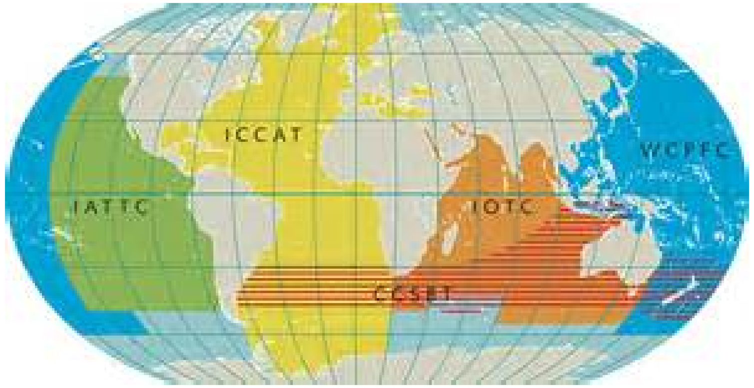
Yellowfin Data Prep (2019)

A NOVEL INDEX OF ABUNDANCE OF JUVENILE YELLOWFIN TUNA IN THE ATLANTIC OCEAN DERIVED FROM ECHOSOUNDER BUOYS (SCRS/2019/075)

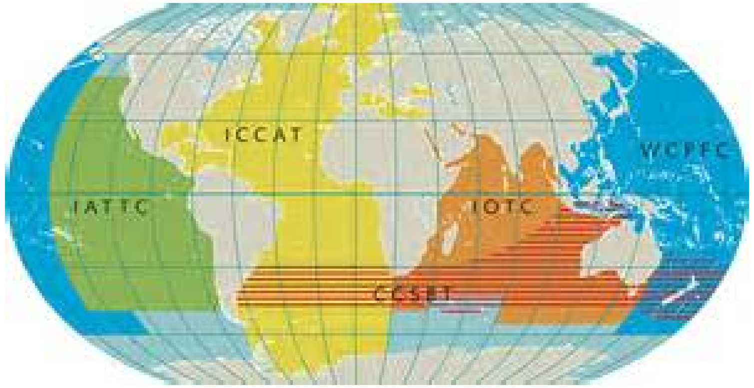
Josu Santiago, Jon Uranga, Iñaki Quincoces, Blanca Orue, Maitane Grande, Hilario Murua, Gorka Merino, Guillermo Boyra

Context



- Purse seine fleets' technology is improving rapidly and also is the increasing use of FADs.
- Therefore, it is **difficult to obtain reliable CPUE** indices for these fleets.
- **Science-industry collaboration** is helping to understand the use of FADs and facilitating the availability of data with **great potential for improving abundance indices** and therefore, for improving the quality of stock assessments.

Context



- The collaboration with the Spanish vessel-owners associations (ANABAC and OPAGAC) and the buoy-providers companies (Marine Instruments, Satlink and Zunibal), has facilitated the recovery of information from echosounder buoys (**2010-2018**).
- These buoys inform fishers in near real-time about the accurate geolocation of the FAD and the presence and abundance of tuna aggregations underneath them.

Methods

- *<u>The acoustic (raw) data:</u>* Satlink echosounders

Name	OwnerName	MD	StoredTime	Latitude	Longitude	Bat	Temp	Speed	Drift	Layer1	Layer2	Layer3	Layer4	Layer5	Layer6	Layer7	Layer8	Layer9	Layer10	Sum	Max	Mag1	Mag2 (1)	Mag3	Mag4 (2)	Mag5	Mag6 (3)	Mag7	Mag8 (4)
DSL+144577	Albacan	168	01/12/2017 1:26							0	0	0	0	0	0	0	0	0	0			0	4	0	0	0	0	0	0
DSL+144577	Albacan	168	01/12/2017 2:26							0	0	0	0	0	2	1	0	0	0			0	1	0	3	0	1	0	0
DSL+144577	Albacan	168	01/12/2017 3:26							0	0	0	0	0	0	0	0	0	1			0	0	0	1	0	0	0	0
DSL+144577	Albacan	168	02/12/2017 1:30							0	0	0	0	0	0	0	0	0	0			0	4	0	0	0	0	0	0

- The echosounder provides acoustic information in 10 different vertical layers, each with a resolution of 11.2 (3 - 115 m).
- Three models: DS+, DSL+ and ISL+.
- The database of acoustic information of the Atlantic Ocean from Satlink buoys comprises around **5 million of records from over 36,000 buoys** for the period from January 2010 to December 2017 [2018]

Methods

- *From acoustic data to a species-specific abundance indicator:*

  - Current echosounder buoys provide a **single acoustic value** without discriminating species or size composition of the fish underneath the FAD.

  - Therefore, these data have been **crossed with fishery data**, species composition and average size, to obtain one abundance index for the three tropical tuna stocks.

Methods

- *From acoustic data to a species-specific abundance indicator:*

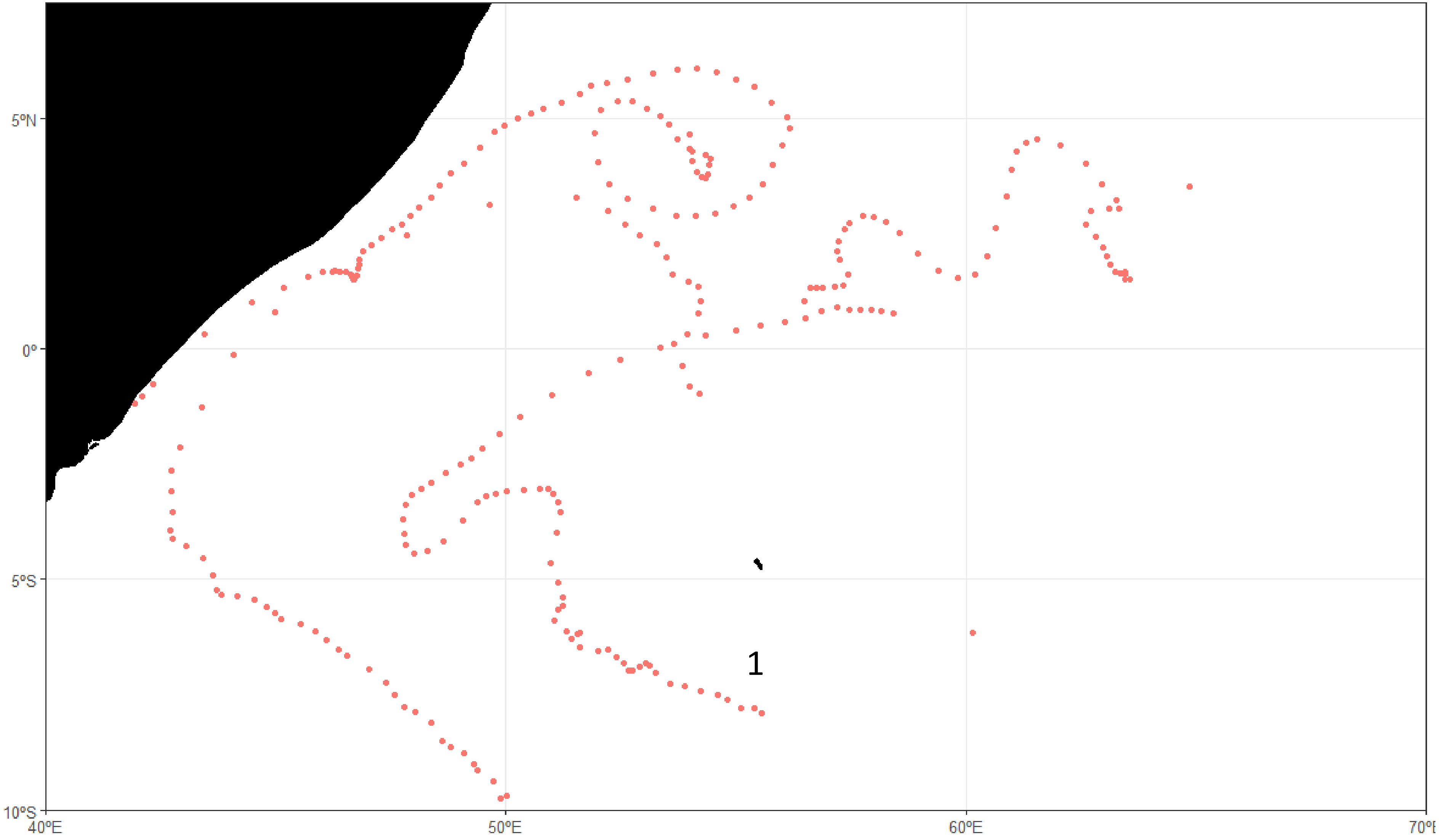
Density of skipjack → **Decibels** → Recalculated Biomass by species (equations on paper)

Range	6-25m	25-115m		
Species	Bycatch	SKJ	BET	YFT
TS (b20)	68.7	-70.5	-63.5	-68.7
Mean Fish Length (cm)	30	*48*	47	46
Species composition (%)	100	x	y	z

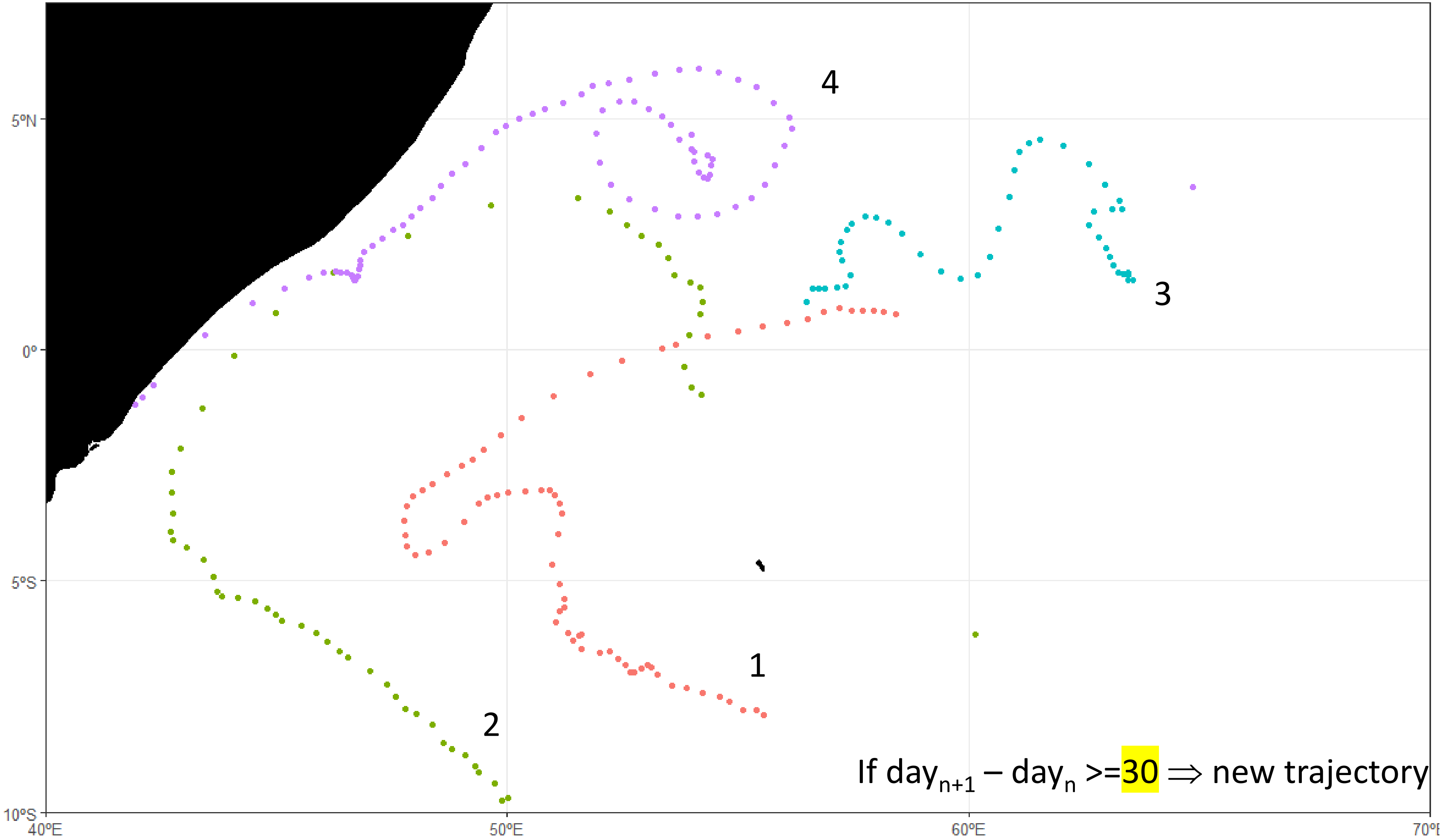
TS: Oshima, 2008 (YFT); Boyra et al., 2018 (SKJ); Boyra et al (submitted to ICESJMS)
Mean length: Length distribution PS-FAD ~~IOTC~~ ICCAT
Species composition (%): PS-FAD catch composition 1ºx1º, month Task2 data.

Methods

- *Acoustic data cleaning and filtering :*
    - Remove records without acoustic information, outliers, bad geolocation, time, or other general variables.
    - Additional considerations for :
        - <25 m discarded.
        - Bottom shallower than 200m discarded.
        - Onboard signals discarded.
        - Only data from 4-8 AM.
        - Very low values discarded (0.1)
        - Days since deployment.

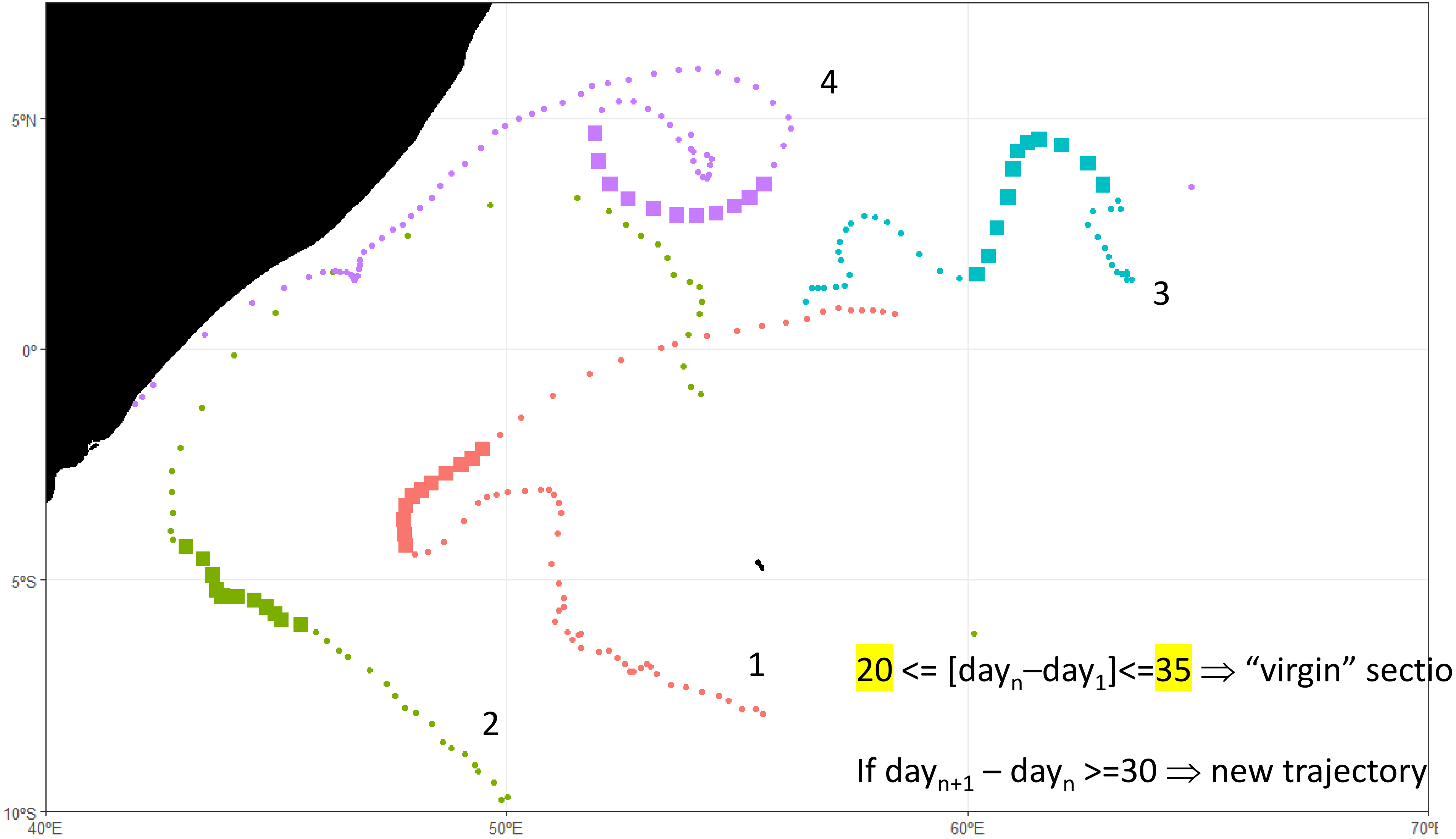


1 buoy



If $day_{n+1} - day_n >= 30 \Rightarrow$ new trajectory

1 buoy – 4 trajectories



$20 <= [day_n – day_1] <= 35 \Rightarrow$ “virgin” section

If $day_{n+1} – day_n >= 30 \Rightarrow$ new trajectory

Orue B, Lopez J, Moreno G, Santiago J, Soto M, Murua H (2019) Aggregation process of drifting fish aggregating devices (DFADs) in the Western Indian Ocean: Who arrives first, tuna or non-tuna species? PLoS ONE 14(1): e0210435. https://doi.org/10.1371/journal.pone.0210435

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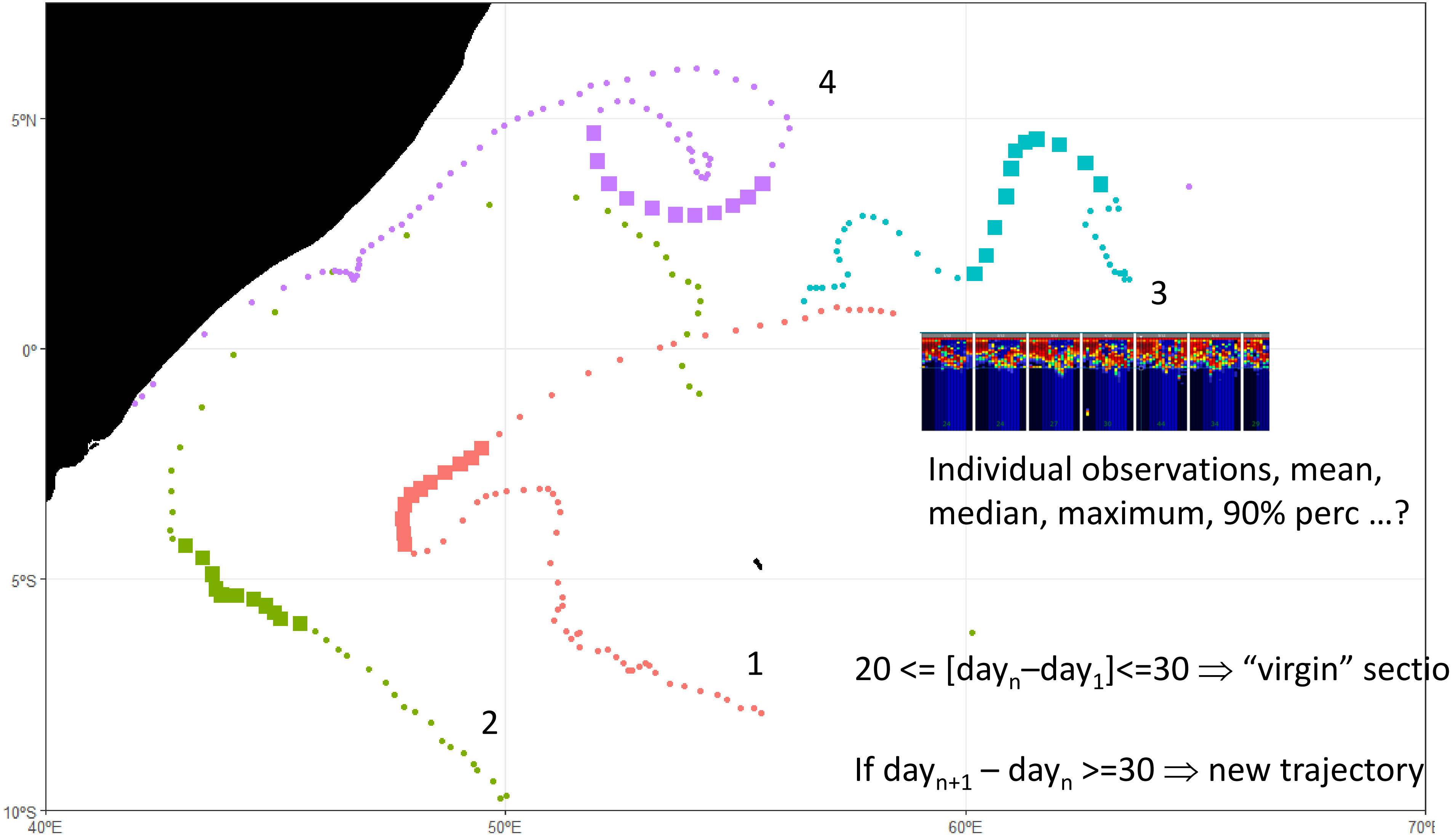

Individual observations, mean, median, maximum, 90% perc …?

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If $day_{n+1} – day_n >= 30 \Rightarrow$ new trajectory

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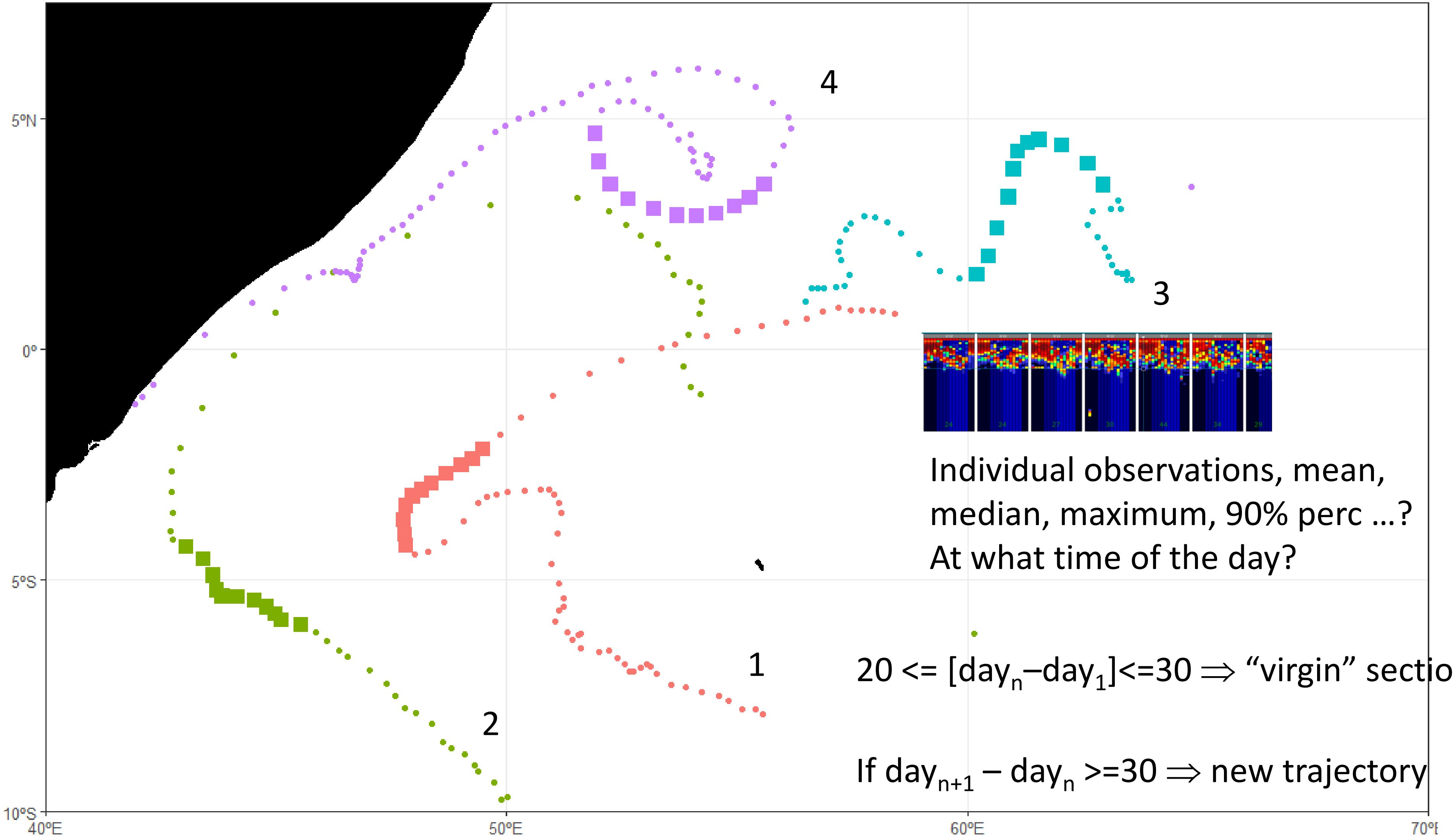
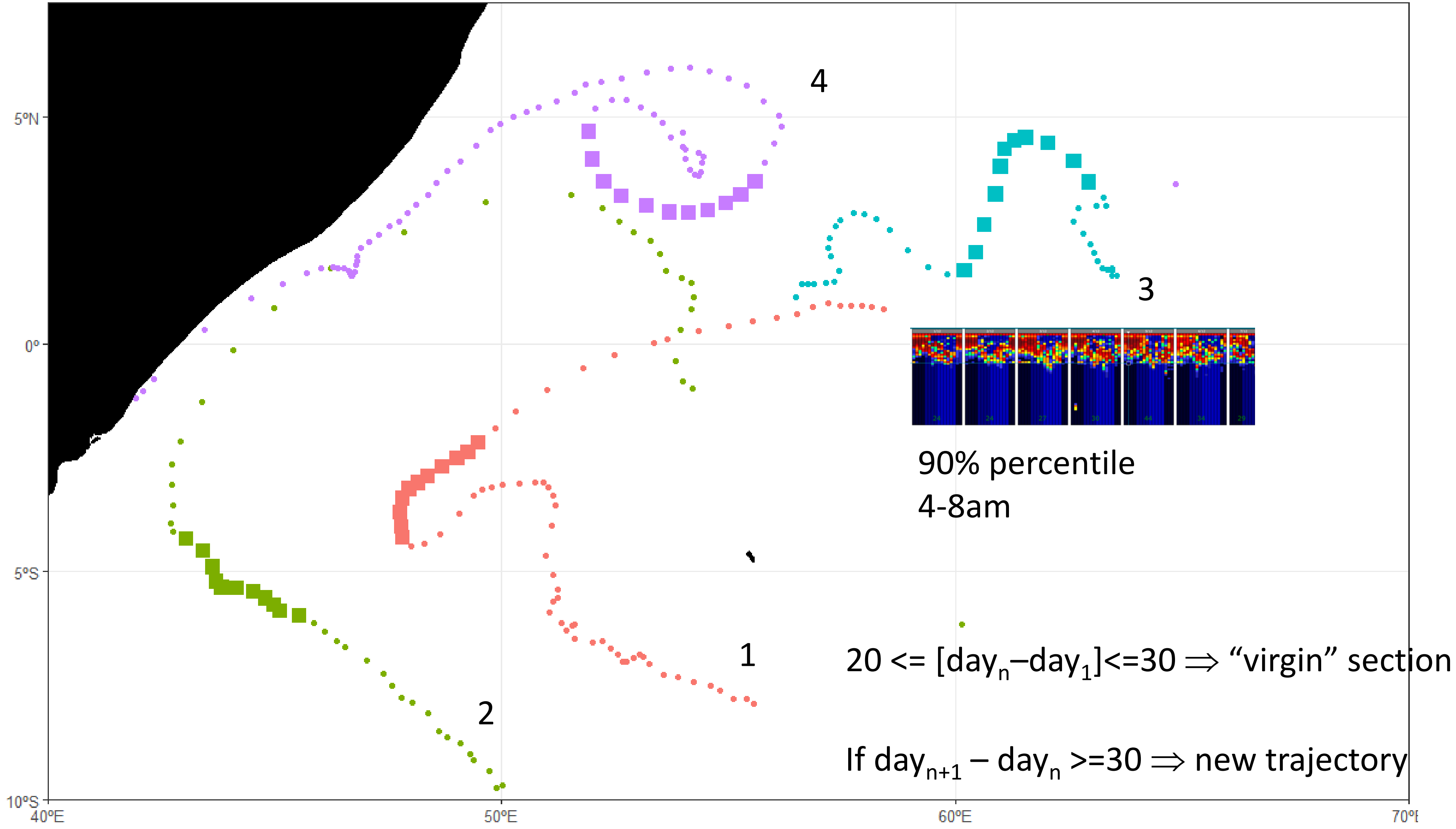


Individual observations, mean, median, maximum, 90% perc …?
At what time of the day?

$20 <= [day_n – day_1] <= 30 \Rightarrow$ "virgin" section

If $day_{n+1} – day_n >= 30 \Rightarrow$ new trajectory

1 buoy – 4 trajectories – 4 sections



1 buoy – 4 trajectories – 4 sections

Methods

- Days since deployment.

$20 <= [day_n – day_1] <= 35 \Rightarrow$ **“virgin” section**

If $day_{n+1} – day_n >= 30 \Rightarrow$ new trajectory

1 buoy – 4 trajectories – 4 sections

- The total number of “virgin” sequences or number of observations was 49,880, (86.85%) positives.

- 90% quantile of the integrated acoustic energy observations in each of the "virgin" sequences.

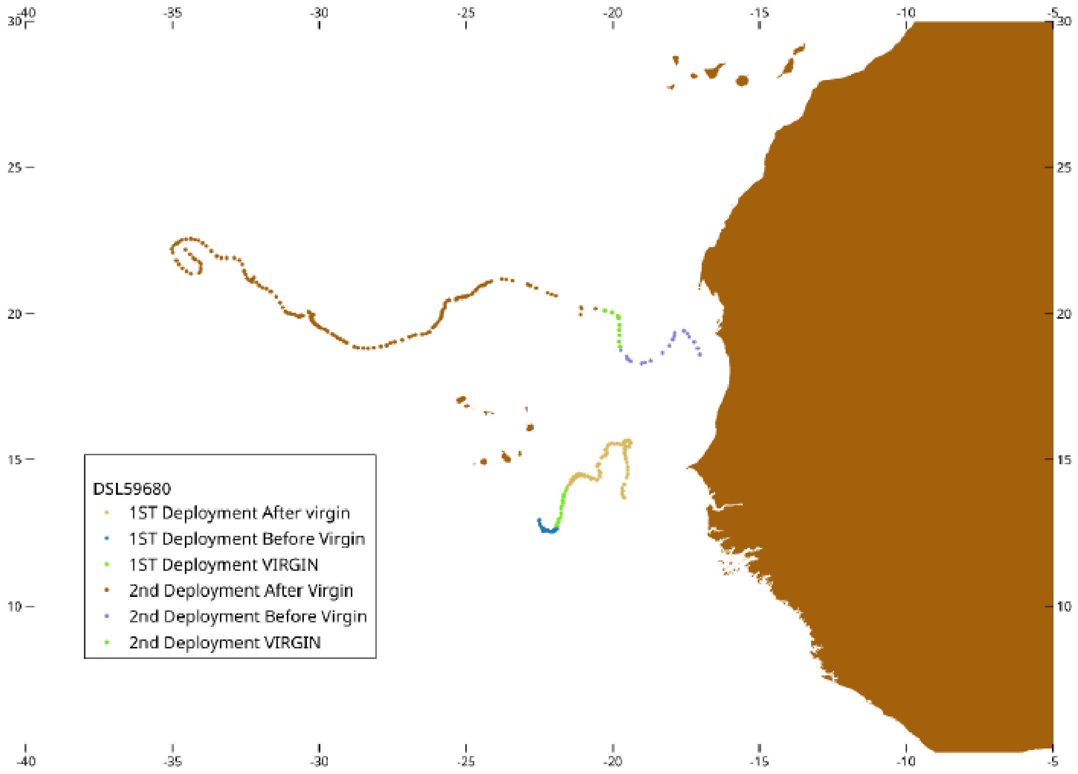


Figure 1. Example of “virgin” segments used for the calculation of the BAI index. Trajectories correspond to buoy DSL59680 with two different paths representing drifts of different FADs. A virgin segment is defined as the segment of a buoy trajectory whose associated FAD likely represents a new deployment, which has been potentially colonized by tuna and not already fished. We consider as virgin segments (i.e. when tuna has aggregated to DFAD) those segments of trajectories from 20-35 days at sea. “Virgin” segments are shown in green in the Figure.

Orue B, Lopez J, Moreno G, Santiago J, Soto M, Murua H (2019) Aggregation process of drifting fish aggregating devices (DFADs) in the Western Indian Ocean: Who arrives first, tuna or non-tuna species? PLoS ONE 14(1): e0210435. https://doi.org/10.1371/journal.pone.0210435

Methods

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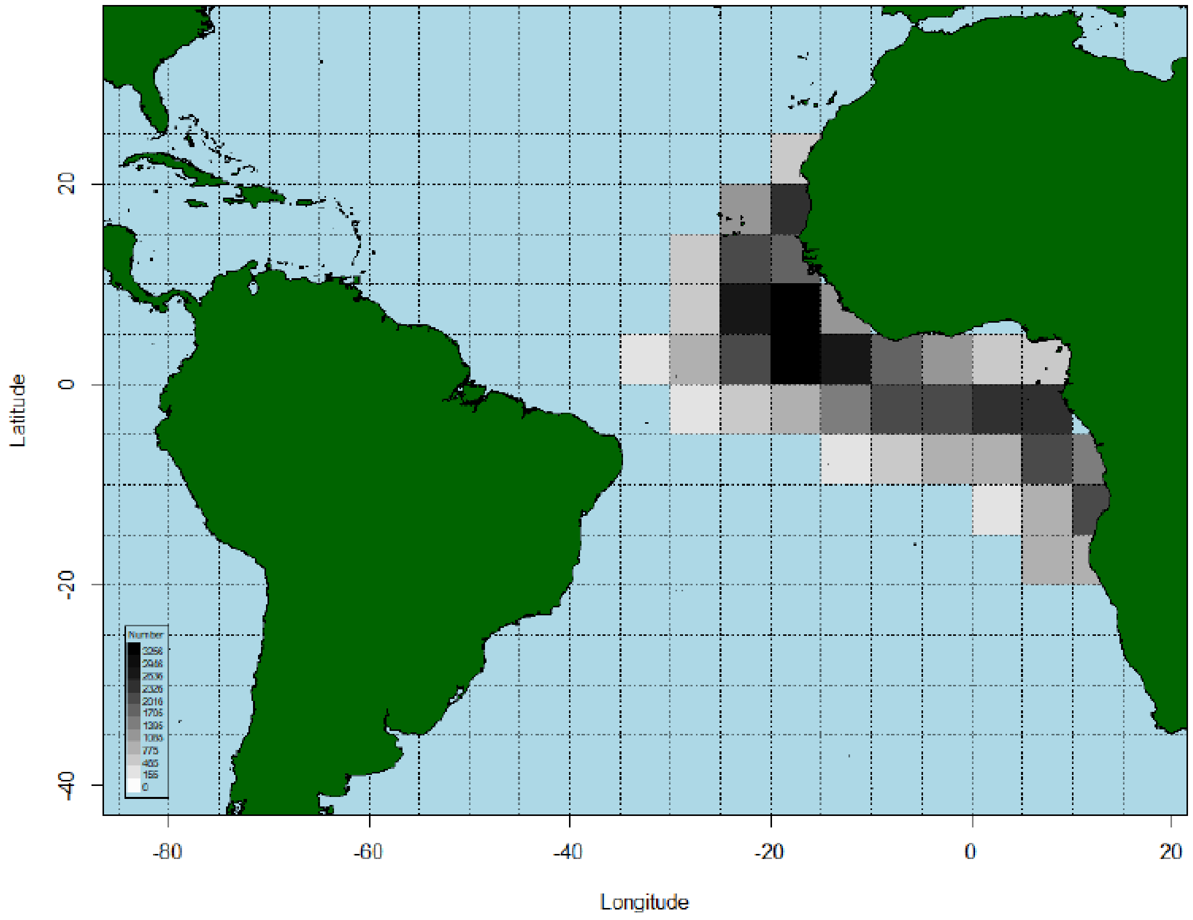


Spatial distribution [5ºx5º] of the “virgin” sequences of buoy trajectories that have been used in the GLM analysis.

Methods

- *The BAI index: Buoy-derived Abundance Index (BAI):*

  - The signal from the echosounder is proportional to the abundance of fish (Santiago et al., 2016):

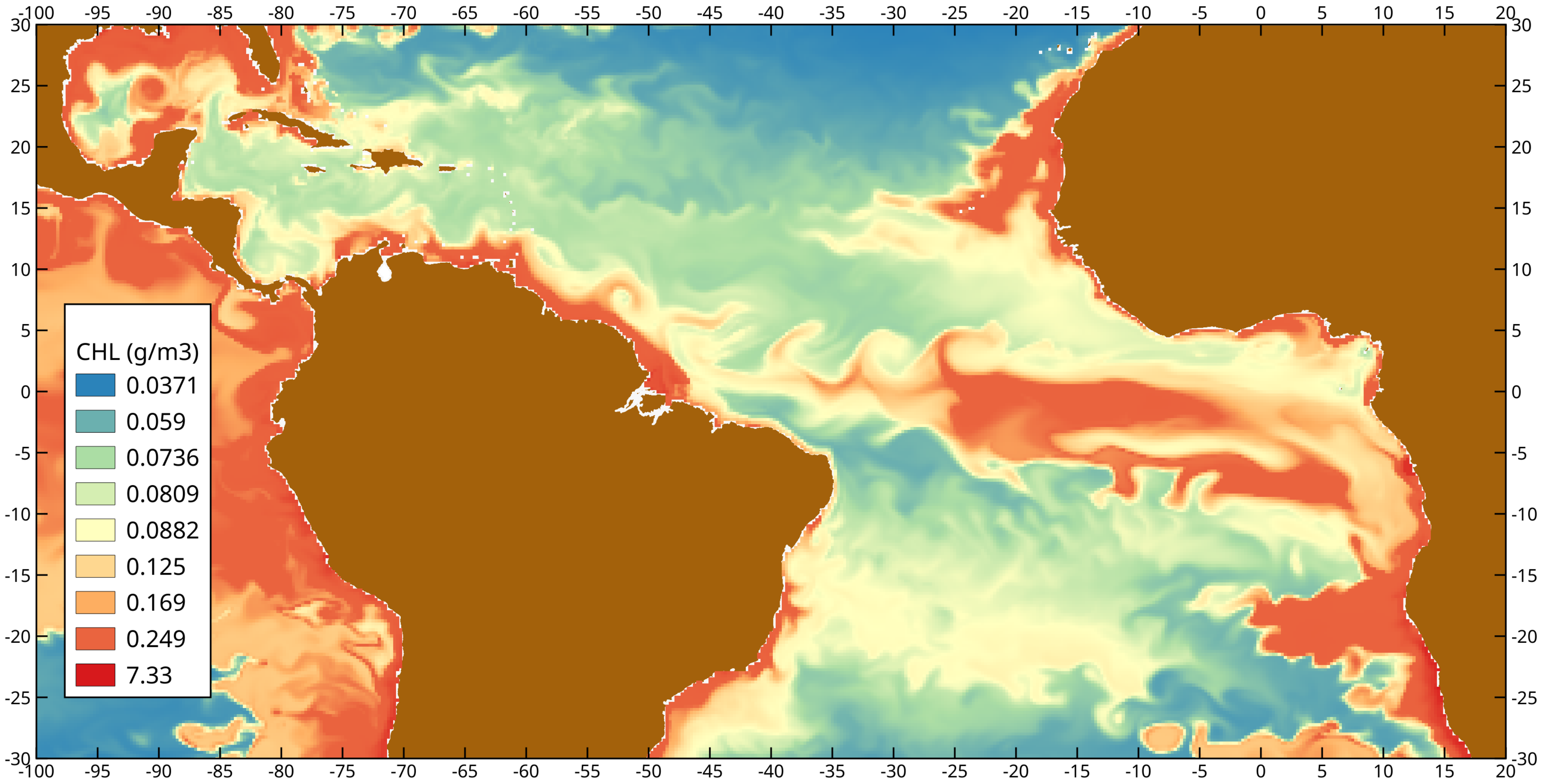
$$\mathrm{BAI_t} = \varphi \,.\, \mathrm{B_t}$$

  - In order to ensure that ϕ can be assumed to be constant a standardization analysis is performed.
  - Delta lognormal analyses (Lo et al., 1992) were carried out using a binomial distribution for the probability of the acoustic record being zero and a lognormal probability distribution for positive observations.

Methods

- *Covariates for standardization:*

- **Categorical**: year-quarter (yyqq), and 5°x5º ICCAT areas
- **Continuous**:
  - velocity of the buoy
  - FAD densities
  - environmental variables:
    - ✓ Ocean mixed layer thickness
    - ✓ Chlorophyll
    - ✓ SST
    - ✓ SST and Chlorophyll front



CHL (g/m3)
0.0371
0.059
0.0736
0.0809
0.0882
0.125
0.169
0.249
7.33
-100
-95
-90
-85
-80
-75
-70
-65
-60
-55
-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
0
5
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10
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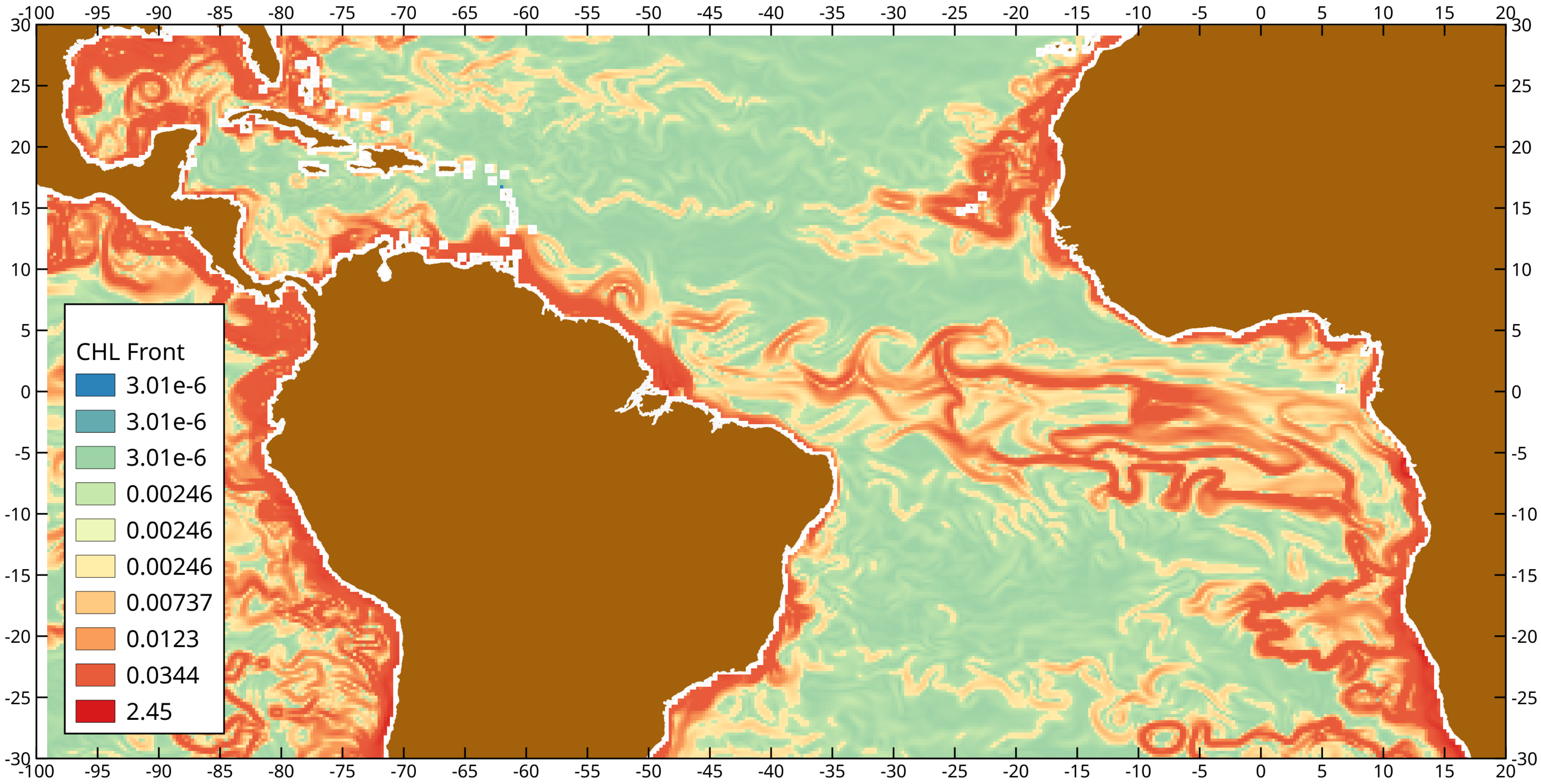
0
-5
-10
-15
-20
-25
-30


CHL Front
3.01e-6
3.01e-6
3.01e-6
0.00246
0.00246
0.00246
0.00737
0.0123
0.0344
2.45
-100
-95
-90
-85
-80
-75
-70
-65
-60
-55
-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
0
5
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15
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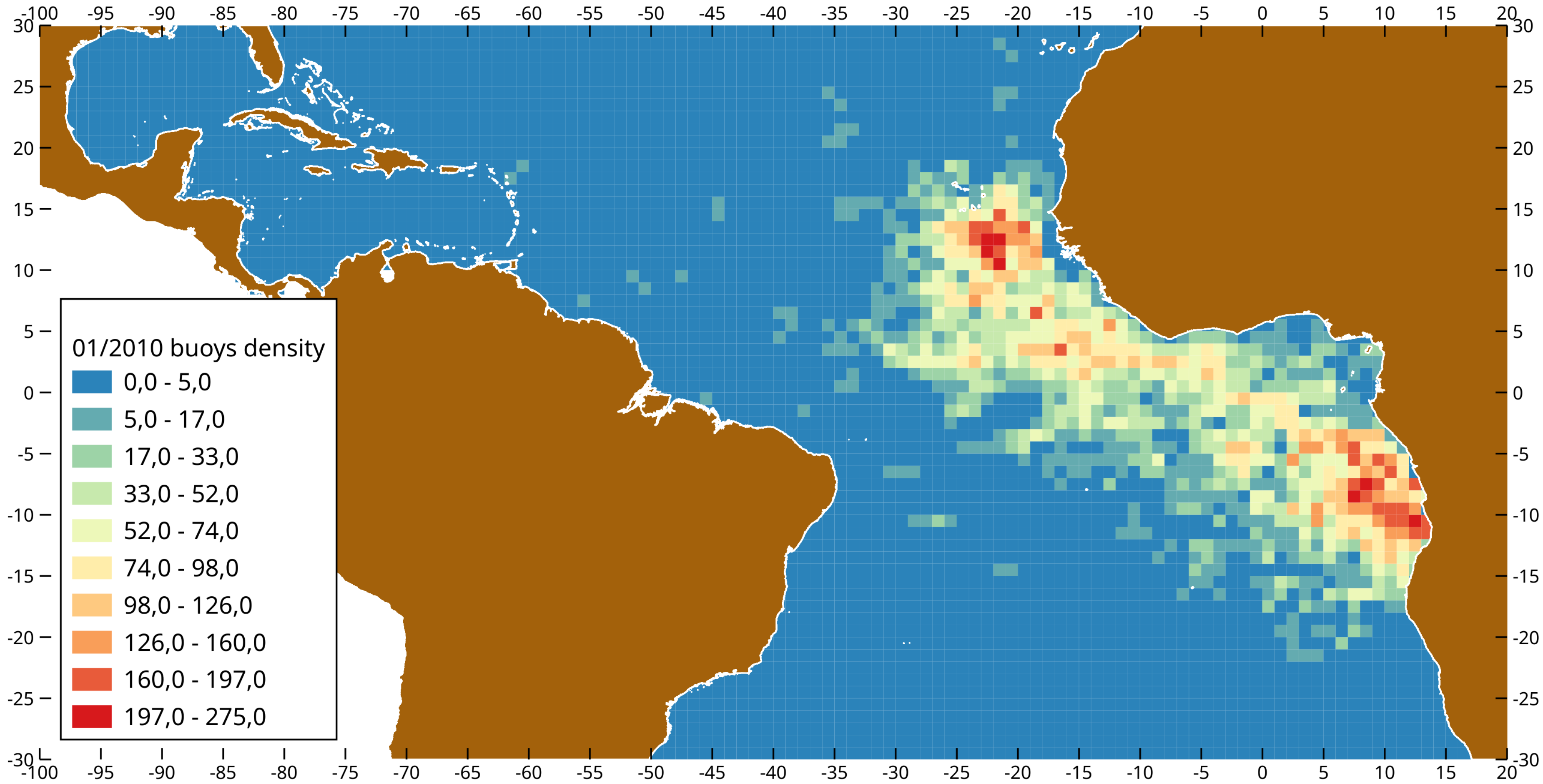
20
15
10
5
0
-5
-10
-15
-20
-25
-30



01/2010 buoys density
0,0 - 5,0
5,0 - 17,0
17,0 - 33,0
33,0 - 52,0
52,0 - 74,0
74,0 - 98,0
98,0 - 126,0
126,0 - 160,0
160,0 - 197,0
197,0 - 275,0

Results

- *Standardization:*

Binomial component

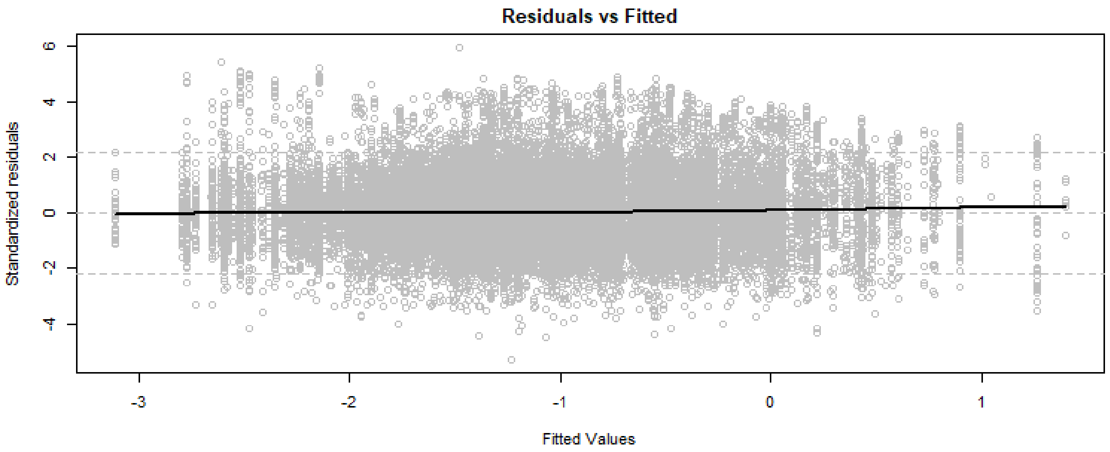
Variable	Df	Deviance	Resid..Df	Resid..Dev	Pr..Chi.	Dev..Exp
NULL	NA	NA	49828	38807	NA	NA
yyqq	31	2496	49797	36311	0.000	6.43 %
area	37	387	49760	35923	0.000	1 %
model	2	1457	49758	34466	0.000	3.75 %
den	1	2	49757	34465	0.190	0 %
chl	1	0	49756	34465	0.751	0 %
chlfront	1	27	49755	34438	0.000	0.07 %
sst	1	0	49754	34437	0.569	0 %
sstfront	1	5	49753	34432	0.024	0.01 %
mld	1	10	49752	34422	0.001	0.03 %
yyqq:model	27	143	49725	34279	0.000	0.37 %
yyqq:chl	31	131	49694	34148	0.000	0.34 %
yyqq:sst	31	246	49663	33902	0.000	0.63 %
yyqq:sstfront	31	106	49632	33796	0.000	0.27 %
yyqq:mld	31	133	49601	33663	0.000	0.34 %

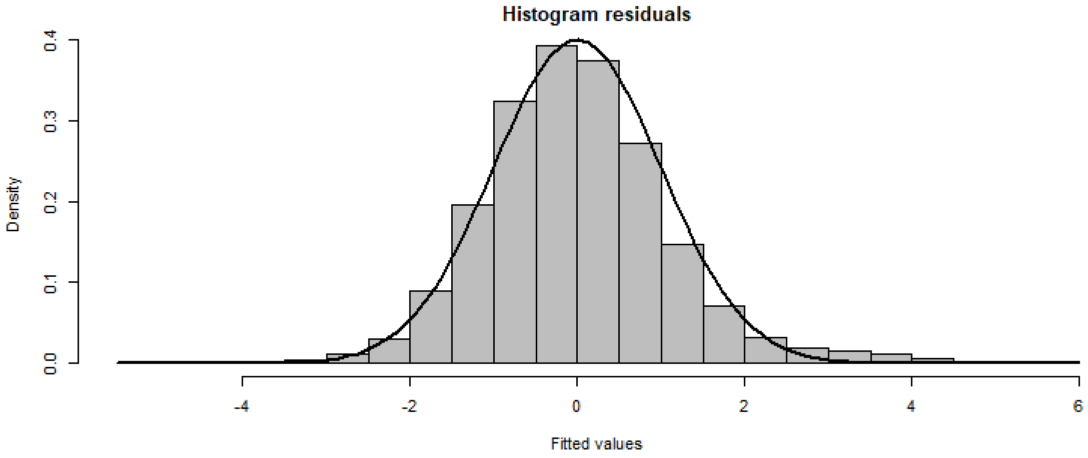
Lognormal component

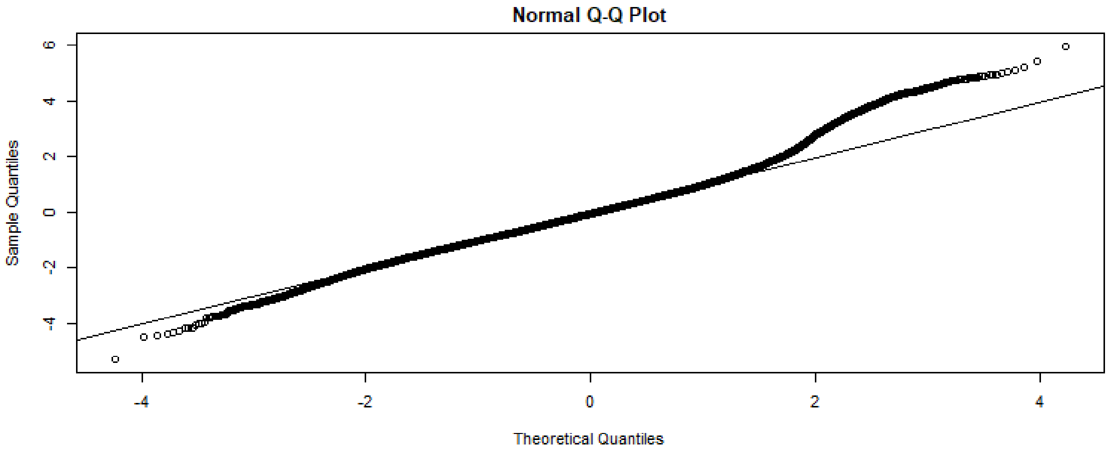
Variable	Df	Deviance	Resid..Df	Resid..Dev	F	Pr..F.	Dev..Exp
NULL	NA	NA	43271	73385	NA	NA	NA
yyqq	31	5537	43240	67848	150	0e+00	7.54 %
area	37	9527	43203	58322	217	0e+00	12.98 %
model	2	542	43201	57780	228	0e+00	0.74 %
den	1	197	43200	57583	166	0e+00	0.27 %
chl	1	1162	43199	56421	977	0e+00	1.58 %
chlfront	1	71	43198	56351	59	0e+00	0.1 %
sst	1	19	43197	56332	16	1e-04	0.03 %
sstfront	1	221	43196	56111	186	0e+00	0.3 %
mld	1	19	43195	56092	16	1e-04	0.03 %
yyqq:area	1087	5191	42108	50902	4	0e+00	7.07 %
yyqq:model	29	171	42079	50731	5	0e+00	0.23 %
yyqq:den	31	228	42048	50503	6	0e+00	0.31 %
yyqq:chl	31	183	42017	50319	5	0e+00	0.25 %
yyqq:chlfront	31	145	41986	50175	4	0e+00	0.2 %
yyqq:sst	31	147	41955	50028	4	0e+00	0.2 %
yyqq:sstfront	31	135	41924	49892	4	0e+00	0.18 %
yyqq:mld	31	94	41893	49799	3	0e+00	0.13 %

Deviance tables for the binomial and the lognormal components of the Delta-lognormal model of the 2010-2017 period. Significant (p<0.05) factors and interactions explaining >4% of total deviance are highlighted.

Results

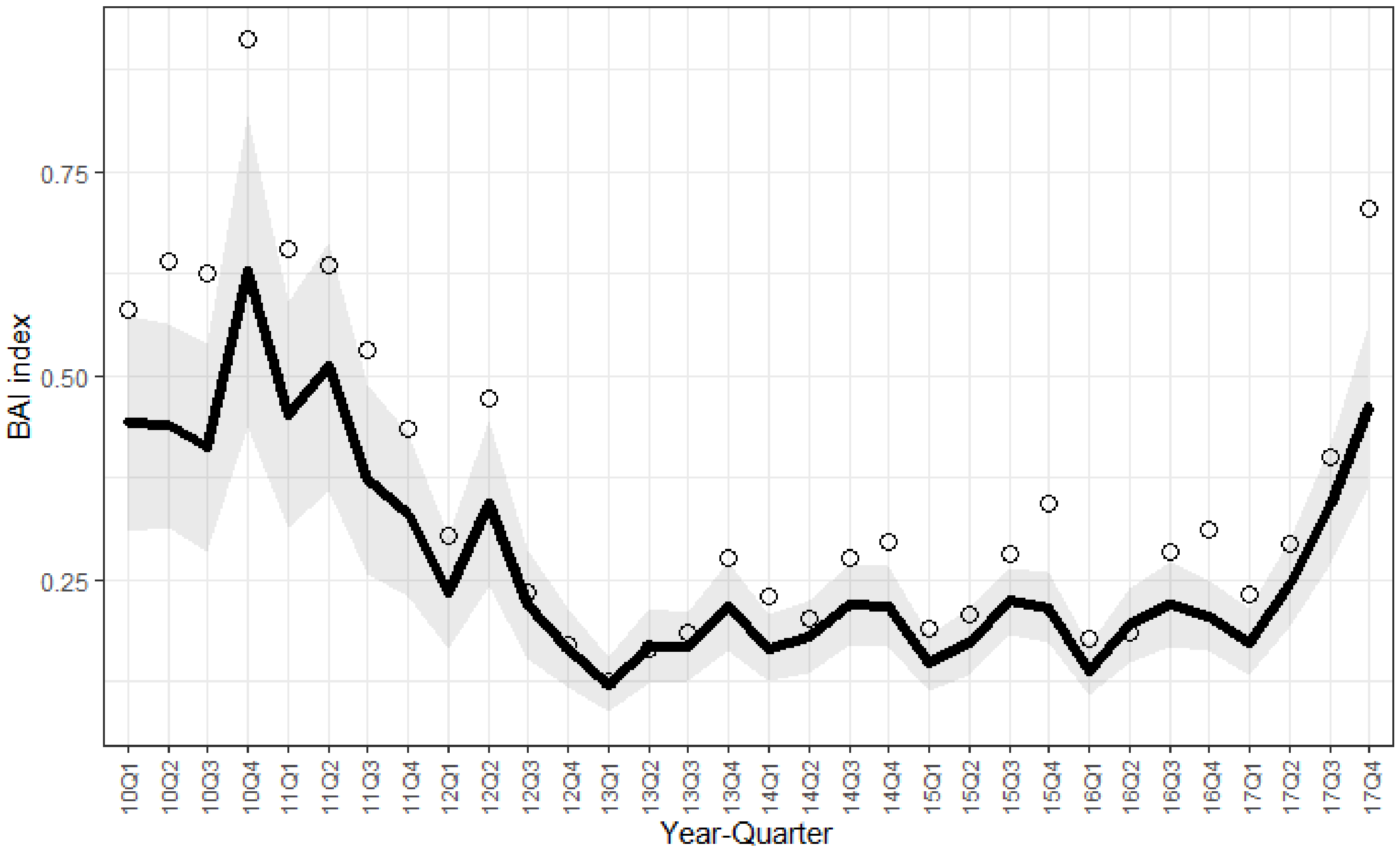






Diagnostics of the lognormal model selected for the period 2010-2017: residuals vs fitted, Normal Q-Q plot and frequency distributions of the residuals.

Results



Quarter	BAI nominal	BAI Index	BAI se	BAI cv
10Q1	0.582	0.442	0.068	0.153
10Q2	0.640	0.439	0.064	0.145
10Q3	0.627	0.412	0.065	0.158
10Q4	0.912	0.628	0.097	0.155
11Q1	0.656	0.452	0.070	0.155
11Q2	0.636	0.511	0.077	0.152
11Q3	0.533	0.373	0.060	0.160
11Q4	0.435	0.330	0.051	0.155
12Q1	0.304	0.234	0.035	0.150
12Q2	0.472	0.344	0.052	0.150
12Q3	0.234	0.220	0.034	0.155
12Q4	0.171	0.165	0.025	0.150
13Q1	0.126	0.122	0.017	0.143
13Q2	0.164	0.168	0.023	0.139
13Q3	0.185	0.168	0.022	0.129
13Q4	0.277	0.217	0.028	0.130
14Q1	0.229	0.166	0.021	0.126
14Q2	0.201	0.180	0.023	0.127
14Q3	0.276	0.219	0.025	0.116
14Q4	0.297	0.217	0.025	0.117
15Q1	0.189	0.147	0.018	0.119
15Q2	0.208	0.174	0.021	0.121
15Q3	0.280	0.224	0.021	0.093
15Q4	0.344	0.215	0.022	0.102
16Q1	0.178	0.139	0.016	0.113
16Q2	0.186	0.194	0.024	0.122
16Q3	0.283	0.220	0.026	0.119
16Q4	0.310	0.205	0.022	0.108
17Q1	0.231	0.174	0.021	0.119
17Q2	0.293	0.244	0.027	0.111
17Q3	0.401	0.342	0.037	0.109
17Q4	0.704	0.463	0.051	0.109

Time series of nominal (circles) and standardized (continuous line) Buoy-derived Abundance Index for the period 2010-2017. The 95% upper and lower confidence intervals of the standardized BAI index are shown.

Acknowledgments

- This work was supported by the Government of the Basque Country and the EU funded projects RECOLAPE and CECOFAD. We thank the Spanish vessel owner associations ANABAC and OPAGAC and those companies that have provided acoustic information from their echosounder buoys were: Albacora SA, Atunera Sant Yago SA, Atunsa, Calvopesca El Salvador SA de CV, Cantabrica de Tunidos SAU, Icube Tuna Fisheries NV, Inpesca Fishing Belize Ltd, Integral Fishing Service INC, Intertuna, NV and Overseas Tuna Company NV. We are also thankful to the three buoy providers companies Marine Instruments, Satlink and Zunibal.