

Supplementary material

Marine hotspots of activity inform protection of a threatened community of pelagic species
in a large oceanic jurisdiction

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Resumen

Las islas oceánicas albergan una biodiversidad única, especialmente en cuanto a especies pelágicas dependientes de los recursos tróficos marinos alrededor de sus colonias de cría. Tristán de Acuña, en el Atlántico Sur, hospeda una comunidad rica en endemismos y en especies globalmente amenazadas que se dispersan y utilizan una amplia extensión del Atlántico Sur. Dada la enorme importancia de este territorio para la conservación de estas especies la localización de las áreas que concentran la actividad y que son críticas para su conservación es fundamental para el diseño de medidas de protección y gestión, y su aplicación antes de la apertura de su Zona Económica Exclusiva (ZEE) a actividades extractivas y comerciales.

Hemos identificado las áreas que concentran una alta actividad estadísticamente significativa a escala de la ZEE ("hotspots" de actividad) a partir de la información obtenida mediante el seguimiento telemétrico de individuos ("tracking") de 10 nueve especies de aves marinas y una de pinnípedos. Sobre una malla regular de celdas cuadradas de 10 km obtuvimos el tiempo estimado que cada una de estas especies invierte localmente en cada una de las estaciones del año. Aplicando estadísticos de asociación espacial sobre estas celdas, hemos detectado las áreas que registran una actividad superior a la esperable al azar y constatado la variabilidad estacional de la distribución espacial.

Los "hotspots" de actividad se localizaron tanto alrededor de las islas como asociados a montañas submarinas, siendo espacialmente consistentes para diferentes estaciones del año. Además, hemos podido confirmar que estas áreas tienen una importancia crítica en algunas de las fases de cría para ciertas especies, que pueden llegar a invertir gran parte del tiempo de búsqueda de recursos en el mar dentro de la ZEE. El enfoque que presentamos proporciona un marco simple y eficaz para detectar las áreas de importancia para las comunidades pelágicas en procesos de planificación para la conservación y la gestión de áreas protegidas, como en el caso de Tristán de Acuña.

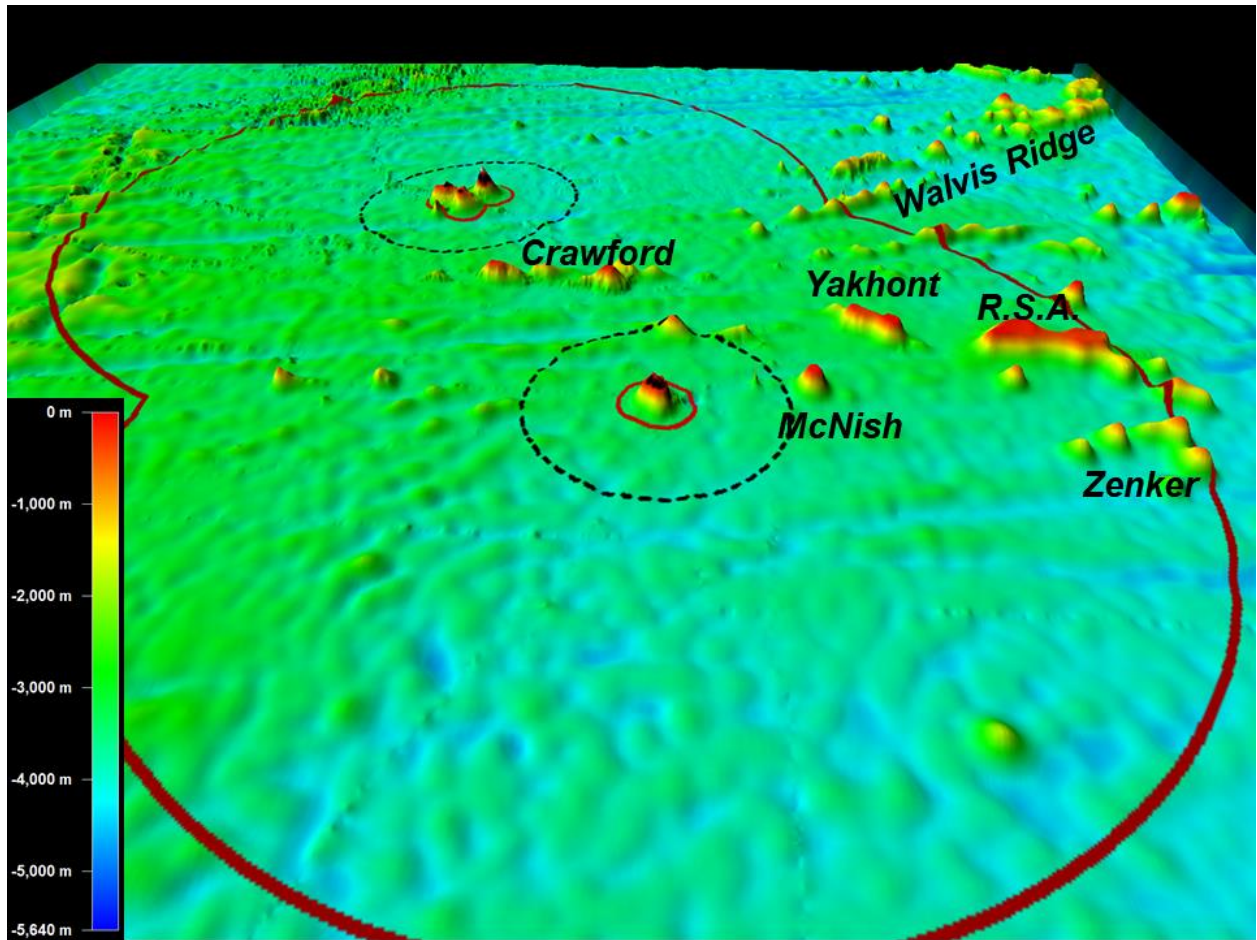


Figure S1. A three-dimensional model of the bathymetry in Tristan da Cunha EEZ highlighting the seamounts. The islands themselves are the emerging peaks of a system of submarine volcanos related to the Walvis Ridge.

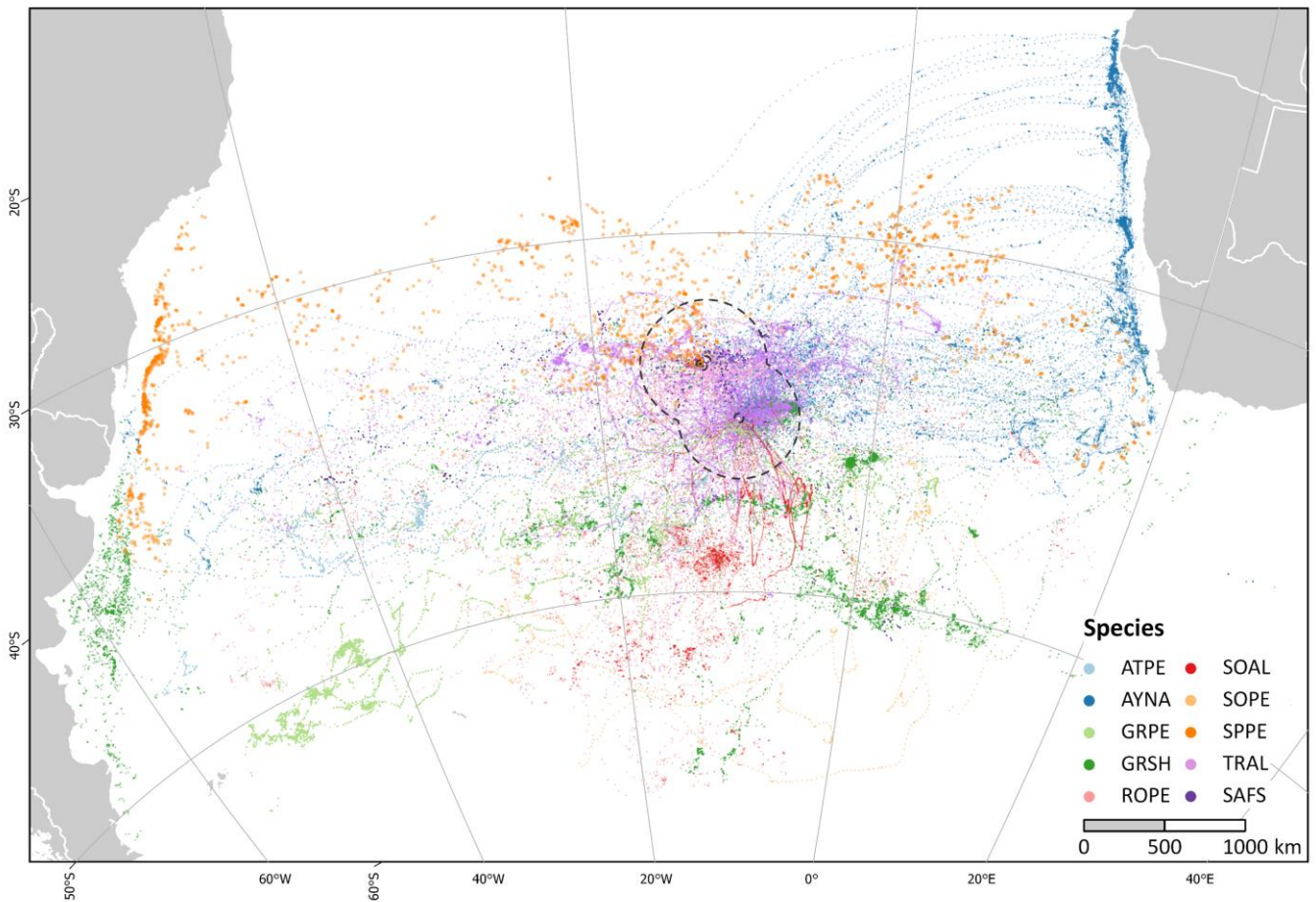


Figure S2. Plot of the raw tracking data of all 10 species considered in our analysis of marine hotspots within the Tristan da Cunha EEZ (indicated by the solid black line). The map uses an Azimuthal equidistant projection centered on the EEZ thus minimising distortions both in directions and distance. The islands and the 50nm fishing exclusion buffer (dashed) are also drawn. Note that due to overlapping points not all species' data are visible within the EEZ. ATPE Atlantic Petrel, AYNA Atlantic Yellow-nosed Albatross, GRPE Grey Petrel, GRSH Great Shearwater, NRPE Northern Rockhopper Penguin, SAFS Subantarctic Fur Seal, SOAL Sooty Albatross, SOPE Soft-plumaged Petrel, SPPE Spectacled Petrel, TRAL Tristan Albatross.

Table S1. Datasets used to identify hotspots of pelagic megafauna activity in the Tristan da Cunha Exclusive Economic Zone. Raw datasets and metadata are publicly available at the Birdlife's Seabird Tacking Database and Movebank or upon request to the data owners (Source). Island: G (Gough), N (Nightingale), I (Inaccessible), TdC (Tristan da Cunha). The temporal resolution is expressed as the median value in hours.

Species	Source	Device	Island	From	To	Temporal resolution (h)
<i>Eudiptes moseleyi</i>	contact	GPS	G	11/10/2012	29/11/2013	0.02
	contact	GPS	N	15/09/2012	18/11/2012	0.02
	contact	GPS	N	15/09/2013	04/11/2013	0.02
	1276	GPS	N	10/09/2016	30/11/2016	0.08
<i>Diomedea dabbenena</i>	422	PTT	G	07/02/2001	01/07/2001	5.8
	1293	GPS	G	20/01/2014	28/03/2014	1.0
	contact	GPS	G	23/03/2018	03/05/2018	0.4
<i>Phoebastria fusca</i>	420	PTT	G	17/09/2006	02/05/2007	19.4
	853	PTT	I	11/01/2009	04/12/2010	1.6
	1290	GPS	G	13/11/2013	28/12/2013	0.9
	1292	GPS	TdC	29/10/2015	18/12/2015	1.0
<i>Thalassarche chlororhynchos</i>	700	PTT	G	22/11/2000	11/01/2001	1.72
	1103	GPS	G	09/11/2013	10/12/2013	0.9
	1104	GPS	G	11/01/2014	12/12/2014	1.0
	1105	GPS	N	17/10/2015	30/11/2015	1.0
<i>Pterodroma incerta</i>	1285	GPS	G	12/07/2014	14/08/2014	1.0
<i>Pterodroma mollis</i>	1289	GPS	G	04/01/2014	08/03/2014	0.9
<i>Procellaria cinerea</i>	1288	GPS	G	04/04/2014	08/05/2014	0.7
<i>Procellaria conspicillata</i>	858	PTT	I	11/01/2009	04/12/2010	6.5
<i>Ardenna gravis</i>	662	PTT	G	30/09/2009	01/06/2010	42.7
	663	PTT	I	21/11/2009	19/06/2010	42.3
	1286	GPS		06/12/2013	13/02/2014	1.0
	1287	GPS	N	15/11/2015	23/12/2016	1.0
<i>Arctocephalus tropicalis</i>	Movebank					
	368049215					
		PTT	G	21/01/2017	16/06/2017	23.3
	PTT	N	15/09/2016	07/02/2017	22.1	
	PTT	TdC	08/09/2016	18/05/2017	19.1	

Table S2. Phenology of the seabird species breeding in the Territory of Tristan da Cunha. Tristan Albatrosses are biennial breeders, hence the extra line plotting the sabbatical years. Based on Dias et al., 2017.

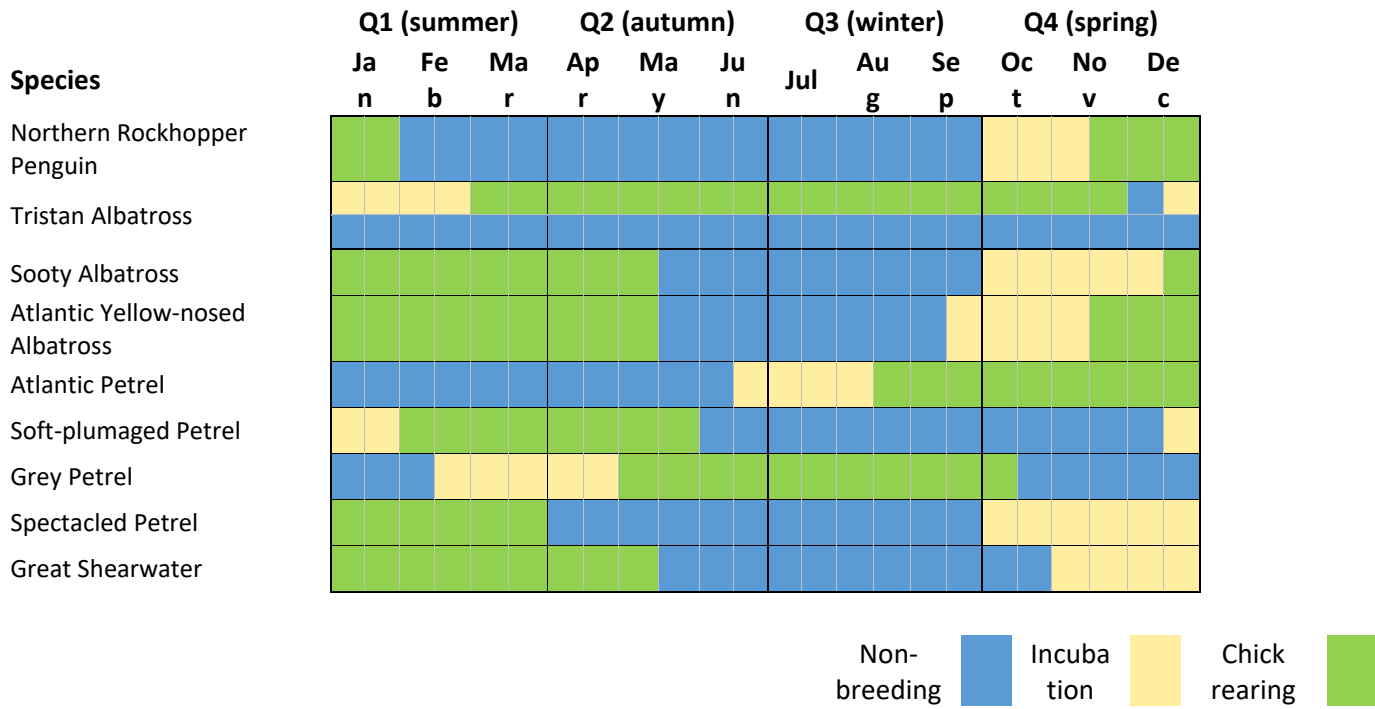


Table S3. Proportion of the time-at-sea spent by different species inside and outside the Tristan EEZ based on tracking data of pelagic megafauna activity in the Tristan da Cunha Exclusive Economic Zone. The numbers indicate the number of adult individuals (Ind) tracked per island (Island) with either Platform Terminal Transmitter (PTT) or Global Positioning System (GPS) devices between 2000 and 2018. See main text for data processing steps. All trips for each species and breeding stage were combined; hence the numbers in this table represent the amount of tracking time regardless of the colony of origin.

	Stage	Island (s)	Device	Years	Individuals	Trips	Completed trips	Total tracking time (h)	Time inside EEZ (h)	% time inside EEZ
Northern Rockhopper Penguin (<i>Eudyptes moseleyi</i>)	Incubation	Nightingale, Gough	GPS	2012, 2013 and 2016	46	47	33	15591	12990	83.3
Northern Rockhopper Penguin (<i>Eudyptes moseleyi</i>)	Brood guard	Nightingale, Gough	GPS	2012, 2013 and 2016	74	132	127	5444	5444	100
Tristan Albatross (<i>Diomedea dabbenena</i>)	Incubation	Gough	GPS	2014-01-20 to 2014-03-28	18	46	39	6248	2476	39.6
Tristan Albatross (<i>Diomedea dabbenena</i>)	Brood guard	Gough	GPS	2018-03-23 to 2018-05-03	29	78	74	4213	3464	82.2
Sooty Albatross (<i>Phoebastria fusca</i>)	Incubation	Gough	GPS	2013-11-15 to 2013-12-27	10	13	13	2476	2476	11.5
Atlantic Yellow-nosed Albatross (<i>Thalassarche chlororhynchos</i>)	Incubation	Gough	GPS	2013-11-09 to 2013-12-10 // 2014-10-29 to 2014-12-11	28	37	37	10434	1476	14.1
Atlantic Yellow-nosed Albatross (<i>Thalassarche chlororhynchos</i>)	Brood guard	Gough	GPS	2018-12-04 to 2018-12-15	35	49	48	1707	1586	92.9
Grey Petrel (<i>Procellaria cinerea</i>)	Incubation	Gough	GPS	2014-04-10 to 2014-05-06	15	15	1	353	36.5	10.3
Great Shearwater (<i>Ardenna gravis</i>)	Incubation	Gough	GPS	2013-12-07 to 2014-01-11	16	16	10	4877	1039	21.3
Subantarctic Fur Seal (<i>Arctocephalus tropicalis</i>)	Lactating: - Short trip - Long trip	Tristan, Gough, Nightingale	PTT	2016-09-08 to 2017-06-16	10	28	17 5	4609 7731	4609 3719	100 48.1

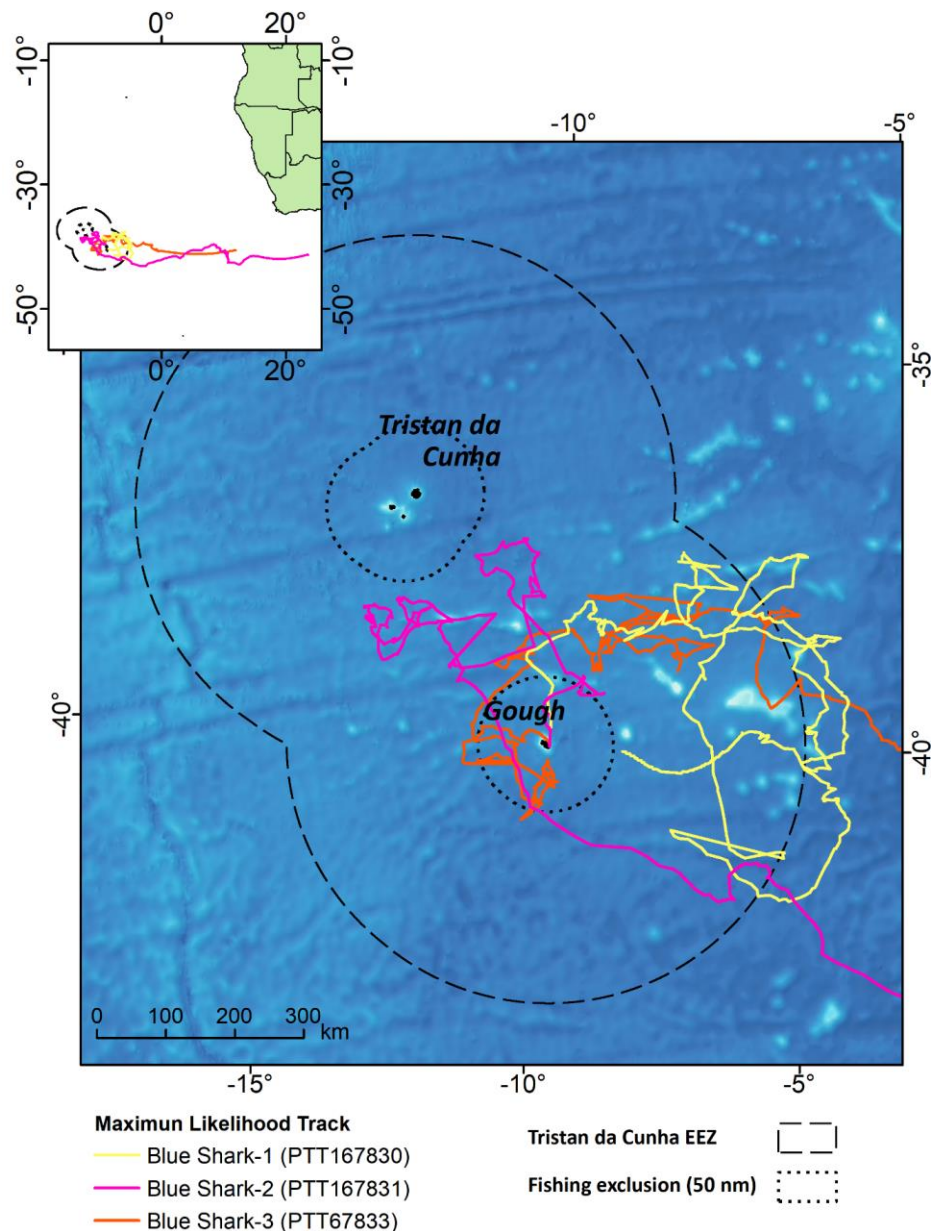


Figure S3 The tracks of three Blue Shark (*Prionace glauca*) tagged during the National Geographic's Pristine Seas expedition to Tristan da Cunha (January to February 2017), using MiniPAT tags (Wildlife Computers). These tags were programmed to be released 180 days post-deployment. The inset shows the same tracks in their entirety. Data not included in our analysis because of the small sample size ($n = 3$). More details on the deployment and results are presented in the report of the expedition (Caselle et al., 2017. Ecosystem Assessment of the Tristan da Cunha Islands. National Geographic Pristine Seas, Royal Society for Protection of Birds and Tristan da Cunha Government. <https://media.nationalgeographic.org/assets/file/PristineSeasTristandaCunhaScientificReport.pdf>)

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