Bird Conservation International (1998) 8:223–235.

The taxonomic and conservation status of the Spectacled Petrel *Procellaria conspicillata*

PETER G. RYAN

Summary

The Spectacled Petrel *Procellaria [aequinoctialis] conspicillata* only breeds at Inaccessible Island, central South Atlantic Ocean. During the early 1980s the population was estimated to be at most 1,000 pairs, but hundreds of Spectacled Petrels have been killed annually in longline fisheries off the east coast of South America since at least 1987. Although the population is characterized by a unique plumage trait, it is still regarded as a subspecies of the White-chinned Petrel *P. aequinoctialis*. Analysis of calls and playback experiments show that the Spectacled Petrel is vocally distinct from White-chinned Petrels and should be regarded as a valid biological species. It is also slightly smaller and breeds earlier than the White-chinned Petrel. Given its small population size and known mortality on longlines, the Spectacled Petrel is Endangered in terms of IUCN criteria C1 and C2b. Longline fisheries operating off South America should institute measures to reduce seabird by-catch. A survey of the breeding population at Inaccessible Island is required to assess the rate at which the population is decreasing.

Introduction

There is increasing concern about the accidental killing of seabirds in longline fisheries (e.g. Brothers 1991, Alexander *et al.* 1997). Most of the birds killed on longlines are albatrosses and petrels; long-lived species with low rates of reproduction which cannot withstand even small increases in mortality (e.g. Croxall *et al.* 1990). The Spectacled Petrel *Procellaria [aequinoctialis] conspicillata* is one such species. Recent observations suggest that hundreds of Spectacled Petrels are killed annually by longline vessels operating off southern Brazil (Vaske 1991, Neves and Olmos 1997), where it is the most abundant seabird attending longline vessels during the austral summer (Olmos 1997). These observations have not attracted the attention they deserve from conservation bodies, however, because the Spectacled Petrel typically is regarded as a subspecies of the more widespread White-chinned Petrel *P. aequinoctialis* (e.g. Marchant and Higgins 1990). The status of the taxon is confused, with some authorities recognizing it as a possible species (e.g. Bourne and Casement 1993) and others not even affording it subspecies status (e.g. Sibley and Monroe 1990). In this paper I review the taxonomic status of the Spectacled Petrel, and show that it warrants recognizing as a valid species. Given this conclusion, I assess the conservation status of the species.

Range and status of Spectacled Petrel

The Spectacled Petrel was described by Gould in 1844. There is considerable confusion regarding the range of the taxon during the nineteenth century, when it may have occurred throughout the Indian Ocean and possibly bred at Amsterdam Island (Southern 1951). The recent finding of bones of *Procellaria* petrels at Amsterdam Island provide additional support for this hypothesis (Bourne and David 1995). At least during the twentieth century, however, Spectacled Petrels have been restricted to the South Atlantic Ocean from 25° to 40°S (Enticott and O'Connell 1985, Olmos 1997). One sight record from the whaling station at Durban in the 1970s is the only recent record from the Indian Ocean (J. C. Sinclair, pers. comm.).

Currently, Spectacled Petrels only breed on the plateau of Inaccessible Island (37° 15'S, 12°50'W), in the Tristan da Cunha group, central South Atlantic Ocean. This is almost 10° farther north than any breeding site of the White-chinned Petrel. Inaccessible Island has seldom been visited by biologists and, of those who have landed, most have remained at the coast (Fraser *et al.* 1988, Ryan *et al.* 1994). The island derived its name for the sheer cliffs that encircle the island, and the breeding site of Spectacled Petrel was first found only in the 1920s (Rowan *et al.* 1951, Hagen 1952).

Breeding is confined to stream banks and boggy areas on the high western plateau of Inaccessible Island. The only published observations of the bird at its breeding grounds are those made by the Norwegian Scientific Expedition in 1937–1938 (Hagen 1952), by Rowan *et al.* (1951) in 1949–1950, and by the Denstone Expedition in 1982–1983 and the Percy FitzPatrick Institute in 1987 (Fraser *et al.* 1988). The only reliable estimate of population size was made in 1982–1983, when it was estimated that some 1,000 pairs breed on the island (Fraser *et al.* 1988).

Methods

I visited Inaccessible Island during October–November 1988, and again from October 1989 to March 1990. Twenty Spectacled Petrels were captured between 14 and 29 October 1988 to obtain mensural data. Most birds were removed from breeding burrows, but some were captured outside burrows when landing or displaying during the late afternoon. Birds were sexed where possible by cloacal inspection; birds incubating eggs and lacking an enlarged cloaca were presumed to be males. Wing length, tarsus, culmen and three measures of bill depth were measured following protocols in Marchant and Higgins (1990) and Ryan (in press). Mass was measured to the nearest 5 g using a Pesola spring balance. Eggs were measured (maximum length and width, to the nearest tenth of a millimetre with Vernier callipers) and weighed (to the nearest gram). All measurements were made by the author.

During October 1989 birds occupying burrows were recorded using a Tect directional microphone (model UEM-83) and a Sony TCM-17 recorder. Several spontaneously calling Spectacled Petrels were recorded for playback experiments. Twenty naive birds were then played recordings of four nominate White-chinned Petrels selected at random from a series of 20 calls recorded on 26 Nov-

ember 1983 at Marion Island by Mike de L. Brooke (see Brooke 1986). This was followed by playback of Spectacled Petrel calls. The order of playback was predetermined to maximize the possible response to White-chinned Petrel calls (i.e. avoiding reduced response to later playbacks), and to prevent response to Spectacled Petrel calls carrying over into White-chinned Petrel playback trials.

Playback experiments were conducted in "Ringeye Valley" above Blenden Hall, whereas playback recordings were made more than 1 km away at Dick's Bog, limiting the likelihood of test subjects recognizing specific individuals used for playback. The duration of vocal responses to each playback call was noted, and a representative sample of the response was recorded. No attempt was made to determine the sex of the birds tested. Brooke (1986) failed to detect consistent differences in calls between the sexes of White-chinned Petrels, and when two birds responded from the same burrow (n=3), I could detect no difference between the birds any greater than the variation between random individuals (but see Warham 1996).

Two types of calls were distinguished (see Warham 1988, 1996): Rattles (or Clacks) are short (generally 70–200 ms) calls and are occasionally interspersed with longer, drawn out Groans (or Squeaks). In order to quantify differences in the frequency and rate of calling, representative samples of calls were analysed using Canary (Charif *et al.* 1995) on an Apple Power PC, and sonograms prepared using MacRecorder (Farallon Computing, 1990). Modal and mean peak energy frequencies (kHz) of Rattle and Groan calls were calculated from narrow-window spectrograms of the calls. Note durations were averaged from 10 randomly selected Rattle calls, and from as many Groans as were uttered during the recording (to a maximum of n=10). Call rate (number per second) was estimated for Rattle calls as the average rate of 10 randomly selected calls (=inverse of call length plus interval to next call).

Results

Plumage and morphometrics

All of the hundreds of *Procellaria* petrels observed at Inaccessible Island during 1988–1990 had a characteristic white spectacle mark on the head. The extent of these marks varied considerably between individuals (cf. Rowan *et al.* 1951, Hagen 1952), but always took the same form. It is quite distinct from the white chin feathering, and its extent does not appear to be closely correlated with the size of the chin patch. The spectacle is found in both sexes and at all ages, including downy chicks (pers. obs.) and fledglings (see photograph in Hagen 1952). Tristan islanders recognize the bird, which they term "Ringeye", as distinct from the White-chinned Petrel or "Shoemaker".

Only 9 of the 20 Spectacled Petrels caught could be sexed, but the sex ratio was close to parity (four females, five males). Although there was considerable overlap, Spectacled Petrels averaged smaller than a sample of nominate White-chinned Petrels from the Prince Edward Islands (Table 1). Spectacled Petrels were significantly smaller in terms of mass, wing length, culmen, and bill depth at the base and the nail (Table 1). Spectacled Petrels also weighed less than

Table 1. Comparative measurements of Spectacled Petrels (n=20) breeding at Inaccessible Island and White-chinned Petrels killed by longline vessels around the Prince Edward Islands during 1996–1997 (n=72, with equal ratio of males to females) (from Ryan in press).

Species	Spectacled Petrel			White-chinned Petrel			Significance (t-test)
	Mean	SD	Range	Mean	SD	Range	
Wing (mm)	381.7	7.6	369–397	388.2	8.3	370–418	P<0.005
Tarsus (mm)	67.5	1.7	65.0–72.0	66.9	1.9	62.0–71.0	NS
Culmen (mm)	50.55	1.88	47.6–54.4	52.87	2.27	46.6–58.2	P<0.001
Bill depth at base (mm)	21.14	1.07	19.1–23.2	21.78	1.02	19.9–24.0	P<0.02
Bill minimum depth (mm)	15.27	0.84	13.9–16.8	15.61	0.91	13.6–17.4	NS
Bill depth at nail (mm)	17.76	0.85	16.0–19.1	18.38	0.91	16.1–20.2	P<0.01
Mass (g)[a]	1191.1	75.9	1010–1315	1277.8	134.6	980–1600	P<0.01

[a] Data for White-chinned Petrels from Berruti *et al.* (1995) for Marion Island, n=337.

White-chinned Petrels breeding at South Georgia (1335±119 g, n=52, P<0.001; data from Hall 1987), but were not significantly different from a small sample of birds breeding at islands south of New Zealand (1178±181 g, n=11, NS; data from Marchant and Higgins 1990). However, within the sample of New Zealand birds, the average mass of incubating birds (1278 g, n=5) was closer to that of nominate birds than Spectacled Petrels weighed at the onset of incubation (1191 g, Table 1), when mass is greatest (cf. Hall 1987).

No eggs were found in five burrows checked on 16 October, but three of six burrows had eggs on 24 October, and one of four burrows on 29 October. The four eggs averaged 81.1±1.96 × 54.6±1.2 mm (range 79.3–83.9 × 53.0–55.6) mm, and weighed 129.8±5.7 g (range 122–135 g). This is not significantly different from eggs of White-chinned Petrels from South Georgia (Hall 1987), Marion Island (Marchant and Higgins 1990, Berruti *et al.* 1995) or the Crozet Islands (Jouventin *et al.* 1985).

Vocalizations

Spectacled Petrel calls have a significantly deeper pitch than those of White-chinned Petrels (Table 2), a difference which is clearly discernible to the human ear. Modal energy of both Rattle and Groan calls of Spectacled Petrels tends to be <1 kHz, whereas that of White-chinned Petrels typically is >1 kHz (Figures 1–4). There is very little overlap between the two taxa based on a bi-plot of Rattle frequency versus call rate (Figure 5). Within Spectacled Petrel, there is a tendency for the mean frequency of Rattle calls to increase as call rate increases (r_{18}=0.644, P<0.01), which was not evident among White-chinned Petrels (r_{18}=0.114, NS; Figure 3). This trend occurs within individual call sequences (Figure 1). However, the lower mean and modal frequency of Spectacled Petrels relative to White-chinned Petrels is not a consequence of slower call rates, because Rattle call rates of Spectacled Petrels averaged significantly greater (Table 2).

There are also qualitative differences between the calls of the two species. Rattle call notes of Spectacled Petrels invariably have two elements (Figure 1), whereas this is unusual in White-chinned Petrels (Figure 2, but see Brooke 1986,

Table 2. Call characteristics of Spectacled Petrels at Inaccessible Island (n=20) and White-chinned Petrels at Marion Island (n=20). See text for description of call types

Species	Spectacled Petrel			White-chinned Petrel			Significance (t-test)
	Mean	SD	Range	Mean	SD	Range	
Rattles (n=20,20)							
Mean frequency (Hz)	1.28	0.32	0.45–1.92	2.20	0.53	0.8–3.3	$P<0.001$
Modal frequency (Hz)	0.84	0.79	0.2–2.6	1.87	0.98	0.3–4.4	$P<0.001$
Call note duration (ms)	111.2	29.4	70–181	145.5	37.3	74–230	$P<0.05$
Call rate (number.s^{-1})	5.86	1.89	2.4–8.8	4.37	1.17	2.1–7.6	$P<0.01$
Groans (n=20, 14)							
Mean frequency (Hz)	1.09	0.54	0.3–2.1	1.76	0.48	0.87	$P<0.001$
Modal frequency (Hz)	0.39	0.10	0.2–0.6	1.28	0.44	0.3–1.8	$P<0.001$
Call note duration (ms)	1099.4	219.3	701–1601	845.0	289.9	370–1314	$P<0.01$

Warham 1988, 1996). Spectacled Petrels also exhibit a greater variety of Groan structures, including Groans with complex harmonic structures (Figure 3A) which are more similar to calls of other species of *Procellaria* than the White-chinned Petrel (Warham 1988, 1996). Individual birds gave all three types of groans (Figure 3). Spectacled Petrels utter Groans significantly more frequently (5.7%, n=3,291 calls) than do White-chinned Petrels (2.1%, n=2,422 calls, χ^2=41.92, $P<0.001$). The differences between the two species are not due to different contextual situations; both species were responding to playback of conspecific song during the egg-laying or incubation period.

There was a highly significant difference in response to playback of Spectacled Petrel and White-chinned Petrel calls (χ^2=11.13, $P<0.001$). All birds tested responded immediately to playback of Spectacled Petrel calls, typically calling for at least 30 seconds, and often continuing to call for several minutes. Despite each bird being played four White-chinned Petrel calls, only three individuals responded, and in each case they responded to only one call. Two birds responded only briefly (<5 seconds). The third bird called for more than 30 seconds in response to the first of four White-chinned Petrel calls, but ignored the following three White-chinned Petrel playbacks, before calling strongly in response to Spectacled Petrel playback. Given that birds frequently started calling in response to the approach of an observer (cf. Warham 1996), it is possible that this last bird was responding to a general disturbance rather than the specific nature of the call.

Discussion

Taxonomic status

Both Rowan *et al.* (1951) and Hagen (1952) comment on the consistent nature of the white spectacle mark on all White-chinned Petrels at Inaccessible Island. Fraser claimed to see two White-chinned Petrels flying over Inaccessible Island in 1982–1983 that lacked the white spectacle (Fraser *et al.* 1988), but they may have been individuals with very reduced spectacles. The extent of the spectacle

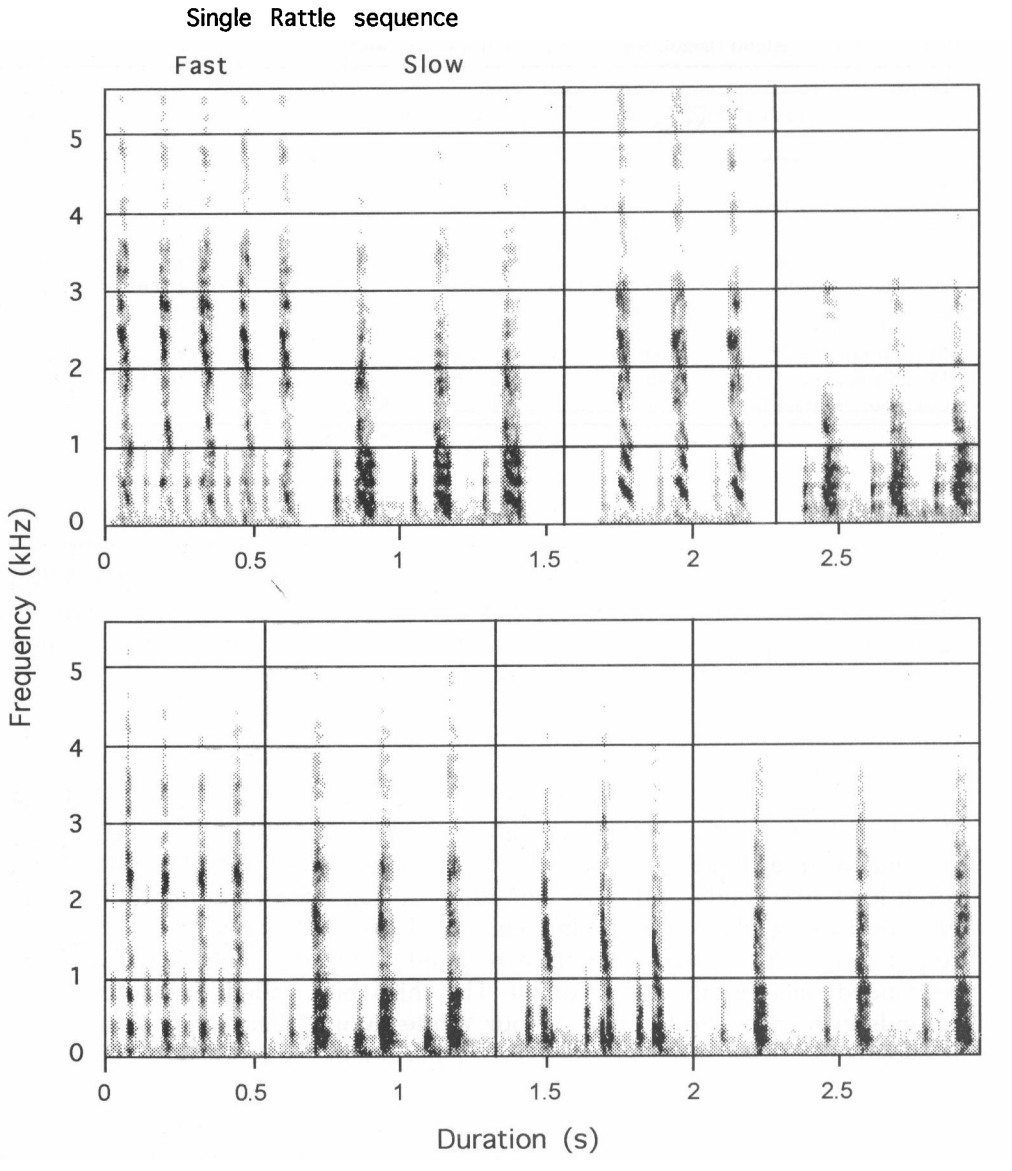

Figure 1. Sonograms of a range of Spectacled Petrel Rattle calls. Typically three calls from each sequence are shown. Vertical lines separate calls from different birds. The first call samples either extreme of a single call sequence, showing the decrease in frequency as call rate slows.

varies between birds, in a manner similar to the inter-individual variation in the extent of the white chin patch in nominate White-chinned Petrels. At a distance, flying birds with reduced spectacles could be mistaken for nominate White-chinned Petrels. Given that a spectacle appears to be an invariable character of the Inaccessible Island population, *conspicillata* warrants recognition as a distinct phylogenetic species (cf. McKitrick and Zink 1988).

https://doi.org/10.1017/S0959270900001891 Published online by Cambridge University Press

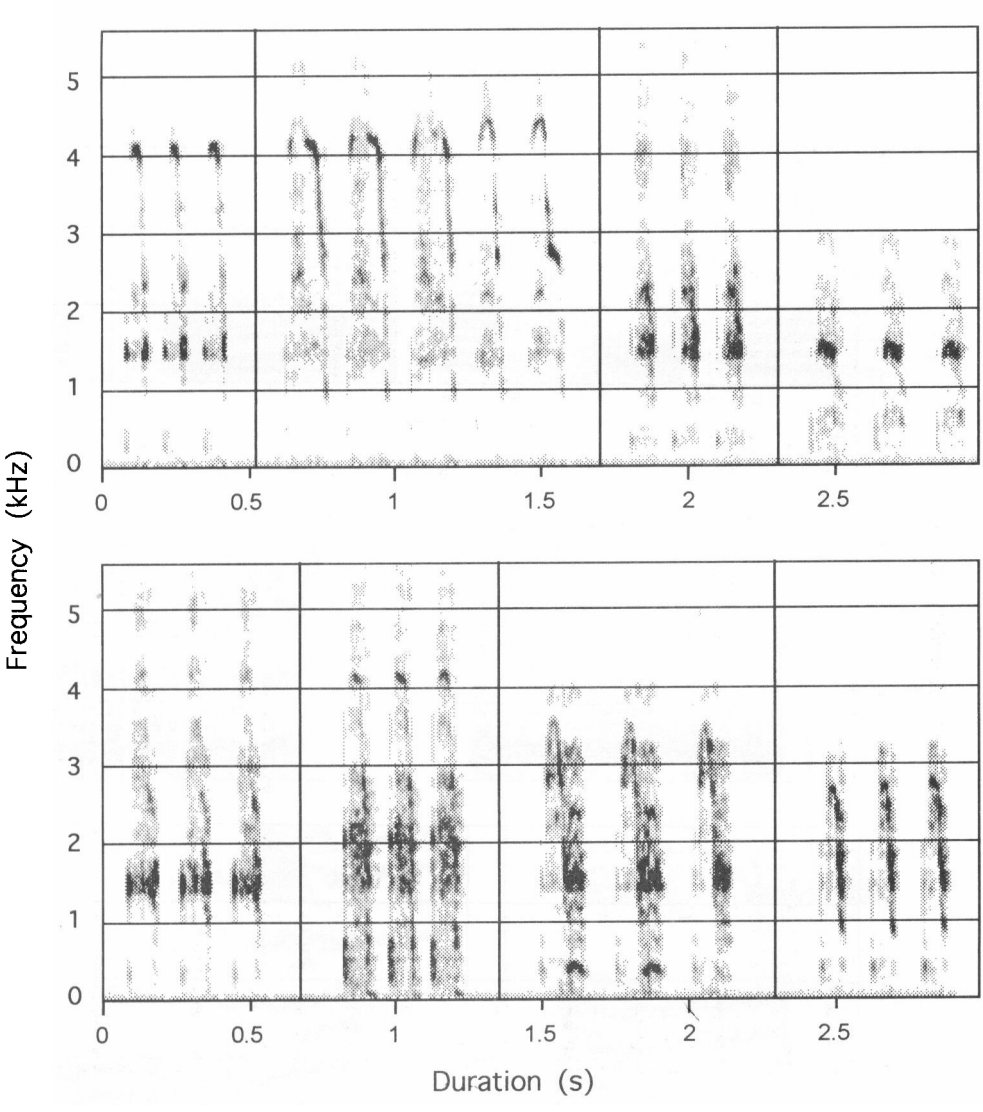

Figure 2. Sonograms of White-chinned Petrel Rattle calls, showing the higher pitch relative to Spectacled Petrels. Three calls from each sequence are shown, except for one sequence of five notes where there was a change in call structure. Vertical lines separate calls from different birds.

Rowan *et al.* (1951) suggested that Spectacled Petrels had shorter wings and perhaps tails than nominate White-chinned Petrels. However, comparing measurements made by different observers is fraught with difficulty because of inter-individual differences in measuring technique. This source of error was eliminated in this study, where all measures were made by the same observer. Spectacled Petrels are slightly smaller on average than nominate birds (at least those breeding at islands in the Atlantic and Indian Ocean sectors of the Southern Ocean). The smaller size of Spectacled Petrel was detected despite the samples

https://doi.org/10.1017/S0959270900001891 Published online by Cambridge University Press

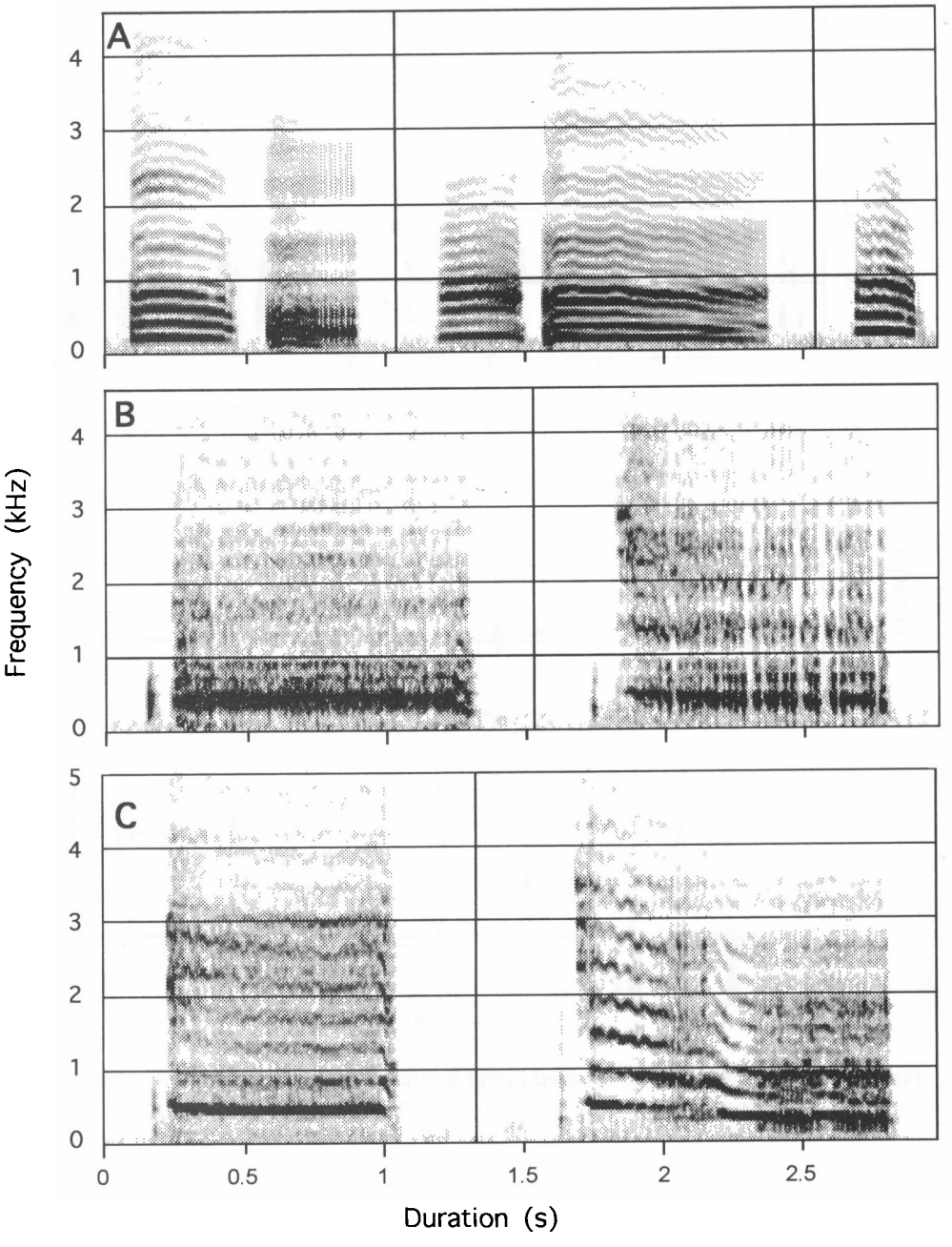

Figure 3. Sonograms of typical Spectacled Petrel Groan calls, showing the three rather distinct types of Groans: melodious Groans with complex harmonic structures (A), guttural Groans, often with a complex temporal structure (B), and harsh Squeals (C). Vertical lines separate calls from different birds.

https://doi.org/10.1017/S0959270900001891 Published online by Cambridge University Press

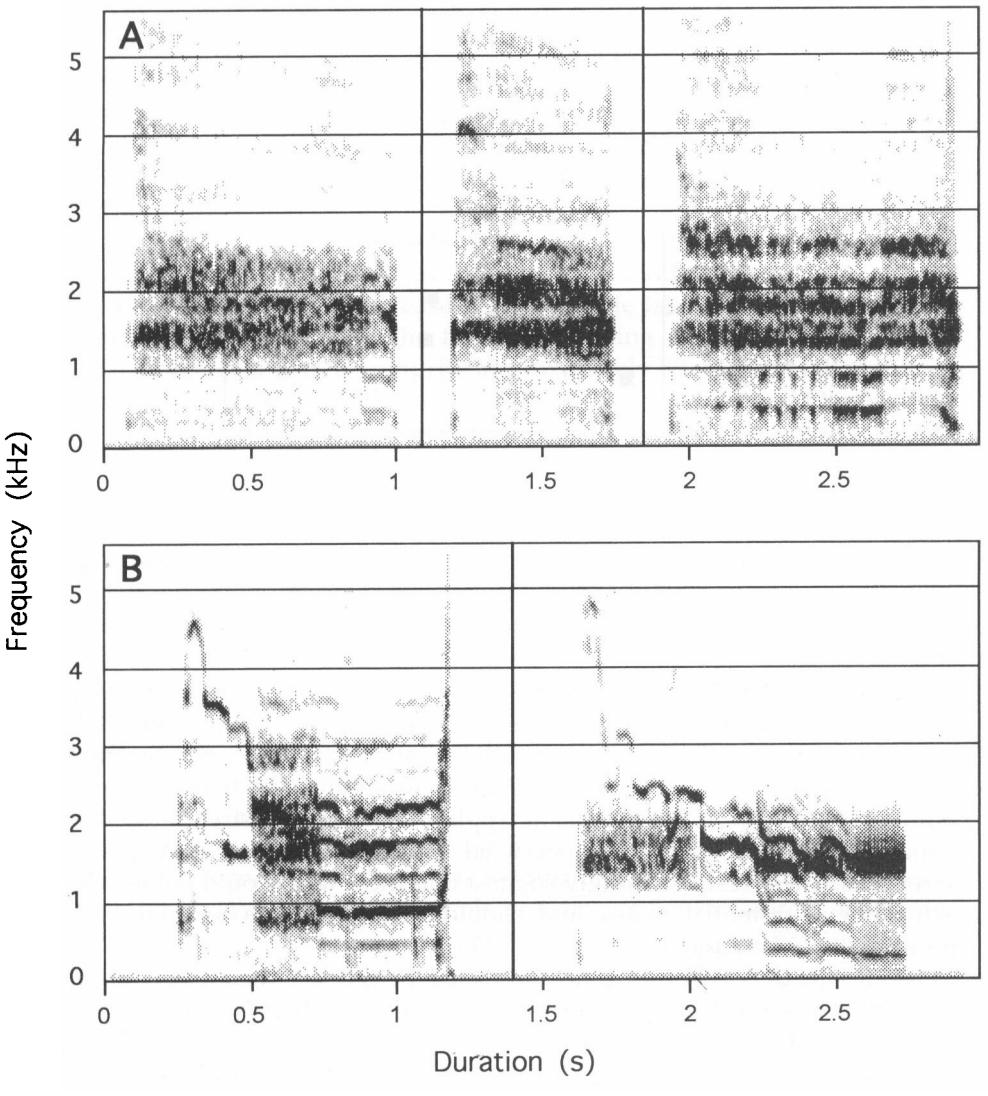

Figure 4. Sonograms of typical White-chinned Petrel Groan calls, showing the higher modal pitch of guttural Groans (A) and Squeals (B) relative to Spectacled Petrels. Vertical lines separate calls from different birds.

containing both males and females. White-chinned Petrels are sexually dimorphic, with males averaging 1–9% larger than females (Hall 1987, Berruti *et al.* 1995, Ryan in press).

However, the most compelling evidence that Spectacled Petrels should be regarded as a distinct species comes from the marked difference in vocalizations compared with White-chinned Petrels and other *Procellaria* petrels (cf. Warham 1988, 1996). Although the calls of Spectacled Petrels are similar in overall structure to those of White-chinned Petrels (Brooke 1986, Warham 1988, Warham 1996), they are markedly lower-pitched, and utter Groans more frequently. Also,

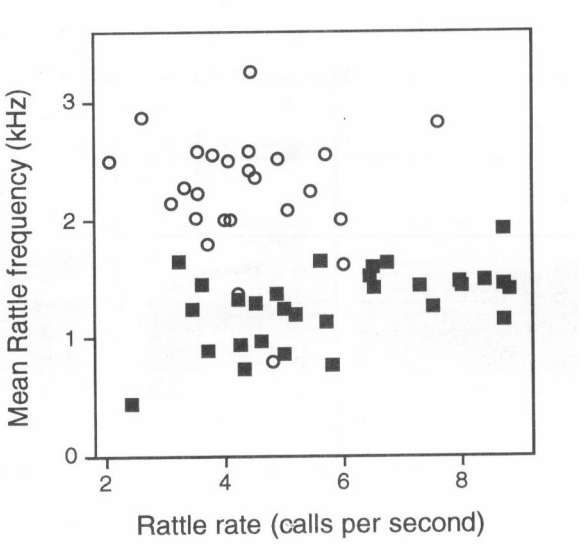

Figure 5. Bi-plot of mean call frequency (kHz) as a function of call rate among 20 Spectacled (filled squares) and White-chinned Petrels (open circles).

the Groans with multiple clear harmonic bands (Figure 3) are more similar to calls of other members of the genus than they are to White-chinned Petrels (Warham 1988, 1996). Warham (1996) uses vocal differences to support the recognition of Westland Black Petrel *P. westlandica* as specifically distinct from White-chinned Petrel. The same argument applies here, and is strengthened by the virtual absence of response by Spectacled Petrels to playback of White-chinned Petrel calls. These results strongly suggest that these taxa would fail to recognize each other as potential mates, and should be regarded as separate biological species (*sensu* Mayr 1963).

Tristan islanders reported that Spectacled Petrels lay their eggs "around 20 October" (Hagen 1952, P. 87). This agrees with my observations of fresh eggs from 24 October. White-chinned Petrels lay from early November to mid-December (Marchant and Higgins 1990), with the earliest recorded egg on 30 October (Berruti *et al.* 1995). Presumably this difference reflects the more southerly distribution of White-chinned Petrels, which breed between 900 and 2,000 km farther south than Spectacled Petrels. The slightly earlier breeding of Spectacled Petrels provides additional support for their specific status (cf. the giant petrels *Macronectes*, Marchant and Higgins 1990).

Conservation status

There is circumstantial evidence that the population of Spectacled Petrels at Inaccessible Island has increased during this century. Tristan islanders reported that "this petrel was discovered breeding [at Inaccessible Island] in about 1930, and [they] did not think it had bred there before" (Hagen 1952, p. 86), and Hagen reports finding only six nests in 1938, despite being at the island during the breeding season (February–March). In 1950 the population was "at least 100

https://doi.org/10.1017/S0959270900001891 Published online by Cambridge University Press

pairs, probably considerably more'' (Rowan *et al.* 1951, p. 170), and by 1982–1983 the population was estimated to be *c.* 1,000 pairs, based on a careful survey of approximately half of the suitable breeding habitat (Fraser *et al.* 1988). It is uncertain whether this apparent increase is real, or merely reflects greater coverage of the island by later visitors. It is possible that the population was reduced during the nineteenth century as a result of predation by feral pigs, which are reported to have consumed significant numbers of other seabirds (Fraser *et al.* 1988). Pigs may have caused the apparent extirpation of *Procellaria* petrels (possibly *P. conspicillata*) from Amsterdam Island (Bourne and David 1995).

Irrespective of the possible increase at Inaccessible Island earlier this century, there is reason for concern for the future well-being of the Spectacled Petrel population. Spectacled Petrels comprise approximately 8% of birds killed in mid-water longline fisheries off southern Brazil (Vaske 1991, Neves and Olmos 1997). They also are killed on demersal longlines, where they comprise some 2% of the seabirds killed (Neves and Olmos 1997). Based on catch rates reported by Vaske (1991), this extrapolates to more than 200 Spectacled Petrels being killed annually during the late 1980s and early 1990s. The mortality rate has decreased during the 1990s (Neves and Olmos 1997), but these are minimum estimates of Spectacled Petrel mortality in longline fisheries. Nothing is known about seabird by-catch by other nations fishing off Brazil (Neves and Olmos 1997), and Spectacled Petrels also may be killed by longline fisheries off Uruguay (Barea *et al.* 1994), southern Africa (Barnes *et al.* 1997) or by the large tuna fishery operating throughout the South Atlantic (Ryan and Boix-Hinzen in press).

A repeat survey of the breeding population at Inaccessible Island is required to assess the impact of longline fishing mortality on the breeding population. Nothing is known about the age structure of birds killed off South America. Olmos (1997) speculates that the birds off Brazil in the austral summer are non-breeders, but it is conceivable that birds feeding chicks could commute to South America to forage. White-chinned Petrels breeding at South Georgia are known to visit shelf waters off Argentina (data from birds equipped with satellite trackers, P. A. Prince, British Antarctic Survey, pers. comm.).

The estimate of 1,000 breeding pairs in 1982–1983 probably is inflated, because any burrow showing recent activity was assumed to be occupied (Fraser *et al.* 1988), and thus include prospecting and other non-breeding birds (cf. Rowan *et al.* 1951). Given a population of fewer than 2,000 mature individuals and mortality in longline fisheries which approached 10% of the population in at least some years, the Spectacled Petrel qualifies as Endangered in terms of IUCN criteria C1 and C2b (Collar *et al.* 1994). The measures required to reduce the by-catch of *Procellaria* and other seabirds in longline fisheries are known (e.g. Alexander *et al.* 1997, Barnes *et al.* 1997). The future well-being of the Spectacled Petrel is dependent on these measures being implemented by fisheries off the east coast of South America and throughout the South Atlantic Ocean.

Acknowledgements

I am grateful to my colleagues in the field, especially Coleen Moloney and Barry Watkins. Mike Brooke graciously sent me copies of his recordings of White-chinned Petrels from Marion Island. Logistical support was received from the South African Department of

Environment Affairs and Tourism, through the South African National Antarctic Programme. Permission to conduct research at Inaccessible Island was granted by the Administrator and Island Council of Tristan da Cunha.

References

Alexander, K., Robertson, G. and Gales, R. (1997) *The incidental mortality of albatrosses in longline fisheries*. Tasmania: Australian Antarctic Division.

Barea, L., Loinaz, I., Marin, Y., Rios, C., Saralegui, A., Stagi, A., Vaz-Ferreira, R. and Wilson, N. (1994) Mortality of albatrosses and other seabirds produced by tuna longline fisheries in Uruguay. CCAMLR WG-IMALF-94/17.

Barnes, K. N., Ryan, P.G. and Boix-Hinzen, C. (1997) The impact of the hake *Merluccius* spp. longline fishery off South Africa on procellariiform seabirds. *Biol. Conserv.* 82: 227–234.

Berruti, A., Cooper, J. and Newton, I. P. (1995) Morphometrics and breeding biology of the White-chinned Petrel *Procellaria aequinoctialis* at sub-Antarctic Marion Island. *Ostrich* 66: 74–80.

Bourne, W. R. P. and Casement, M. B. (1993) RNBWS checklist of seabirds. *Sea Swallow* 42: 16–27.

Bourne, W. R. P. and David, A. C. F. (1995) The early history and ornithology of St Paul and Amsterdam Islands, southern Indian Ocean. *Gerfaut* 85: 19–36.

Brooke, M. de L. (1986) The vocal systems of two nocturnal burrowing petrels, the White-chinned *Procellaria aequinoctialis* and the Grey *P. cinerea*. *Ibis* 128: 502–512.

Brothers, N. (1991) Albatross mortality and associated bait loss in the Japanese longline fishery in the Southern Ocean. *Biol. Conserv.* 55: 255–268.

Charif, R. A., Mitchell, S. and Clark, C. W. (1995) *Canary 1.2 user's manual*. Ithaca, New York: Cornell Laboratory of Ornithology.

Collar, N. J., Crosby, M. J. and Stattersfield, A. J. (1994) *Birds to watch 2: the world list of threatened birds*. Cambridge, U.K.: BirdLife International (BirdLife Conserv. Series 4).

Croxall, J. P., Rothery, P., Pickering, S. P. C. and Prince, P. A. (1990) Reproductive performance, recruitment and survival of Wandering Albatrosses *Diomedea exulans* at Bird Island, South Georgia. *J. Anim. Ecol.* 59: 775–796.

Enticott, J. W. and O'Connell, M. O. (1985) The distribution of the spectacled form of the White-chinned Petrel (*Procellaria aequinoctialis conspicillata*) in the South Atlantic Ocean. *Br. Antarct. Surv. Bull.* 66: 83–86.

Fraser, M. W., Ryan, P. G. and Watkins, B. P. (1988) The seabirds of Inaccessible Island, South Atlantic Ocean. *Cormorant* 16: 7–33.

Hagen, Y. (1952) Birds of Tristan da Cunha. *Res. Norwegian Sci. Exped. Tristan da Cunha, 1937–1938* 20: 1–248.

Hall, A. J. (1987) The breeding biology of the White-chinned Petrel *Procellaria aequinoctialis* at South Georgia. *J. Zool.* 212: 605–617.

Jouventin, P., Mougin, J.-L., Stahl, J.-C. and Weimerskirch, H. (1985) Comparative breeding biology of the burrowing petrels of the Crozet islands. *Notornis* 32: 157–220.

Marchant, S. and Higgins, P. J. (eds) (1990) *Handbook of Australian, New Zealand and Antarctic birds, 1*. Melbourne: Oxford University Press.

Mayr, E. (1963) *Animal species and evolution*. Cambridge, Mass.: Belknap Press.

McKitrick, M. C. and Zink, R. M. (1988) Species concepts in ornithology. *Condor* 90: 1–14.

Neves, T. and Olmos, F. (1997) Albatross mortality in fisheries off the coast of Brazil. Pp 214–219 in G. Robertson and R. Gales, eds. *The albatross: biology and conservation*. Chipping Norton, U.K.: Surrey Beatty and Sons.

Olmos, F. (1997) Seabirds attending bottom longline fishing off southwestern Brazil. *Ibis* 139: 685–691.

Rowan, A. N., Elliott, H. F. I. and Rowan, M. K. (1951) The "spectacled" form of the Shoemaker *Procellaria aequinoctialis* in the Tristan da Cunha group. *Ibis* 93: 169–174.
Ryan, P. G. (in press) Sexual dimorphism, body condition and moult of seabirds killed by long-line fishing around the Prince Edward Islands, 1996–97. *Ostrich.*
Ryan, P. G. and Boix-Hinzen, C. (in press) Tuna longline fisheries off southern Africa: the need to limit seabird bycatch. *S. Afr. J. Sci.*
Ryan, P. G., Moloney, C. L. and Hudon, J. (1994) Color variation and hybridization among *Nesospiza* buntings on Inaccessible Island, Tristan da Cunha. *Auk* 111: 314–327.
Sibley, C. G. and Monroe, B. L. Jr (1990) *Distribution and taxonomy of birds of the world.* New Haven: Yale University Press.
Southern, H. N. (1951) The status of *Procellaria conspicillata. Ibis* 93: 174–179.
Vaske, T. (1991) Seabirds mortality on longline fishing for tuna in southern Brazil. *Ciencia e Culture* 43 (5): 388–390.
Warham, J. (1988) Vocalisations of *Procellaria* petrels. *Notornis* 35: 169–183.
Warham, J. (1996) *The behaviour, population biology and physiology of the petrels.* London: Academic Press.

PETER G. RYAN
Percy FitzPatrick Institute, University of Cape Town, Rondebosch 7701, South Africa.
e-mail: pryan@botzoo.uct.ac.za