Progressing inshore designations of Key Biodiversity Areas for seabirds, and their application to management of the marine environment.

Supplementary Material

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Identifying inshore marine KBAs for seabirds at the Falkland Islands using the most comprehensive dataset on breeding locations and abundance, coupled with estimates of at-sea distribution.

Delineating marine KBAs for Falklands seabird

Delineating relevant boundaries for marine areas that can be assessed against KBA criteria is an essential prerequisite of the KBA identification process. Boundaries should be ecologically relevant and should provide a basis for potential management activities (KBA Standards and Appeals Committee, 2020). The typical data required to determine relevant marine boundaries for areas of assessment against species specific KBA criteria for seabirds are breeding location data and at-sea distribution data (or estimates thereof) coupled with site and global population (abundance) estimates, and the IUCN Red List threat status of the species.

Quantitative data are needed to identify marine KBAs

In areas where no KBAs exist, biodiversity element layers (layers specific to individual species) can be identified first before being aggregated into a specific global KBA. These element layers will be useful for informing species specific management actions that could occur within the boundaries of individual element layers (KBA Secretariat, 2019).

Preliminary data for species specific marine KBA element layers for seabirds at the Falkland Islands

Recent studies have collated numerous datasets and estimated the distribution and abundance of primarily seabirds within the waters of the Falkland Islands Exclusive Economic Zone (Augé et al., 2018; Baylis et al., 2019, 2021a). A preliminary assessment to identify KBA element layers for Falklands seabirds, utilised the 33 species specific output layers from (Augé et al., 2018). In this preliminary assessment, the layers for nine species from the (Augé et al., 2018) outputs were deemed to be appropriate for assessment of areas as potential global KBAs, owing to the likely feasibility of management units; a key requirement of KBAs. However, for 5 of 9 species, estimated KBA boundaries were considered to be of medium to low quality; particularly for the inshore environment of the Falkland Islands. The low-quality boundaries in the inshore area are likely a result of data collection which primarily occurred via at-sea surveys.

Notably, a previous study found that data collected by at-sea observers (primarily on off-shore fishing vessels) showed no demonstrable link between seabed bathymetry, and distance from land with areas containing a high number of unique species, aggregations of listed threatened species, or terrestrial locations with high seabird abundance (Forster, 2010). Therefore, it is likely that these at-sea surveys - which were not specific to the inshore environment - were unable to fully elucidate the inshore distribution of many species, particularly during the breeding period. As such, we concluded that new data would be needed to assess for areas in the inshore waters of the Falkland Islands which might meet global KBA criteria.

Revised data for species specific marine KBA element layers for seabirds at the Falkland Islands

To further consider marine areas in Falklands waters that may meet KBA criteria, particularly in the inshore environment, we collated a new dataset on the distribution of seabird breeding locations and their associated abundance estimates throughout the Falkland Islands, coupled with estimates of species specific at-sea distribution. To our knowledge this is the most comprehensive record available for seabird breeding colony location and abundance at the Falkland Islands. This dataset provides a new baseline through which to consider marine KBA boundaries for a number of species known to utilise the inshore environment.

Population estimates: Distribution of seabird breeding locations and their associated abundance estimates

Seabird breeding location records and their associated abundance estimates were collated from several sources which included data from published and unpublished records: the Falkland Islands Seabird Monitoring Programme (FISMP) (Crofts and Stanworth, 2019), the Falkland Islands' Biodiversity Database (FIBDB) (FIG, 2013) and the Falkland Island Coastal Bird Dataset (FICBD) (Echevarría, 2020).

In total, 5,182 records relating to breeding areas for 28 species were obtained (Table 1).

Table 1: Preliminary species list for consideration of seabird breeding locations and their associated abundance estimates

Group	Common Name	Scientific Name	Family	Code	In Augé et al., 2018
Albatrosses	Black-browed Albatross	*Thalassarche melanophris*	Diomedeidae	BBAL	Y
Cormorants	Rock Shag	*Leucocarbo magellanicus*	Phalacrocoracidae	ROSH	Y
Cormorants	Imperial Shag	*Leucocarbo atriceps*	Phalacrocoracidae	IMSH	Y
Ducks & Geese	**Kelp Goose**	***Chloephaga hybrida***	**Anatidae**	**KEGO**	**N**
Ducks & Geese	Falkland Steamerduck	*Tachyeres brachypterus*	Anatidae	FLSD	Y
Ducks & Geese	**Flying Steamerduck**	***Tachyeres patachonicus***	**Anatidae**	**FLYD**	**N**
Gulls	Dolphin Gull	*Larus scoresbii*	Laridae	DOGU	Y
Gulls	Kelp Gull	*Larus dominicanus*	Laridae	KEGU	Y
Gulls	**Brown-hooded Gull**	***Larus maculipennisl***	**Laridae**	**BHGU**	**N**
Large petrels and shearwaters	Southern Giant Petrel	*Macronectes giganteus*	Procellariidae	SGPE	Y
Large petrels and shearwaters	Sooty Shearwater	*Ardenna grisea*	Procellariidae	SOSH	Y
Large petrels and shearwaters	Slender-billed Prion	*Pachyptila belcheri*	Procellariidae	SBPR	Y
Large petrels and shearwaters	Common Diving-petrel	*Pelecanoides urinatrix*	Procellariidae	CDPE	Y
Large petrels and shearwaters	White-chinned Petrel	*Procellaria aequinoctialis*	Procellariidae	WCPE	Y
Large petrels and shearwaters	Prion species	*NA*	Procellariidae	PRNS	Y
Large petrels and shearwaters	Great Shearwater	*Ardenna gravis*	Procellariidae	GESH	Y
Oystercatchers	**Magellanic Oystercatcher**	***Haematopus leucopodus***	**Haematopodidae**	**MAOY**	**N**
Oystercatchers	**Blackish Oystercatcher**	***Haematopus aterr***	**Haematopodidae**	**BLOY**	**N**
Penguins	Gentoo Penguin	*Pygoscelis papua*	Spheniscidae	GEPE	Y
Penguins	Magellanic Penguin	*Spheniscus magellanicus*	Spheniscidae	MGPE	Y
Penguins	Southern Rockhopper Penguin	*Eudyptes chrysocome*	Spheniscidae	SRPE	Y
Penguins	**Macaroni Penguin**	***Eudyptes chrysolophus***	**Spheniscidae**	**MCPE**	**N**
Penguins	King Penguin	*Aptenodytes patagonicus*	Spheniscidae	KIPE	Y
Sheathbills	**Snowy Sheathbill**	***Chionis albus***	**Chionidae**	**SNSH**	**N**
Skuas	Brown Skua	*Catharacta antarctica*	Stercorariidae	BRSK	Y
Storm Petrels	Wilson's Storm-petrel	*Oceanites oceanicus*	Oceanitidae	WSPE	Y
Storm Petrels	Grey-backed Storm-petrel	*Garrodia nereis*	Oceanitidae	GBSP	Y
Terns	South American Tern	*Sterna hirundinacea*	Laridae	SATE	Y

Standardisation of data

Given the array of collated records, data were standardised in a stepwise fashion:

Breeding or Non-breeding records: We separated breeding records from non-breeding records based on our initial collation of 13,457 records.

Presence/Abundance/Absence record: each record was filtered to indicate whether a data point represented a presence, abundance, or absence record.

Abundance records: where indicated, these records were assigned a best, minimum or maximum record.

Date standardisation: given dates of records were reported in several formats, date entry required standardisation.

Species names: similarly, given species names were reported in several formats, entries required standardisation.

Incorrect location records: several location records were incorrectly assigned (e.g. colony positioned far out to sea) and required manual correction.

Location record names: Given the array of collated records often utilised different naming conventions for islands or regions around the Falkland Islands, we standardised these names based on a 2017 spatial layer of the Falkland Islands, which contains unique names for each of the islands and islets comprising the Falkland Islands archipelago. We first corrected location points that did not overlap land owing to GPS fixes from records being allocated over the sea as opposed to the land (these results were a consequence of GPS accuracy). We did this through a custom function in R which snaps points to the nearest landmass (polygon). Then, via a spatial intersection, we assigned records to standardised location names based on the 2017 spatial layer of the Falkland Islands.

Survey type: Not all records were indicative of exact breeding locations, hence location records were categorised on a scale of most accurate to least accurate depending on how the individual record was captured:

- Actual: the actual breeding location
- Approximate: approximate breeding location
- Island/Region: breeding location assigned to a specific island or region of one of the main islands.
- Grid10: breeding location associated to a 10km grid square.
- Grid 20: breeding location associated to centre point of two 10km grid squares.

Based on the summarised number of records per species and survey type, overall records primarily reflected actual locations, then island/region locations, approximate locations, and there were only a few locations which only reflected surveys at the scale of 10km grids (Table 2).

Table 2: Summary of survey type data for 28 seabird species (incl. 1 waterbird species) at the Falkland Islands. Survey types are described in the main text.

Species	Actual	Approximate	Island/Region	Grid10	Grid20
Black-browed Albatross	24	0	26	0	0
Blackish Oystercatcher	189	0	171	0	0
Brown-hooded Gull	1	0	5	0	0
Brown Skua	19	0	52	0	0
Common Diving-petrel	2	0	10	0	0
Dolphin Gull	2	0	79	5	1
Falkland Steamerduck	1166	0	202	0	0
Flying Steamerduck	0	0	3	0	0
Gentoo Penguin	0	0	164	0	0
Great Shearwater	0	0	1	0	0
Grey-backed Storm-petrel	0	0	11	0	0
Imperial Shag	75	81	51	0	0
Kelp Goose	917	0	187	0	0
Kelp Gull	6	0	19	0	0
King Penguin	0	0	1	0	0
Macaroni Penguin	0	0	1	0	0
Magellanic Oystercatcher	429	0	131	0	0
Magellanic Penguin	366	0	168	0	0
Prion species	0	0	1	0	0
Rock Shag	176	0	103	0	0
Slender-billed Prion	13	0	17	0	0
Snowy Sheathbill	1	0	0	0	0
Sooty Shearwater	22	0	14	0	0
South American Tern	2	0	29	0	0
Southern Giant Petrel	103	0	25	0	0
Southern Rockhopper Penguin	85	0	17	0	0
White-chinned Petrel	4	0	3	0	0
Wilson's Storm-petrel	0	0	2	0	0
Total	3602	81	1493	5	1

Species richness by grid cell (all seabird species considered)

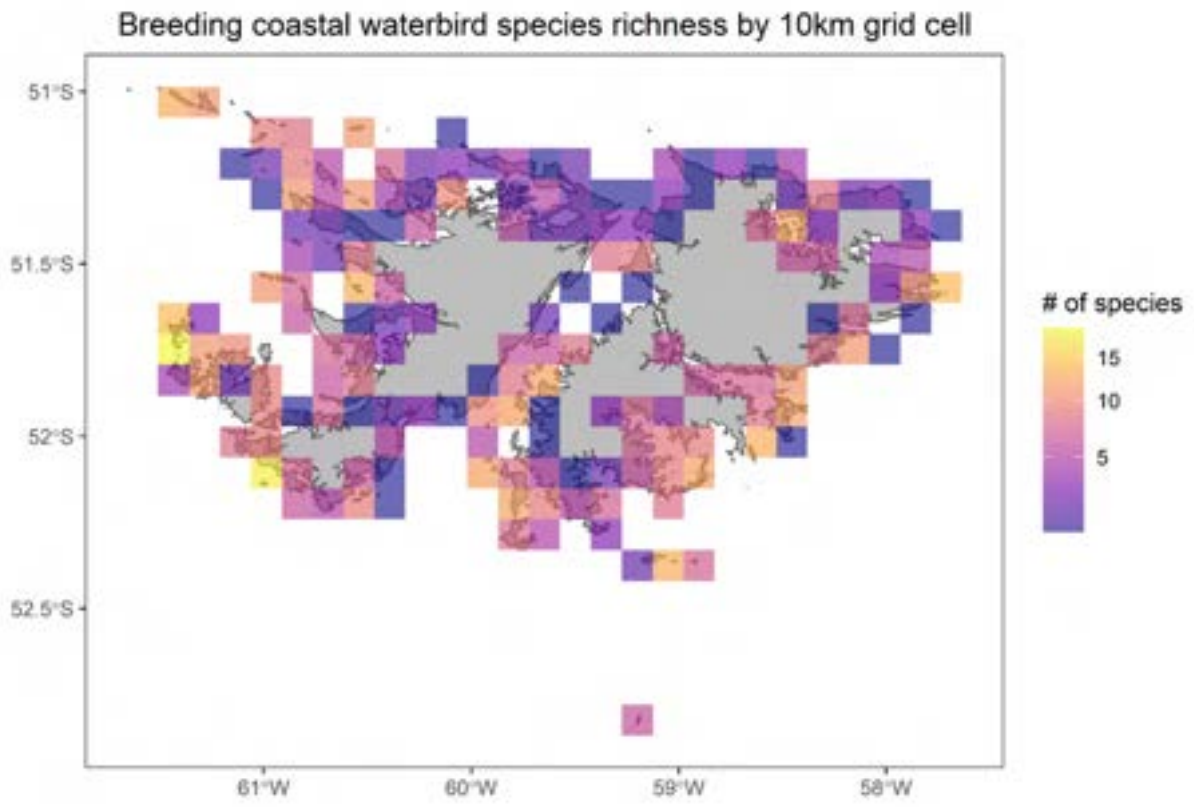


Figure 1: Species richness (number of different species) by 10km grid cell based on breeding location data for 28 seabird species (incl. 1 waterbird species).

Species richness by location/island (all coastal species considered)

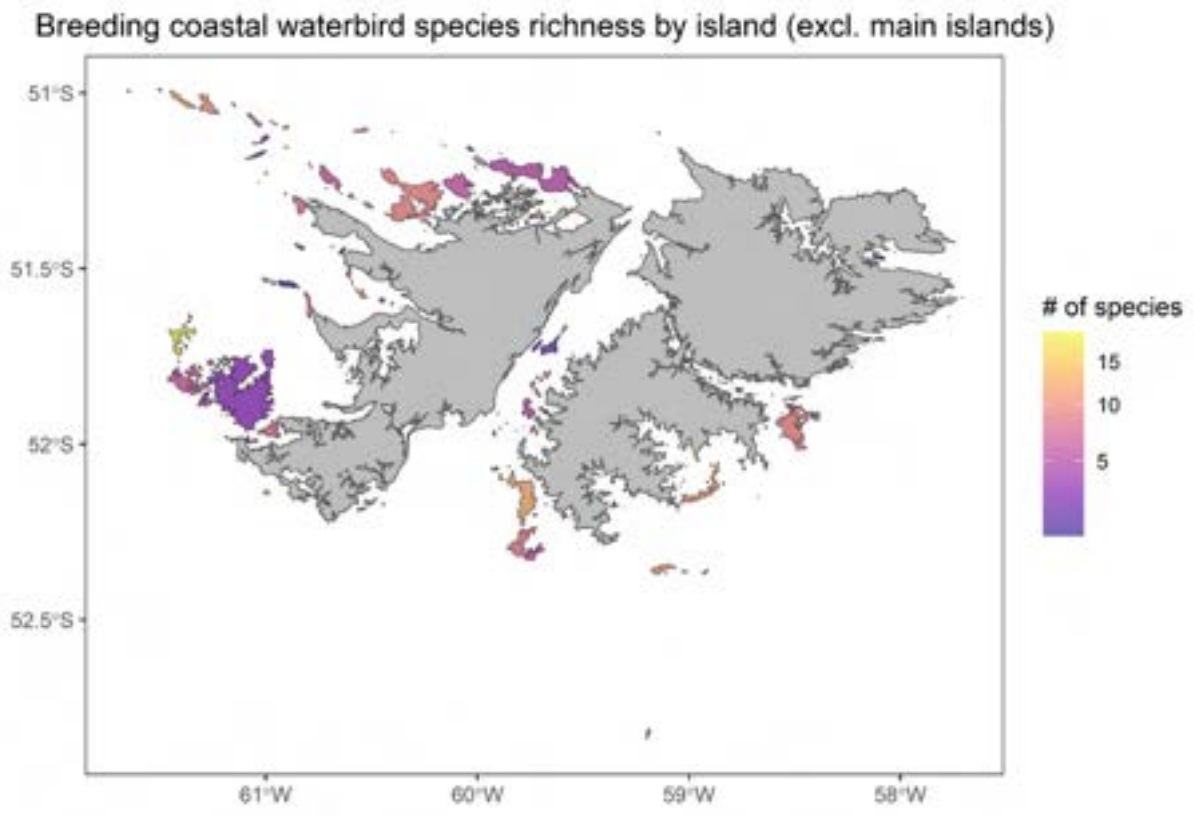


Figure 2: Species richness (number of different species) by island or islet location (excluding West and East Falklands) based on breeding location data for 28 seabird species (incl. 1 waterbird species).

Count types: Absence, Presence, Abundance estimates

An initial filtering step led to whether a data point represented a presence, abundance, or absence record. However, abundance records for individual species and breeding locations were reported in several ways (Table 3):

- A best abundance estimate only
- A minimum abundance estimate only
- A maximum abundance estimate only
- A best abundance estimate with an associated minimum and maximum abundance estimate
- A minimum and maximum abundance estimate only
- A minimum and best estimate

Table 3: Overview of absence, presence or abundance record types for individual species per breeding location

Count types	**Number of records**
Presence only record	1430 (688 (all other data) + 742 (FICBD records)
Best abundance only	3083 325 (all other data) + 2761 (FICBD records)
Min abundance only	1
Max abundance only	205
Best, Min, Max abundance estimates	48
Min and Max abundance estimate	402
Minimum and best estimate	10
Absence record	14

FICBD = Falkland Islands Coastal Bird Dataset

Given, few records had data relating to all count types (min, max and best count), we determined the 'Best Count' for a particular record as follows (Table 4) :

Table 4: Overview of how Best Counts for individual records were assigned depending on how abundance data were recorded.*

Count types	**Rule for determining Best Count**
Presence only record	No count assigned
Best abundance only	Best abundance assigned as Best Count
Min abundance only	Min abundance assigned as Best Count
Max abundance only	Max abundance assigned as Best Count
Best, Min, Max abundance estimates	Best abundance assigned as Best Count
Min and Max abundance estimate	Average of min and max abundance assigned as Best Count
Minimum and best estimate	Best abundance assigned as Best Count

*Table 4 relates to all other data not recorded in the Coastal Bird Surveys Data.

Records from the Coastal Bird Survey Dataset, were reported as number of:

- Adults
- Subadults
- Chicks
- Eggs
- Pairs Breeding

- Pairs All Year
- Potential Pairs
- Missing Adults

The data rules associated with these records indicated that Pairs Breeding were indicative of breeding pairs at a location. Hence, the record associated with Pairs Breeding for the Coastal Bird Surveys Data was assigned as the 'Best Count' for further analyses.

Identifying marine KBAs

Species considered for analysis

Based on the collated dataset (Table 2) and quality of records for individual species, and given the primary objective of the project was to identify marine KBAs (i.e. KBAs where the primary area considered is at sea), we identified a key suite of 12 species for which to identify species-specific KBA element layers in the inshore environment of the Falkland Islands (Table 5, Table 6). Critically, for the seabird species not considered in further analyses, it is likely that many of these species may also be susceptible to impacts from certain human activities in the marine environment.

Table 5: Global population estimates and IUCN Red List Status of key suite of species for which it was deemed feasible to consider identification of species-specific KBA element layers in the inshore environment of the Falkland Islands.

Common Name	Code	IUCN Red List	BEST Global Other	BEST IUCN Global (Mature Individuals)	MIN IUCN Global (Mature Individuals)	MAX IUCN Global (Mature Individuals)	Reference
Black-browed Albatross	BBAL	LC	-	1,400,000	-	-	A
Brown Skua	BRSK	LC	-	27,000	26,000	28,000	A
Dolphin Gull	DOGU	LC	-	12,850	6,700	19,000	A
Falkland Steamerduck	FLSD	LC	12,500	-	9,000	16,000	B*
Gentoo Penguin	GEPE	LC	-	774,000	-	-	A
Imperial Shag	IMSH	LC	-	UNKNOWN	-	-	C
Magellanic Penguin	MGPE	LC	-	2,700,000	2,200,000	3,200,000	A
Rock Shag	ROSH	LC	-	UNKNOWN	-	-	C
Slender-billed Prion	SBPR	LC	7,000,000	-	-	-	B
Sooty Shearwater	SOSH	NT		8,800,000	-	-	A
Southern Giant Petrel	SGPE	LC	-	101,800	95,600	108,000	A
Southern Rockhopper Penguin	SRPE	VU (A2, A3, A4)	-	2,500,000	-	-	A

A: See species specific IUCN Red List accounts, B: (Woods and Woods, 1997; Falabella et al., 2019), B*: Estimates in KBA dataform reflect mature individuals (breeding pairs x 3) as per the Waterbird Population Estimates (See here) C: Falabella et al. (2019) also do not provide a global population assessment.

Table 6: Global (as per IUCN Red List) and local population trends (as per recent studies or expert consultation), and IUCN Red List Conversion factor of key suite of species for which it was deemed feasible to consider identification of species-specific KBA element layers in the inshore environment of the Falkland Islands.

Common Name	Red List Conversion Factor Breeding pairs to Mat. Ind's.	Year of estimate Global	Current global pop trend (2019)[B]	Current global pop trend derivation (2019)[B]
Black-browed Albatross	2	2015	Increasing	Estimated
Brown Skua	2	1996	Decreasing	Suspected
Dolphin Gull	A	2009	Stable	Suspected
Falkland Steamerduck	3[c]	2009	Stable	Suspected
Gentoo Penguin	2	2013	Stable	Suspected
Imperial Shag	A	Unknown	Unknown	Not Applicable
Magellanic Penguin	2	1998	Decreasing	Suspected
Rock Shag	A	2009	Unknown	Not Applicable
Slender-billed Prion	A	2009	Stable	Suspected
Sooty Shearwater	2	2013	Decreasing	Estimated
Southern Giant Petrel	2	2007	Increasing	Estimated
Southern Rockhopper Penguin	2	2016	Decreasing	Estimated

A: Given no published estimates for breeding success are available for these species – and that KBAs require assessment against number of mature individuals at a site compared to the global population estimate for mature individuals (depending on the criteria) – we followed the approach of the Red List and used a conservative conversion factor of 2 for these species also.

B: Current global population trends were derived from Red List assessments finalised in 2019.

C: mature individuals (breeding pairs x 3) as per the Waterbird Population Estimates (See here)

Methods for marine KBA boundary delineation

Several methodologies for estimating seabird at-sea distribution in un-sampled regions have been proposed (Franklin, 2010; Grecian et al., 2012; Thaxter et al., 2012; Grimm et al., 2016; Soanes et al., 2016; Warwick-Evans et al., 2018; Zhang et al., 2017; Wakefield et al., 2017; Warwick-Evans et al., 2017; Critchley et al., 2018, 2019; Dias et al., 2018b). Determining which method is most appropriate to derive species at-sea distributions should be considered in the context of available data for a given species and its typical foraging ecology (Cleasby et al., 2018; Oppel et al., 2018; Bolton et al., 2019).

Given the degree of endemism and differing foraging ecologies across the 12 key species considered, and the low levels or absence of tracking data available for 7 of the 12 key species, we tailored the approach to delineate marine KBA boundaries for each species accordingly (See below and summary in Table 7). We did this so as to define geographic boundaries of areas to be assessed against KBA criteria that provide the best conditions for the persistence of the biodiversity elements (i.e. the specific species), in the context of the inshore environment of the Falkland Islands and alongside the conservation goals being considered (Cleasby et al., 2020). As such, the areas identified are intended to be ecologically relevant and provide the basis for potential management activities (KBA Standards and Appeals Committee, 2020).

Given the quantitative nature of KBAs, we only delineated marine KBA boundaries where actual abundance records were present (excl. Falkland Steamer Duck because this species is endemic to the Falklands). Data exploration revealed that few breeding locations had been surveyed sufficiently to derive trends for individual species at specific breeding locations. Therefore, we used the Best Count associated with the latest record for a particular location when assigning abundance estimates for species within delineated marine KBA boundaries.

We mapped the distribution and estimated the abundance of birds at sea from individual colonies on a 1 km x 1 km grid.

To avoid the cell based nature of areas through the identification process and to delineate practicable management units, the final marine KBA boundaries were converted to polygons which were further smoothed using Gaussian kernel regression, where the bandwidth was set according to the number of vertices in each polygon (Strimas-Mackey, 2018).

We identified areas which (Table 7):

- accounted for the year-round distribution of an endemic species (Falkland Steamer Ducks), via an island buffer-based approach,
- accounted for key preening and washing areas, rafting areas, or transit corridors for wide-ranging non-volant species (Black-browed Albatross, Slender-billed Prion, Southern Giant Petrel, Sooty Shearwaters, Magellanic Penguins, Southern Rockhopper Penguins, Brown Skua, Dolphin Gull), via an island or colony buffer-based approach,
- accounted for the likely foraging areas of nearshore foraging species (Gentoo Penguin, Imperial Shag, Rock Shag), via a radius based density decay function (Critchley et al., 2018; Handley et al., 2021)

Depending on the species-specific approach, we either estimated the distribution of birds at-sea only from colonies which met relevant KBA criteria, or we estimated the island-wide distribution of birds at-sea and then identified the specific areas which met global KBA criteria

1. *Island buffers (Falkland Steamer Duck)*

No tracking data exists for Falkland Steamer Ducks. Records from at-sea surveys indicate that this bird has been observed up to 8km at sea (White et al., 2002). However, given these records are likely rarer (no detailed at-sea surveys for Falklands Steamer Ducks exist, nor do any tracking studies), we utilised a more conservative buffer of 5km to align with those buffers used for several other species (see below).

Given Falkland Steamer Ducks typically nest as territorial pairs and are endemic to the Falkland Islands (a key factor for assessing species against KBA criteria B1: 'Geographically restricted species'), we delineated 5km buffers around all islands with known breeding pairs.

2. *Island / Colony Buffer (Black-browed Albatross, Slender-billed Prion, Southern Giant Petrel, Sooty Shearwaters, Magellanic Penguins, Southern Rockhopper Penguins, Brown Skua, Dolphin Gull)*

As the Procellariiformes typically forage over distances where certain area-based management tools may not always be feasible (Oppel et al., 2018), delineation of marine KBAs must be considered accordingly. Critically, all four Procellariiformes are recognised to use marine areas directly adjacent to colonies for preening, bathing or rafting activities.

A recent tracking study for Black-browed Albatrosses at the Falkland Islands found that 98% of birds utilise marine areas within 5km of their breeding colony (Granadeiro et al., 2017). The authors recognised that the close marine area around seabird colonies are potentially highly sensitive areas, and should be taken into account when carrying out risk assessments or during marine spatial planning exercises.

Although no Southern Giant Petrels have been tracked from the Falkland Islands, elsewhere in their range birds always showed periods on the sea surface immediately after departure and just before arrival, indicating that all birds started and finished foraging trips by bathing at sea (González-Solís et al., 2002).

Given this reliance on at sea areas adjacent to colonies and a recognised distance threshold, we delineated 5km buffers around all islands or breeding locations for these Procellariiformes.

Given the comparatively far range of Magellanic Penguin and Southern Rockhopper Penguin foraging trips compared to Gentoo Penguins (Ratcliffe and Trathan, 2011), likely deeming areas as potential KBAs to be too large in the context of the inshore environment of the Falkland Islands and the concept of 'management unit' as per the KBA guidelines, we followed this same approach for Southern Rockhopper Penguins. Areas adjacent to these penguin's breeding colonies are used for preening and washing activities, and these areas also serve as critical departure and return transit routes of foraging trips where penguins cannot fly over at-sea areas immediately around colonies.

The foraging ecology of Brown Skuas and Dolphin Gulls varies considerably given that these birds forage on coastal resources (Masello et al., 2013). However, these species also rely on marine areas adjacent to colonies for preening and bathing. Therefore, in the absence of detailed tracking studies at the Falkland Islands, particularly for Brown Skuas and Dolphin Gulls, conservative 2km buffers were delineated around the main islands birds breed on in alignment with the buffers specified for Rock Shags (the smallest buffers used in the study).

3. Mean-max radius with density decay function (Gentoo Penguin, Imperial Shag, Rock Shag)

This method involves estimating the distribution of seabirds from a source colony out to a specified buffer distance – the mean maximum distance travelled by birds based on other tracking studies – and gives preferential weighting to those cells closest to the colony. It has recently been applied to breeding seabirds in the United Kingdom (Critchley et al., 2018) and Antarctica (Handley et al., 2021).

Following this method, we specified a buffer around each colony that accounts for travel around landmasses, and weighted cells closest to the colony via an inverse log function. The weighting of cells means that cells closest to a breeding colony represent those cells likely used by a higher percentage of the population. For each species, the maximum potential radius of the buffer specified around colonies was based on previously published estimates used in other studies (Table 7).

The density distribution surfaces from each colony were then summed; providing a Falklands-wide estimate of each species likely distribution at sea. From the density distribution surfaces, we noted which cells met KBA criteria for specific species to delineate the areas of species specific KBA element layers.

Table 7: Twelve key species considered for marine KBA delineation and the approaches (Buffer types), with associated metrics, to delineate marine KBA boundaries for species in the inshore environment of the Falkland Islands.

Common Name **Code** **Red List Status**	**Buffer type**	**Buffer rationale**	**Buffer distance**	**Buffer details**	**References (Buffer)**	**Global population estimate (Best count: mature individuals)**
Black-browed Albatross BBAL *LC*	Colony	Preening and bathing area	5 km	Buffer is based on preening and washing areas determined from GPS and immersion loggers during the incubation and brood-guard period.	(Granadeiro et al., 2017)	1,400,000 [A]
Brown Skua BRSK *LC*	Island	Preening and bathing area	2 km	Given there are no published tracking studies for this species at the Falkland Islands, and because the species relies on marine areas for preening and bathing, a buffer was set in accordance with the most conservative estimate based on available records for Rock Shags.	Other studies: (Carneiro et al., 2015)	27,000 [A]
Dolphin Gull DOGU *LC*	Island	Preening and bathing area	2 km	Given there are limited tracking studies for this species at the Falkland Islands, and because the species relies on marine areas for preening and bathing, a buffer was set in accordance with the most conservative estimate based on available records for Rock Shags.	(Masello et al., 2013)	12,850 [A]
Falkland Steamer duck FLSD *LC*	Island (incl. main islands)	Year-round distribution	5 km	White et al., (2002) reported no records further than 8 km from shore. Augé et al. (2018) assumed equal distribution around all of Falkland Islands. 5 km is a conservative buffer in alignment with that used for the procellariiformes, and based on expert consultation. Given Falkland Steamer Ducks typically nest as territorial pairs and are endemic to the Falkland Islands (a key factor for assessing species against KBA criteria B1: 'Geographically restricted species'), we delineated buffers around all islands with known breeding pairs.	(White et al., 2002; Augé et al., 2018), expert consultation: Sally Poncet, Paulo Catry	12500 [B]
Gentoo Penguin GEPE *LC*	Mean-max radius with density decay function	Island-wide foraging areas	21 km	Mean-maximum distance travelled from colony during incubation / chick-rearing.	(Baylis et al., 2019)	774,000 [A]
Imperial Shag IMSH *LC*	Mean-max radius with density decay function	Island-wide foraging areas	16 km	Mean-maximum distance travelled from colony during chick-rearing.	(Masello et al., 2010; Crofts et al., 2014)	TBC [D]
Magellanic Penguin MAPE *LC*	Colony	Preening and bathing area, transit corridors.	5 km	As a wide-ranging, non-flying species, with a mean-maximum distance travelled from colonies during incubation / chick-rearing of 298km, we rather considered a conservative buffer of 5km around colonies in accordance with buffers set for other species. This conservative approach aligns with the concept of 'manageable unit' for KBAs in the context of assessing inshore areas for conservation at the Falkland Islands.	(Boersma et al., 2002; Putz et al., 2002)	2,700,000 [A]
Rock Shag ROSH *LC*	Mean-max radius with density decay function	Island-wide foraging areas	2 km	Mean-maximum distance travelled from colony during chick-rearing	(Crofts et al., 2014)	TBC [D]
Slender-billed Prion SBPR *LC*	Island	Preening and bathing area	5 km	Buffer is based on species with similar known ecology; Black-browed Albatross.	See Black-browed Albatross	7,000,000 [C]
Sooty Shearwater SOSH	Island	Rafting area	5 km	Given there are limited tracking studies for this species at the Falkland Islands, and because shearwaters are known to rely on marine areas surrounding colonies	(Richards et al., 2019; Bonnet-	8,800,000 [A]

NT				for rafting (Warham, 1996), a buffer was set in accordance with species of similar known ecology; Black-browed Albatross.	Lebrun et al., 2020)	
Southern Giant Petrel SGPE *LC*	Colony	Preening and bathing area	5 km	Buffer is based on species with similar known ecology; Black-browed Albatross, and because elsewhere in their range birds always showed periods on the sea surface immediately after departure and just before arrival, indicating that all birds started and finished foraging trips by bathing at sea.	((González-Solís et al., 2002)	101,800 [A]
Southern Rockhopper Penguin SRPE *VU* (A2, A3, A4)	Colony	Preening and bathing area, transit corridors.	5 km	As a wide-ranging, non-flying species, with a mean-maximum distance travelled from colonies during chick-rearing of 139km, we rather considered a conservative buffer of 5km around colonies in accordance with buffers set for other species. This conservative approach aligns with the concept of 'manageable unit' for KBAs in the context of assessing inshore areas for conservation at the Falkland Islands.	Tracking studies for consideration: ((Masello et al., 2010; Pütz et al., 2018)	2,500,000 [A]

Global population estimate references: A: See species specific IUCN Red List accounts, B: (Woods and Woods, 1997), but also see the Waterbird Population Estimates (See here) for mature individuals (breeding pairs x 3), C: (Falabella et al., 2019), D: Yet to be confirmed subject to taxonomic revision. Red List Status: LC: Least Concern, NT: Near Threatened, VU: Vulnerable.

Results - KBA Overall layers

Overall areas to be considered as inshore KBAs for Falklands seabirds are outlined in the subsequent figures.

Summary: How were the overall KBA layers for Falklands seabirds developed?

We generated density distribution surfaces (1 x 1km grids) by estimating the at-sea distribution along with associated abundances (see Methods for Marine KBA Boundary Delineation) for individual species (see Results – KBA Species layers). From the density distribution surfaces, we noted which cells met KBA criteria for specific species to delineate the species specific KBA element layers (see Results – KBA Species layers). We aggregated these species specific KBAs to identify areas with the highest number of overlapping species specific KBA element layers (Figure 4) in the inshore environment of the Falklands. We did this based on data for:

1. 28 species considered originally:
    a. Breeding location data and population estimates (where available) were collated for 28 seabird species.
2. 12 species considered for KBA specific analyses:
    a. Given many species likely had population estimates <1% of their global population (key for the KBA criteria we considered – but not all KBA criteria)) at the Falklands OR had movement patterns that meant they would be less suited to an area-based management approach, we identified a key suite of 12 species for which to identify species-specific KBA element layers in the inshore environment of the Falkland Islands.
3. 9 species triggered KBA criteria.
4. When overlapping the 9 individual species KBA element layers, some areas of the Falklands inshore waters had up to 6 KBA element layers overlapping in the overall KBA areas being considered (Figure 4).

KBAs: Global KBAs identified

Within the inshore waters of the Falkland Islands, we identified marine Key Biodiversity Areas for nine of the 12 target species (Table 8). Many of the areas identified overlap with an existing global KBA while some areas do not overlap any existing global KBAs. As such, we propose:

- A revision to the currently adopted global KBA (http://www.keybiodiversityareas.org/site/factsheet/49174). However, please note the request to change the name of this KBA to the 'Falklands Islands Inshore'. Request sent on 21 July 2021 by David Diaz after correspondence with Andy Stanworth)
- And we propose a new global KBA: Beauchêne Island Marine

These KBAs represent some of the most important areas globally for between a maximum of 2.7% - 100% of target species populations depending on the species. The KBAs extended a maximum of 5 km from the coastline. Per species, these KBAs were either island wide (Falkland Steamer Duck – criterion B1) or were concentrated around a specific breeding location (Sooty Shearwater – criterion D1a) (

Figure 3). When overlapping the nine individual species KBA element layers, some areas of the Falklands inshore waters had up to six KBA element layers overlapping in the overall KBA area being considered. These areas with highest overlap in individual species KBAs were around the Jason Islands, New Island, Bird Island and Saunders Island (Figure 4).

Table 8: Overview of target species assessment against global KBA criteria showcasing population information and KBA criteria met. Spatial data in Figure 3.

Global KBA	Species (Common Name)	Minimum # mature individuals in KBA[A]	Maximum # mature individuals in KBA[A]	% Global pop threshold in KBAs (min : max)	Number of breeding locations contributing to KBA[B]	Breeding stage	KBA Criteria
Falkland Islands Inshore	Black-browed Albatross	16821	570398	1.2 : 40.7	14 (Tot = 19, Ab = 19)	Breeding	D1a
	Brown Skua	450	1116	1.7 : 4.1	2 (Tot = 33, Ab = 18)	Breeding	D1a
	Dolphin Gull	192	1272	1.5 : 9.9	4 (Tot = 50, Ab = 11)	Breeding	D1a
	Falkland Steamerduck	37500	37500	100 : 100	Island wide	Year-round	B1
	Gentoo Penguin	7746	105984	1 : 13.7	23 (Tot = 75, Ab = 74)	Breeding	D1a
	Imperial Shag	DNQ	DNQ	-	- (Tot = 123, Ab = 89)	Breeding	-
	Magellanic Penguin	DNQ	DNQ	-	- (Tot = 183, Ab = 58)	Breeding	-
	Rock Shag	DNQ	DNQ	-	- (Tot = 88, Ab = 21)	Breeding	-
	Slender-billed Prion	688000	4668000	9.8 : 66.7	2 (Tot = 11, Ab = 4)	Breeding	D1a
	Sooty Shearwater	280000	280000	3.2 : 3.2	1 (Tot = 16, Ab = 5)	Breeding	D1a
	Southern Giant Petrel	1090	38184	1.1 : 37.5	11 (Tot = 41, Ab = 31)	Breeding	D1a
	Southern Rockhopper Penguin	5012	388828	0.2 : 15.6	35 (Tot = 61, Ab = 59)	Breeding	A1b, A1d, D1a
Beauchêne Island Marine	Black-browed Albatross	14232	216376	1 : 15.5	4 (Tot = 4, Ab = 4)	Breeding	D1a
	Southern Rockhopper Penguin	21154	211552	0.8 : 8.5	3 (Tot = 3, Ab = 3)	Breeding	A1b, A1d, D1a

A: Minimum number of mature individuals in KBA refers to lowest abundance estimate of any single cell meeting KBA criteria within overall global KBA, whereas maximum number of mature individuals in KBA refers to summed maximum abundance estimates for species across the entire global KBA.

B: Tot refers to Total number of breeding locations considered from the initial scoping exercise to identify areas for assessment against KBA criteria. Ab refers to the number of breeding locations that had associated abundance records. Where Tot = Ab, this indicates that all breeding locations could be use to identify areas for assessment against KBA criteria. Where Tot != Ab, this means future research and monitoring efforts should work toward comprehensive assessments of species populations across the Falkland Islands.

DNQ: Species data did not qualify given lack of official global population estimates as per the IUCN Red List.

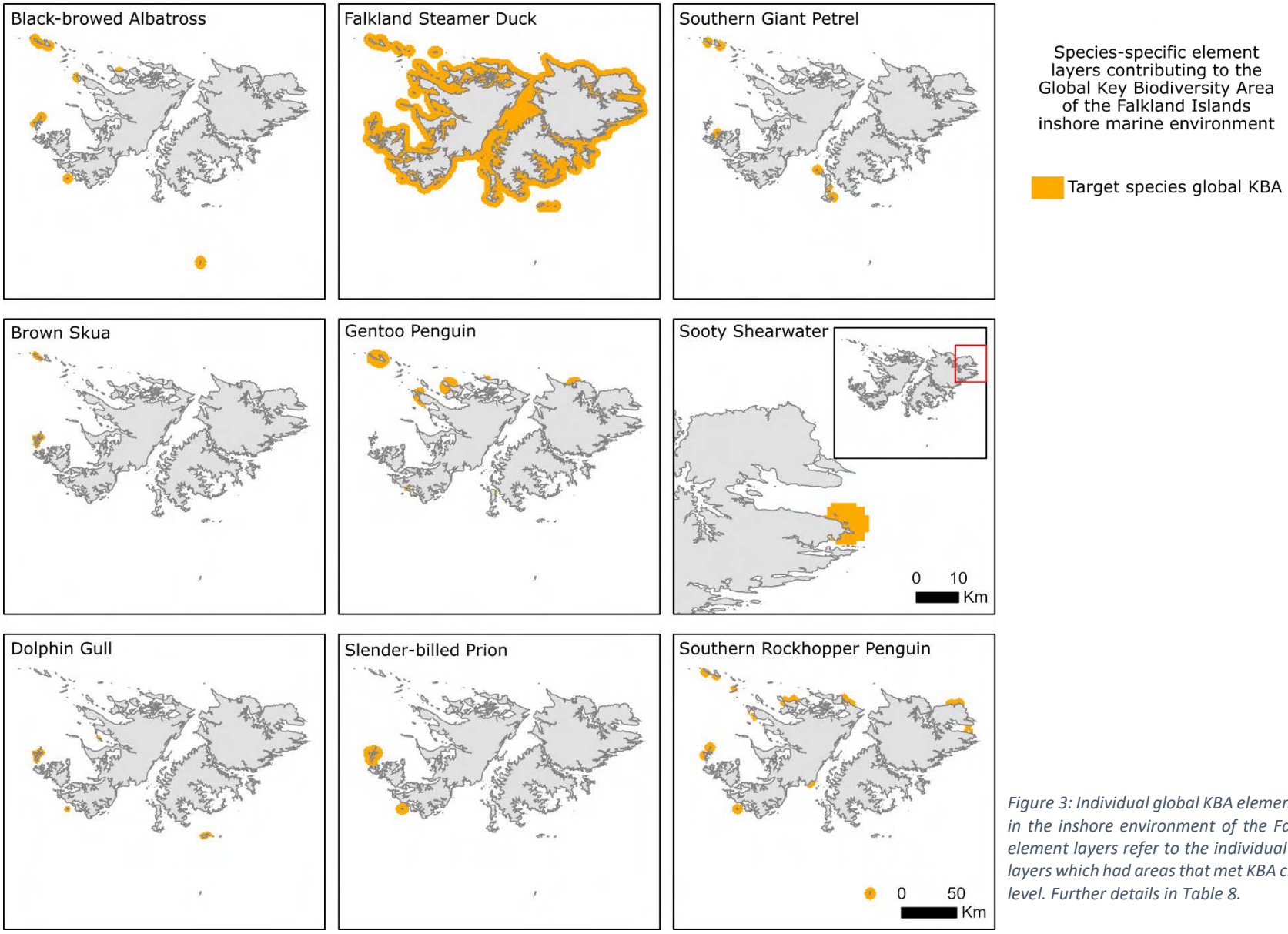


Figure 3: Individual global KBA element layers for seabirds in the inshore environment of the Falkland Islands. KBA element layers refer to the individual species distribution layers which had areas that met KBA criteria at the species level. Further details in Table 8.

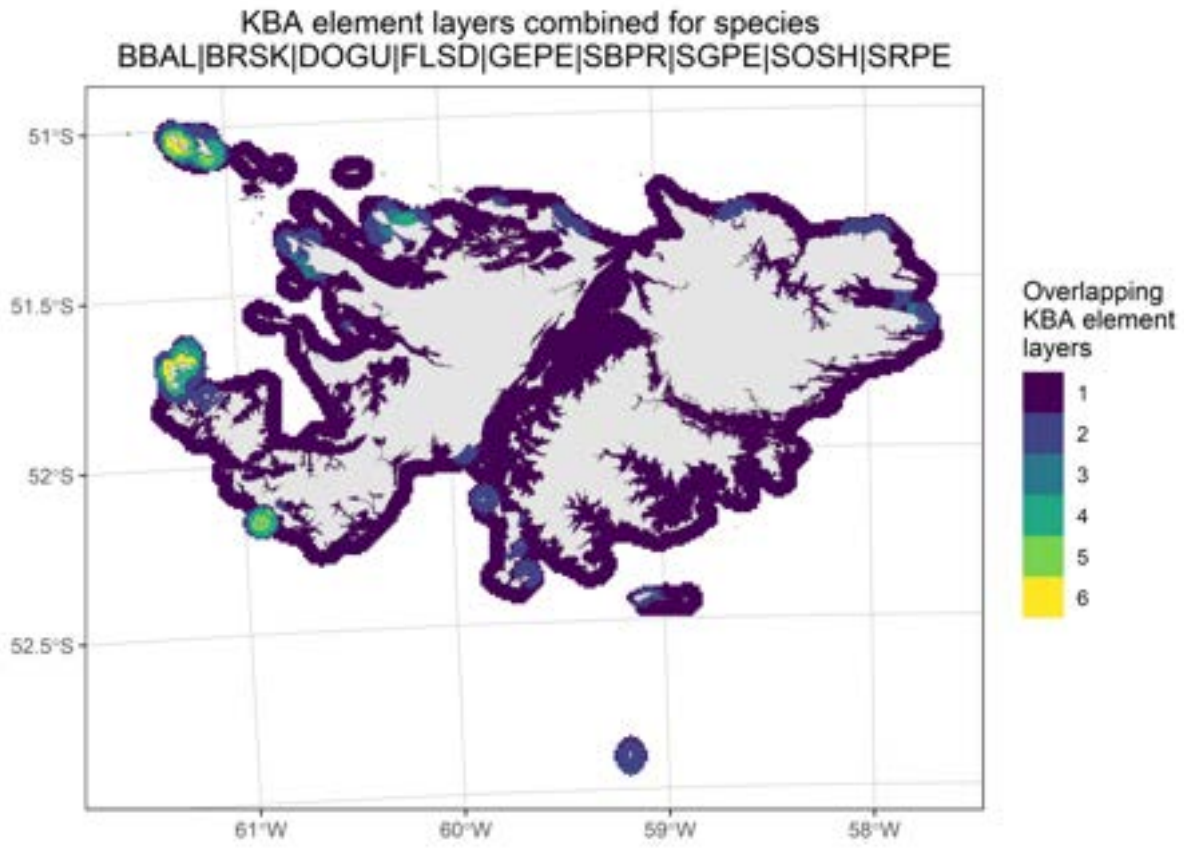
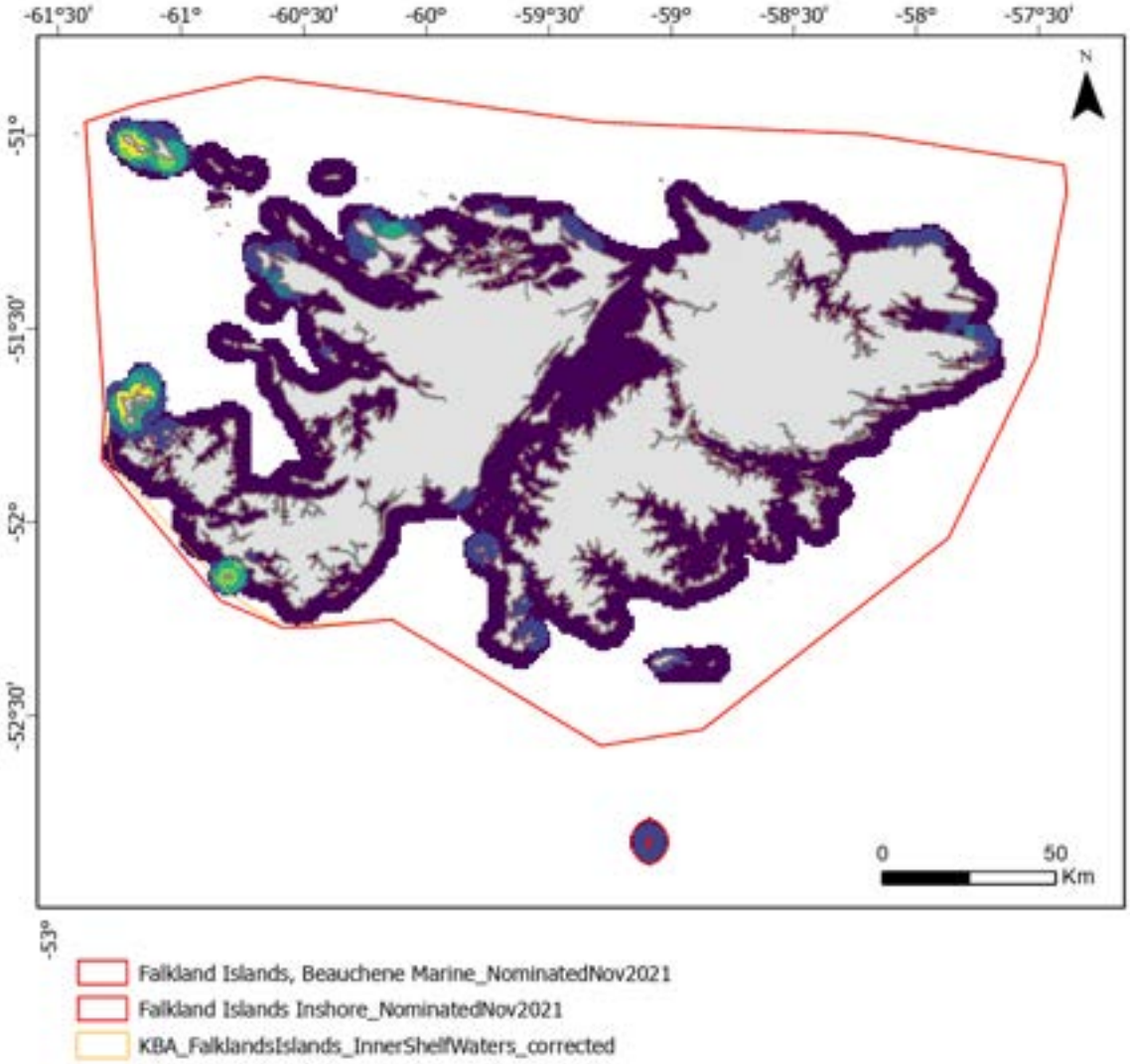
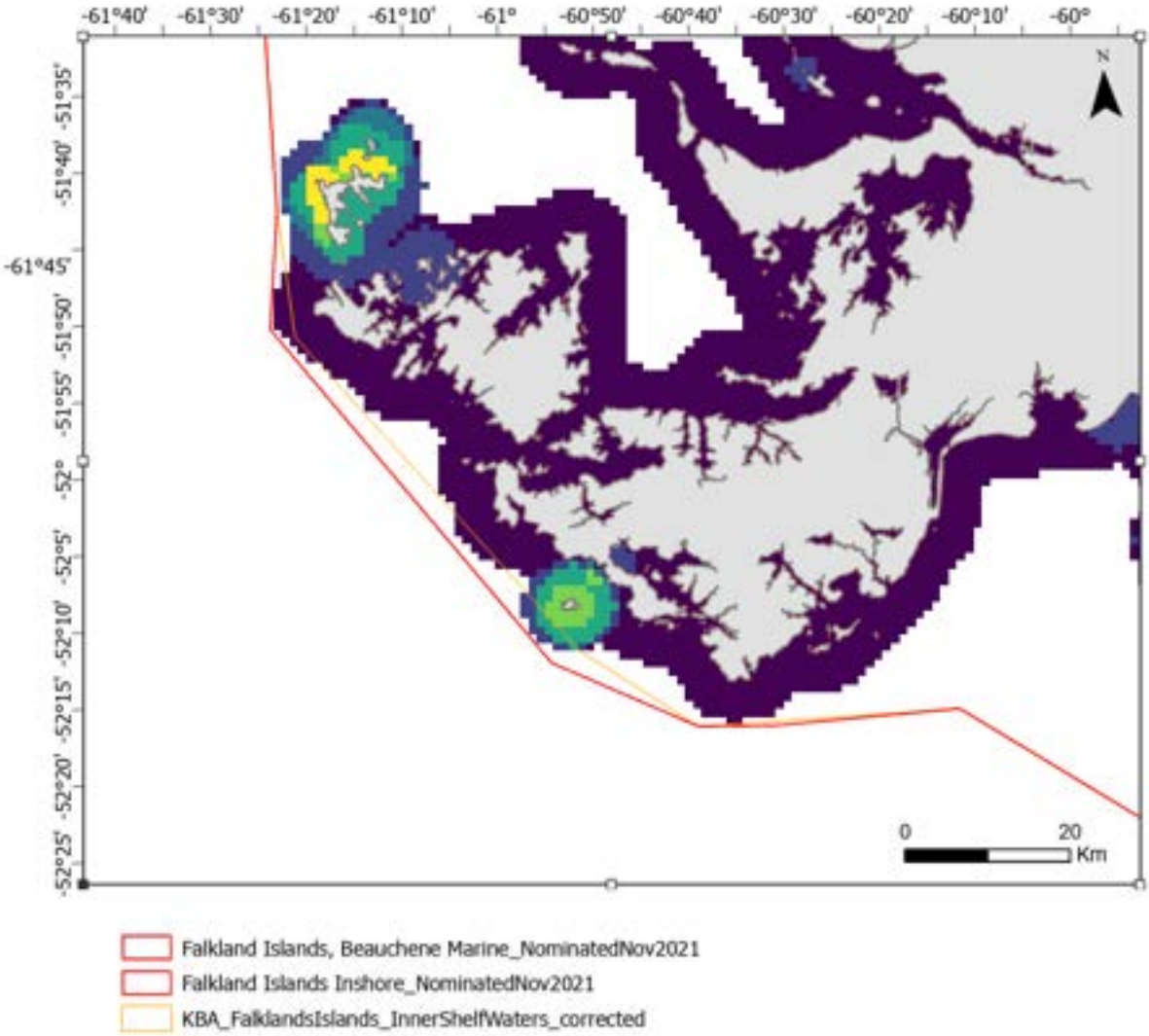


Figure 4: Overlapping KBA element layers for seabirds in the inshore environment of the Falkland Islands. KBA element layers refer to the individual species distribution layers which had areas that met KBA criteria at the species level. We considered data from 28 species originally. Data from 9 species met global KBA criteria within in the inshore area of the Falkland Islands. We note that in some instances data paucity (lack of data) rendered it unfeasible to assess several species data against global KBA criteria. The 8 species (and their associated global KBA criteria) which had distribution layers that met global KBA criteria are: Black-browed Albatross (D1a), Slender-billed Prion (D1a), Southern Giant Petrel (D1a), Gentoo Penguin (D1a), Southern-Rockhopper Penguin (A1b, A1d, D1a), Brown Skua (D1a), Dolphin Gull (D1a), Falklands Steamer Duck (B1), Sooty Shearwater (D1a). KBA criteria refer to globally threatened biodiversity (Crit. A), geographically restricted biodiversity (Crit. B), biological processes such as demographic aggregations (Crit. D)

Overlap with currently adopted global KBA: 'Falklands Islands Inshore'

The species specific KBA element layers overlapped almost entirely with the currently adopted global KBA noted in orange in the figure below. (Sei Whale KBA (http://www.keybiodiversityareas.org/site/factsheet/49174). However, please note the request to change the name of this KBA to the 'Falklands Islands Inshore'. Request sent on 21 July 2021 by David Diaz after correspondence with Andy Stanworth). Given part of the newly identified areas fall beyond the currently adopted global KBA boundary, we propose to extend the global KBA boundary as indicated by the new boundary in red in the figure below. This new boundary would then encapsulate the newly recognised areas of global significance for seabirds.

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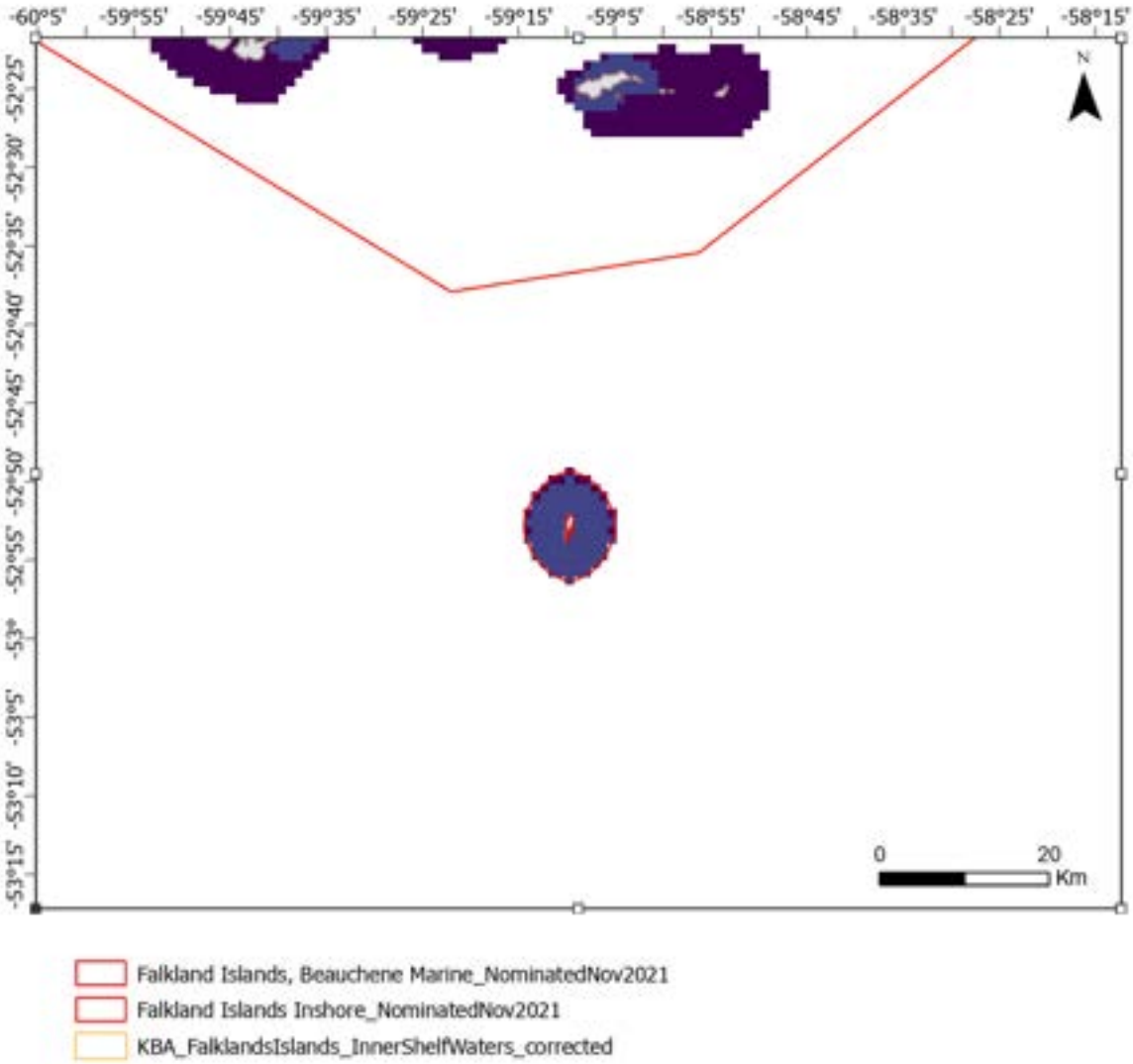
Falkland Islands, Beauchene Marine_NominatedNov2021
Falkland Islands Inshore_NominatedNov2021
KBA_FalklandsIslands_InnerShelfWaters_corrected

Proposing a new global KBA: 'Falkland Islands, Beauchêne Marine'

Given two of the biodiversity element layers (data from two species) had areas which met global KBA criteria that did not overlap with any existing global KBAs, we also propose a new global KBA. This newly proposed global KBA is situated to the south of the main islands and encompasses the waters around Beauchêne Island. We propose this new global KBA as: Falkland Islands, Beauchêne Marine. See red polygon in figure below.



Results - KBA species layers

Below outlines the processes related to the development of each species specific biodiversity element layer contributing to the new global KBAs.

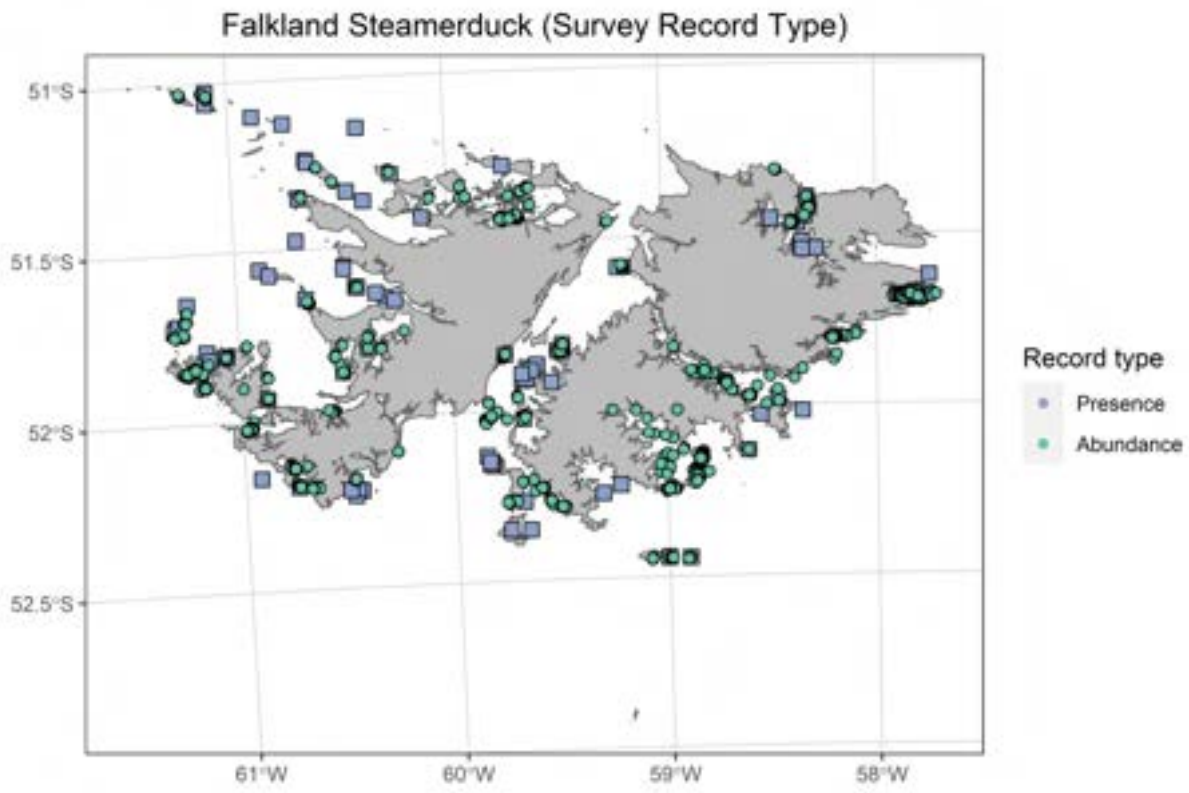
1. Island Buffers (FLSD)

FLSD - Falkland Steamer Duck

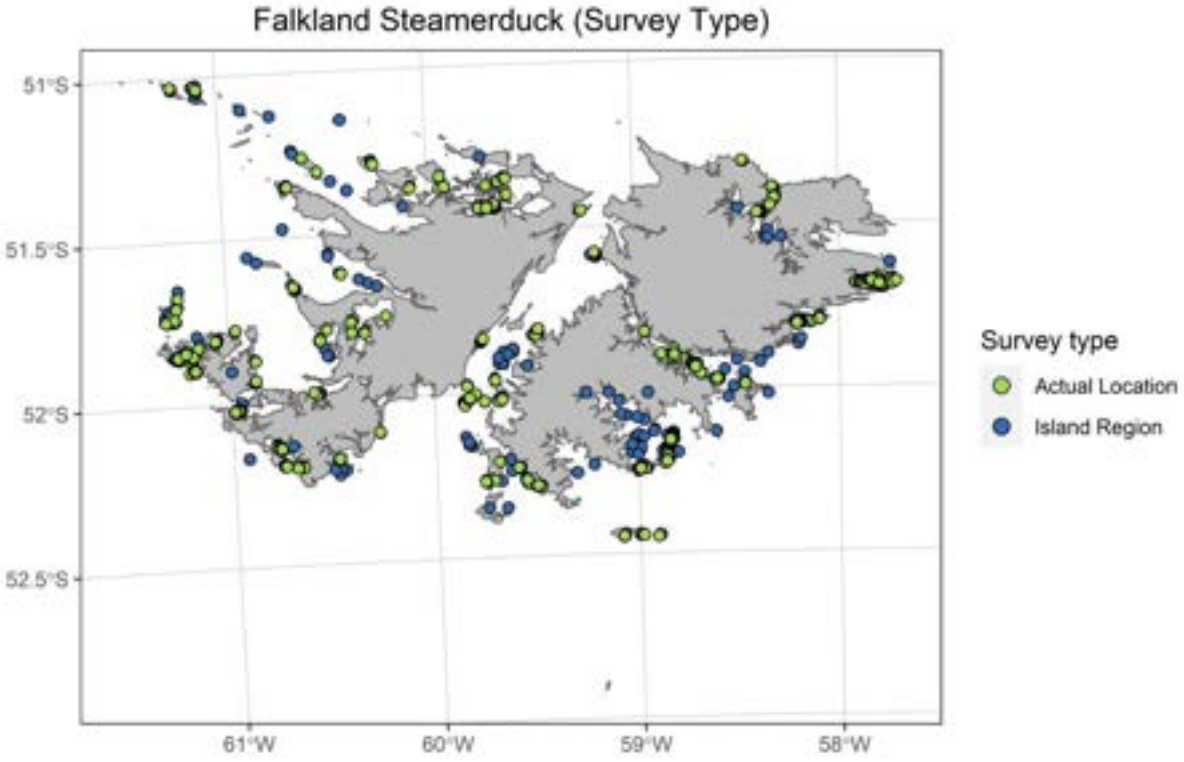
Red List Status: LC

KBA Criteria for assessment: B1 (Geographically restricted species)

Limited monitoring of Falkland Steamer Duck breeding locations has been conducted across the Falkland Islands. Given these birds typically nest as territorial pairs and are endemic to the Falkland Islands (a key factor for assessing species against KBA criteria B1) we included all records for assessment of KBAs.

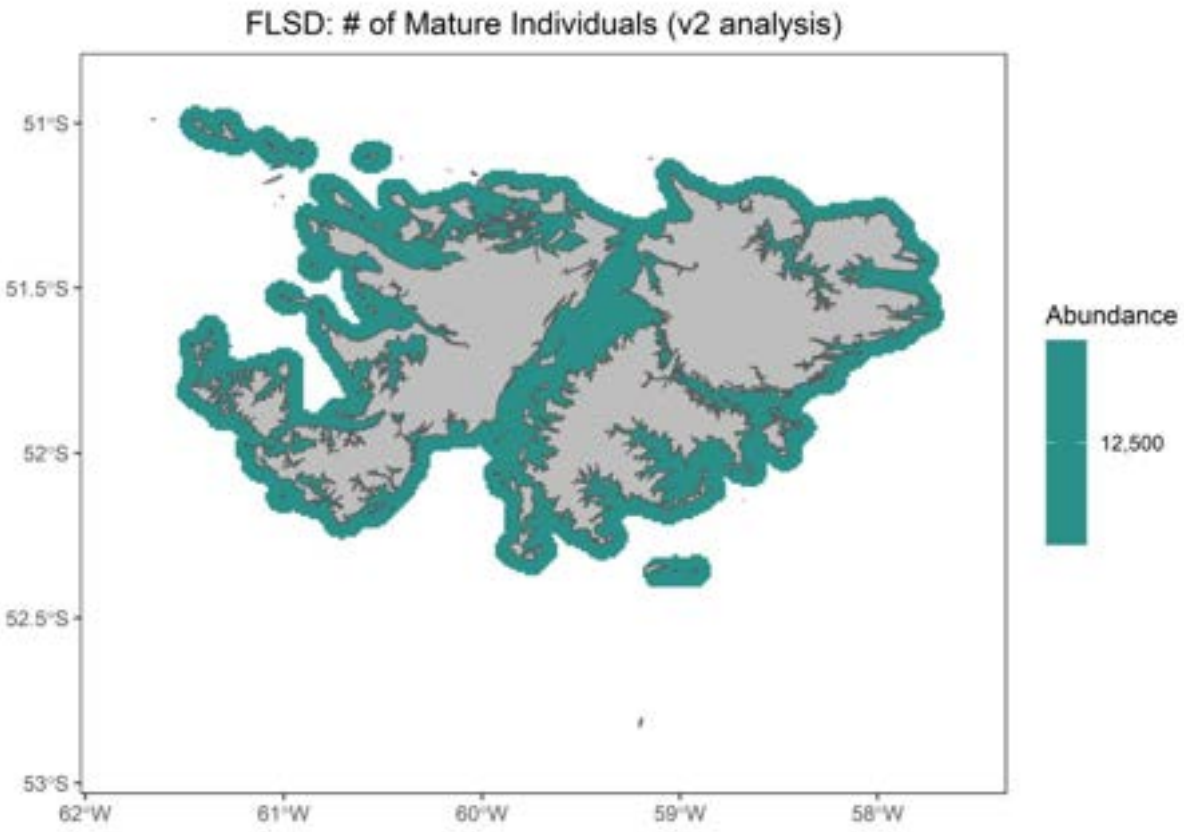


In terms of survey types, and again given these birds typically nest as territorial pairs and are endemic to the Falkland Islands (a key factor for assessing species against KBA criteria B1), we included all records for assessment of KBAs.



Given Falkland Steamer Ducks typically nest as territorial pairs and are endemic to the Falkland Islands, we delineated conservative 5km buffers around all islands with known breeding pairs. This estimate is based on expert knowledge (Sally Poncet, Paulo Catry). The buffer is conservative and is in alignment with the 5km buffer used to delineate marine KBA boundaries for procellariiformes (see below). We note that (White et al., 2002) report observing Falkland Steamer Ducks up to 8km from the coastline during at-sea surveys. We note that area identified as a KBA covers all islands with known breeding locations; areas where there is an absence of records likely reflect those areas where there is an absence of survey effort as oppose to a potential absence of birds given previous census efforts note that this species is present throughout all coastal waters of the Falkland Islands (Woods and Woods, 1997).

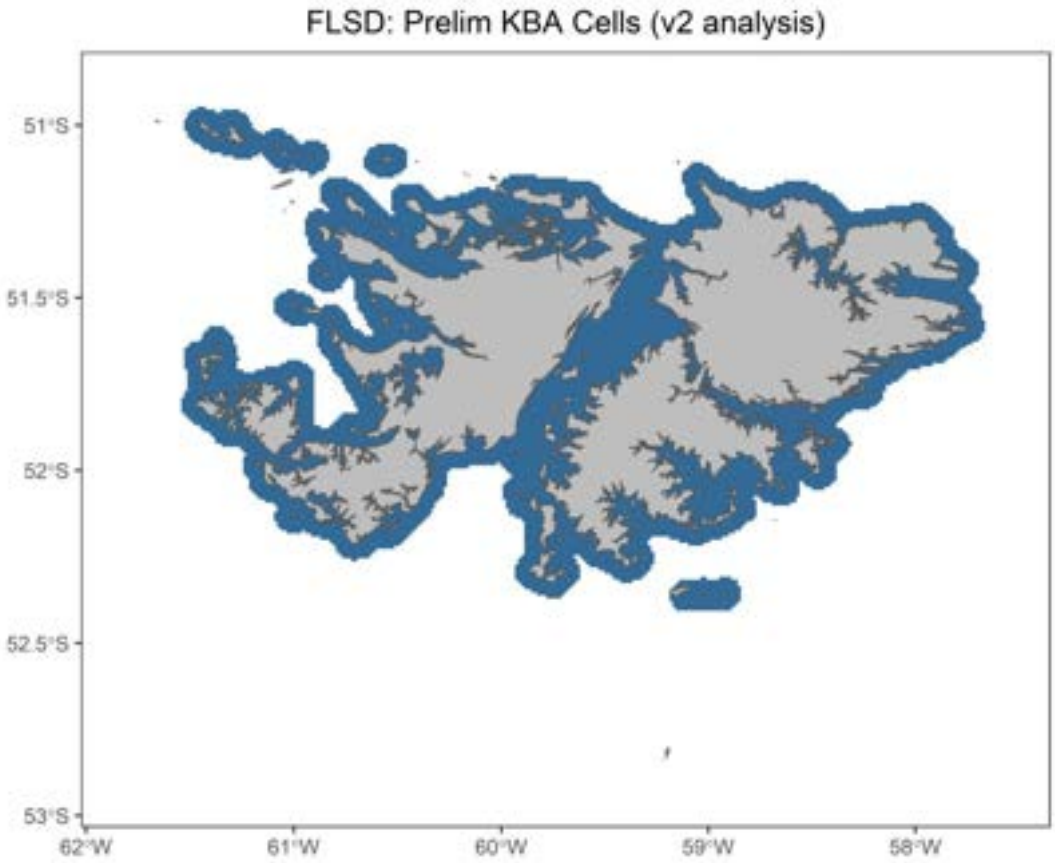
Within the 5km buffer and based on the records from (Woods and Woods, 1997), there are an estimated 12,500 breeding pairs (37,500 mature individuals) across the Falkland Islands.



- Abundance here actually represents number of breeding pairs. Number of mature individuals is determined by: breeding pairs x 3, as per the Waterbird Population Estimates (See here)

We propose this area (in blue) as a KBA for Falklands Steamer Ducks under criterion B1 (Geographically restricted species), given this area is critical marine habitat for 100% of this endemic species year-round.

As per the KBA guidelines (relevant to criterion B1): the area regularly holds this species year-round as it is continually present within this area.



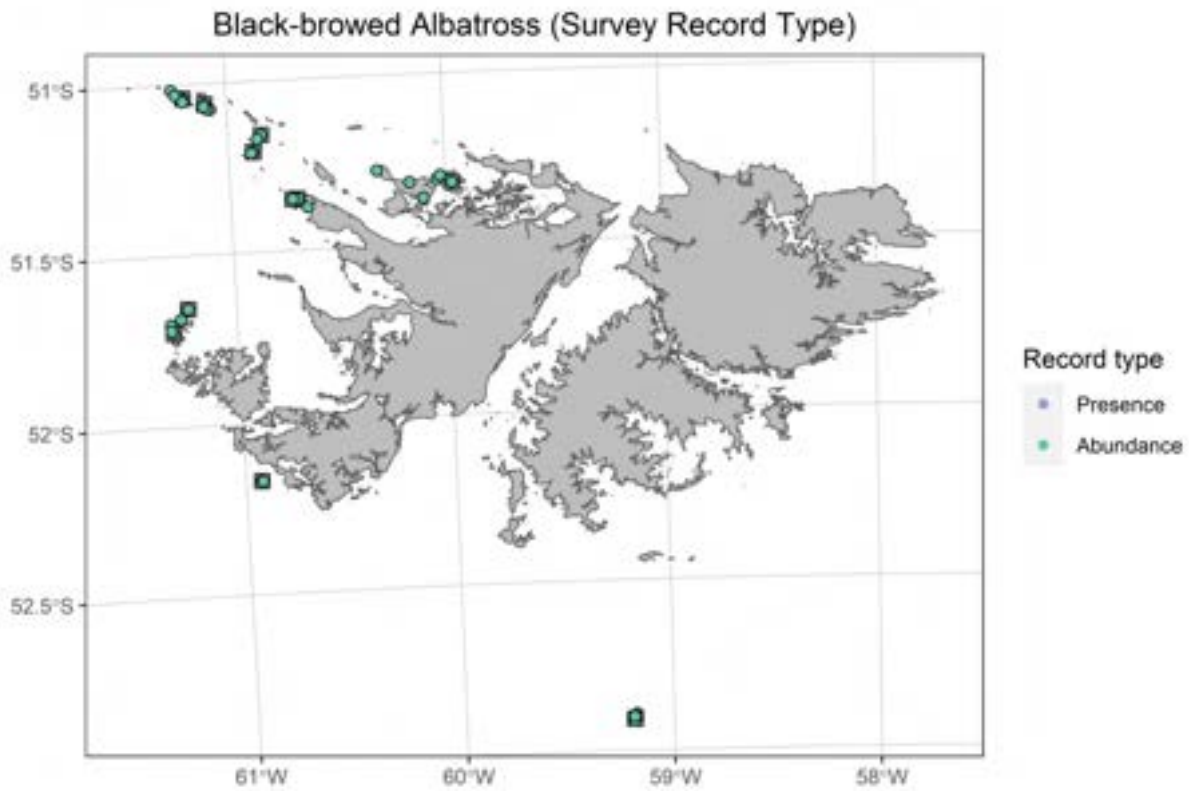
2. Island/Colony Buffers

BBAL – Black-browed Albatross

Red List Status: LC

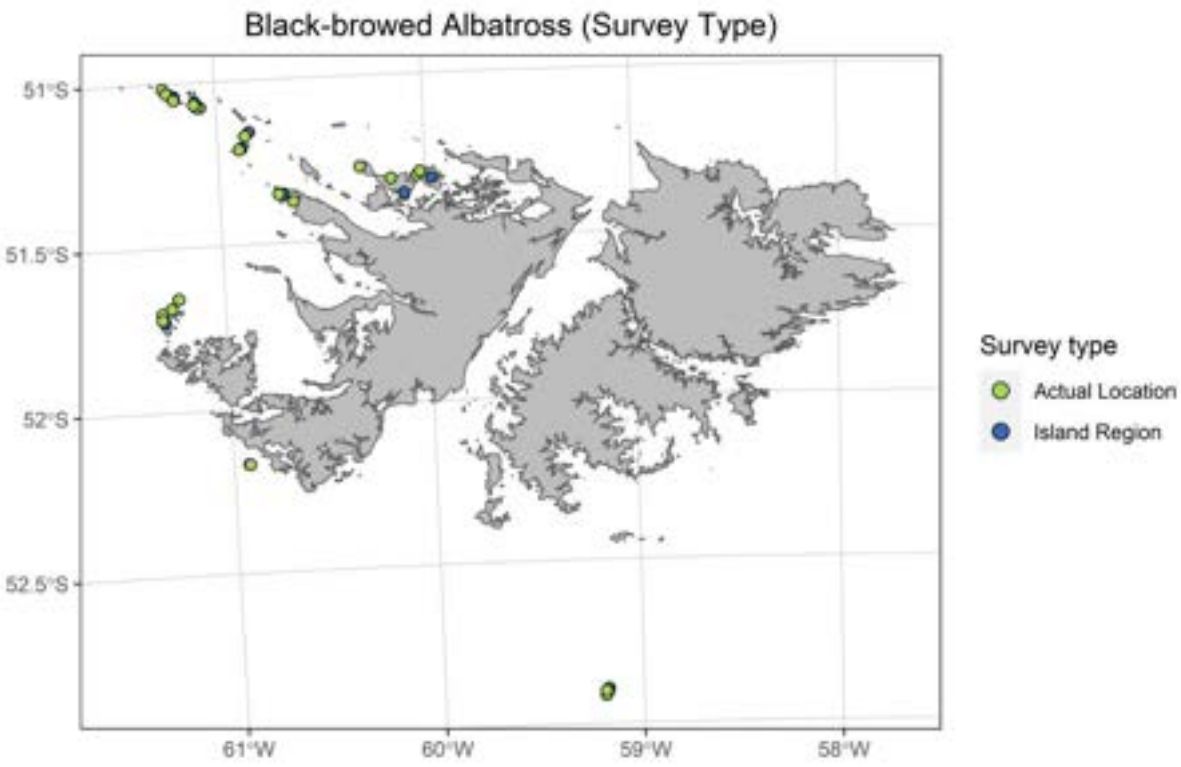
KBA Criteria for assessment: D1a (Demographic aggregations)

For all records for Black-browed albatrosses, abundance records where present from all major breeding locations.



In terms of survey type, Island / Region counts were only present for locations where Actual Location records were available too. Therefore, Actual Location records were used only.

- Actual locations are those locations indicative of the main colony position relative to the scale of the analysis (1km grids)
- e.g. while BBAL breed along a continuous stretch of coastline at Steeple Jason Island, we used several Actual Location records for this island indicative of distinct sections of the overall colony on this island.



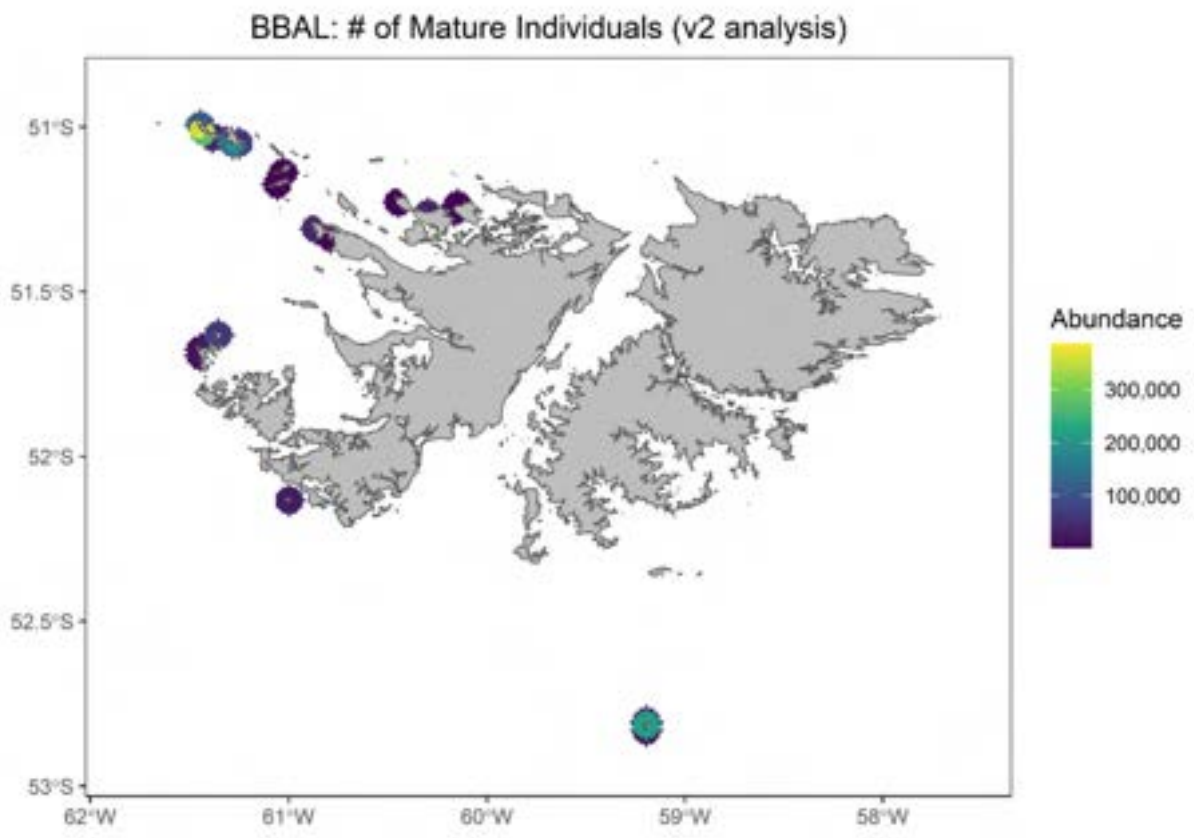
As this species typically forages over distances where certain area-based management tools may not always be feasible (Oppel et al., 2018), delineation of marine KBAs must be considered accordingly.

A recent tracking study for Black-browed Albatrosses at the Falkland Islands found that 98% of birds utilise marine areas within 5km of their breeding colony (Granadeiro et al., 2017). The authors recognised that the close marine areas around seabird colonies are potentially highly sensitive areas and should be considered when carrying out risk assessments or during marine spatial planning exercises.

Given this species reliance on at sea areas adjacent to colonies and a recognised distance threshold based on tracking studies from the Falkland Islands, we delineated 5km buffers around key islands or breeding locations. Abundance estimates within buffer areas from each colony were summed, providing a Falklands-wide estimate of at-sea abundance within key buffer areas for the species.

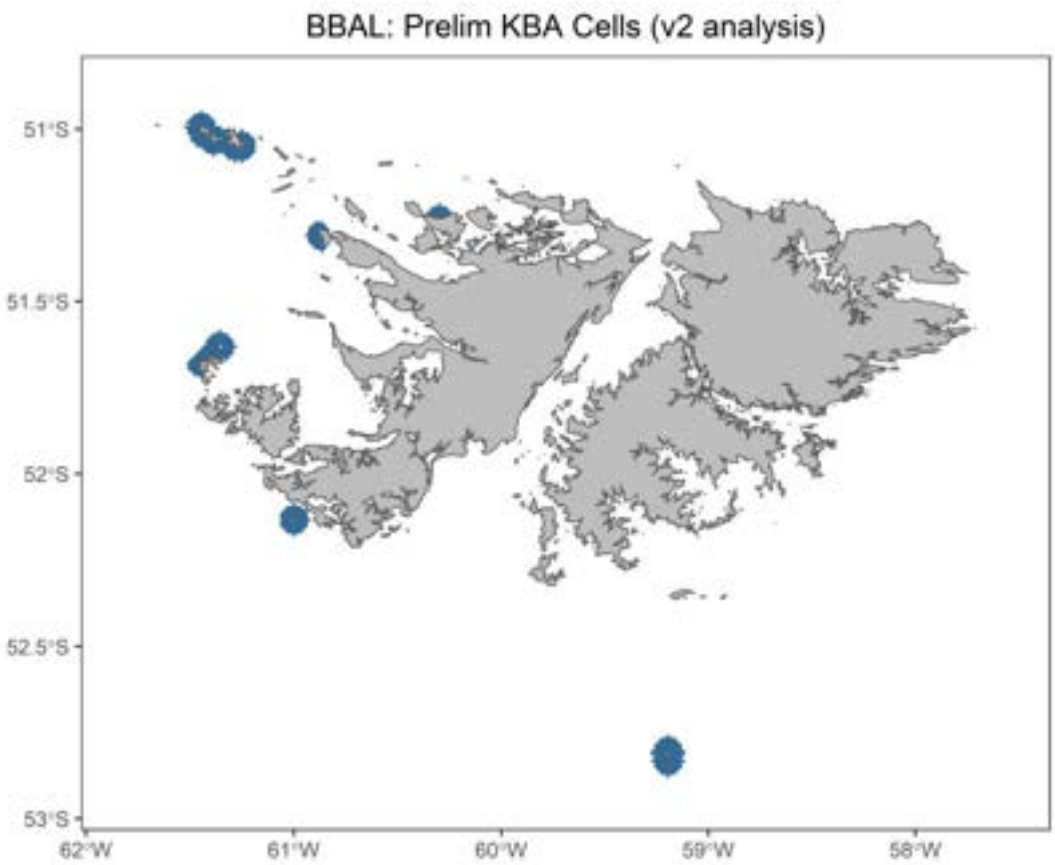
Based on the collated records and estimates of distribution within buffer areas from all key colonies, the estimated maximum number of mature individuals for a given cell is 385,965 mature individuals (breeding pairs x 2).

Given the global population estimate for this species is 1,400,000 mature individuals, and the KBA criterion we are assessing cells against is KBA criterion D1a, cells that would meet the criterion are those with ≥ 14,000 mature individuals (i.e. ≥1% of the global population)

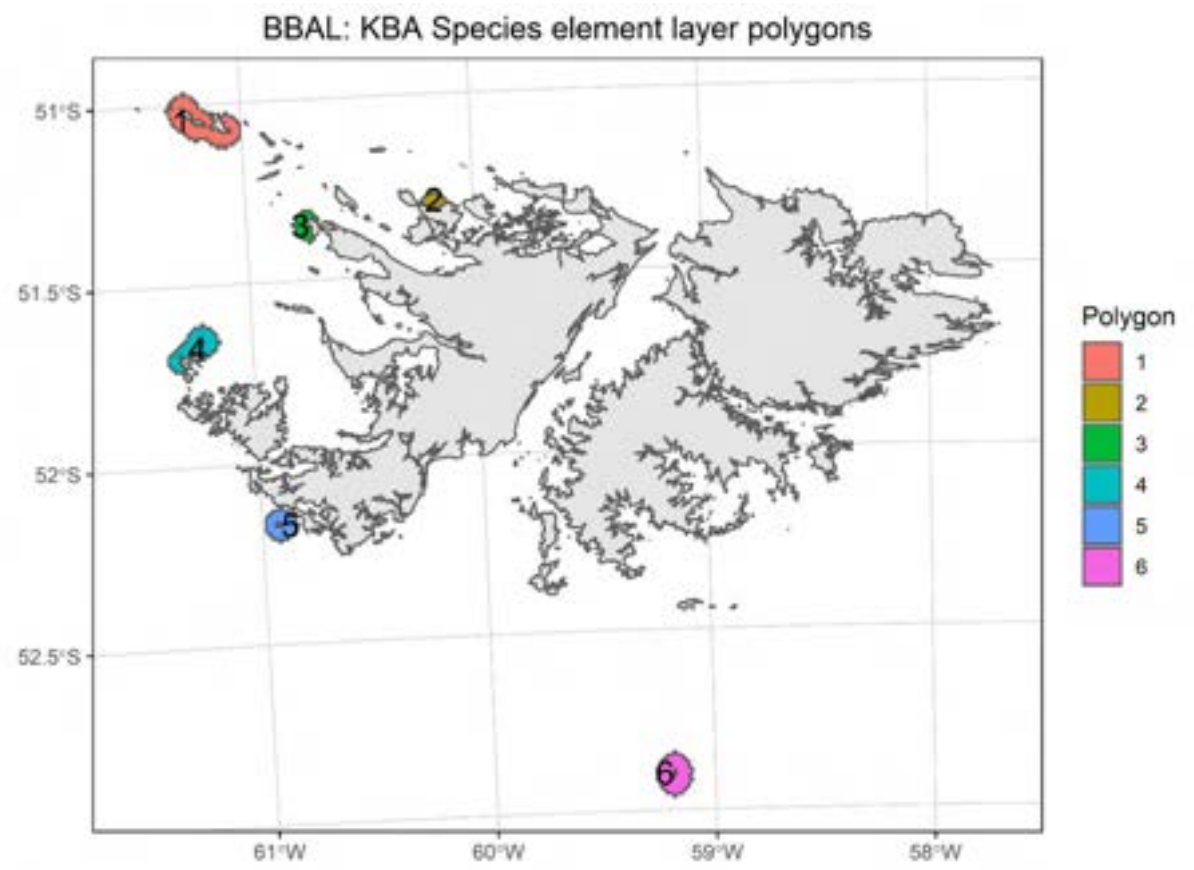


We propose these areas (in blue) as a KBA for Black-browed Albatrosses under criterion D1a (Demographic aggregations), given these areas are estimated to have a minimum abundance estimate of ≥1% of the global population (≥ 14,000 mature individuals for BBAL) during the breeding period.

As per the KBA guidelines: These areas predictably hold aggregations of Black-browed Albatrosses during the breeding period on a seasonal basis. Aggregations relate to those areas adjacent to breeding colonies used for preening and washing activities; as such, the areas have highly localised relative abundance (Granadeiro et al., 2017)**.**



The figure and table below show unique KBA polygons per species specific KBA element layers. Tabular data indicates which at-sea density distribution surfaces from specific colonies (or breeding regions where appropriate – see methods) contributed to the area meeting KBA criteria D1 in each specific polygon.



A: for those records where minimum number (#) of mature individuals is zero, this indicates that the at-sea density distribution from a given colony only partially overlapped the final area meeting KBA criteria. Additionally, where a minimum population estimates is the same as the maximum population estimate these counts show where a best count only was available to delineate the final KBA area.

Unique KBA Polygon for species KBA element layer	Species (By code – see Table 1)	Unique Site Name	Year of Count	Minimum # mature individuals [A]	Maximum # mature individuals
1	BBAL	Steeple North West tip 1.2 km	2017	111152	111152
1	BBAL	Steeple North (south west coast) 3 km	2017	0	245220
1	BBAL	Steeple Jason South (south west coast) 1 km	2017	29593	29593
1	BBAL	Grand East colonies	2017	58283	58283
1	BBAL	Grand central coast	2017	0	76823
1	BBAL	Grand West coast	2017	56244	56244
2	BBAL	Neck to Rookery	2017	37965	37965
3	BBAL	West Point Island	2017	40766	40766
3	BBAL	Grave Cove	2017	1091	1091
4	BBAL	Albatross Bay 1km	2017	12485	12485
4	BBAL	Lands end bluff to Albatross Bay 3km	2017	0	5987

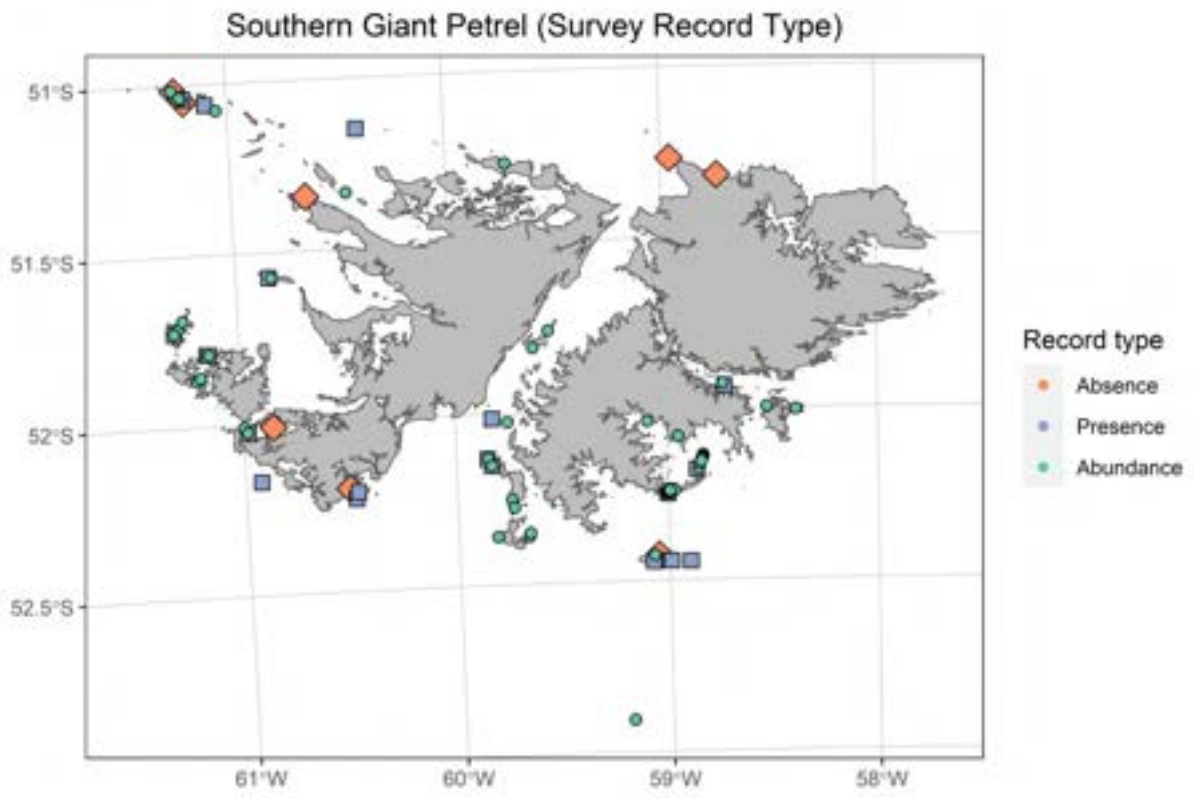
4	BBAL	West Coast 4km	2017	10834	10834
4	BBAL	North Island	2017	59826	59826
5	BBAL	Bird Island	2017	26313	26313
6	BBAL	Beauchene Whirlwind Pt	2017	0	14481
6	BBAL	Beauchene central East coast 1.5 km	2017	4274	4274
6	BBAL	Beauchene South Arena and Citadel 1km	2017	0	14232
6	BBAL	Beauchene Main colony west coast 1.5 km	2017	183389	183389

SGPE – Southern Giant Petrel

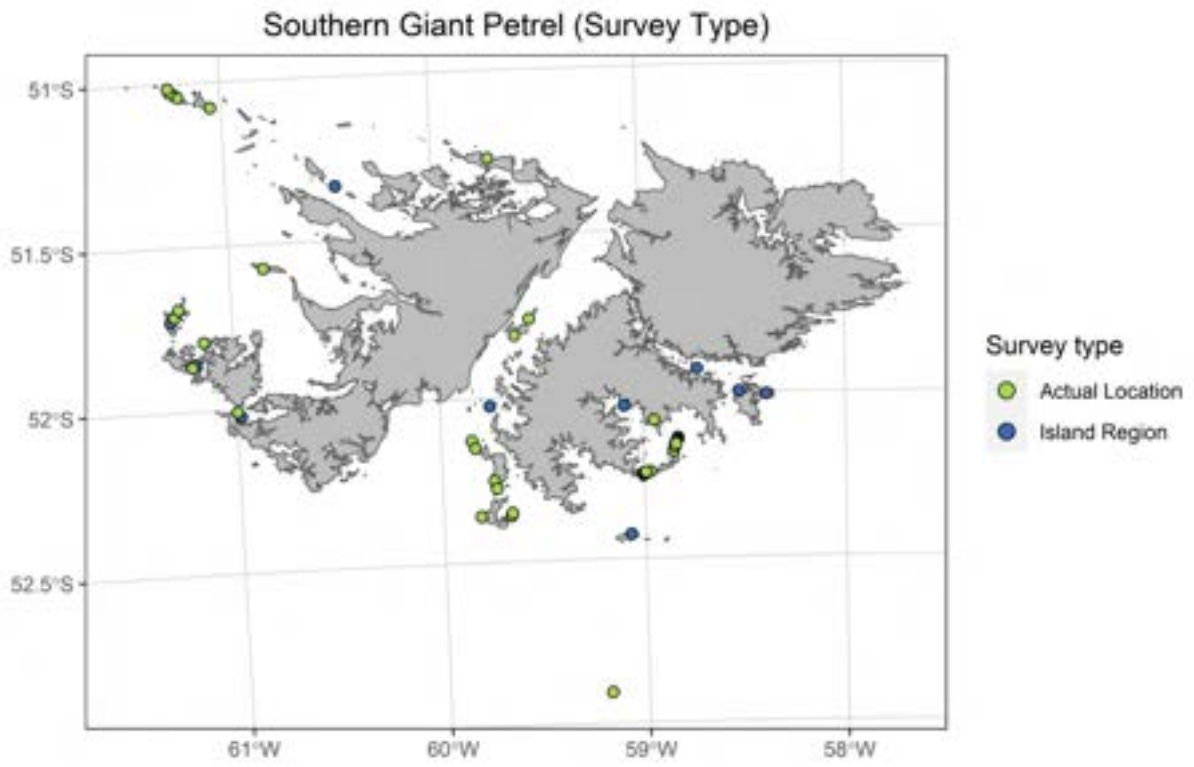
Red List Status: LC

KBA Criteria for assessment: D1a (Demographic aggregations)

For all breeding records for Southern Giant Petrels, there are certain sites with presence only data, or sites where the species are now absent. For the identification of KBAs, we only utilised information from sites with abundance records.



Regarding survey types, while certain Island Region records are present for Southern Giant Petrels, a recent island wide report (Stanworth and Crofts, 2017) indicated which Actual Locations had true abundance records. Hence, only these Actual Locations with abundance records were used for further analysis.



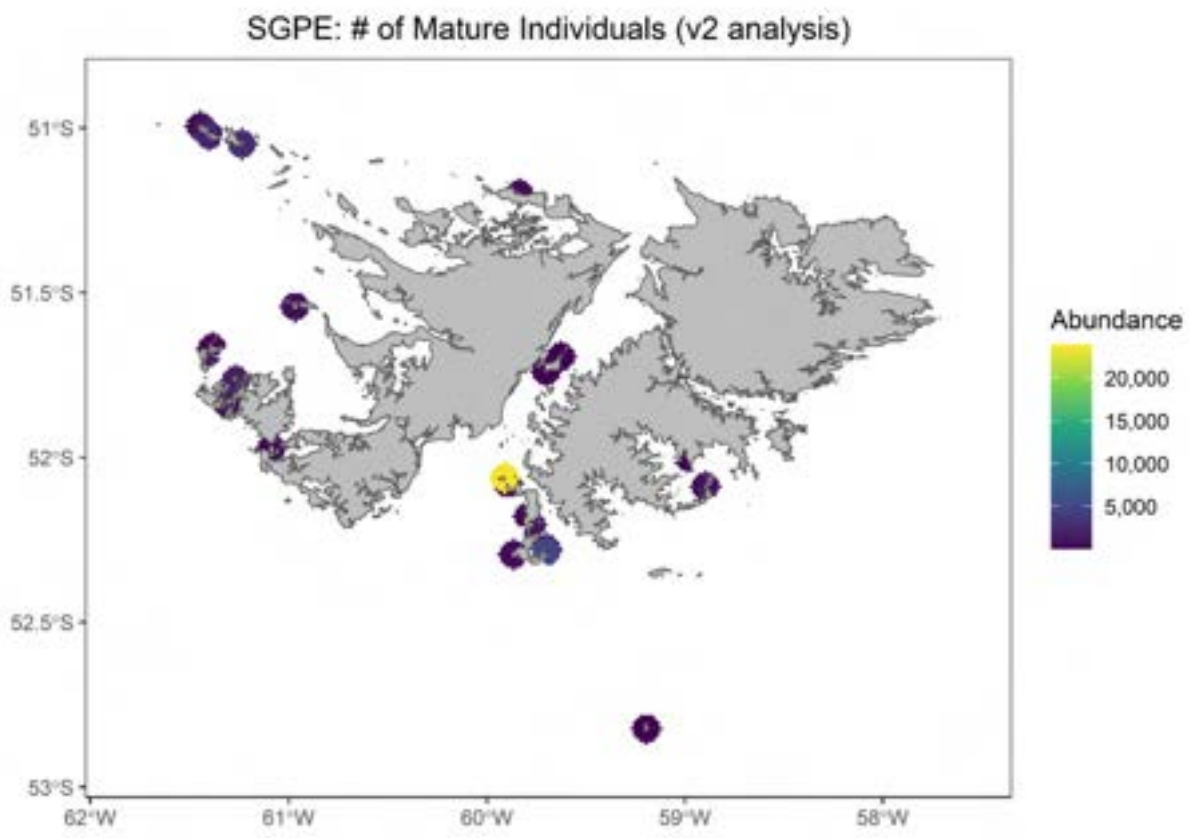
Similarly to Black-browed Albatrosses this species may forage over distances where certain area-based management tools may not always be feasible (Oppel et al., 2018); especially when accounting for sex-specific foraging strategies (González-Solís et al., 2002). Therefore, delineation of marine KBAs must be considered accordingly.

Although no Southern Giant Petrels have been tracked from the Falkland Islands, elsewhere in their range birds always showed periods on the sea surface immediately after departure and just before arrival, indicating that all birds started and finished foraging trips by bathing at sea (González-Solís et al., 2002).

Given this species reliance on at sea areas adjacent to colonies and a recognised distance threshold based on tracking studies from similar species at the Falkland Islands (Black-browed Albatross, see above), we delineated 5km buffers around all islands or breeding locations. Abundance estimates within buffer areas from each colony were summed; providing a Falklands-wide estimate of at-sea abundance within key buffer areas for the species.

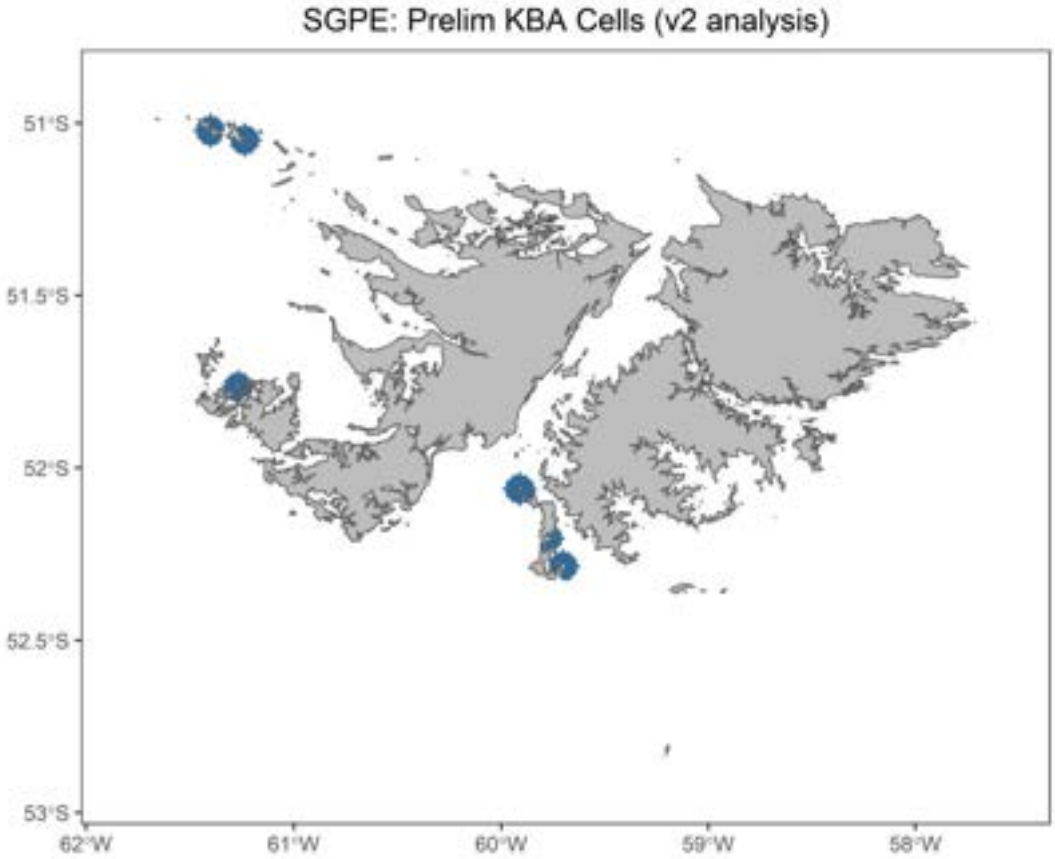
Based on the collated records and estimates of distribution within buffer areas from all key colonies, the estimated maximum number of mature individuals for a given cell is 23,870 mature individuals (breeding pairs x 2).

Given the global population estimate for this species is 101,800 mature individuals, and the KBA criterion we are assessing cells against is KBA criterion D1a, cells that would meet the criterion are those with ≥ 1,018 mature individuals (i.e. ≥1% of the global population)

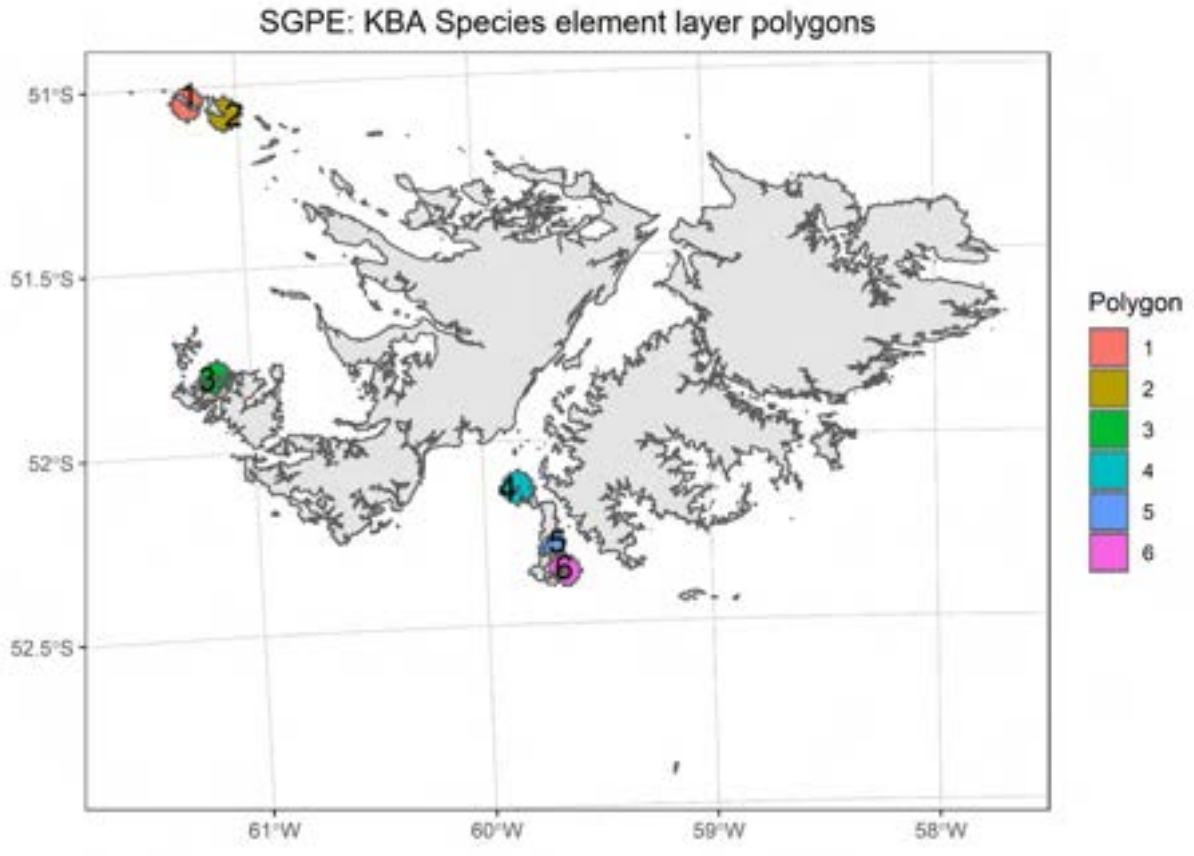


We propose these areas (in blue) as a KBA for Southern Giant Petrels under criterion D1a (Demographic aggregations), given these areas are estimated to have a minimum abundance estimate of ≥1% of the global population (≥ 1,018 mature individuals for SGPE) during the breeding period.

As per the KBA guidelines: These areas predictably hold aggregations of Southern Giant Petrels during the breeding period on a seasonal basis. Aggregations relate to those areas adjacent to breeding colonies used for preening and washing activities; as such, the areas have highly localised relative abundance (as per expert consultation and observations at other breeding localities (González-Solís et al., 2002)).



The figure and table below show unique KBA polygons per species specific KBA element layers. Tabular data indicates which at-sea density distribution surfaces from specific colonies (or breeding regions where appropriate – see methods) contributed to the area meeting KBA criteria D1 in each specific polygon.



A: for those records where minimum number (#) of mature individuals is zero, this indicates that the at-sea density distribution from a given colony only partially overlapped the final area meeting KBA criteria. Additionally, where a minimum population estimates is the same as the maximum population estimate these counts show where a best count only was available to delineate the final KBA area.

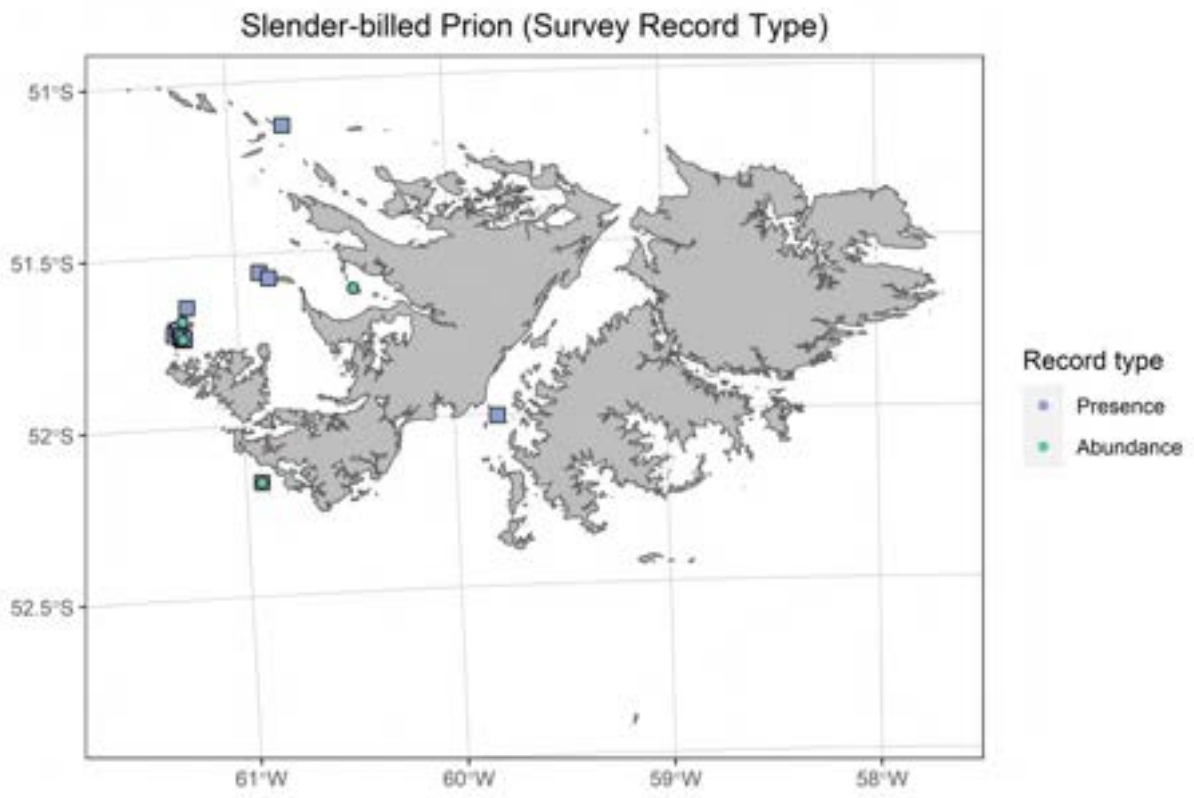
Unique KBA Polygon for species KBA element layer	Species (By code – see Table 1)	Unique Site Name	Year of Count	Minimum # mature individuals [A]	Maximum # mature individuals
1	SGPE	Steeple Jason Neck	2015	1858	1858
1	SGPE	Steeple Jason South of Ridge	2015	898	898
1	SGPE	Steeple Jason NW Flat	2015	12	12
2	SGPE	Grand Jason	2015	2892	2892
3	SGPE	Penn Island	2015	1744	1744
3	SGPE	Governor Island	2015	696	696
4	SGPE	Sandy Cay	2015	23340	23340
4	SGPE	Golden Knob	2015	0	530
5	SGPE	Speedwell Island Point	2015	1090	1090
6	SGPE	Barren Island Tea Point Beach	2015	4374	4374
6	SGPE	Barren Island Tea Point	2015	0	750

SBPR - Slender-billed Prion

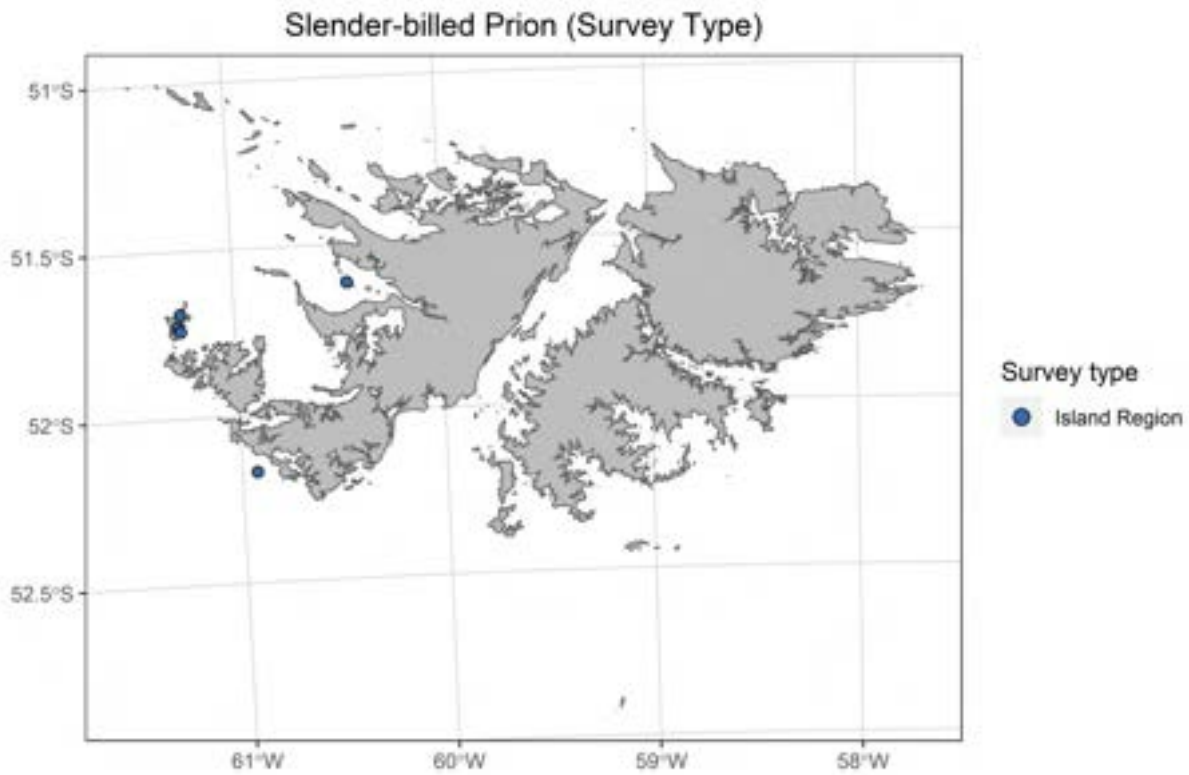
Red List Status: LC

KBA Criteria for assessment: D1a (Demographic aggregations)

For all records for Slender-billed Prions, there are certain sites with presence only data. For the identification of KBAs, we only utilised information from sites with abundance records.



Given this species nests in burrows as opposed to tightly clustered colonies, we selected only those Island Regions with abundance estimates ≥1% of the global population given this species is being assessed against KBA Criterion D1a (Demographic aggregations).

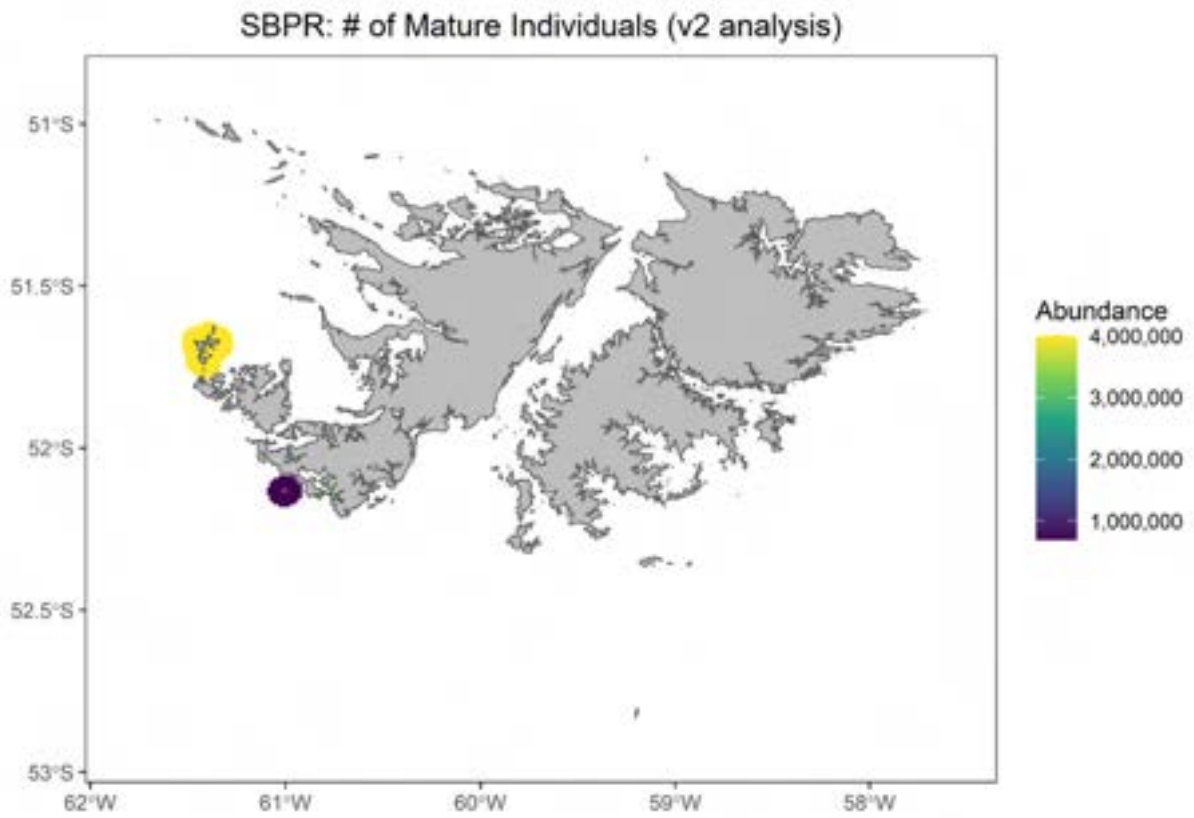


As this species typically forages over distances where certain area-based management tools may not always be feasible (Oppel et al., 2018), delineation of marine KBAs must be considered accordingly.

Similarly to other procellariiformes (Black-browed Albatross and Southern Giant Petrels), this species relies on at sea areas adjacent to colonies. Therefore, using a recognised distance threshold based on tracking studies from similar species at the Falkland Islands (Black-browed Albatross, see above), we delineated 5km buffers around key breeding locations.

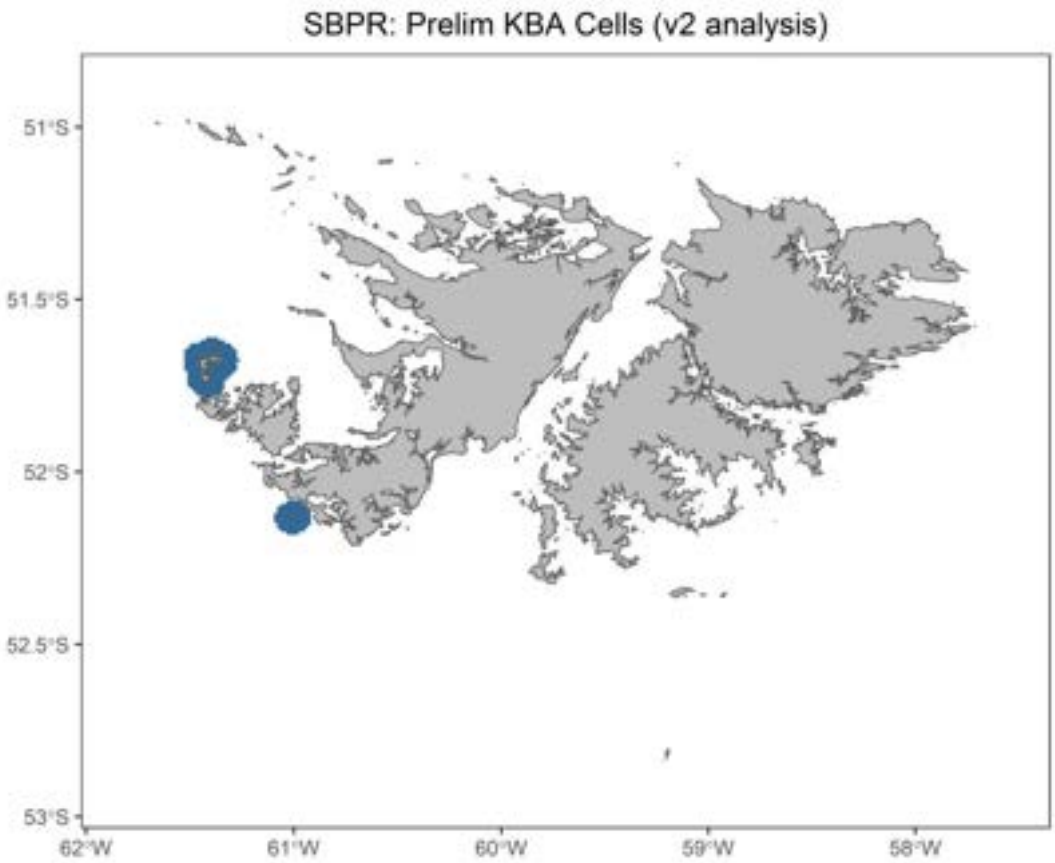
Based on the collated records and estimates of distribution within buffer areas from all key colonies, the estimated maximum number of mature individuals for a given cell is 4,000,000 mature individuals (breeding pairs x 2).

Given the global population estimate for this species is 7,000,000 mature individuals, and the KBA criterion we are assessing cells against is KBA criterion D1a, cells that would meet the criterion are those with ≥ 70,000 mature individuals (i.e. ≥1% of the global population)

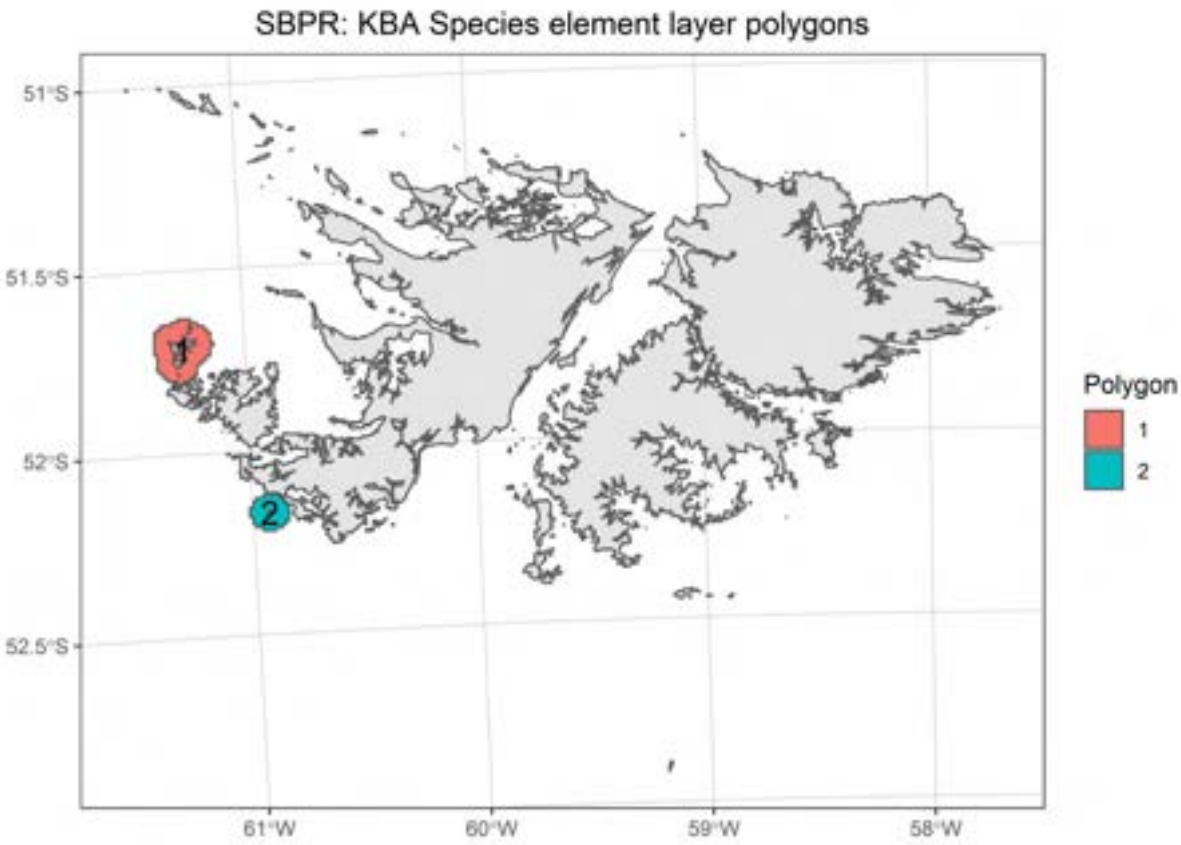


We propose these areas (in blue) as a KBA for Slender-billed Prions under criterion D1a (Demographic aggregations), given these areas are estimated to have a minimum abundance estimate of ≥1% of the global population (≥ 70,000 mature individuals for SBPR) during the breeding period.

As per the KBA guidelines: These areas predictably hold aggregations of Slender-billed Prions during the breeding period on a seasonal basis. Aggregations relate to those areas adjacent to breeding colonies used for preening and washing activities; as such, the areas have highly localised relative abundance.



The figure and table below show unique KBA polygons per species specific KBA element layers. Tabular data indicates which at-sea density distribution surfaces from specific colonies (or breeding regions where appropriate – see methods) contributed to the area meeting KBA criteria D1 in each specific polygon.



A: for those records where minimum number (#) of mature individuals is zero, this indicates that the at-sea density distribution from a given colony only partially overlapped the final area meeting KBA criteria. Additionally, where a minimum population estimates is the same as the maximum population estimate these counts show where a best count only was available to delineate the final KBA area.

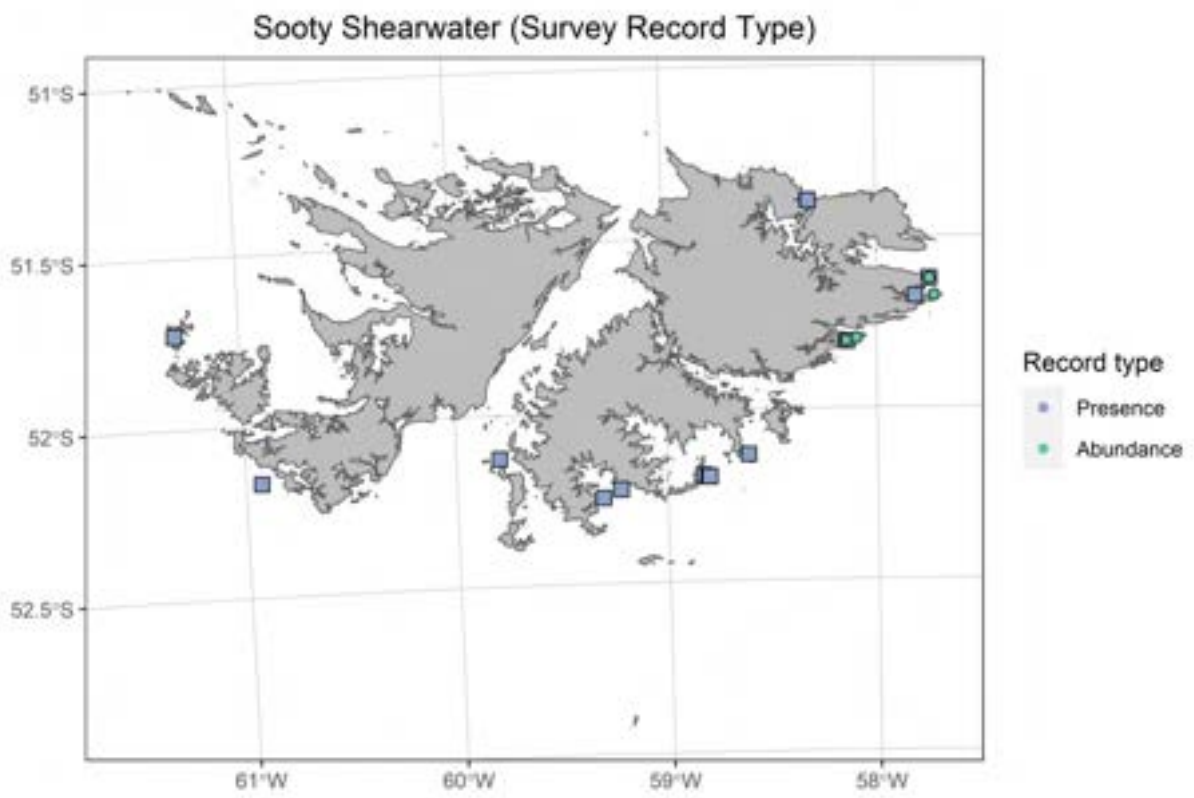
Unique KBA Polygon for species KBA element layer	Species (By code – see Table 1)	Unique Site Name	Year of Count	Minimum # mature individuals [A]	Maximum # mature individuals
1	SBPR	New Island	2002	4000000	4000000
2	SBPR	Bird Island	2018	688000	688000

SOSH – Sooty Shearwater

Red List Status: NT

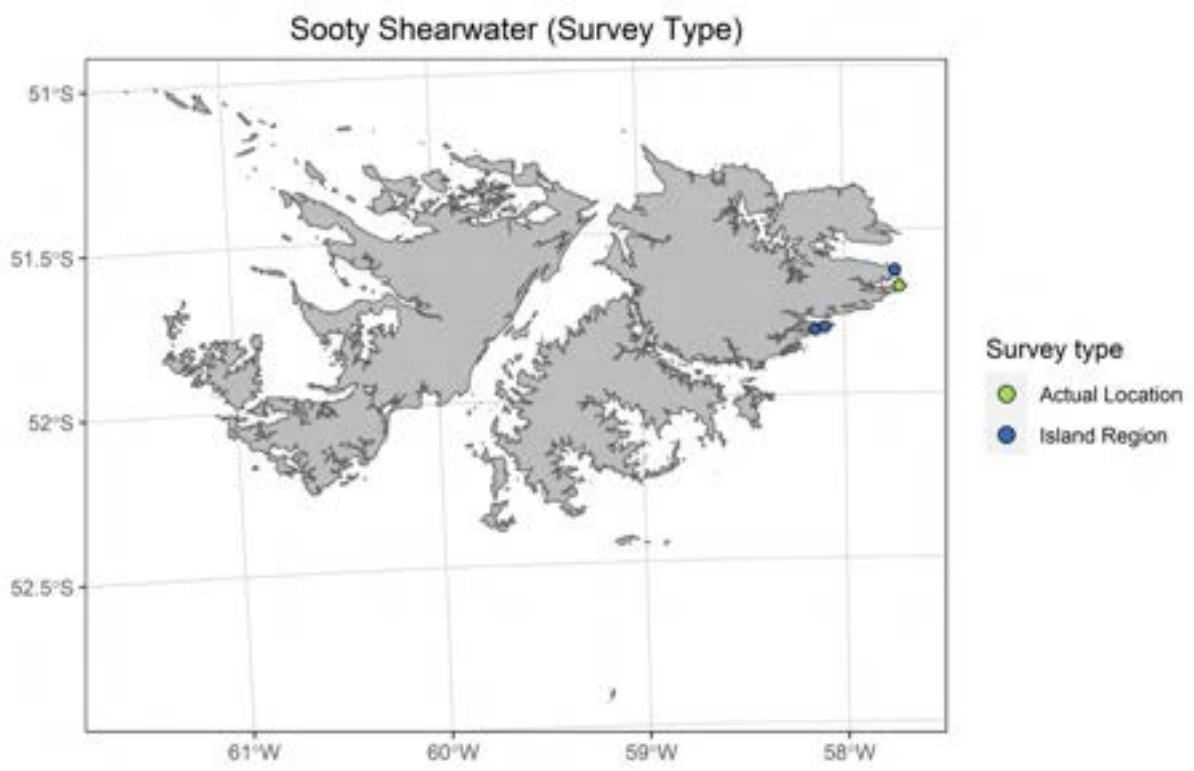
KBA Criteria for assessment: D1a (Demographic aggregations)

Sooty Shearwaters have received less attention in monitoring efforts throughout the years at the Falkland Islands. Hence, several records indicative of breeding birds relate to presence only records. We use only the abundance records for further analysis.



Where Actual Location records were present for Sooty Shearwaters, some of these related to transects conducted on various islands. Therefore, where transect data were present, the total number of birds was first calculated to provide an abundance estimate at the scale of the Island Region.

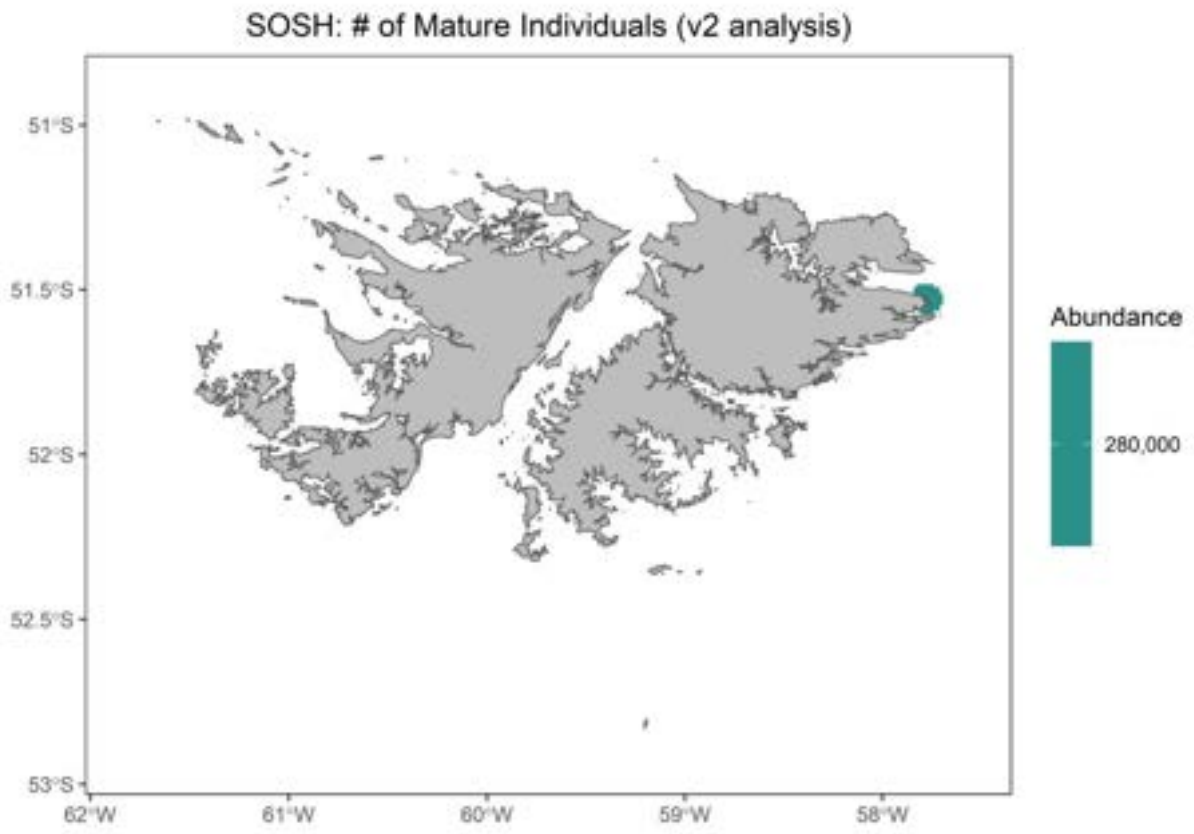
Given this species nests in burrows typically dispersed across an island, we selected only those Island Regions with abundance estimates ≥1% of the global population given this species is being assessed against KBA Criterion D1a (Demographic aggregations).



Given there are limited tracking studies for this species at the Falkland Islands, and because shearwaters are known to rely on marine areas surrounding colonies for rafting (Warham, 1996), a 5km buffer was set in accordance with species of similar known ecology which have been studied via telemtry studies at the Falkland Islands; the Black-browed Albatross.

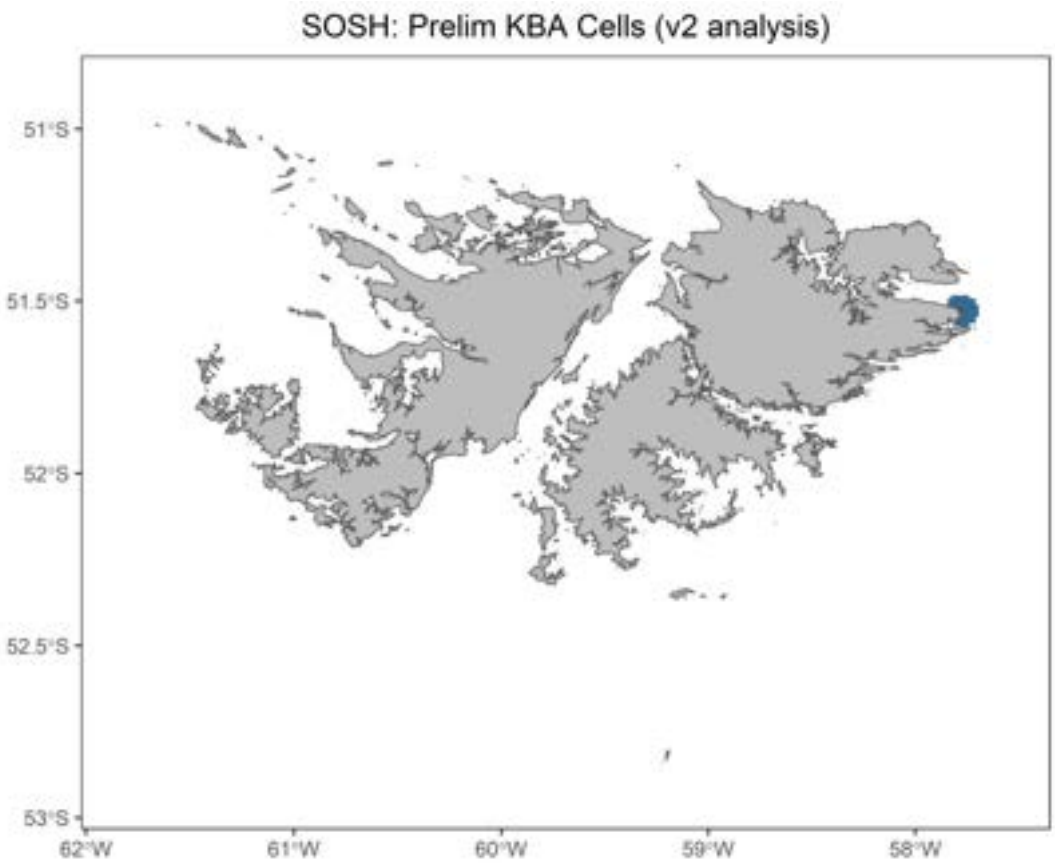
Based on the collated records, the estimated maximum number of mature individuals is up to 280,000 mature individuals (breeding pairs x 2) utilising waters around specific SOSH breeding islands which host ≥1% of the global population.

Given the global population estimate for this species is 8,800,000 mature individuals, and the KBA criterion we are assessing cells against is KBA criterion D1a, cells that would meet the criterion are those with ≥ 88,000 mature individuals (i.e. ≥1% of the global population)

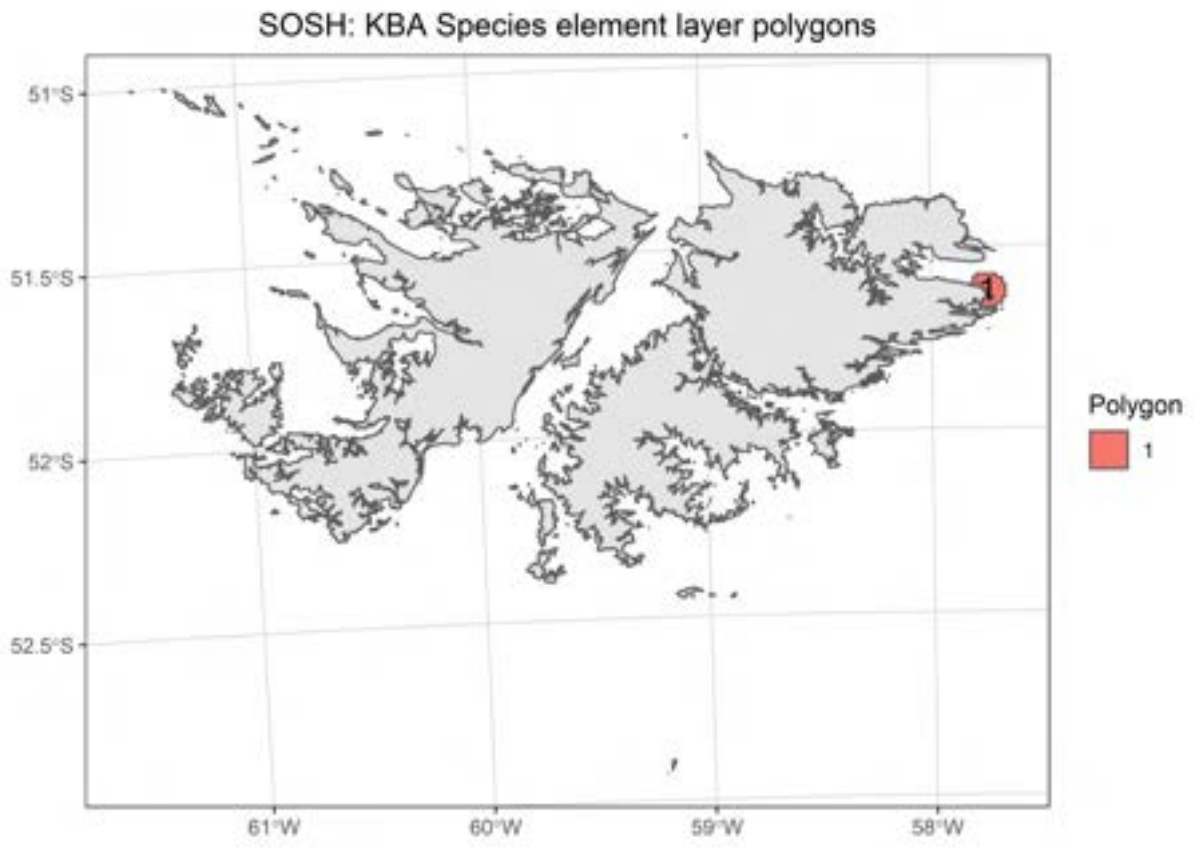


We propose these areas (in blue) as a KBA for Sooty Shearwaters under criterion D1a (Demographic aggregations), given these areas are estimated to have a minimum abundance estimate of ≥1% of the global population (≥ 88,000 mature individuals for SOSH) during the breeding period.

As per the KBA guidelines: These areas predictably hold aggregations of Sooty Shearwaters during the breeding period on a seasonal basis. The birds rely on adjacent marine areas for rafting. During the breeding period, areas around key breeding areas have highly localised relative abundance, two or more orders of magnitude larger than the species' average recorded numbers or densities at other stages during its life-cycle (i.e. the non-breeding period). Furthermore, in the context of the inshore environment of the Falkland Islands, these areas are considered as 'manageable units' that would require appropriate management actions to support the persistence of the identified KBAs for this species.



The figure and table below show unique KBA polygons per species specific KBA element layers. Tabular data indicates which at-sea density distribution surfaces from specific colonies (or breeding regions where appropriate – see methods) contributed to the area meeting KBA criteria D1 in each specific polygon.



A: for those records where minimum number (#) of mature individuals is zero, this indicates that the at-sea density distribution from a given colony only partially overlapped the final area meeting KBA criteria. Additionally, where a minimum population estimates is the same as the maximum population estimate these counts show where a best count only was available to delineate the final KBA area.

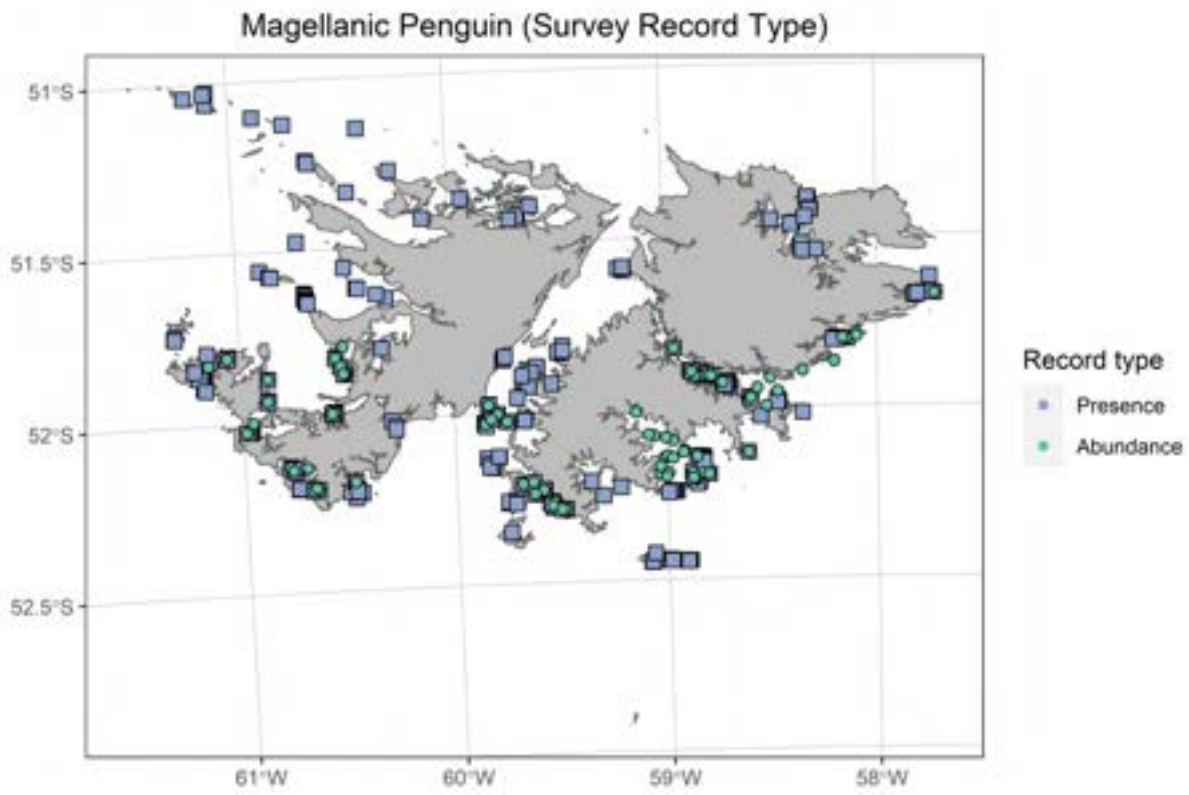
Unique KBA Polygon for species KBA element layer	Species (By code – see Table 1)	Unique Site Name	Year of Count	Minimum # mature individuals [A]	Maximum # mature individuals
1	SOSH	Kidney Island	2017	280000	280000

MGPE – Magellanic Penguins

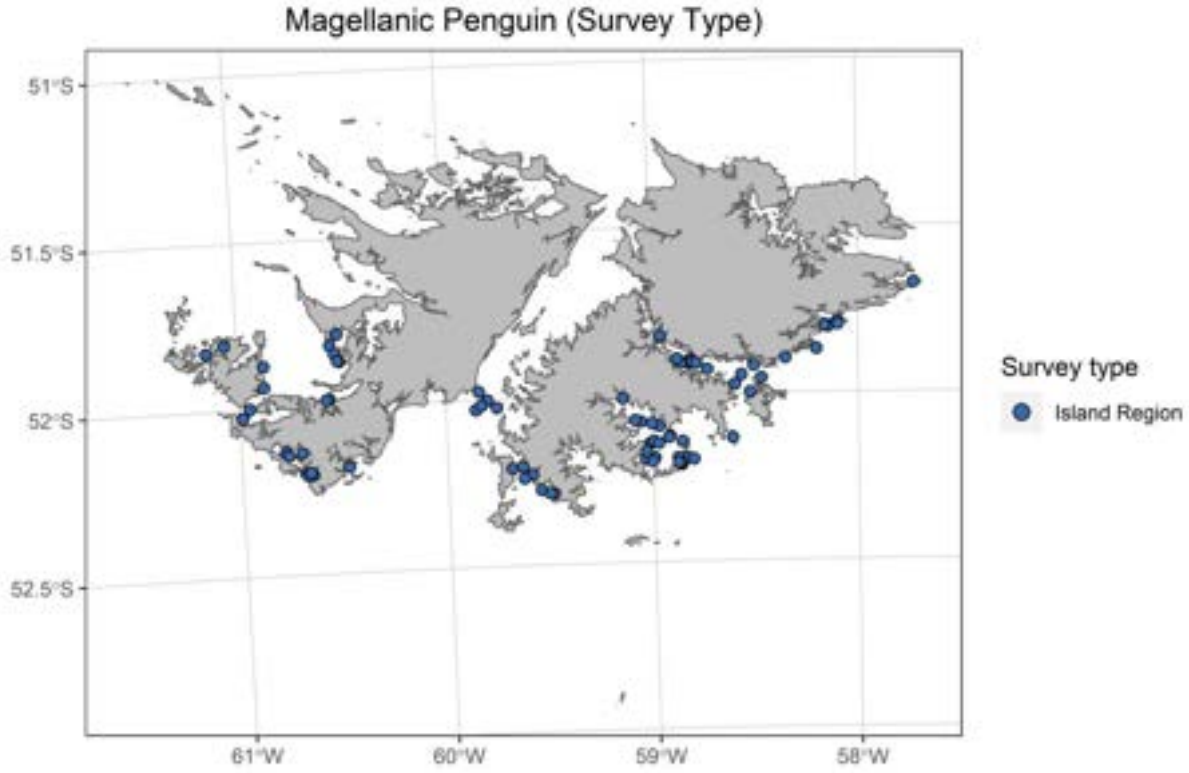
Red List Status: LC

KBA Criteria for assessment: D1a (Demographic aggregations)

Magellanic Penguins have received less attention in monitoring efforts throughout the years at the Falkland Islands given the difficulty in surveying this burrow nesting species. Hence, several records indicative of breeding birds relate to presence only records. We use only the abundance records for further analysis.



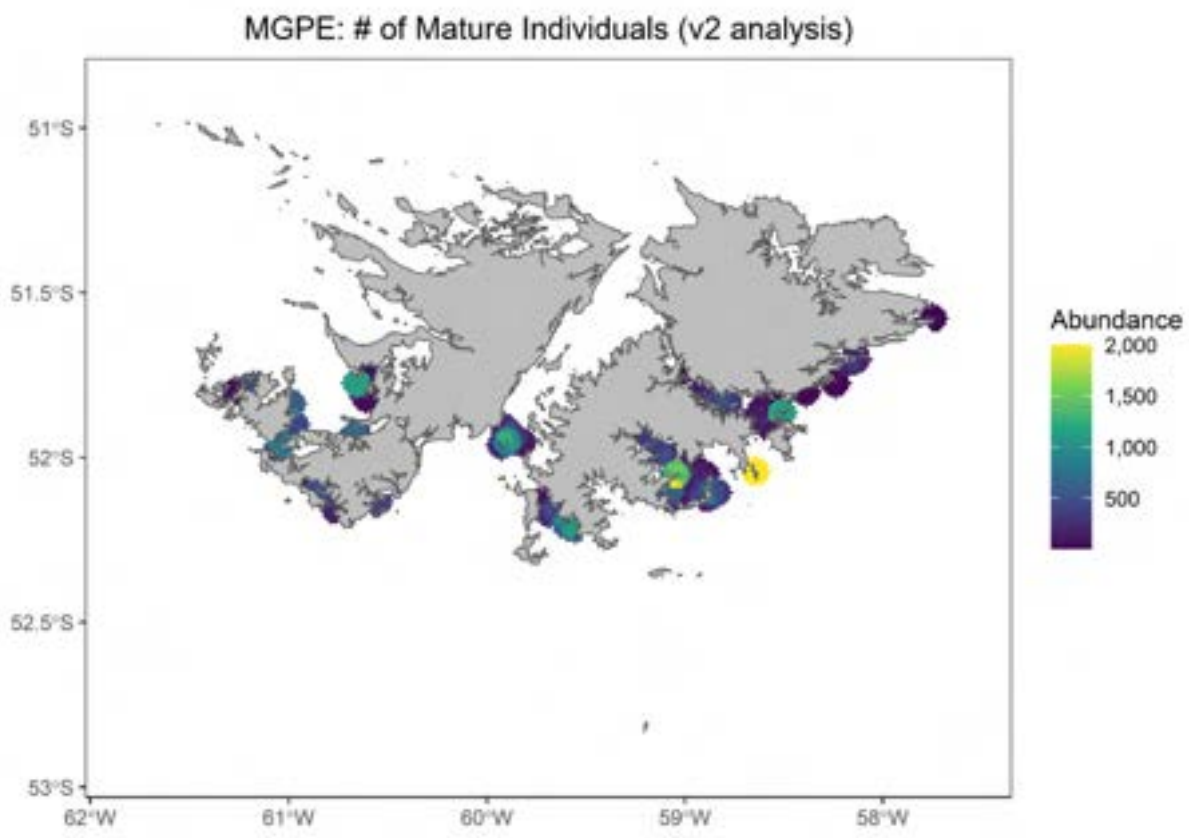
Where abundance records were available, these relate to Island Region location type records only; somewhat expected given this species does not form tightly clustered colonies at the Falkland Islands.



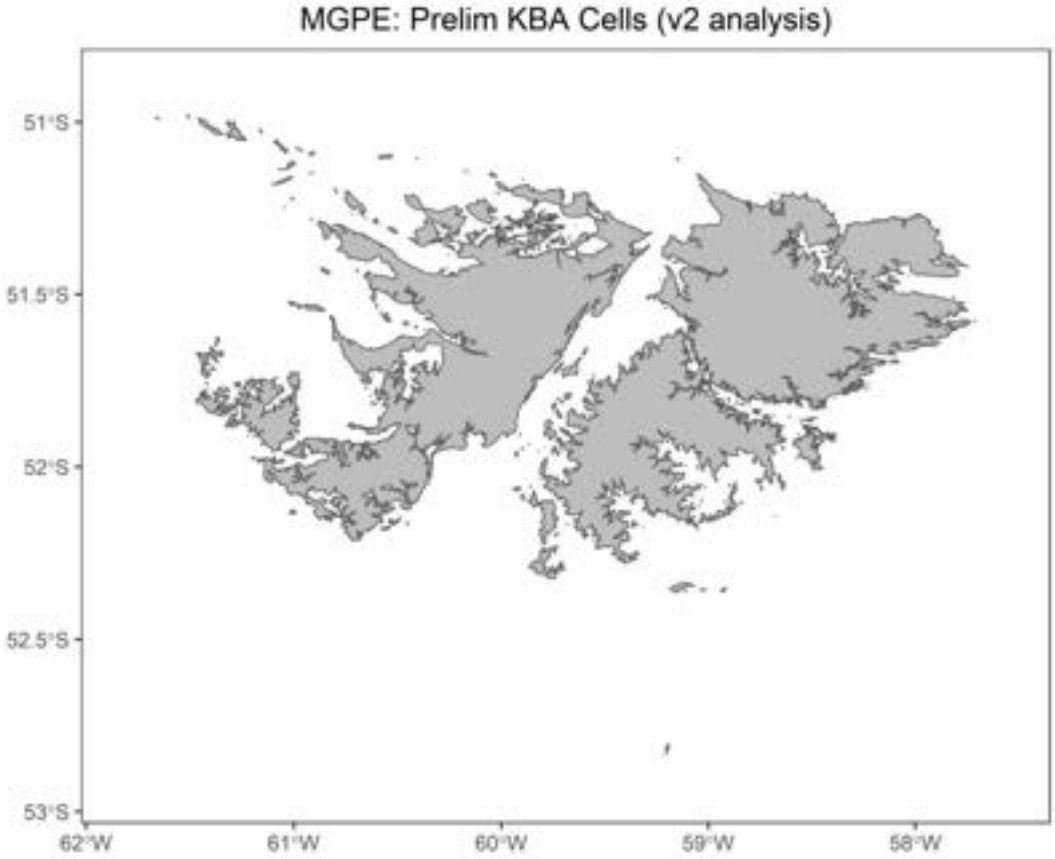
While a mean-maximum foraging radius approach has been applied for penguins and other seabirds elsewhere (Grecian et al., 2012; Critchley et al., 2018, 2019; Handley et al., 2021), we favour the approach of considering nearshore preening/washing areas and transit corridors for delineating buffers for assessment of potential KBA areas for Magellanic Penguins. The mean-maximum foraging radius for Magellanic Penguins at the Falklands Islands is approximately 298km (Table 7). Rather than using this buffer of 298km, we use a buffer of 5km only around Magellanic Penguin Colonies in alignment with the areas being proposed for Procellariiformes (see above). In the context of the inshore environment of the Falkland Islands, these areas are better suited to the definitions of "management unit" and "aggregation" as defined in the KBA standards. Abundance estimates within buffer areas from each colony were summed, providing a Falklands-wide estimate of at-sea abundance within key buffer areas for the species.

Based on the collated records and estimates of distribution from all colonies, the estimated maximum number of mature individuals for a given cell is 2,000 mature individuals (breeding pairs x 2).

Given the global population estimate for this species is 2,700,000 mature individuals, and the KBA criterion we are assessing cells against is KBA criterion D1a, cells that would meet the criterion are those with ≥ 27,000 mature individuals (i.e. ≥1% of the global population)



Given the global population estimate of mature individuals for Magellanic Penguins, means a minimum of 27,000 mature individuals should be present to trigger a KBA under Criterion D1a ('Demographic aggregations) we do not propose any area as a global KBA for Magellanic Penguins across the inshore area of the Falkland Islands.

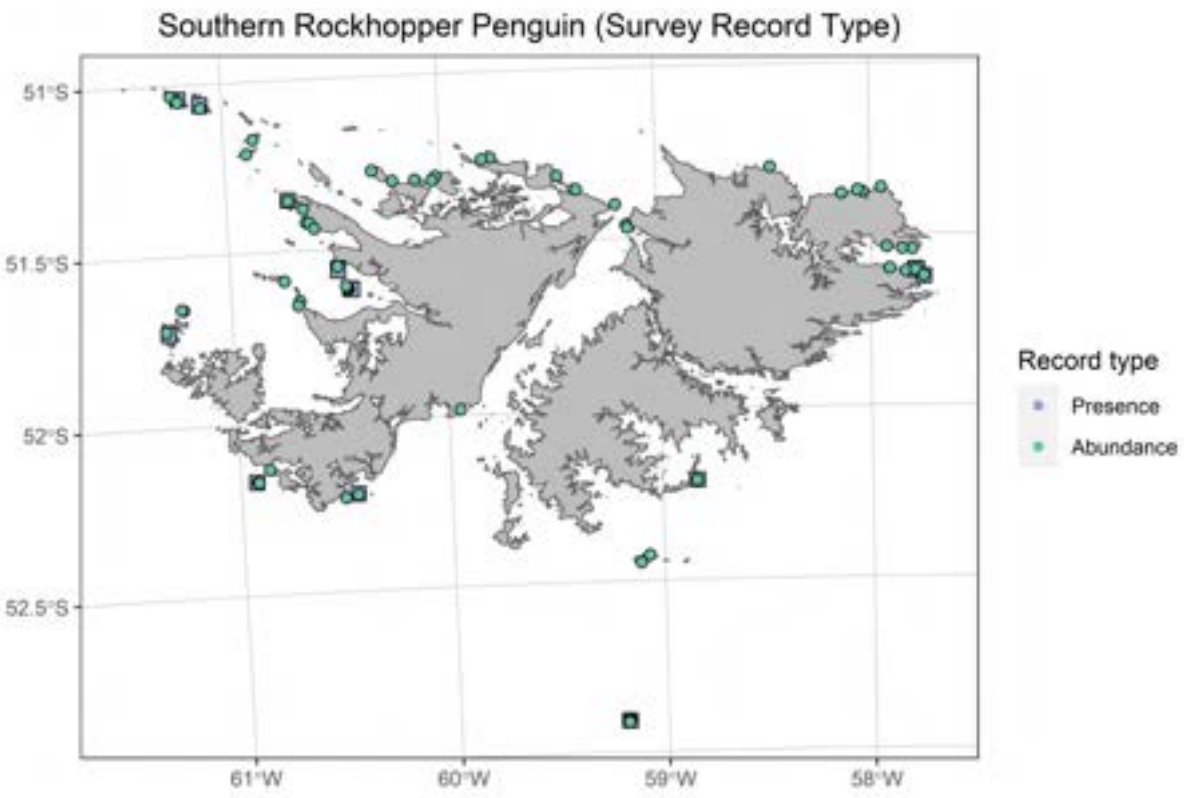


SRPE – Southern Rockhopper Penguin

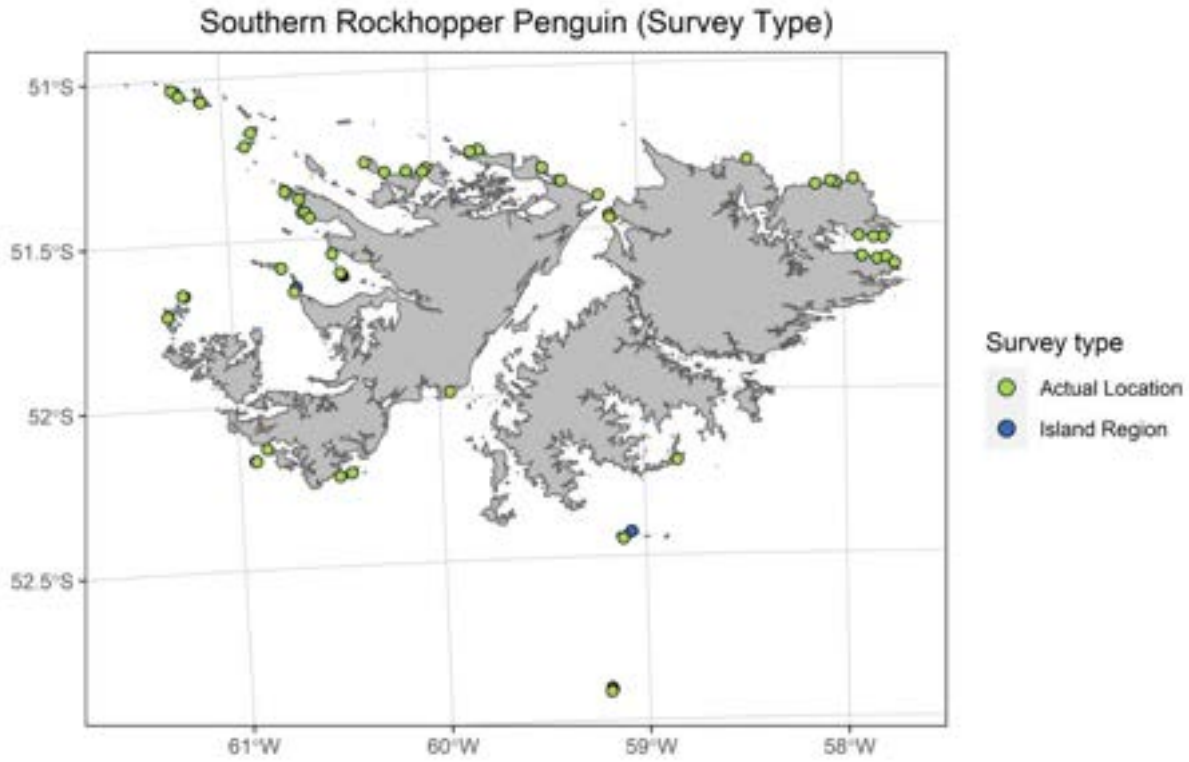
Red List Status: VU (A2, A3, A4)

KBA Criteria for assessment: A1b and A1D (Threatened Biodiversity), D1a (Demographic aggregations)

Southern Rockhopper Penguins are well monitored across the Falkland Islands, hence nearly all records are Abundance records. We used these abundance records for further analyses.



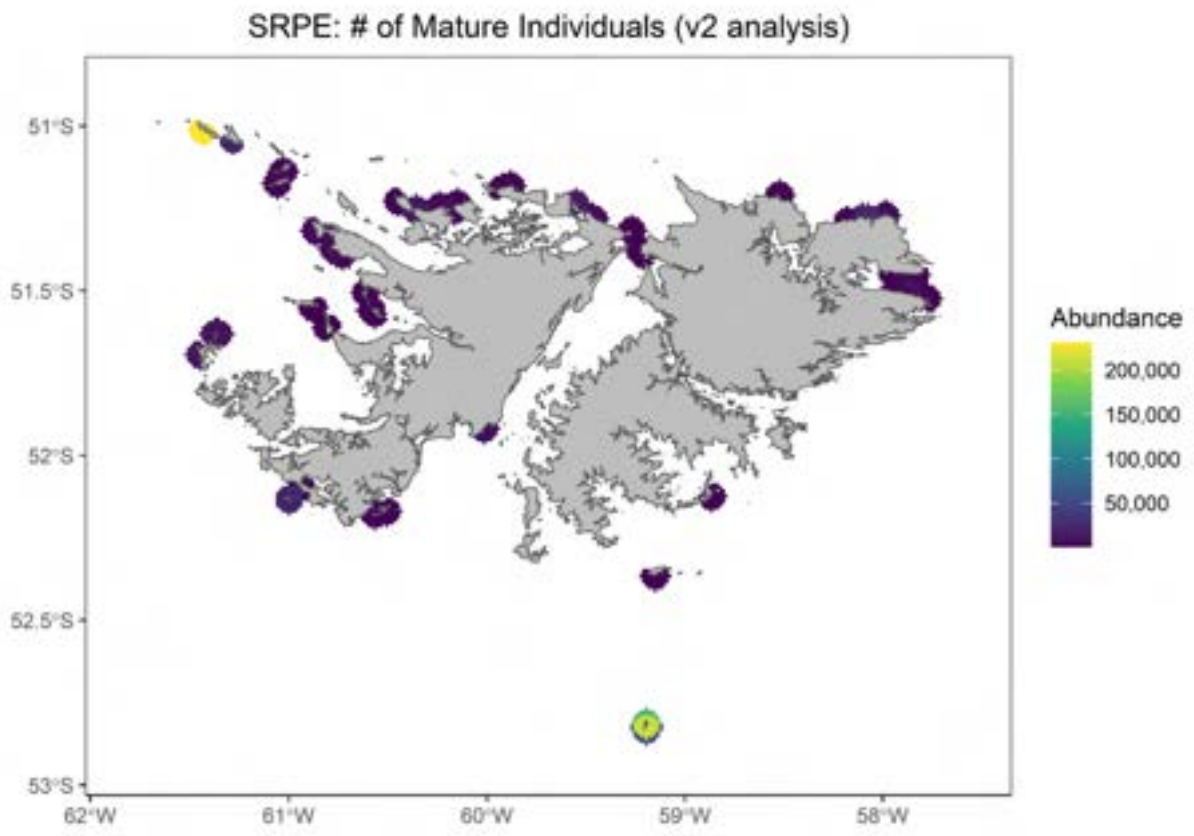
Records for Southern Rockhopper Penguin colonies primarily relate to Actual Location records, reflecting either an individual colony or geographically distinct sub-colonies. These Actual Location records were used for the KBA analysis.



While a mean-maximum foraging radius approach has been applied for penguins and other seabirds elsewhere (Grecian et al., 2012; Critchley et al., 2018, 2019; Handley et al., 2021), we favour the approach of considering nearshore preening/washing areas and transit corridors for delineating buffers for assessment of potential KBA areas for Southern Rockhopper Penguins. The mean-maximum foraging radius for Southern Rockhopper Penguins at the Falklands Islands is approximately 139km (Table 7). Rather than using this buffer of 139km, we use a buffer of 5km only around Southern Rockhopper Penguin Colonies in alignment with the areas being proposed for Procellariiformes (see above). In the context of the inshore environment of the Falkland Islands, these areas are better suited to the definitions of "management unit" and "aggregation" as defined in the KBA standards; particularly as the key KBA criterion for assessment was KBA criterion A1d, meaning that areas with only ≥ 0.02% of the global population could be considered as a KBA. Abundance estimates within buffer areas from each colony were summed, providing a Falklands-wide estimate of at-sea abundance within key buffer areas for the species.

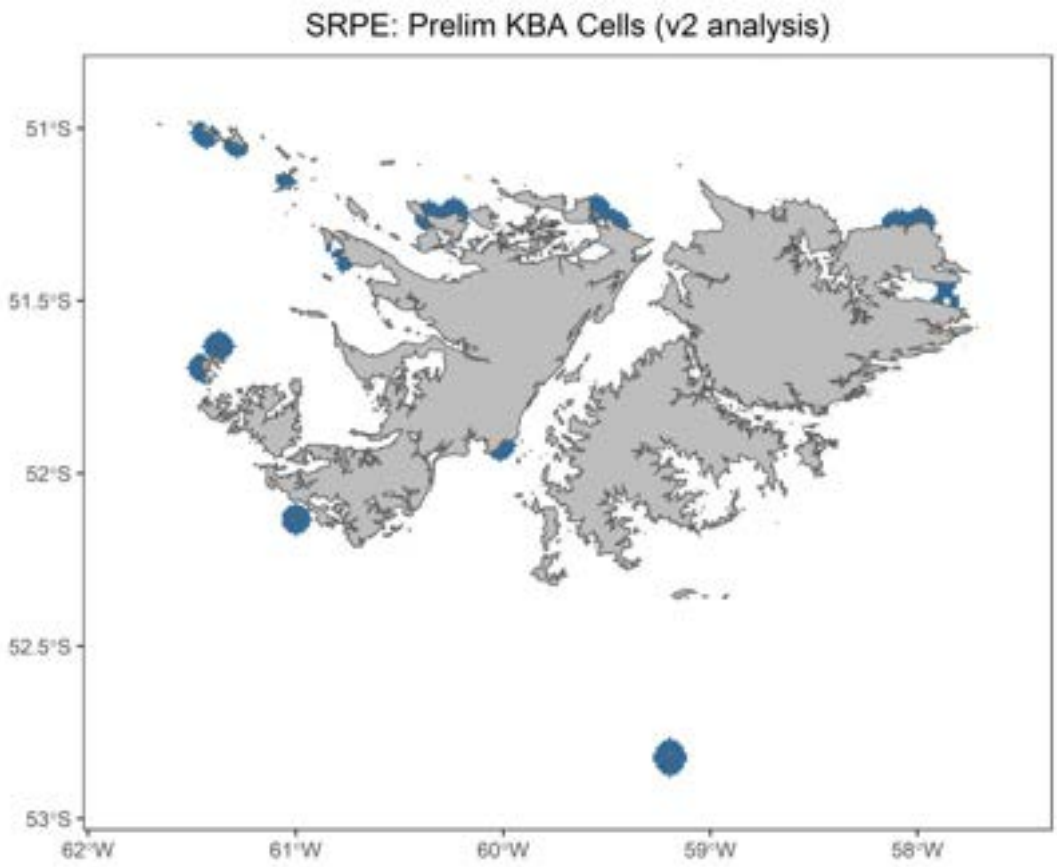
Based on the collated records and estimates of distribution from all colonies, the estimated maximum number of mature individuals for a given cell is 230,652 mature individuals (breeding pairs x 2).

Given the global population estimate for this species is 2,500,000 mature individuals, and the key KBA criterion we assessed cells against was KBA criterion A1d, cells that would meet the criterion are those with ≥ 5,000 mature individuals (i.e. ≥ 0.02 % of the global population).

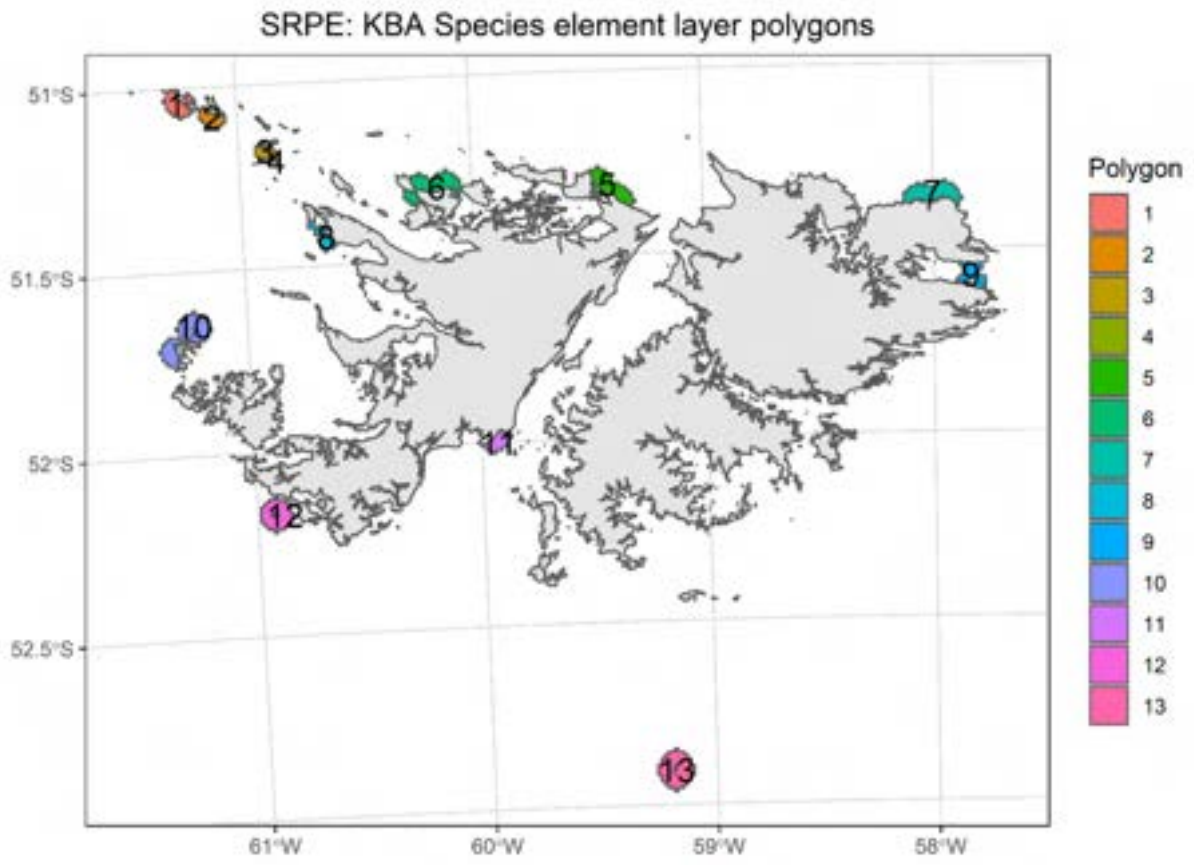


We propose these areas (in blue) as a KBA for Southern Rockhopper Penguins under criterion A1d (Threatened Biodiversity), given these areas are estimated to have a minimum abundance estimate of ≥ 0.02% of the global population (≥ 5,000 mature individuals for SRPE) during the breeding period.

As per the KBA guidelines (with respect to criterion A1d): These areas regularly hold aggregations of Southern Rockhopper Penguins during the breeding period on a seasonal basis. Regular occurrence of the species is further noted as the layer is reflective of the area likely used by birds simultaneously on a daily basis during parts of the breeding period (Dehnhard et al., 2016)**. The aggregations relate to those areas adjacent to breeding colonies used for preening and washing activities, and also departure and return areas of foraging trips because penguins cannot fly over these areas; as such, the areas have highly localised relative abundance.**



The figure and table below show unique KBA polygons per species specific KBA element layers. Tabular data indicates which at-sea density distribution surfaces from specific colonies (or breeding regions where appropriate – see methods) contributed to the area meeting KBA criteria D1 in each specific polygon.



A: for those records where minimum number (#) of mature individuals is zero, this indicates that the at-sea density distribution from a given colony only partially overlapped the final area meeting KBA criteria. Additionally, where a minimum population estimates is the same as the maximum population estimate these counts show where a best count only was available to delineate the final KBA area.

Unique KBA Polygon for species KBA element layer	Species (By code – see Table 1)	Unique Site Name	Year of Count	Minimum # mature individuals [A]	Maximum # mature individuals
1	SRPE	Steeple Jason	2010	230652	230652
2	SRPE	Grand Jason	2010	20992	20992
3	SRPE	Elephant Jason	2010	2726	2726
3	SRPE	South Jason	2010	2602	2602
4	SRPE	Elephant Jason	2010	2726	2726
4	SRPE	South Jason	2010	2602	2602
5	SRPE	Pebble Tamar (4 colonies)	2010	14076	14076
5	SRPE	Tamar Point 1 & 2	2010	6282	6282
6	SRPE	Keppel Island North	2010	1702	1702
6	SRPE	Keppel Island South	2010	1106	1106
6	SRPE	Saunders Holy City	2010	2738	2738

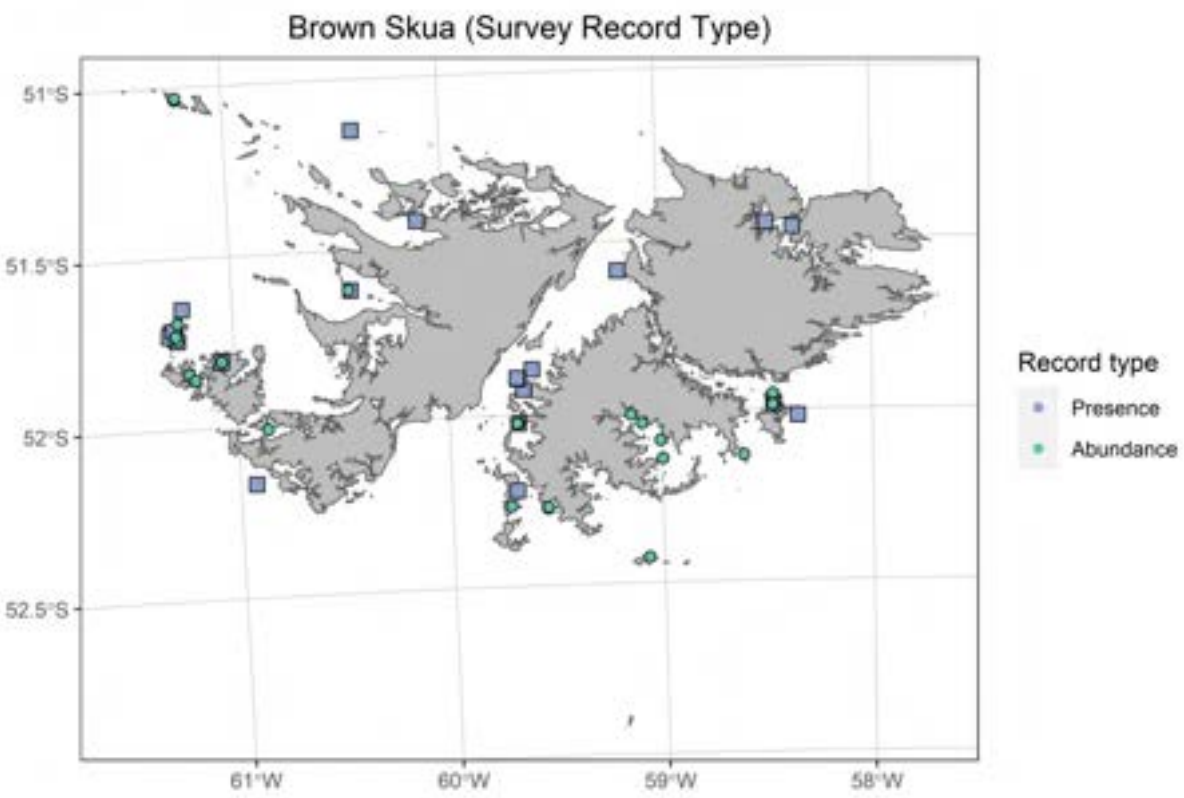
6	SRPE	Saunders Neck	2010	12890	12890
6	SRPE	Saunders Rookery	2010	5492	5492
7	SRPE	Campa Menta	2010	900	900
7	SRPE	McBride Head (many groups)	2010	6146	6146
7	SRPE	Rabbit Rincon	2005	5460	5460
7	SRPE	Seal Bay	2010	17468	17468
8	SRPE	Boxwood Point	2005	1050	1050
8	SRPE	Death Head	2005	3354	3354
8	SRPE	Death Ridge	2005	1152	1152
8	SRPE	Penguin Point	2010	576	576
8	SRPE	West Point Island	2010	4498	4498
9	SRPE	Cochon Island	2010	1104	1104
9	SRPE	Diamond Cove	2019	344	344
9	SRPE	Eagle Hill (6 colonies)	2019	3400	3400
9	SRPE	Kidney Island	2010	594	594
9	SRPE	Long Island	2010	750	750
9	SRPE	Murrell (4-5 colonies)	2010	3632	3632
9	SRPE	Rookery Valley	2010	630	630
9	SRPE	Rugged Hill (2 colonies)	2019	2116	2116
10	SRPE	New Island	2010	11334	11334
10	SRPE	North Island East Coast	2010	478	478
10	SRPE	North Island West Coast	2010	9048	9048
11	SRPE	Carcass Bay 1 & 2	2010	5792	5792
12	SRPE	Bird Island Main 1	2010	10254	10254
12	SRPE	Bird Island Main 2	2010	10254	10254
12	SRPE	Stephen's Peak	2019	2400	2400
13	SRPE	Beauchene Citadel colony	2010	42310	42310
13	SRPE	Beauchene East colony	2010	21154	21154
13	SRPE	Beauchene Main colony	2010	148088	148088

BRSK – Brown Skua

Red List Status: LC

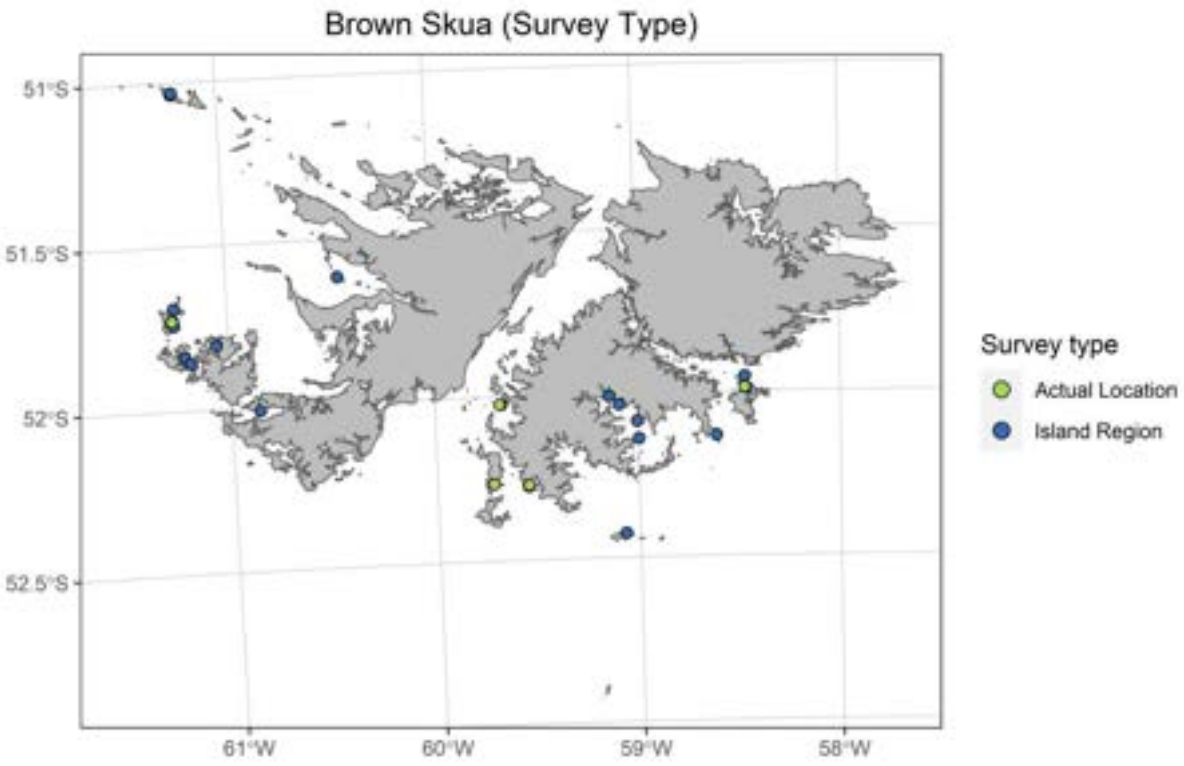
KBA Criteria for assessment: D1a (Demographic aggregations)

Brown Skuas have received less attention in monitoring efforts throughout the years at the Falkland Islands. Hence, several records indicative of breeding birds relate to presence only records. We use only the abundance records for further analysis.



Where Actual Location records were present for Brown Skuas, some of these related to transects conducted on various islands. Therefore, where transect data were present, the total number of birds was first calculated for each Island Region where Actual Locations were present. This allowed us to estimate an abundance estimate for each Island Region.

Given this species nests in loose aggregations over an area as opposed to tightly clustered colonies, we selected only those Island Regions with abundance estimates ≥1% of the global population given this species is being assessed against KBA Criterion D1a (Demographic aggregations).

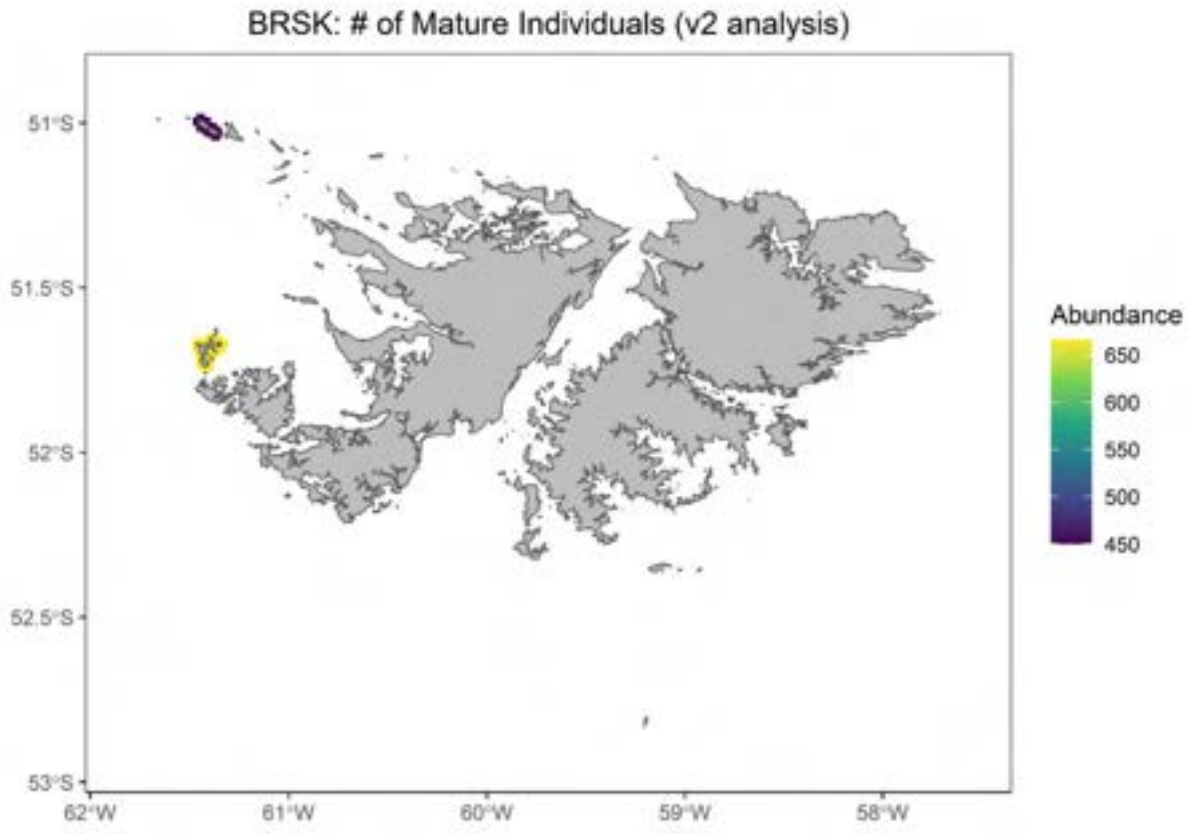


For each of the selected Island Region locations that hosted ≥1% of the global population, we delineated conservative buffers of 2kms around each island. This conservative buffer was set in alignment with the smallest buffer set for a species in the study where tracking data was available from the Falkland Islands; specifically, based on the 2km buffer set for Rock Shags (see above).

Furthermore, this conservative buffer was set because while birds likely do range further from a respective breeding location, as volant scavengers they generally tend to travel to a particular location (which could also be on land) and forage there, as opposed to searching the surrounding marine area for food. The adjacent marine area that the 2km buffer represents is of the area typically used for preening and bathing. Brown Skuas also engage in mobbing behaviours on other returning seabirds.

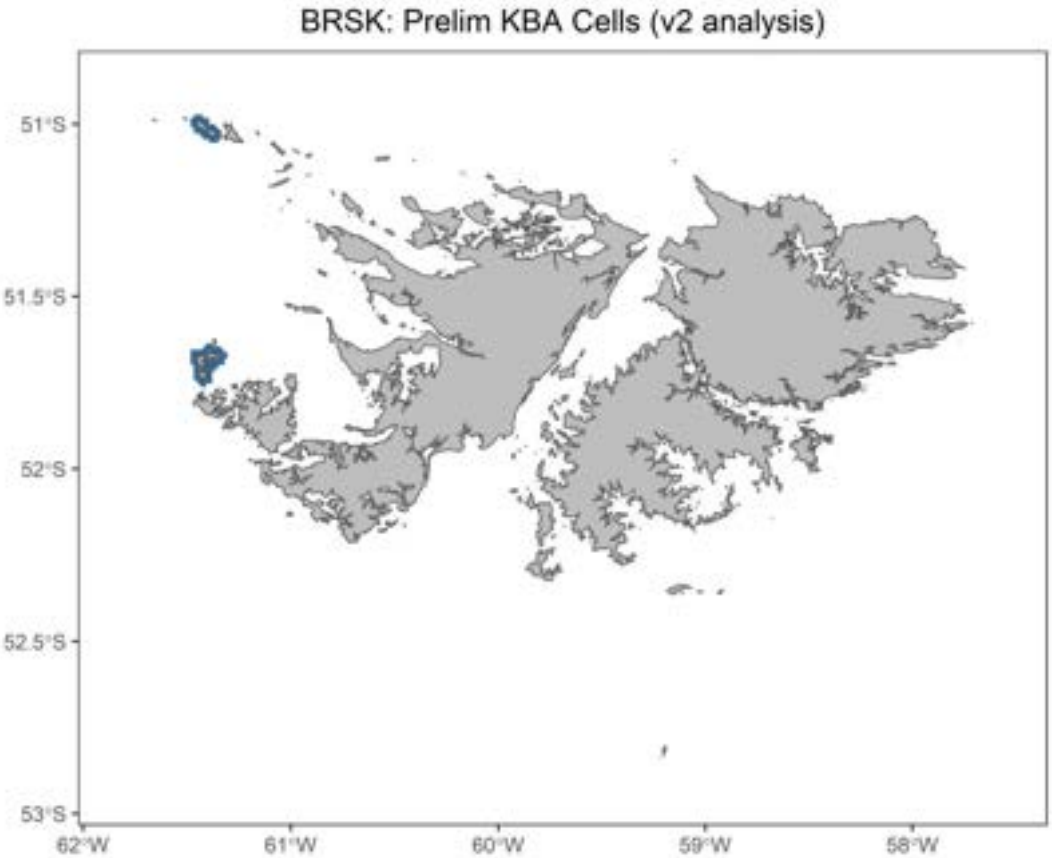
Based on the collated records, the estimated maximum number of mature individuals is up to 666 mature individuals (breeding pairs x 2) utilising waters around specific BRSK breeding islands which host ≥1% of the global population.

Given the global population estimate for this species is 27,000 mature individuals, and the KBA criterion we are assessing cells against is KBA criterion D1a, cells that would meet the criterion are those with ≥ 270 mature individuals (i.e. ≥1% of the global population)

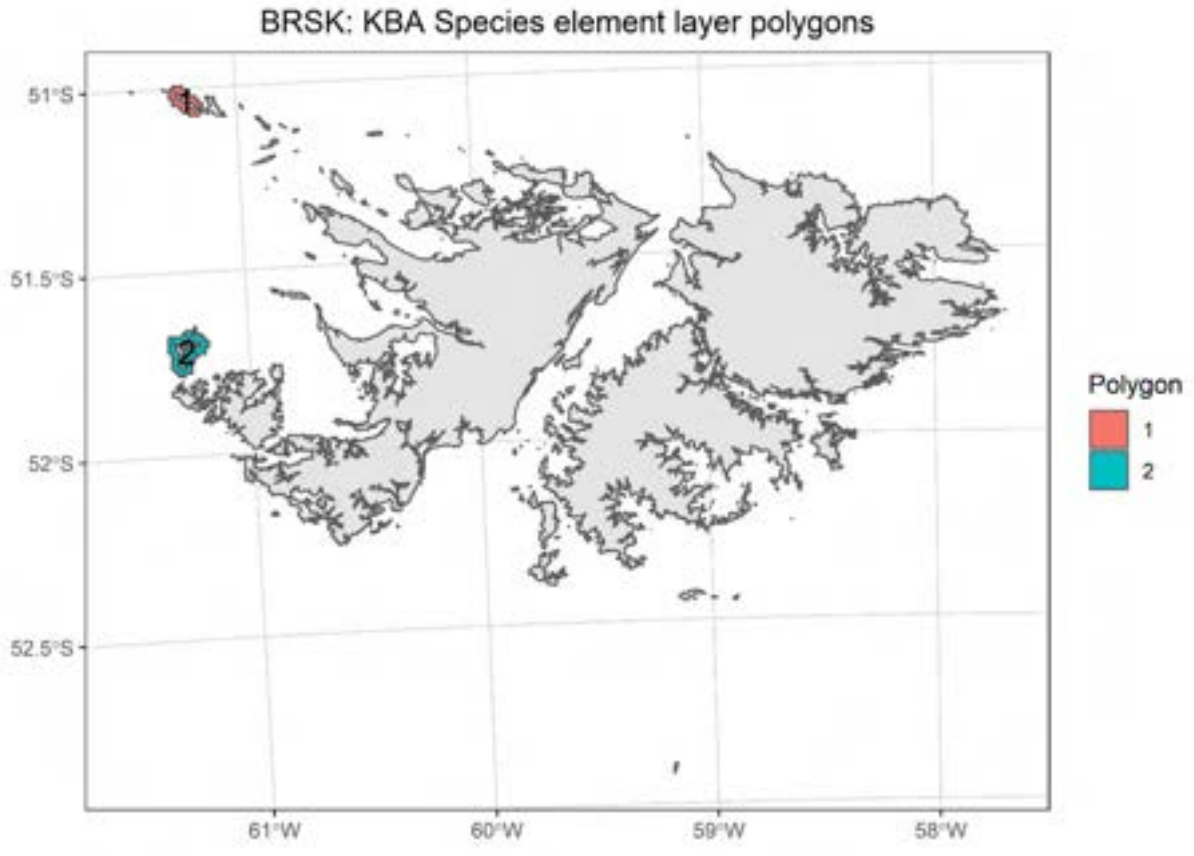


We propose these areas (in blue) as a KBA for Brown Skuas under criterion D1a (Demographic aggregations), given these areas are estimated to have a minimum abundance estimate of ≥1% of the global population (≥ 270 mature individuals for BRSK) during the breeding period.

As per the KBA guidelines: These areas predictably hold aggregations of Brown Skua during the breeding period on a seasonal basis. While these bird feed on a variety of marine and terrestrial resources, the birds rely on adjacent marine areas for preening and bathing. During the breeding period, areas around key breeding areas have highly localised relative abundance, two or more orders of magnitude larger than the species' average recorded numbers or densities at other stages during its life-cycle (i.e. the non-breeding period) (Phillips et al., 2007; Carneiro et al., 2015)**. Furthermore, in the context of the inshore environment of the Falkland Islands, these areas are considered as 'manageable units' that would require appropriate management actions to support the persistence of the identified KBAs for this species.**



The figure and table below show unique KBA polygons per species specific KBA element layers. Tabular data indicates which at-sea density distribution surfaces from specific colonies (or breeding regions where appropriate – see methods) contributed to the area meeting KBA criteria D1 in each specific polygon.



A: for those records where minimum number (#) of mature individuals is zero, this indicates that the at-sea density distribution from a given colony only partially overlapped the final area meeting KBA criteria. Additionally, where a minimum population estimates is the same as the maximum population estimate these counts show where a best count only was available to delineate the final KBA area.

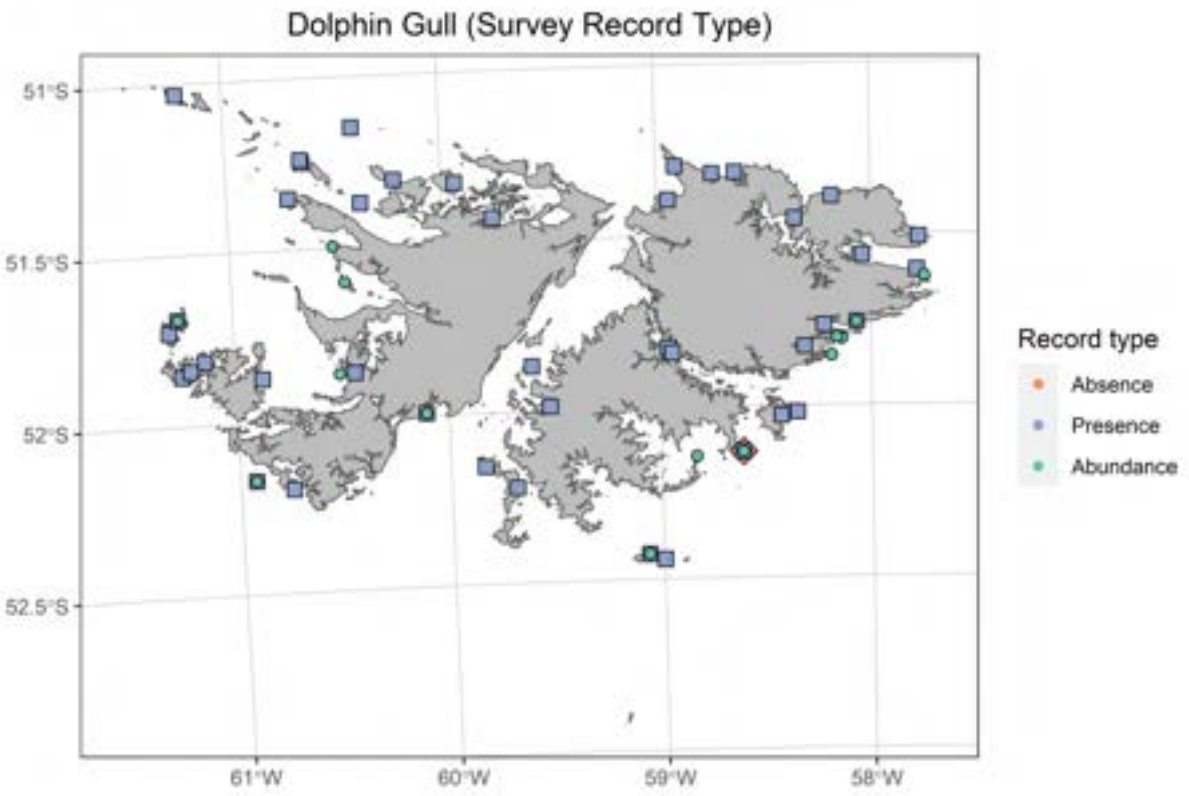
Unique KBA Polygon for species KBA element layer	Species (By code – see Table 1)	Unique Site Name	Year of Count	Minimum # mature individuals [A]	Maximum # mature individuals
1	BRSK	Steeple Jason	2019	450	450
2	BRSK	New Island	2009	666	666

DOGU – Dolphin Gulls

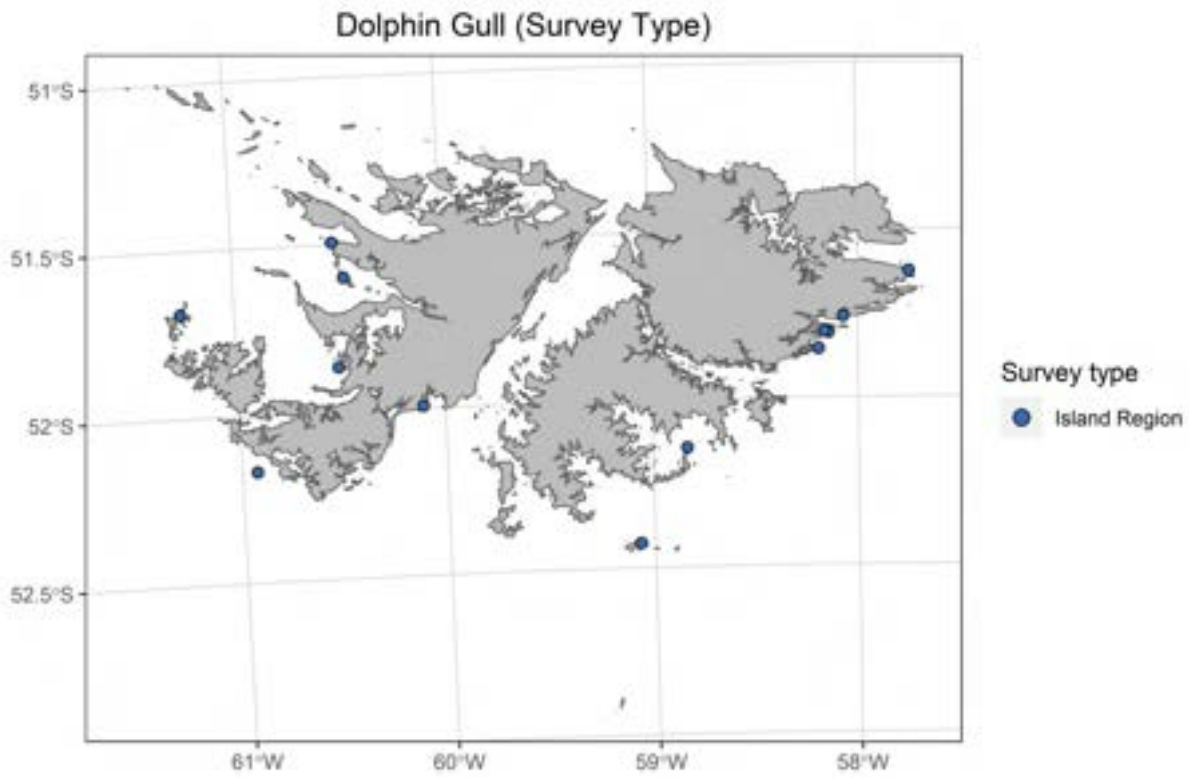
Red List Status: LC

KBA Criteria for assessment: D1a (Demographic aggregations)

Dolphin Gulls have received less attention in monitoring efforts throughout the years at the Falkland Islands. Hence, several records indicative of breeding birds relate to presence only records. We use only the abundance records for further analysis.



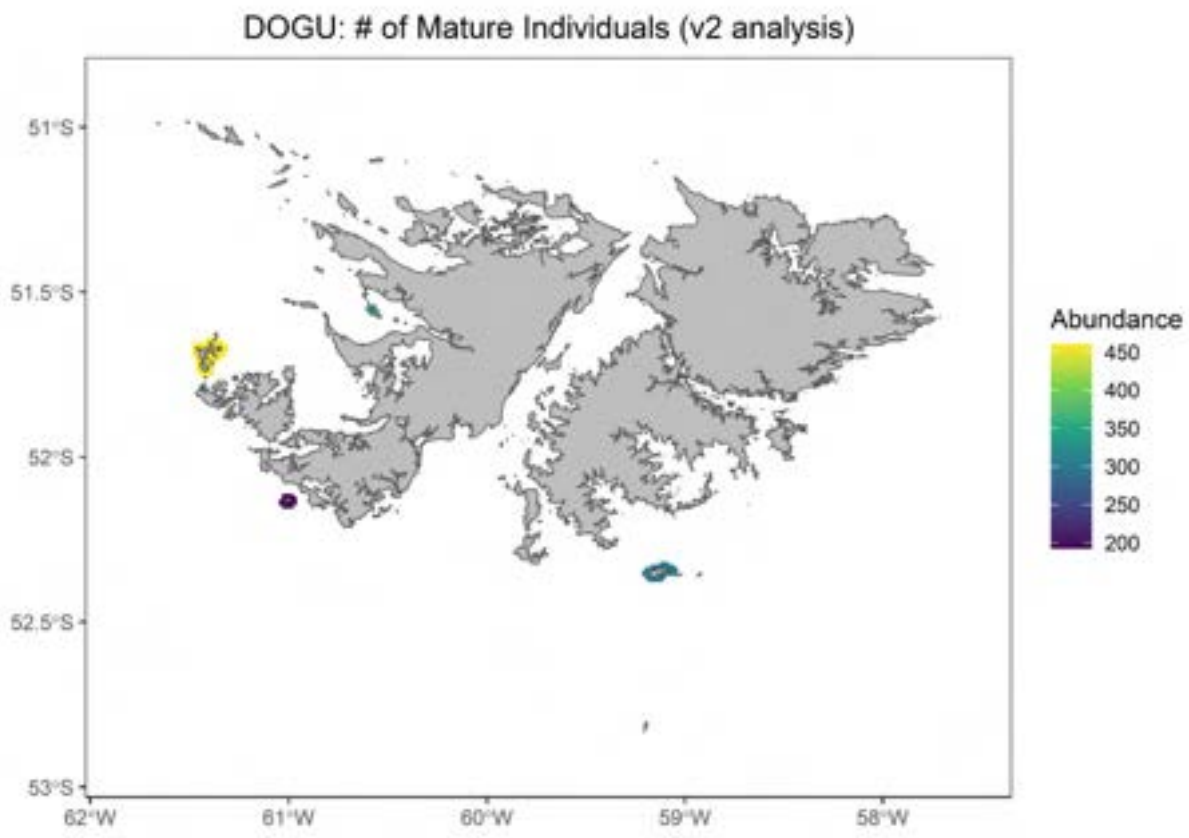
Abundance records for Dolphin Gulls only related to Island Region survey types. We selected only those Island Regions with abundance estimates ≥1% of the global population given this species is being assessed against KBA Criterion D1a (Demographic aggregations).



For each of the selected Island Region locations that hosted ≥1% of the global population, we delineated conservative buffers of 2kms around each island. This conservative buffer was set in alignment with the smallest buffer set for a species in the study where tracking data was available from the Falkland Islands; specifically, based on the 2km buffer set for Rock Shags (see above). Furthermore, this conservative buffer was set because while birds likely do range further from a respective breeding location (Masello et al., 2013), as volant scavengers they generally tend to travel to a particular location (which could also be on land) and forage there, as opposed to searching the surrounding marine area for food. The adjacent marine area that the 2km buffer represents is of the area typically used for preening and bathing.

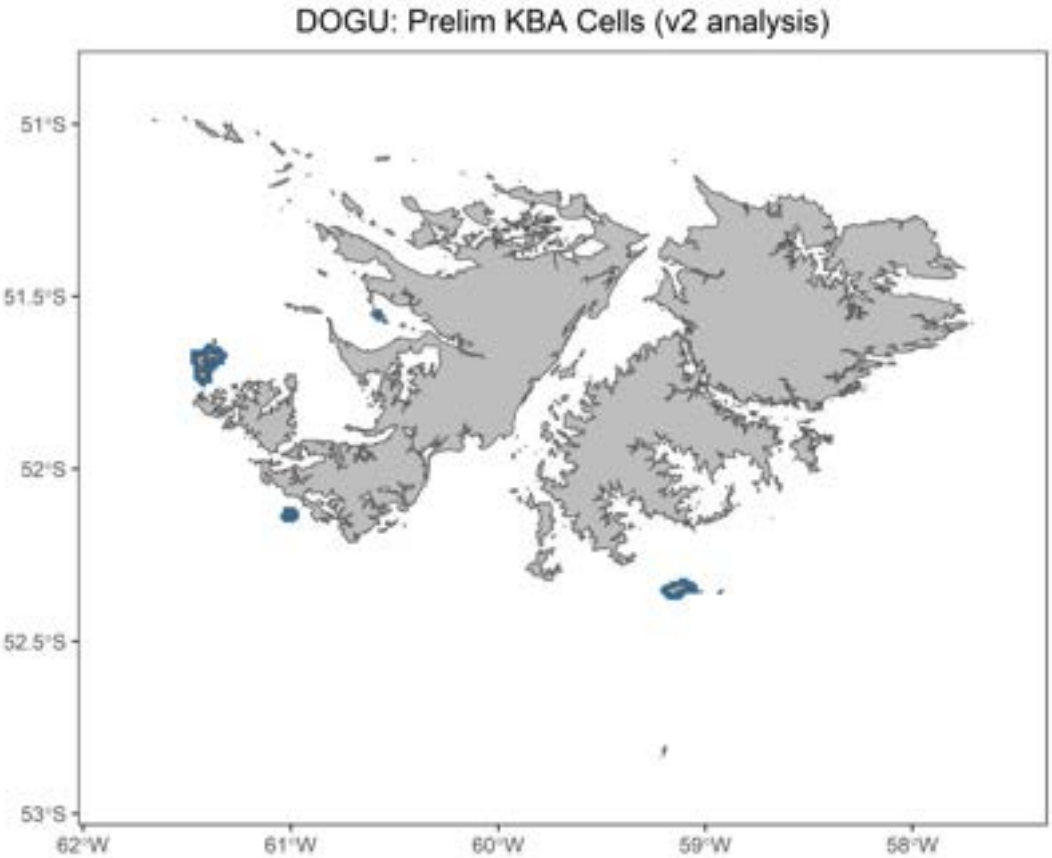
Given the global population estimate for this species is 12,900 mature individuals, and the KBA criterion we are assessing cells against is KBA criterion D1a, cells that would meet the criterion are those with ≥ 129 mature individuals (i.e. ≥1% of the global population)

Based on the collated records, the estimated maximum number of mature individuals is up to 460 mature individuals (breeding pairs x 2) utilising waters around specific DOGU breeding islands which host ≥1% of the global population.

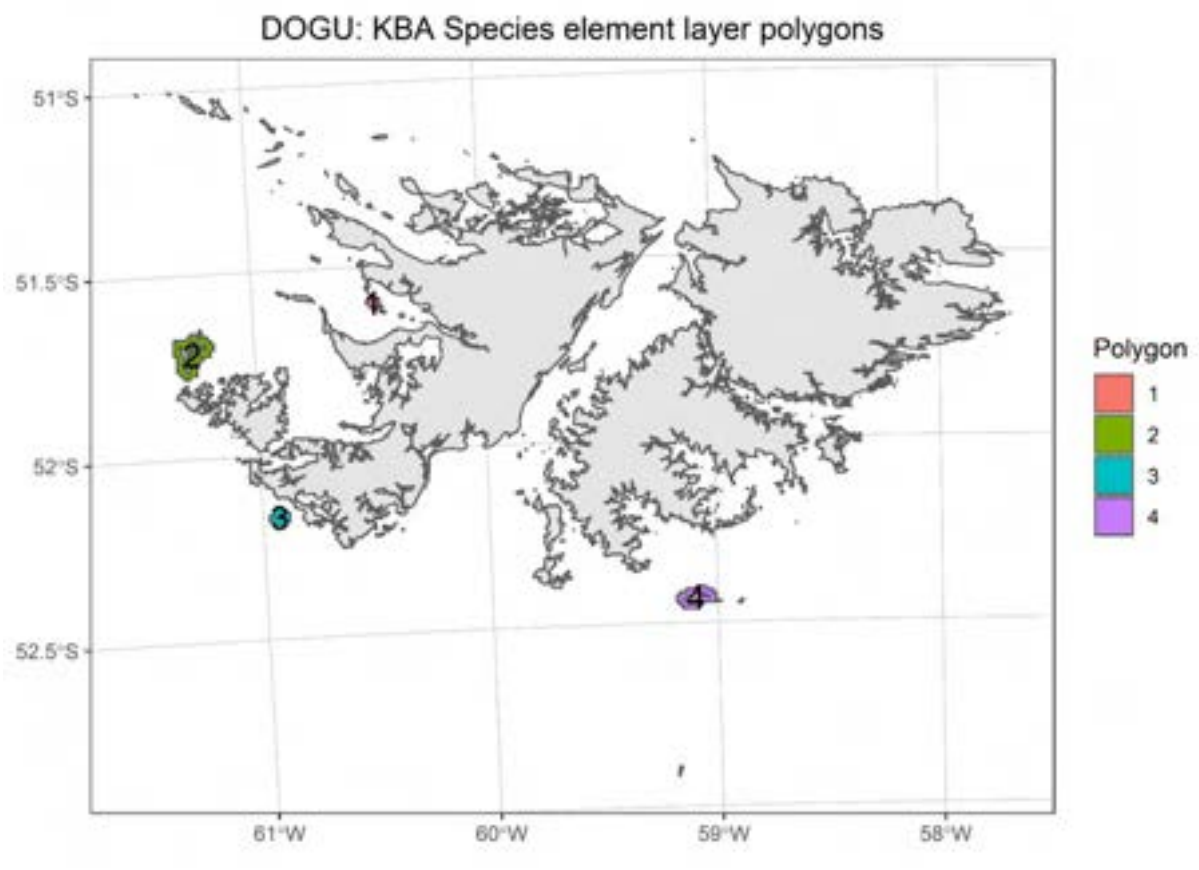


We propose these areas (in blue) as a KBA for Dolphin Gulls under criterion D1a (Demographic aggregations), given these areas are estimated to have a minimum abundance estimate of ≥1% of the global population (≥ 129 mature individuals for DOGU) during the breeding period.

As per the KBA guidelines: These areas predictably hold aggregations of Dolphin Gulls during the breeding period on a seasonal basis. While these bird feed on a variety of marine and terrestrial resources, the birds rely on adjacent marine areas for preening and bathing. During the breeding period, areas around key breeding areas have highly localised relative abundance, two or more orders of magnitude larger than the species' average recorded numbers or densities at other stages during its life-cycle (i.e. the non-breeding period) (Masello et al., 2013; Stanworth, 2019)**. Furthermore, in the context of the inshore environment of the Falkland Islands, these areas are considered as 'manageable units' that would require appropriate management actions to support the persistence of the identified KBAs for this species.**



The figure and table below show unique KBA polygons per species specific KBA element layers. Tabular data indicates which at-sea density distribution surfaces from specific colonies (or breeding regions where appropriate – see methods) contributed to the area meeting KBA criteria D1 in each specific polygon.



A: for those records where minimum number (#) of mature individuals is zero, this indicates that the at-sea density distribution from a given colony only partially overlapped the final area meeting KBA criteria. Additionally, where a minimum population estimates is the same as the maximum population estimate these counts show where a best count only was available to delineate the final KBA area.

Unique KBA Polygon for species KBA element layer	Species (By code – see Table 1)	Unique Site Name	Year of Count	Minimum # mature individuals [A]	Maximum # mature individuals
1	DOGU	Hummock Islet	2019	320	320
2	DOGU	New Island	2015	460	460
3	DOGU	Bird Island	2018	192	192
4	DOGU	Sea Lion Island	2019	300	300

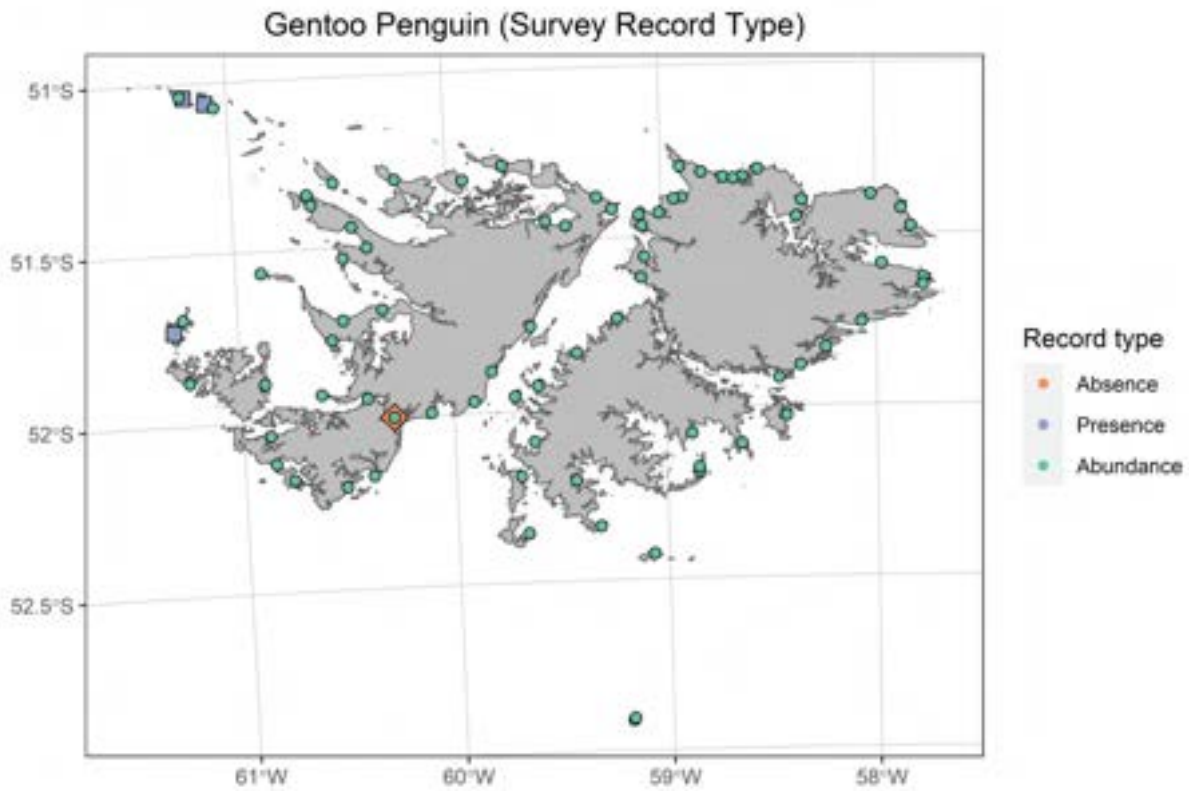
3. Mean-maximum foraging radius buffers.

GEPE – Gentoo Penguins

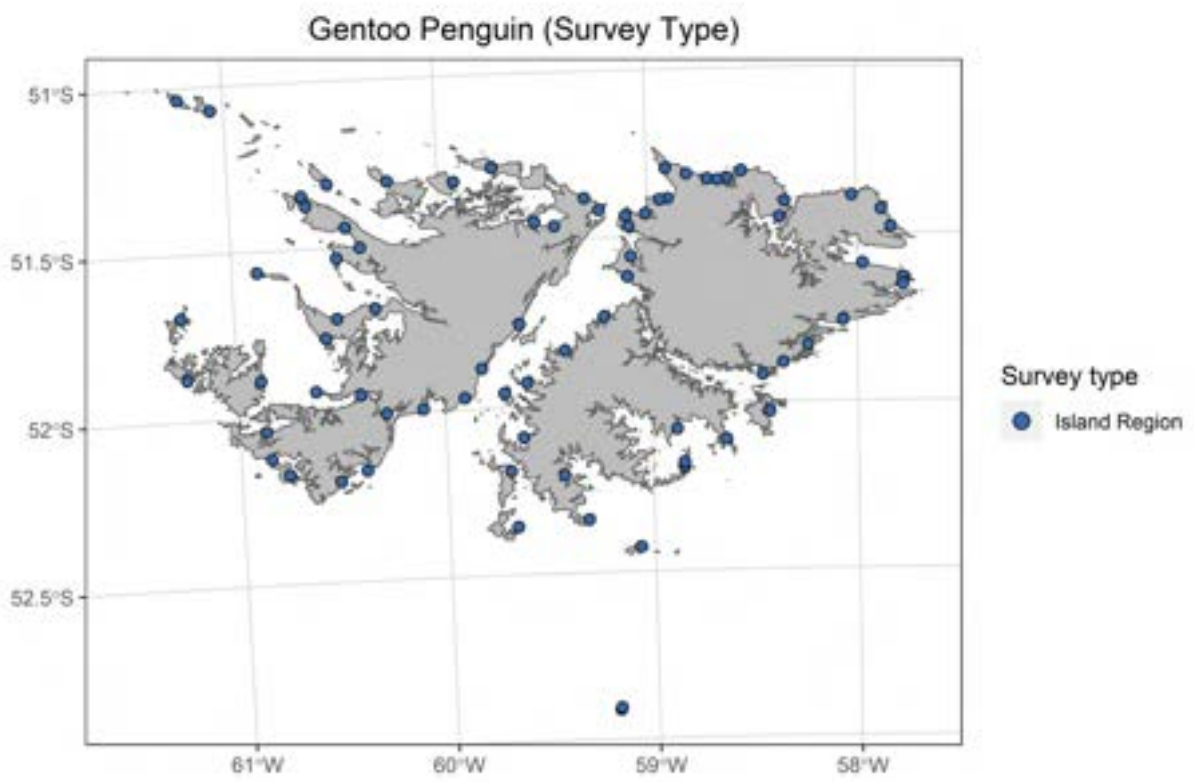
Red List Status: LC

KBA Criteria for assessment: D1a (Demographic aggregations)

Gentoo penguins are well monitored across the Falkland Islands, hence nearly all records are Abundance records. We used these abundance records only.



Regarding survey types, while many records likely relate to Actual Locations of colonies, the avaialble data is represented as records indicateve at the Island Region scale. For example, Steeple Jason island is represented by a single Island Region location, however, there are several unique colonies on this island.



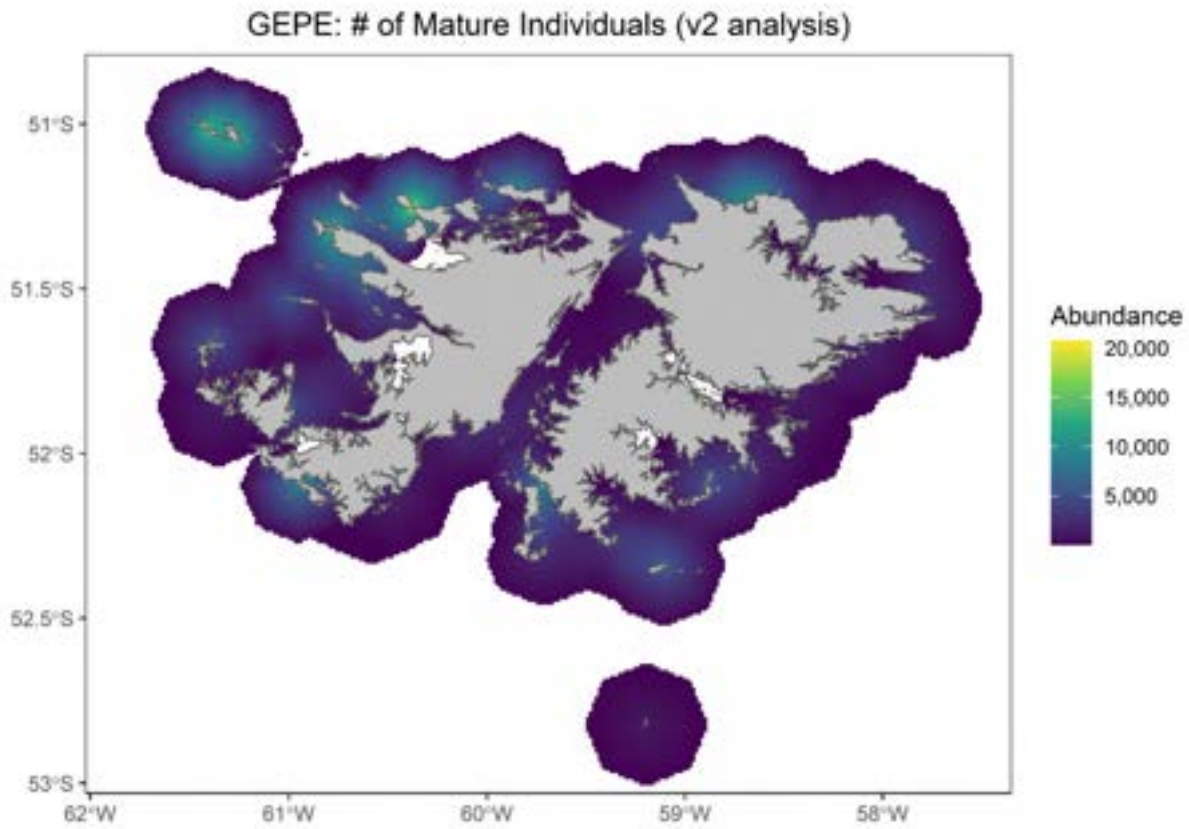
Using the mean-maximum foraging radius approach, as has been recently applied to breeding seabirds in the United Kingdom (Critchley et al., 2018) and Antarctica (Handley et al., 2021) we estimated the distribution of birds from a source colony out to a

- specified buffer distance of 21km,
- where the buffer distance is based on the mean maximum distance travelled by birds based on reported and published literature from other tracking studies at the Falkland Islands (Table 7).

We preferentially weighted those cells closest to the source colony, which means that these cells represent the areas likely used by a higher percentage of the source population. The density distribution surfaces from each colony were summed; providing a Falklands-wide estimate of at-sea abundance.

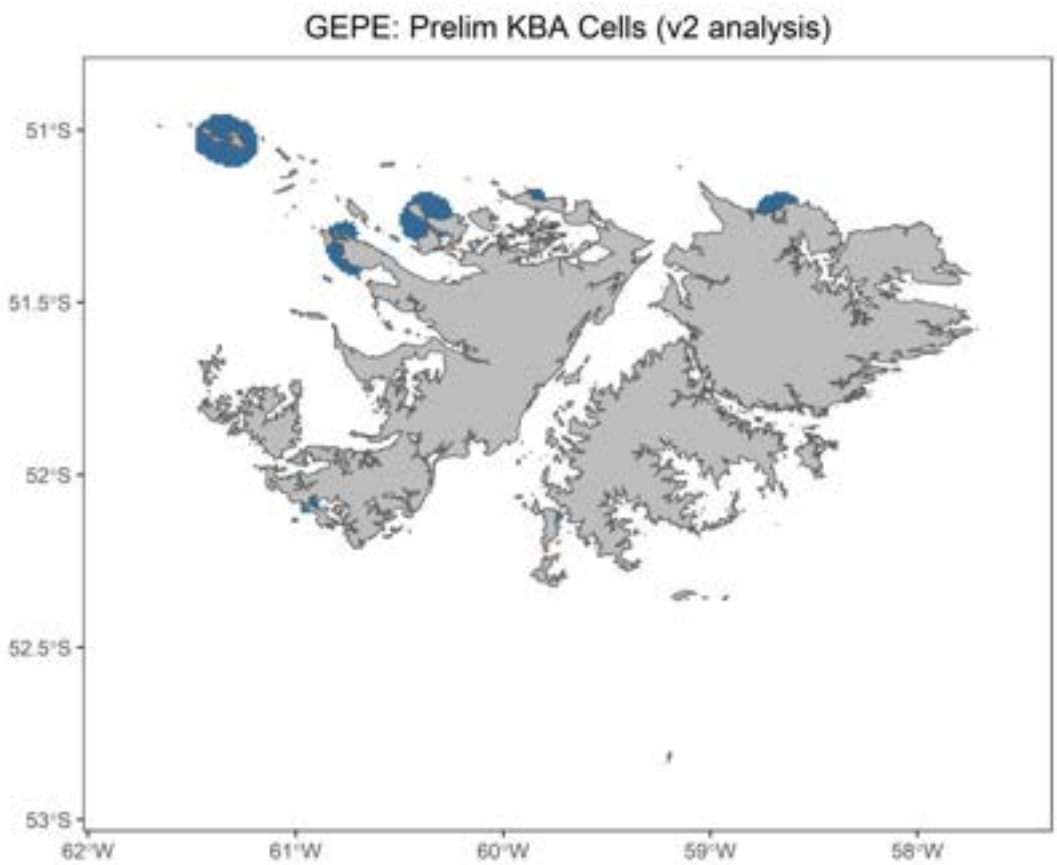
Based on the collated records and estimates of distribution from all colonies, the estimated maximum number of mature individuals for a given cell is 20,734 mature individuals (breeding pairs x 2).

Given the global population estimate for this species is 774,000 mature individuals, and the KBA criterion we are assessing cells against is KBA criterion D1a, cells that would meet the criterion are those with ≥ 7,740 mature individuals (i.e. ≥1% of the global population)

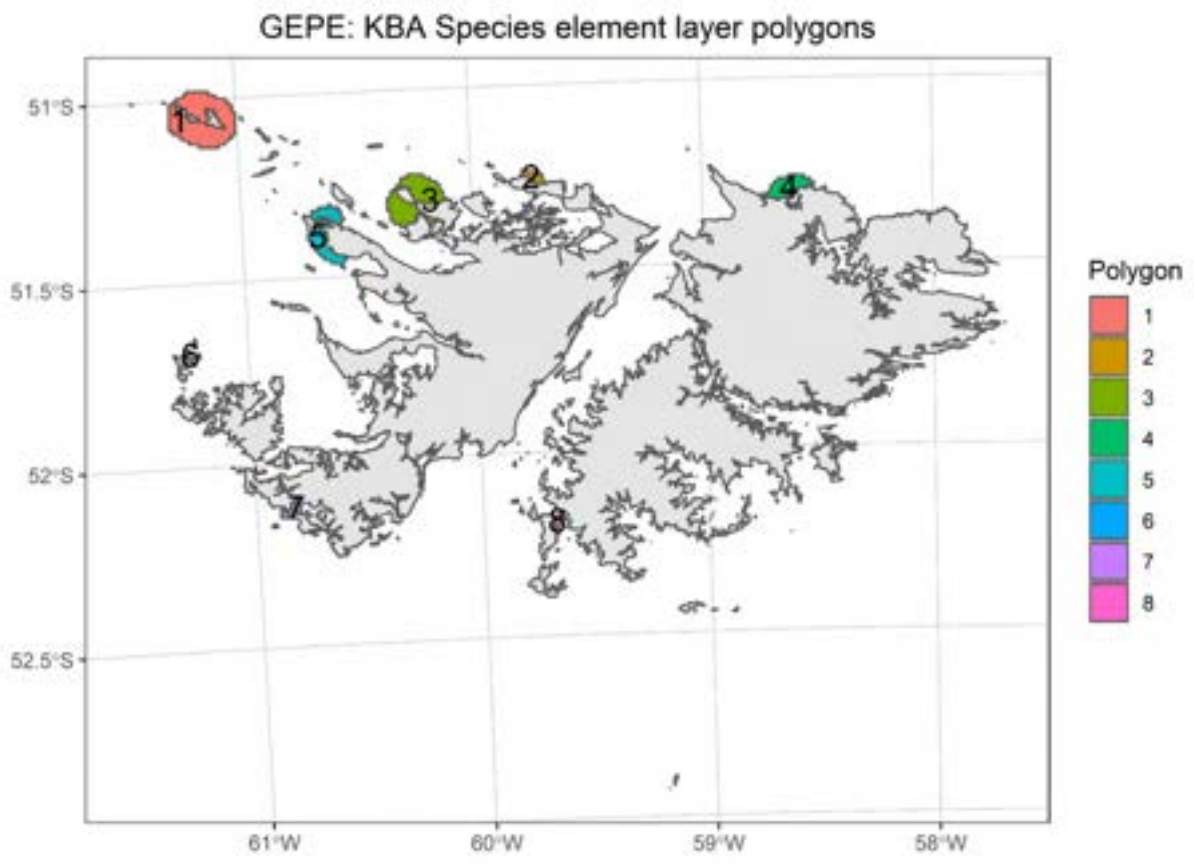


We propose these areas (in blue) as a KBA for Gentoo Penguins under criterion D1a (Demographic aggregations), given these areas are estimated to have a minimum abundance estimate of ≥1% of the global population (≥ 7,740 mature individuals for GEPE) during the breeding period.

As per the KBA guidelines: These areas predictably hold aggregations of Gentoo Penguins during the breeding period on a seasonal basis. The layer is reflective of the area likely used by birds simultaneously on a daily basis during parts of the breeding period. Given the limited foraging range of this species during the breeding period, those areas which include foraging activities are considered as 'manageable units' with respect to the inshore environment of the Falkland Islands. Furthermore given the limited foraging range of this species during the breeding period (Baylis et al., 2019) **compared to the winter** (Baylis et al., 2021b)**, the areas identified have highly localised relative abundance, two or more orders of magnitude larger than the species' average recorded numbers or densities at other stages during its life-cycle (i.e. the non-breeding period).**



The figure and table below show unique KBA polygons per species specific KBA element layers. Tabular data indicates which at-sea density distribution surfaces from specific colonies (or breeding regions where appropriate – see methods) contributed to the area meeting KBA criteria D1 in each specific polygon.



A: for those records where minimum number (#) of mature individuals is zero, this indicates that the at-sea density distribution from a given colony only partially overlapped the final area meeting KBA criteria. Additionally, where a minimum population estimates is the same as the maximum population estimate these counts show where a best count only was available to delineate the final KBA area.

Unique KBA Polygon for species KBA element layer	Species (By code – see Table 1)	Unique Site Name	Year of Count	Minimum # mature individuals [A]	Maximum # mature individuals
1	GEPE	Steeple Jason	2019	1255	13200
1	GEPE	Grand Jason Island	2010	563	10668
2	GEPE	Pebble Island	2010	6821	13992
2	GEPE	Keppel Island	2010	121	1150
3	GEPE	Saunders Island	2010	7350	20716
3	GEPE	Keppel Island	2010	10	458
3	GEPE	Carcass Island	2010	3	294
4	GEPE	Lion Point + limpet creek	2010	1942	8264
4	GEPE	Moss Side (North Pond)	2010	25	1066
4	GEPE	Concordia	2010	2004	4646
4	GEPE	Elephant Beach (little creek)	2010	139	728
4	GEPE	Lorenzo Pond	2010	710	2736

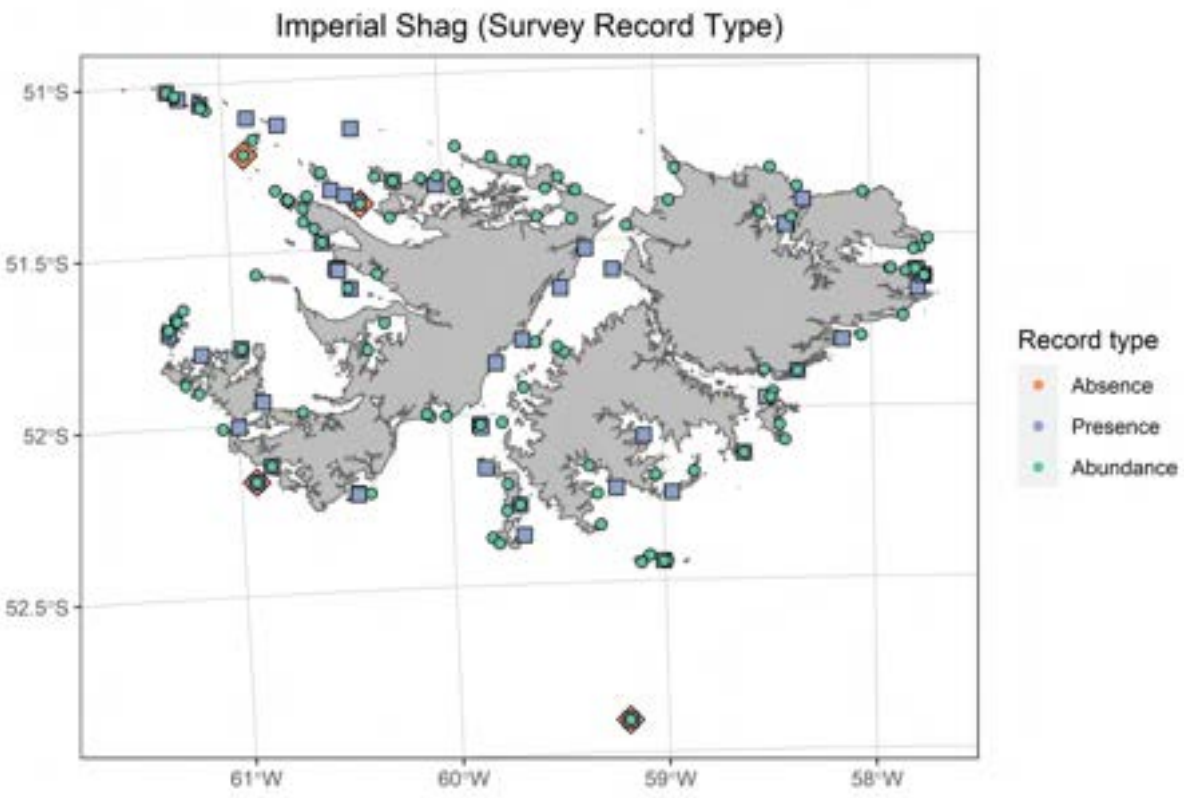
4	GEPE	Brazo del Mar	2010	31	31
5	GEPE	Carcass Island	2010	3	636
5	GEPE	Hope/Bramble Point	2010	215	1696
5	GEPE	Grave Cove	2010	3024	14058
5	GEPE	Stevelly Bay	2010	12	2457
5	GEPE	Port North (Sand Grass)	2010	0	277
5	GEPE	Whaler bay	2010	5	2153
6	GEPE	New Island	2010	8862	8862
7	GEPE	Stephens Peak (&Indian Village)	2010	7861	12022
7	GEPE	Ten Shilling Bay	2010	46	100
8	GEPE	Moffit Harbour	2010	9	35
8	GEPE	Speedwell Island	2010	7519	11026
8	GEPE	Barren Island	2010	65	405

IMSH – Imperial Shag

Red List Status: LC

KBA Criteria for assessment: D1a (Demographic aggregations)

Imperial shags have received less attention in monitoring efforts throughout the years at the Falkland Islands. Hence, several records indicative of breeding birds relate to presence only records. We use only the abundance records for further analysis.

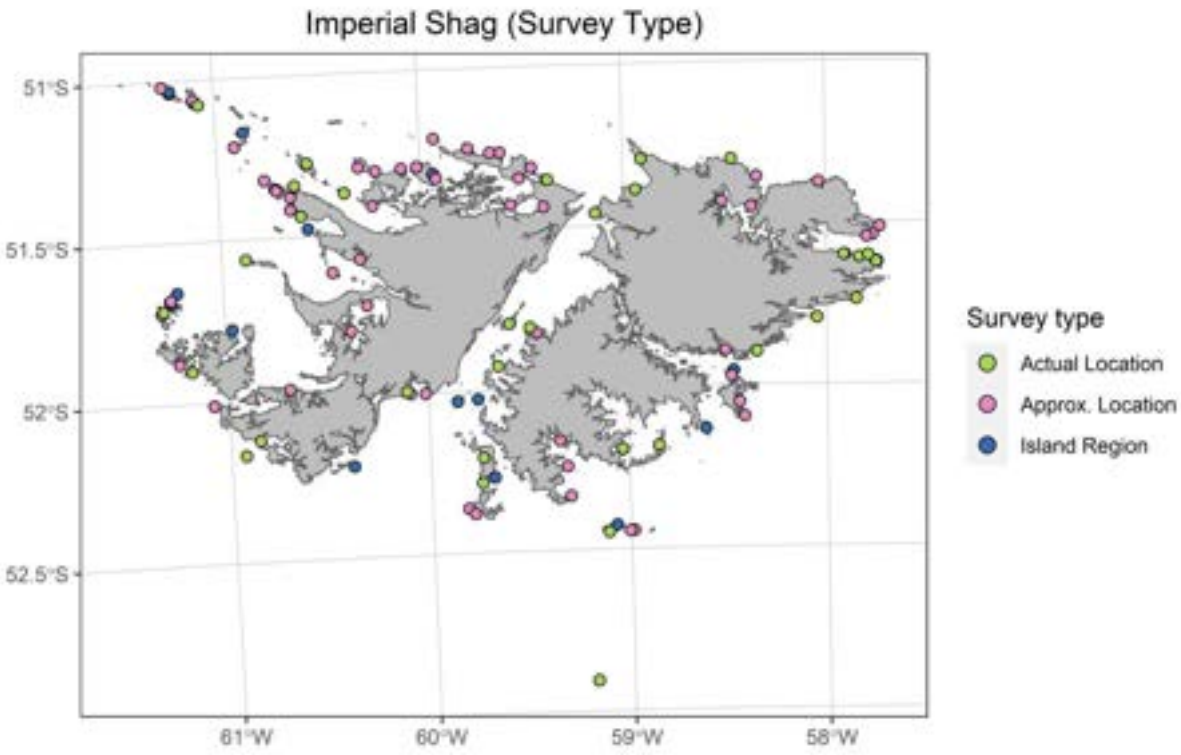


Where abundance records were available, several different types of survey records were present. To account for these different types of records and to ensure that we avoided double counting, all locations that had an Island Region location AND either an Actual Location OR Approx. Location, were filtered to remove the Island Region location and keep the more specific colony record instead.

For example: Records for Saunders Island include:

- **Approx. Location:** Saunders Island - Rame Head
- **Approx. Location:** Saunders Island - The Neck
- **Approx. Location:** Saunders Island – Cliff Point
- **Approx. Location:** Saunders Island – Holy City
- **Island Region:** Saunders Island

Therefore, the Island Region record for the whole of Saunders Island was removed for the analysis and the four more specific colony records were kept.



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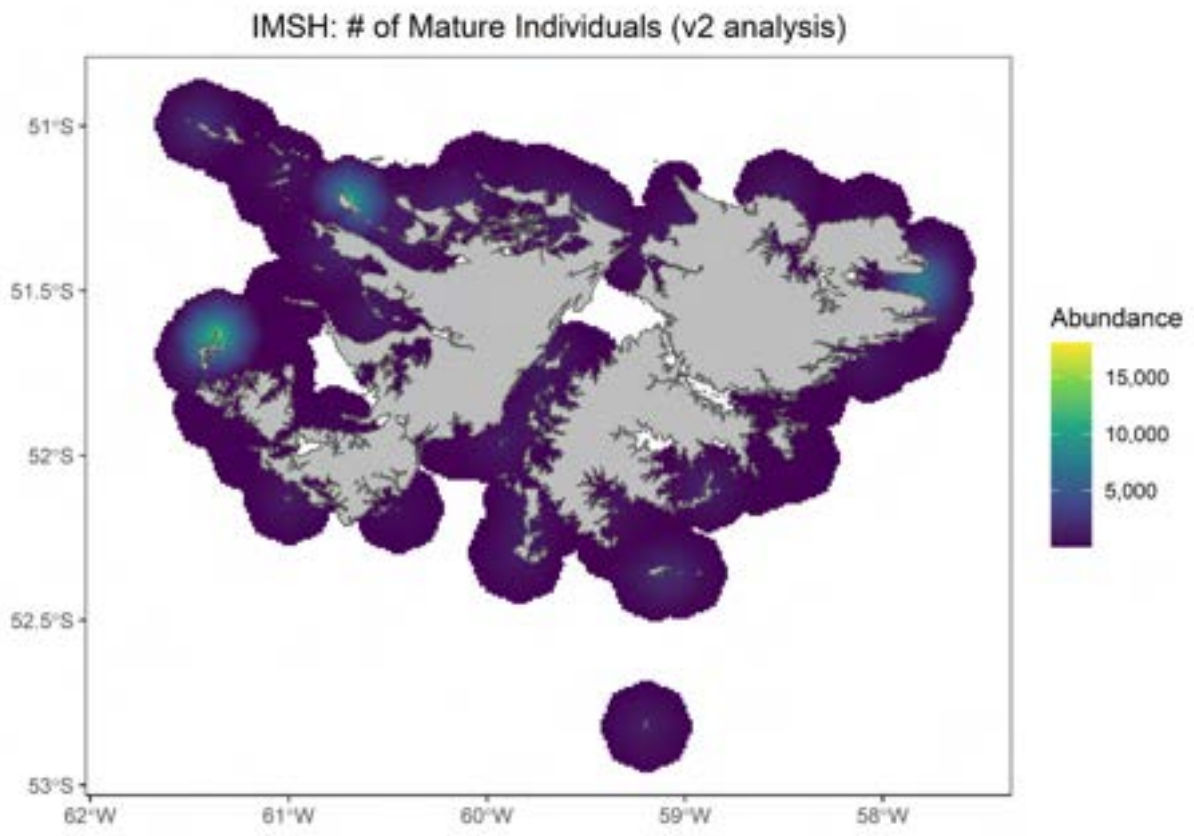
Using the mean-maximum foraging radius approach, as has been recently applied to breeding seabirds in the United Kingdom (Critchley et al., 2018) and Antarctica (Handley et al., 2021) we estimated the distribution of birds from a source colony out to a

- specified buffer distance of 16km,
- where the buffer distance is based on the mean maximum distance travelled by birds based on reported and published literature from other tracking studies at the Falkland Islands (Table 7).

We preferentially weighted those cells closest to the source colony, which means that these cells represent the areas likely used by a higher percentage of the source population. The density distribution surfaces from each colony were summed; providing a Falklands-wide estimate of at-sea abundance.

Based on the collated records and estimates of distribution from all colonies, the estimated maximum number of mature individuals for a given cell is 18,004 mature individuals (breeding pairs x 2).



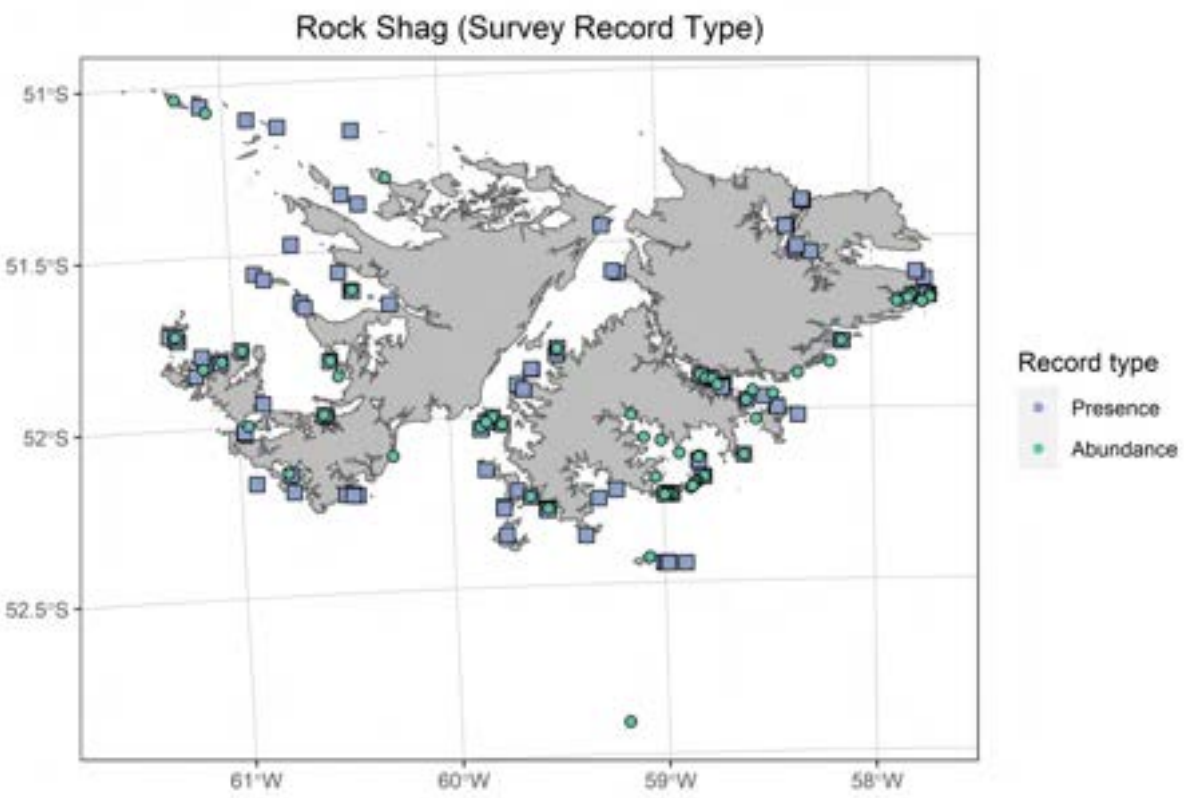
Given there is no global population estimate of mature individuals for Imperial Shags, we were unable to consider which cells might meet KBA Criterion D1a ('Demographic aggregations) for birds during the breeding period

ROSH – Rock Shags

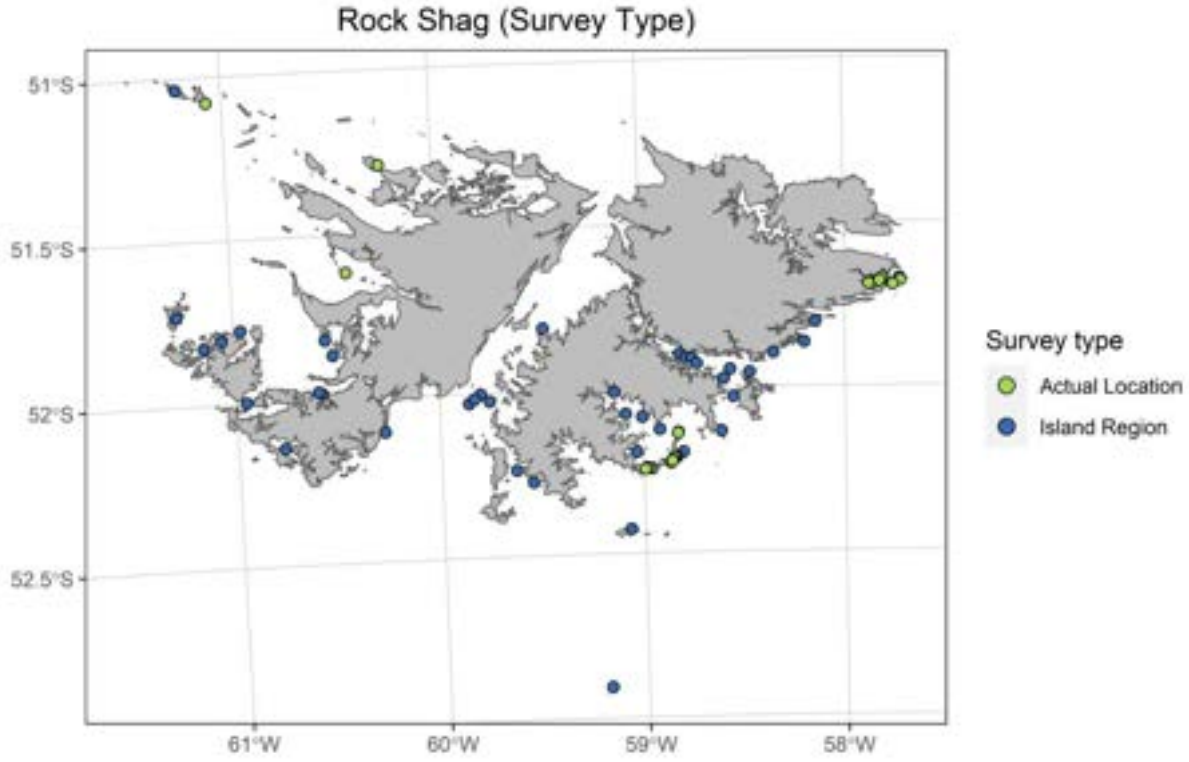
Red List Status: LC

KBA Criteria for assessment: D1a (Demographic aggregations)

Rock shags have received less attention in monitoring efforts throughout the years at the Falkland Islands. Hence, several records indicative of breeding birds relate to presence only records. We use only the abundance records for further analysis.



Similarly to Imperial Shags, where abundance records were available, several different types of survey records were present. To account for these different types of records and to ensure that we avoided double counting, all locations that had an Island Region location AND an Actual Location, were filtered to remove the Island Region location and keep the more specific colony record instead (See Imperial Shag KBA overview for an example).

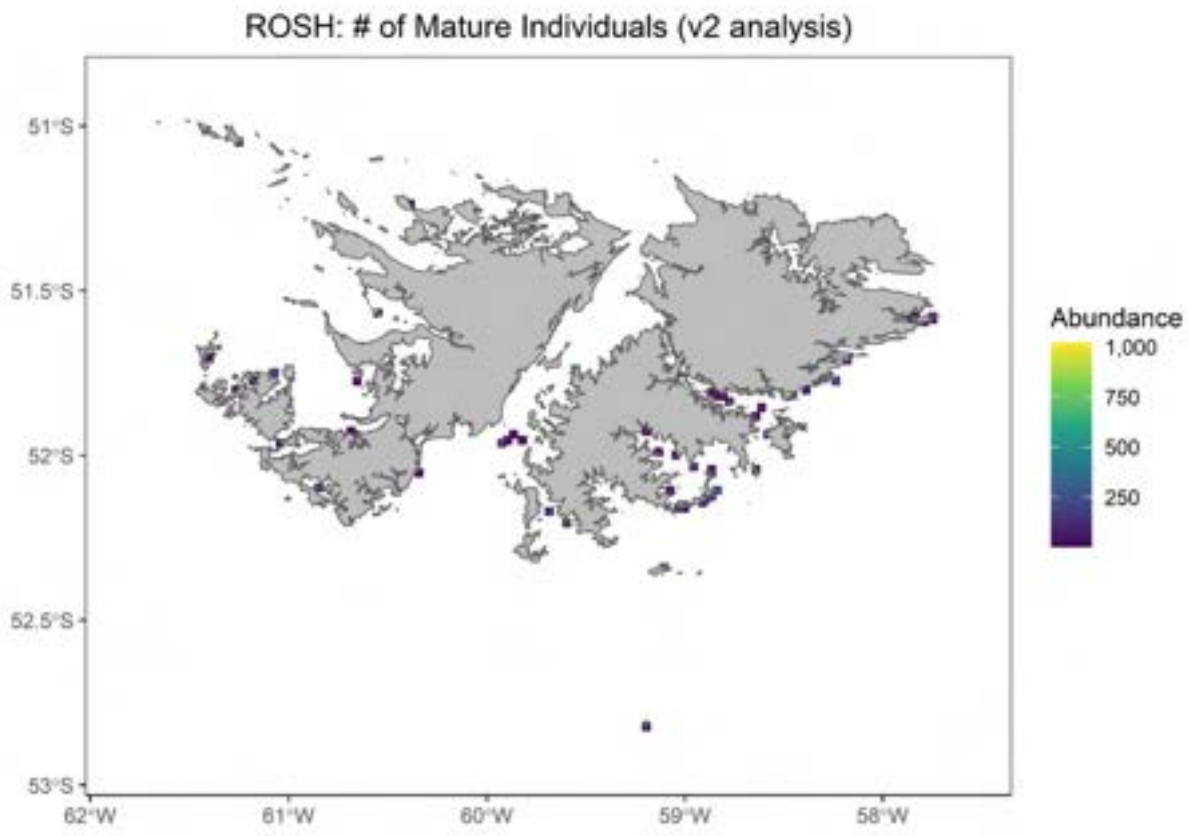


Using the mean-maximum foraging radius approach, as has been recently applied to breeding seabirds in the United Kingdom (Critchley et al., 2018) and Antarctica (Handley et al., 2021) we estimated the distribution of birds from a source colony out to a

- specified buffer distance of 2km,
- where the buffer distance is based on the mean maximum distance travelled by birds based on reported and published literature from other tracking studies at the Falkland Islands (Table 7).

We preferentially weighted those cells closest to the source colony, which means that these cells represent the areas likely used by a higher percentage of the source population. The density distribution surfaces from each colony were summed; providing a Falklands-wide estimate of at-sea abundance.

Based on the collated records and estimates of distribution from all colonies, the estimated maximum number of mature individuals for a given cell is 1,020 mature individuals (breeding pairs x 2).



Given there is no global population estimate of mature individuals for Rock Shags, we were unable to consider which cells might meet KBA Criterion D1a ('Demographic aggregations) for birds during the breeding period.

Appendices

Appendix 1: KBAs with regionally important populations

In the global analysis (Figure 4) we were unable to assess areas against KBA criteria for the two shag species (Imperial Shag and Rock Shag) which breed at the Falkland Islands given no global population estimates exist for these species (Table 7). Therefore, in addition to the global KBA analysis, we utilised Falklands wide population estimates for the two shag species and reassessed the estimated at-sea distribution data with abundance estimates (See: Results - KBA species layers) against the most recent island-wide population estimate (Woods and Woods, 1997). This analysis fosters an understanding of which areas might be considered KBAs for Imperial Shags and Rock Shags in Falklands waters and furthers our understanding of important areas throughout the islands with the inclusion of such data (Figure 5). The analysis reaffirms that the areas with highest overlap in individual species KBAs were around the Jason Islands, New Island, Bird Island and Saunders Island, and further reinforces the importance of the inshore area around the Falkland Islands for seabirds.

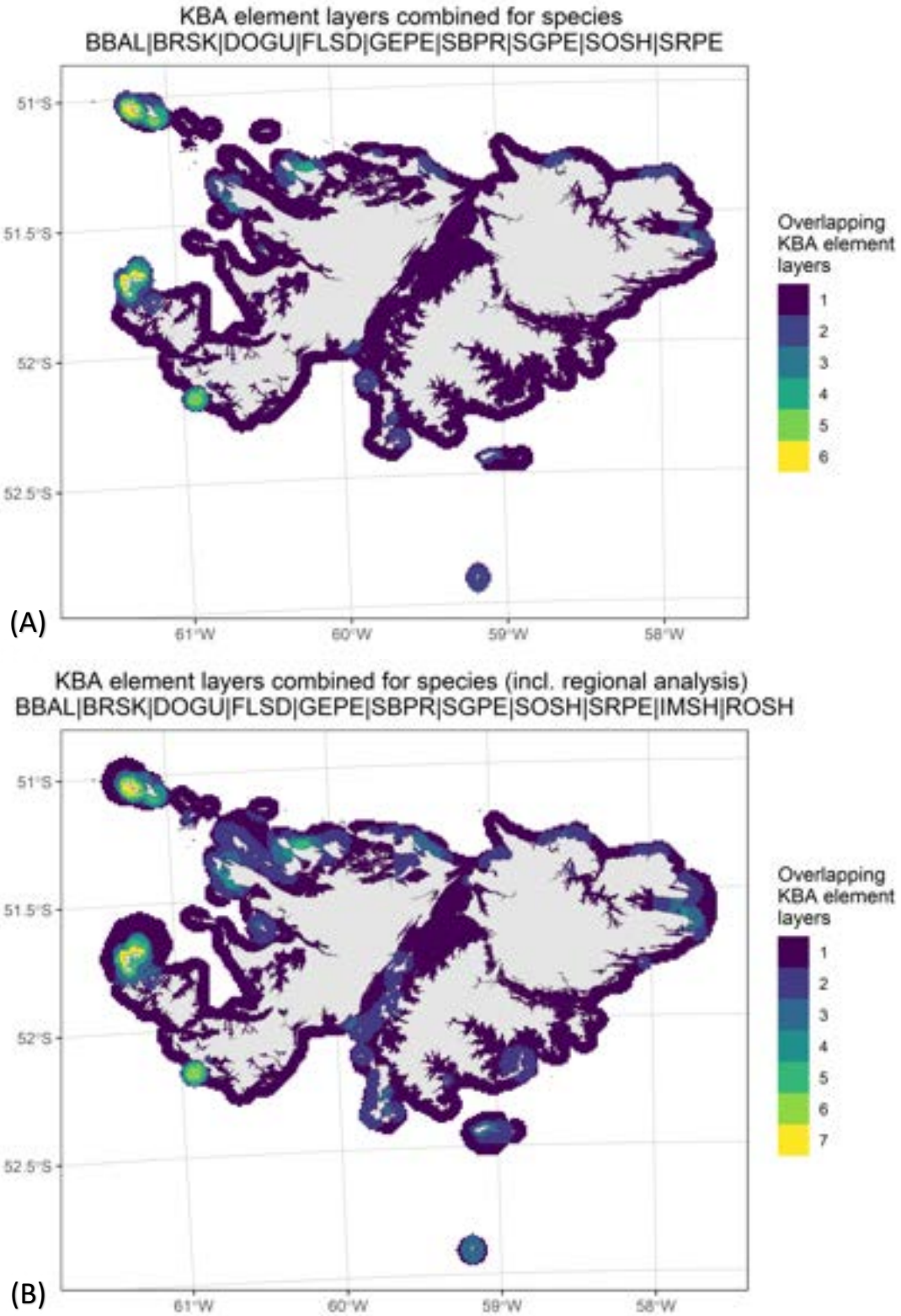


Figure 5: Overlapping KBA element layers for seabirds in the inshore environment of the Falkland Islands when comparing the element layers contributing to the (A) global KBA and (B) considering the inclusion of regionally important population estimates for Imperial Shags and King Shags, given no global population estimates for these species exist (i.e. we were unable to assess for global KBAs for these species in the final analysis). KBA element layers refer to the individual species distribution layers which had areas that met relevant KBA criteria.

Appendix 2: Future research and monitoring

To identify Key Biodiversity Areas for species in this study required two key data sources:

- population size data for individual breeding locations, and
- estimates of species at-sea distribution.

While much progress has been made regarding these two data sources for the species considered, this study highlights several areas of research that could support enhanced marine spatial planning efforts across the Falkland Islands.

Database – hosting census records for all species

The records from published and unpublished sources, the Falkland Islands Seabird Monitoring Programme (FISMP), the Falkland Islands' Biodiversity Database (FIBD) (FIG, 2013) and the Falkland Island Coastal Bird Dataset (FICBD) (Echevarría, 2020), were critical to the success of this study.

However, readily accessible data relating to population sizes and breeding location estimates collated in a single repository would have significantly enhanced our ability to perform such a review.

We suggest that population estimate and breeding location data from all past and future survey work be collated in a central repository.

Maintaining a database that includes up to date population estimates and breeding location records for all species would benefit the Falkland Islands, in that it would allow for rapid reassessments of the state of the Islands biodiversity.

Example platforms which host population size data for seabirds include the Global Seabird Data Portal and MAPPPD (Humphries et al., 2017), and these may serve as suggested templates or sources to contribute to.

Population monitoring

Population monitoring is clearly biased by numerous factors (e.g. visibility - burrowing nature of White-chinned-petrels making them hard to monitor; life-history strategies - King Penguins having staggered breeding). Nevertheless, monitoring of population sizes will greatly enhance the ability to measure indices of biodiversity and thus maintain, improve and protect species, while considering the economic opportunities of the Falkland Islands.

We suggest the continued research and development toward a Falklands wide population monitoring strategy. For some species direct census efforts may be required, for others, the use of contemporary tools for monitoring in remote locations such as acoustic monitoring, time-lapse cameras, satellite or aerial imagery, may offer solutions for obtaining these abundance (in some case likely only relative abundance) estimates in future (Walsh et al., 1995; Brownlie et al., 2020; Edney and Wood, 2021).

Species that would benefit from island wide (given incomplete abundance records) and revised (given age of records) population estimates include; Brown Skuas, Dolphin Gulls, Falkland Steamer Ducks, Imperial Shags, Magellanic Penguin, Rock Shags, Slender-billed Prions, Sooty Shearwaters.

Species distribution

Better understanding the fine-scale at-sea distribution of species recognised as requiring further data has been identified as a priority by others (Baylis et al., 2021a). We support initiatives to collect such data.

Beyond the Falkland Islands Exclusive Economic Zone

The purpose of this study was to inform marine spatial planning efforts within inshore waters of the Falkland Islands. However, while appropriate management actions at the national level are a critical first step for conserving migratory species which span jurisdictions, continued efforts to support species conservation across and beyond borders should be maintained.

Appendix 3: Survey record types for species – status and overview

There is an expected stability in the locations of the globally important sites we identified, given the conservative approach adopted to identify sites relied on breeding location data which had associated abundance records, typically collected from in-situ field observations.

However, without future research and monitoring efforts, the globally important sites identified may underrepresent the total number of globally important areas that may be present within the inshore waters of the Falkland Islands; particularly for species requiring island wide (given incomplete abundance records for all known breeding locations) or revised (given age of records) population estimates.

The key species from this study requiring further survey effort include (Figure 6, and species specific plots within appendix); Brown Skuas, Dolphin Gulls, Falkland Steamer Ducks, Imperial Shags, Magellanic Penguin, Rock Shags, Slender-billed Prions, Sooty Shearwaters.

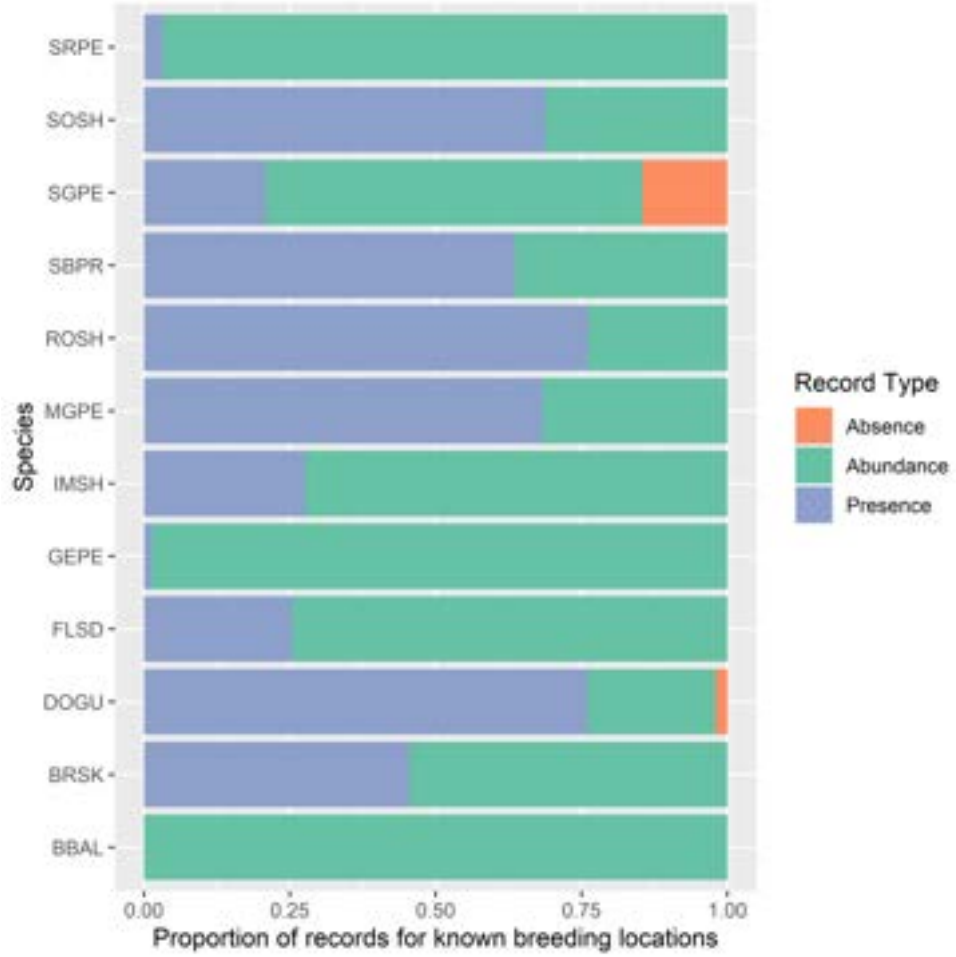
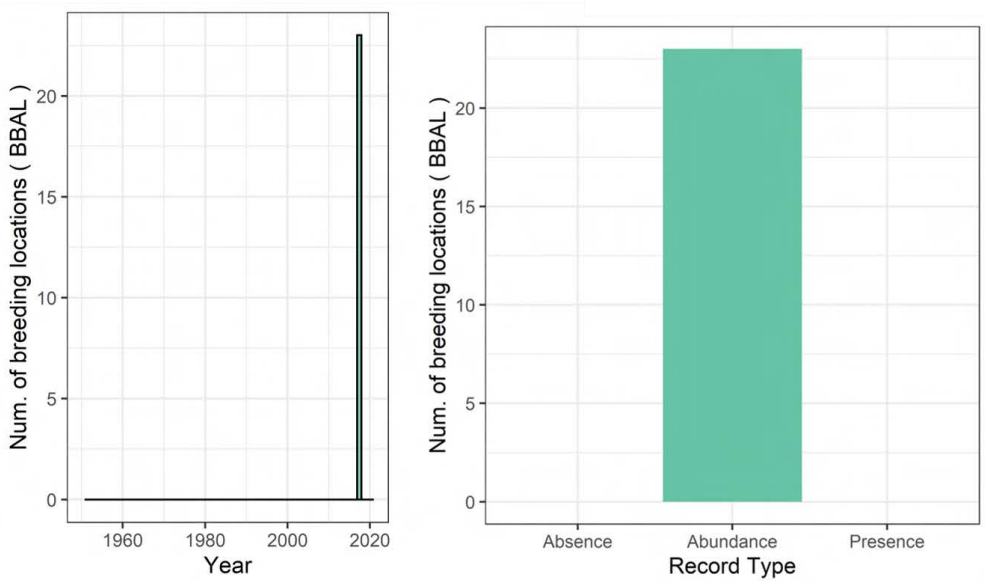
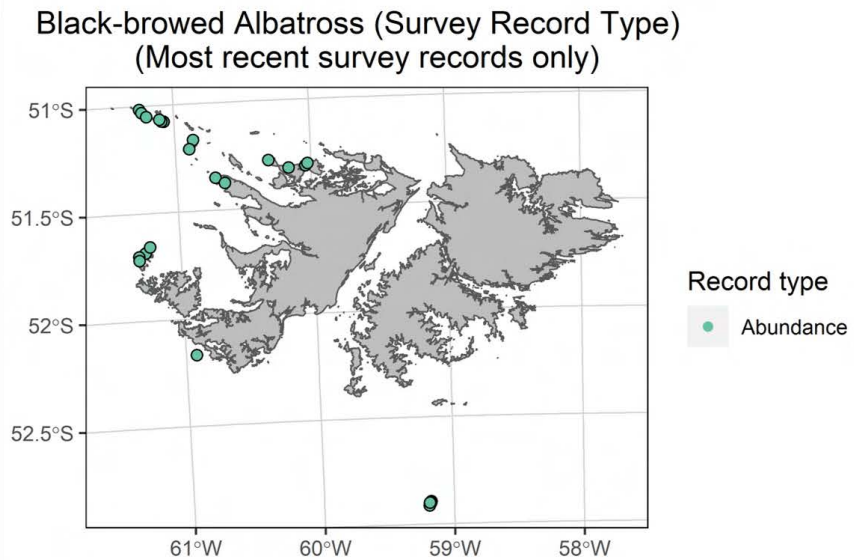


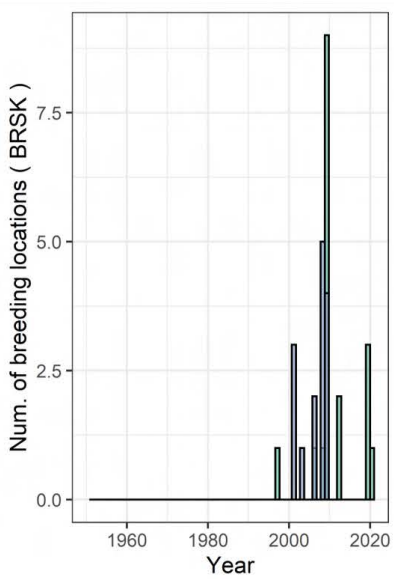
Figure 6: Proportion of the type of available records for all known breeding locations for a given species. Records reflect the most recent estimate available for a given location. Record types include; Absence (a species was previously recorded breeding at the site but as of the most recent count, the species was not recorded as breeding at the site), Abundance (the species was recorded as breeding at the site and a record indicating the number of birds is available), Presence (the species was recorded as breeding at the site but a record indicating the number of birds is not available). While only abundance records were used for the Global KBA Analysis, for those species which have a majority of presence only records, further research and monitoring efforts to obtain abundance estimates for these species would enhance marine spatial planning efforts across the Falkland Islands.

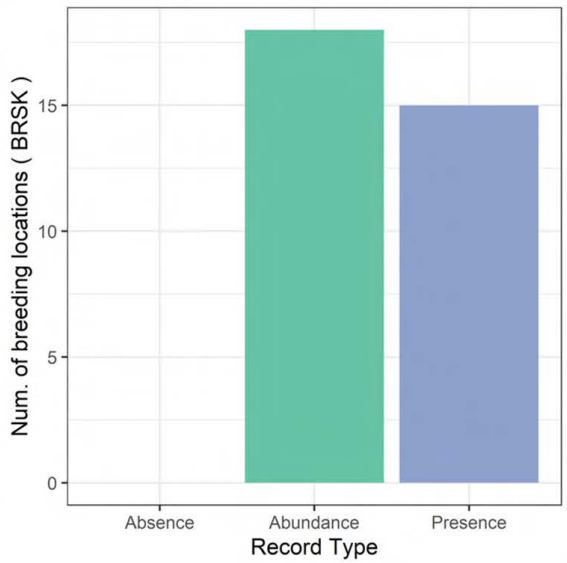
BBAL – Black-browed Albatross (Most recent survey records only)

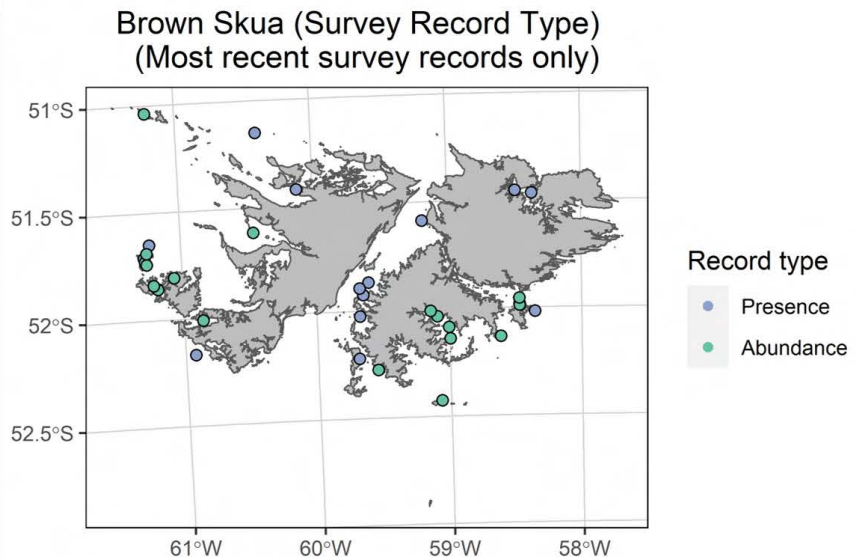




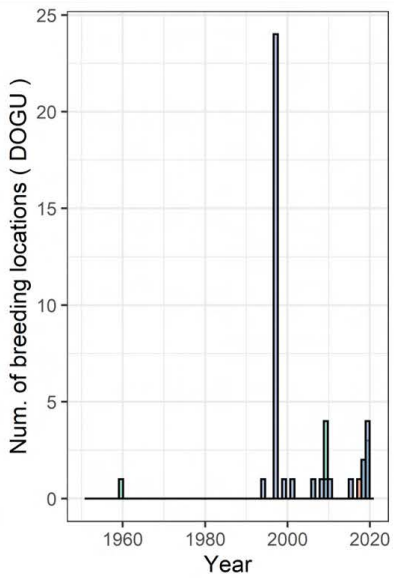
BRSK – Brown Skua (Most recent survey records only)

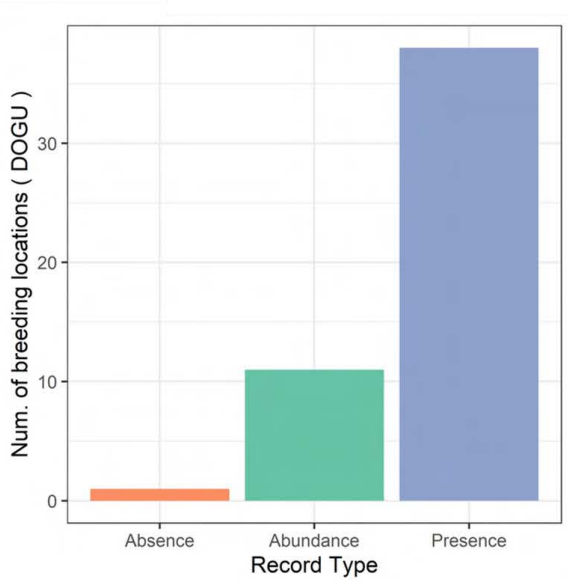


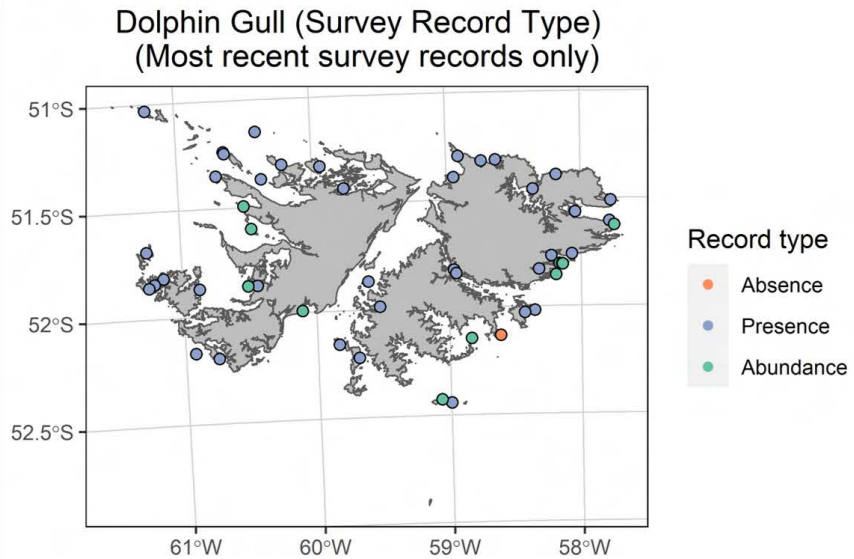




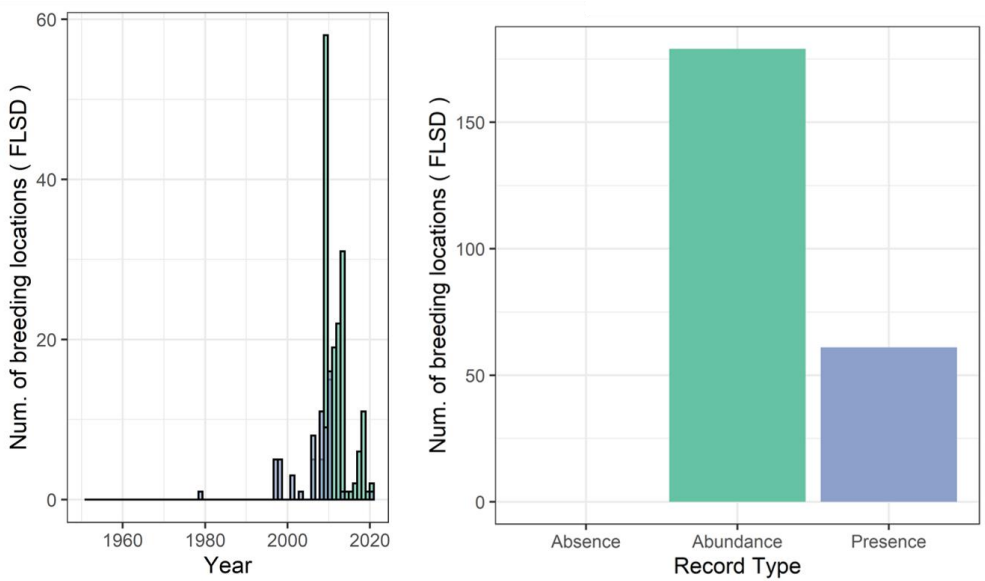
DOGU – Dolphin Gull (Most recent survey records only)

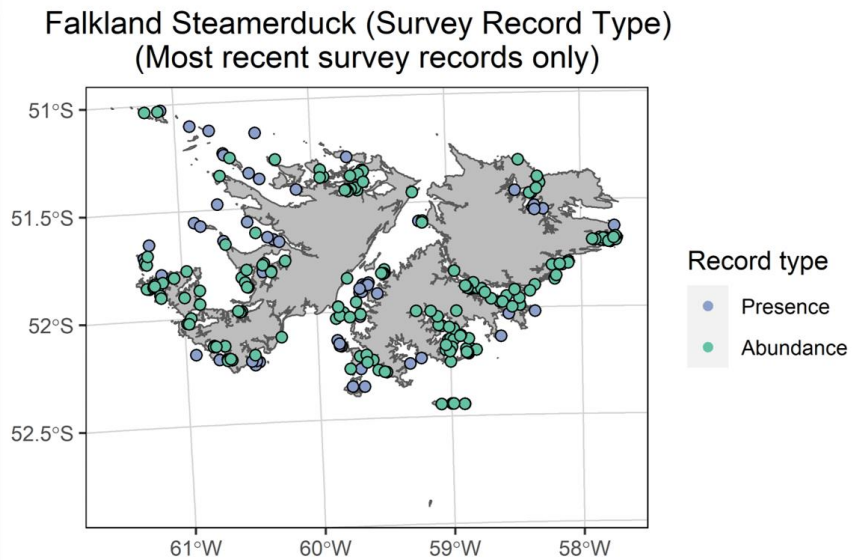




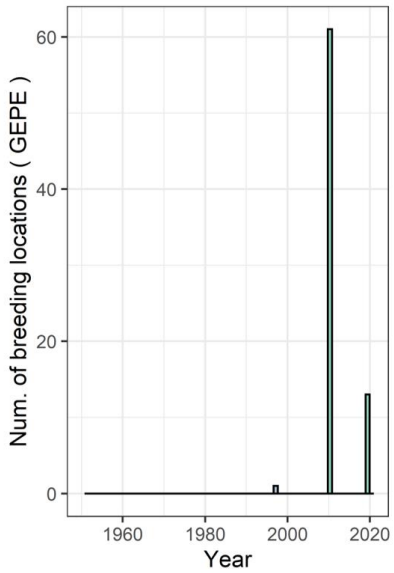


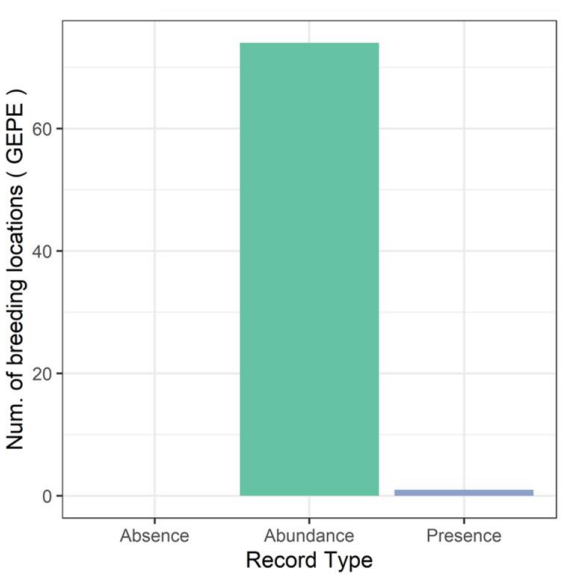
FLSD – Falkland Steamer Duck (Most recent survey records only)

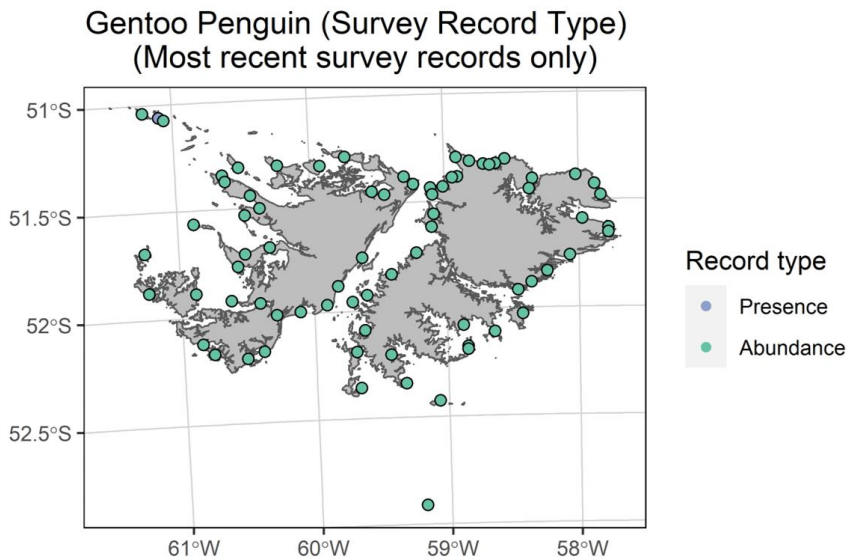




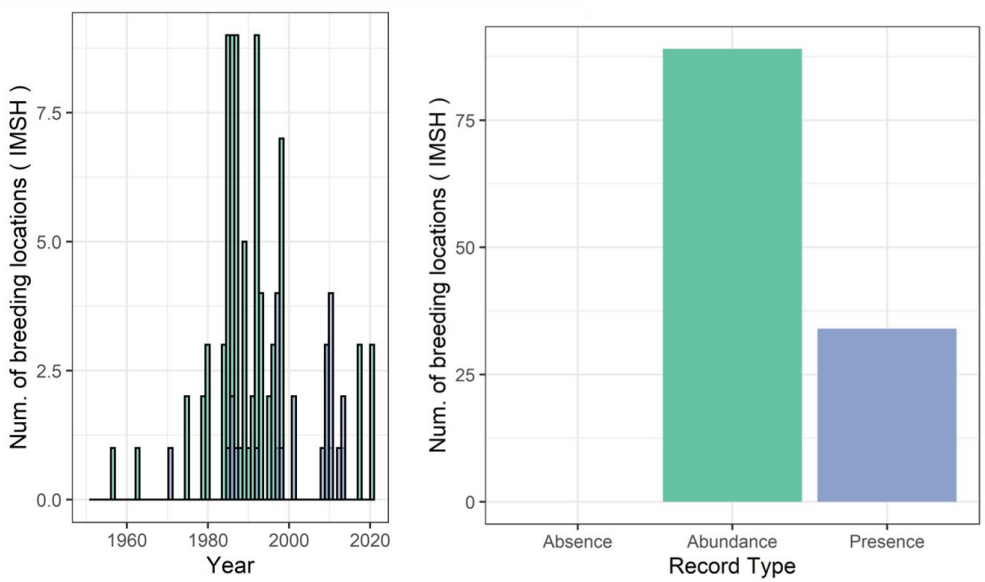
GEPE – Gentoo Penguin (Most recent survey records only)

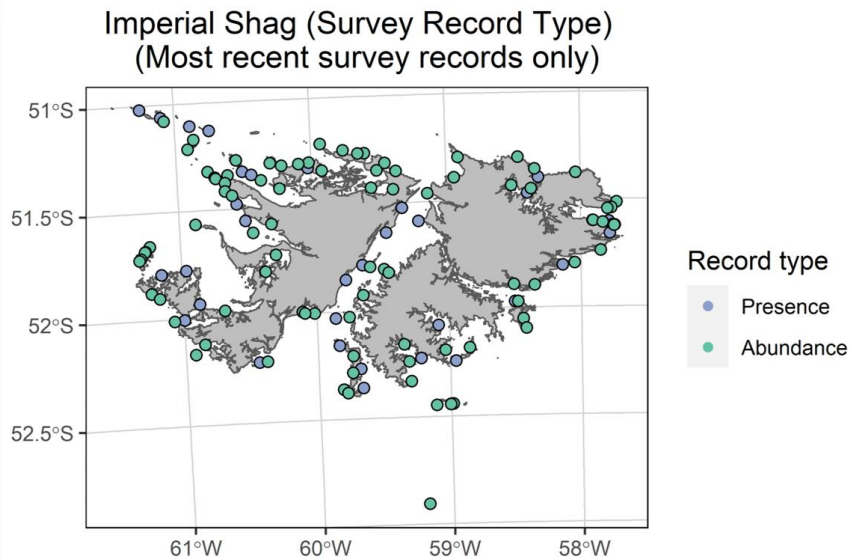




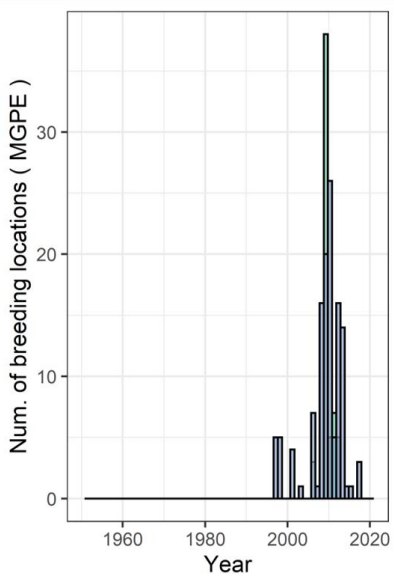


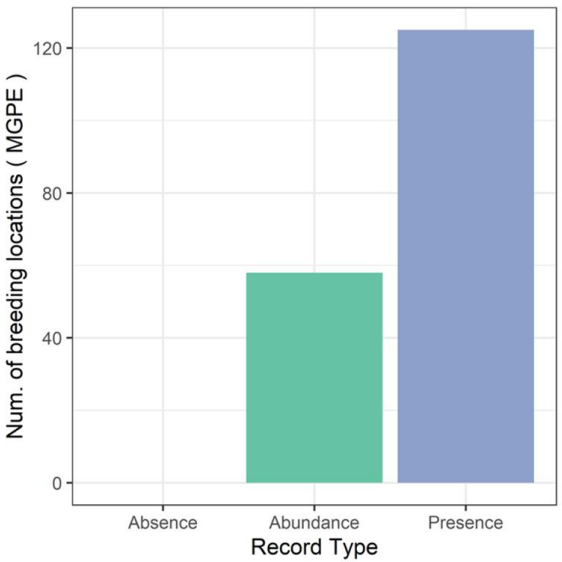
IMSH – Imperial Shag (Most recent survey records only)

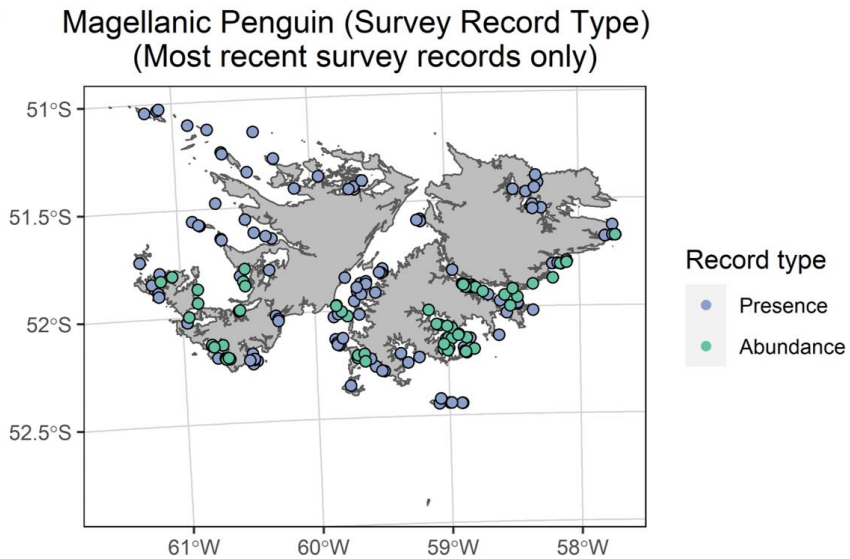




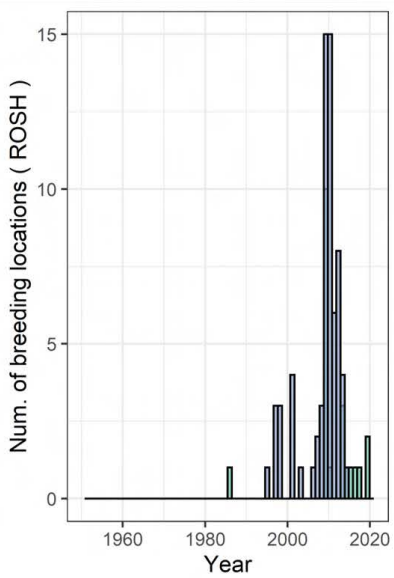
MGPE - Magellanic Penguin (Most recent survey records only)

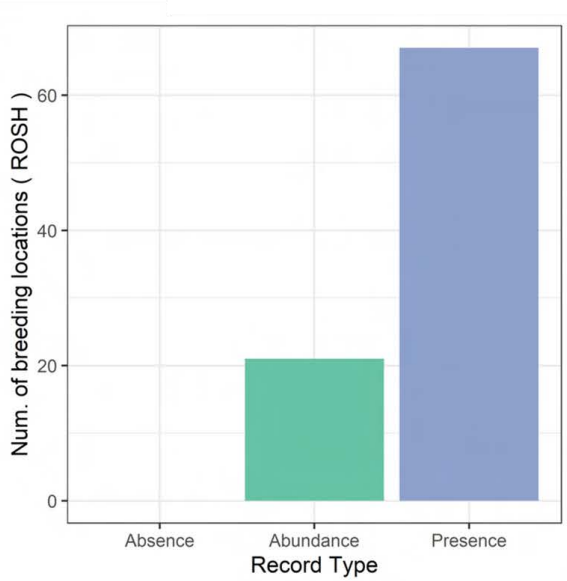


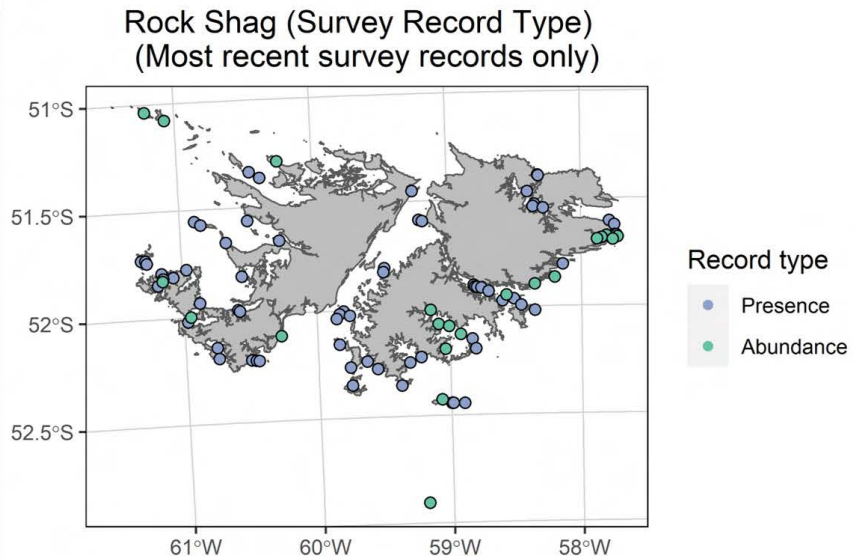




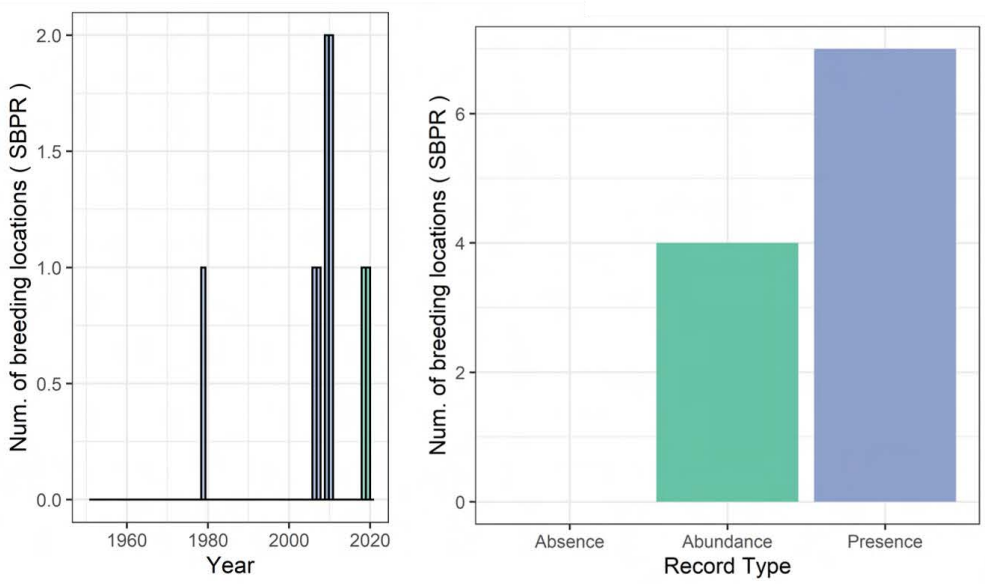
ROSH – Rock Shag (Most recent survey records only)

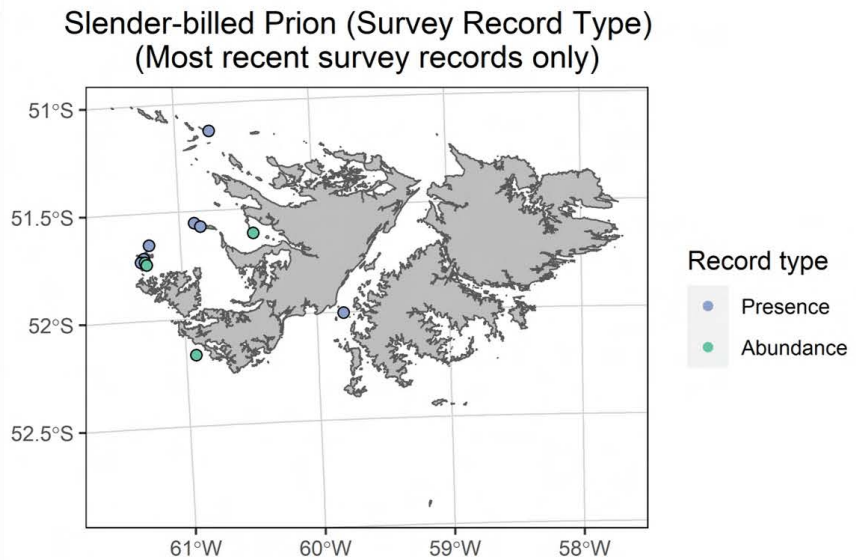




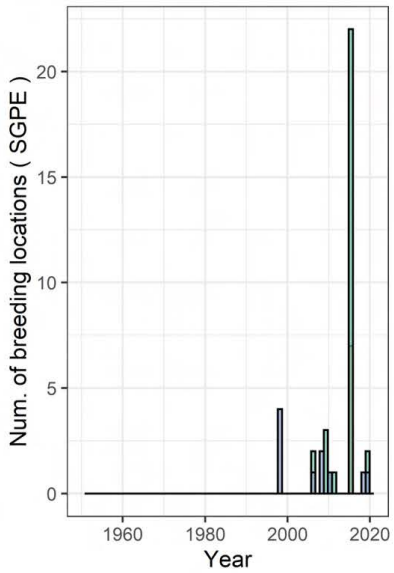


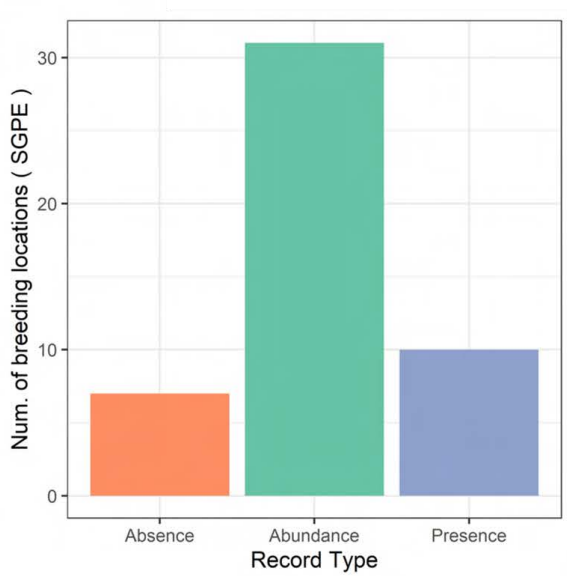
SBPR – Slender-billed Prion (Most recent survey records only)

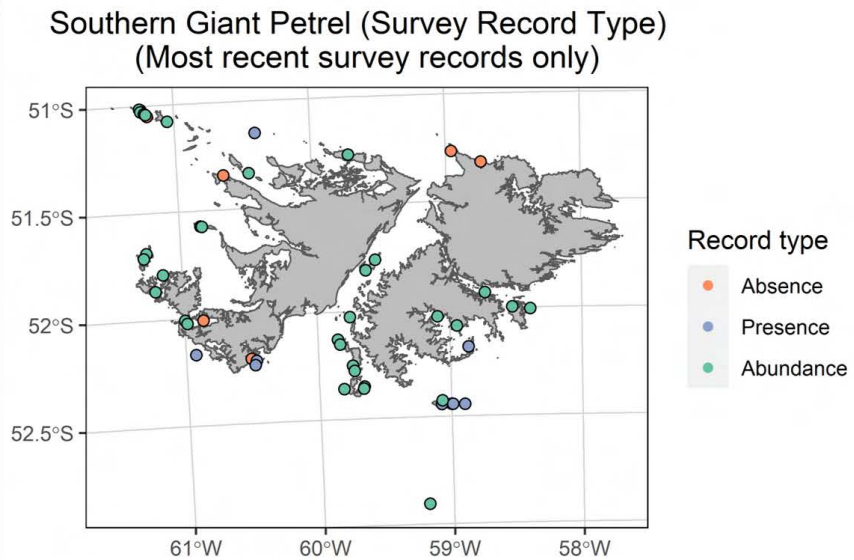




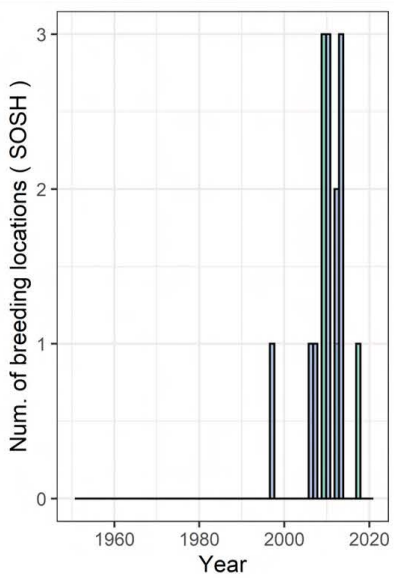
SGPE – Southern Gian Petrel (Most recent survey records only)

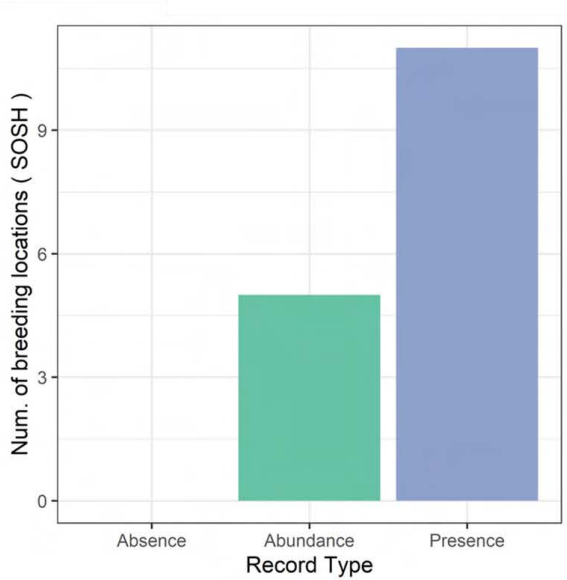


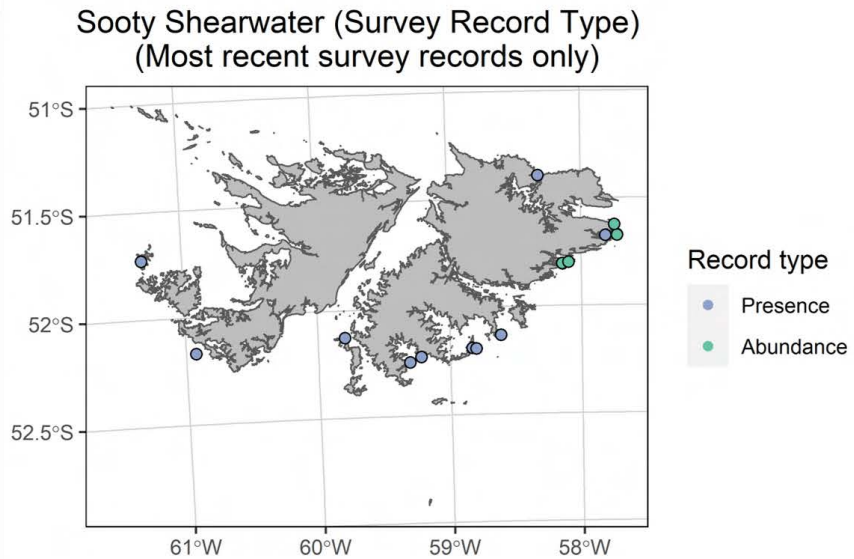




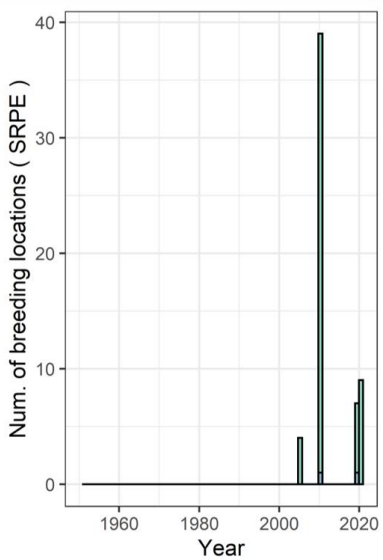
SOSH – Sooty Shearwater (Most recent survey records only)

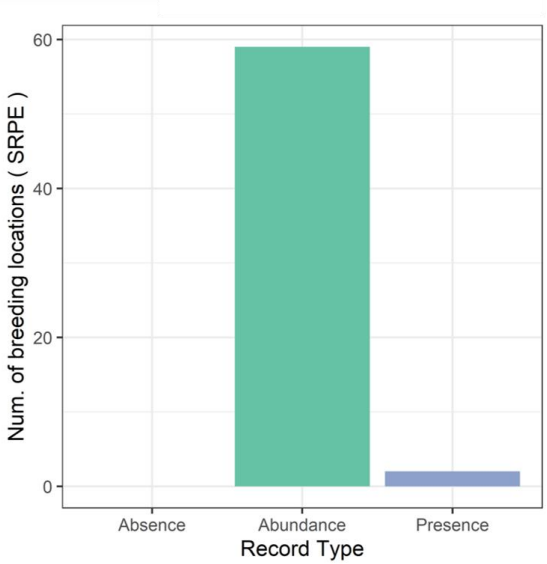


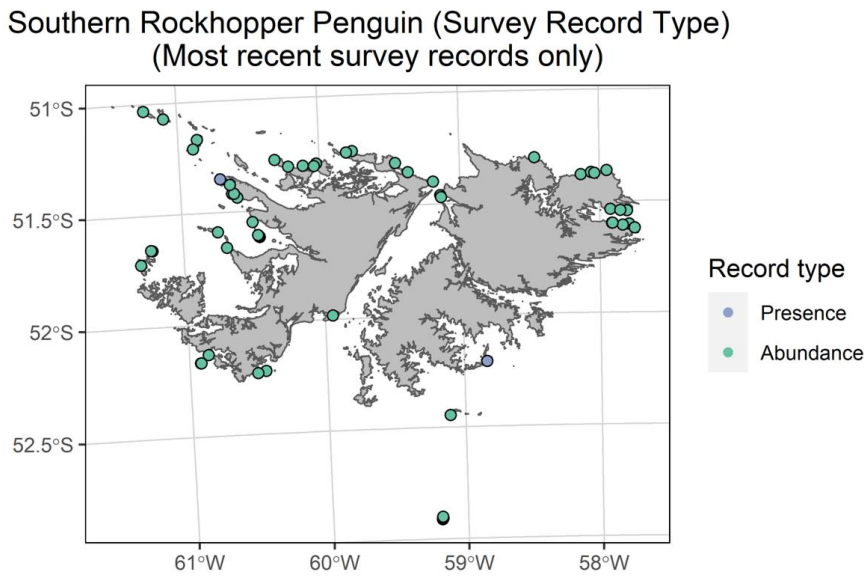




SRPE – Southern Rockhopper Penguin (Most recent survey records only)







References

Augé, A. A., Dias, M. P., Lascelles, B., Baylis, A. M. M., Black, A., Boersma, P. D., et al. (2018). Framework for mapping key areas for marine megafauna to inform Marine Spatial Planning: The Falkland Islands case study. *Mar. Policy* 92, 61–72. doi:10.1016/j.marpol.2018.02.017.

Baylis, A. M. M., de Lecea, A. M., Tierney, M., Orben, R. A., Ratcliffe, N., Wakefield, E., et al. (2021a). *Overlap between marine predators and proposed Marine Managed Areas on the Patagonian Shelf*. doi:10.1002/eap.2426.

Baylis, A. M. M., Tierney, M., Orben, R. A., González de la Peña, D., and Brickle, P. (2021b). Non-breeding movements of Gentoo Penguins at the Falkland Islands. *Ibis (Lond. 1859).* 163, 507–518. doi:10.1111/ibi.12882.

Baylis, A. M. M., Tierney, M., Orben, R. A., Warwick-ev, V., Wakefield, E., Gr, W. J., et al. (2019). Important At-Sea Areas of Colonial Breeding Marine Predators on the Southern Patagonian Shelf. *Sci. Rep.*, 1–13. doi:10.1038/s41598-019-44695-1.

Boersma, P. D., Stokes, D. L., and Strange, I. J. (2002). Applying ecology to conservation: Tracking breeding penguins at New Island South reserve, Falkland Islands. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 12, 63–74. doi:10.1002/aqc.477.

Bolton, M., Conolly, G., Carroll, M., Wakefield, E. D., and Caldow, R. (2019). Review A review of the occurrence of inter-colony segregation of seabird foraging areas and the implications for marine environmental impact assessment. *Ibis (Lond. 1859).* 161, 241–259. doi:10.1111/ibi.12677.

Bonnet-Lebrun, A. S., Catry, P., Clark, T. J., Campioni, L., Kuepfer, A., Tierny, M., et al. (2020). Habitat preferences, foraging behaviour and bycatch risk among breeding sooty shearwaters Ardenna grisea in the Southwest Atlantic. *Mar. Ecol. Prog. Ser.* 651, 163–181. doi:10.3354/meps13439.

Brownlie, K. C., Monash, R., Geeson, J. J., Fort, J., Bustamante, P., and Arnould, J. P. Y. (2020). Developing a passive acoustic monitoring technique for Australia's most numerous seabird, the Short-tailed Shearwater (Ardenna tenuirostris). *Emu* 120, 123–134. doi:10.1080/01584197.2020.1732828.

Carneiro, A. P. B., Manica, A., Trivelpiece, W. Z., and Phillips, R. A. (2015). Flexibility in foraging strategies of Brown Skuas in response to local and seasonal dietary constraints. *J. Ornithol.* 156, 625–633. doi:10.1007/s10336-015-1156-y.

Cleasby, I. R., Owen, E., Wilson, L., and Bolton, M. (2018). *Combining habitat modelling and hotspot analysis to reveal the location of high density seabird areas across the UK: Technical Report. RSPB Research Report no. 63. RSPB Centre for Conservation Science, RSPB, The Lodge, Sandy, Bedfordshire, SG19 2DL.*

Cleasby, I. R., Owen, E., Wilson, L., Wakefield, E. D., O'Connell, P., and Bolton, M. (2020). Identifying important at-sea areas for seabirds using species distribution models and hotspot mapping. *Biol. Conserv.* 241, 1–12. doi:10.1016/j.biocon.2019.108375.

Critchley, E. J., Grecian, W. J., Bennison, A., Kane, A., Wischnewski, S., Cañadas, A., et al. (2019). Assessing the effectiveness of foraging radius models for seabird distributions using biotelemetry and survey data. *Ecography (Cop.).* 42, 1–13. doi:10.1111/ecog.04653.

Critchley, E. J., Grecian, W. J., Kane, A., Jessopp, M. J., and Quinn, J. L. (2018). Marine protected areas show low overlap with projected distributions of seabird populations in Britain and Ireland. *Biol. Conserv.* 224, 309–317. doi:10.1016/j.biocon.2018.06.007.

Crofts, S., Reeves, M., Stanworth, A., and Ratcliffe, N. (2014). Tracking Imperial and Rock Shags at two islands (Middle Island and Steeple Jason) at the Falkland Islands A Summary Report.

Crofts, S., and Stanworth, A. (2019). Falkland Islands seabird monitoring programme annual report 2018/2019 (SMP26).

Dehnhard, N., Ludynia, K., Masello, J. F., Voigt, C. C., McGill, R. A. R., and Quillfeldt, P. (2016). Plasticity in foraging behaviour and diet buffers effects of inter-annual environmental differences on chick growth and survival in southern rockhopper penguins *Eudyptes chrysocome chrysocome*. *Polar Biol.* 39, 1627–1641. doi:10.1007/s00300-015-1887-5.

Dias, M. P., Warwick-Evans, V., Carneiro, A. P. B., Harris, C., Lascelles, B. G., Clewlow, H. L., et al. (2018). Using habitat models to identify marine important bird and biodiversity areas for Chinstrap Penguins Pygoscelis antarcticus in the South Orkney Islands. *Polar Biol.*, 1–9. doi:10.1007/s00300-018-2404-4.

Echevarría, P. (2020). Falkland Island Coastal Bird Dataset. https://github.com/eLucidataLLC/Pajaritos.

Edney, A. J., and Wood, M. J. (2021). Applications of digital imaging and analysis in seabird monitoring and research. *Ibis (Lond. 1859).* 163, 317–337. doi:10.1111/ibi.12871.

Falabella, V., Tamini, L., Garcia Borboroglu, P., Frere, E., Seco Pon, J., Cabrera, S., et al. (2019). Report of the IUCN Regional Red List First Workshop for Species of the Patagonian Sea: SeaBirds. Forum for the Conservation of the Patagonian Sea.

FIG, . (2013). Falkland Islands Government Environmental and Planning Department Falklands Biodiversity Database.

Forster, I. P. (2010). Analysis of seabird observation and satellite tracking data in the Falkland Islands to assess suitability for proposing Marine Important Bird Areas.

Franklin, J. (2010). *Mapping species distribution: Spatial inference and prediction*. Cambridge: Cambridge University Press.

González-Solís, J., Croxall, J. P., and Briggs, D. R. (2002). Activity patterns of giant petrels, Macronectes spp., using different foraging strategies. *Mar. Biol.* 140, 197–204. doi:10.1007/s002270100684.

Granadeiro, J. P., Campioni, L., and Catry, P. (2017). Albatrosses bathe before departing on a foraging trip: Implications for risk assessments and marine spatial planning. *Bird Conserv. Int.* 28, 208–215. doi:10.1017/S0959270916000459.

Grecian, W. J., Witt, M. J., Attrill, M. J., Bearhop, S., Godley, B. J., Grémillet, D., et al. (2012). A novel projection technique to identify important at-sea areas for seabird conservation: An example using Northern gannets breeding in the North East Atlantic. *Biol. Conserv.* 156, 43–52. doi:10.1016/j.biocon.2011.12.010.

Grimm, V., Ayllón, D., and Railsback, S. F. (2016). Next-generation individual-based models integrate biodiversity and ecosystems: Yes we can, and yes we must. *Ecosystems* 20, 229–236. doi:10.1007/s10021-016-0071-2.

Handley, J., Rouyer, M. M., Pearmain, E. J., Warwick-Evans, V., Teschke, K., Hinke, J. T., et al. (2021). Marine Important Bird and Biodiversity Areas for Penguins in Antarctica, Targets for Conservation Action. *Front. Mar. Sci.* 7. doi:10.3389/fmars.2020.602972.

Humphries, G. R. W., Naveen, R., Schwaller, M., Che-Castaldo, C., McDowall, P., Schrimpf, M., et al. (2017). Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD): Data

and tools for dynamic management and decision support. *Polar Rec. (Gr. Brit).* 53, 160–166. doi:10.1017/S0032247417000055.

KBA Secretariat (2019). *Key Biodiversity Areas Proposal Process Guidance on Proposing , Reviewing , Nominating and Confirming Sites. Version 1.0. Prepared by the KBA Secretariat and KBA Committee of the KBA Partnership*. Cambridge.

KBA Standards and Appeals Committee (2020). Guidelines for using a Global Standard for the Identification of Key Biodiversity Areas. Version 1.1. Prepared by the KBA Standards and Appeals Committee of the IUCN Species Survival Commission and IUCN World Commission on Protected Areas. Gland, Switzerl.

Masello, J. F., Mundry, R., Poisbleau, M., Demongin, L., Voigt, C. C., Wikelski, M., et al. (2010). Diving seabirds share foraging space and time within and among species. *Ecosphere* 1, art19. doi:10.1890/ES10-00103.1.

Masello, J. F., Wikelski, M., Voigt, C. C., and Quillfeldt, P. (2013). Distribution Patterns Predict Individual Specialization in the Diet of Dolphin Gulls. *PLoS One* 8. doi:10.1371/journal.pone.0067714.

Oppel, S., Bolton, M., Carneiro, A. P. B., Dias, M. P., Green, J. A., Masello, J. F., et al. (2018). Spatial scales of marine conservation management for breeding seabirds. *Mar. Policy* 98, 37–46. doi:10.1016/j.marpol.2018.08.024.

Phillips, R. A., Catry, P., Silk, J. R. D., Bearhop, S., McGill, R., Afanasyev, V., et al. (2007). Movements, winter distribution and activity patterns of Falkland and brown skuas: Insights from loggers and isotopes. *Mar. Ecol. Prog. Ser.* 345, 281–291. doi:10.3354/meps06991.

Pütz, K., Harris, S., Ratcliffe, N., Rey, A. R., Poncet, S., and Lüthi, B. (2018). Plasticity in the foraging behavior of male Southern Rockhopper Penguins (Eudyptes chrysocome) during incubation in the Falkland/Malvinas Islands. *Polar Biol.* 41, 1801–1814. doi:10.1007/s00300-018-2320-7.

Putz, K., Ingham, R. J., and Smith, J. G. (2002). Foraging movements of Magellanic penguins Spheniscus magellanicus during the breeding season in the Falkland Islands. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 12, 75–87.

Ratcliffe, N., and Trathan, P. (2011). A review of the diet and at-sea distribution of penguins breeding within the CAMLR convention area. *CCAMLR Sci.* 18, 75–114.

Richards, C., Padget, O., Guilford, T., and Bates, A. E. (2019). Manx shearwater (Puffinus puffinus) rafting behaviour revealed by GPS tracking and behavioural observations. *PeerJ* 2019, 1–16. doi:10.7717/peerj.7863.

Soanes, L. M., Bright, J. A., Angel, L. P., Arnould, J. P. Y., Bolton, M., Berlincourt, M., et al. (2016). Defining marine important bird areas: Testing the foraging radius approach. *Biol. Conserv.* 196, 69–79. doi:10.1016/j.biocon.2016.02.007.

Stanworth, A. (2019). *Dolphin Gull (Larus scoresbii) – a Breeding Population Review for the Falkland Islands*. Falklands Conservation.

Stanworth, A., and Crofts, S. (2017). Population status and trends of Southern Giant Petrels (Macronectes giganteus) in the Falkland Islands. Stanley.

Strimas-Mackey, M. (2018). smoothr: Smooth and Tidy Spatial Features. R package version 0.1.0. https://CRAN.R-project.org/package=smoothr.

Thaxter, C. B., Lascelles, B., Sugar, K., Cook, A. S. C. P., Roos, S., Bolton, M., et al. (2012). Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas. *Biol.*

Conserv. 156, 53–61. doi:10.1016/j.biocon.2011.12.009.

Wakefield, E. D., Owen, E., Baer, J., Carroll, M. J., Daunt, F., Dodd, S. G., et al. (2017). Breeding density, fine-scale tracking, and large-scale modeling reveal the regional distribution of four seabird species. *Ecol. Appl.* 27, 2074–2091. doi:10.1002/eap.1591.

Walsh, P. M., Halley, D. J., Harris, M. P., del Nevo, A., Sim, I. M. ., and Tasker, M. L. (1995). *Seabird monitoring handbook for Britain and Ireland*. Stroud: Alan Sutton Publishing Limited.

Warham, J. (1996). *The Behaviour, Population Biology and Physiology of the Petrels*. London: Academic Press.

Warwick-Evans, V., Atkinson, P. W., Walkington, I., and Green, J. A. (2017). Predicting the impacts of wind farms on seabirds: An individual-based model. *J. Appl. Ecol.* 55, 503–515. doi:10.1111/1365-2664.12996.

Warwick-Evans, V., Ratcliffe, N., Lowther, A. D., Manco, F., Ireland, L., Clewlow, H. L., et al. (2018). Using habitat models for chinstrap penguins *Pygoscelis antarctica* to advise krill fisheries management during the penguin breeding season. *Divers. Distrib.*, 1756–1771. doi:10.1111/ddi.12817.

White, R. W., Gillon, K. W., Black, A. D., and Reid, J. (2002). The distribution of seabird and marine mammals in Falkland Islands waters. Available at: http://marefateadyan.nashriyat.ir/node/150.

Woods, R. W., and Woods, A. (1997). *Atlas of breeding birds of the Falkland Islands*. Owestry: Anthony Nelson.

Zhang, J., Dennis, T. E., Landers, T. J., Bell, E., and Perry, G. L. W. (2017). Linking individual-based and statistical inferential models in movement ecology: A case study with black petrels (*Procellaria parkinsoni*). *Ecol. Modell.* 360, 425–436. doi:10.1016/j.ecolmodel.2017.07.017.