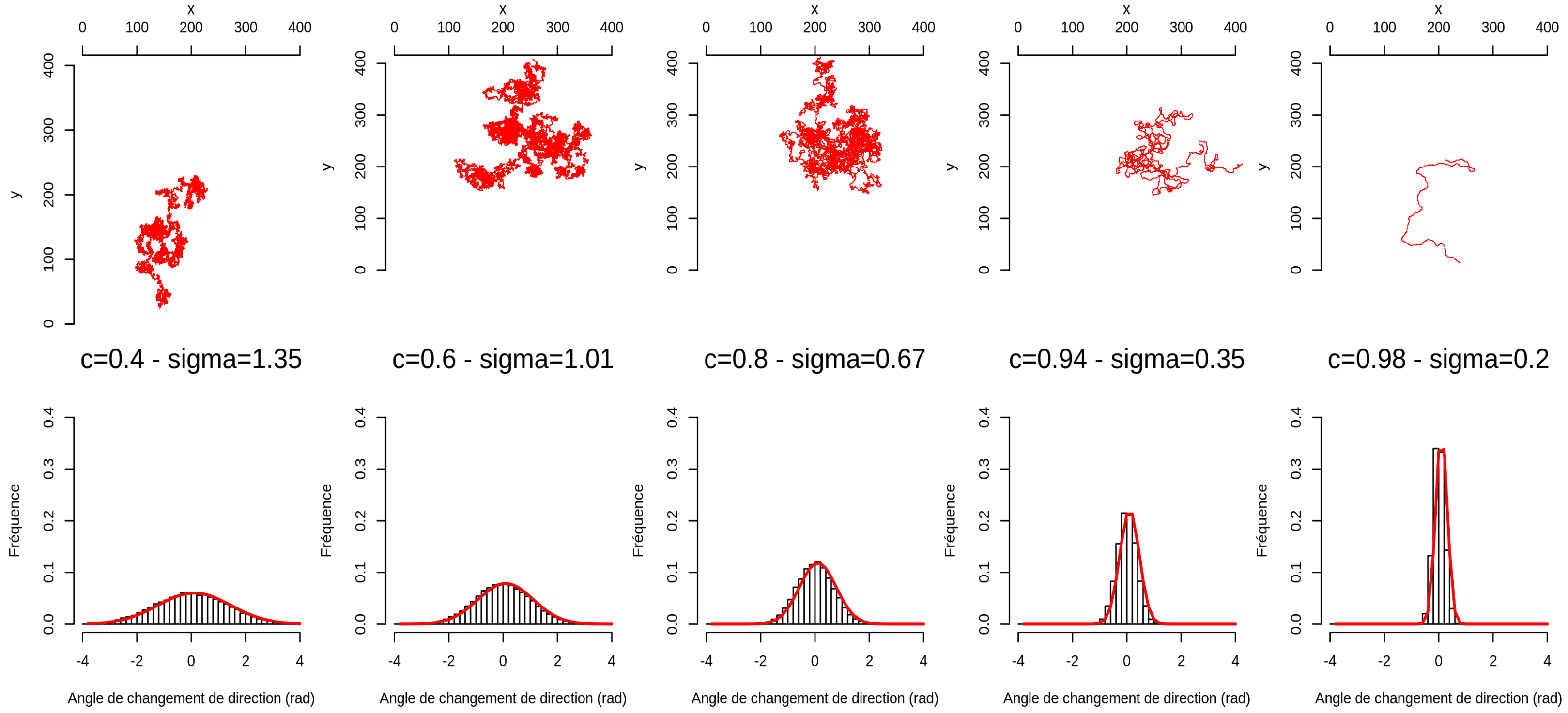



**Fig 5**: Values of sinuosity tested in the model. The 5 figures at the top show an example path according to the turning angle distributions from distributions shown at the bottom.

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# Calibrating parameters using acoustic tagging data in Hawaii and Mauritius

The Diel model shows slightly better results than the Persistent model.

Girard et *al.* (2004)
Orientation radius = 9 - 11 km

Our model
Orientation radius = 5 - 7  km

Girard et *al.* (2004)
Sinuosity = 0.8

Our model
Sinuosity = 0.8 - 0.94

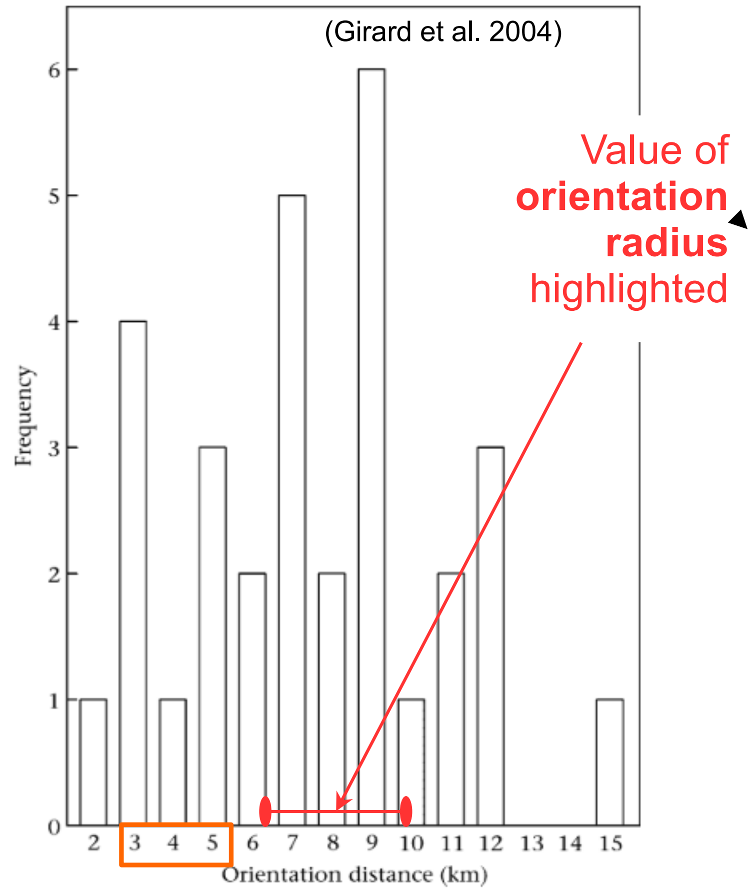


**Figure 4.** Frequency distribution of the orientation distances to on-FAD areas. Note that, with 2-km radius on-FAD areas, the distances to the FADs themselves should be longer by about 2 km.

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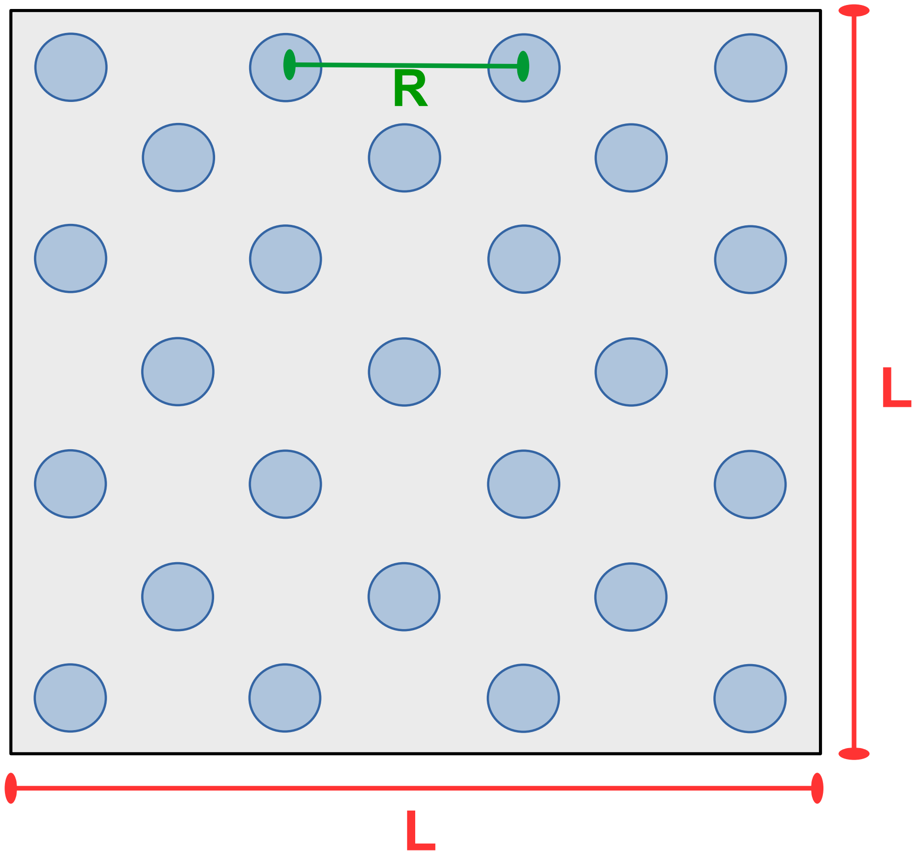
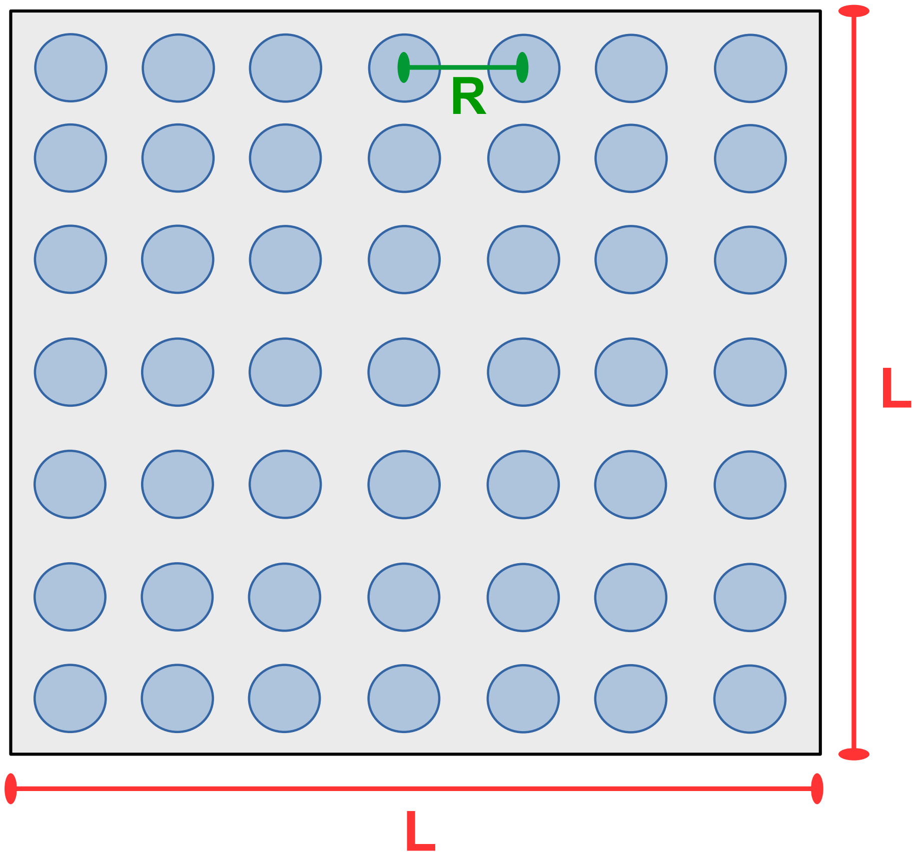
# Theoretical model, with different distances between FADs

R ∈ [20, 30, 40, 50, 100, 150, 200] km

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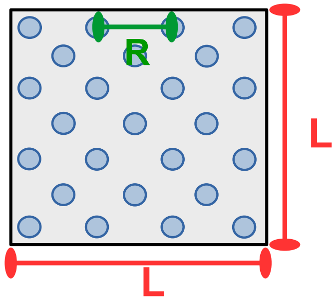
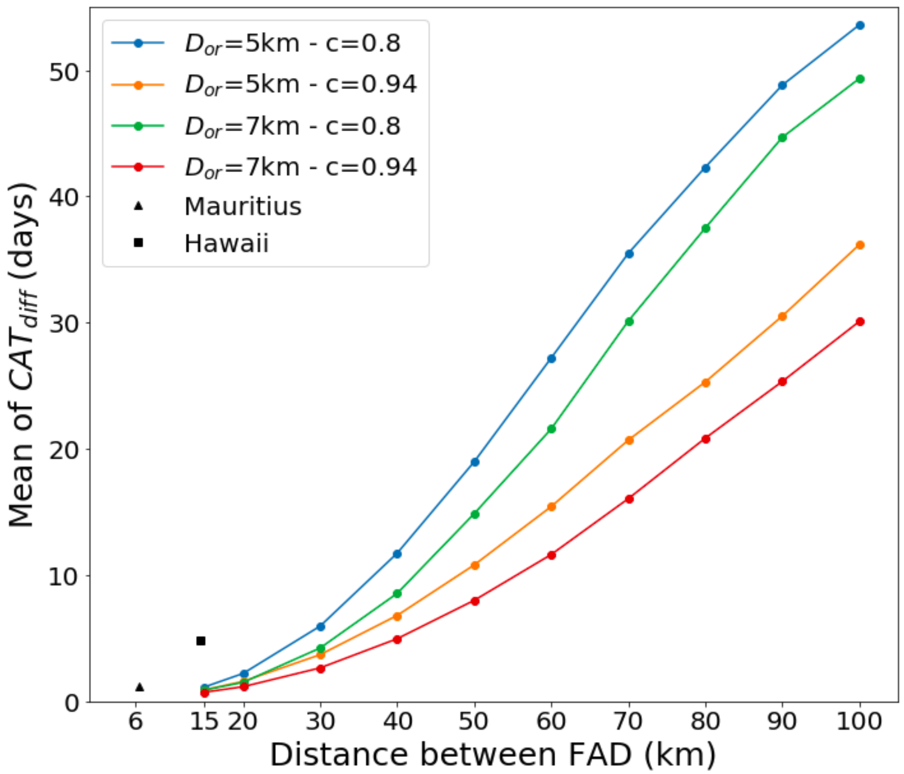
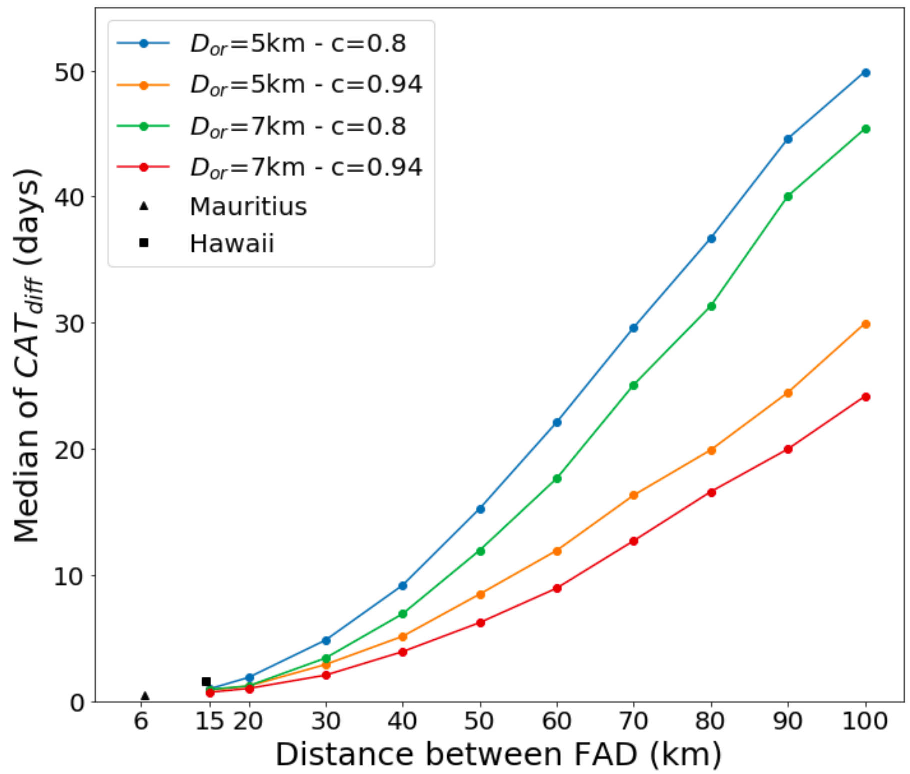



# Sinuosity vs orientation radius




→ The variation of the sinuosity (c) has more impacts than the orientation radius ($D_{or}$).

→ Need to conduct new active tracking to collect more sinuosity data

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# Theoretical environment

## What differences in CAT (time between two FAD associations) can we expect between environments with or without artificial FADs?

Nearest neighbor drifting floating object (FOB) in the Indian Ocean (Dagorn et al. 2013):

- With no FAD and only natural FOBs: **100 km**
- FOBs + FADs: **25 km**

(Dagorn et al. 2013)

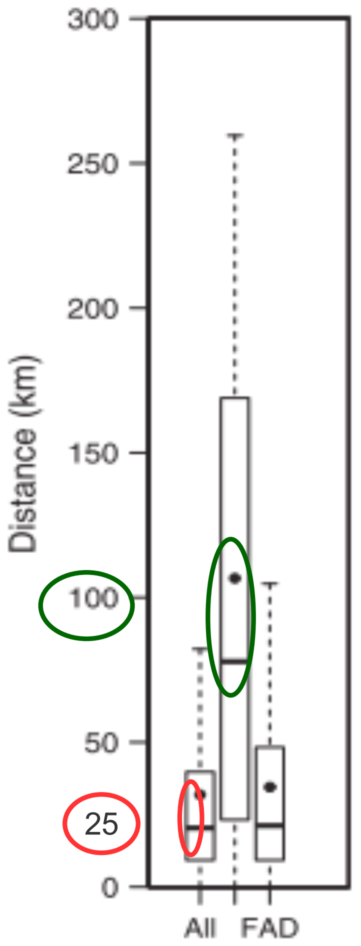
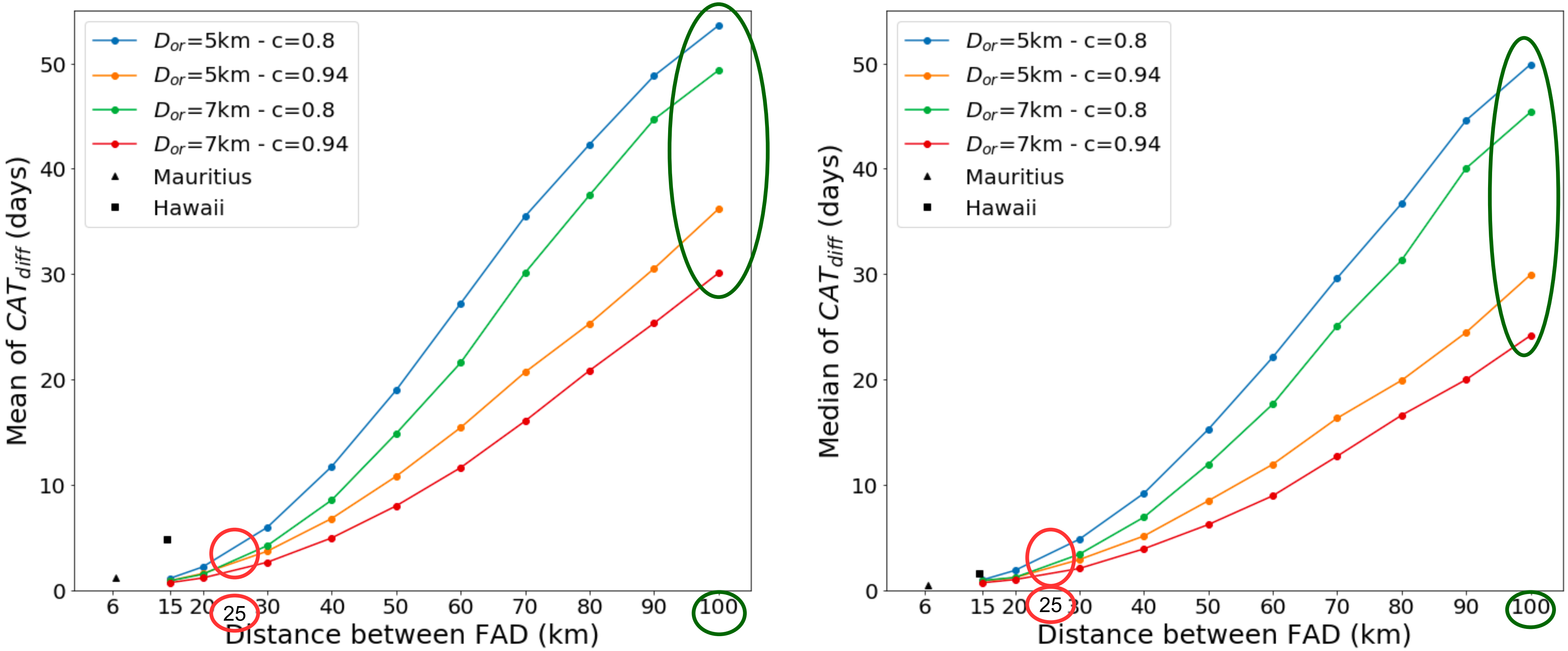



**Figure 3.** Boxplots representing the distributions of distance towards the nearest neighbour by quarter. Results obtained for all types of floating objects, and for logs and FADs, respectively. Points are situated at the mean level (to be compared with the median indicated by the boxplots).

Natural floating object

FAD + naturals floating object

# Increasing the density of floating objects (FOBs)




- If only natural FOBs: **1-2 months** between 2 FOB associations
- If natural FOBs + FADs: **< 5 days** between 2 FOB associations

→ Tool to estimate effects of changing densities of FOBs on tuna behavior

→ Need to measure the time between 2 FOB associations (challenge for DFOBs)

→ Need to conduct new active tracking