Supporting information S1 to **"Methods to detect spatial biases in tracking studies caused by differential representativeness of individuals, populations, and time"**

Virginia Morera-Pujol[1,2,*], Paulo Catry[3], Maria Magalhães[4], Clara Péron[5], José Manuel Reyes-González[1,2], José Pedro Granadeiro[6], Teresa Militão[1,2], Maria P. Dias[7], Daniel Oro[8],[9], Giacomo Dell'Omo[10], Martina Müller[11], Vitor H. Paiva[12], Benjamin Metzger[13], Verónica Neves[14], Joan Navarro[15,16], Georgios Karris[17], Stavros Xirouchakis[18], Jacopo G. Cecere[19], Antonio Zamora-López[20], Manuela G. Forero[21], Ridha Ouni[22], Mohamed Salah Romdhane[23], Fernanda De Felipe[1,2], Zuzana Zajková[1,2,8], Marta Cruz-Flores[1,2], David Grémillet[24,25], Jacob González-Solís[1,2], Raül Ramos[1,2]

1 Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Facultat de Biologia, Universitat de Barcelona (UB), Av. Diagonal 645,Barcelona 08028, Spain.
2 Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona (UB), Barcelona, Spain
3 MARE, Marine and Environmental Sciences Centre, ISPA-Instituto Universitário, Rua Jardim do Tabaco 34, 1149-041 Lisbon, Portugal.
4 Regional Secretariat for the Sea, Science and Technology, Regional Directorate for Sea Affairs (DRAM), Azores, Portugal.
5 Laboratoire de Biologie des Organismes et Ecosystèmes Aquatiques (UMR BOREA) MNHN, CNRS, IRD, SU, UCN, UA, Paris, France
6 CESAM, Departamento de Biologia Animal, Faculdade de Ciências, Universidade de Lisboa, Lisboa, Portugal.
7 Centre for Ecology, Evolution and Environmental Changes (cE3c), Department of Animal Biology, Faculdade de Ciências da Universidade de Lisboa, Portugal
8 Centre d'Estudis Avançats de Blanes (CSIC), Carrer Accés Cala Sant Francesc, 14, 17300 Blanes, Spain.
9 IMEDEA (CSIC-UIB), Miquel Marques 21, 07190 Esporles, Spain.
10 Ornis Italica, Rome, Italy.
11 Department of Natural Resources Science at the University of Rhode Island, USA
12 University of Coimbra, Department of Life Sciences, MARE-Marine and Environmental Sciences Centre / ARNET - Aquatic Research Network, Calçada Martim de Freitas, 3000-456 Coimbra, Portugal
13 BirdLife Malta, 7/28 Marina Court, Triq l-Abate Rigord, Ta' Xbiex, Malta.
14 MARE – Marine and Environmental Sciences Centre, IMAR & Okeanos, Department of Oceanography and Fisheries, University of the Azores, PT-9901-862 Horta, Azores, Portugal.

15 Centre d'Ecologie Fonctionnelle et Evolutive, UMR 5175, CNRS - Université de Montpellier - Université Paul-Valéry Montpellier - EPHE, Montpellier, France.
16 Institut de Ciències del Mar, CSIC, Barcelona, Spain.
17 Department of Environment, Faculty of Environment, Ionian University, GR-29100, Zakynthos, Greece.
18 University of Crete, Natural History Museum of Crete, PO Box 2208, GR-71409 Crete, Greece.
19 Area per l'Avifauna Migratrice (BIO-AVM) Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) Via Ca'Fornacetta 9 I-40064 Ozzano Emilia, Italy.
20 Southeast Naturalists Association (ANSE). Pza. Pintor José María Párraga nº11, 30002 Murcia (Spain) and Department of Zoology and Physical Anthropology, University of Murcia, Espinardo Campus, 30100 Murcia, Spain.
21 Estación Biológica de Doñana CSIC, Sevilla, Spain.
22 Université de Tunis El Manar, Faculté des Sciences Mathématiques, Physiques et Naturelles de Tunis (FST)
23 Université de Carthage Institut National Agronomique de Tunisie, 43 Avenue Charles Nicole, CP 1082 Tunis, Tunisia.
24 Centre d'Etudes Biologiques de Chizé, UMR7372, Université La Rochelle, Villiers-en-Bois, France.
25 Percy Fitzpatrick Institute of African Ornithology, NRF-DST Centre of Excellence at the University of Cape Town, Rondebosch 7701, South Africa.
* Current address: School of Biology and environmental Sciences, University College Dublin, Belefield, Dublin 4 (Ireland), e-mail: morera.virginia@gmail.com

Description:

Here we show (1) the process to generate the simulated datasets for the power and performance tests of the IndEffectTest function, (2) the process to test the function and (3) the results of the test on different sampling sizes and sampling frequencies. The results of the power tests for different levels of individual site fidelity are shown in the main test. The code for all functions can be found in the *functions* folder, and the code for the different performance tests in the *simulations* folder of the GitHub repository at https://github.com/VirginiaMorera/Tracking_data_analysis

Generating the simulated datasets

In order to generate the simulated tracks, correlated random walk movement models were used via the state.CRW() and simulate() functions in the package 'SiMRiv' (Quaglietta L 2019). We generated a dataset of 10 trips for 10 different individuals (100 trips in total).

To simulate the effect of individual site fidelity (animals have a strong preference for a section of the available area), for each individual we generate a resistance surface (package 'raster') with a "hole" of null resistance (hereafter *allowed area*). Then, we generate the 10 tracks for each individual within that resistance surface, so the positions will be predominantly in the *allowed area*, thus simulating the preference for that area. To generate datasets with decreasing degrees of ISF, we sequentially decrease the level of resistance in the resistance surface outside the *allowed area*, from 1 (maximum level of resistance) to 0 (no resistance outside the *allowed area*, either). A detailed walkthrough of the process can be found at http://rpubs.com/V_Morera-Pujol/supmat.

Testing the function

Three different types of tests were performed using simulated datasets. First of all, to test whether the function would detect individual site fidelity, at varying degrees of fidelity, we generated datasets with sequentially decreasing levels of fidelity and run the test in each of them, then comparing the results. We did this for datasets simulating foraging trios from central-place foraging individuals, but from a hypothetical non-colonial species (trips with different origins for each individual, Fig. S1). The results of the power test are shown and discussed in the main text.

Additional tests

With a dataset simulating high ISF for a simulated non-colonial species, and performed additional tests for the effect of sampling frequency (original dataset, subset every 5th position, and subset every 10th position), and for different levels of sampling effort unbalance among individuals. Our results on the sampling frequency test indicate that the function is able to detect ISF in the original dataset as well as a dataset thinned for every 5th and every 10th location. Lastly, our results on the sampling unbalance test demonstrate that the ISF test is also robust to sampling unbalances. All the code and results of the power test, sampling frequency and sampling unbalance tests can be found in the detailed walkthrough at http://rpubs.com/V_Morera-Pujol/supmat.

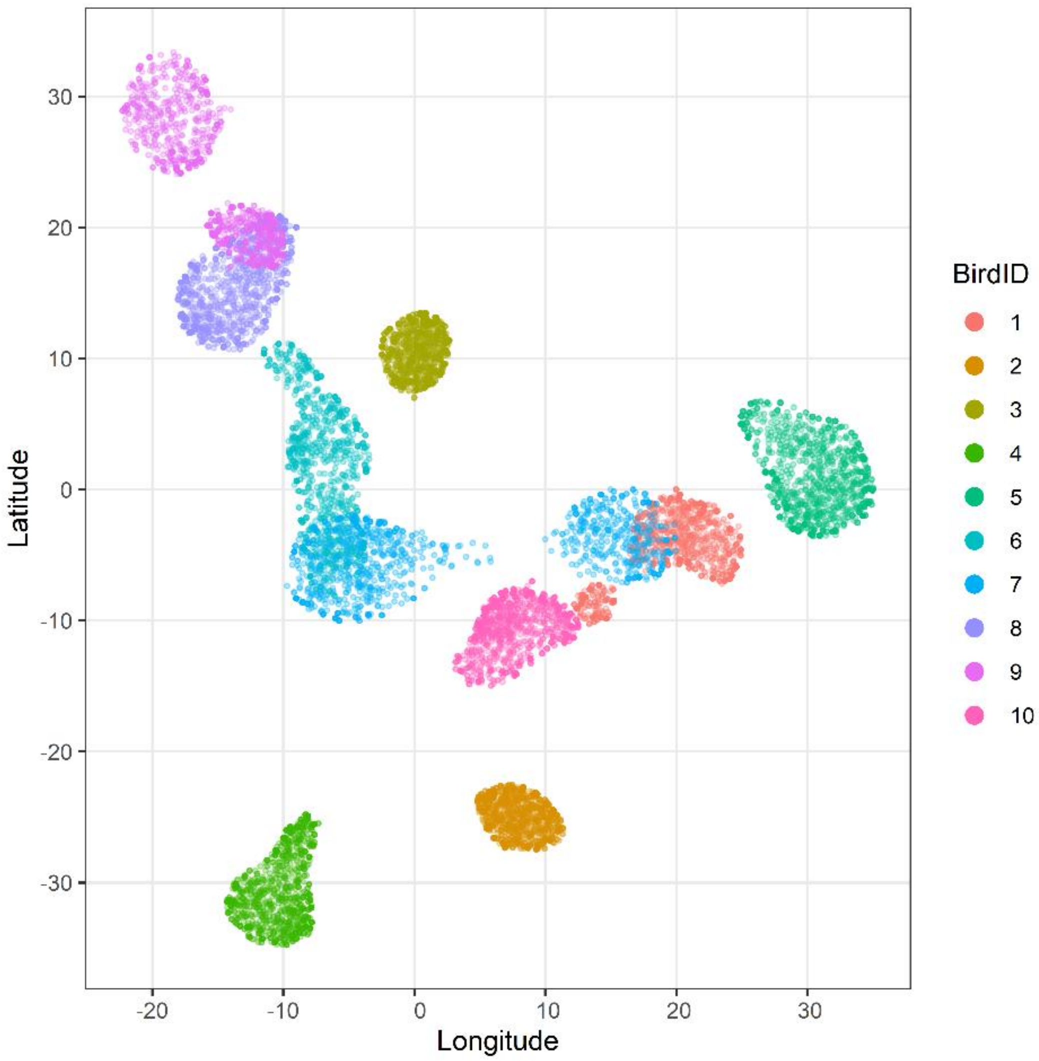

Fig. S1. Simulated datasets for 10 individuals (10 tracks for each individual, 100 positions per track)