Falkland Islands Seabird Monitoring Programme

Annual Report 2023/2024

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Summary

Background

The Falkland Islands support regionally and globally important seabird populations. Numerically, they can influence the global conservation status of individual species, and their abundance makes them important components of the local marine and coastal terrestrial ecosystems, as well as a celebrated part of the Islands' identity. Falklands Conservation set up the Falkland Islands Seabird Monitoring Programme (FISMP) in 1989, to monitor populations of several important seabird species in the Falkland Islands. The current report details results from the 2023/2024 season, updates the long-term trends of individual species, and discusses associated threats and conservation actions.

Key results

Season 2023/2024

In general, counts in breeding pair metrics were higher compared to 2022/2023, but remained below the annual average (**Table S1**). All species experienced reduced breeding success this year compared to 2022/2023, and values fell below the annual average for black-browed albatross and southern rockhopper penguin. This season marked the confirmed incursion of the Highly Pathogenic Avian Influenza virus (HPAI H5N1) into the Falkland Islands and associated mortality in various species, including black-browed albatross, gentoo penguin and Falkland skua. However, observed large-scale lethal outbreaks have so far been limited. The season of 2023/2024 also experienced a moderately intense El Niño event, which can further affect seabirds in the Falkland Islands.

Table S1: 2023/2024 species-specific changes in breeding pair and breeding success metrics compared to last season and the annual average.

Species	2023 vs 2022		2023 vs annual average	
	Breeding pair metrics	Breeding success metrics	Breeding pair metrics	Breeding success metrics
Black-browed albatross	↓	↓	↑	↓
Falkland skua	=		↑	
Gentoo penguin	↑	↓	↓	↑
Imperial shag	↑		↑	
King penguin		↓		↑
Magellanic penguin	↓		↓	
Southern giant petrel	↑	↓	↓	↑
Southern rockhopper penguin	↑	↓	↓	↓

Long-term trends

Multi-season oscillations of decline and recovery are evident in some species (see main report). Others may yet exhibit similar larger-scale oscillating trends with longer monitoring, and understanding such longer-term population patterns is critical in identifying genuine circumstances for conservation concern. Currently, the long-term breeding pair index (modelled for species with more than 10 years of data) mainly suggests increasing or stable trends for monitored seabirds, although many species have been experiencing downward trends over the past ~10 years since 2015/2016 – a period marked by a strong El Niño (**Table S2**). Consistent long-term declines in southern rockhopper penguin breeding success are of significant concern, with no indication of recovery seen in over 30 years in this species of globally vulnerable conservation status. Ongoing recent breeding success declines in black-browed albatrosses will be important to monitor particularly in light of additional HPAI impacts on this species.

Table S2: Long-term trends in species-specific breeding pair and breeding success metrics.

Species	Longer term (>10 years)		Last 10 years	
	Breeding pair metrics	Breeding success metrics	Breeding pair metrics	Breeding success metrics
Black-browed albatross	↑	↘	↑	↓
Falkland skua			↗	
Gentoo penguin	=	=	↓	↗
Imperial shag			↗	
King penguin		↑		↑
Magellanic penguin	=		↓	
Southern giant petrel	↑	↘	↗	↗
Southern rockhopper penguin	=	↓	↓	↘

Increasing ↑= breeding measure is clearly increasing; Stable-increasing ↗ = breeding measure is either stable or possibly increasing; Stable = = breeding measure is clearly stable; Stable-decreasing ↘ = breeding measure is either stable or possibly decreasing; Decreasing ↓ = breeding measure is clearly decreasing.

Seabird outlook and conservation

Whilst most seabirds breeding in the Falkland Islands are listed as *Least Concern* on the IUCN Red List, several are identified as declining globally. In the Falklands, the FISMP population indices continue to generally suggest oscillating but overall stable monitored populations; however, the developing climate crisis continues to exacerbate many pressures on seabirds, such as by impacting food availability, increasing disease outbreaks and increasing the frequency and strength of extreme weather events. Under these new and changing conditions, it remains uncertain as to whether recovery seen as part of previous population oscillations will follow the current downward population trend, and whether it will be sufficient to maintain positive trends.

The continuing climate crisis alarmingly poses threats that cannot easily be mitigated. Avoiding impacts on inshore areas, and prioritising an ecosystem-based approach to fisheries management in offshore areas could prevent additional pressures on food availability, whilst fire contingency planning could potentially reduce impacts of increasing wildfires at Falkland colonies. Resilience of populations to climate change can, and is, being bolstered at colonies through predator removal, disturbance reduction, habitat improvement and biosecurity measures; however, long-term prospects for seabird populations in the Islands are likely best served by measures to mitigate the climate crisis. Nationally, this includes decarbonisation, protecting carbon- and species- rich habitats, and restoration of carbon sinks.

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Introduction

The Falkland Islands support significant seabird populations, including those of global importance, both numerically, and in terms of their conservation status. These include:

- An estimated 72% of the global population of black-browed albatross (*Thalassarche melanophris*) (IUCN Red Listed as 'Least Concern', BirdLife International 2018a);
- An estimated 36–70% of the world's population of brown skua (*Catharacta antarctica*) (IUCN Red Listed as 'Least Concern', Woods and Woods 1997; BirdLife International 2018b);
- An estimated 30% of the world's population of gentoo penguin (*Pygoscelis papua*) (IUCN Red Listed as 'Least Concern', BirdLife International 2020b);
- An estimated 43% of the global population of southern giant petrel (*Macronectes giganteus*) (IUCN Red Listed as 'Least Concern', BirdLife International 2018d); and
- An estimated 36% of the world's population of southern rockhopper penguin (*Eudyptes c. chrysocome*) (IUCN Red Listed as 'Vulnerable', BirdLife International 2020a).

Trends in Falkland Islands populations are likely to affect the global conservation status of these species. In addition, seabirds play crucial roles in regulating ecosystems such as by acting as higher predators (Brooke 2004; Cury et al. 2011) and driving nutrient cycling between terrestrial and marine ecosystems (Otero et al. 2018). Their sensitivity to changes in food availability, pollution and other environmental factors, makes seabirds useful indicators of the overall health of the marine environment (Cairns 1987; Velarde et al. 2019). Monitoring seabird populations in the Falkland Islands is therefore important both in terms of their conservation and management, and more generally as a tool to detect changes in the marine environment.

Falklands Conservation initiated the Falkland Islands Seabird Monitoring Programme (FISMP) in 1989. Its initial purpose was to monitor the diet and population dynamics of gentoo penguin, Magellanic penguin (*Spheniscus magellanicus*), southern rockhopper penguin, and black-browed albatross. Diet sampling was discontinued in 2003. Since then, annual population monitoring has continued, with some changes to the original format, such as the addition and loss of monitoring sites and species. Key changes to the FISMP since 2021 are listed in **Appendix 1**, and a summary of the current programme is provided in **Table 1**.

Today, the FISMP provides an important long-term dataset on population trends and breeding success across a diverse array of species portraying a wide range of ecologies traits and breeding behaviours, and plays a crucial role in fulfilling Falkland Islands Government (FIG) seabird monitoring commitments under the Agreement on the Conservation of Albatrosses and Petrels (ACAP) and FIG management plans. The data generated by FISMP serve as a cornerstone for understanding seabird population health, contribute to IUCN Red List evaluations, support research on species responses to environmental factors and human-induced stressors, and help identify key conservation priorities.

Table 1 Summary of the FISMP species, survey effort and survey coverage of the estimated national breeding populations.

Species	IUCN Status	Annual survey effort	Percentage of national estimate
Large Procellariiformes			
Black-browed albatross (*Thalassarche melanophris*)	*Least Concern* [a]	2 site (7 colonies) + data provided from Dunbar	~1% of c. 550,400 pairs. Includes Steeple Jason which is the most important breeding site globally and holds c. 39% of the national population[1]
Southern giant petrel (*Macronectes giganteus*)	*Least Concern* [b]	2 site (5 colonies) + data provided from Bleaker Is.	~9% of c. 20,970 pairs[5]
Penguins			
Gentoo penguin (*Pygoscelis papua*)	*Least Concern* [c]	13 sites (20 colonies) + data provided from Bleaker Is.	~18% of c. 132,000 pairs[3]
King penguin (*Aptenodytes patagonicus*)	*Least Concern* [d]	1 site (1 colony)	>95% of c. 1,500 pairs[4]
Magellanic penguin (*Spheniscus magellanicus*)	*Least Concern* [e]	1 site (1 colony)	<1% of c.76,000–142,000 pairs[2]
Southern rockhopper penguin (*Eudyptes c. chrysocome*)	*Vulnerable* [f]	5 sites (11 colonies) + data provided from Bleaker Is.	~2.6% of c. 319,000 pairs. Includes Steeple Jason which holds c. 38% of the national population[6]
Cormorants and shags			
Imperial shag (*Leucocarbo atriceps*)	*Least Concern* [g]	2 sites (3 colonies)	1–2% of c. 45,000–85,000 pairs[2]
Skuas			
Falkland skua (*Catharacta a. antarctica*)	*Least Concern* [h]	1 site (multiple colonies)	3–5% of c. 5,000–9,000 pairs[2]
Burrowing petrels*			
Sooty shearwater (*Ardenna grisea*)	*Near-threatened* [i]	2 sites (2 colonies)	~92% of estimated average of c.155,000 pairs[7,8]

White-chinned petrel (*Procellaria aequinoctialis*)	*VU* [k]	3 sites (3 colonies)	>99% of estimated average of c.530 pairs at known breeding sites[8,9]

IUCN Red List sources: [a]BirdLife International 2018a; [b]BirdLife International 2018d; [c]BirdLife International 2020a; [d]BirdLife International 2020b; [e]BirdLife International 2020c; [f]BirdLife International 2020d; [g]BirdLife International 2018c; [h]BirdLife International 2018b; [i]BirdLife International 2024a, [k]BirdLife International 2024b. **National estimate sources**: [1]Crofts 2020; [2]Woods and Woods 1997; [3]Baylis et al. 2013a; [4]Pistorius et al. 2012; [5]Stanworth and Crofts 2017; [6]Baylis et al. 2013b; [7]Clark et al. 2019; [8]Kuepfer et al. 2024; [9]Reid et al. 2007. *2 sites are currently monitored under the FIG Small Works Contract in support of the Stanley Tussac Grass Islands Management Plan 2018–2023, and are not monitored annually, see Kuepfer et al. 2024 for details.

Methods

Within this report, 'site' refers to a named geographical area, such as a settlement, farm or island, and this may support more than one colony; e.g. Race Point 'site' has gentoo penguin colonies at Rookery Sands and Fanning Harbour. A 'colony' refers to a group or groups (sub-colonies) of birds in close proximity, typically within 50–100 m, and/or with shared or proximate access from the sea.

Data collection of breeding seabirds

Monitoring sites are shown in **Figure 1**, with individual colonies listed in **Table 2**. Most of the monitoring was carried out by Falklands Conservation and volunteers under FIG Research Licences (No: R23/2023 and R22/2023). Additional data has kindly been provided by various contributors as specified in **Table 2**. GPS locations of monitored colonies are provided in **Appendices 3**–**7.** Where possible, GPS locations were taken due south of the approximate centres, 5 m from the sub-/colony edge.

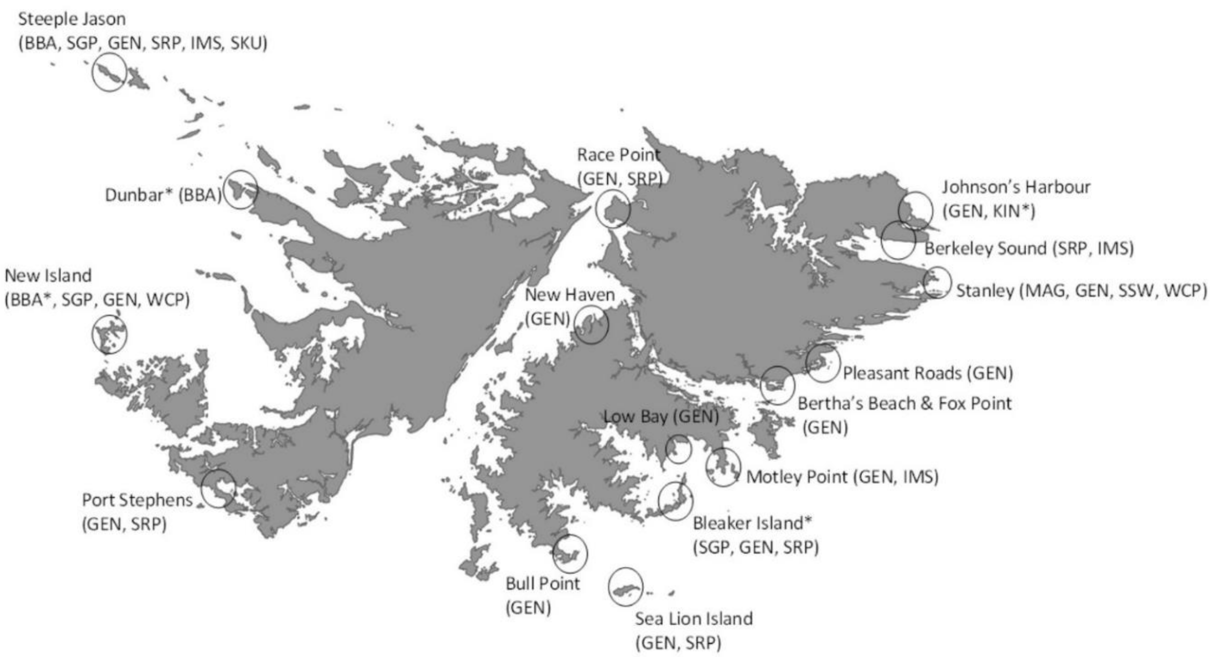

Figure 1 Map of the FISMP monitoring sites. Asterisks* indicate sites where data are provided by contributors. BBA = Black-browed albatross; GEN = Gentoo penguin; IMS = Imperial shag; KIN = King penguin; MAG = Magellanic penguin; SGP = Southern giant petrel; SKU = Falkland skua; SRP = Southern rockhopper penguin; SSW = Sooty shearwater; WCP = White-chinned petrel.

Table 2 Species-specific monitoring details for 2023/2024. AON = Apparently Occupied Nests; PFC = Pre-Fledged Chicks; AOT = Apparently Occupied Territories; BO = Burrow Occupancy rate; EOB = Estimated Occupied Burrows; AOB = Apparently Occupied Burrows. We differentiate "Chicks" from PFC as these data were collected during early chick-rearing, as opposed to mid to late chick-rearing.

Species	Monitored sites and colonies (in brackets)	Count units	Date
Black-browed albatross	• Steeple Jason (NW Flat, Penthouse, S5 Tip, Study Site, S5 Finger)	AON PFC	25/11/2023 – 28/11/2023 29/02/2024 – 01/03/2024
	• New Island (PC Demo, Bowl)[1]	AON PFC	Oct 2023 17/02/2024
	• Dunbar (Penguin Point South)[2]	Chicks	23/12/2023 & 01/02/2024
Falkland skua	• Steeple Jason	AOT	18/01/2024 & 19/01/2024
Gentoo penguin	• Johnson's Harbour (Volunteer Green, Cow Bay, Lagoon Sands) • Race Point (Fanning Harbour, Rookery Sands) • Sea Lion Island • New Haven • Bull Point area (Bull Point, Bull Roads) • Motley Point • Low Bay • Bertha's Beach • Fox Point • Pleasant Roads • Steeple Jason (House, Neck) • Yorke Bay • New Island (South, North, House)	AON PFC	31/10/2023 – 25/11/2023 01/01/2024 – 31/01/2024
	• Bleaker Island[3]	AON	02/11/2023
Imperial shag	• Walker Creek (Motley Point) • Berkeley Sound (Eagle Hill and Rugged Hill)	AON* AON*	01/11/2023 – 13/11/2023 02/01/2024 – 08/01/2024
King penguin	• Volunteer Green[4]	PFC	Oct 2023

Magellanic penguin	• Gypsy Cove	BO	14/12/2023
Southern giant petrel	• Steeple Jason (Neck, House, S of Ridge West)	AON PFC	22/11/2023 – 27/11/2023 01/03/2024 – 04/03/2024
	• New Island (Airstrip, Ship Island)	AON	07/11/2023
	• Bleaker Island[3]	Chicks	06/01/2024 – 09/01/2024
Southern rockhopper penguin	• Steeple Jason (NW Flat, S5 Tip, Study Site, S5 Finger) • Sea Lion Island (Rockhopper Point) • Race Point (Fanning Head North, Fanning Head South) • Berkeley Sound (Diamond Cove, Rugged Hill, Eagle Hill) • Port Stephens (Stephen's Peak)	AON PFC	05/11/2023 – 27/11/2023 07/01/2024 – 30/01/2024
	• Bleaker Island[3]	AON	25/11/2023
Sooty shearwater	• Kidney Island, Top Island	EOB	26/11/2023 – 10/12/2023
White-chinned petrel	• Kidney Island, Top Island • New Island (Rookery Hill)	AOB	26/11/2023 – 10/12/2023

Data kindly provided for inclusion by contributors: [1]Paulo Catry; [2]Marie-Paul Guillaumot; [3]Nick Rendell; [4]Derek Pettersson. *Only January counts of imperial shag are presented in this report.

Apparently Occupied Nests (AON) and Pre-Fledged Chicks (PFC)

For **black-browed albatrosses**, **gentoo penguins**, **southern giant petrels** and **southern rock-hopper penguins**, we counted Apparently Occupied Nests (AON) during the egg incubation period to obtain an estimate of breeding pair numbers (**Table 2**). In addition, Pre-Fledged Chicks (PFC) were counted during mid to late chick-rearing (**Table 2**). AON and PFC counts were used to calculate breeding success (BS) (see Data analysis section). For **imperial shags**, AON were counted in November and January, given the asynchronous breeding behaviour of this species, although only January counts are presented here.

For **king penguins**, where the breeding cycle extends over a year and consequently is not synchronised to summer breeding as with the other penguin species, the unit of measure was PFC that have survived the winter, with counts conducted between mid-September and mid-October (**Table 2**).

AON and PFC counts made by Falklands Conservation were conducted from drone images whenever possible (model DJI Phantom 4); if conditions were too adverse for safe drone flying, counts were obtained from Go-Pro images and/or field counts (see Kuepfer and Stanworth 2023 for details). Where multiple counting methods exist for the same colony, the data used for analyses were those that exhibited the least differences between counts (**Appendices 3**–**7**).

Apparently Occupied Territories (AOT)

For breeding Falkland (brown) skuas (hereafter, **Falkland skuas**), which are later nesting and easily disturbed, the count unit used is Apparently Occupied Territories (AOT), classified as an adult with egg/s and or chick/s observed, or seen sitting tightly on a nest and assumed to be incubating/brooding. AOT counts are conducted in January (**Table 2**).

Burrow Occupancy

As **Magellanic penguins** in the Falkland Islands nest in burrows, population trends for this species are based on burrow occupancy rate at an annually monitored site (Gypsy Cove) during chick-rearing (December). Monitoring involves a series of 4-m wide transects at ca. 100-m intervals, spanning from Engineer Point to the car park at Yorke Bay. Transects start at the shoreline, and run inland, perpendicular to the shoreline, for a distance of 40 m beyond the last burrow found. GPS locations are taken for the start and end points of each transect and the last burrow found. Burrows within transects are categorised as either ‘occupied’, ‘unoccupied’ or ‘unknown’ if it is not possible to determine occupancy. Burrow density for each transect is derived as the number of burrows in the area between the transect start and the last recorded burrow. To assess habitat preference associated with burrow density, a series of habitat characteristics are recorded within 10-m sections along transects, including tussac density, tussac height, soil moisture and the presence of sooty shearwater burrows.

Other counts

As part of an FIG Small Works Contract in support of the Stanley Tussac Grass Islands Management Plan 2018–2023, we conducted surveys of **sooty shearwater** and **white-chinned petrel** populations at Kidney and Top Islands this season. The methodology, detailed in Kuepfer et al. (2024), involved counting and assessing the occupancy of burrows within designated survey plots across pre-defined grids on the islands. Spatial-temporal modelling, incorporating a range of environmental co-variates, was used to estimate population size. We present this information here for completeness.

Environmental information

At each colony, we recorded information on a range of visible environmental and anthropogenic factors that have the potential to influence the health of a population. This includes evidence of weather-related stressors, disease, disturbance, predation pressure, oiling to seabirds, presence and direct impact of (marine) plastic debris.

Data analysis

Data were analysed following Kuepfer and Stanworth (2023) using R statistical software (R Core Team 2023). In summary, counts of AON, PFC and AOT were averaged by species and colony to obtain counts as mean ± standard deviation. Breeding pair data were mean-centred to generate species-specific breeding population indices. Breeding success (BS) was calculated as $BS = \frac{PFC}{AON}$ (i.e. number of chicks per number of breeding pairs).

For species for which we have more than 10 years of data, we calculated long-term trend estimates of breeding population indices and breeding success by fitting Generalised Additive (Mixed) Models (GAM, GAMMs) using the ‘gam’ or ‘gamm’ function from the *mgcv* package in R (R Core Team 2023), employing a Gaussian distribution. For this purpose, current data were combined with historic data available from the FISMP and (for rockhopper and gentoo penguins) additional sites from across the Falkland Islands. Apart from Magellanic penguins, colonies with an average population size of <150 breeding pairs were discarded to reduce the influence of smaller population size stochastic fluctuation obscuring the overall trend. To account for the non-linear relationship between the response variables and season, we used cubic regression or thin-plate regression spline functions.

The modelling approach applied for burrowing petrel population estimates is detailed in Kuepfer et al. (2024). Finally, to assess the effects of habitat characteristics on Magellanic penguin burrow numbers, we employed a Generalised Linear Mixed Model (GLMM) with Poisson distribution (R package *glmmTMB;* Brooks et al. 2017).

Results

Breeding seabirds

A summary of counts at individual colonies is provided in **Appendices 3**–**7**. We grouped site-based results broadly geographically for ease of presentation. Breeding seasons are referred to by the year in which they commenced; e.g. 2023 describes the 2023/2024 austral summer breeding period. Long-term trends are generally described as one of the following:

- **Increasing** – the breeding measure is increasing beyond confidence intervals;
- **Stable-increasing** – the breeding measure is either stable or possibly increasing;
- **Stable** – the breeding measure is stable;
- **Stable-decreasing** – the breeding measure is either stable or possibly decreasing;
- **Decreasing** – the breeding measure is decreasing beyond confidence intervals.

Black-browed albatross

This season: Black-browed albatross breeding pair counts at FISMP sites were generally lower compared to last season, but overall still +8% above their annual average (**Figure 2**), with counts at both Steeple Jason and New Island sitting above the annual average (+7% and +10%, respectively). Breeding pair numbers at the largest monitoring location at Steeple Jason (S5 Finger) were at a record low for the second year in a row (-12% compared to the annual average, **Figure 2**).

Overall breeding success dropped to 0.25 chicks per pair, which is substantially below the annual average at all sites on Steeple Jason (-54%) and New Island (-25%) (**Figure 3**). The low breeding success at Steeple Jason (0.21 chicks/pair) is similar to values seen in 2010 (0.21 chicks/pair) and 2019 (0.23 chicks/pair) (**Figure 6 B**).

At Dunbar, chicks numbered above the annual average (n = 248), although only 90 chicks had survived by February and April (M-P. Guillaumot pers. comm.) (**Figure 4**).

Long-term trend: The long-term black-browed albatross breeding population index shows a positive trend, which is particularly evident with the inclusion of New Island data (**Figure 5 A**). There is indication that this trend may be stabilising (**Figure 5 A**), although less so when considering only Steeple Jason, where almost 40% of the Falkland Islands' black-browed albatrosses breed (**Figure 6 A**). The long-term trend of breeding success has been declining over the past 9–11 years, following a stable / stable-increasing trend in the 9–10 years prior (**Figure 5 B, Figure 6 B**).

Other observations

HPAI H5N1 (hereafter HPAI) was confirmed at the Steeple Jason Island black-browed albatross colony. In November, unusually high numbers of dead adult birds were detected (counted >30, estimated 100s) between the northwest end and the Study Site located along the southwest coast. A single swabbed bird in the northwest tested positive, while a swab from the Study Site tested negative for HPAI. In January, a survey of the entire length of the Steeple Jason albatross colony was conducted in collaboration with A. Clessin (CEFE, CNRS, Université de Montpellier, EPHE, IRD) and J. Emerit and A. Gamble (Department of Public & Ecosystem Health, Cornell University), and rendered an estimate of ~3000 dead adult birds at the colony based on carcass counts. Terrain, weather and carcass conditions made counts challenging. In addition, large clusters of dead chicks and empty nests were recorded amounting to several tens of thousands. The southern lobe of Steeple Jason appeared unaffected at the time. By March, large-scale breeding failure had affected additional areas in the northern lobe of the island. Within FISMP sites, HPAI was confirmed at the NW Flat, the S5 Finger and the Study Site, although with varying degrees of progression. At the Study Site, fresh chick carcasses (n = 2, both HPAI positive) only appeared in the very final days of monitoring in March. Despite substantial observations of the colony, only a couple of symptomatic birds were seen.

On New Island, two dead breeding adults tested negative for HPAI in December (FIG 2024a). No evidence of HPAI was found in black-browed albatrosses at Dunbar (a single dead chick swabbed in January tested negative (FIG 2024a)). Elsewhere in the Falklands, a single positive swab was returned from an adult black-browed albatross on Saunders Island in November (FIG 2024a). At Beauchêne Island, no evidence of HPAI was observed in February (A. Baylis pers. comm.) but the virus was suspected in April (K. Passfield pers. comm.). At Grand Jason Island, the crew of the MV Austral conducted land and sea-based observations in March and did not observe any evidence of HPAI presence or impacts (F. Schmitt and V. Nivet-Mzerolles pers. obs.; V. Heuacker pers. comm.). No testing was conducted at either Beauchêne or Grand Jason Islands in 2023/2024.

Aside from HPAI, observable factors of potential consequence for breeding success included unusually high chick predation on New Island in January, primarily by skuas, but also southern giant petrels (E. Correia pers. comm.).

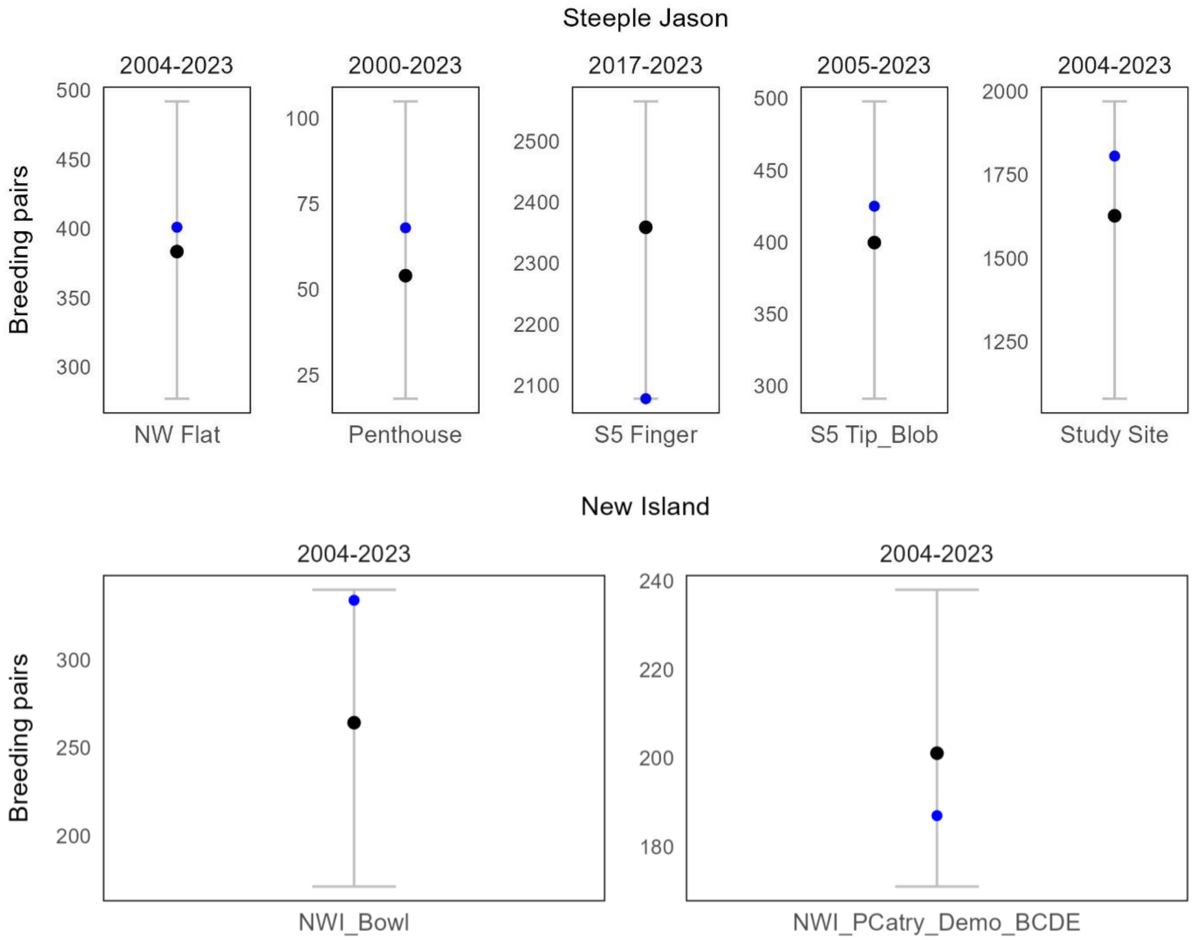

Figure 2 Black-browed albatross breeding pair numbers at FIMSP sites on Steeple Jason and New Island. Bars indicate the minimum, maximum, annual mean (black dot), and the current season's (blue dot) breeding pair numbers. The season range for which data exist is indicated at the top of the panel for each site. Data from New Island were kindly provided by P. Catry.

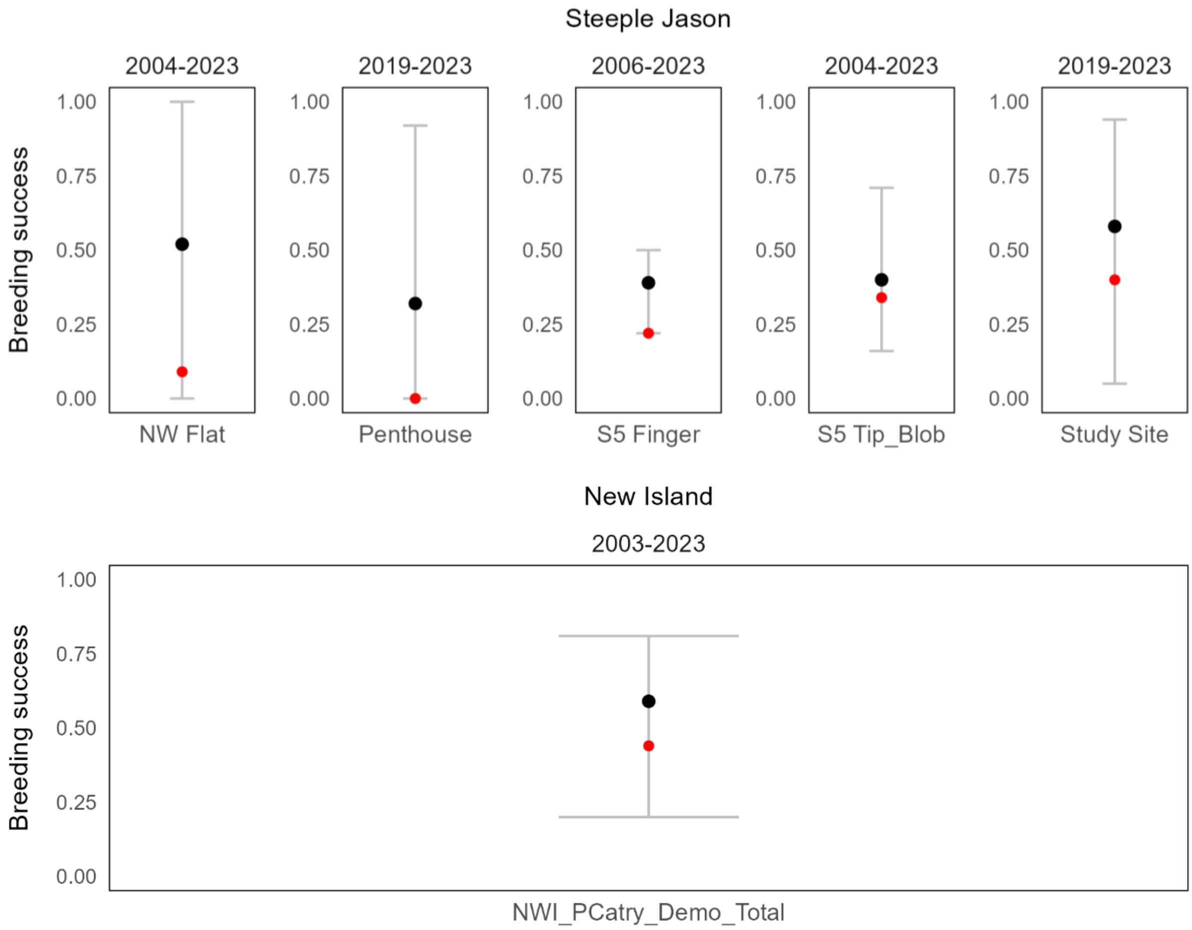

Figure 3 Black-browed albatross estimated breeding success at FISMP sites on Steeple Jason and New Island. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (red dot) breeding success. Data from New Island were kindly provided by P. Catry.

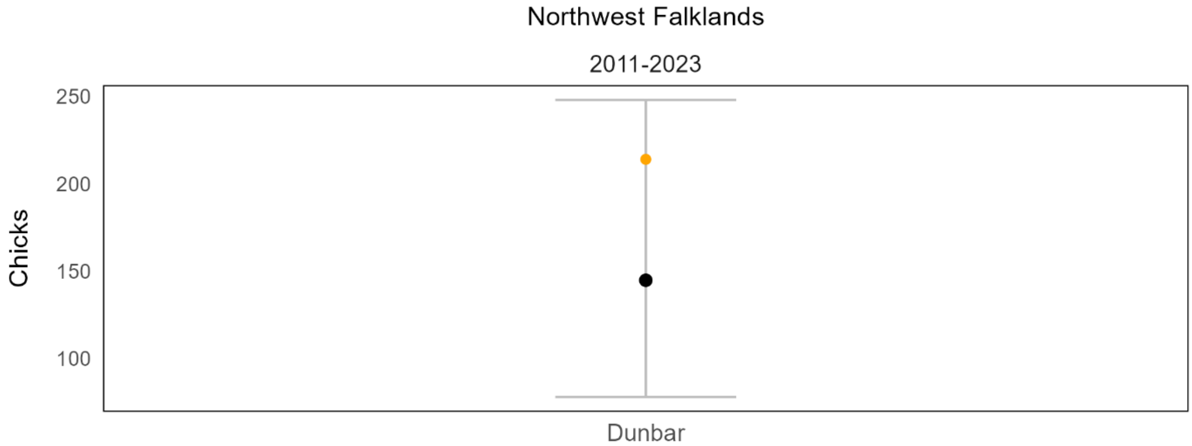

Figure 4 Black-browed albatross chicks counted at Dunbar, Northwest Falklands. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (orange dot) chick counts. Data were kindly provided by Dunbar landowners.

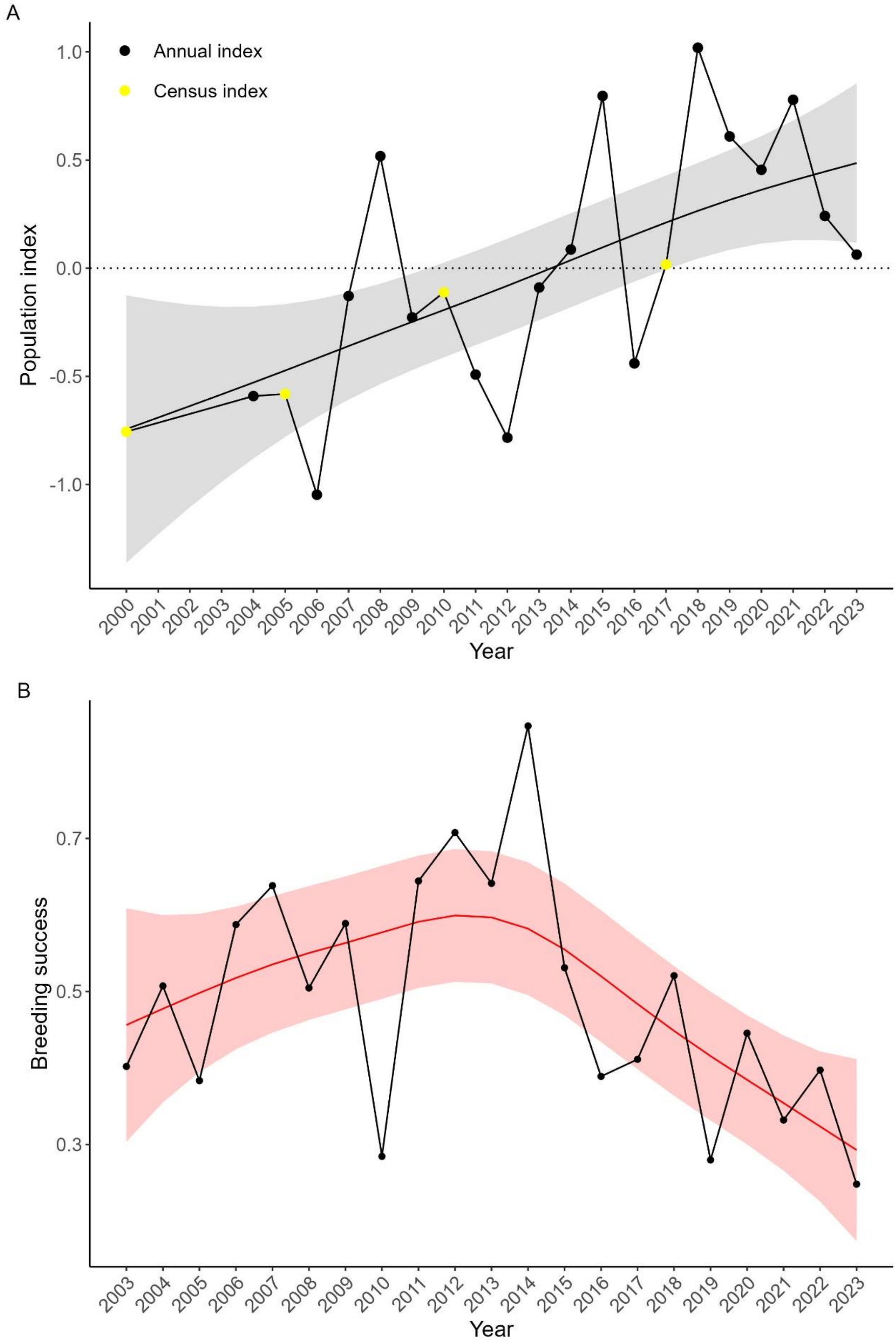

Figure 5 Estimated effect of season on the black-browed albatross breeding population index (**A**) and breeding success (**B**), using data from FIMSP sites at Steeple Jason and New Island. The estimated effect is represented as a smoothing function, with shaded areas representing the 95% confidence interval.

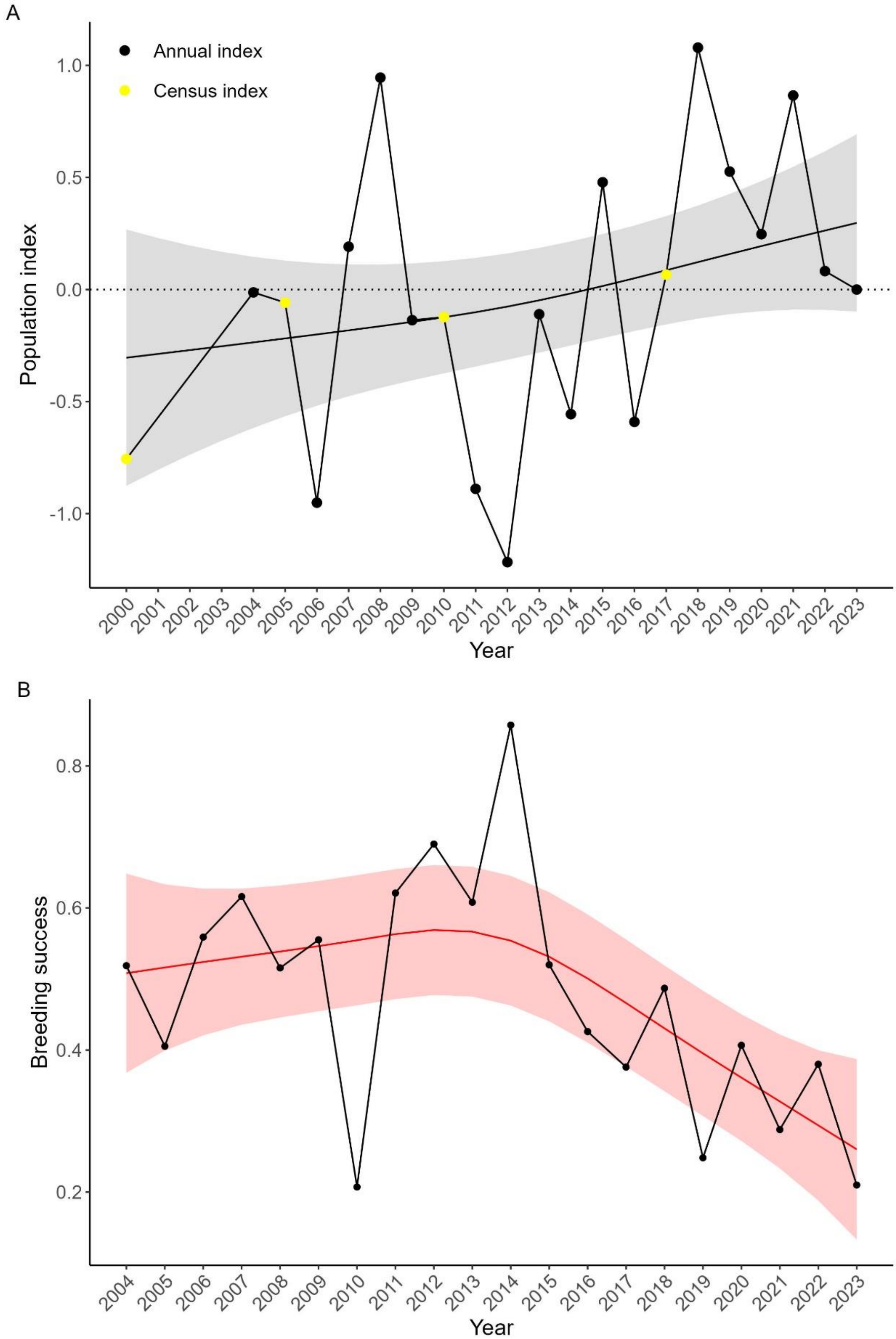

Figure 6 Estimated effect of season on the black-browed albatross breeding population index (**A**) and breeding success (**B**), using data from FIMSP sites at Steeple Jason only. The estimated effect is represented as a smoothing function with shaded areas representing the 95% confidence interval.

Falkland skua

The number of Apparently Occupied Territories of Falkland skua across Steeple Jason Island remained stable from last year after having increased since 2016 by +24% (**Figure 7**).

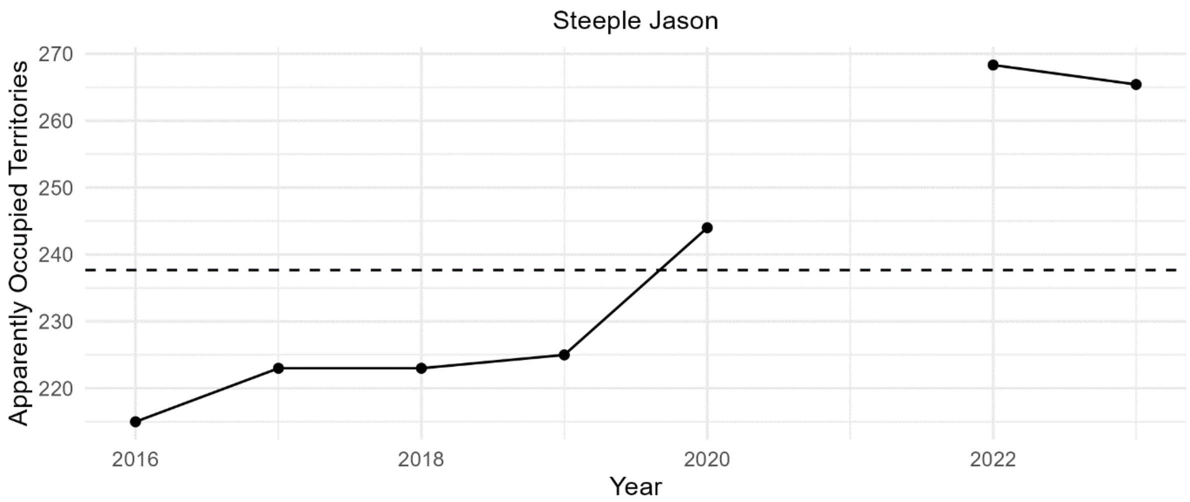

Figure 7 Falkland skua Apparently Occupied Territories at Steeple Jason, 2016–2023. The dashed line represents the overall annual mean.

Other observations

Seven carcasses of adult birds were found during counts on Steeple Jason in January, of which the three freshest were swabbed and tested positive for HPAI. HPAI was also confirmed in skuas on New Island in January and March and on Carcass Island in March (FIG 2024a). On New Island, six skua carcasses were seen within a c. 100 m stretch along the beach near the airstrip, although all carcasses were too old for swabbing.

Gentoo penguin

This season: Breeding pair numbers at FISMP sites were higher overall than last season but below the annual average (-10%) (**Figure 8**). Apart from the northeast, where breeding pair counts were +10% above the annual average, counts were below the annual average in all other geographical areas, particularly in the southeast, on Steeple Jason Island and on New Island (-21% all sites) (**Figure 8**).

The breeding success of 1.1 chicks per pair was lower than last year but overall +10% above the annual average (**Figure 9**; **Figure 10 B**). Breeding success varied substantially across geo-graphical areas, from +33% in Falkland Sound to -17% on Steeple Jason compared to their annual average (**Figure 9**). Note that breeding success at Port Stephens (southwest Falklands) is based on the small sub-colony located along Port Stephens Harbour northeast of the main colony. This is because the chick count could only be conducted relatively late in the season (31 January) which reduced certainty in drone counts from the main colony.

Long-term trend: The breeding population index of gentoo penguins has been declining over the last 9–11 years. Over the longer-term, a fluctuating trend is apparent, suggesting an overall stable population for gentoo breeding pairs (**Figure 10 A**). For breeding success, the long-term trend also shows a fluctuating stable pattern across years, with oscillations running coarsely inversely to breeding pair numbers (**Figure 10 B**).

Other observations

HPAI was confirmed in gentoo penguins on Steeple Jason Island (adults only) in January and March, as well as on Sea Lion Island (chicks and adults) in January and on Carcass Island in March (FIG 2024a). At Sea Lion Island, chick counts were conducted shortly before HPAI was confirmed.

At Lagoon Sands (Johnson's Harbour), many eggs were found several metres away from the colony following a storm during egg incubation (D. Pettersson pers. comm., A. Kuepfer pers. obs.). The colony also experiences high predation pressure from skuas (min. 6 breeding pairs around the colony). Multiple fishing gear remnants were observed within this colony. Plastic debris was also found in the gentoo colony at Port Stephens.

The Yorke Bay colony experiences high levels of visitor activity. Additional signs and a fence were erected late in the season following repeated incidents of active penguin disturbance.

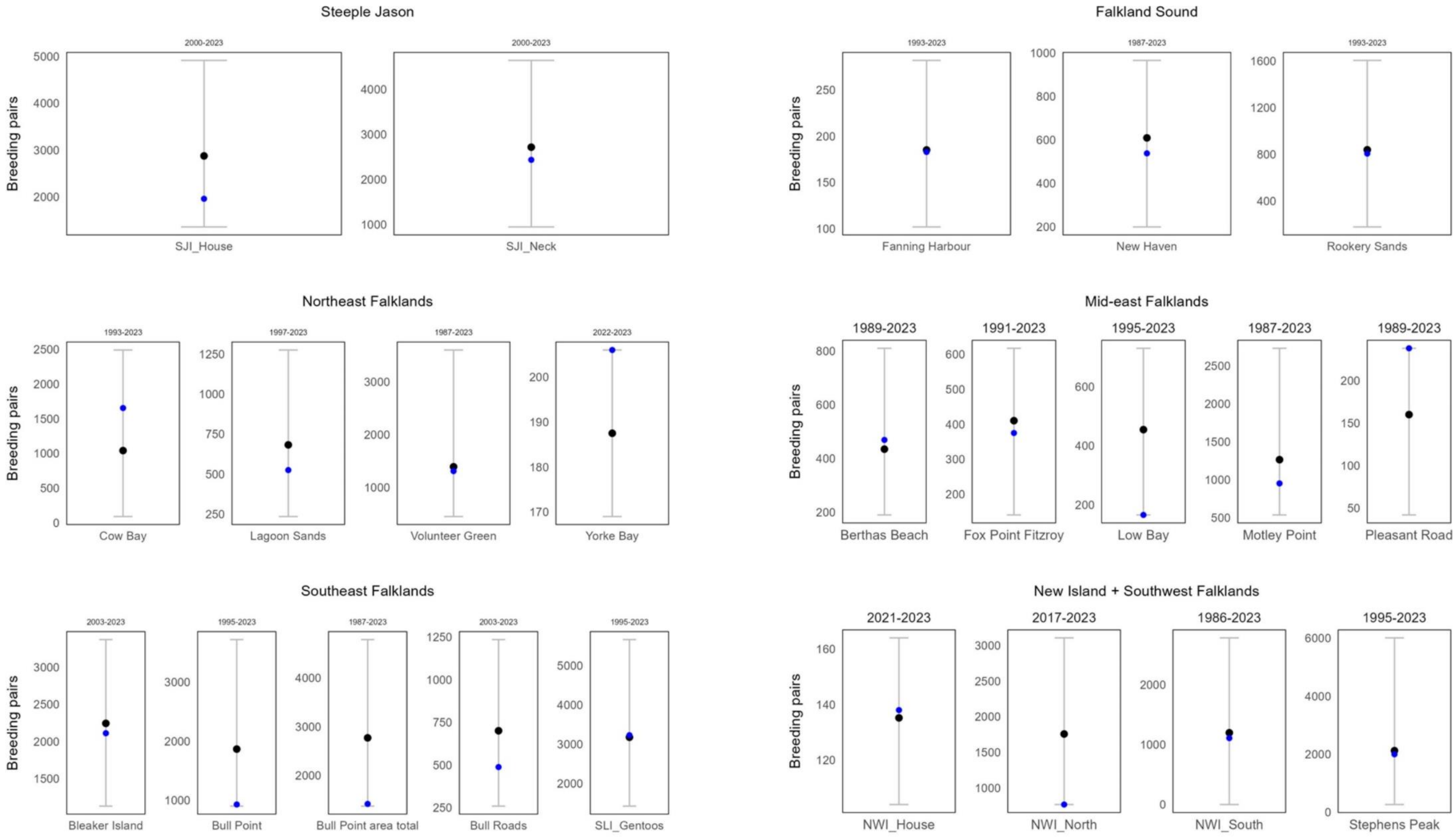

Figure 8 Gentoo penguin breeding pair numbers at FIMSP sites and Bleaker Island. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (blue dot) breeding pair numbers. Data from Bleaker Island were kindly provided by landowners. Historic data from New Island were kindly provided by P. Quillfeldt.

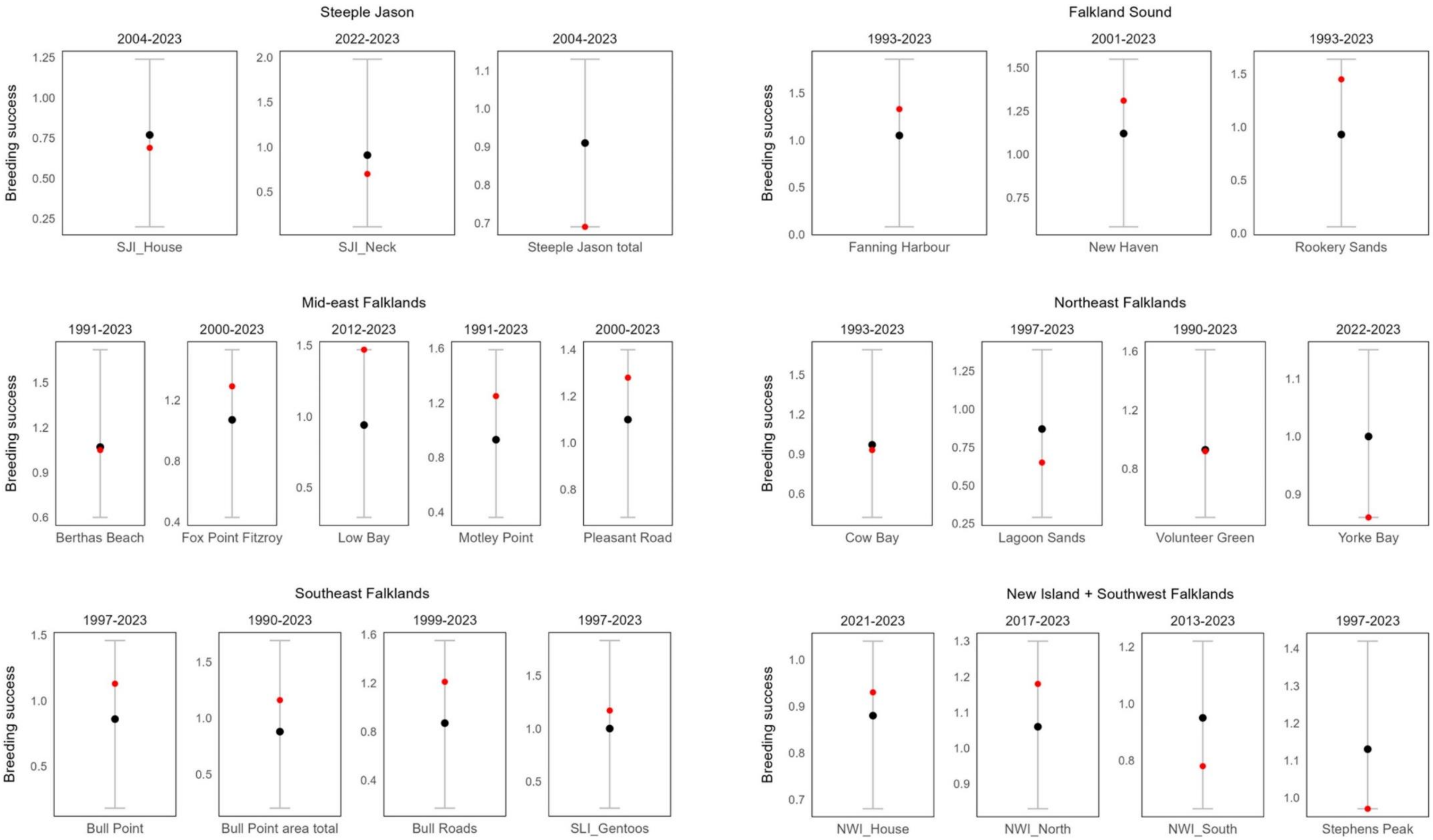

Figure 9 Gentoo penguin estimated breeding success at FIMSP sites. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (red dot) breeding success. Historic data from New Island were kindly provided by P. Quillfeldt.

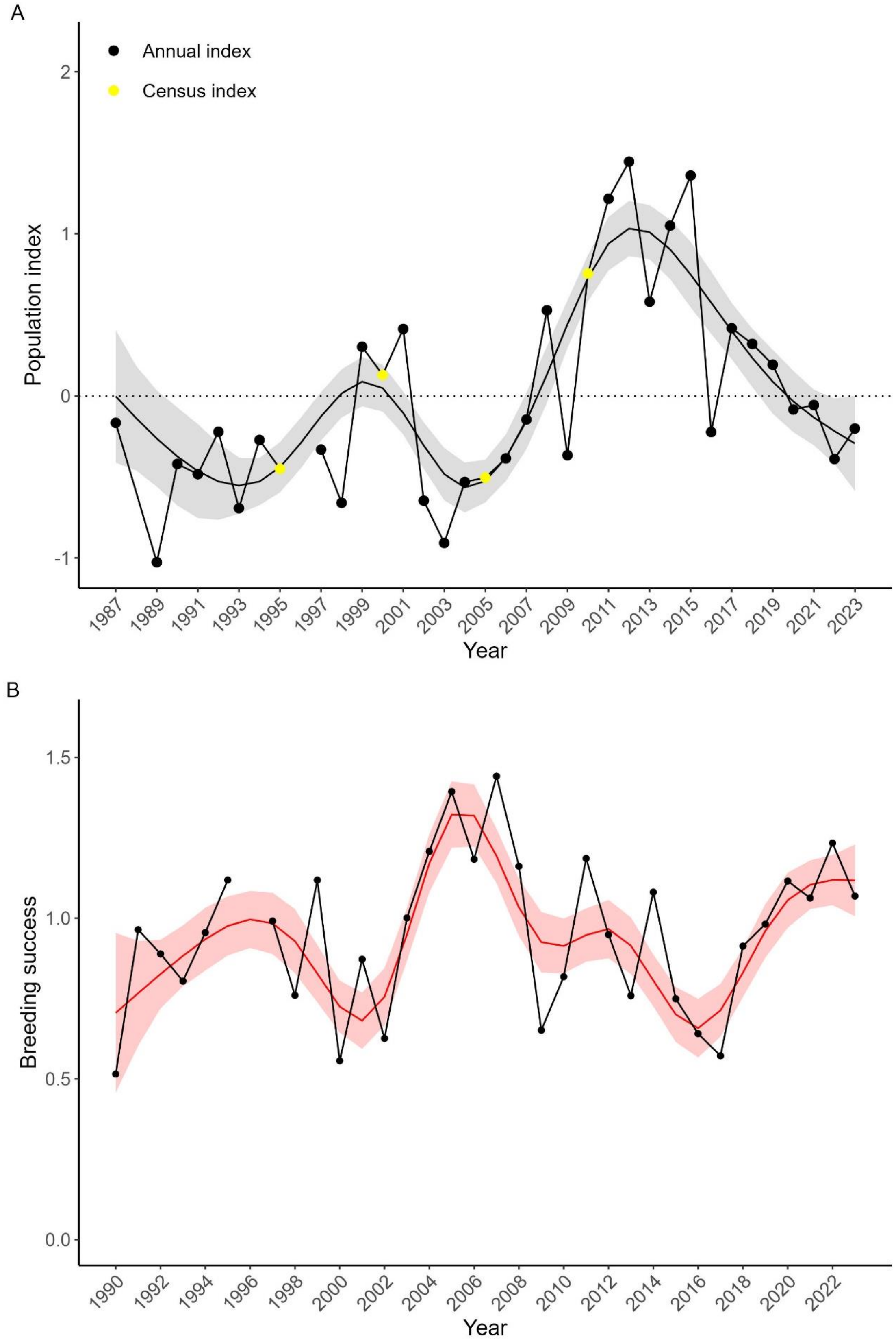

Figure 10 Estimated effect of season on gentoo penguin breeding population index (**A**) and breeding success (**B**), using data from sites across the Falkland Islands. The estimated effect is represented as a smoothing function, with shaded areas representing the 95% confidence interval.

Imperial shag

The number of imperial shag breeding pairs increased from last year, and was above the annual average both at Motley Point (+35%) and at Berkeley Sound (+21%) (**Figure 11**). The breeding population index, based on these colonies, shows a stable long-term trend following an increase from 2014–2016 (**Figure 12**).

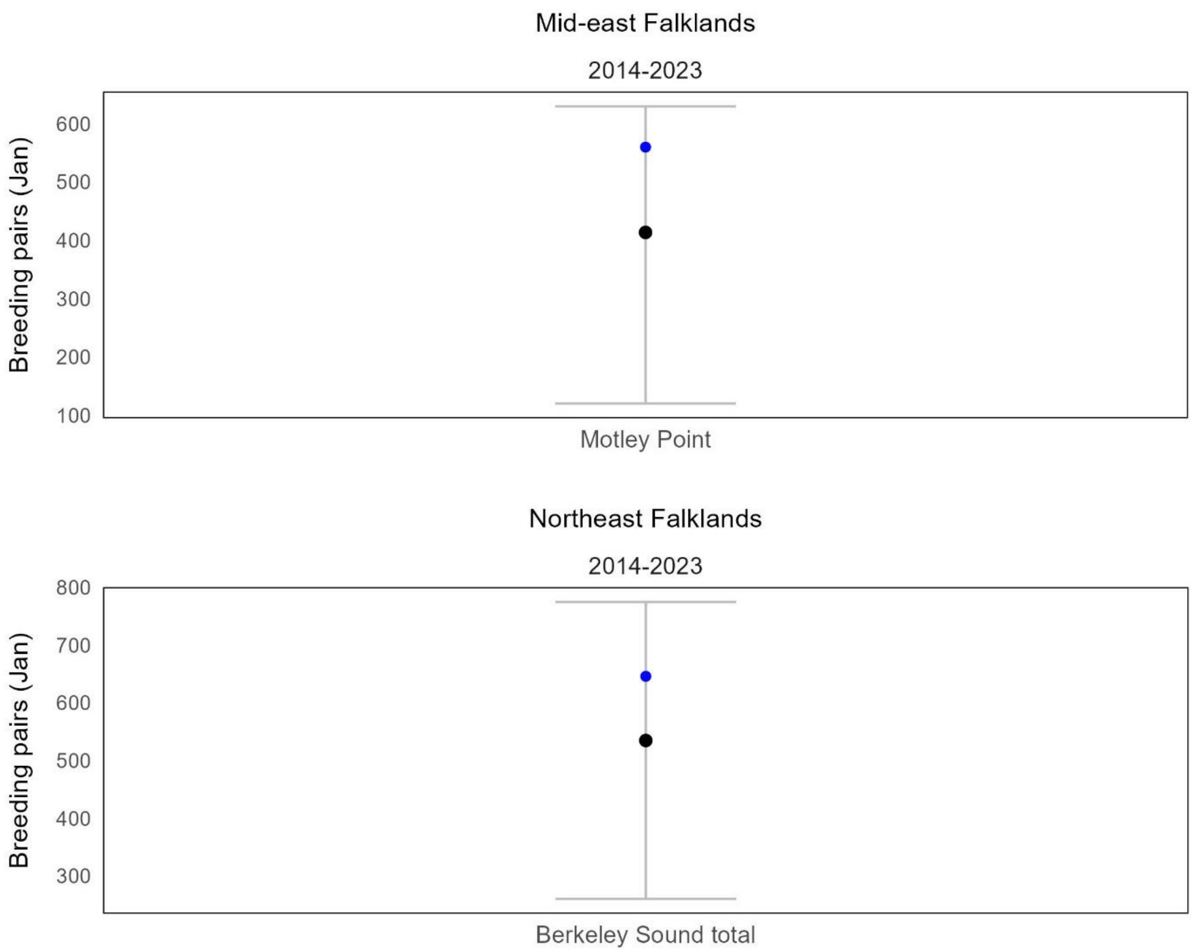

Figure 11 Imperial shag estimated breeding pairs in January at FIMSP sites. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (blue dot) breeding pair counts.

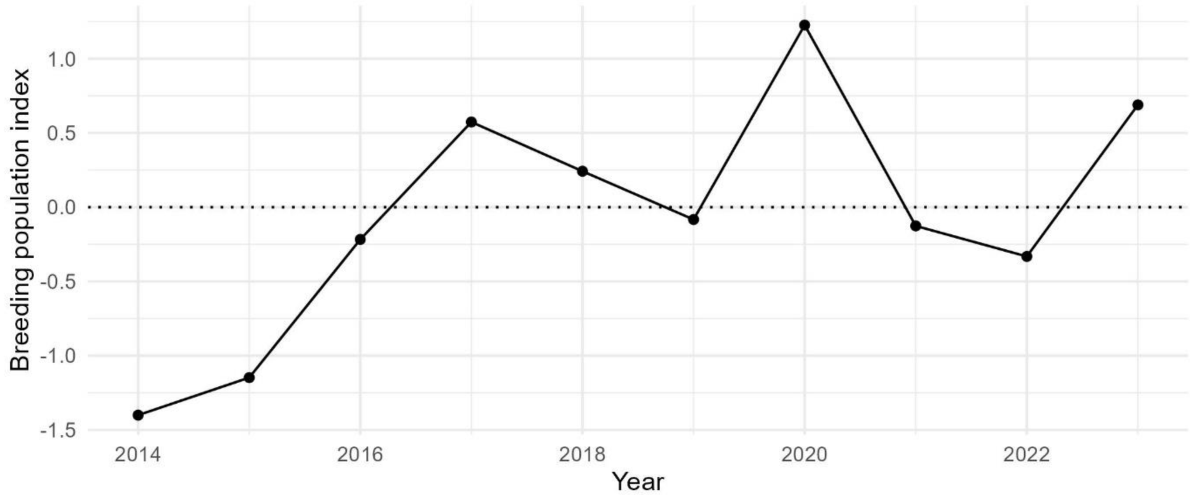

Figure 12 Imperial shag breeding population index, 2014–2023, using data from Motley Point and Berkeley Sound Total. The dashed line represents the overall annual mean.

King penguin

This season: Pre-fledged chicks of king penguins numbered 804 in October 2023, which is lower than last season (n = 987), but +80% above the annual average.

Long-term trend: Over the long-term, king penguin pre-fledged chicks continue to show a strong upward trend since monitoring started, with periodic stable states every 5–6 years (**Figure 13**).

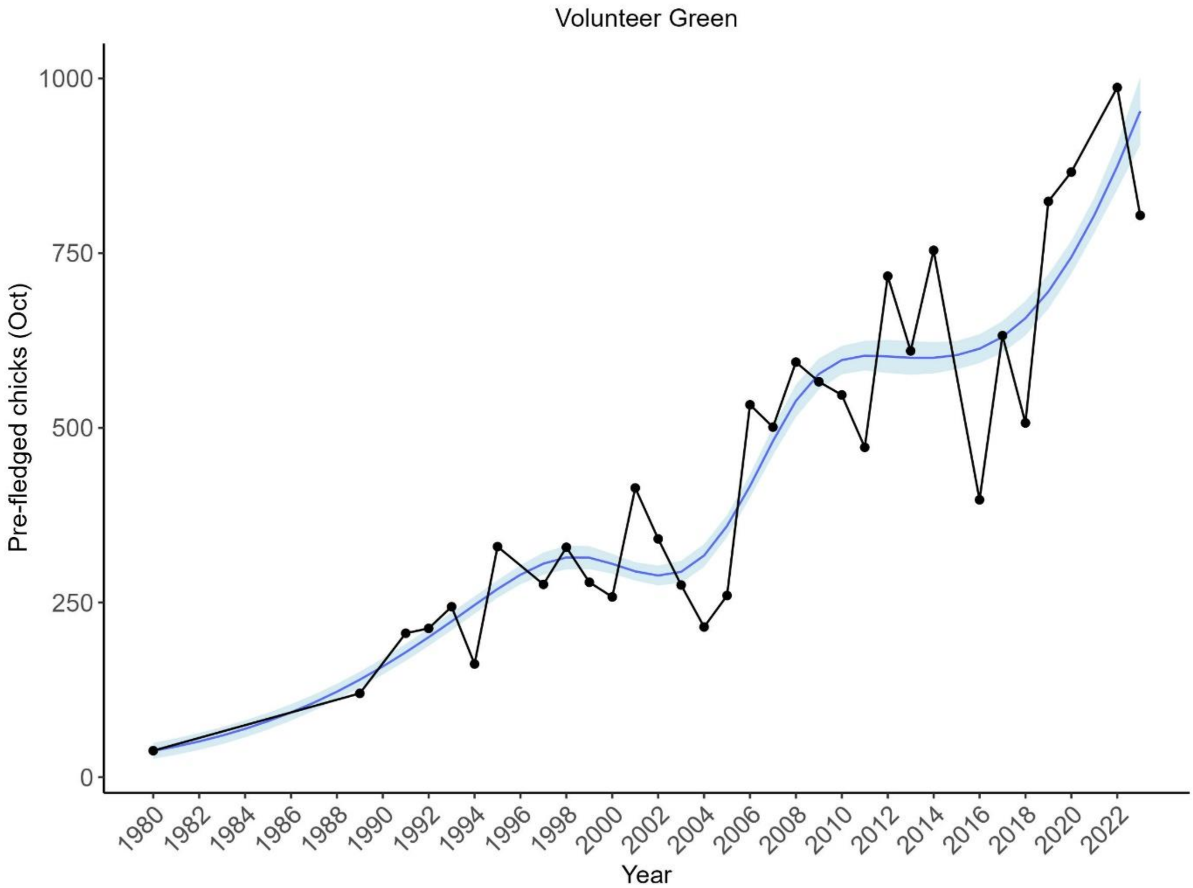

Figure 13 Estimated effect of season on the abundance of king penguin pre-fledged chicks in October at Volunteer Green. The estimated effect is represented as a smoothing function, with shaded areas representing the 95% confidence interval. Data were kindly provided by D. Pettersson.

Other observations:

Adult king penguins at this colony are regularly observed to be predated by southern sea lions (*Otaria flavescens*) (D. Pettersson pers. obs.).

Magellanic penguin

This season: Of the 32 transects, 14 contained occupied Magellanic penguin burrows (**Figure 14**). Where occupied burrows occurred, estimated occupancy density ranged from 2,739–47,796 occupied burrows/km² (mean ± SE: 18,800 ± 4,073 occupied burrows/km²). Considering all burrows for which there was certainty over occupancy status (n = 194), the occupancy rate was 21.1%, which is slightly lower compared to last year, and -32% below the annual average (**Figure 15**). Burrow density was likely underestimated within transects containing high density of gorse (*Ulex europaeus*) (transects T23 and T25, **Figure 14**). Occupied burrow numbers were significantly higher in sections of higher tussac density ($z = 5.627$; $p < 0.001$), supporting the importance of tussac presence for this species.

Long-term trend: Over the longer term, Magellanic penguin burrow occupancy has been declining sharply over the past 9–10 years, following a stable-increasing trend prior to that. Nonetheless, burrow occupancy has not yet declined significantly beyond the initial count in 2002, and the overall trend is therefore currently considered stable (**Figure 15**).

Other observations

No HPAI was suspected at this colony. Across the Falklands, a single symptomatic Magellanic penguin was reported from Bleaker Island, although no tests could be conducted to confirm HPAI infection.

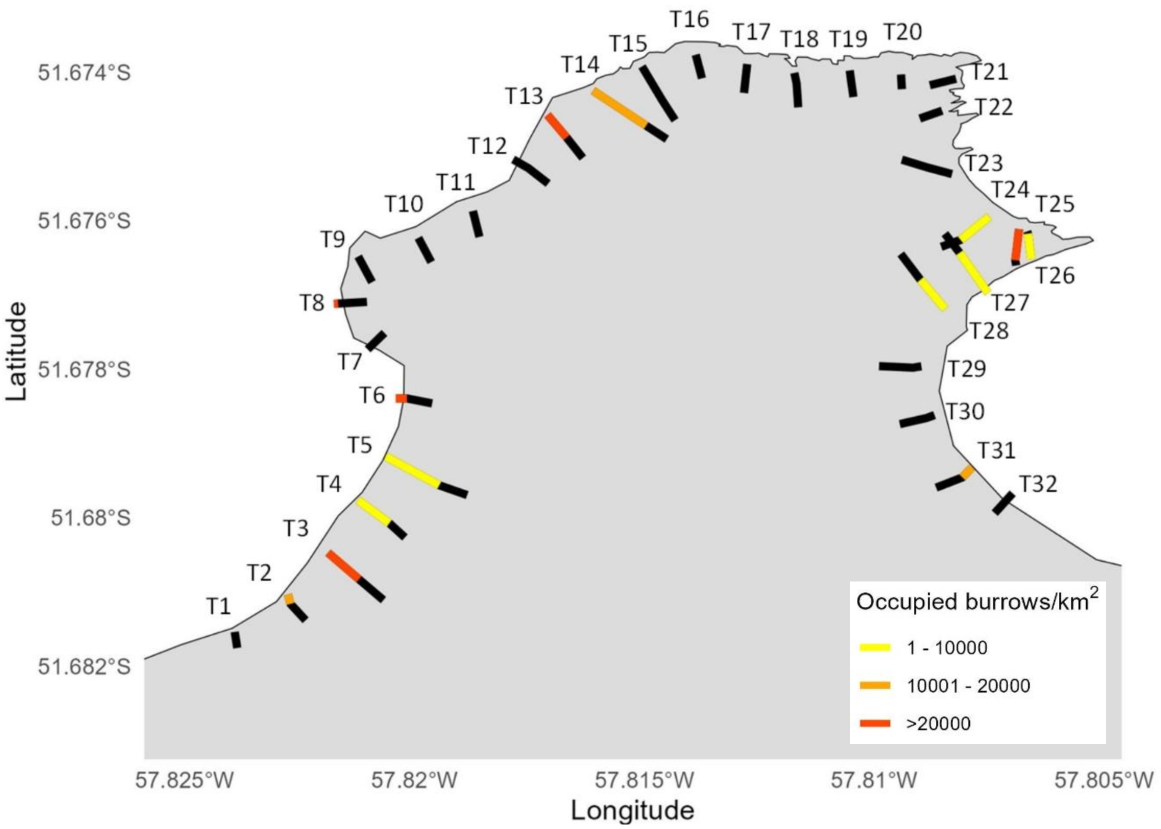

Figure 14 Transect locations for the Magellanic penguin survey at Gypsy Cove, 2023. Black lines represent the section of transects where no burrows were found.

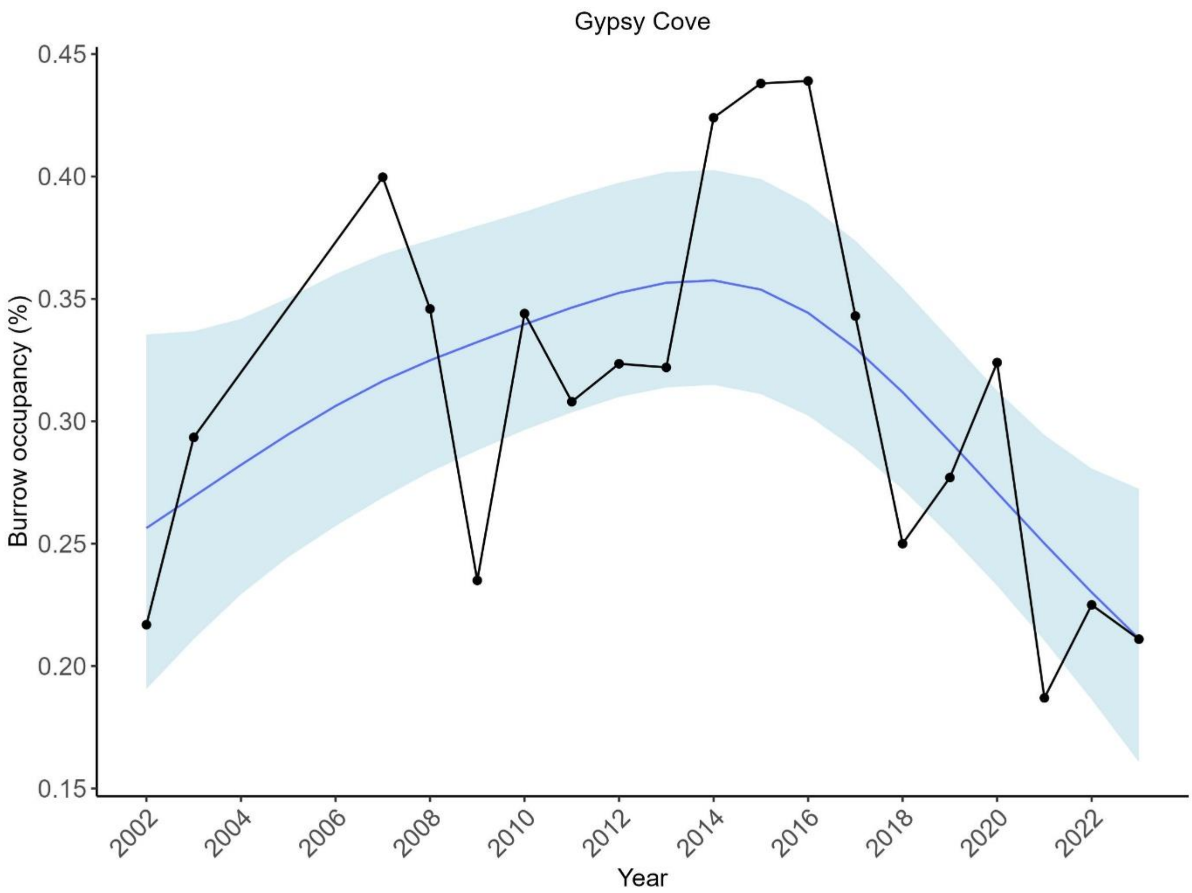

Figure 15 Estimated effect of season on Magellanic penguin burrow occupancy at Gypsy Cove. The estimated effect is represented as a smoothing function, with shaded areas representing the 95% confidence interval.

Southern giant petrel

This season: Breeding pair counts at Steeple Jason were slightly above last year's; no data were obtained at New Island last year. Overall, counts at FISMP sites were -25% below the annual average (**Figure 16**); however, this value is heavily influenced by (1) the extinction of the NW_S of Ridge_West colony on Steeple Jason (a pattern that started in 2021), and (2) the -43% decline at the Ship Island colony on New Island. Given that 181 ± 5.6 breeding pairs were counted at a newly established colony near the New Island airstrip, a possible re-distribution of birds from Ship Island cannot be excluded.

For logistical reasons, breeding success data were only obtained at Steeple Jason, where an overall breeding success of 0.30 chicks per pair was lower compared to last year, but higher compared to the annual average at both remaining colonies (Neck +13%, and House +100%) (**Figure 17**, **Figure 19 B**).

At Bleaker Island, chick counts (n = 244) were higher than last year, and +8% above their annual average (**Figure 18**).

Long-term trend: Due to the uncertainty of the New Island data in regard to potential bird redistribution effects, we excluded these data from the overall population index model until a complete survey can be conducted. The breeding population index based on data from Steeple Jason continues to show an overall stable-increasing trend (**Figure 19 A**). Breeding success at Steeple Jason declined from 2004 (when monitoring started) until 2015–2017, and has since shown a stable-increasing trend (**Figure 19 B**).

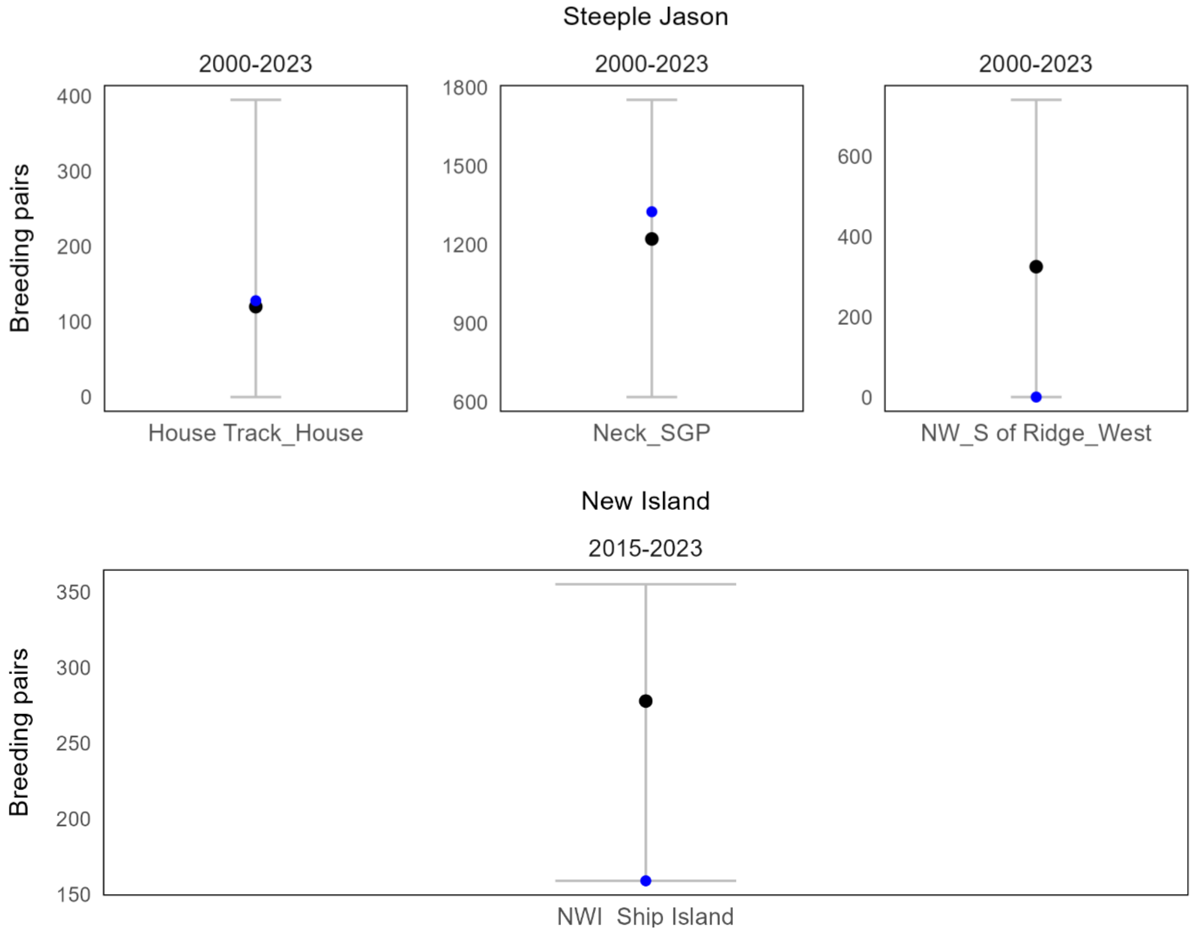

Figure 16 Southern giant petrel breeding pair numbers at FIMSP sites on Steeple Jason and New Island. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (blue dot) breeding pair numbers.

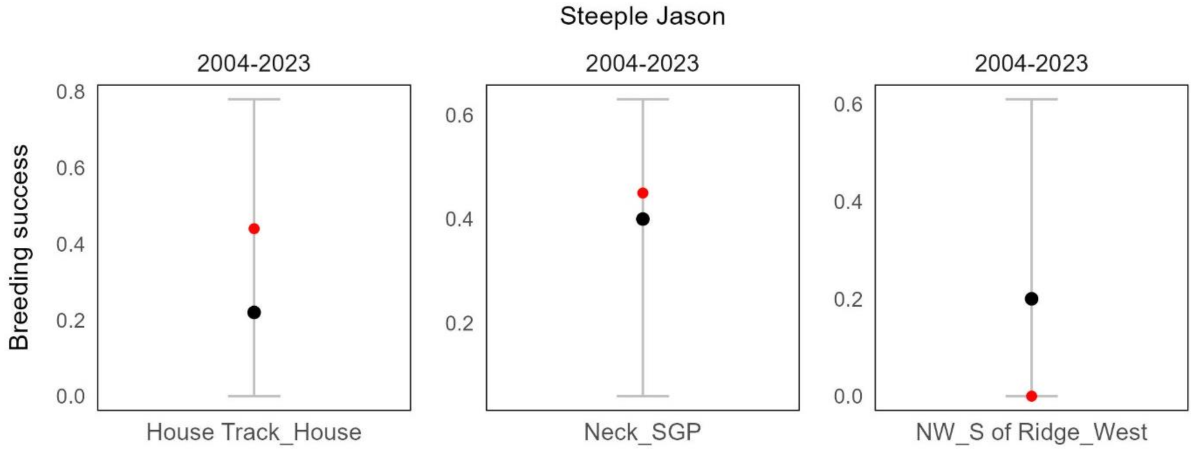

Figure 17 Southern giant petrel estimated breeding success at FIMSP sites on Steeple Jason. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's breeding success (red dot).

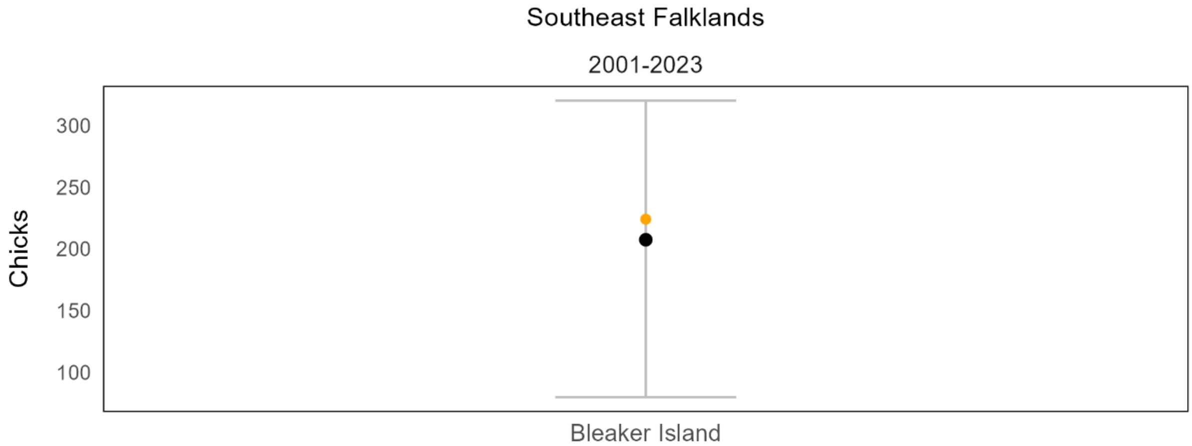

Figure 18 Southern giant petrel chicks counted at Bleaker Island, Southeast Falklands. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (orange dot) chick counts. Data kindly provided by Bleaker Island landowners.

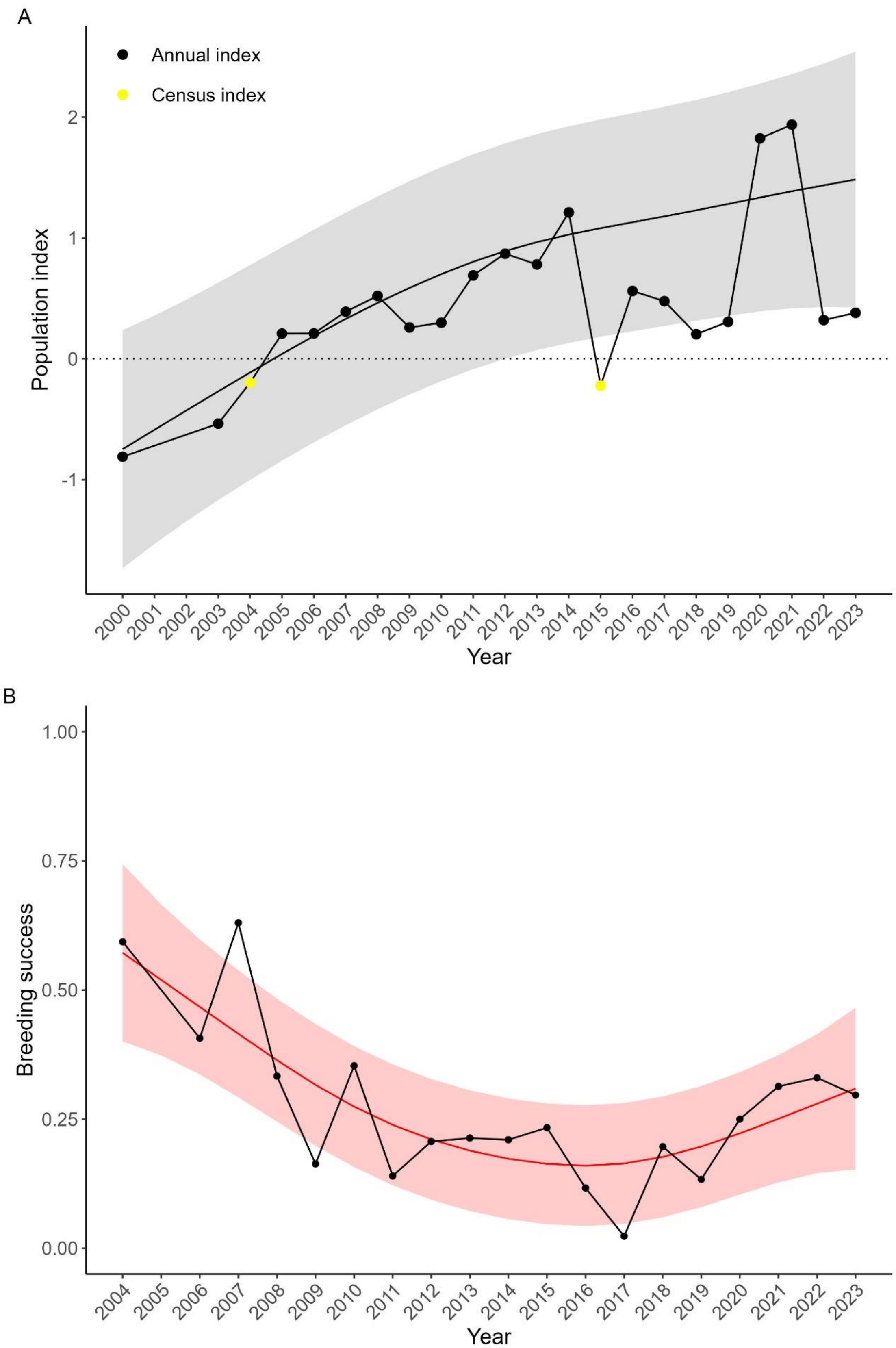

Figure 19 Estimated effect of season on southern giant petrel breeding population index (**A**) and breeding success (**B**), using data from Steeple Jason only. The estimated effect is represented as a smoothing function, with shaded areas representing the 95% confidence interval.

Southern rockhopper penguin

This season: Breeding pair numbers of southern rockhopper penguins at FISMP sites slightly increased from last year but were overall -18% below their annual average (**Figure 20**). The number of breeding pairs compared to the annual average was particularly low at Port Stephens (southwest, -46%) and at Race Point (Falkland Sound, -36%), but was above the annual average at Berkeley Sound (+14%).

The overall breeding success of 0.56 chicks per pair was slightly lower than last year's, and -2% below the annual average (**Figure 21**, **Figure 22 B**). Breeding success was lowest at Racepoint (Falkland Sound, -10%) and in the southeast (-5%). Northeast and southwest Falklands held above annual average breeding success (+5% and +7%, respectively).

Long-term trend: The breeding population index of southern rockhoppers shows a continuing decline over the last 8–10 years, although data from across the Falklands since 1991 suggest a fluctuating stable trend (**Figure 22 A**). At Steeple Jason, where 38% of the Falkland Islands' southern rockhopper population resides (Baylis et al. 2013a), the long-term trend since 2003 is overall declining, although it is currently unclear whether a longer time series would also reveal a fluctuating trend (**Figure 23 A**). In terms of breeding success, data from colonies across the Falklands has shown a long-term declining trend since monitoring began 30 years ago, although data from recent years suggest that breeding success may be stabilising (**Figure 22 B**). At Steeple Jason, the long-term breeding success since 2003 is showing a fluctuating stable trend (**Figure 23 B**).

Other observations

Unusually high numbers (several dozens) of dead adult southern rockhopper penguins were found in January at Steeple Jason Island within the area where the albatross mortality rate was highest (Falklands Conservation, unpubl. data). Swabs from three fresher carcasses tested positive for HPAI (FIG 2024a). Dead rockhopper chicks were also observed, though not necessarily in numbers exceeding what is expected during a typical breeding season, and no swabs were taken. Live adult birds in this area showed exceptionally aggressive behaviour.

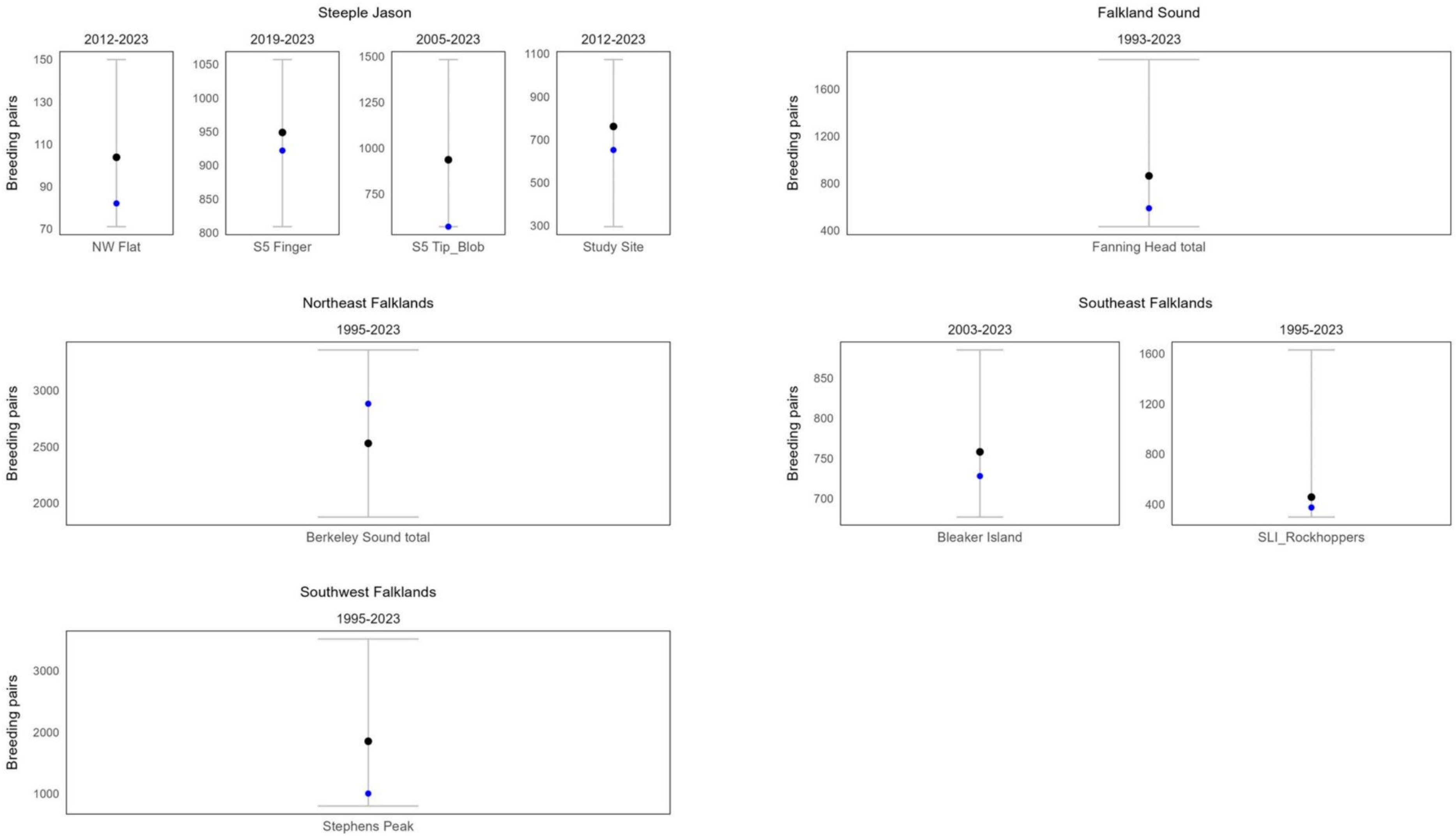

Figure 20 Southern rockhopper penguin breeding pair numbers at FIMSP sites. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (blue dot) breeding pair numbers.

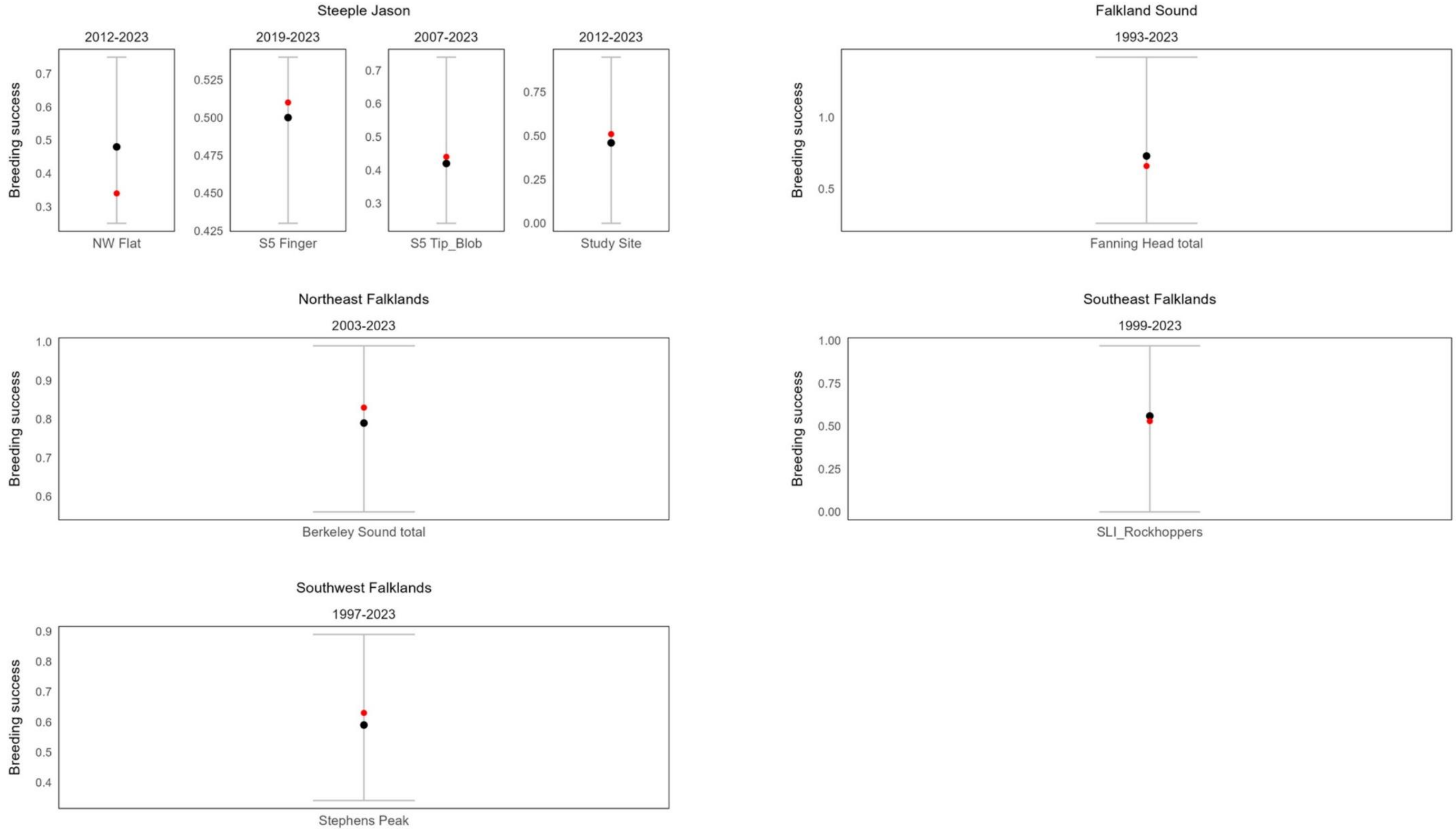

Figure 21 Southern rockhopper penguin estimated breeding success at FIMSP sites. Bars indicate the minimum, maximum, annual mean (black dot) and the current season's (red dot) breeding success.

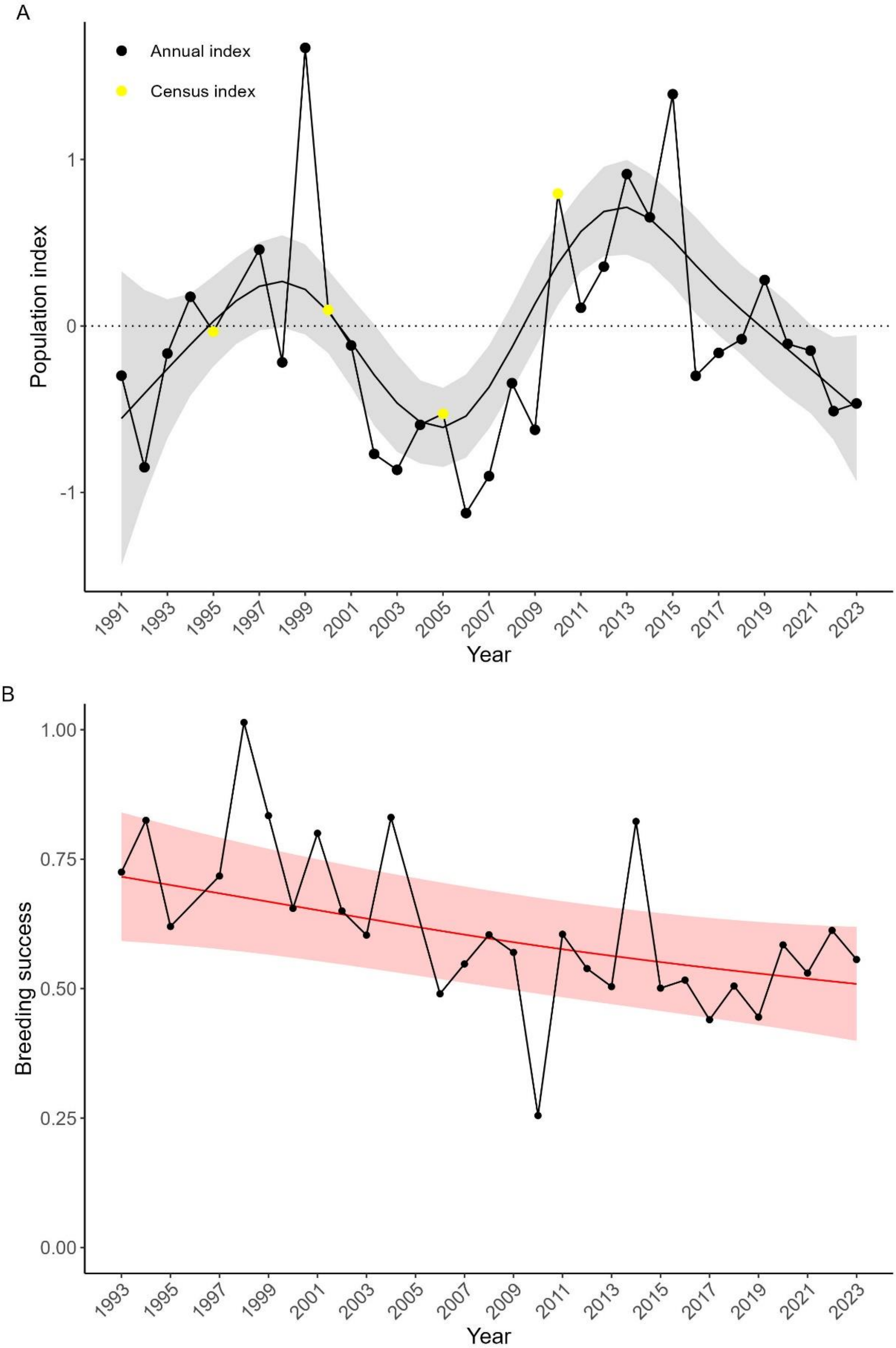

Figure 22 Estimated effect of season on southern rockhopper breeding population index (**A**) and breeding success (**B**), using data from sites across the Falkland Islands. The estimated effect is represented as a smoothing function, with shaded areas representing the 95% confidence interval.

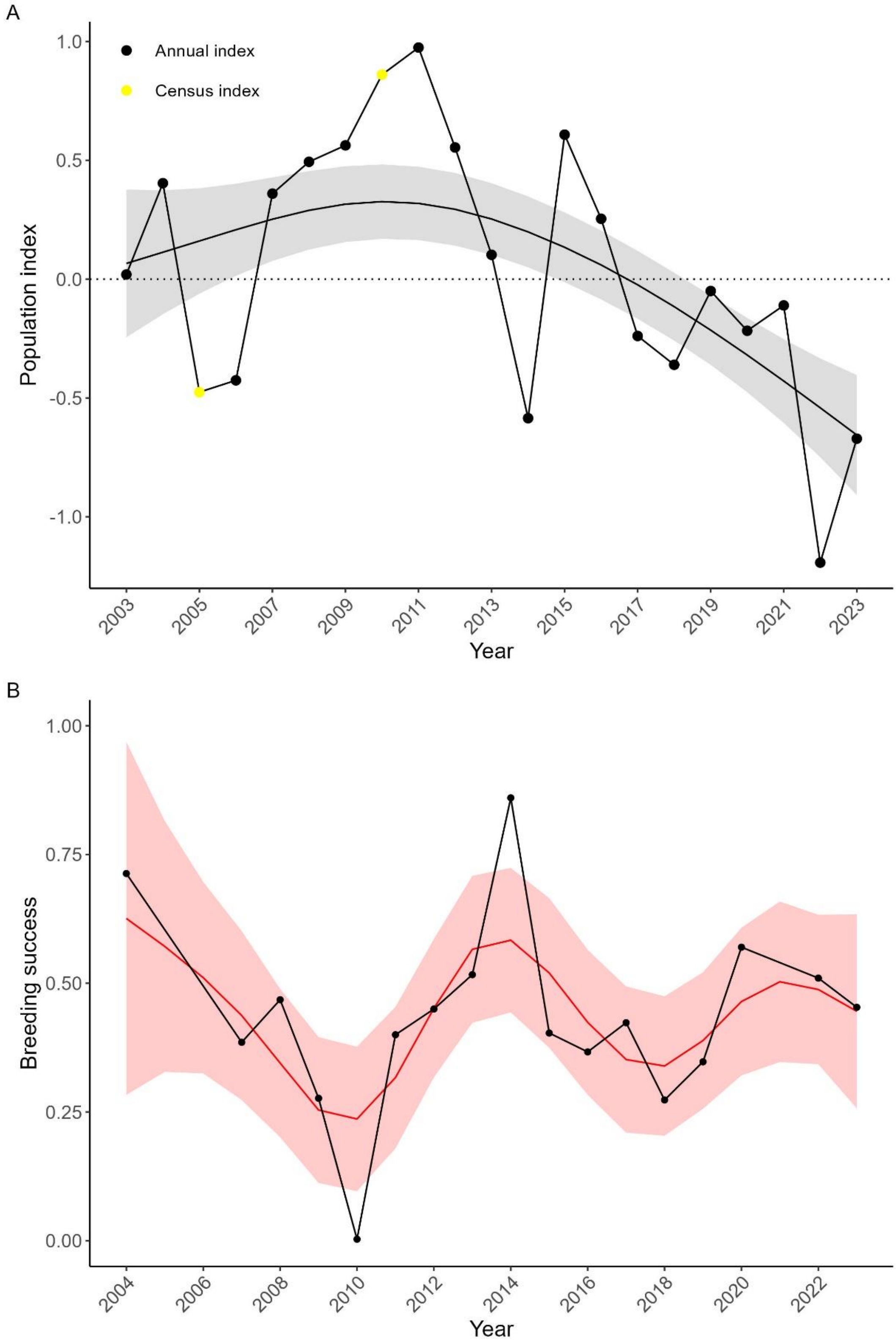

Figure 23 Estimated effect of season on southern rockhopper breeding population index (**A**) and breeding success (**B**), using data from Steeple Jason only. The estimated effect is represented as a smoothing function, with shaded areas representing the 95% confidence interval.

Sooty shearwater

The Kidney Island population size was estimated at 131,000 (95% CI: 95,000–176,000) breeding pairs (Kuepfer et al. 2024). This estimate is not notably different from 2016 (123,000; 95% CI: 87,000–167,000 breeding pairs), and gives no strong indication of an important change in breeding pairs at this site (Kuepfer et al. 2024). The predicted effect of space on sooty shearwater abundance is depicted in (**Figure 24**).

The Top Island population size was estimated at 12,000 (95% CI: 7,000–19,000) breeding pairs (Kuepfer et al. 2024). This represents a baseline estimate. The predicted effect of space on sooty shearwater abundance is depicted in (**Figure 25**).

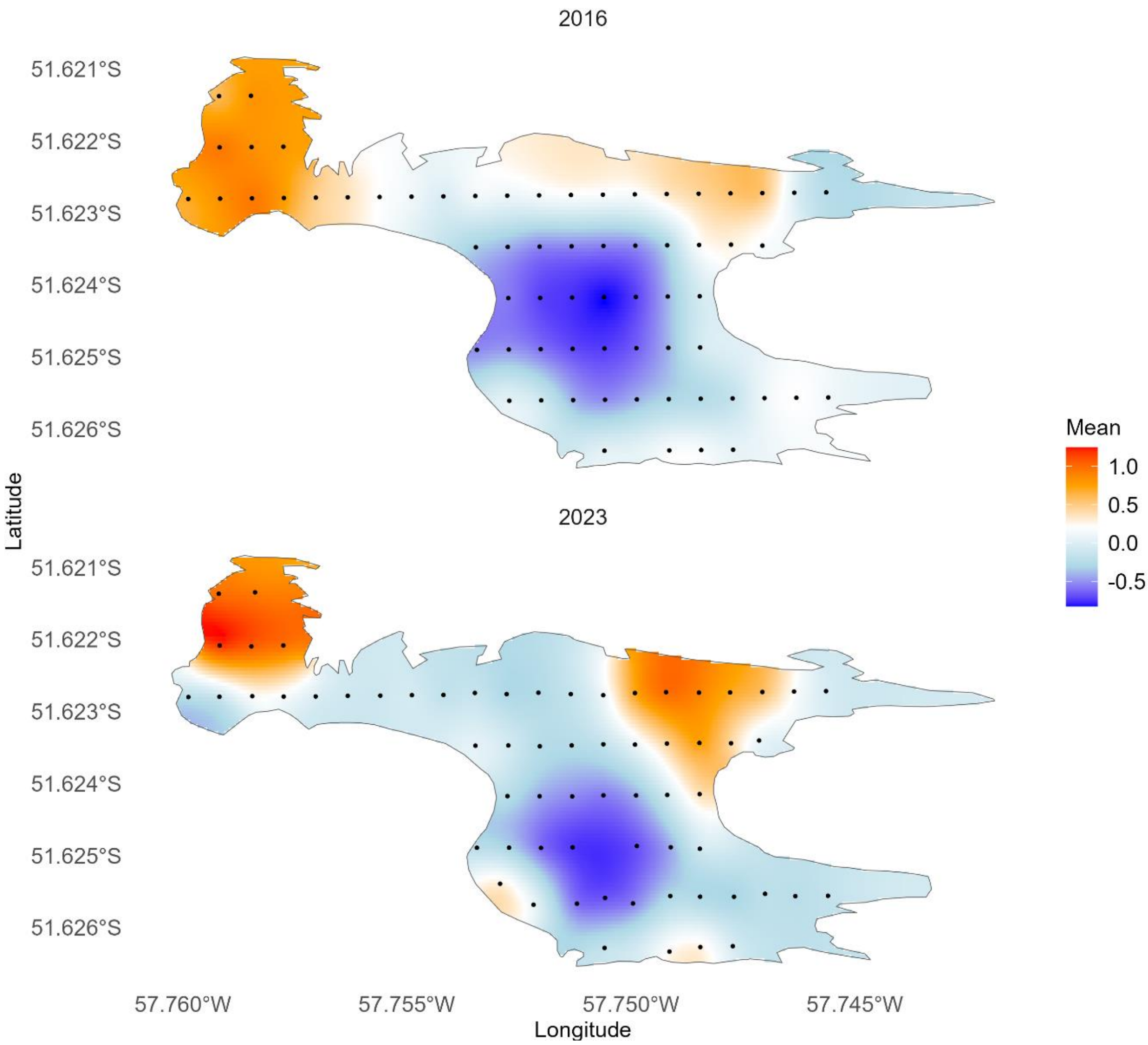

Figure 24 The posterior mean for the spatial random field with progressive spatial-temporal correlation for Year, demonstrating the partial effect of space on number of sooty shearwater breeding pairs across Kidney Island. Source: Kuepfer et al. 2024.

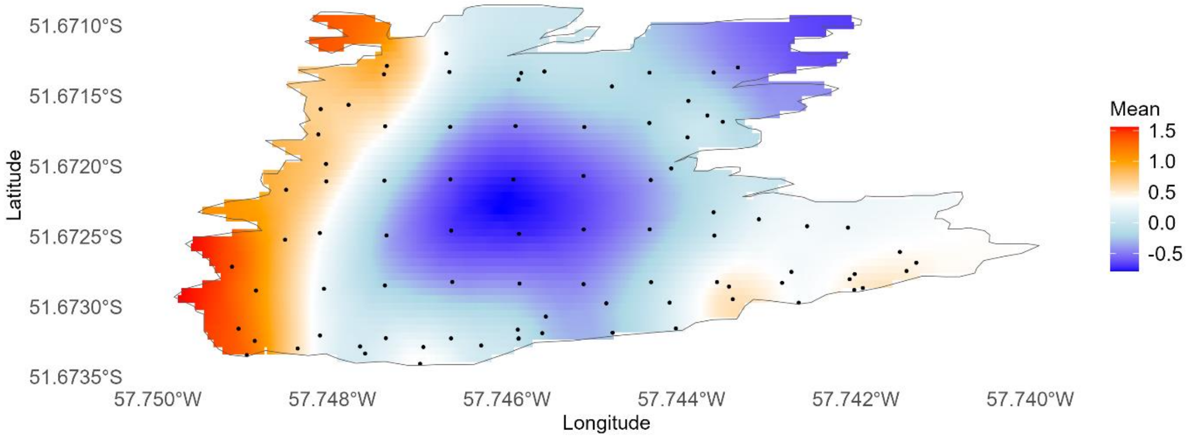

Figure 25 The posterior mean for the spatial random field, demonstrating the partial effect of space on number of sooty shearwater breeding pairs across Top Island. Source: Kuepfer et al. 2024.

White-chinned petrel

The Kidney Island population size was estimated at 331 (95% CI: 52–1043) breeding pairs (Kuepfer et al. 2024). This represents a baseline estimate using a model-based approach. The predicted effect of space on white-chinned petrel abundance is depicted in (**Figure 26**).

The Top Island population size was estimated at 199 (95% CI: 33–594) breeding pairs (Kuepfer et al. 2024). This represents a baseline estimate. The predicted effect of space on white-chinned petrel abundance is depicted in (**Figure 27**).

At New Island, artificial repairs to damaged burrows (carried out as part of the Darwin PLUS project 169) increased apparent breeding opportunities, and six breeding pairs were recorded at the start of the season (Falklands Conservation unpubl. data). Activity was recorded throughout the main part of the season using remote cameras; however, cameras were unable to determine whether breeding was successful or not. Cats, rats, mice and Johnny rooks (*Phalcoboenus australis*) were frequently recorded by the cameras, and surveys during the previous season recorded no successful breeding at the site.

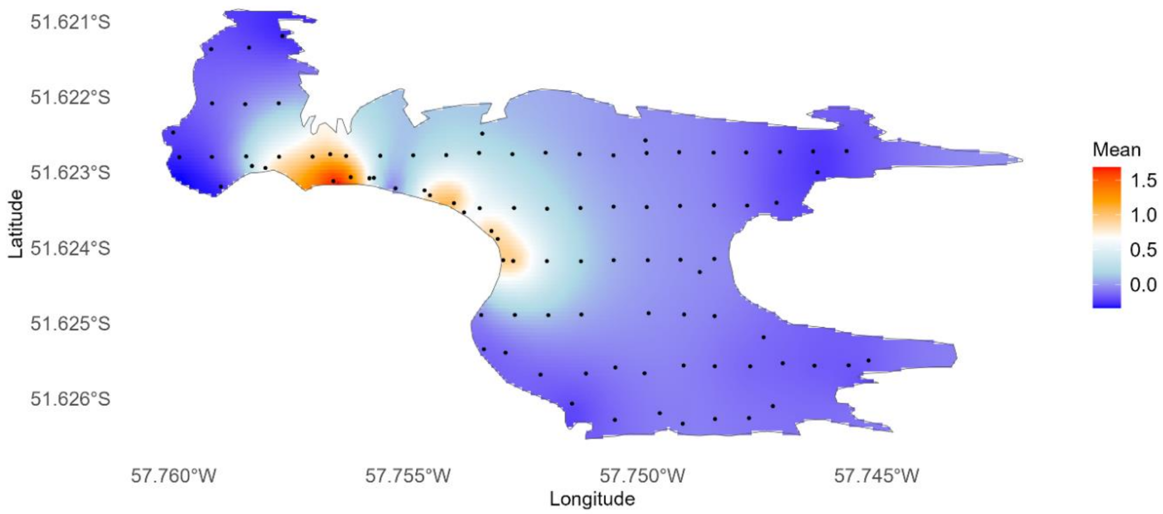

Figure 26 The posterior mean for the spatial random field with persistent spatial-temporal correlation, demonstrating the partial effect of space on number of white-chinned petrel breeding pairs across Kidney Island. Source: Kuepfer et al. 2024.

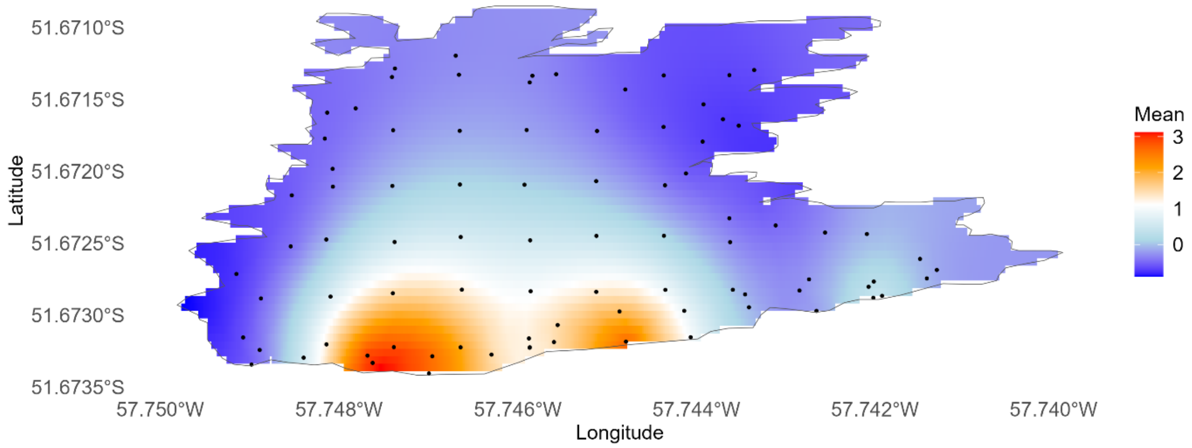

Figure 27 The posterior mean for the spatial random field with persistent spatial-temporal correlation, demonstrating the partial effect of space on number of white-chinned petrel breeding pairs across Top Island. Source: Kuepfer et al. 2024.

Environmental and anthropogenic impacts on seabirds

Climate

The austral summer of 2023/2024 experienced a moderately intense El Niño event, which peaked in December 2023 (**Figure 28**) (NASA 2024; WMO 2024).

At Lagoon Sands, many eggs were found several metres away from the colony following a storm during egg incubation (D. Pettersson pers. comm., A. Kuepfer pers. obs.).

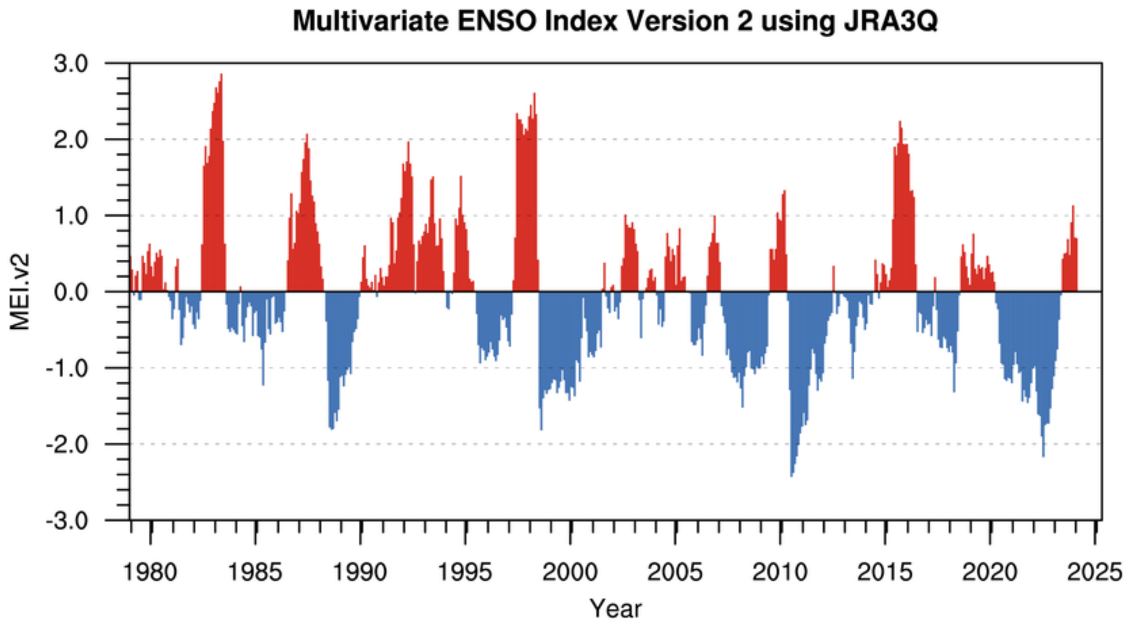

Figure 28 Bi-monthly Multivariate El Niño/Southern Oscillation (ENSO) Index. Source: https://psl.noaa.gov/enso/mei/. Positive red values indicate warmer El Niño conditions; blue negative values indicate cooler La Niña conditions.

Diseases

The 2023/2024 season marked the confirmed incursion of the Highly Pathogenic Avian Influenza (HPAI H5N1) virus to the Falkland Islands, which affected several species across the archipelago, including at FISMP sites. Overall, the FIG surveillance programme, which involved incident reporting, swabbing and AIV RNA screening, confirmed ten sporadic cases and three main outbreaks (with evidence of local transmission) (FIG 2024a, Emerit et al. in prep.). Key lethal outbreaks were recorded on Steeple Jason (predominantly black-browed albatrosses, but also gentoo penguins, rockhopper penguins, and skuas), Sea Lion Island (gentoo penguins) and Carcass Island (gentoo penguins and skuas). Isolated cases were recorded on Saunders Island (black-browed albatross), New Island (skuas), Pebble Island (southern fulmar *Fulmarus glacialoides*) and in Stanley (southern fulmar, gentoo penguin, crested caracara *Phalcoboenus australis*, and variable hawk *Geranoaetus polyosoma*) (see FIG 2024a for details; Emerit et al. in prep.).

Disturbance

The Yorke Bay gentoo penguin colony experiences high levels of visitor activity. Additional signs and a fence were erected late in the season following repeated incidents of active penguin disturbance.

Fisheries bycatch

The Falkland Islands Fisheries Department reported the following seabird bycatch in the Falkland Islands fishing fleet from January to December 2023 (FIG 2024b): An estimated 140 and 135 mortalities of ACAP-listed seabirds occurred in the finfish and loligo trawl fleets, respectively, including 234 black-browed albatrosses, 30 white-chinned petrels and 11 giant petrel species (*Macronectes sp.*) (observer effort: Finfish = 6.4% of trawling days; Loligo = 1,330 h). Numerous additional incidental captures occurred, which resulted in live releases. No seabird bycatch was reported in the longline fleet (observer effort = 7.9% of hooks set / 2.8% of hooks retrieved).

Invasive species

The presence of invasive mammals (cats, rats, mice) was frequently recorded by cameras monitoring white-chinned petrel burrows on New Island. Active predation of sooty shearwater adults and fledglings by feral cats was recorded elsewhere in the Falklands (Hadassa Bay near Gypsy Cove; S. Poncet and R. James unpubl. data).

Marine plastics

Fishing net remnants were recorded in the gentoo colony at Lagoon Sands and incorporated into numerous black-browed albatross nests on Steeple Jason. Numerous plastics of unknown origin were found in and around the gentoo colony at Port Stephens. Beach cleans conducted by Falklands Conservation and volunteers show that marine debris, predominantly derived from fishing activities, remains a constant feature near and around seabird colonies.

Natural predation

Unusually high levels of predation, predominantly by skuas, were observed at the New Island black-browed albatross colony during chick-rearing. High predation risk by skua could also be expected at the Lagoon Sands gentoo colony throughout breeding, given the presence of multiple breeding pairs around this small colony. Southern sea lions have been observed to target adult king penguins at Volunteer Point (D. Pettersson pers. comm.).

Oiling

No oiled birds were seen at FISMP sites; however, one oiled king penguin at Saunders was reported to Falklands Conservation in August 2024; the source of the oil is yet to be determined.

Wildfires

No FISMP sites were impacted by wildfires. However, wildfires this season impacted seabird colonies on Bird Island, Grand Jason Island and Sea Lion Island. On Bird Island, estimates from February 2024 suggest that the fire likely led to the complete breeding failure and loss of 210,000–315,000 nests of thin-billed prions (*Pachyptila belcheri*), 100–1000 mortalities of black-browed albatross chicks, and 100 mortalities of southern rockhopper penguins (Munro et al. 2024). Caution with these estimates is warranted given the limited possible observations and subsequent extrapolations on which they are based (Munro et al. 2024). All fires are believed to have been ignited by electrical storms, although the Grand Jason fire likely involved a re-ignition from a previous fire. As of August 2024, Bird Island is still burning (S. Poncet pers. comm.).

Discussion

The FISMP collects long-term data on measures of change in seabird breeding pairs and breeding success in the Falkland Islands. Long-term data are crucial for assessing population health and provide a fundamental basis for understanding impacts of climatic and anthropogenic drivers (Jenouvrier et al. 2005; Ventura et al. 2021a, 2023). While annual data can highlight the effect of acute influences like disease or extreme weather events, long-term datasets are essential for detecting multi-annual fluctuations and gradual changes driven by longer-term influences in long-lived seabirds, such as climate change or habitat degradation.

Season overview

The season of 2023/2024 showed mixed results for individual species (**Table 3**). In general, counts in breeding pair metrics were higher compared to 2022/2023, but remained below the annual average. All species experienced reduced breeding success compared to last season, and values fell below the annual average for black-browed albatross and southern rockhopper penguins.

The season was characterised by two atypical environmental phenomena: (1) the first confirmed presence of the Highly Pathogenic Avian Influenza virus (HPAI H5N1), and (2) a moderately strong El Niño event.

Table 3 Summary of species-specific changes in breeding pair and breeding success metrics compared to last season and the annual average.

Species	2023 vs 2022		2023 vs annual average	
	Breeding pair metrics	Breeding success metrics	Breeding pair metrics	Breeding success metrics
Black-browed albatross	↓	↓	↑	↓
Falkland skua	=		↑	
Gentoo penguin	↑	↓	↓	↑
Imperial shag	↑		↑	
King penguin		↓		↑
Magellanic penguin	↓		↓	
Southern giant petrel	↑	↓	↓	↑
Southern rockhopper penguin	↑	↓	↓	↓

HPAI

The potential effects of HPAI H5N1 on our globally and nationally important wildlife are of great concern, both in terms of species conservation, ecosystem functioning, and associated implications for tourism, public health and our wider economy.

The FIG surveillance programme confirmed that HPAI affected several species across the archipelago (FIG 2024a). Fortunately, records of larger-scale mortality in birds as a result of HPAI have so far been limited. To date, the most significant impact associated with HPAI has been recorded within the black-browed albatross colony on Steeple Jason Island. Confirmed HPAI cases and the characteristics of carcasses strongly suggest the multiple 1000s of dead adults at the colony and high chick mortality resulted from HPAI. However, assessing the actual impact of HPAI on the overall status of seabird populations is challenging, particularly against the backdrop of many other influencing factors (see also Tremlett et al. 2024).

Firstly, there are several confounding factors to consider: whilst any observable adult bird mortality will indicate an impact at an individual level, it may not necessarily result in detectable or correlating changes in population measures like breeding pair counts. This is because such measures do not account for the extent to which birds in the non-breeding population may move in to replace lost breeders. Mortality estimates through carcass counts are also likely to result in underestimates, due to birds dying away from the colony (A. Kuepfer pers. obs.). Colony counts conducted outside standard counting periods are difficult to compare, and may incorrectly attribute mortality to breeders who have merely failed and left the colony, but who will potentially return the following year.

Secondly, caution is needed when attributing population changes to specific threats in isolation. HPAI represents a threat amidst a complex range of other factors that impact seabird populations. For example, breeding failure comparable to this season's rate has been observed among black-browed albatrosses on Steeple Jason in 2010 following a violent December storm, and on New Island in 2016, following large-scale chick mortality caused by an unidentified disease (P. Catry pers. comm.).

Critically, long-term trends highlight the importance of baseline data when assessing acute impacts. This season, despite the apparent absence of HPAI within black-browed albatrosses at New Island, breeding success was nonetheless at its second lowest in the past decade (0.43 chicks/pair), potentially as a consequence of unusually high levels of chick predation which may have been linked to poor natural foraging conditions in the presence of an El Niño event. Also, this season on Steeple Jason, despite the apparent extensive mortality associated with HPAI, breeding success did not differ substantially from the longer-term trend, which has shown low breeding success of about 0.3 chicks per pair, on average, over several years (**Figure 6 A**).

This is not to suggest that HPAI has not had an impact on seabirds in the Islands. Rather, it is to highlight the uncertainty and challenges associated with quantifying its effects and predicting whether seemingly associated population-level changes as indicated by the FISMP will manifest in future years.

An interdisciplinary approach is critical for better understanding the potential impacts of HPAI on our seabirds. The FISMP remains an overall comprehensive measure of population status and trends, reflecting the combined influence of all factors rather than isolated events. Demographic study sites with ringed individuals, such as those managed on Steeple Jason by Falklands Conservation and on New Island by Dr. P. Catry, provide complementary insight into population age structures and could highlight changes that may mask impacts at a breeding population level. Further, while movement studies can inform on transmission pathways (Boulinier 2023; Riaz et al. 2024), epidemiology studies are pivotal for assessing species-specific infection rates and immunology within and across colonies, for understanding the short- and long-term dynamics of HPAI, and for identifying or discounting HPAI as an explanatory factor affecting seabird populations in the future (Falchieri et al. 2022; Leguia et al. 2023).

El Niño

The summer of 2023/2024 was also marked by a moderately strong El Niño event (NASA 2024; WMO 2024). The climate phenomenon of the El Niño Southern Oscillation (ENSO) has a large influence on global environmental conditions and sea surface temperatures, and is known to have wide-scale impacts on marine ecosystems, including seabird distribution and demography (Surman and Nicholson 2009; Sprogis et al. 2018). Amongst others, the ENSO affects patterns of wind and ocean currents, which have important implications for prey distribution and cost of travel in marine vertebrates like seabirds (Thorne et al. 2016). Impacts can last multiple years and can start with a time-lag (Schoen et al. 2024). Most FISMP species (black-browed albatross, gentoo penguin, Magellanic penguin, southern giant petrel and rockhopper penguin) have shown trend inflexions in estimated population size and/or breeding success around the time of the strong El Niño in 2015/2016, indicating a likely impact from this event.

Species-specific information

Black-browed albatross

Globally, the population is considered to be increasing (*Least Concern*, BirdLife International 2018a). In the Falkland Islands, where >72% of this species breeds, breeding pair data from the FISMP continue to support this trend. The reasons for this increase remain speculative, but may in parts be linked to improved seabird bycatch mitigation and reduced fishing effort within their range (McInnes et al. 2017; Kuepfer et al. 2022; Kuepfer 2023). Fisheries discards may also artificially enhance survival rates during vulnerable life stages, although they do not seem to compensate for poor foraging conditions during breeding (Kuepfer et al. 2022; Kuepfer 2023).

On the contrary, breeding success has been declining since 2015/2016. Breeding success in seabirds is influenced by various extrinsic and intrinsic factors, including environmental conditions and parental breeding experience (Ollason and Dunnet 1978; Goutte et al. 2010; Ventura et al. 2021b). At this stage, it is unclear as to whether the current downward trend in breeding success forms part of a larger-scale and naturally oscillating trend for albatrosses, or whether there is genuine cause for concern.

While adult survival is a key driver of population dynamics in these long-lived birds (Ventura et al. 2021a), sustained low productivity will eventually limit the number of birds that can mature into breeding adults. Climate change-driven increases in existing threats such as severe weather events, poor foraging conditions and infectious diseases now present significant risks. For example, increased adult mortality in albatrosses following violent storms could drive population declines by almost 2% if this occurred once every 5 years (Ventura et al. 2023). Threats like HPAI could have a similar impact and will worsen this prospect.

Falkland skua

Globally, the population trend for brown skua is considered decreasing (*Least Concern*, BirdLife International 2018b). The increase in Falkland skuas (which represent a sub-species of the brown skua) recorded on Steeple Jason opposes trends recorded elsewhere in the Falkland Islands (New Island (Catry et al. 2011) and Sea Lion Island (Galimberti and Sanvito 2020)). Causes for declines at these sites may be linked to increased competition and predation pressure from striated caracara (Catry et al. 2008, 2011) or unfavourable foraging conditions (Galimberti and Sanvito 2020).

Despite the near-endemic status of the Falkland skua, this sub-species remains severely understudied (Catry et al. 2011). Additional resources would be required to improve our understanding of the population patterns and trends associated with this species.

Gentoo penguin

The global population of gentoo penguins is considered stable (*Least Concern*, BirdLife International 2020c). The FISMP data suggests that the Falkland Islands population is consistent with this trend, though exhibiting oscillating patterns across years in both breeding pair numbers and breeding success.

In the past, significant population downturns were linked to harmful algal bloom poisoning (2002), increased disease incidence and reduced food availability aligning with a strong El Niño event (2015/2016) (Crofts and Stanworth 2016). These threats are predicted to increase in a warming climate (Gobler 2020).

Industry interactions may also pose localised threats to this species, specifically oil spills (Lynch 2013). Disturbance from unregulated tourism has also been shown to result in decreased breeding productivity (Trathan et al. 2008; Dunn et al. 2019). Disturbance is particularly a concern at the Yorke Bay colony, which is situated in very close proximity to Stanley, open to the public since 2020 following landmine clearance, and now receives large numbers of visitors, especially during the breeding period. Effective visitor management is essential to mitigate potential negative impacts. In support of this, FIG and the Falkland Islands Tourist Board recently published guidelines for tour operators and tourists accessing the colony.

Imperial shag

Globally, this species has a very large range and a favourable conservation status (*Least Concern*, BirdLife International 2018c; see also Yorio et al. 2020). However, this status assessment includes several sub-species due to the complexity of the species' taxonomy (BirdLife International 2018c). A splitting of the taxonomy could affect the future conservation status of the imperial shag in the Falkland Islands. The few monitored sites currently suggest a stable trend, following an increase from 2014–2016, although they are likely limited in their ability to accurately reflect national trends.

Monitoring imperial shags is challenging due to colony locations, the species' asynchronous breeding behaviour (see also Yorio et al. 2020), and the difficulty of assessing reproductive success without causing undue disturbance. The species' regular establishment and extinction of individual colonies further complicates tracking population dynamics through time.

Being largely dependent on coastal marine environments (Crofts 2015; Baylis and Tierney 2023), the species is subject to increasing pressures from human activities and climate-mediated changes (Yorio et al. 2020). Amongst others, increasing frequency and severity of extreme weather, disease outbreaks, competition for food, or predation pressure on eggs and chicks from predatory birds like the Falkland skua and southern giant petrel are all threats likely to increase in a changing climate (see e.g. Sherley and Ludynia 2012; BirdLife International 2015, Yorio et al. 2020). Accessible colonies can also be affected by human disturbance resulting from unregulated visitors (Yorio et al. 2001).

King penguin

Globally, king penguins are thought to be increasing (*Least Concern,* BirdLife International 2020a). The colony at Volunteer Green aligns with this trend despite occupying the northern limit of the species' range. Natural predation from sea lions poses a threat (D. Pettersson pers. comm.), although this currently appears insufficient to impede the population's growth.

Suitable feeding conditions are suspected to have contributed to the growth of the Falkland king penguin population (Pistorius et al. 2012). However, climate change models have shown that, even under a reduced greenhouse gas emissions scenario, the Falkland Islands king population will come under direct threat from a shift in suitable foraging grounds at the Antarctic Polar Front before 2050 (Cristofari et al. 2018). Unlike other populations of this species, the Falkland population frequently forages on the Patagonian shelf break which may provide a buffer (Pütz and Cherel 2005); however, the Patagonian Shelf, being under increasing pressure from climate change itself, may be unable to sustain a growing king penguin population (Cristofari et al. 2018).

Magellanic penguin

Globally, Magellanic penguin numbers are fluctuating and considered stable-declining (*Least Concern,* BirdLife International 2020d). In the Falkland Islands, which represent the south-eastern limit of this species' breeding range (Woods and Woods 1997), the single monitored colony at Gypsy Cove shows a similar trend. Burrow occupancy initially increased, but has been decreasing sharply since 2017. Historic data at other sites in the Falklands show similar fluctuating patterns with 7/8-year declines before recovery (Stanworth and Crofts 2022). It is therefore possible that the trend observed at Gypsy Cove represents part of a more long-term oscillation pattern. Opportunities to assess breeding performance at a broader scale for the Falklands population would be beneficial, as the trend may be site-specific.

Magellanic penguins exclusively excavate burrows for nesting in the Falkland Islands as opposed to other locations in South America where they also nest above ground (Borboroglu et al. 2009). Breeding distribution is therefore limited by soil depth and structure. Drying soils leading to burrow collapse or burrowing difficulties, burrow collapse due to footfall or loss of soil through vegetation loss and erosion are obvious threats. At Middle Island, loss of vegetation has resulted in drying windblown peat that has filled burrows making them unusable (Falklands Conservation unpubl. data). Flooding of burrows is also a threat. Predictions of a drying terrestrial environment in the Falklands and increased frequency of extreme weather are likely to significantly increase pressures on this species. Vegetation restoration, specifically tussac planting, could mitigate such impacts through soil stabilisation, soil moisture retention and prevention of flash flooding. At Gypsy Cove, the number of Magellanic penguin burrows was significantly higher in areas of increased tussac density (this report).

Southern giant petrel

Globally, southern giant petrels are considered to be increasing (*Least Concern,* BirdLife International 2018d). The Falkland Islands hold over 40% of the world's breeding southern giant petrels, of which 8% breed on Steeple Jason (Stanworth and Crofts 2017), where the trend is consistent with global patterns. Opportunities to assess breeding performance at a broader scale for the Falklands population would be beneficial, as the trend may be site-specific.

Historically, key threats of southern giant petrels included hunting (Williams 1984), and fisheries bycatch (Sullivan et al. 2006; BirdLife International 2018d). However, improved protective laws on land and mitigation measures in fisheries means that these threats have been virtually eliminated (hunting) and likely reduced (fisheries bycatch) (BirdLife International 2018d; Kuepfer et al. 2018; FIG 2024b). Other threats include ingestion of marine plastic debris and oil spills at sea (BirdLife International 2018d). On land, feral cats and rats, as well as habitat degradation from introduced rabbits and sheep have historically posed threats to this species elsewhere (Elliott 1957), although their impacts in the Islands are unknown.

Southern rockhopper penguin

Globally, the southern rockhopper penguin holds an unfavourable conservation status (*Vulnerable*), given its continued rapid decline since the first half of the 20th century (BirdLife International 2020d). In the Falkland Islands, the breeding population appears to be stable across the islands, but declining at Steeple Jason, which held an estimated 38% of the national breeding population in 2010. Breeding success appears stable at Steeple; across the Falklands, the trend has been declining, although data from more recent years suggest that this trend may be stabilising.

A key driver behind the long-term declines of rockhopper, globally, is believed to be reduced food availability linked to warming sea temperatures (Crawford et al. 2008; Dehnhard et al. 2013; BirdLife International 2020b; although see e.g. Raya Rey et al. 2014). Specifically in the Falklands, warming temperatures have been related to delayed breeding, lighter eggs and likely reduced breeding success in this species (Dehnhard et al. 2015a, b). Further threats to the species include climate-mediated increases in severe weather events (Demongin et al. 2010), diseases and HABs (Gobler 2020), fishery-mediated changes to food-webs (Hilton et al. 2006), and oil pollution (Falklands Conservation 2012).

Sooty shearwater

The global sooty shearwater population is declining due to declines at core breeding sites in New Zealand and wintering sites in the North Pacific (*Near-threatened,* McKechnie et al. 2008, Moller et al. 2009, BirdLife International 2024). In the Falkland Islands, historic design-based surveys at Kidney Island – the largest known colony in the Islands – suggested dramatic increases from c. 2000 breeding pairs to c. 100,000 breeding pairs in the second half of the 20th century (Woods and Woods 2006). Recent model-based estimates in 2016 and 2023 show no indication of significant changes in the population size (Kuepfer et al. 2024). Surveys at nearby islands (Top Island (baseline survey conducted in 2023), Cochon and Bottom Islands) will offer additional population insight in the future.

The absence of rodents and recovery of tussac are believed to play a critical role in the positive / stable population of sooty shearwater on Kidney Island. On both Kidney and Top Islands, sooty shearwaters were found in greater numbers in areas with dense tussac over peat (Kuepfer et al. 2024). Birds may also be experiencing more favourable conditions and reduced fishery bycatch at their wintering site in the Northwest Atlantic (Shaffer et al. 2006; Hazen et al. 2013). In the Falkland Islands, sooty shearwater fisheries bycatch appears limited, although batch entanglements in trawl nets do occur (Kuepfer et al. 2018; Winter 2018). At breeding sites, sooty shearwaters are extremely vulnerable to habitat loss (e.g. from fire, drought and grazing) and invasive species. Predation of adults and fledglings by feral cats has for example been recorded at Hadassa Bay near Gypsy Cove (S. Poncet and R. James pers. obs.).

White-chinned petrel

Globally, white-chinned petrels are declining (*Vulnerable,* BirdLife International 2024b). In the Falklands, known breeding sites are Kidney Island, Top Island, Bottom Island and New Island. On Kidney Island, estimates by Kuepfer et al. (2024) correspond with previous estimates by Woods and Woods (1997) and A. Stanworth (unpubl. data; but see Reid et al. 2007). However, differences in methods make comparisons challenging. At New Island, the colony appears to have declined from 26 pairs in 2004/2005/2006 (Reid et al. 2007) to 0-6 breeding pairs recorded this season (Falklands Conservation unpubl. data).

Although records of bycatch of this species in the Falklands have in the past been rare (Kuepfer et al. 2018), they have recently become more regular in the trawl fleet (FIG 2021, 2023, 2024b). White-chinned petrels are also amongst the most frequently recorded procellariiformes in fisheries bycatch of southern hemisphere longline fisheries (Rollinson et al. 2018), which may impact our local population. Furthermore, white-chinned petrels are extremely vulnerable to invasive mammals and loss of breeding habitat. On New Island, the declines are thought to be driven by predation from feral cats and degradation in breeding habitat through soil desiccation and loss (Reid et al. 2007, Falklands Conservation unpubl. data). On Kidney and Top Islands, white-chinned petrels were most numerous in areas of tussac peat with high moisture content (Kuepfer et al. 2024). A changing climate is expected to decrease soil moisture content and impact soil health in the Falkland Islands, leading to increased erosion risks (Upson et al. 2016).

Implications for management

Outlook

Whilst most seabirds breeding in the Falkland Islands are listed as *Least Concern* on the IUCN Red List, several are identified as declining globally. In the Falklands, the FISMP population indices continue to generally suggest oscillating but overall stable populations; however, seabirds face numerous and additive pressures, including diseases, predation, fire, loss of breeding habitat (from fire, grazing and erosion), impacts on prey availability through climate change and fishing, severe weather events (storms and heat stress), and incidental mortality in fishing gear, and the continuing climate crisis is exacerbating these existing pressures on land and at sea (Crawford et al. 2008; Cohen et al. 2014, 2020; Ventura et al. 2021b, 2023). El Niño events, which appear to negatively affect Falklands' breeding seabirds, are predicted to increase with climate change (e.g. Wang et al. 2019). Even relatively small changes in the occurrence and severity of threats could have significant and national-scale (and therefore global) effects on seabird populations in the Falklands (Ventura et al. 2023).

Conservation

A growing body of research and documented impacts highlight the continuing climate crisis as the most significant and urgent overarching threat to seabirds in the Falklands, presenting threats that are difficult to mitigate. Avoiding impacts on inshore areas, and prioritising an ecosystem-based approach to fisheries management in offshore areas could prevent additional pressures on food availability, whilst fire contingency planning could potentially reduce impacts of increasing wildfires at colonies. Resilience of populations to climate change can, and is, being bolstered at colonies through predator removal, disturbance reduction, habitat improvement and biosecurity measures; however, long-term prospects for seabird populations in the Islands are likely best served by measures to mitigate the climate crisis. Nationally, this includes decarbonisation, protecting carbon- and species-rich habitats, and restoration of carbon sinks.

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References

Baylis AMM, Tierney M (2023) Darwin Plus: Improving Falklands marine management effectiveness for marine higher predators. Final Report. SAERI, Stanley, Falkland Islands

Baylis AMM, Wolfaardt AC, Crofts S, Pistorius PA, Ratcliffe N (2013a) Increasing trend in the number of Southern Rockhopper Penguins (*Eudyptes c. chrysocome*) breeding at the Falkland Islands. Polar Biol 36:1007–1018. doi: 10.1007/s00300-013-1324-6

Baylis AMM, Crofts S, Wolfaardt AC (2013b) Population trends of Gentoo Penguins *Pygoscelis papua* breeding at the Falkland Islands. Mar Ornithol 5:1–5.

BirdLife International (2015) Extreme weather will lead to more frequent mass mortality in European Shags. http://www.birdlife.org. Accessed 29 Jun 2023

BirdLife International (2018a) Black-browed Albatross *Thalassarche melanophris*. The IUCN Red List of Threatened Species 2018: e.T22698375A132643647. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22698375A132643647.en. Accessed 21 Jan 2023

BirdLife International (2018b) Brown Skua *Catharacta antarctica*. The IUCN Red List of Threatened Species 2018: e.T62289571A132674404.

BirdLife International (2018c) Imperial Shag *Leucocarbo atriceps*. The IUCN Red List of Threatened Species 2018. http://datazone.birdlife.org/species/factsheet/imperial-shag-leucocarbo-atriceps. Accessed 14 Jun 2023

BirdLife International (2018d) Southern Giant Petrel *Macronectes giganteus*. The IUCN Red List of Threatened Species 2018: e.T22697852A132608499.

BirdLife International (2020a) Gentoo Penguin *Pygoscelis papua*. The IUCN Red List of Threatened Species 2020: e.T22697755A157664581.

BirdLife International (2020b) King Penguin *Aptenodytes patagonicus*. The IUCN Red List of Threatened Species 2020: e.T22697748A184637776.

BirdLife International (2020c) Magellanic Penguin *Spheniscus magellanicus*. The IUCN Red List of Threatened Species 2020: e.T22697822A157428850.

BirdLife International (2020d) Southern Rockhopper Penguin *Eudyptes chrysocome*. The IUCN

Red List of Threatened Species 2020: e.T22735250A182762377.

BirdLife International (2024a) Species factsheet: *Ardenna grisea*. https://datazone.birdlife.org/species/factsheet/sooty-shearwater-ardenna-grisea . Accessed 30 May 2024

BirdLife International (2024b) Species factsheet: *Procellaria aequinoctialis*. https://datazone.birdlife.org/species/factsheet/white-chinned-petrel-procellaria-aequinoctialis on 30/05/2024. Accessed 30 May 2024

Borboroglu P, Yorio P, Boersma PD, Del Valle H, Bertellotti M (2009) Habitat Use and Breeding Distribution of Magellanic Penguins in Northern San Jorge Gulf, Patagonia, Argentina. Auk 119:233–239. doi: 10.1642/0004-8038(2002)119

Boulinier T (2023) Avian influenza spread and seabird movements between colonies. Trends Ecol Evol 38:391–395. doi: 10.1016/j.tree.2023.02.002

Brooke MDL (2004) The food consumption of the world’s seabirds. Biol Lett 9:246–248. doi: 10.1098/rsbl.2003.0153

Brooks ME, Kristensen K, van Benthem KJ, Magnusson A, Berg CW, Nielsen A, Skaug HJ, Mächler M, Bolker BM (2017) glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. R J 9:378–400. doi: 10.32614/rj-2017-066

Cairns DK (1987) Seabirds as indicators of marine food supplies. Biol Oceanogr 5:261–271. doi: 10.1080/01965581.1987.10749517

Catry P, Lecoq M, Strange IJ (2008) Population growth and density, diet and breeding success of striated caracaras *Phalcoboenus australis* on New Island, Falkland Islands. Polar Biol 31:1167–1174. doi: 10.1007/s00300-008-0454-8

Catry P, Almeida A, Lecoq M, Granadeiro JP, Matias R (2011) Low breeding success and sharp population decline at the largest known Falkland skua colony. Polar Biol 34:1239–1241. doi: 10.1007/s00300-011-0978-1

Clark TJ, Matthiopoulos J, Bonnet-Lebrun A-S, Campioni L, Catry P, Marengo I, Poncet S, Wakefield E (2019) Integrating habitat and partial survey data to estimate the regional population of a globally declining seabird species, the sooty shearwater. Glob Ecol

Conserv 17:e00554. doi: 10.1016/j.gecco.2019.e00554

Cohen JM, Sauer EL, Santiago O, Spencer S, Rohr JR (2020) Divergent impacts of warming weather on wildlife disease risk across climates. Science 370:6519. doi: 10.1126/science.abb1702.Divergent

Cohen LA, Pichegru L, Grémillet D, Coetzee J, Upfold L, Ryan PG (2014) Changes in prey availability impact the foraging behaviour and fitness of Cape gannets over a decade. Mar Ecol Prog Ser 505:281–293. doi: 10.3354/meps10762

Crawford RJM, Makhado AB, Upfold L, Dyer BM (2008) Mass on arrival of rockhopper penguins at Marion Island correlated with breeding success. African J Mar Sci 30:185–188. doi: 10.2989/AJMS.2008.30.1.19.469

Cristofari R, Liu X, Bonadonna F, Cherel Y, Pistorius P, Le Maho Y, Raybaud V, Stenseth NC, Le Bohec C, Trucchi E (2018) Climate-driven range shifts of the king penguin in a fragmented ecosystem. Nat Clim Chang 8:245–251. doi: 10.1038/s41558-018-0084-2

Crofts S (2015) Tracking cormorants at the Falkland Islands. Seab. Gr. Newsl. 128

Crofts S (2020) Notes on population census of black-browed albatrosses in the Falkland Islands in 2017. Falklands Conservation, Stanley, Falkland Islands

Crofts S, Stanworth A (2016) Falkland Islands Seabird Monitoring Programme: Annual Report 2015/2016 (SMP23). Falklands Conservation, Stanley, Falkland Islands

Cury PM, Boyd IL, Bonhommeau S, Anker-Nilssen T, Crawford RJM, Furness RW, Mills JA, Murphy EJ, Österblom H, Paleczny M, Piatt JF, Roux JP, Shannon L, Sydeman WJ (2011) Global seabird response to forage fish depletion - One-third for the birds. Science 334:1703–1706. doi: 10.1126/science.1212928

Dehnhard N, Eens M, Demongin L, Quillfeldt P, Poisbleau M (2015a) Individual consistency and phenotypic plasticity in rockhopper penguins: Female but not male body mass links environmental conditions to reproductive investment. PLoS One 10:e0128776. doi: 10.1371/journal.pone.0128776

Dehnhard N, Eens M, Demongin L, Quillfeldt P, Suri D, Poisbleau M (2015b) Limited individual phenotypic plasticity in the timing of and investment into egg laying in southern rockhopper penguins under climate change. Mar Ecol Prog Ser 524:269–281. doi:

10.3354/meps11154

Demongin L, Poisbleau M, Strange I, Qullfeldt P (2010) Effects of severe rains on the mortality of Southern Rockhopper Penguin (*Eudyptes chrysocome*) chicks and its impact on breeding success. Ornitol Neotrop 21:1–5.

Dunn MJ, Forcada J, Jackson JA, Waluda CM, Nichol C, Trathan PN (2019) A long-term study of gentoo penguin (*Pygoscelis papua*) population trends at a major Antarctic tourist site, Goudier Island, Port Lockroy. Biodivers Conserv 28:37–53. doi: 10.1007/s10531-018-1635-6

Elliott H (1957) A contribution to the ornithology of the Tristan da Cunha group. Ibis 99:545–586.

Falchieri M, Reid S, Ross C, James J, Byrne A, Zamfir M, Brown I, Banyard A, Tyler G, Philip E, Miles W (2022) Shift in HPAI infection dynamics causes significant losses in seabird populations across Great Britain. Vet Rec 191:294–296. doi: doi: 10.1002/vetr.2311

Falklands Conservation (2012) Foraging and diet of Southern Rockhopper penguins at Steeple Jason and Beauchêne Island, Falkland Islands – a summary report. Falklands Conservation, Stanley, Falkland Islands

FIG (2021) Fisheries Department Fisheries Statistics, Volume 25, 2020. FIG Fisheries Department, Stanley, Falkland Islands

FIG (2023) Fisheries Department Fisheries Statistics, Volume 27, 2022. FIG Fisheries Department, Stanley, Falkland Islands

FIG (2024a) Avian Influenza Information. https://falklands.gov.fk/agriculture/avian-influenza. Accessed 20 Aug 2024

FIG (2024b) Fisheries Department Fisheries Statistics. FIG Fisheries Department, Stanley, Falkland Islands

Galimberti F, Sanvito S (2020) Reproductive success of Falkland skua at Sea Lion Island, Falkland Islands. Elephant Seal Research Group, Stanley, Falkland Islands

Gobler CJ (2020) Climate Change and Harmful Algal Blooms: Insights and perspective. Harmful Algae 91:101731. doi: 10.1016/j.hal.2019.101731

Goutte A, Antoine É, Weimerskirch H, Chastel O (2010) Age and the timing of breeding in a long-lived bird: A role for stress hormones? Funct Ecol 24:1007–1016. doi: 10.1111/j.1365-2435.2010.01712.x

Hazen EL, Jorgensen S, Rykaczewski RR, Bograd SJ, Foley DG, Jonsen ID, Shaffer SA, Dunne JP, Costa DP, Crowder LB, Block BA (2013) Predicted habitat shifts of Pacific top predators in a changing climate. Nat Clim Chang 3:234–238. doi: 10.1038/nclimate1686

Hilton GM, Thompson DR, Sagar PM, Cuthbert RJ, Cherel Y, Bury SJ (2006) A stable isotopic investigation into the causes of decline in a sub-Antarctic predator, the rockhopper penguin. Glob Chang Biol 12:611–625. doi: 10.1111/j.1365-2486.2006.01130.x

Jenouvrier S, Barbraud C, Cazelles B, Weimerskirch H (2005) Modelling Population Dynamics of Seabirds: Importance of the Effects of Climate Fluctuations on Breeding Proportions. Oikos 108:511–522.

Kuepfer A (2023) Influence of fisheries on the foraging ecology and demography of breeding black-browed albatross *Thalassarche melanophris* in the Falkland Islands. A thesis for the degree of Doctor of Philosophy in Biological Sciences. Universiy of Exeter

Kuepfer A, Stanworth A (2023) Falkland Islands Seabird Monitoring Programme: Annual Report 2022/2023 (SMP30). Falklands Conservation, Stanley, Falkland Islands

Kuepfer A, Crofts S, Tierney M, Blake D, Goyot L (2018) Falkland Islands National Plan of Action for Reducing Incidental Catch of Seabirds in Trawl Fisheries, 2019 (FI NPOA-S-T-2019). FIG Fisheries Department, Stanley, Falkland Islands

Kuepfer A, Votier SC, Sherley RB, Ventura F, Matias R, Anderson O, Brickle P, Arkhipkin A, Catry P (2022) Prey-switching to fishery discards does not compensate for poor natural foraging conditions in breeding albatross. ICES J Mar Sci fsac069. doi: 10.1093/icesjms/fsac069

Kuepfer A, Lee B, Stanworth A (2024) Burrowing Seabird Survey 2023/2024: Population estimates of sooty shearwaters and white-chinned petrels on Kidney Island and Top Island, Falkland Islands. Report to Falkland Islands Government. Falklands Conservation, Stanley, Falkland Islands

Leguia M, Garcia-glaessner A, Muñoz-saavedra B, Juarez D, Barrera P, Calvo-mac C, Jara J, Silva

W, Ploog K, Amaro, Lady, Colchao-claux P, Johnson CK, Uhart MM, Nelson MI, Lescano J (2023) Highly pathogenic avian influenza A (H5N1) in marine mammals and seabirds in Peru. Nat Commun 14:5489. doi: 10.1038/s41467-023-41182-0

Lynch H (2013) The Gentoo Penguin (*Pygoscelis papua*). In: Borboroglu PG, Boersma P (eds) Biology and Conservation of the World's penguins. University of Washington Press, Seattle, USA,

McInnes JC, Alderman R, Deagle BE, Lea MA, Raymond B, Jarman SN (2017) Optimised scat collection protocols for dietary DNA metabarcoding in vertebrates. Methods Ecol Evol 8:192–202. doi: 10.1111/2041-210X.12677

McKechnie S, Moller H, Bragg C, Newman J, Scott DS, Cruz JB (2008) Recovery of a sooty shearwater (*Puffinus griseus*) breeding area after habitat destruction. N Z J Ecol 32:34–40.

Moller H, Fletcher D, Johnson PN, Bell BD, Flack D, Bragg C, Scott D, Newman J, McKechnie S, Lyver PO (2009) Changes in sooty shearwater (*Puffinus griseus*) abundance and harvesting on the Rakiura Tītī Islands. New Zeal J Zool 36:325–341. doi: 10.1080/03014220909510158

Munro G, Baylis A, Tierney M (2024) Bird Island Bird Numbers and Estimated Mortality from a Wild-Fire February 2024. Falklands Conservation, Stanley, Falkland Islands

NASA (2024) El Niño exits. https://earthobservatory.nasa.gov/images/153058/el-nino-ex-its. Accessed 20 Aug 2024

Ollason J, Dunnet G (1978) Age, Experience and Other Factors Affecting the Breeding Success of the Fulmar, Fulmarus glacialis, in Orkney. J Anim Ecol 47:961–976.

Otero XL, Peña-lastra SD La, Huerta-diaz MA, Pérez-alberti A, Ferreira TO (2018) Seabird colonies as important global drivers in the nitrogen and phosphorus cycles. Nat Commun 9:246. doi: 10.1038/s41467-017-02446-8

Pistorius PA, Baylis A, Crofts S, Pütz K (2012) Population development and historical occurrence of king penguins at the Falkland Islands. Antarct Sci 24:435–440. doi: 10.1017/S0954102012000302

Pütz K, Cherel Y (2005) The diving behaviour of brooding king penguins (Aptenodytes patagonicus) from the Falkland Islands: variation in dive profiles and synchronous underwater swimming provide new insights into their foraging strategies. Mar Biol 147:281–290. doi: 10.1007/s00227-005-1577-x

R Core Team (2023) R - A language and environment for statistical computing.

Raya Rey A, Rosciano N, Liljesthröm M, Sáenz Samaniego R, Schiavini A (2014) Species-specific population trends detected for penguins, gulls and cormorants over 20 years in sub-Antarctic Fuegian Archipelago. Polar Biol 37:1343–1360. doi: 10.1007/s00300-014-1526-6

Reid TA, Lecoq M, Catry P (2007) The white-chinned petrel *Procellaria aequinoctialis* population of the Falkland Islands. Mar Ornithol 35:57–60.

Riaz J, Orben RA, Gamble A, Catry P, Campioni L, Tierney M, Baylis AMM (2024) Shelf during the highly pathogenic avian influenza outbreak. Ecography (Cop) e07415. doi: 10.1111/ecog.07415

Rollinson DP, Dilley BENJ, Davies D, Ryan PG (2018) Year-round movements of white-chinned petrels from Marion Island, south-western Indian Ocean. Antarct Sci 30:1–13. doi: 10.1017/S0954102018000056

Schoen SK, Arimitsu ML, Marsteller CE, Piatt JF (2024) Lingering impacts of the 2014−2016 northeast Pacific marine heatwave on seabird demography in Cook Inlet, Alaska (USA). Mar Ecol Prog Ser 737:121–136. doi: 10.3354/meps14177

Shaffer SA, Tremblay Y, Weimerskirch H, Scott D, Thompson DR, Sagar PM, Moller H, Taylor GA, Foley DG, Block BA, Costa DP (2006) Migratory shearwaters integrate oceanic resources across the Pacific Ocean in an endless summer. PNAS 103:12799–12802. doi: 10.1073/pnas.0603715103

Sherley RB, Ludynia K (2012) Storms and heat limit the nest success of Bank Cormorants: implications of future climate change for a surface-nesting seabird in southern Africa. J Ornithol 153:441–455. doi: 10.1007/s10336-011-0760-8

Sprogis KR, Christiansen F, Wandres M, Bejder L (2018) El Niño Southern Southern Oscillation influences the abundance and El Niño movements of a marine top predator in coastal waters. Glob Chang Biol 24:1085–1096. doi: 10.1111/gcb.13892

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

Stanworth A, Crofts S (2022) Falkland Islands Seabird Monitoring Programme - Annual Report 2021/2022 (SMP29). Falklands Conservation, Stanley, Falkland Islands

Sullivan BJ, Reid TA, Bugoni L (2006) Seabird mortality on factory trawlers in the Falkland Islands and beyond. Biol Conserv 131:495–504. doi: 10.1016/j.biocon.2006.02.007

Surman CA, Nicholson LW (2009) The good, the bad and the ugly: ENSO-driven oceanographic variability and its influence on seabird diet and reproductive performance at the Houtman Abrolhos, Eastern Indian Ocean. Mar Ornithol 37:129–138.

Thorne LH, Conners MG, Hazen EL, Bograd SJ, Antolos M, Costa DP, Shaffer SA (2016) Effects of El Niño-driven changes in wind patterns on North Pacific albatrosses. J R Soc Interface 13:20160196. doi: 10.1098/rsif.2016.0196

Trathan PN, Forcada J, Atkinson R, Downie R, Shears J (2008) Population assessments of gentoo penguins (*Pygoscelis papua*) breeding at an important Antarctic tourist site, Goudier Island, Port Lockroy, Palmer Archipelago, Antarctica. Biol Conserv 141:3019–3028.

Tremlett CJ, Morley N, Wilson LJ (2024) UK seabird colony counts in 2023 following the 2021-22 outbreak of Highly Pathogenic Avian Influenza. Research Report 76. Sandy, UK.

Upson R, Williams JJ, Wilkinson TP, Clubbe CP, Maclean IMD, McAdam JH, Moat JF (2016) Potential impacts of climate change on native plant distributions in the Falkland Islands. PLoS One 11:e0167026. doi: 10.1371/journal.pone.0167026

Velarde E, Anderson DW, Ezcurra E (2019) Seabird clues to ecosystem health. Science 365:116–117. doi: 10.1126/science.aaw9999

Ventura F, Lukacs P, Granadeiro JP, Matano R, Catry P (2021a) Demographic responses to environmental change of the black-browed albatross, sentinel of the Patagonian Shelf Large Marine Ecosystem. Mar Ecol Prog Ser 668:107–120. doi: 10.3354/meps13743

Ventura F, Granadeiro JP, Lukacs PM, Kuepfer A, Catry P (2021b) Environmental variability directly affects the prevalence of divorce in monogamous albatrosses. Proc R Soc B Biol

Sci 288:20212112. doi: 10.1098/rspb.2021.2112

Ventura F, Stanworth A, Crofts S, Kuepfer A, Catry P (2023) Local-scale impacts of extreme events drive demographic asynchrony in neighbouring top predator populations. Biol Lett. doi: 10.1098/rsbl.2022.0408

Wang B, Luo X, Yang Y, Sun W, Cane MA, Cai W, Yeh S (2019) Historical change of El Niño properties sheds light on future changes of extreme El Niño. PNAS 116:22512–22517. doi: 10.1073/pnas.1911130116

Williams A (1984) The status and conservation of seabirds on some islands in the African sector of the Southern Ocean. In: Croxall JP, Evans PGH, Schrieber R (eds) Status and Conservation of the World's Seabirds. International Council for Bird Conservation, Cambridge, UK, pp 627–634

Winter A (2018) Stock assessment of Doryteythis gahi for the 2nd season 2018. FIG Fisheries Department, Stanley, Falkland Islands

WMO (2024) El Niño is forecasted to swing to La Niña later this year. https://wmo.int/news/media-centre/el-nino-forecast-swing-la-nina-later-year. Accessed 20 Aug 2024

Woods R, Woods A (1997) Atlas of Breeding Birds of the Falkland Islands. Anthony Nelson, Oswestry, UK

Woods RW, Woods A (2006) Birds and Mammals of the Falkland Islands. Princeton University Press, Princeton, NJ, U.S.A.

Yorio P, Frere E, Gandini P (2001) Tourism and recreation at seabird breeding sites in Patagonia, Argentina: Current concerns and future prospects. Bird Conserv Int 11:231–245. doi: 10.1017/S0959270901000314

Yorio P, Pozzi L, Herrera G, Punta G, Svagelj WS, Quintana F, Yorio P, Pozzi L, Herrera G, Punta G, Walter S, Yorio P (2020) Population trends of Imperial Cormorants (*Leucocarbo atriceps*) in northern coastal Argentine Patagonia over 26 years. Emu - Austral Ornithol 120:114–122. doi: 10.1080/01584197.2020.1730192

Appendix

Appendix 1: Summary of FISMP changes since 2021

Year	Change	Justification
2023/2024	• Addition of black-browed albatross and gentoo penguin breeding pair and breeding success data from New Island. • Addition of southern giant petrel breeding pair data from New Island (collection of breeding success is not currently possible for logistical reasons).	• New Island is FC-owned, a recognised area of wildlife significance, and is of geographical importance contributing to the representative distribution of FISMP sites. Long-term data exists thanks to efforts led by P. Catry (ISPA – Instituto Universitário) and P. Quillfeldt (Justus-Liebig-University Giessen).
	• Inclusion of sooty shearwater and white-chinned petrel information from Top Island and Kidney Island. • Inclusion of white-chinned petrel data from New Island.	• Surveys conducted as part of an FIG Small Works Grant in support of the Stanley Tussac Grass Islands Management Plan 2018–2023. Results are included in the FISMP report for completeness. • White-chinned petrel = ACAP species.
2022/2023	• Dropped NW Ridge colony on Steeple Jason due to significant encroachment of South American fur seals (*Arctocephalus australis*).	• The NW Ridge colony is no longer deemed representative.
2021/2022	• Inclusion of modelled long-term trends for species for which more than 10 years of data exist.	• To provide an improved indication of long-term population trends.

Appendix 2: Seabird counts conducted by Falklands Conservation and volunteers

Species	Colony	AON Dates	AON Counters	PFC Dates	PFC Counters
BBA	NW Flat	27/11/2023	Stanworth A, Hæstrup J	01/03/2024	Kuepfer A, Stanworth A
BBA	NWI_Settlement	25/10/2023	Hoyer P	17/02/2024	Kuepfer A
BBA	Penthouse	25/11/2023	Kuepfer A, Stanworth A	01/03/2024	Kuepfer A, Stanworth A
BBA	S5 Finger	25/11/2023	Hæstrup J, Stanworth A	01/03/2024	Kuepfer A, Stanworth A
BBA	S5 Tip_Blob	25/11/2023	Kuepfer A, Fournier-Carnoy L, Stanworth A	29/02/2024	Kuepfer A, Stanworth A
BBA	Study Site	28/11/2023	Hæstrup J, Stanworth A	01/03/2024	Kuepfer A, Stanworth A
G	Berthas Beach	13/11/2023	Morrison M	02/01/2024	Morrison M
G	Bull Point	31/10/2023	Kuepfer A, Welch G, Markovic D	01/01/2024	Fournier-Carnoy L, Kuepfer A, McKee H
G	Bull Roads	01/11/2023	Kuepfer A, Welch G	01/01/2024	Kuepfer A, Fournier-Carnoy L
G	Cow Bay	11/11/2023	Evans B, Welch G	06/01/2024	Kuepfer A, Fournier-Carnoy L
G	Fanning Harbour	13/11/2023	Kuepfer A, Fournier-Carnoy L	08/01/2024	Fournier-Carnoy L, Kuepfer A
G	Fox Point Fitzroy	13/11/2023	Morrison M	02/01/2024	Morrison M
G	House_Gentoos	25/11/2023	Hæstrup J, Kuepfer A	17/01/2024	Kuepfer A, Evans B
G	Lagoon Sands	11/11/2023	Evans B, Kuepfer A, Welch G, Evans B, Valler-Nannig V	06/01/2024	Kuepfer A, Lee B, Fournier-Carnoy L
G	Low Bay	02/11/2023	Kuepfer A, Matosevic N, Markovic D	03/01/2024	Kuepfer A, McKee H, Fournier-Carnoy L
G	Motley Point	01/11/2023	Kuepfer A, Welch G	02/01/2024	Kuepfer A, Evans B, Fournier-Carnoy L
G	NWI_House	07/11/2023	Sampson J, Welch G	11/01/2024	Correia E
G	NWI_North	02/11/2023	Sampson J, Welch G, Kuepfer A	13/01/2024	Correia E
G	NWI_South	03/11/2023	Sampson J, Welch G, Kuepfer A	11/01/2024	Correia E
G	Neck_Gentoos	25/11/2023	Welch G, Kuepfer A	17/01/2024	Kuepfer A, Evans B
G	New Haven	02/11/2023	Kuepfer A, Welch G	03/01/2024	Kuepfer A, Evans B
G	Pleasant Road	04/11/2023	Morrison M	02/01/2024	Morrison M
G	Rookery Sands	13/11/2023	Kuepfer A, Fournier-Carnoy L	08/01/2024	Fournier-Carnoy L, Kuepfer A
G	SLI_Gentoos	06/11/2023	Morrison M	07/01/2024	Morrison M
G	Stephen's Peak	05/11/2023	Kuepfer A, Fournier-Carnoy L, Evans B	31/01/2024	Kuepfer A, Welch G
G	Volunteer Green	10/11/2023	Kuepfer A, Evans B, Valler-Nannig V	06/01/2024	Kuepfer A, Lee B, McKee H, Fournier-Carnoy L
G	Yorke Bay	07/11/2023	Kuepfer A, Taylor B	09/01/2024	Kuepfer A

IMS	Eagle Hill Centre	09/11/2023	Kuepfer A, Hoyer P	07/01/2024	Kuepfer A, Lee B, Fournier-Carnoy L, McKee H
IMS	Eagle Hill West	09/11/2023	Kuepfer A, Hoyer P, Stanworth A	07/01/2024	Kuepfer A, Lee B, McKee H
IMS	Fanning Head South	13/11/2023	Welch G, Kuepfer A	08/01/2024	Kuepfer A, Fournier-Carnoy L
IMS	Motley Point	01/11/2023	Kuepfer A, Stanworth A, Welch G	02/01/2024	Kuepfer A, Stanworth A
IMS	Rugged Hill Centre	09/11/2023	Kuepfer A, Hoyer P	07/01/2024	Kuepfer A, Lee B, Fournier-Carnoy L
IMS	Rugged Hill West	09/11/2023	Kuepfer A, Hoyer P	07/01/2024	Kuepfer A, Lee B, McKee H
SRH	Diamond Cove	10/11/2023	Kuepfer A, Evans B, Valler-Nannig V	07/01/2024	Kuepfer A, Lee B, McKee H
SRH	Eagle Hill Centre	09/11/2023	Kuepfer A, Stanworth A	07/01/2024	Kuepfer A, Lee B, Fournier-Carnoy L
SRH	Eagle Hill East	09/11/2023	Kuepfer A, Evans B	07/01/2024	Kuepfer A, Lee B
SRH	Eagle Hill West	09/11/2023	Kuepfer A, Stanworth A	07/01/2024	Kuepfer A, Lee B, McKee H
SRH	Fanning Head North	13/11/2023	Fournier-Carnoy L, Evans B, Kuepfer	08/01/2024	Kuepfer A, Fournier-Carnoy L
SRH	Fanning Head South	13/11/2023	Evans B, Fournier-Carnoy L, Kuepfer A	08/01/2024	Kuepfer A, Fournier-Carnoy L
SRH	NW Flat	27/11/2023	Welch G, Kuepfer A	17/01/2024	Kuepfer A, Welch G
SRH	Rugged Hill Centre	09/11/2023	Kuepfer A, Stanworth A	07/01/2024	Kuepfer A, Lee B, Fournier-Carnoy L
SRH	Rugged Hill East	09/11/2023	Kuepfer A, Stanworth A	07/01/2024	Kuepfer A, Lee B, Fournier-Carnoy L
SRH	Rugged Hill West	09/11/2023	Kuepfer A, Stanworth A	07/01/2024	Kuepfer A, Lee B, McKee H
SRH	S5 Finger	25/11/2023	Welch G, Kuepfer A	21/01/2024	Kuepfer A, Lee B
SRH	S5 Tip_Blob	25/11/2023	Kuepfer A, Stanworth A	21/01/2024	Kuepfer A, Lee B
SRH	Sea Lion Island_Rockhoppers	05/11/2023	Morrison M	08/01/2024	Morrison M
SRH	Stephen's Peak	05/11/2023	Fournier-Carnoy L, Kuepfer A	30/01/2024	Kuepfer A, Welch G
SRH	Study Site	27/11/2023	Kuepfer A, Hæstrup J	18/01/2024	Kuepfer A, Lee B
SGP	House Track_House	25/11/2023	Kuepfer A, Hæstrup J	01/03/2024	Kuepfer A, Lee B
SGP	NWI_Airstrip	20/11/2023	Kuepfer A, Welch G	NA	NA
SGP	NW_S Ridge_West	22/11/2023	Kuepfer A, Hæstrup J, Welch G	04/03/2024	Kuepfer A, Stanworth A
SGP	Neck_SGP	27/11/2023	Stanworth A, Kuepfer A, Welch G, Hæstrup J	01/03/2024	Welch G, Kuepfer A, Stanworth A
SGP	Ship_Island	07/11/2023	Kuepfer A, Stanworth A	NA	NA
SKU*	Steeple_Skuas	19/01/2024	Kuepfer A, Lee B	NA	NA

AON – Apparently Occupied Nests (breeding pairs); PFC – Pre-Fledged Chicks *Apparently Occupied Territory count. BBA = Black=browed albatross, G = Gentoo penguin, IMS = Imperial shag, SRH = Southern rockhopper penguin, SGP = Southern giant petrel, SKU = Falkland skua.

Appendix 3: Black-browed albatross count data

Location	Colony	Grid ref	AON		PFC	
			mean ± sd	Count type	mean ± sd	Count type
Steeple Jason	NW Flat	-51.012; -61.252	401 ± 2.2	D	35 ± 0	TR
Steeple Jason	Penthouse	-51.031; -61.228	68 ± 1.6	D	0	D
Steeple Jason	S5 Finger	-51.031; -61.231	2078 ± 7.1	D	454 ± 2.2	D
Steeple Jason	S5 Tip_Blob	-51.037; -61.220	425 ± 2	D	146 ± 1.9	D
Steeple Jason	Study Site	-51.046; -61.207	1806 ± 10.3	D	717 ± 0	TA
New Island	NWI_Bowl	-51.718; -61.311	334	TR	-	-
New Island	NWI_PCatry_Demo_BCDE	-51.714; -61.214	187	TR	82 ± 0	-

AON – Apparently Occupied Nests (breeding pairs); PFC – Pre-Fledged Chicks; TR – Tally Repeated; TA – Tally Agreed; GP – Go-Pro image counts; D – Drone image counts. See methods details in Kuepfer and Stanworth 2023. GPS grid references represent an average location of sub-colonies.

Appendix 4: Gentoo penguin count data

Location	Colony	Grid ref	AON		PFC	
			mean ± sd	Count type	mean ± sd	Count type
Fitzroy	Berthas Beach	-51.8801; -58.3553	469 ± 0.6	NA	494 ± 10	NA
Fitzroy	Fox Point Fitzroy	-51.9221; -58.4608	375 ± 4	TR	484 ± 10.3	TR
Fitzroy	Pleasant Road	-51.8304; -58.2425	238 ± 3.1	TR	305 ± 1.5	TR
New Haven	New Haven	-51.7365; -59.2202	538 ± 5.6	TR	707 ± 6.6	D
New Island	NWI_House	-51.7262; -61.2988	138 ± 5.5	D	128	TR
New Island	NWI_North	-51.6919; -61.2571	766 ± 3.5	D	905	TR
New Island	NWI_South	-51.7446; -61.2967	1109 ± 4.1	D	864	TR
North Arm	Bull Point	-52.3444; -59.3198	928 ± 2.6	D, TR	1049 ± 4	D, TR
North Arm	Bull Roads	-52.3130; -59.3959	488 ± 2.2	D	593 ± 5.2	D
Port Stephens	Stephens Peak	-52.1268; -60.8538	1999 ± 5.1	D	See results	D
Race Point	Fanning Harbour	-51.4653; -59.0875	183 ± 2.9	D	243 ± 5.6	D
Race Point	Rookery Sands	-51.4341; -59.1096	807 ± 1.5	D	1171 ± 4.2	D
Sea Lion Island	SLI_Gentoos	-52.4266; -59.0725	3227 ± 3.6	NA	3762 ± 8.5	NA

Stanley	Yorke Bay	-51.6763; -57.7829	206 ± 0	TA	176 ± 3.5	TR
Steeple Jason	SJI_House	-51.0201; -61.2267	1959 ± 13.6	NA	1346 ± 9.2	NA
Steeple Jason	SJI_Neck	-51.0348; -61.2149	2436 ± 5.9	NA	1704 ± 6.2	NA
Volunteer	Cow Bay	-51.4342; -57.8784	1654 ± 10.5	D	1538 ± 5.4	D
Volunteer	Lagoon Sands	-51.5120; -57.7803	525 ± 4.2	D, TR	344 ± 1.7	D, TR
Volunteer	Volunteer Green	-51.4793; -57.8381	1309 ± 4.6	TR	1203 ± 11.7	TR
Walker Creek	Low Bay	-52.0760; -58.8769	166 ± 13.1	TR	244 ± 7.7	TR
Walker Creek	Motley Point	-52.1151; -58.6523	952 ± 14.5	D	1189 ± 10.1	D

AON – Apparently Occupied Nests (breeding pairs); PFC – Pre-Fledged Chicks; TR – Tally Repeated; TA – Tally Agreed; GP – Go-Pro image counts; D – Drone image counts. See methods details in Kuepfer and Stanworth 2023. GPS grid references represent an average location of sub-colonies.

Appendix 5: Imperial shag count data

Location	**Colony**	**Grid ref**	**AON (Jan)**	
			mean ± sd	**Count type**
Berkeley Sound	Eagle Hill Centre	-51.544476; -57.802756	198 ± 8.7	TR
Berkeley Sound	Eagle Hill West	-51.545082; -57.810499	272 ± 8.1	TR
Berkeley Sound	Rugged Hill Centre	-51.54320; -57.85185	13 ± 0	TR
Berkeley Sound	Rugged Hill West	-51.54314; -57.85783	164 ± 9.2	TR
Walker Creek	Motley Point	-52.1151; -58.6523	560 ± 2.5	D

AON – Apparently Occupied Nests (breeding pairs); PFC – Pre-Fledged Chicks; TR – Tally Repeated; TA – Tally Agreed; GP – Go-Pro image counts; D – Drone image counts. See methods details in Kuepfer and Stanworth 2023. GPS grid references represent an average location of sub-colonies.

Appendix 6: Southern giant petrel count data

Location	**Colony**	**Grid ref**	**AON**		**PFC**	
			mean ± sd	**Count type**	**mean ± sd**	**Count type**
Steeple Jason	House Track_House	-51.017; -61.241	128 ± 3.4	D	56 ± 0	D
Steeple Jason	Neck_SGP	-51.042; -61.206	1326 ± 2.5	D, TR	592 ± 2	D
Steeple Jason	NW_S of Ridge_West	-51.024; -61.248	1 ± 0	NA	0 ± 0	TA
New Island	NWI_Airstrip	-51.744; -61.276	181 ± 5.6	D	-	-

New Island	NWI_Ship Island	-51.709; -61.281	159 ± 4	D	-	-

AON – Apparently Occupied Nests (breeding pairs); PFC – Pre-Fledged Chicks; TR – Tally Repeated; TA – Tally Agreed; GP – Go-Pro image counts; D – Drone image counts. See methods details in Kuepfer and Stanworth 2023. GPS grid references represent an average location of sub-colonies.

Appendix 7: Southern rockhopper penguin count data

Location	Colony	Grid ref	AON		PFC	
			mean ± sd	Count type	mean ± sd	Count type
Berkeley Sound	Diamond Cove	-51.538059;-57.923512	118 ± 2.2	TR	119 ± 2.4	TR
Berkeley Sound	Eagle Hill Centre	-51.544476; -57.802756	720 ± 2.2	D	591 ± 10.8	TR
Berkeley Sound	Eagle Hill East	-51.544064; -57.785118	107 ± 6.3	TR	119 ± 0.6	TR
Berkeley Sound	Eagle Hill West	-51.545082; -57.810499	792 ± 10.7	D	646 ± 7.9	TR
Berkeley Sound	Rugged Hill Centre	-51.54320; -57.85185	429 ± 8.2	D	330 ± 10.2	TR
Berkeley Sound	Rugged Hill East	-51.543674; -57.845031	408 ± 2.4	D	310 ± 5.8	TR
Berkeley Sound	Rugged Hill West	-51.54314; -57.85783	308 ± 3.5	D	278 ± 6	TR
Port Stephens	Stephen's Peak	-52.133250; -60.861010	1004 ± 5.7	NA	633 ± 13.8	NA
Race Point	Fanning Head North	-51.460831; -59.141540	232 ± 3.1	D	166 ± 8.7	GP
Race Point	Fanning Head South	-51.469284; -59.137749	357 ± 2.4	D	225 ± 2	TR, GP
Sea Lion Island	SLI_Rockhoppers	-52.446670; -59.115083	374 ± 6.7	NA	199 ± 2.7	NA
Steeple Jason	NW Flat	-51.012810; -61.252682	82 ± 0.9	D	28 ± 1.7	D
Steeple Jason	S5 Finger	-51.031884;-61.231434	922 ± 11.7	D, D	471 ± 5.7	TA
Steeple Jason	S5 Tip_Blob	-51.037932; -61.220460	572 ± 22.3	D	251 ± 5.5	TR
Steeple Jason	Study Site	-51.046215; -61.206635	652 ± 2.8	TR	331 ± 1.1	TA

AON – Apparently Occupied Nests (breeding pairs); PFC – Pre-Fledged Chicks; TR – Tally Repeated; TA – Tally Agreed; GP – Go-Pro image counts; D – Drone image counts. See methods details in Kuepfer and Stanworth 2023. GPS grid references represent an average location of sub-colonies.