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1 **Changes and consistencies in marine and coastal bird numbers on Kidney Island (Falkland Islands)**  
2 **over half a century**

3  
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16  
17 **Abstract**

18 Detecting change is necessary for effective ecosystem management, yet temporal data on key  
19 ecosystem components are lacking for many polar and subpolar regions. For example,  
20 although the Falkland Islands hosts internationally important marine and coastal bird  
21 populations, few of these were surveyed until the late 20<sup>th</sup> century. The avifauna of one small  
22 island, Kidney Island, was surveyed between 1958 and 1963, however. This typical tussac-  
23 covered island has remained free of non-native predators, so changes in its avifauna may  
24 reflect variation in the wider marine environment. In order to obtain a rare snapshot of such  
25 changes, we re-surveyed Kidney Island’s avifauna between 2017 and 2019, counting either  
26 individuals, breeding pairs or nest sites of marine and coastal waterbirds. Waterfowl, waders  
27 and cormorant populations were broadly stable, but several populations showed profound  
28 differences over the six decades between surveys. In particular, Southern Rockhopper  
29 penguins *Eudyptes chrysocome* collapsed from >3000 to 200 pairs, while Sooty Shearwaters  
30 *Ardenna grisea* expanded by two orders of magnitude. Due to its isolation and tight fisheries  
31 management, the Falklands marine environment is assumed to be relatively pristine. Our  
32 limited results suggest that sufficient changes may nevertheless have occurred in the region’s  
33 marine ecosystem to have detectable impacts on breeding seabirds.

34  
35  
36 **Keywords:** Kelp Goose, Falkland Steamer Duck, Rockhopper Penguin, *Ardenna gravis*, *Haematopus*  
37 *ater*, Falkland Islands

38  
39  
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47  
48 **Compliance with Ethical Standards**

49 The authors declared no conflicts of interest. Work on Kidney Island was approved by the Environmental  
50 Committee of the Falkland Islands Government.

51 **Introduction**

52 Data on long-term changes in key components of marine ecosystems are of intrinsic interest, both from  
53 historical and ecological perspectives. They are of potential relevance to the identification of ecological  
54 baselines, the understanding of ecosystem dynamics and their drivers, and ultimately may help to forecast  
55 future changes.

56 Birds are important and highly visible constituents of many marine ecosystems. In some regions,  
57 their populations have been monitored over long periods and the drivers of their population changes are  
58 relatively well understood. However, within the Patagonian Shelf Large Marine Ecosystem and coastal  
59 areas of Southern South America, few quantitative population studies of marine and coastal birds were  
60 undertaken prior to the late 20th century. In the Falkland Islands, long-term monitoring of seabirds began  
61 in 1997 and shorebirds in 2008 (e.g. Pistorius et al. 2010; Baylis et al. 2013; Crofts and Stanworth 2018;  
62 Poncet et al. 2018). However, no long-term monitoring is carried out of some petrels, and many shorebird  
63 and waterfowl species. In the late 1950s and early 1960s, Robin Woods surveyed bird numbers on Kidney  
64 Island, a small island with a diverse avifauna, near Stanley in the northeast of the archipelago (Fig 1.)  
65 (Woods 1970a, b). In addition, he and others made less systematic counts in the decades before and after  
66 that period (Woods 2017).

67 Kidney Island has been a Nature Reserve since 1964, an Important Bird and Biodiversity Area  
68 since 2006, and a priority Key Biodiversity Area since 2016 (BirdLife International 2019). The only  
69 substantive direct impacts humans are known to have had on the island occurred before the 1960s. These  
70 included regular harvesting of tussac *Poa flabellata*, occasional fires, and the collection of Southern  
71 Rockhopper penguins' *Eudyptes chrysocome* eggs (Carstairs 1995, FIG 2008). Despite being only 0.4 km  
72 from the mainland, the island is free of introduced mammals. In the Falklands, such predator-free islands  
73 typically have twice as many coastal waterbirds as those with cats or rodents (Poncet et al. 2018). Many,  
74 like Kidney Island, also have large populations of burrowing seabirds, and the endemic Tussacbirds  
75 *Cinclodes antarcticus* and Cobb's wrens *Troglodytes cobbi* (Strange 1992; Tabak et al. 2014). The aim of  
76 the present study was to gain a snapshot of current seabird and coastal waterbird numbers on Kidney  
77 Island relative to those six decades earlier by repeating Wood's surveys of the 1950s and 1960s. Although  
78 Kidney Island harbours only a small proportion of the Falklands' bird populations, gross changes at this  
79 comparatively undisturbed site could provide valuable clues about how the region's avifauna has changed  
80 over an otherwise data deficient period.

81

82 **Methods**

83 Kidney Island (51° 38', 57° 45'W, area = 0.32 km<sup>2</sup>, coastline length = 4.2 km) is located 0.4 km off East  
84 Falkland (Fig. 1). It is low-lying, with cliffs (< 20 m) dominating its north coast. The intertidal zone is  
85 generally narrow (<10 m), with a rock or boulder substrate, and small areas of sand. Extensive kelp beds,  
86 dominated by giant kelp *Macrocystis pyrifera*, surround the island and inland it is almost completely  
87 covered with dense tussac.

88 Woods censused or estimated numbers of birds on Kidney Island during multiple visits between  
89 1958 and 1963. The majority of observations in the early surveys were made in December 1960 and  
90 December 1961; survey effort comprised seven weeks of camping on the island during those years  
91 (Woods 1970a, b). Occasional observations during shorter visits at other times were compiled in Woods  
92 and Woods (1997) and in Woods (2017).

93 Our surveys were carried out during January 2017, November 2018 and January 2019.  
94 Between November the 17<sup>th</sup> and 19<sup>th</sup>, 2018 and January the 8<sup>th</sup> to 10<sup>th</sup>, 2019 we censused waterfowl,  
95 waders and surface-nesting seabirds by replicating the method used by Woods (1970a) in the 1960s.  
96 These birds are highly conspicuous and allow close approach by humans in the Falkland Islands. We  
97 searched the entire perimeter of the island by walking along the coastline or viewing the shoreline from  
98 the cliff top, and recorded all breeding pairs detected. We defined the presence of a breeding pair as a bird  
99 in incubating position on a nest containing eggs or chicks. In addition, we assumed that the presence of a  
100 lone male Kelp Goose *Chloephaga hybrida* or Falkland Steamer Duck *Tachyeres brachypterus* displaying  
101 territorial behaviour during the breeding season indicated a breeding pair. Repeated counts in sub-sections

102 of the coastline revealed absolute consistency in numbers. In addition, we systematically surveyed Sooty  
103 shearwaters *Ardenna grisea* across the island in January 2017 (for details, see Clark et al. 2019).

104

## 105 **Results**

106 Counts of Southern Rockhopper penguins and Imperial shags *Leucocarbo atriceps* made in 2017-2018  
107 were an order of magnitude lower than those made in the late 1950s-1960s. In contrast, counts of Sooty  
108 shearwaters suggest an increase of two orders of magnitude over this period, while counts of Falkland  
109 Steamer ducks and Kelp geese were of the same order (Table 1).

110

## 111 **Discussion**

112 The majority of the population estimates we presented are snapshots at two points in time, rather than the  
113 more extensive time series typically used to investigate population dynamics. Hence, any inference we  
114 draw about sustained trends are necessarily tentative. Nevertheless, several of the changes are so large  
115 that they deserve highlighting.

116 Rockhopper penguins were estimated to have declined in the Falkland Islands by over 80%  
117 between the early 1930s and 1995 (Pütz et al. 2003). Subsequently, numbers have fluctuated (Baylis et al.  
118 2013; Crofts and Stanworth 2018). The Kidney Island population may have been in decline prior to the  
119 1930s as a result of intensive egg harvesting: in 1914, around 25,000 eggs were collected but by 1952  
120 only 1,000 were taken (Cawkell and Hamilton 1961). Although egg collecting ceased in 1960 (at which  
121 time > 3,000 pairs of Rockhopper penguins were estimated to breed on Kidney Island (Woods 1970a),  
122 our results suggest that the population has continued to decline. Our 2017/18 count was less than 10% of  
123 that of 1960, when the population was likely to have been already depleted. This ongoing decline may be  
124 due to changes in oceanographic conditions and, consequently, prey availability, which are thought to  
125 have driven declines in Rockhopper penguins' populations across the Southern Ocean during the 20th  
126 century (Pütz et al. 2003; Hilton et al. 2006).

127 The sooty shearwater population of Kidney Island, estimated at 2,000 breeding pairs in 1960  
128 (Woods 1970a) and 140,000 breeding pairs in 2017, is by far the largest known in the Falklands (Clark et  
129 al. 2019). The species was first recorded breeding on the island in the 1930s, when "small numbers" were  
130 found in 3 discrete colonies on the slopes of the western headland (B.B. Roberts in Woods 2017). The  
131 two orders of magnitude increase over the past 80 years is in strong contrast to sharp declines in the  
132 species' core range in the South Pacific (Scott et al. 2008). Reasons for the increase on Kidney Island  
133 remain unknown but may include the recovery of tussac cover on the island after the cessation of  
134 harvesting in the 1960s (Clark et al. 2019).

135 The population trend for White-chinned petrels *Procellaria aequinoctialis* on Kidney Island is  
136 unknown - various past estimates reveal contradictory numbers (reviewed in Woods and Woods 1997;  
137 Woods 2017). However, this species is thought to be in decline in South Georgia (Martin et al. 2009) and  
138 elsewhere, largely due to fisheries bycatch (Barbraud et al. 2008) and is therefore classified as Vulnerable  
139 by the IUCN.

140 Great shearwaters *Ardenna gravis* were first recorded breeding in small numbers on Kidney  
141 Island in 1961, making this the only known colony outside the Tristan da Cunha group (Woods 1970b).  
142 The population was subsequently estimated to be 50-100 pairs (Woods and Woods 1997). We counted  
143 Great shearwaters in rafts of Sooty shearwaters that form around Kidney Island prior to the birds entering  
144 the colony each evening. These typically contained 5,000-10,000 Sooty shearwaters and a mean of 12  
145 Great shearwaters (N= 7 counts/days, range 1-29 birds). If the ratio of great shearwaters in the rafts to  
146 those attending the island is the same as for Sooty shearwaters, we speculatively estimate that  
147 approximately 168-336 Great shearwaters' pairs could breed there. It is possible that an increasing  
148 number of Great shearwaters are recruiting to the colony. Tracking data show that birds breeding on  
149 Gough Island in the Tristan group regularly forage on the Patagonian Shelf, adjacent to the Falklands  
150 (Ronconi et al. 2010).

151 Counts of Kelp geese in 2018-2019 were approximately twice those recorded six decades earlier.  
152 As with Sooty shearwaters, this could be due to increased tussac cover. In nearby Tierra del Fuego, Kelp  
153 geese only nest on islands free of mammalian predators, and are associated with islands with greater bush

154 cover, perhaps because this conceals nests from predators (Liljeström et al. 2013). In the Falklands, the  
155 species does manage to breed in the presence of feral cats *Felis catus* and Norway rats *Rattus norvegicus*  
156 but possibly at a depressed density. It is interesting to note that the density of Kelp geese on Kidney  
157 Island is extremely high, compared to the adjacent East Falkland (pers.obs.), despite the relatively poor  
158 availability of the species' marine algae food on Kidney Island (very low surface covered by green algae  
159 such as *Ulva* or *Enteromorpha*).

160 Counts of Falkland Steamer ducks were approximately the same across the two recording  
161 periods. This species is resident, with pairs occupying the same coastal territories year-round (Poncet  
162 2014), making it likely that this consistency in numbers reflects a true neutral population trend.

163 Counts of Rock shags breeding on Kidney Island were similar but those of Imperial shags were  
164 dramatically lower during the recent count than in the 1960s. The latter species can switch nest sites  
165 regularly. It remains very numerous in waters adjacent to Kidney Island (pers.obs.), with many hundreds  
166 regularly flying past and foraging nearby so the Kidney Island population may simply have shifted to a  
167 nearby location. There are no data on regional or overall numbers or trends of Imperial shags in the  
168 Falklands. Population trends in Argentina in recent decades have differed in sign across regions, but have  
169 remained stable overall (Frere et al. 2005; Raya Rey et al. 2014). Similarly, Rock shag numbers have  
170 fluctuated temporally and regionally in Argentina over the past 20-30 years (Frere et al. 2005; Raya Rey  
171 et al. 2014).

172 In late November 1936, three pairs of Blackish oystercatchers *Haematopus ater* were recorded  
173 on Kidney Island (B.B. Roberts in Woods 2014). Woods recorded five pairs in 1960 and four pairs in  
174 1961, and seven pairs in both 1969 and 2002 (Woods 2014). We recorded four pairs in November 2018,  
175 suggesting that the population has remained small but stable over the past 82 years. Although this species  
176 is classified as Least Concern, as far as we are aware, there are no other data on its population trends.

177 The marked decline of Rockhopper penguins and Imperial shags on Kidney Island may have also  
178 affected birds that scavenge or predate in their colonies – for example Skuas *Stercorarius antarcticus* and  
179 Dolphin gulls *Leucophaeus scoresbii*. There is scant information on population trends of these two  
180 species in the Falklands. In Patagonia, Dolphin Gull populations appear to be broadly stable, with local  
181 increases in the past few decades (Suárez and Yorio 2005; Raya Rey et al. 2014; Pablo Yorio, pers.com.).  
182 Skuas have declined recently elsewhere in the Falklands (Catry et al. 2011), but current data are  
183 insufficient to estimate regional population trends robustly.

184 Brown-hooded gulls *Chroicocephalus maculipennis* and South American terns *Sterna*  
185 *hirundinacea* often relocate *en masse* to new breeding sites, making the differences in numbers we found  
186 difficult interpret. Both species are still present in the vicinity of Kidney Island in numbers apparently of  
187 the same order as in 1960 but few bred on the island during our visits there. Brown-hooded gulls may be  
188 increasing in South America (Burger et al. 2019), while some South American tern populations have  
189 declined in Chile, seemingly due to human disturbance (Gochfeld et al. 2019).

190 Kidney Island has long been afforded protection as a Nature Reserve under national legislation.  
191 Moreover, the wider Falklands marine environment is relatively pristine, due both to its isolation and  
192 relatively strict fisheries management. Our limited results suggest that despite this, some marine bird  
193 populations in the region have changed substantially over the past six decades. Future studies should seek  
194 to understand the causes of these changes, especially among Southern Rockhopper penguins and Sooty  
195 shearwaters, as well as clarify the status and trends of White-chinned petrels. Given the paucity of time  
196 series data, consideration should also be given to broadening long-term monitoring in the region to cover  
197 a wider range of marine and coastal bird species.

198

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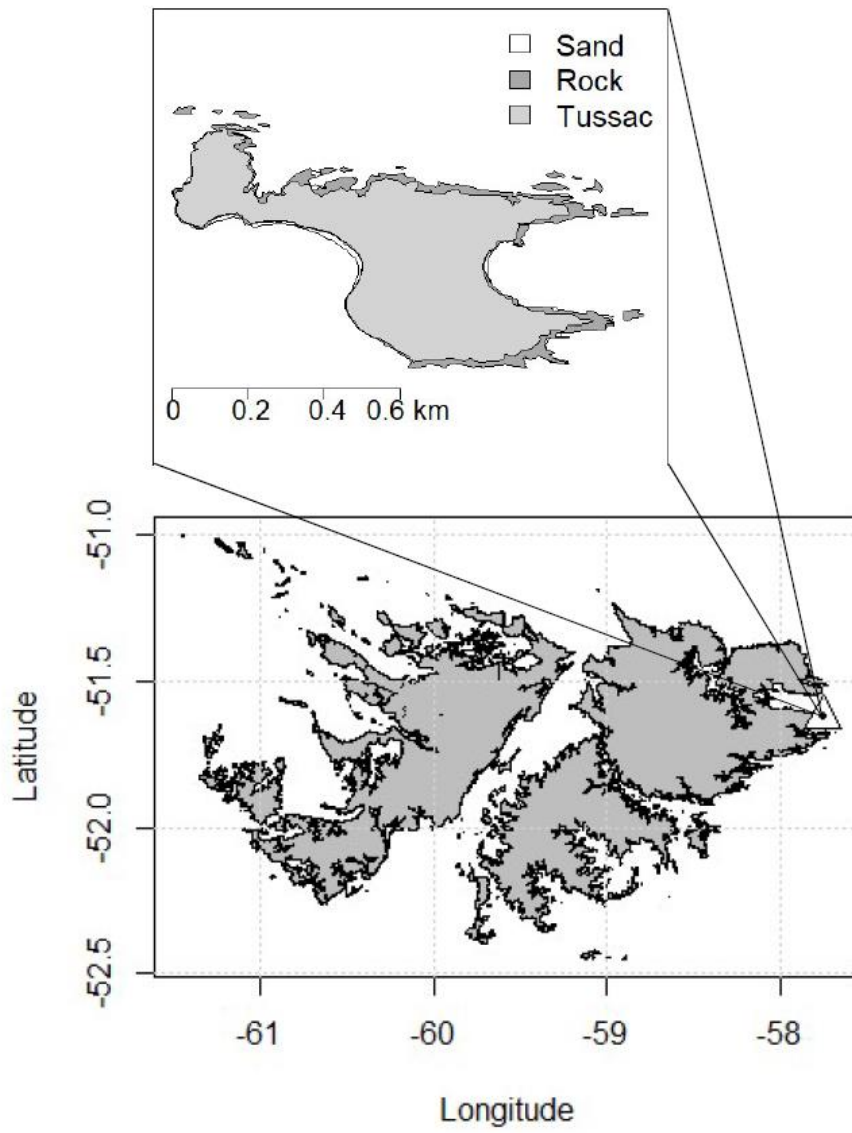
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312 **Table 1.** Estimated populations of marine birds on Kidney Island in the 1960s and in the early 21st  
 313 century. Unless stated otherwise, estimates from 1960 and 1961 are from Woods 1970a and estimates  
 314 from 2016-2019 are from this study.

	1960 (pairs)	2018 (pairs)	Notes
White-chinned Petrel <i>Procellaria aequinoctialis</i>	“Few hundred”	“Few hundred”	27 pairs in 2006, but numbers most likely were underestimated (Reid et al. 2007).
Sooty Shearwater <i>Ardenna grisea</i>	2,000	140,000	Clark et al. 2019
Great Shearwater <i>Ardenna gravis</i>	Present nesting (in 1961)	Present, probably nesting	Seen ashore in Jan 2017, Jan 2018 and Nov 2018. (see Discussion).
Grey-backed Storm-petrel <i>Garrodia nereis</i>	Present nesting	Present nesting	
Southern Rockhopper Penguin <i>Eudyptes chrysocome</i>	3000+	202	25,000 eggs collected in 1914, but only 1,000 in 1952 (Cawkell and Hamilton 1961)
Macaroni Penguin <i>Eudyptes chrysolophus</i>	1-2	0	
Magellanic Penguin <i>Spheniscus magellanicus</i>	Several hundred pairs	Widespread, but possibly in small numbers; tens?	
Patagonian Crested Duck <i>Lophonetta specularioides</i>	0	1	Adult plus chick in Jan 2018; one individual in Nov 2018 (nest hidden) and pair with 3 ducklings in March 2019 (Sally Poncet, pers. comm.).
Kelp Goose <i>Chloephaga hybrida</i>	14 (in 1961)	26	Despite 26 pairs in Nov 2018, only 9 males and a total of 6 broods remaining in Jan 2019.
Steamer Duck <i>Tachyeres brachypterus</i>	10	7-8	7 pairs (6 with brood) and a single male in Nov 2018. Still 7 pairs in Jan 2019.
Night Heron <i>Nycticorax nycticorax</i>	8	0	Still present in each recent year, no confirmed nesting; fledged juveniles seen in Jan 2018
Imperial Shag <i>Leucocarbo atriceps</i>	440	20	Similar number in 2016/17 but large numbers (many hundred) flying past the island in all years
Rock Shag <i>Leucarbo magellanicus</i>	134	51	41 and 51 occupied nests in Nov 2018 and Jan 2019 respectively. Still occupies the same 5 subcolonies as in 1960
Black Oystercatcher <i>Haematopus ater</i>	5	4	See text for details
Falkland Skua <i>Stercorarius antarcticus</i>	1	0	No breeding in 2016 and 2018 but present in the area
Kelp Gull <i>Larus dominicanus</i>	1	0	No breeding in 2016 and 2018 but present in the area
Brown-hooded Gull <i>Chroicocephalus maculipennis</i>	20	0	2 possible nests in Jan 2017, present in the area in Nov 2018, (not nesting) when up to 6 adults seen close inshore
Dolphin Gull <i>Leucophaeus scoresbii</i>	50	0	No breeding in 2016 and 2018 but present in the area (<10 individuals)
South American Tern <i>Sterna hirundinacea</i>	50	0	No nests in Nov 2018 or Jan 2019, but a colony with <10 nests and ca 100-120 individuals in Jan 2017 and 105 individuals observed in Nov 2018.

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318 Fig. 1. Location of Kidney Island (triangle) relative the Falkland Islands.