Estimating density of non-tracked dFADs with spatial capture-recapture models

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European Commission

Catch, Effort and eCOsystem impacts of FAD-fishing

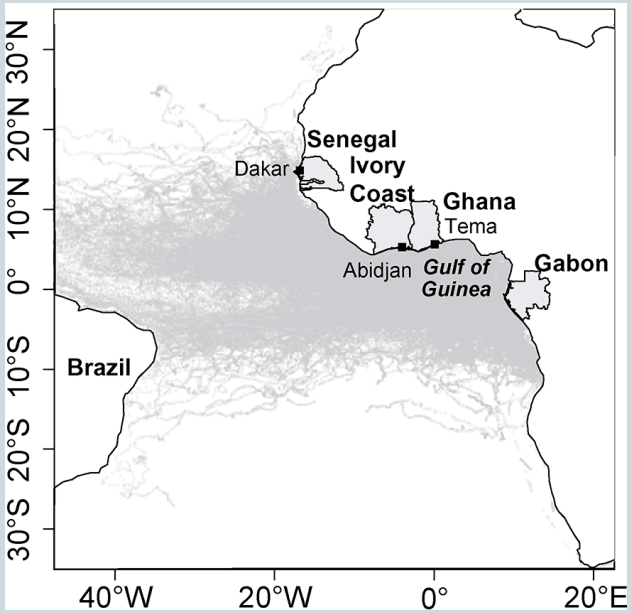
Institut de Recherche pour le Développement FRANCE

Drifting Fish Aggregating Devices (dFADs)

- Changes in efficiency and selectivity of purse seiners
- Increased by-catch and juvenile catches, possible changes in fitness and migrations
- Integrate this type of information in the CPUE standardization process
- FAD Management Plans (ICCAT Recommendation 16/01):
  - the number of FADs actually deployed on a monthly basis per 1*1 degree square

How to get this number of deployed dFADs?

- Ideal case: GPS buoys trajectories



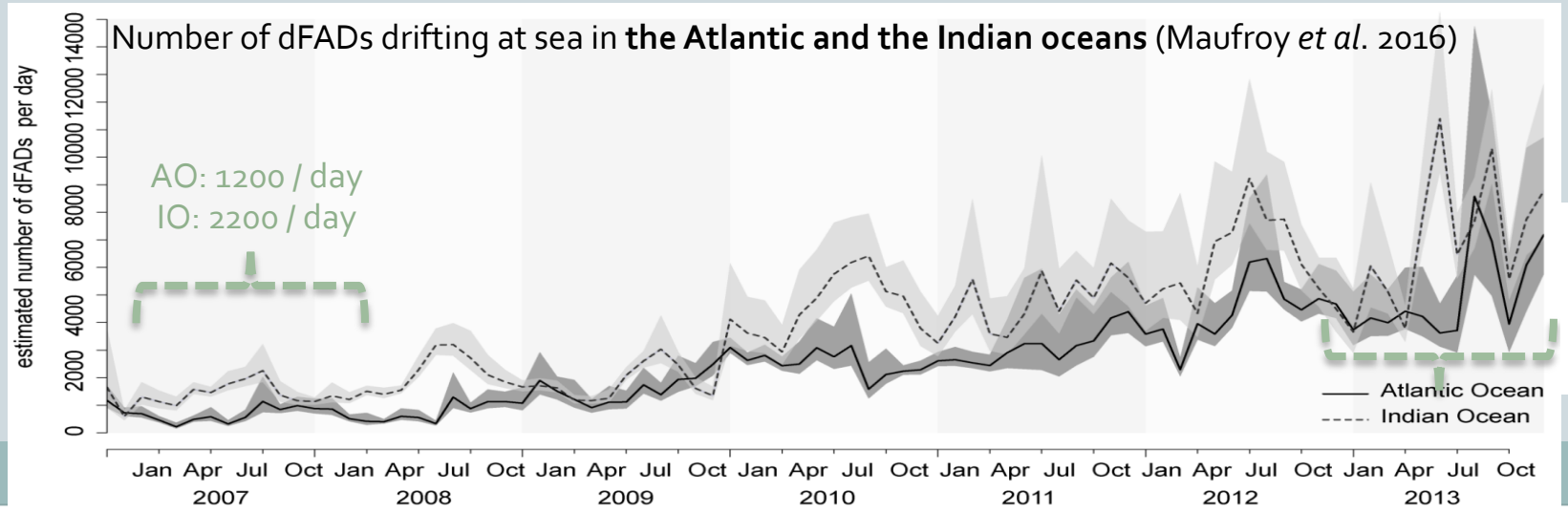
Ex: Location of raw french GPS buoy positions in the Atlantic Ocean from January 2007 to December 2011

Maufroy *et al.* (2016) – Plos One

- Challenge: all tracking data are not available everywhere at any time

Actual methodology with a raising procedure

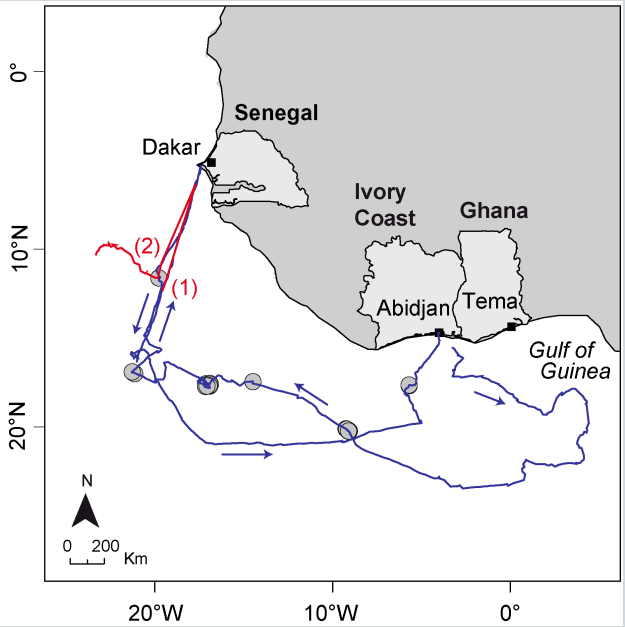
Step	Data	Spatio-temporal strata	Method and variables
1	French GPS buoy data	1 degree 1 month/1 year	Total number of French GPS buoys (FOB_{fr})
2	Observer data	9 degree 2007–2009/2010–2013	Bayesian estimation of the distribution of relative proportion of GPS buoys ($p_{fr} + p_{sp} + p_{oth}$) and GPS buoy-equipped FOBs that are FAD (α)
3	FOB_{fr} p and α distributions	whole ocean 1 month/1 year	Raising factor to estimate FAD and FOB numbers



AO: 7000/d
IO: 10300/d

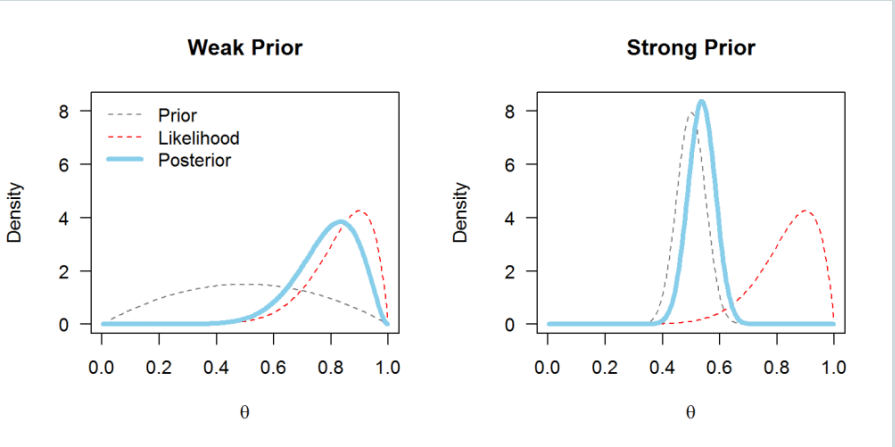
Some limits

- Variation in sampling effort not taken into account

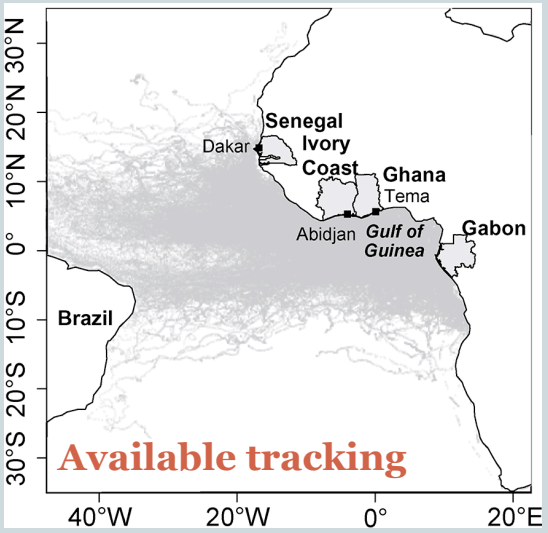


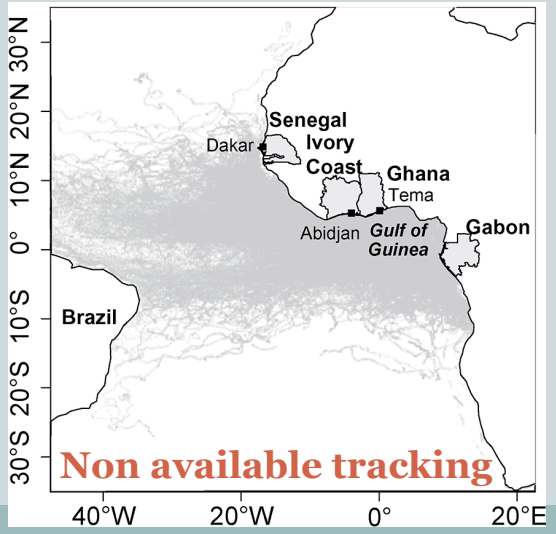
  - Different sampling between each 1*1 degree cell (sample or not)
  - Different searching time

- Flat prior in the Bayesian analysis



Proposed methodology



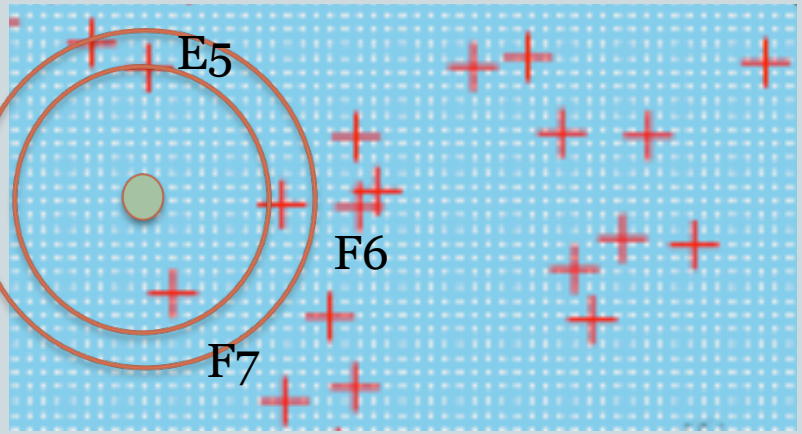


* Direct density from GPS buoy positions

* Estimated density with Spatially Explicit Capture Recapture models (detection probability < 1)

Spatially Explicit Capture Recapture models

- For a single individual: detection probability as a function of distance from activity center traps



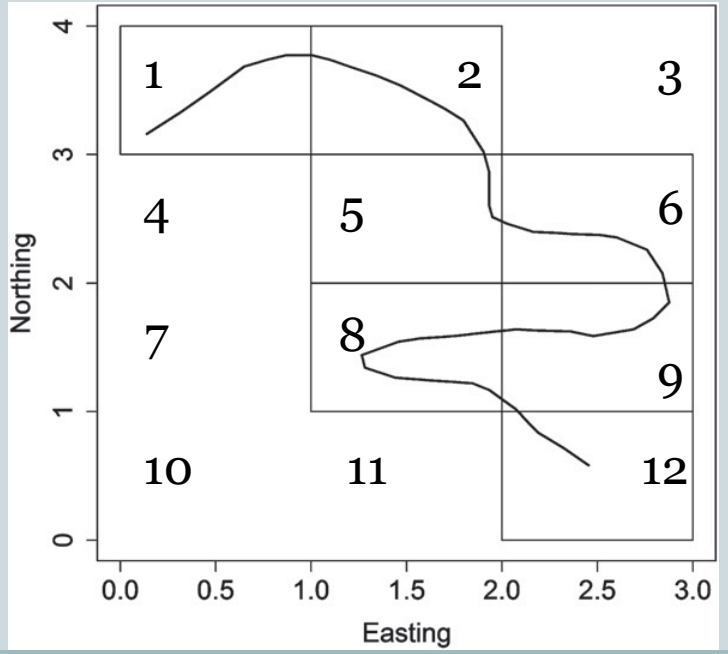
Year	Indiv ID	Occ	Trap ID
2010	34	191	57
2010	29	175	13
2010	20	79	24
2010	20	53	12
2010	19	1	7

Trap ID	X	Y	Occ 1	Occ 2	Occ 3
1	-28.5	20.5	1	0	1
2	-27.5	20.5	0	0	0
3	-24.5	20.5	1	1	0
4	-23.5	20.5	1	0	1
5	-22.5	20.5	0	0	0
…					

Adapted to purse senners and buoys

- Transfer the method to estimate non-tracked buoys density considering:
  - Buoys as animals
  - Traps = square/cell of 1*1 degree
  - Detectors = vessels with activities on non-tracked buoys
  - Occasion = Day

Cell	X	Y	Day 1
1	0.5	3.5	1
2	1.5	3.5	1
3	2.5	3.5	0
4	0.5	2.5	0
5	1.5	2.5	1



Material and procedure

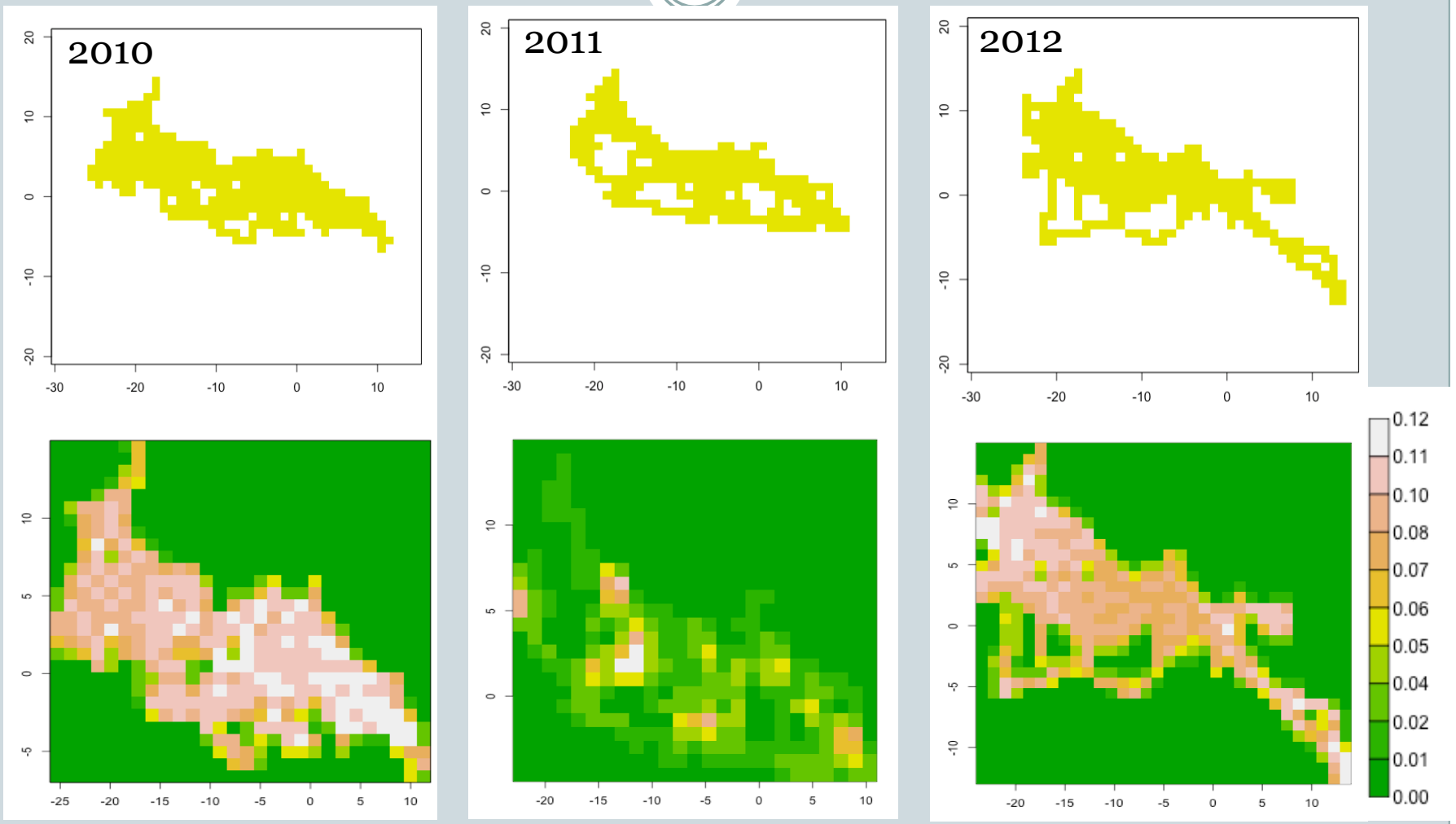
- Step 1: Activities from different sources (Logbooks and observer datasets)
- Step 2: List of tracked buoys ID to remove them from the dataset as they are included in direct density maps
- Step 3: Cells sampled and time spend in them by anonym vessels with activities on non-tracked buoy

vessel_code	dbq_date	Date	latitude	longitude	ID	dbq_date2
324	<NA>	2010-01-03	4.816805	-4.466806	23509	2010/01/25
324	<NA>	2010-01-03	4.050139	-4.166805	23509	2010/01/25
324	<NA>	2010-01-20	1.916806	-10.383472	23507	2010/01/25
324	<NA>	2010-01-20	2.166806	-10.816806	23516	2010/01/25
324	<NA>	2010-01-21	2.483472	-9.383472	23512	2010/01/25
324	<NA>	2010-01-22	1.533472	-5.233472	23518	2010/01/25

Example of results (French data)

Sampled cells

dFADs density



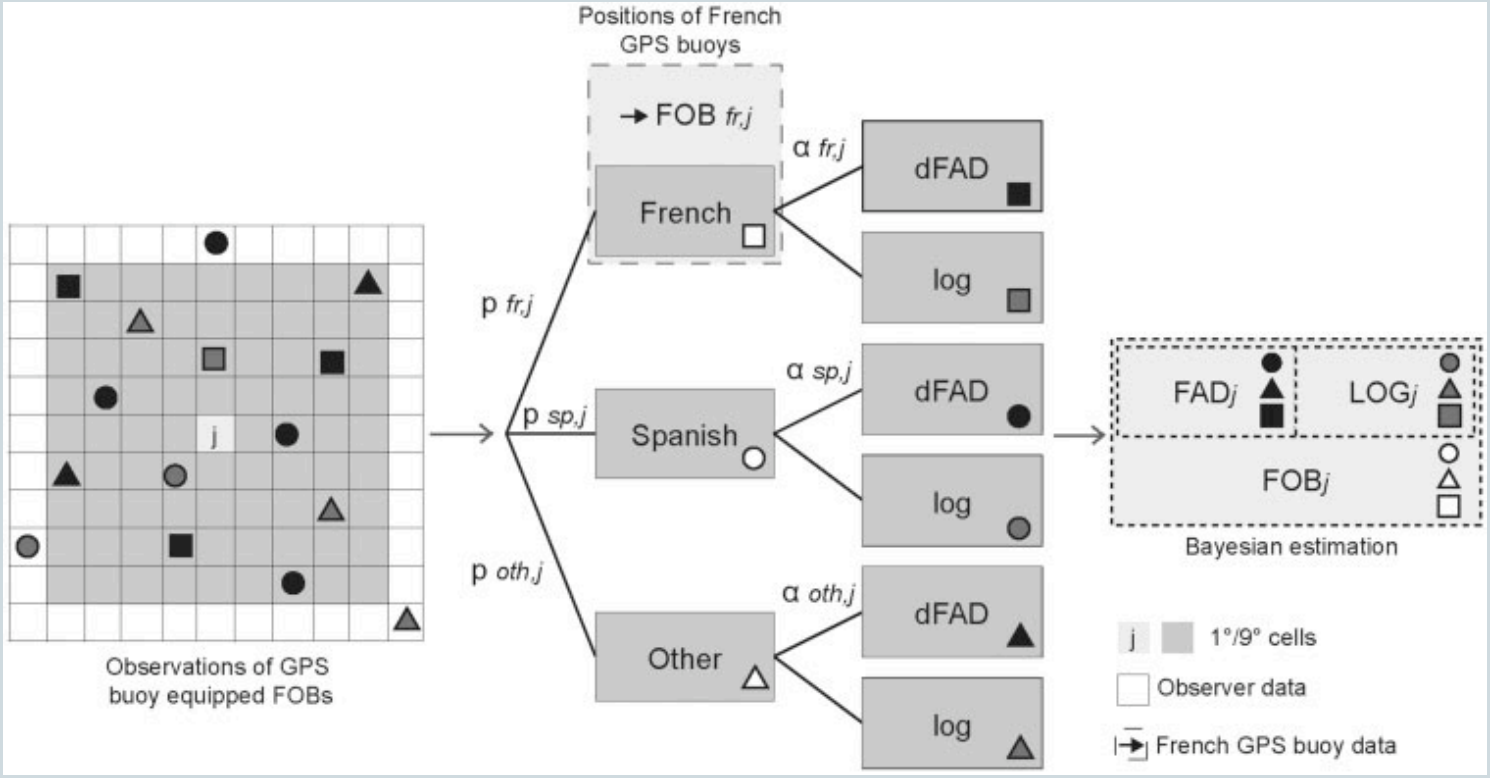
Validation

- Material and Methods
  - Creation of a dataset with a random sampling of activities on buoys with known trajectories (sample size = activities on buoys with unknown trajectories
  - Application of the SECR model to this dataset
  - Comparison of the estimated density to the observed density from the tracking data
- Preliminary results with 1*1 degree cells per year
  - Densities significantly correlated
  - R^2 sensitive to sample size

Perspectives

- Useful method as soon as trajectories data are missing
- Transfer to whole EU data
- Analyses in open population : GPS-equipped FOB survival and lifetime
- Time or group effect
- Constraint sampling effort with time spend in 1 square 1*1 degree
- Combine spatial CR data and count data to estimate total FOB density

Number of dFADs drifting at sea in Atlantic and Indian oceans : Actual methodology



Extrapolation procedure (Maufroy *et al.* 2016)