Staten Island, Tierra del Fuego: The Largest Breeding Ground for Southern Rockhopper Penguins?

ADRIÁN SCHIAVINI

Consejo Nacional de Investigaciones Científicas y Técnicas, Centro Austral de Investigaciones Científicas
CC 92, 9410 Ushuaia, Tierra del Fuego, Argentina
Internet: schiavini@arnet.com.ar

Abstract.—This paper provides new data on the location and size of Southern Rockhopper Penguin (*Eudyptes chrysocome chrysocome*) populations at Staten Island, Tierra del Fuego, Argentina, in view of population sizes previously reported for all the subspecies. Surveys were performed mainly during November-December 1998 and 1999. Mean nests were calculated in circular plots of 100 m^2. Nest density was then extrapolated to the area occupied by nests, estimated from aerial pictures and through ground controls. Nests are distributed mainly on areas of tussock grass (*Poa flabellata*). Most of the nests were located in tightly-knit subcolonies. Nest density (±SD) was estimated at 102.5 (±29.7) nests/100m^2. Two localities, Cabo San Juan and Bahía Franklin, together held 173,793 nests, 166,762 located in Bahía Franklin, extending over a radius of 3.2 km. Based on the reported population data for this subspecies, the global population for Southern Rockhopper Penguins is likely to be close to 636,000 pairs, with Staten Island holding 27.3% of the world population and Bahía Franklin alone holding 26.2% of the world population. The Southern Rockhopper Penguins of Staten Island were almost undisturbed and unknown during the 20th century. The population importance of Bahía Franklin for the species was not previously recognized, but it should now occupy a central place of concern for the conservation of this species. *Received 6 December 1999, accepted 26 January 2000.*

Key-words.—Southern Rockhopper Penguin, *Eudyptes chrysocome chrysocome*, Staten Island, Tierra del Fuego, population, Argentina.

Waterbirds 23(2): 286-291, 2000

There is international concern about substantial decreases in Southern Rockhopper Penguin (*Eudyptes chrysocome chrysocome*) populations at most of the subantarctic islands where they nest (Woehler and Croxall 1997). These decreases, as well as the potential competition with fisheries for food, have led to recommendations that this species be listed as *Vulnerable* by the International Union for the Conservation of Nature (Woehler and Croxall 1997; Ellis *et al.* 1998).

This paper provides new data on the location and size of Southern Rockhopper Penguin colonies at Staten Island. The relevance of the new data is examined in view of the population size and of the conservation status reported for this subspecies.

Staten Island (54°45' S, 64°20' W) is the most easterly island of the Tierra del Fuego archipelago, at the southernmost tip of South America. It covers an area of 63,000 ha and is located at the border of the continental shelf break. Previous reports of Southern Rockhopper Penguins nesting at Staten Island are scarce. Vairo (1997) quoted historic documents that suggest the presence of a colony at Bahía Franklin during the second half of the 1800s. Payró (1898) reported a colony at Cabo San Juan, specifying that the colony occupied "700 by 250 feet" of surface (*ca.* 19,000 m^2). This colony is also mentioned in the Pilot Book of the Argentine Hydrography Service (Servicio de Hidrografía Naval 1981). Murphy (1936) quoted De Agostini that rockhoppers nested at Isla Observatorio (known as Isla Año Nuevo by then) without any further details. Hartert and Venturi (1909) reported finding one egg at Isla Observatorio. More recently, Imshaug (1972) documented Rockhopper Penguins nesting in the southeastern corner of Bahía Franklin, and Chapman (1987) mentioned "several colonies" at Bahía Franklin. Chébez and Bertonatti (1994) reported their own sightings in waters around the island. Bingham (1998a) reported "10,000 nests" for Staten Island, based on a survey performed during the 1996/97 season, without further details.

METHODS

From previous reports, nesting has occurred at Cabo San Juan and Bahía Franklin during the 20th century. The exact locations of the two colonies was confirmed

by an aerial survey on 23 March 1994 (Schiavini *et al.* 1994) and by sailing vessel visits to Cabo San Juan (20 November 1995, see Parera *et al.* 1997) and to Bahía Franklin (2 March 1998, see Niekisch and Schiavini, 1998). No evidence of nesting by Rockhopper Penguins was found on 28-29 November 1995 at Isla Observatorio (see Parera *et al.* 1997).

The numbers of nesting pairs at Cabo San Juan and Bahía Franklin were estimated during the 1998-1999 and 1999-2000 breeding seasons. Due to the large extent of these colonies and difficult access, the abundance of nests was estimated through the assessment of nest density at Bahía Franklin and extrapolation to the minimum area occupied by nests at both Cabo San Juan and Bahía Franklin, as determined by aerial pictures. It was assumed that nest density was constant between colonies and even between sectors of the same colony.

The density of nests at Bahía Franklin was established at the start of hatching, between 25 and 27 November 1998 and between 26 and 30 November 1999, by counting the number of active nests in 33 circular plots of 100 m^2 located randomly in 14 subcolonies spread all over the colony (Table 1). A sub-colony was defined as a tightly knit group of nests whose limit is easily identifiable on the ground and from aerial pictures, by the differences in soil and vegetation modified by birds. The subcolonies surveyed extended over ⅔ of the total area of the colony at the northeast coast of Bahía Franklin, from Punta Grimoldi to the south of Punta Tibaldo (Fig. 1). For the estimation of nest numbers, data for both years were pooled.

The area of the colony was estimated from aerial pictures (35 mm slides, 200 ASA Sensia Fuji film) obtained with a high-wing twin engine Coast Guard CASA-212 flying at 1500 feet. Pictures were taken as perpendicularly to the ground as possible. On the pictures the locations where nesting occurred were identified only where there was clear and easily recognizable ornithogenic soil. The aerial slides were digitized at a resolution of 3000 dpi (600 dpi optical resolution enhanced by software extrapolation of a Hewlett Packard 6250C Scanner with slide adapter). The limits of the sub-colonies were marked and the number of pixels enclosed for each colony were counted. The error in area estimation was assessed by replicating five area measurements in five subcolonies of different size. Estimates of nest numbers are presented together with 95% confidence intervals, based on the CI of the mean density of nests.

RESULTS

Population Size

Nest density for both years differed markedly, as the 95% C.I. did not overlap (Table 1). The average nest density (± SD) at Bahía Franklin pooled for both years was estimated at 102.5 (±29.7) nests/100m^2 (CI 95%: 92.4-112.6 nests/100m^2).

The colony at Cabo San Juan comprised four large subcolonies located on a steep slope of about 100 m height with 7,031 nesting pairs (Table 2). The colony at Bahía Franklin was the largest on the island, comprised of a main colony and a minor colony (Table 2, Fig. 1). The main colony occupied the northeast coast of the bay, from Punta Tello and extended south of Punta Tibaldo, along 6.5 km of coastline. The secondary colony was located on two steep areas on slopes in excess of 30°, at Punta Ruíz and Punta Vilca, separated by 1.3 km from the former sector. The whole Bahía Franklin area held 166,762 nesting pairs in 102 subcolonies. The northeast coast of Bahía Franklin held 93% of the nests for the bay (154,391), while Punta Ruíz and Punta Vilca held 7% (12,372).

Table 1. Nest density estimated at the 1998 and 1999 seasons at Bahía Franklin.

1998			1999		
Subcolony identification	Nests/100m^2 (±SD)	Plots	Subcolony identification	Nests/100m^2 (±SD)	Plots
24v	132.0 ± 49.7	3	19	114.0 ± 2.8	2
17	136.0 ± 14.1	2	27	88.3 ± 19.7	3
28	140	1	30'	98.8 ± 5.5	4
27	152	1	32	85.5 ± 3.5	2
25	146	1	37	78.7 ± 17.6	3
26	136	1	34'	97.5 ± 19.1	2
			39 vii	74.5 ±34.6	2
			39 viii	71	2
			45'	89.8 ± 16.5	4
Mean	**138.0 ± 26.3**	**9**		**86.7 ± 16.6**	**24**
95% C.I.	**(120.8; 155.2)**			**(80.1; 93.3)**	

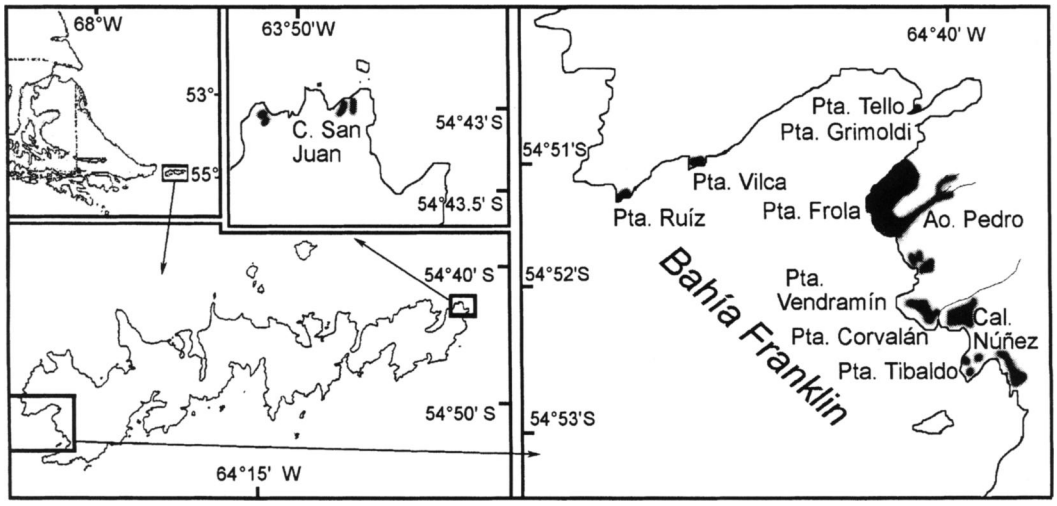

Figure 1. Diagram of the study area. Shaded areas indicate general location of Southern Rockhopper Penguin subcolonies.

Sources of Variation in these Data

1. Nest density was assessed in 33 circular plots in 15 subcolonies, and Staten Island had 106 subcolonies. Although nest density was estimated over a wide range of subcolony sizes, smaller subcolonies, and those on steep slopes, may have had lower densities.
2. Colony area assessment. The five replicates revealed an average coefficient of variation of 3.1%. The error in the digitizing of colony boundaries will remain the same no matter what scale is used, but density estimates will be more accurate for larger colonies (Woehler and Riddle 1998). Another underestimation comes from the per-

Table 2. Mean number of subcolonies and 95% Confidence Intervals for nest counts for Southern Rockhopper Penguins at Staten Island.

Locality	Subcolonies	Nests	CI 95%
Bahía Franklin	**99**	**166,762**	**150,350; 183,175**
Punta Tello	1	201[1]	
Punta Grimoldi to Punta Frola	28	50,638	45,649; 55,628
Arroyo Pedro (5, 2)	17	20,644	18,610; 22,679
Arroyo Pedro to Punta Vendramín (3, 3)	3	5,863	5,285; 6,440
Punta Vendramín to Punta Corvalán (1,0)	5	13,858	12,493; 15,224
Caleta Núñez (0, 8)	11	13,339	12,024; 14,653
Punta Tibaldo (0, 3)	6	19,863	17,906; 21,820
South of Punta Tibaldo (0, 8)	17	29,984	27,030; 32,939
Punta Ruiz	6	4,450	4,011; 4,888
Punta Vilca	8	7,922	7,141; 8,702
Cabo San Juan	**4**	**7,031**	**6,338; 7,724**
Total for Staten Island	**106**	**173,793**	**156,688; 190,899**

Locality names refer to Figure 1.

[1]Direct count.

Numbers between parentheses in locality names refer to the number of plots visited to assess nest density in the 1998 and 1999 surveys, respectively.

Arroyo Pedro was named by us as a tribute to Peter Prince.

spective of aerial pictures used to assess the area. Any deviation of the airplane from the vertical would have produced an underestimation of the area and also hidden some nests or birds behind others. Pictures of the subcolonies of Arroyo Pedro, Caleta Núñez and Punta Tibaldo were not vertical. For these subcolonies, the scale for both the closest and farthest subcolonies in the pictures was taken and adjusted for the change of scale in the other subcolonies in the same picture.

3. The degree of occupation of subcolonies. The actual occupation of the subcolonies delimited by the presence of ornithogenic soil was not evaluated. However, I assumed that this error was minimal, because during the survey of almost ¾ of the subcolonies at Bahía Franklin, nests occupied more than 90% of the ornithogenic soil in the subcolonies. Thus the same density rates were used for all the subcolonies.
4. Time during the breeding season. The surveys were performed around the first days of hatching, during both seasons (hatching observed beginning 27 November in 1998 and 26 November in 1999). This is another source of under-estimation, as some nests would have been abandoned before the survey.
5. Nesting outside subcolonies. Nests between Punta Grimoldi and Punta Frola were spread all over the tussock grass, out of the boundary of the subcolonies. Density of nests was not surveyed here because of the steep slopes and risk of disturbance. Thus, the real nest number for this sector (Table 2) must be underestimated. In the subcolonies from Arroyo Pedro to Punta Tibaldo, nesting was restricted to the subcolonies. In view of the large area between Punta Grimoldi and Punta Frola, nesting outside subcolonies should outweigh other sources of error.

DISCUSSION

Population Size

The Southern Rockhopper Penguin breeds on the coasts of southern South America and the Falkland (Malvinas) Islands, in approximately 52 locations. Staten Island and Isla Pingüino (47°45'S, 65°54'W; with 180 pairs, Frere *et al.* 1993), hold the only three known breeding localities for Argentinian Patagonia. The Falkland (Malvinas) Islands holds 297,000 pairs (Bingham 1998b) while southern Chile holds about 164,800 pairs (data recalculated from Schlatter 1984; Schlatter and Riveros 1997; Bingham 1998a; Venegas 1998). The results reported here show that the total population for the Southern Rockhopper Penguin is closer to 636,000 pairs, and that Staten Island holds 27.3% of the world population. Bahía Franklin holds 26.2% of the world population in a radius of just 3.2 km, representing one of the most important breeding locality for this subspecies throughout its range. Bingham (1998a) reported "10,000 nests" for all of Staten Island, but did not present the exact location of the colony or colonies, methods or dates of surveys, so that it is impossible to compare the present results with his.

The two colonies of Staten Island are separated by 58 km in a straight line. The next closest breeding grounds are as distant as 380 km (Beauchêne Island, 52°53'S 59°12'W) and 170 km (Terhalten Island 52°28'S 67°01'W, in Chilean waters).

Staten Island is located about 10 km from the continental shelf break, approximately 100 km from the Polar Frontal Zone, between the Subantarctic and Polar fronts. The oceanographic features related to the presence of the shelf break and the Subantarctic Front close to the island could help explain the distribution and abundance of rockhoppers on Staten Island. The shelf and break along the Patagonian coast are important for larval myctophids (Ciechomski and Sánchez, 1995), the most abundant small pelagic fish in the area. Also, the break holds frequent blooms of coccolithophorids (Brown and Podestá 1997), indicating the potential for

elevated primary production in this area. Similarly, the waters of the Polar Frontal Zone close to Macquarie Island (54°30'S 158°55'E) are important feeding grounds for Rockhopper Penguins (Hull 1999).

Population Trends

From the scarce historical information available it is impossible to assess population trends; however, it is clear that Cabo San Juan and Bahía Franklin have held breeding Rockhopper Penguins since at least the last part of the 19th century. The only historical record available derives from aerial pictures taken by the *Servicio de Hidrografía Naval* in March 1971. When comparing these pictures with the current aerial photographs, many of the conspicuous subcolonies present during the current survey are clearly present in 1971, as are the ones at Arroyo Pedro.

Although it is not possible to assess trends, there is evidence of complex dynamics of the colony, either from changes in density and/or from changes in the nesting area. The differences between the nest density for the 1998 and 1999 seasons could be related to the fact that the surveys were not made in the same subcolonies in both years. The first survey was done in what seems to be one of the oldest sectors of the colony, Arroyo Pedro and surroundings, with ornithogenic soil deeply eroded and subcolonies located in crater-like surfaces with lateral walls of peaty soil of 2 m depth. The 1999 survey was carried out largely on the southern part of the colony, where nests here are found in partly vegetated areas and the soil is not deeply eroded, suggesting a more recent colonization. Another evidence of colonization dynamics is the small subcolony at Punta Tello, holding 22 nests during the 1998 survey and 201 nests in 1999.

Changes in nesting area are also suggested by the presence of nesting and evidence of nesting that reflect all parts of the cycle of colonization and abandonment of nesting areas. Nesting can be found in places where the only remains of the original vegetation are dead tussock pedestals or erect stems of *Nothofagus betuloides* trees and of *Berberis ilicifolia* bushes. Also, nesting can be found in areas of partly vegetated tussock grass, like the area between Punta Grimoldi and Punta Frola and some subcolonies found along the rest of the colony. Finally, some subcolonies show clear evidence of recent colonization, such as nests among living Juncaceae and bushes of *Berberis* sp.

The evidence presented above does not seem to agree with the dramatic decrease reported for the colonies in the Falkland (Malvinas) Islands. Instead, the population at Staten Island appears stable or increasing, perhaps the result of a flux of birds from the Falklands (Malvinas) Islands.

Further research needs are to establish a monitoring scheme for population trends, past and future, and to understand the colony dynamics of nest distribution and or immigration from neighboring breeding grounds. Moreover, it is important to study the trophic ecology and the relationships of this species, one of the most abundant top predators of the Southwestern Atlantic Ocean, along with the oceanographic features of the area.

Acknowledgments

Funds and logistic support were provided by the National Scientific and Research Council of Argentina (CONICET), Total Austral S.A., the National Coast Guard, Wildlife Conservation Society, *Fundación Patagonia Natural*, National Geographic Society, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), *Subsecretaría de Recursos Naturales y Ambiente Humano de la Provincia de Tierra del Fuego* and the *Plan de Manejo Integrado de la Zona Costera Patagónica* (project GEF/PNUD). S. Gigli, L. Mack and C. Vairo helped with the field work. A special acknowledgment to the Argentine Navy for safe transportation to Staten Island under severe conditions. Eric Woehler and Andrea Raya Rey kindly reviewed earlier versions of the manuscript

References Cited

Bingham, M. 1998a. The penguins of South America and the Falkland Islands. Penguin Conservation 11: 8-15.

Bingham, M. 1998b. The distribution, abundance and population trends of gentoo, rockhopper and king penguins in the Falkland Islands. Oryx 32: 209-222.

Brown, C. W. and G. P. Podestá. 1997. Remote sensing of Coccolithophore blooms in the Western South Atlantic Ocean. Remote Sensing of the Environment 60: 83-91.

Chapman, A. 1987. La Isla de los Estados en la prehistoria: Primeros datos arqueológicos. Editorial Universitaria de Buenos Aires. Buenos Aires.

Chébez, J. C. and C. C. Bertonatti 1994. La avifauna de la Isla de los Estados, Islas de Año Nuevo y mar circundante (Tierra del Fuego, Argentina). Literature of Latina America, Buenos Aires.

De Agostini, A. M. 1956. Treinta años en Tierra del Fuego. Ediciones Peuser, Buenos Aires.

Ellis, S., J. P. Croxall and J. Cooper (Eds.). 1998. Penguin conservation assessment and management plan. IUCN/SSC Conservation Breeding Specialist Group: Apple Valley, MN.

Frere, E., M. Gandini, P. Gandini, T. Holik, V. Lichtschein and M. Oliva Day. 1993. Variación anual en el número de adultos reproductivos en una nueva colonia de Pingüino Penacho Amarillo *Eudyptes crestatus* (Spheniscidae) en Isla Pingüino (Santa Cruz, Argentina). Hornero 13: 293-294.

Hartert, E. and S. Venturi.1909. Notes sur les oiseaux de la République Argentine. Novitates Zoologicae 26: 159-271.

Hull, C. J. 1999. Comparison of the diets of breeding royal (*Eudyptes schlegeli*) and rockhopper (*Eudyptes chrysochome*) penguins on Macquarie Island over three years. Journal of Zoology 247: 507-529.

Imshaug, H. A. 1972. R/V *Hero* cruise 71-5 to Isla de los Estados. Antarctic Journal of United States 7: 42-44.

Murphy, R. C. 1936. Oceanic birds of South America. American Museum of Natural History, New York.

Niekisch, M. and A. C. M. Schiavini. 1998. Desarrollo y conservación de la Isla de los Estados (Tierra del Fuego, Argentina). Unpublished report, available at Subsecretaría de recursos Naturales de la Provincia de Tierra del Fuego, Ushuaia, Argentina.

Parera, A., A. Schiavini and E. Frere. 1997. Relevamiento ecológico de la Isla de los Estados. Observaciones sobre su estado de conservación y sugerencias de manejo. Boletín Técnico de la Fundación Vida Silvestre Argentina 38: 1-37.

Payró, R. J. 1898. La Australia Argentina. Excursión periodística a las costas patagónicas, Tierra del Fuego, e Isla de los Estados. Imprenta de "La Nación," Buenos Aires.

Sánchez, R. P. and J. D. de Ciechomski. 1995. Spawning and nursery grounds of pelagic fish species in the sea-shelf off Argentina and adjacent areas. Scientia Marina 59: 455-478.

Schiavini, A. C. M., M. E. Lizurume, E. Frere, M. Bertelotti, N. García and A. Chizzini. 1994. Relevamiento aéreo otoñal de la fauna superior costera de Tierra del Fuego. Unpublished report available at Fundación Patagonia Natural, Marcos Zar 760, Puerto Madryn, Argentina.

Schiavini, A. C. M., E. Frere, P. Yorio and A. Parera. 1999. Las aves marinas de la Isla de los Estados, Tierra del Fuego, Argentina: revisión histórica, estado poblacional y problemas de conservación. Anales del Instituto de la Patagonia, Serie Ciencias Naturales (Chile) 27: 25-40.

Schlatter, R. P. and G. G. Riveros. 1987. Historia Natural del Archipiélago Diego Ramírez, Chile. Serie Científica del Instituto Antártico Chileno 47: 87-112.

Schlatter, R. P. 1984. The status and conservation of seabirds in Chile. Pages 261-269 *in* Status and Conservation of the World's Seabirds (J. P. Croxall, P. G. H. Evans and R. W. Schreiber, Eds.). Technical Publication No. 2, International Council for Bird Preservation, Cambridge.

Servicio de Hidrografía Naval 1981. Derrotero Argentino, Parte III. Archipiélago Fueguino e Islas Malvinas. Armada Argentina, Servicio de Hidrografía Naval, Buenos Aires.

Strange, I. J. 1982. Breeding ecology of the rockhopper penguin (*Eudyptes crestatus*) in the Falkland Islands. Le Gerfaut 72: 137-188.

Vairo, C. P. 1997. La Isla de los Estados y el Faro del Fin del Mundo. Zaguier y Urruty Publicaciones. Ushuaia, Argentina.

Venegas, C. 1998. Pingüinos crestados (*Eudyptes chrysochome* Forster 1781, *E. chrysolophus* Brandt 1837) y de Magallanes (*Spheniscus magellanicus* Forster 1781) en Isla Noir, Chile. Anales del Instituto Patagonia, Serie Ciencias Naturales (Punta Arenas) 26: 59-67.

Woehler, E. J. and J. P. Croxall. 1997. The status and trends of Antarctic and Subantarctic seabirds. Marine Ornithology 25: 43-66.

Woehler, E. J. and M. J. Riddle. 1998. Spatial relationships of Adélie penguin colonies: implications for assessing population changes from remote imagery. Antarctic Science 10: 449-454.