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► To cite this version:

Guillon Jerome, Soumah Mohamed. GPSMonitoring: A R package for small scale fisheries monitoring using GPS logger. *Software Impacts*, 2023, 17, pp.100573. 10.1016/j.simpa.2023.100573 . hal-04206196

HAL Id: hal-04206196

<https://institut-agro-rennes-angers.hal.science/hal-04206196v1>

Submitted on 13 Sep 2023

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Original software publication

GPSMonitoring: A R package for small scale fisheries monitoring using GPS logger

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ARTICLE INFO

Keywords:

Small scale fisheries monitoring
GPS tracking
GPS data analysis
Guinean dataset
Fishing event detection

ABSTRACT

After many pilot studies, fisheries monitoring is now ready to generalized the use of GPS logger to improve fishing area knowledge. This is a critical need for fisheries management support for spatial regulation of fleets activities.

The GPSMonitoring R package, aims to gather previous studies feedback and provide a set of tools to cure, prepare and analyze GPS data for fishing event detection. A set of data related to Guinean Canoe collected by the CNSHB is provided with the package. This data is used to produce the vignette that illustrate a full use of the package.

Code metadata

Current code version
Permanent link to code/repository used for this code version
Permanent link to reproducible capsule
Legal code license
Code versioning system used
Software code languages, tools and services used
Compilation requirements, operating environments and dependencies

v1.0.0
<https://github.com/SoftwareImpacts/SIMPAC-2023-217>

GNU GPL License
git
r
R (>= 3.5.0)
Dependencies : ggplot2,parallel,dplyr, tidyr,adehabitatLT,sf, sqldf, shiny,kableExtra,htmlwidgets,leaflet, leaflet.extras,ggpubr,caret,ranger, randomForest,geojsonsf

If available, link to developer documentation/manual
Support email for questions

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1. Introduction

Low cost data logger is now fully accessible. Thus, it become a useful tool to investigate fishing area of small-scale fisheries. For industrial fisheries, on board observers, VMS and AIS are common tool available to produce fishing effort or catches maps. For small scale fisheries and especially in on developing countries context, with no place for observers, no energy supply and lower revenue that limit the use of real time tools that use satellite communication (as VMS), the GPS logger is the main solution for fleets activity mapping. This mapping could be used to estimate a spatial fishing intensity (to estimate Marine protected area efficiency [1] by example).

Another barrier to use GPS data, is the ability for fisheries science center to manage and analyze the big amount of data produced. For the

data management, database with spatial capabilities are now freely and widely available (i.e. Postgres with Rpostgis extension). For curation and analysis no whole solution exists. Regarding past experience, some piece of the data curation is made using GIS software, some other with R or with ad hoc GPS software. The main purpose of this GPSMonitoring package is to provide a unique package for all the data curation and analysis steps.

2. Data curation

This stage of the process is composed of 3 main activities. The first one is the filtering part, the second one is splitting process where

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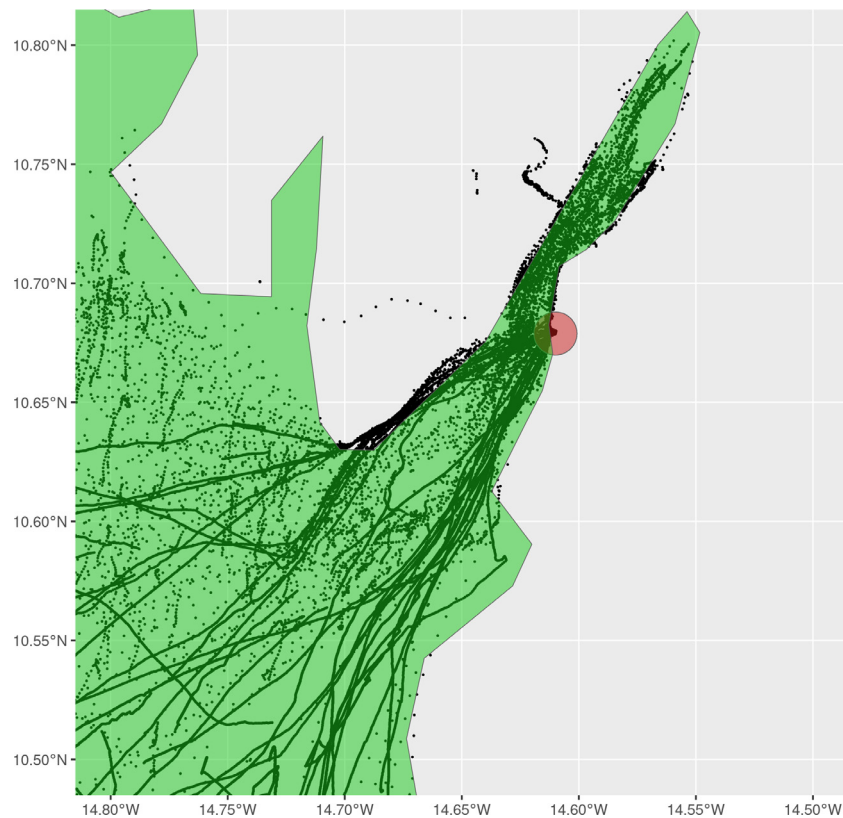


Fig. 1. GPS.curation function keep all position in green Area of Interest and delete locate included in the red perimeter (i.e. port area). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

we want to split the trajectory in fishing trips. The third one is the recalibration process that will update position regarding a constant acquisition frequency.

For the first filtering stage, we want first to avoid having location that will be outside our Area of interest. And the Area of interest could be defined as potential fishing area (see Fig. 1). That means that we want to avoid position outside my study area (Guinean EEZ by example) that could be outside the scope of my interest. We also want to avoid position located near the port. We will not consider positions included in a perimeter of n meters (to be defined) around the port. Deleting those position will help us to define fishing trips as a trajectory split by a period during which the Canoe is on port (and so, after filtering, without position). This first filtering stage will delete many positions collected during the night or when fishermen are on earth. That will speed up next process.

And the fishing trip definition will also speed up next process as we will be able to parallelized the same fishing event for all the fishing trip.

The last one step in the Curation process is the frequency standard using the Redis.traj function (including redisltraj function from adehabitatLT package). The frequency acquisition on GPS is not always constant. This last curation function will consider a constant frequency, end will recalculate each position of a given trajectory, in order to simplify next step (the model set up).

3. Fishing event detection

The fishing event detection part of the analysis is described in 2 steps. First Knowledge of expert acquisition (observation part) and second the use of this expertise to model fishing event and to predict them (model part).

National fisheries expert should have knowledge on fishermen behavior during fishing events. This knowledge transcription will used

fishing trips shape and Canoe speed. Using these two parameters, expert can flag fishing events on a map or on a time series of speed distribution. Once several fishing trips are described as fishing event (True or False), this observation is used to develop a model that could predict fishing event without observers, function of quantitative parameters of pings that compose the trip (i.e. speed or cap...) (see Figs. 2 and 3).

Several frameworks could be used for this kind of model. Within the package, we currently propose Generalized Linear Model (GLM) and Random Forest (RF) one. They are both relevant and could be selected using available statistical skills criteria or on execution speed criteria.

The corresponding function model.traj.glm and model.traj.RF will provide information on the fitting quality, these provided by functions glm (base package) and ranger (ranger package).

Then between models, quality could be compared using SENSITIVITY, SPECIFICITY AND ACCURACY indicators. (quality.ind function)

4. Impact overview

The GPSMonitoring package has been developed to support Small scale fisheries monitoring development using GPS on board electronic device. This additional tool (in addition to landing survey data collection) will help fisheries science institution to provide spatial overview of fishing activities. Regular data collection toward small scale fisheries in a on developing countries context give information on the catches composition (What) and on effort (How) and GPSMonitoring package will support information development on fishing area (Where).

Once we have where the catches occur (using GPS) and what catches are landed (using surveys) we still have to investigate the right way to mix the two information to know where the species are caught. Investigation was made during the DEMERSTEM project but still need to be strengthened in a real context, i.e. with a higher number of GPS logger.

The software provides a complete example based on publicly available data (a set of about 600 000 positions of Guinean Canoe collected

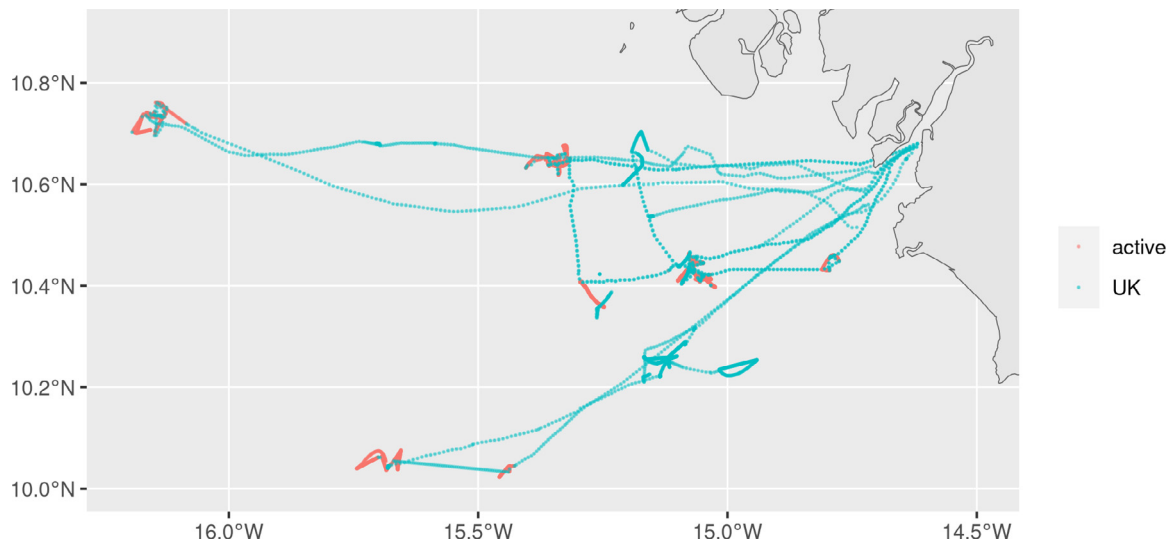


Fig. 2. Fishing events (red position) flagged by expert observation for a selection of fishing trip. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

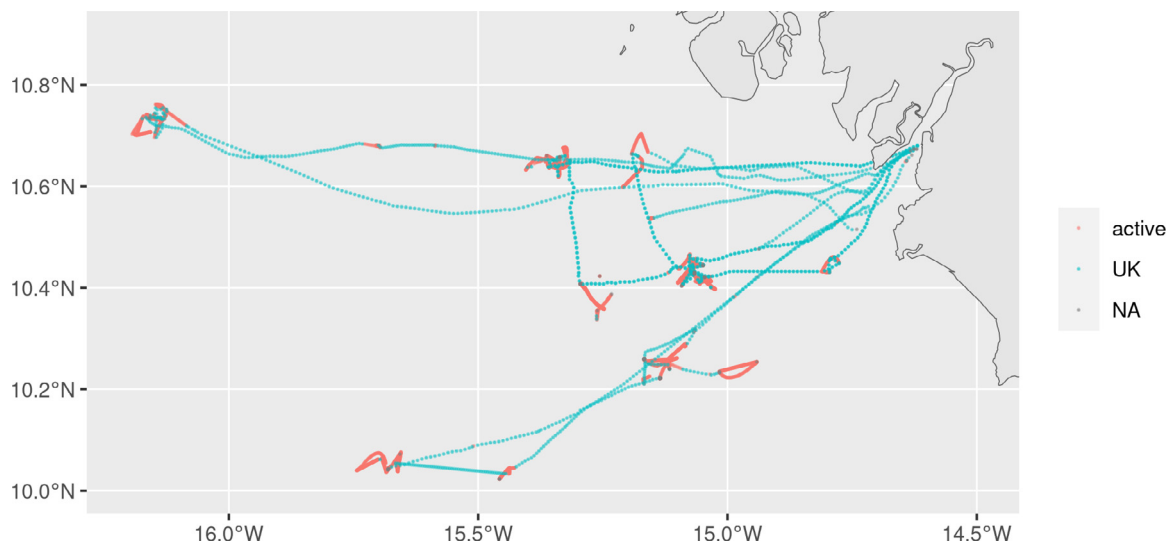


Fig. 3. Fishing event predict (red position) by GLM model based on expert observation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

during DEMERSTEM project [2]). The vignette, is so fully reproducible by the package users and will help them to understand the use of each function of the package. All the functions were thought through past experience on GPS data collection and Fishing event observation [3,4]. It also takes benefit of new statistical tools develop for ten years to support trajectory analysis and to detect different behaviors within the movement [5–7].

5. Conclusion

Fishing area of small-scale fisheries will become a key information for spatial/time regulation of fisheries activities. The first step of fishing regulation in on developing countries was designed for industrial fisheries (most of the time led by foreign counties). Now the second step has to consider small scale fisheries, too big to be ignored. For this consideration we need more information on small scale fisheries activities and especially where they occur to be able to support regulation for a sustainable fishing sector. The GPSMonitoring package could be part of the regular rata regulation toolbox.

The package development was conduct under the DEMERSTEM EU project which aims to improve knowledge on demersal fisheries (2019–2023). Within this project the Work package 3 was dedicate to the pilot study on GPS logger integration in the regular data collection on small scale fisheries in West Africa.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The work was supported by European union and Ecowas under the FED/2018/402-604 - DEMERSTEM, DEMERSal ecosySTEMs project. Authors would like to thanks Marc Leopold (IRD), Marie Pierre Etienne (Institut Agro) and Faustinato Behivoke (I.S.H.M.) for feedback and development made during the similar experiment made in Madagascar.

We are also grateful to Nicolas Bez (IRD) for his capabilities in rising right question to improve our analysis.

Illustrative examples

Video included in the vignette that illustrate the `silicoTraj` function used to collect expert knowledge on trajectory shape and speed of Canoe during fishing events.

<https://www.youtube.com/embed/CMCZmXLH6IM>

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