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Review

Seabirds of Easter Island, Salas y Gómez Island and Desventuradas Islands, southeastern Pacific Ocean

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ABSTRACT. We reviewed available information on seabirds inhabiting Easter Island, Salas y Gómez Island and Desventuradas Islands and their adjacent waters through an analysis of published and grey literature. Results obtained indicate that a total of 37 species are present in the study area and that, among the orders represented, the Procellariiformes and Charadriiformes are the dominant taxa (29 species). Moreover, the family Procellariidae is represented by 13 species and Laridae by 7 species. There has been an increase in new records over the past six years but no systematic studies have been developed. The need for further research that focuses on ecological aspects and anthropogenic impacts is critical in order to develop adequate conservation strategies.

Keywords: seabirds, breeding colonies, oceanic islands, southeastern Pacific.

Las aves marinas de Isla de Pascua, Isla Salas y Gómez e Islas Desventuradas, Océano Pacífico suroriental

RESUMEN. Se revisó la información disponible sobre las aves marinas que habitan Isla de Pascua, Isla Salas y Gómez, Islas Desventuradas y aguas adyacentes, mediante el análisis de la literatura publicada y literatura gris. Los resultados obtenidos indican que en el área de estudio se encuentran presentes 37 especies y entre los órdenes representados, Procellariiformes y Charadriiformes son los taxa dominantes (29 especies). Las familias Procellariidae y Laridae están representadas por 13 y 7 especies, respectivamente. Durante los últimos seis años, ha habido un incremento de nuevos registros, sin embargo aún no se desarrollan estudios sistemáticos de la avifauna. La necesidad de mayor investigación científica enfocada en aspectos ecológicos e impactos antropogénicos es crítica para desarrollar estrategias adecuadas de conservación**.**

Palabras clave: aves marinas, colonias de nidificación, islas oceánicas, Pacífico suroriental.

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INTRODUCTION

The study of seabirds can promote the understanding of oceanic ecosystems since this group has several attributes that make them a good indicator species (*e.g.*, easy to detect and identify; depend entirely on marine ecosystems to obtain their food; are highly mobile and consequently integrate ecosystem variability across different spatial and temporal scales) (Ballance, 2007). Seabird distribution patterns are quite well understood (Harrison, 1987) and have usually been correlated to habitat characteristics such as sea surface temperature, salinity or productivity (Pocklington, 1979; Schneider & Brown, 1986; Schneider, 1990; Elphick & Hunt, 1993).

Oceanic islands possess a significant cultural and economic relevance to mankind throughout the world (Moller *et al.*, 2009), but from an ornithological point of view, many have been severely degraded through the centuries by human societies (Moller *et al.*, 2009), both directly and indirectly. Some islands have been substantially altered through a long history of seabird predation by introduced mammals such as rats, dogs, cats and foxes, among others. These introduced species have been responsible for an important proportion of the decline of seabird populations (Courchamp *et al.*,

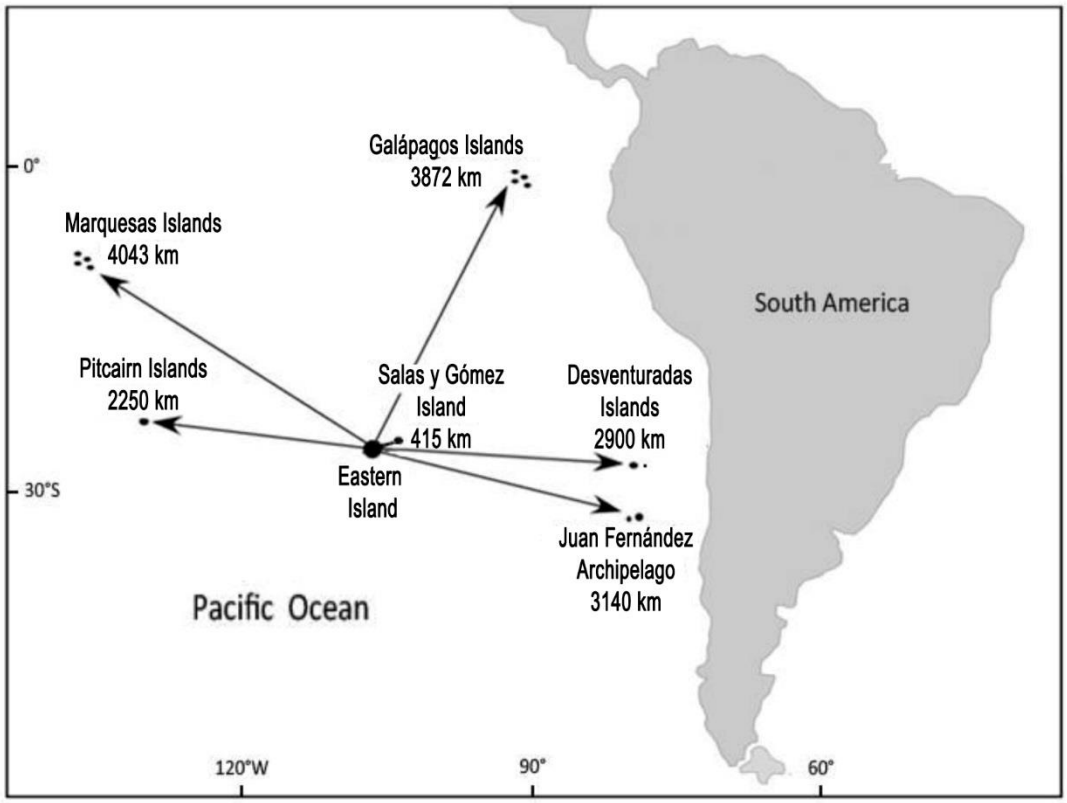

Figure 1. Location of Easter Island, Salas y Gómez Island and Desventuradas Islands in relation to the closest islands in the South Pacific and South America (modified from Glynn *et al.*, 2007).

2003; Jones *et al.*, 2008; Baker *et al.*, 2014), on occasions even more so than other factors such as by-catch in fisheries and the effects of overfishing and pollution (Blackburn *et al.*, 2004; Jones *et al.*, 2008).

In the present day, knowledge regarding seabirds inhabiting Chilean oceanic islands: Easter, Salas y Gómez and Desventuradas islands, is rather scarce and the conservation status of these islands is depressed, as pointed out by Schlatter (1987). The Juan Fernandez Archipelago presents a more advanced level of scientific information only because NGO Oikonos conducted systematic research, filling in these knowledge gaps (see http://oikonos.org/juan-fernandez-islands-conservancy/).

In this paper we aim to update the information about the birds of these islands based on the available literature since 1914 to present and propose categories of residence for Chilean territory according to the current state of knowledge.

MATERIALS AND METHODS

The present study pertains to Easter Island (27°09'S, 109°26'W), Salas y Gómez Island (26°27'S, 105°28'W) and Desventuradas Islands (26°20'S, 79°58'W), all located in the subtropical eastern South Pacific Ocean. The degree of isolation of Easter and Salas y Gómez islands with respect to other oceanic islands is high: Pitcairn is located 2,250 km to the west, Galapagos 3,872 km to the northeast, Juan Fernandez, 3,140 km to the southeast, Desventuradas Islands, 2,900 km to the east and the closest land mass, South America, some 3,700 and 3,400 km to the east, respectively (Fig. 1).

This paper includes a bibliographic review from the libraries of both public and private universities in Valparaíso and Santiago, the "William Mulloy" library of the "Father Sebastian Englert" Anthropological Museum on Easter Island, private libraries of national and international ornithologists and the archives of the provincial office of the Corporación Nacional Forestal (CONAF) on Easter Island. A literature search was done with Google Scholar (see http://scholar.google.cl, accessed march-october 2012) using the keywords: bird*, Easter Island, Salas* y Gómez and Desventuradas. Additional articles were found though references cited in articles resulting from our searches.

Taxonomy, scientific and common English names used in this review are those proposed by the South American Classification Committee (SACC) of the

American Ornithologist Union (AOU) (Remsen *et al.*, 2012). Statuses are proposed by the authors according to the information gathered in this review. Regular: birds regularly observed throughout the year and with several records in different years; Occasional: birds with few observations on the islands which are not regularly; Breeder: birds with reported breeding colonies across different years; Undetermined: birds without enough information to be included in a previous category.

Additionally, the Jaccard Similarity Coefficient was calculated to express the degree of similarity between sites (Pielou, 1975; Magurran, 1988) based on the number of species present at each one of them. The coefficient was obtained using the number of breeding species on each island, according to the following expression:

$$I_j = \frac{c}{(a + b - c)}$$

where a = number of species breeding in site A, b = number of species breeding in site B and c = number of species breeding in both sites A and B.

RESULTS AND DISCUSSION

Our results show that seabirds present in the study area are composed of 4 orders, 9 families and 37 species. Easter Island encompasses 4 orders, 7 families and 25 species. Salas y Gómez Island includes 4 orders, 6 families and 16 species and Desventuradas Islands include 4 orders, 8 families and 22 species. Table 1 details the seabird species recorded for each island.

Among the registered orders, the Procellariiformes (*e.g.*, petrels and shearwaters) and Charadriiformes (*e.g.*, sandpipers, noddies and terns) are the most noteworthy, with 17 and 12 species, respectively (Fig. 2). However, under a family level analysis, there is a clear predominance of Procellariidae, with 13 species, followed by Laridae, with 7 species, together accounting for 54.1% of the overall seabird species richness in the study area (Fig. 3). Seabird representatives from these two orders are quite consistent with those reported for other oceanic islands (*e.g.*, Williams, 1960; Benton & Spencer, 1995; Thibault & Bretagnolle, 1999), as they are characterized by high mobility and widespread distributions (Carboneras, 1992).

When comparing seabirds present within and between each island in the study area, we observed that Easter Island holds 89.3% (25 spp.) of the total reported species, Salas y Gómez Island 57.1% (16 spp.) and Desventuradas Islands 59.5% (22 spp.). The Jaccard Similarity Coefficient obtained shows that Easter Island and Salas y Gómez Island share a significant number of species (0.64) while Salas y Gómez Island and Desventuradas Islands have the smallest value (0.4) (Table 2).

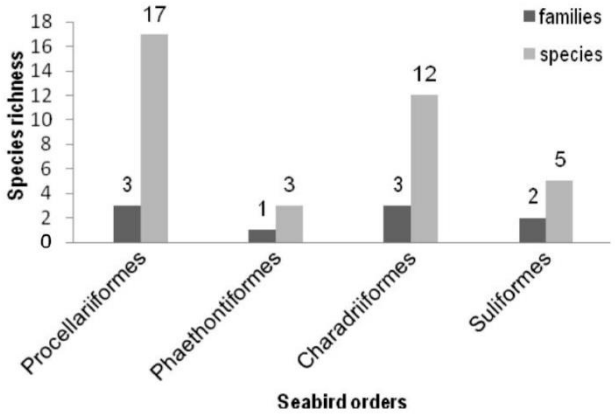

Figure 2. Number of families and species for each of the seabird orders recorded in the study area.

The values obtained are significantly higher than those reported by Schlatter (1987) because this study includes a greater number of species for all the islands in this study. Schlatter (1987) reported 14 species on Easter Island. Later, Marin & Cáceres (2010) reported a total of 19 species for Easter Island, while this study updated the list up to 25 species. The case for Salas y Gómez Island is similar: Schlatter (1987) reported 9 species, Vilina & Gazitúa (1999) 14 species and this work increases that number of species to 16. For Desventuradas Islands, Millie (1963) reported 8 species, Schlatter (1987) 9 species, Aguirre *et al.* (2009) 19 and this work 22 species (Table 3).

A total of 17 species have been recorded as breeding in the study area. Among these, 12 species breed on Easter Island, 11 on Salas y Gómez Island and 10 on Desventuradas Islands. Published information from 2008 to date has substantially increased records of breeding species in the study area at a rate of one new species per year. Jaramillo *et al.* (2008) confirmed nesting of *Anous stolidus* as originally suggested by Schlatter (1987); Aguirre *et al.* (2009) confirmed nesting of *Phaethon lepturus*, *P. rubricauda* and *Sula nebouxii* on Desventuradas Islands. Marin & Cáceres (2010) provided an account of nesting *Pterodroma ultima*, a first for Chile; Lazo (2011) confirmed nesting of *Pterodroma neglecta* for the first time on Salas y Gómez Island and nesting of *Fregeta minor* on Easter Island. Additionally, in the same period, 6 new species for Chile and/or Easter Island and Salas y Gómez Island have been reported, a rate of 0.85 new sightings per year (Table 4).

The results presented here indicate that, while there has been an increase in the number of species recorded in the study area, not much else has been achieved in

Table 1. Seabirds recorded in Easter Island, Salas y Gómez Island and Desventuradas Islands and its proposed residency status for Chilean territory (RE: regular, OC: occasional, B: breeder, U: undetermined). Conservation status according to International Union for the Conservation of Nature (IUCN, 2013) and the Ministry of the Environment, Chile (MMA, 2009): EN: endangered, VU: vulnerable, LC: least concern.

Scientific name	Common name	Status			Conservation status	
		Easter Island	Salas y Gómez Island	Desventuradas Islands	IUCN (2013)	MMA (2009)
Order Procellariiformes						
Family Diomedeidae						
Thalassarche melanophris	Black-browed albatross	RE	-	RE	EN	-
Thalassarche salvini	Salvin's albatross	-	-	RE	VU	
Family Procellariidae						
Macronectes giganteus	Southern giant-petrel	RE	RE	RE	LC	-
Macronectes halli	Northern giant-petrel	OC	-	-	LC	-
Fulmarus glacialoides	Southern fulmar	-	-	OC	LC	
Daption capense	Cape petrel	RE	-	RE	LC	-
Pterodroma defilippiana	Mas a Tierra petrel	-	-	B[3,6,14,20]	VU	VU
Pterodroma alba	Phoenix petrel	U	-	-	EN	-
Pterodroma ultima	Murphy's petrel	B[22]	-	-	NT	-
Pterodroma neglecta	Kermadec petrel	B[11,14,18,19,22]	B[23]	B[6,14,20]	LC	EN
Pterodroma arminjoniana	Herald petrel	B[8,14,22,23,25]	RE	-	VU	-
Pterodroma externa	Juan Fernandez petrel	-	-	RE	VU	EN
Pterodroma atrata	Henderson petrel	RE	-	-	EN	-
Puffinus bulleri	Buller's shearwater	-	-	RE	VU	
Puffinus nativitatis	Christmas Island shearwater	B[10,14,19,25]	B[14,15,18,23]	-	LC	-
Family Hidrobatidae						
Fregetta grallaria	White-bellied storm-petrel	-	-	B[6,14,20]	LC	EN
Nessofregetta fuliginosa	White-throated storm-petrel	-	B[15,18,23,25]	-	EN	-
Order Phaethontiformes						
Family Phaethontidae						
Phaethon aethereus	Red-billed tropicbird	-	B[18]	-	LC	-
Phaethon rubricauda	Red-tailed tropicbird	B[10,18,23,25]	B[14,15,18,23]	B[20]	LC	-
Phaethon lepturus	White-tailed tropicbird	B[22,25]	-	B[20]	LC	-
Order Suliformes						
Family Fregatidae						
Fregata minor	Great frigatebird	B[23]	B[14,15,18,23]	U	LC	-
Family Sulidae						
Sula nebouxii	Blue-footed booby	-	-	B[20]	LC	
Sula dactylatra	Masked booby	B[19,22,25]	B[14,15,18,23]	B[3,6,13,14,20]	LC	-
Sula sula	Red-footed booby	OC	U	-	LC	-
Sula leucogaster	Brown booby	U	-	-	LC	-
Order Charadriiformes						
Family Scolopacidae						
Numenius tahitiensis	Bristle-thighed curlew	OC	-	-	VU	-
Calidris alba	Sanderling	OC	-	-	LC	-
Calidris acuminata	Sharp-tailed sandpiper	U	-	-	LC	-
Heteroscelus incanus	Wandering tattler	OC	-	-	LC	-
Family Stercorariidae						
Stercorarius marccormickii	South polar skua	-	-	OC	LC	
Family Laridae						
Creagrus furcatus	Swallow-tailed gull	-	-	OC	LC	
Anous stolidus	Brown noddy	B[8,10,14,19]	B[14,15,18]	B[14,20]	LC	-
Anous minutus	Black noddy	-	U	-	LC	-
Procelsterna albivitta	Grey noddy	B[8,14]	B[19,22,23,25]	B[6,14,20]	LC	-
Gygis alba	Common white tern	B[7,12]	B[18]	-	LC	-
Onychoprion fuscatus	Sooty tern	B[8,9,10,14]	B[15,18,23]	B[3,6,14,20]	LC	-
Onychoprion lunatus	Grey-backed tern	U	U	-	LC	-

Sources: [1]Fuentes (1914); [2]Lonnberg (1921); [3]Murphy (1936); [4]Barros (1939) ; [5]Goodall *et al.* (1951); [6]Millie (1963); [7]Bahamonde (1966); [8]King (1967); [9]Johnson *et al.* (1970); [10]Millie & Johnson (1970); [11]Harrison (1971); [12]Devillers (1972); [13]Bahamonde (1974); [14]Schlatter (1987); [15]Harrison & Jehl (1988); [16]Vilina *et al.* (1992); [17]Rauch & Toro (1997); [18]Vilina & Gazitúa (1999); [19]Jaramillo *et al.* (2008); [20]Aguirre *et al.* (2009); [21]González-Acuña *et al.* (2010); [22]Marín & Cáceres (2010); [23]Lazo (2011); [24]Flores *et al.* (2013); [25]Flores *et al*. (2014).

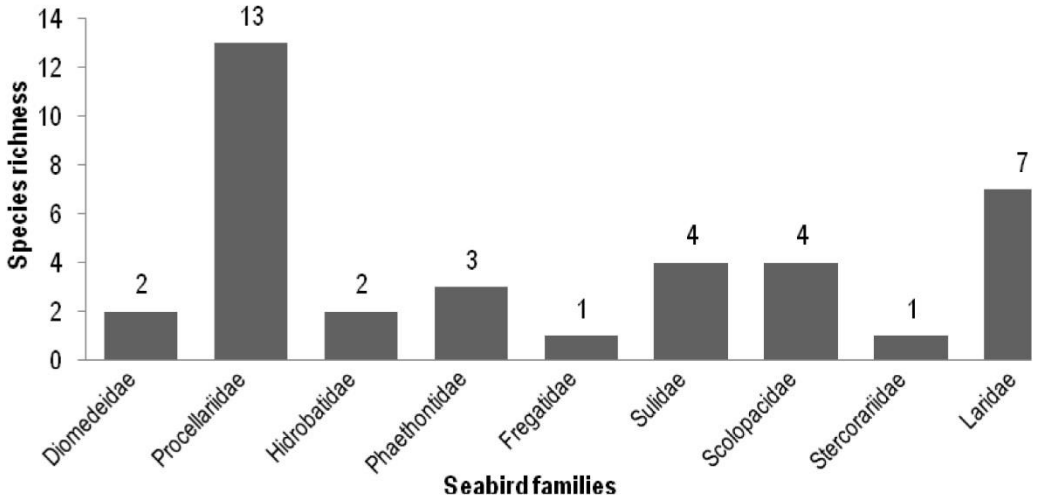

Figure 3. Seabird species richness by family recorded in the study area.

Table 2. Jaccard Similarity Coefficient (J) of breeding seabird species, on Easter Island, Salas y Gómez Island and Desventuradas Islands. In parenthesis the values reported by Schlatter (1987).

Island	Easter I.	Salas y Gómez I.	Desventuradas Is.
Easter Island	-	-	-
Salas y Gómez Island	0.64 (0.4)	-	-
Desventuradas Islands	0.47 (0.36)	0.4 (0.3)	-

Table 3. Number of seabird species reported by scientific papers and bibliographic reviews for Easter Island, Salas y Gómez Island and Desventuradas Islands.

Source/Island	Easter I.	Salas y Gómez I.	Desventuradas Is.
Millie (1963)	-	-	8
Schlatter (1987)	14	9	9
Vilina & Gazitúa (1999)	-	14	-
Aguirre *et al.* (2009)	-	-	19
Marin & Cáceres (2010)	19	-	-
This study	25	16	22

terms of understanding fundamental aspects of their biology and ecology. Most of the new records are opportunistic observations conducted during field trips but no systematic research has been conducted thus far. Thus it is understandable that Easter Island presents a higher number of new species recorded than the other islands, given that it is the only one inhabited by people and an increasing number of tourists are visiting the island for birwatching purposes (Jaramillo *et al.*, 2008). As a national park, trained personnel in charge of protecting wildlife provide regular observation effort for seabirds on their patrols.

Salas y Gómez Island is uninhabited, landing by sea is very difficult and the only regular visits to the island

Table 4. Sightings of new species for Chile and/or Easter Island and Salas y Gómez Island.

Scientific name	Authorship
Pterodroma atrata	Jaramillo *et al.* (2008)
Calidris acuminata	Jaramillo *et al.* (2008)
Pterodroma ultima	Marin & Cáceres (2010)
Sula sula	González-Acuña *et al.* (2010)
Calidris alba	Lazo (2010) *pers. comm.*
Heteroscelus incanus	Lazo (2012) *pers. comm.*
Sula leucogaster	Flores *et al.* (2013)
Calidris mauri	Bugueño (2013) *pers. comm.*

are conducted by the Chilean Navy for maintenance of marine signaling equipment using helicopters, finishing their tasks within h. This means access for both scientists and civilians is difficult. Given that the distance from Easter Island is *ca.* 400 km, there are no vessels based on Easter Island that can cover the distance round trip without refueling at sea. Further research is urgently needed on this island because since 2010, it corresponds to the largest marine park in Chile known as Motu Motiro Hiva (Ministerio de Economía D.S. N°235/2010).

Access to the Desventuradas Islands is completely restricted due to the presence of a Chilean navy base, so the approach to the islands and its adjacent waters has been prohibited since the early 1980's. An easing of restrictions in the early 2000's opportunistically allowed scientists to visit the islands to gather information, but no systematic research has been conducted since the 1960's (Millie, 1963; Bahamonde, 1966, 1974).

Although Easter Island provides optimal conditions for developing systematic studies on some particularly accessible seabird populations, these have not yet been undertaken, mainly because of the lack of funding agencies interested in funding mid to long term studies in this remote and costly location. This trend is starting to be reverted by joint efforts of public institutions, universities, NGOs and local islanders. Involving the Chilean Navy and other stakeholders in promoting studies in the relatively unperturbed marine park around Salas y Gómez Island, the most important and isolated breeding site for several oceanic seabirds in the central Pacific, and in the restricted Desventuradas Islands will allow to scientists to have a better view of population sizes and breeding ecology for these species. Subsequently, studies involving interactions with fisheries, effects of marine debris and impacts of introduced species, among other topics, are the next logical step to fill in these knowledge gaps.

In conclusion, although knowledge regarding seabirds inhabiting the Chilean oceanic islands remains scarce, important contributions have been made in recent years. It is imperative to generate joint efforts among institutions and funding to develop appropriate and efficient conservation strategies.

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