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MOVEMENT PATTERNS OF SKIPJACK TUNAS IN THE TROPICAL ATLANTIC, DESCRIBED THROUGH TAG ATTRITION MODELS BASED ON HISTORICAL AND RECENT TAG AND RECAPTURE DATA

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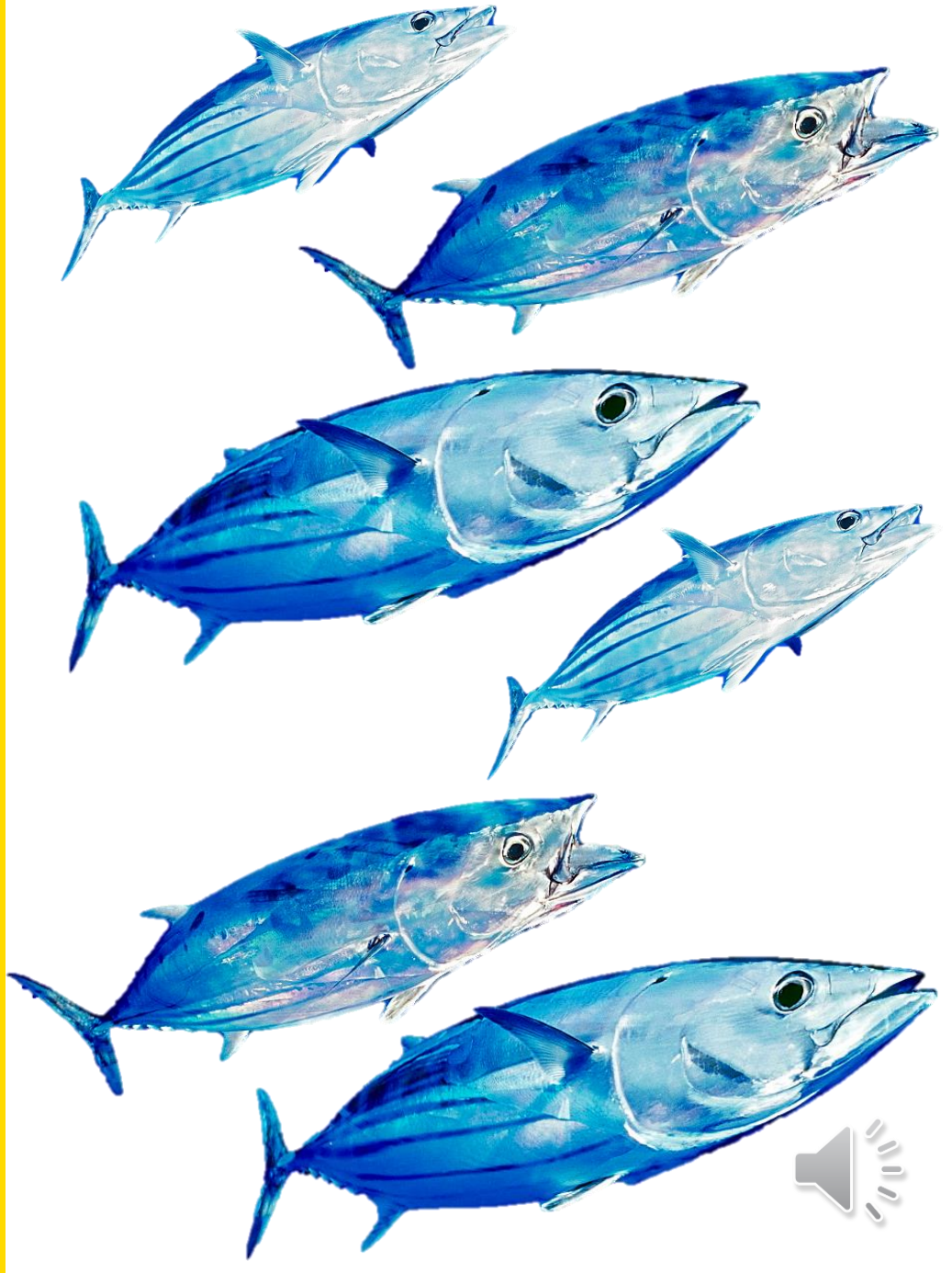
- Framework: CISEF consortium in charge of mortality and movement analyses

Goals:

- Overall description of skipjack tuna movement patterns, based on conventional tag recoveries
- Application of tag-attrition models to historical and AOTTP data



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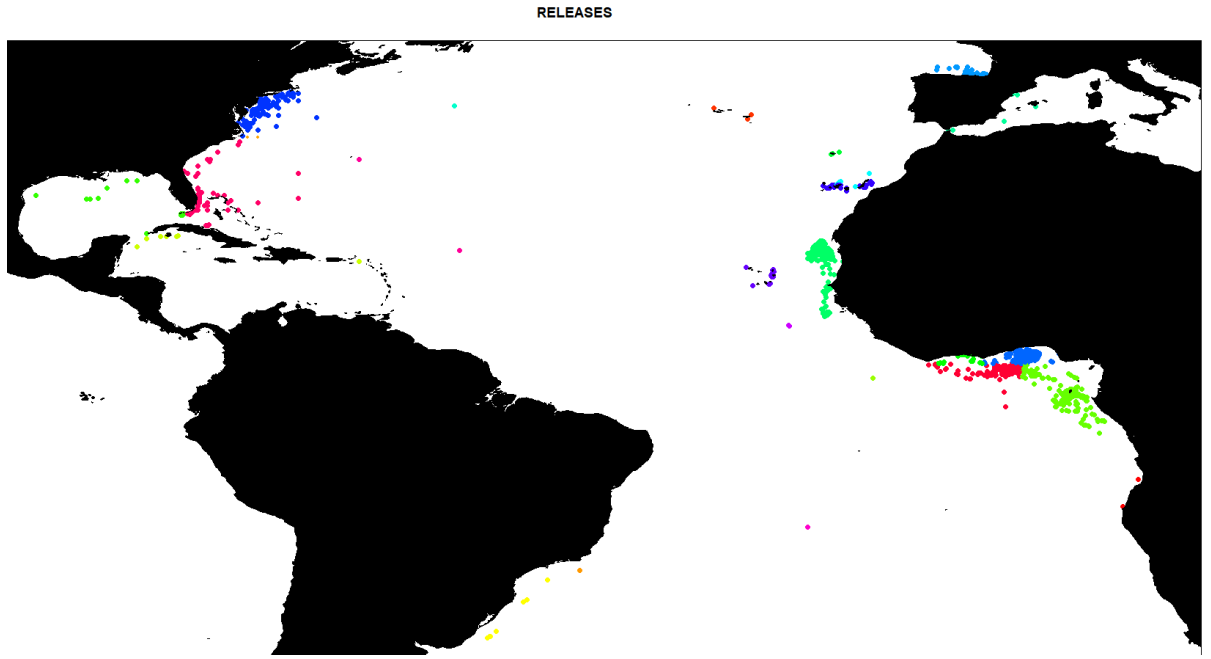
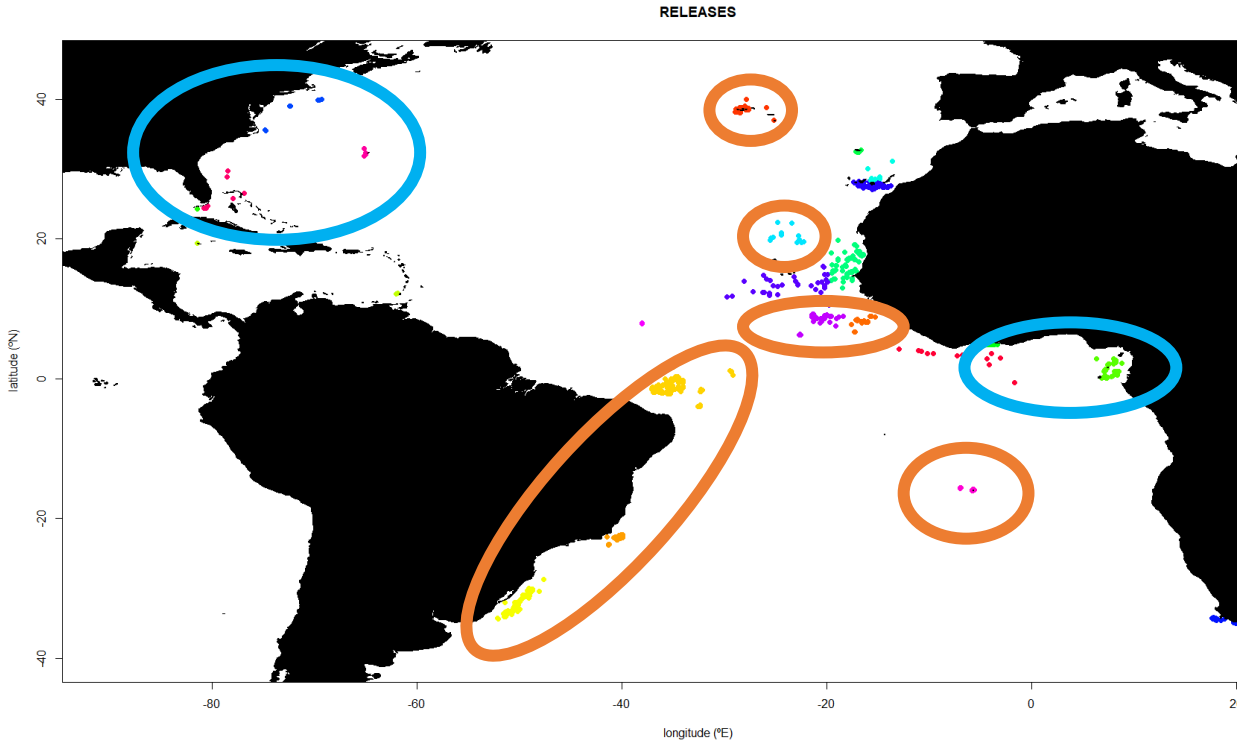


Historical SKJ releases (1959 to 2014)



AOTTP SKJ releases (2016 to present)

Colors: 29 ad-hoc areas defined for movement descriptions

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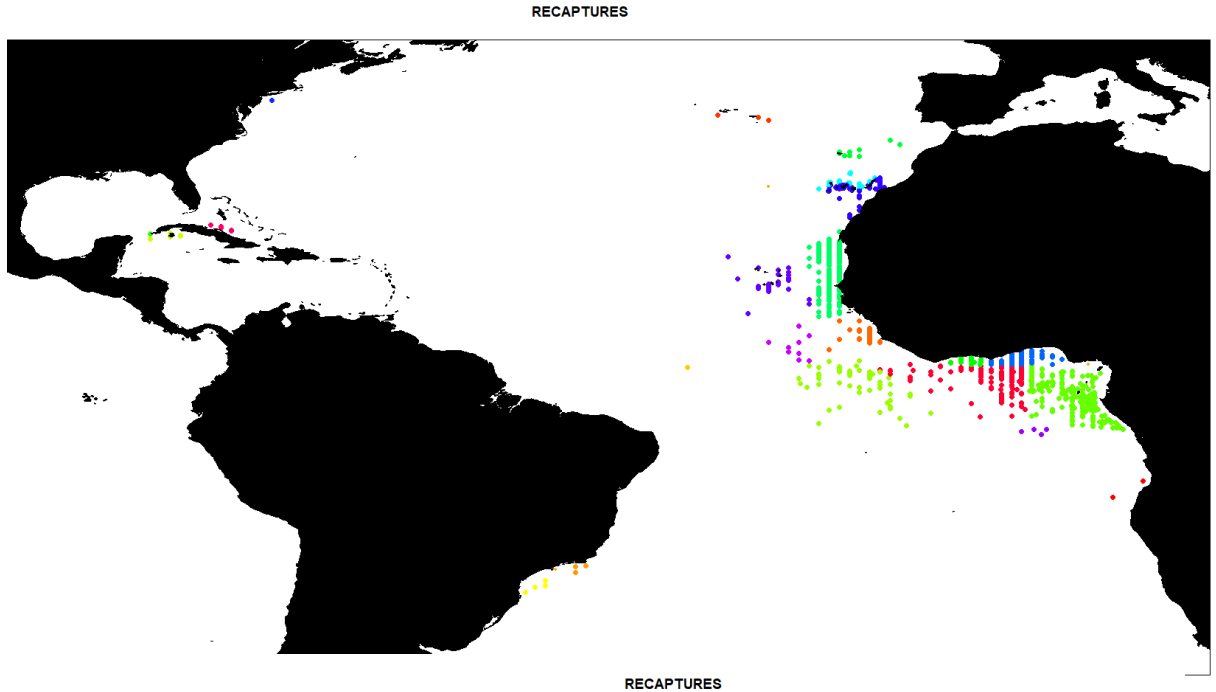
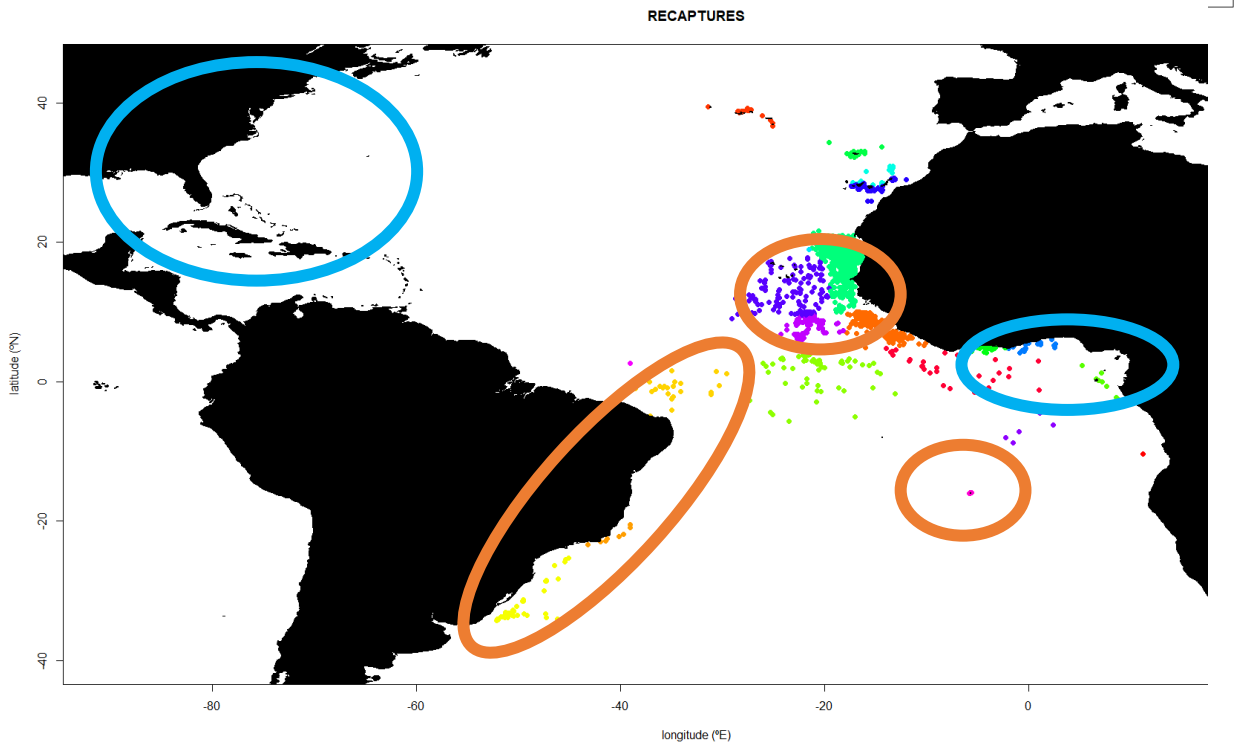


Historical SKJ recoveries (1959 to 2014)



AOTTP SKJ recoveries (2016 to present)

29 ad-hoc areas defined for movement descriptions

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Observed movements between the areas defined (1959 to 2014)

		recovery area																			
n	release area	Brazil south	Brazil centre	Brazil north	South. Gulf of Guinea	Angola	East. Gulf of Guinea	Ghana-Nigeria	Ivory Coast	West. Gulf of Guinea	Central Atlantic	Sierra Leone Rise	Sierra Leone Basin	Cabo Verde South	Mauritania Senegal	Canaries South	Canaries North	Madeira	Azores	West Atlantic	Caribbean	Gulf of Mexico
8	Brazil south	63%	38%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	Angola	0%	0%	0%	0%	13%	63%	13%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
521	East. Gulf of Guin	0%	0%	0%	1%	0%	79%	3%	2%	10%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
245	Ghana-Nigeria	0%	0%	0%	0%	0%	24%	23%	9%	31%	7%	0%	2%	0%	3%	0%	0%	0%	0%	0%	0%	0%
9	Ivory Coast	0%	0%	0%	0%	0%	11%	44%	0%	44%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
322	West. Gulf of Guir	0%	0%	0%	0%	0%	17%	16%	11%	40%	8%	0%	2%	0%	3%	0%	0%	0%	0%	0%	0%	0%
35	Sierra Leone Rise	0%	0%	3%	0%	0%	3%	0%	0%	0%	23%	63%	0%	0%	9%	0%	0%	0%	0%	0%	0%	0%
79	Cabo Verde Soutl	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	96%	4%	0%	0%	0%	0%	0%	0%	0%
604	Mauritania Senega	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	5%	2%	89%	2%	0%	0%	0%	0%	0%	0%
677	Canaries South	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	76%	19%	2%	0%	0%	0%	0%
176	Canaries North	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	90%	9%	1%	0%	0%	0%	0%
3	Azores	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
9	West Atlantic	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
3	Caribbean	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
2	Gulf of Mexico	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%

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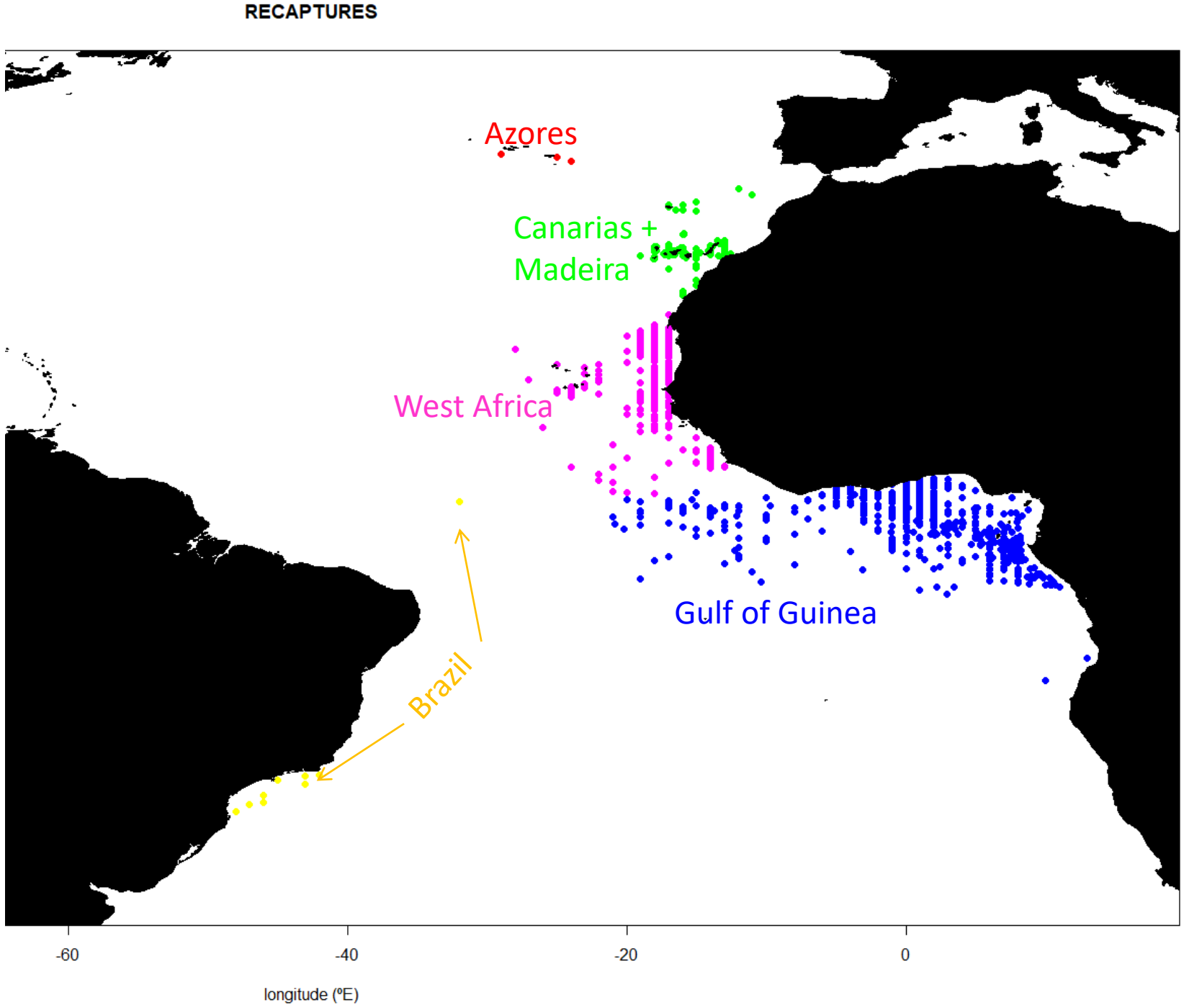
5 broader regions defined for tag-attrition model (1959 to 2014)



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Observed movements between the areas defined (2016 to present)

		recovery aea																			
n	release area	Brazil south	Brazil centre	São Pedro e São Paulo	Brazil north	East. Gulf of Guinea	South. Gulf of Guinea	Ghana-Nigeria	Ivory Coast	West. Gulf of Guinea	Central Atlantic	Sierra Leone Basin	Sierra Leone Rise	Cabo Verde South	Mauritania Senegal	Cabo Verde North	Canaries South	Canaries North	Madeira	Azores	Saint Helena	Angola
78	Brazil south	95%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4	Brazil Centre	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	São Pedro e São Paulo	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
31	Brazil North	0%	3%	6%	84%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11	East. Gulf of Guinea	0%	0%	0%	0%	27%	9%	18%	9%	36%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
21	Ivory Coast	0%	0%	0%	0%	0%	0%	43%	48%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
64	West. Gulf of Guinea	0%	0%	0%	0%	0%	0%	31%	9%	19%	6%	28%	0%	3%	3%	0%	0%	0%	0%	0%	0%	0%
111	Sierra Leone Basin	0%	0%	0%	0%	0%	0%	1%	0%	4%	0%	77%	8%	1%	8%	0%	0%	0%	0%	1%	0%	0%
251	Sierra Leone Rise	0%	0%	0%	0%	0%	1%	0%	0%	0%	19%	11%	33%	22%	10%	0%	3%	0%	0%	0%	0%	0%
90	Cabo Verde South	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%	29%	10%	13%	41%	0%	2%	0%	0%	0%	0%	0%
668	Mauritania Senegal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	2%	8%	85%	0%	1%	0%	0%	0%	0%	0%
6	Cabo Verde North	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	17%	50%	17%	0%	0%	0%	0%	0%	0%	0%
118	Canaries South	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	8%	11%	0%	69%	10%	0%	0%	0%	0%
66	Canaries North	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	2%	0%	2%	15%	0%	15%	61%	3%	0%	0%	0%
26	Madei	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	27%	8%	62%	0%	0%	0%
60	Azores	0%	0%	0%	0%	0%	0%	2%	0%	5%	3%	8%	12%	32%	18%	0%	8%	2%	3%	7%	0%	0%
21	Saint Helena	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	95%	0%

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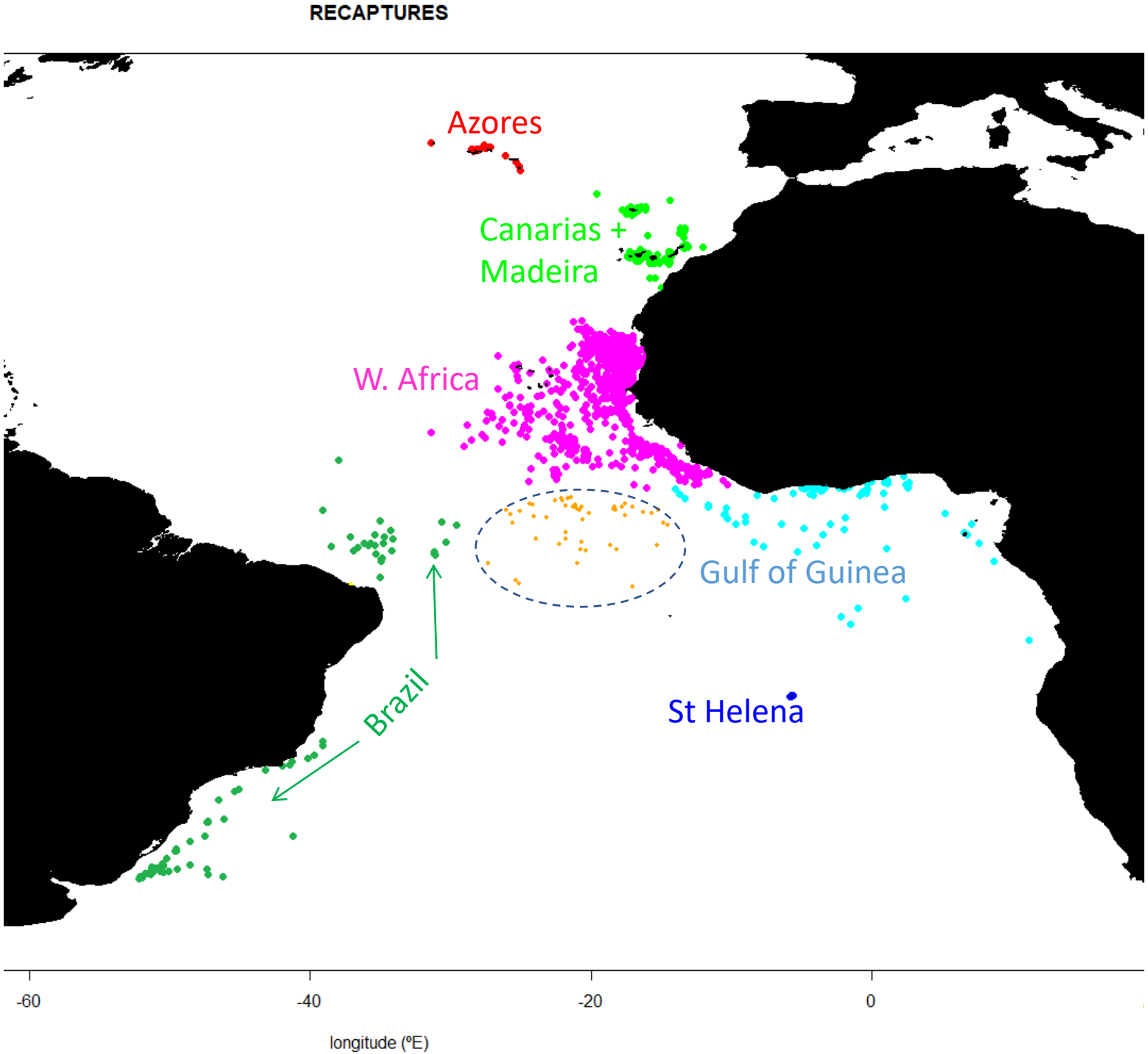
6 broader regions defined for tag-attrition model (2016 to present)



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Tag-attrition model parameters

- *eP (*age of the plus group), set to 5 years. Growth model by Hallier and Gaertner (2006).
- Type I tag shedding was set to 0.2, type II to 0.26 (Gaertner et al. 2004).
- The tag reporting rate was set arbitrarily to 0.8 for all fleets and regions.
- Size-dependent natural mortality (Gaertner et al. 2004).

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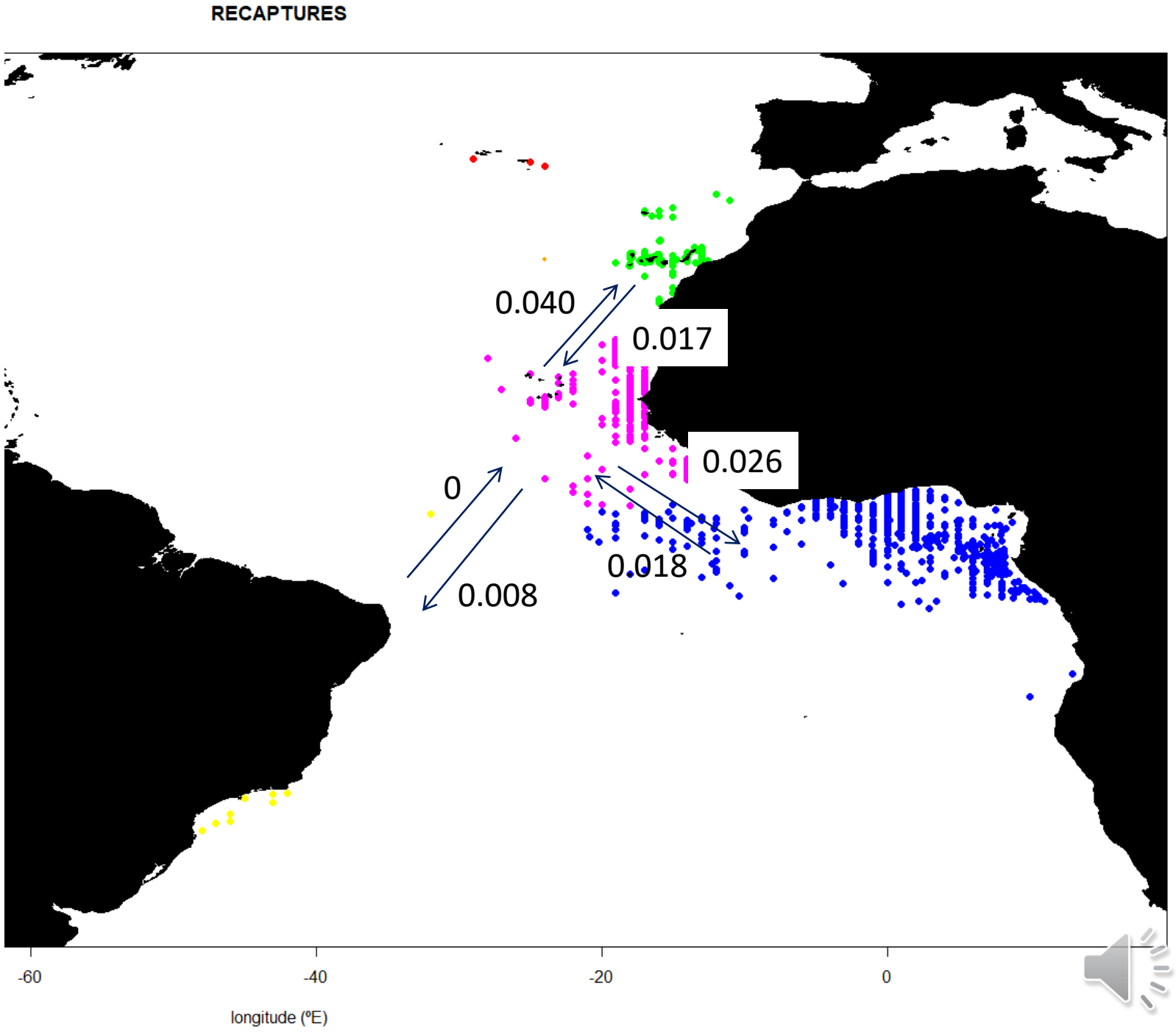
Model outputs
(1959 to 2014)

No significant transoceanic movement

Other movement rates 1.5 to 4%



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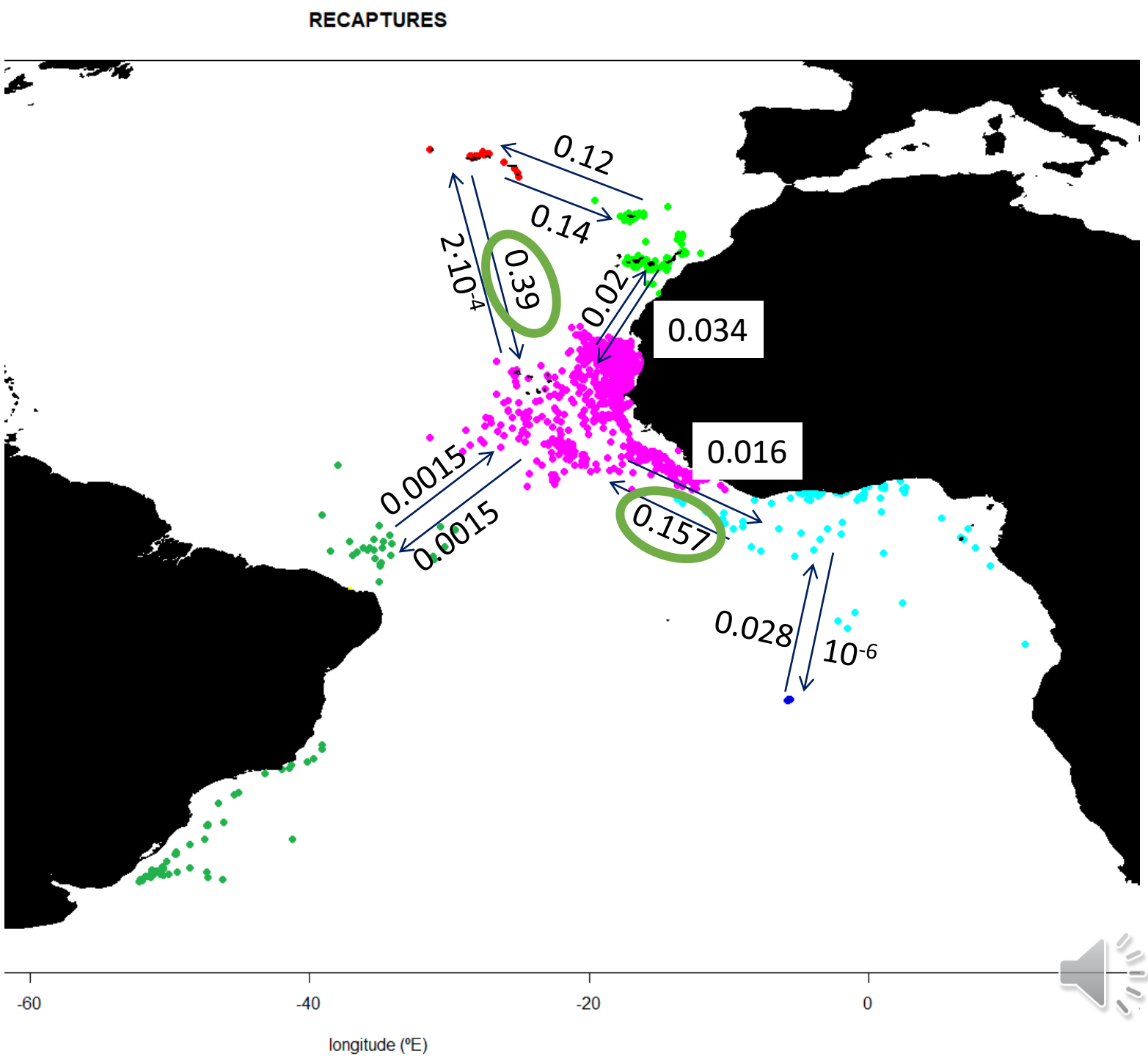
Model outputs (2016 to present)

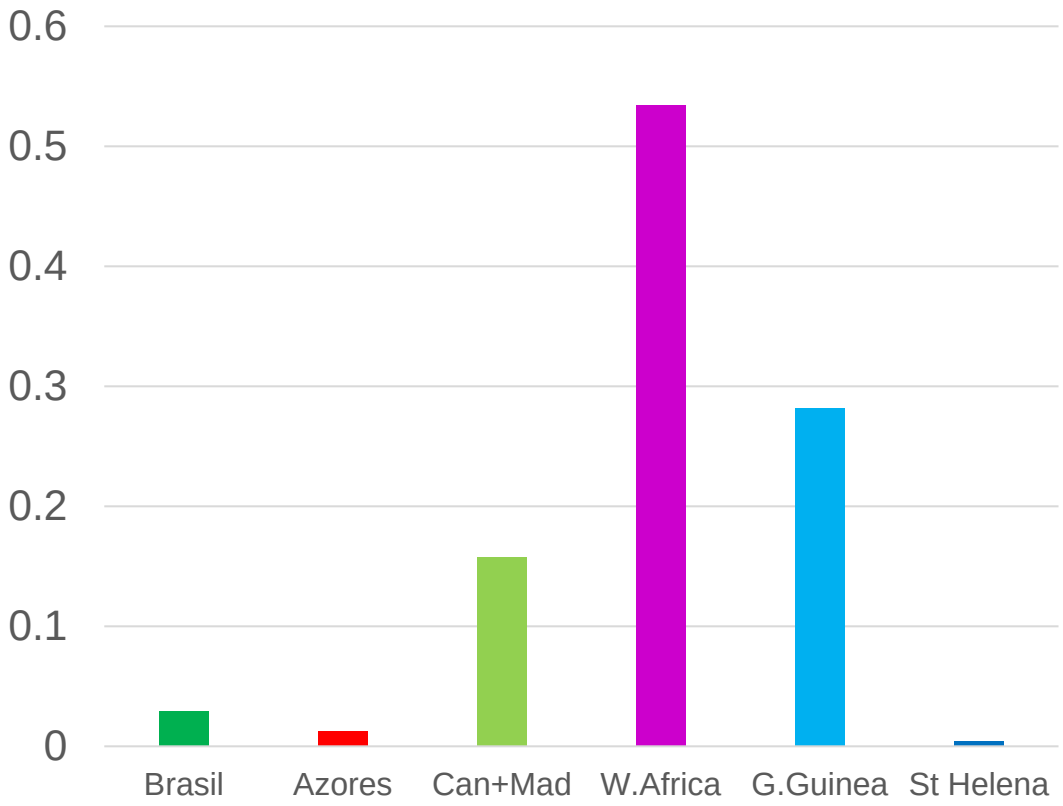
No significant transoceanic displacement

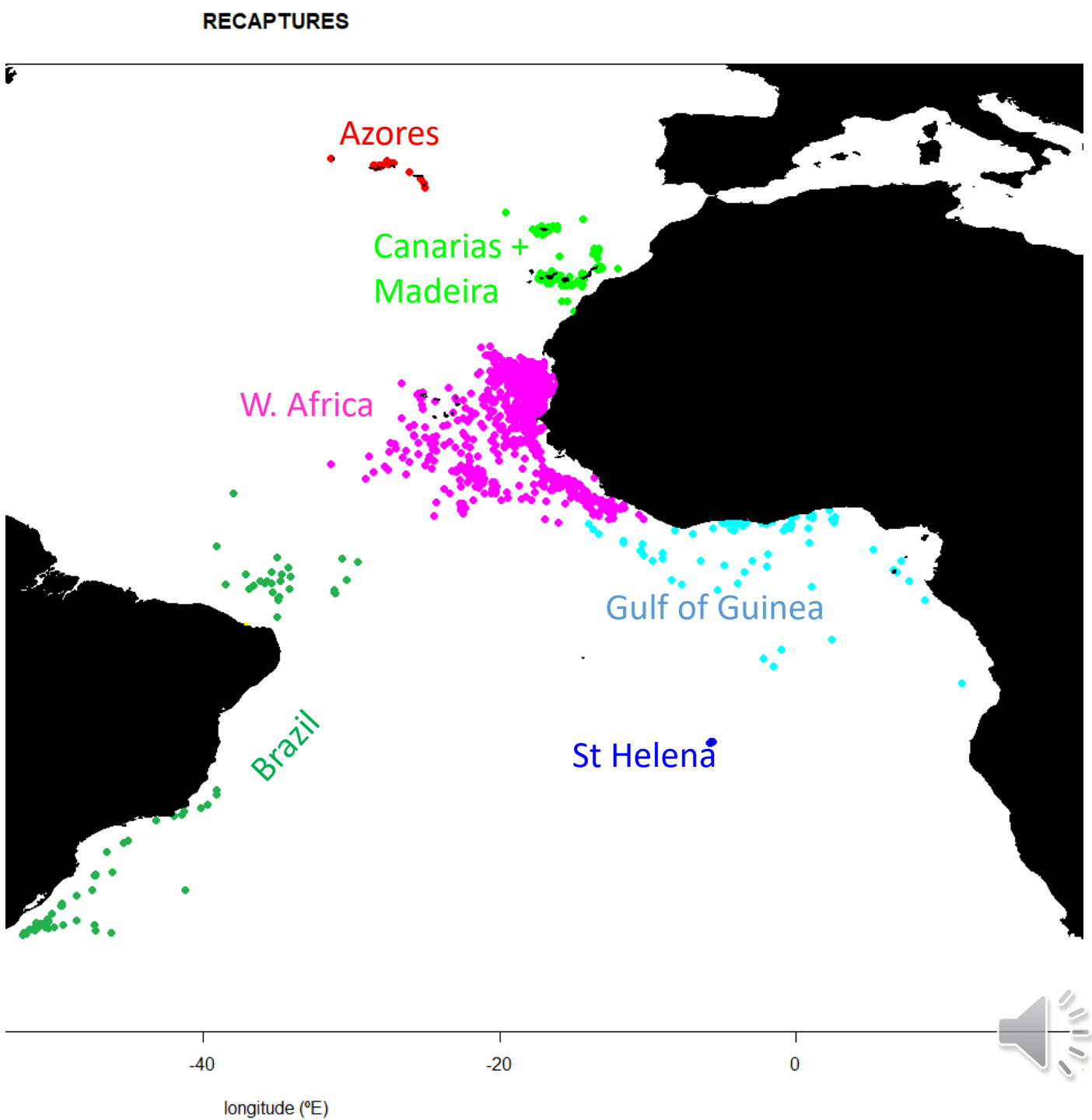
Most movement rates in the Eastern Atlantic under 4%

Important movement rates from Azores and from Gulf of Guinea to West Africa



Model outputs (2016 to present)
Fishing mortality





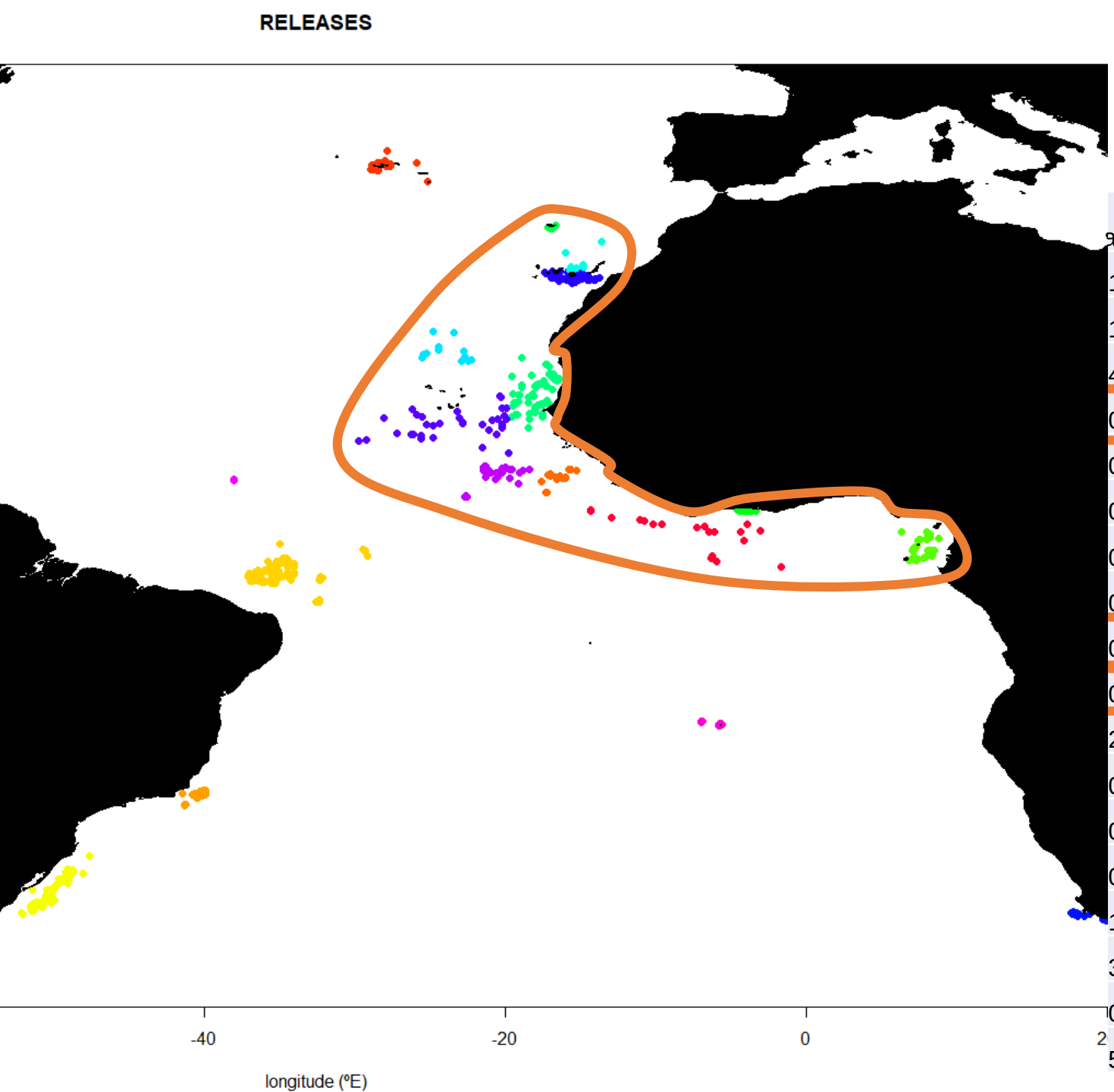
Model sensitivity to input data

separate removal of subsets from initial release areas

Sensitivity of some parameters based on little data

Other convergence points through removing specific areas

	base case	!=MauSen	!=SCan	!=Azores	!=SCaVer	!=BraNor	!=StHel	!=BaSL	!=Ncan	!=NCaVer	!=SLRis	!=EGoG	!=Madei	!=IvCo
p(Az->CM)	0.1381	0.1349	0.1431	0.0749	0.1535	0.1587	0.1226	0.1230	0.1286	0.1260	0.1176	0.1181	0.1195	0.1214
p(CM->Az)	0.1169	0.0874	0.0833	0.3786	0.1641	0.1796	0.0863	0.0769	0.0916	0.0896	0.0842	0.1145	0.1167	0.0810
p(Az->WA)	0.3908	0.3529	0.4459	0.3895	0.4533	0.4742	0.3409	0.3291	0.3504	0.3493	0.3470	0.3205	0.3165	0.3358
p(WA->Az)	$2 \cdot 10^{-5}$	0.1093	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0034	0.0286	0.0331	0.0003
p(Br->WA)	0.0015	0.0008	0.0011	0.0013	0.0013	0.0014	0.0003	0.0015	0.0008	0.0003	0.0007	0.0115	0.0115	0.0017
p(WA->Br)	0.0016	0.0035	0.0013	0.0012	0.0012	0.0014	0.0014	0.0048	0.0016	0.0015	0.0000	0.0000	0.0000	0.0012
p(CM->WA)	0.0344	0.0674	0.0767	0.0349	0.0390	0.0373	0.0547	0.0505	0.0368	0.0493	0.0613	0.0738	0.0878	0.0532
p(WA->CM)	0.0200	0.0059	0.0186	0.0223	0.0208	0.0205	0.0202	0.0398	0.0208	0.0269	0.0147	0.0132	0.0107	0.0183
p(GG->SH)	10^{-6}	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0003	0.0015	0.0062	0.0047	0.0000
p(SH->GG)	0.0275	0.0278	0.0134	0.0135	0.0161	0.0145	0.0200	0.0303	0.0314	0.0321	0.0332	0.0349	0.0283	0.0300
p(GG->WA)	0.1570	0.1370	0.1874	0.2100	0.1885	0.2045	0.1240	0.1198	0.1299	0.1296	0.1372	0.1408	0.1318	0.1320
p(WA->GG)	0.0158	0.0334	0.0163	0.0148	0.0157	0.0150	0.0165	0.0244	0.0145	0.0182	0.0135	0.0354	0.0429	0.0153
F(AZ)	0.0128	0.0118	0.0407	0.0033	0.0198	0.0127	0.0192	0.0088	0.0141	0.0157	0.0214	0.0153	0.0237	0.0189
F(Br)	0.0293	0.0297	0.0295	0.0298	0.0296	0.0306	0.0293	0.0537	0.0300	0.0296	0.0295	0.0593	0.0562	0.0297
F(CM)	0.1578	0.1518	0.2156	0.2325	0.1615	0.1659	0.1540	0.1649	0.1415	0.1537	0.1596	0.1427	0.1259	0.1593
F(GG)	0.2822	0.1996	0.3194	0.3169	0.3404	0.3803	0.1974	0.1841	0.2169	0.2172	0.2102	0.1712	0.1466	0.1042
F(SH)	0.0041	0.0000	0.0070	0.0050	0.0128	0.0057	0.0984	0.0444	0.0000	0.0000	0.0000	0.0000	0.0000	0.0404
F(WA)	0.5344	0.4238	0.5360	0.5392	0.5466	0.5362	0.5306	0.5323	0.5429	0.5481	0.4932	0.3080	0.3083	0.5345



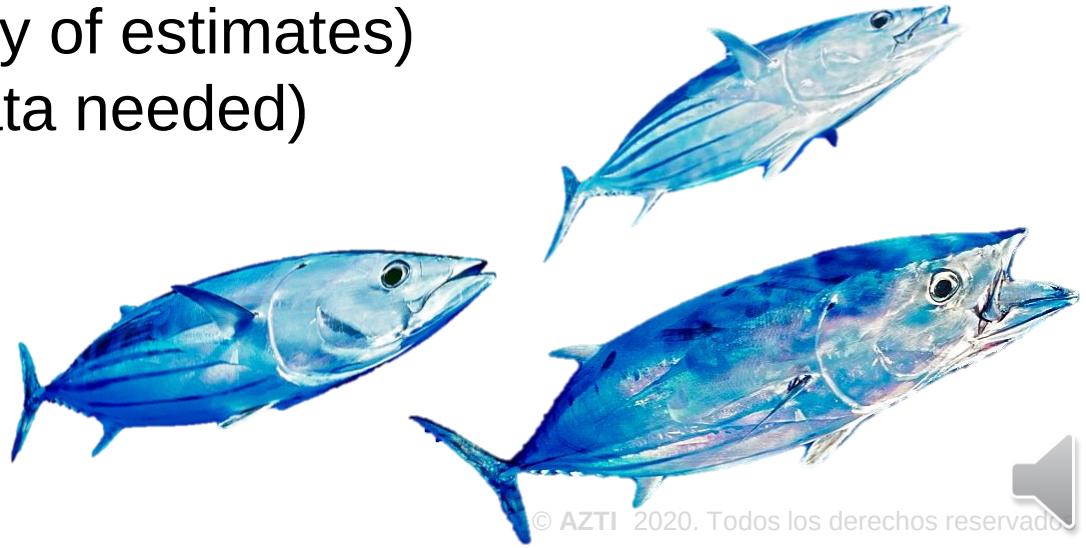
aNor	!=StHel	!=BaSL	!=Ncan	!=NCaVer	!=SLRis	!=EGoG	!=Madei	!=IvCo
1587	0.1226	0.1230	0.1286	0.1260	0.1176	0.1181	0.1195	0.1214
1796	0.0863	0.0769	0.0916	0.0896	0.0842	0.1145	0.1167	0.0810
4742	0.3409	0.3291	0.3504	0.3493	0.3470	0.3205	0.3165	0.3358
0000	0.0000	0.0000	0.0000	0.0003	0.0034	0.0286	0.0331	0.0003
0014	0.0003	0.0015	0.0008	0.0003	0.0007	0.0115	0.0115	0.0017
0014	0.0014	0.0048	0.0016	0.0015	0.0000	0.0000	0.0000	0.0012
0373	0.0547	0.0505	0.0368	0.0493	0.0613	0.0738	0.0878	0.0532
0205	0.0202	0.0398	0.0208	0.0269	0.0147	0.0132	0.0107	0.0183
0000	0.0000	0.0002	0.0000	0.0003	0.0015	0.0062	0.0047	0.0000
0145	0.0200	0.0303	0.0314	0.0321	0.0332	0.0349	0.0283	0.0300
2045	0.1240	0.1198	0.1299	0.1296	0.1372	0.1408	0.1318	0.1320
0150	0.0165	0.0244	0.0145	0.0182	0.0135	0.0354	0.0429	0.0153
0127	0.0192	0.0088	0.0141	0.0157	0.0214	0.0153	0.0237	0.0189
0306	0.0293	0.0537	0.0300	0.0296	0.0295	0.0593	0.0562	0.0297
1659	0.1540	0.1649	0.1415	0.1537	0.1596	0.1427	0.1259	0.1593
3803	0.1974	0.1841	0.2169	0.2172	0.2102	0.1712	0.1466	0.1042
0057	0.0984	0.0444	0.0000	0.0000	0.0000	0.0000	0.0000	0.0404
5362	0.5306	0.5323	0.5429	0.5481	0.4932	0.3080	0.3083	0.5345

Conclusive remarks

Main result: does not suggest any change to the management units, no significant connectivity between east and west, despite tagging in farther open ocean in the recent period

Main pending uncertainty: lack of data from NW quarter

Specially relevant regions regarding potential future tagging activities:
Eastern Gulf of Guinea and Madeira (sensitivity of estimates)
Azores and Saint Helena (new areas, more data needed)



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