SHORT NOTES

COMPARISON BETWEEN WET AND DRY OXIDATION METHODS FOR TOTAL NITROGEN ANALYSIS OF ANTARCTIC PEAT SAMPLES

PETER CHRISTIE*

British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, UK

Between 1969 and 1981 an intensive study of ecosystem processes in two contrasting bryophyte communities on Signy Island, South Orkney Islands, was undertaken by numerous biologists. The two study sites, known as the Signy Island terrestrial reference sites (Tilbrook, 1973) were (*a*) a semi-ombrogenous, relatively dry and well-drained moss turf community co-dominated by the mosses *Chorisodontium aciphyllum* and *Polytrichum alpestre*, and (*b*) a soligenous poorly-drained moss carpet community co-dominated by *Calliergidium austro-stramineum*, *Calliergon sarmentosum* and *Drepanocladus uncinatus*.

During an 18-month study of the nitrogen dynamics of these sites (Christie, 1987) core samples were collected at monthly intervals. The cores collected from September 1978 to March 1979 were oven dried, and ground subsamples were analysed for total N by two different methods: dry combustion in an elemental analyser and wet digestion followed by colorimetry. Organic carbon (C) was also determined using dry combustion (Christie, in press). This paper compares the accuracy and precision of the two methods of analysis for total N content of peat.

MATERIALS AND METHODS

Cores were taken from plots selected on a stratified random basis. From September to December 1978 (there was no October sample) the cores were removed using an electric drill fitted with a 5-cm diameter stainless-steel corer, and from January to March 1979 the samples were taken by hand using 5.6- or 3.0-cm diameter corers with longitudinal slots to minimize compression of the cores. Five cores were taken from each site on each occasion, sealed individually in plastic bags and taken to the laboratory at the research station. Each core (including the living shoots) was immediately cut into 3-cm sections and dried at 80 °C for 48 h. The oven-dried material was ground in a hammer mill and stored in air-tight plastic containers for shipment to the UK and subsequent chemical analysis.

Subsamples (1 mg) of ground oven-dried moss and peat from each core were analysed for organic C and total N simultaneously by dry combustion in a Perkin–Elmer Model 240 elemental analyser. Total N was also determined on separate subsamples (0.4 g) by wet digestion and colorimetry using standard methods (Allen and others, 1974). The results were subjected to nested analysis of variance because the sample depths were not statistically independent. Individual mean values of each variable at different depths within each profile were compared by calculation of least

* Present address: Agricultural and Food Chemistry Department, The Queen's University of Belfast and Department of Agriculture for Northern Ireland, Newforge Lane, Belfast BT9 5PX, N. Ireland.

significant differences ($P = 0.05$). Few cores from the wet carpet exceeded 12 cm in length, therefore statistical analysis of all samples was restricted to the top 12 cm of the peat profile. Thus, for each variable there were 6 sampling occasions, 2 sites, 4 depths and 5 replicates, giving a total of 240 values.

Results

The mean organic C and total N results did not show any significant differences between sampling dates and no seasonal trends were observed (Table I). The mean organic C content of the dry turf peat was slightly higher than that of the wet carpet peat ($P < 0.05$) and decreased with depth in the turf peat while remaining constant in the profile of the wet carpet peat. The dry turf peat had a much lower N content than did the wet carpet peat. Total N content under the dry moss turf was uniform to a depth of about 9 cm and then increased at greater depths, while the N content of the wet carpet was lowest in the top 3 cm and was uniformly higher in the deeper layers.

The elemental analyser consistently gave higher values for total N content than did the wet oxidation method. The results from the two methods of analysis for total N were strongly correlated with one another ($r = 0.821$, $n = 233$, $P < 0.001$). However, the results obtained by dry combustion were much more variable, with a coefficient of variation of 32.5% compared with 20.6% for the wet oxidation method. The organic C results by dry combustion had a much lower coefficient of variation (9.2%) than did the total N results by either method.

Table I. Mean organic C and total N (percent of dry weight) in cores from both sites

Site	Depth (cm)	*Dry combustion*		*Wet digestion*
		Organic C	*Total N*	*Total N*
Turf	0–3	45.4 a*	0.77 b	0.63 b
	3–6	43.1 b	0.75 b	0.65 b
	6–9	43.8 a b	0.87 a b	0.77 b
	9–12	42.6 b	1.12 a	1.09 a
	> 12†	41.3	1.89	1.44
Carpet	0–3	43.0 a	1.97 b	1.87 b
	3–6	41.7 a	2.50 a	2.30 a
	6–9	41.7 a	2.43 a	2.33 a
	9–12	41.7 a	2.34 a	2.25 a
	> 12	43.4	2.46	2.53
Significance of difference between:				
Sampling dates		NS	NS	NS
Sites		$P < 0.05$	$P < 0.001$	$P < 0.001$
Depths		$P < 0.05$	$P < 0.001$	$P < 0.001$
Sites × depths		NS	$P < 0.01$	$P < 0.001$

All data are means of 30 samples, i.e. 5 per month over 6 months.

* For each variable within each site, means from different depths which are followed by the same letter (a, b) are not significantly different ($P < 0.05$) by least significant difference.

† Results for depths > 12 cm were omitted from statistical analysis because of the large number of missing values.

NS, not significant.

Discussion

The differences between the organic C, total N contents and C/N ratios at different depths within the two bryophyte communities have been discussed by Christie (1987, in press). The lower N contents in the top 3 cm of both profiles reflect the concentrations in the living surface vegetation.

The elemental analyser gave results which were consistently higher than those derived from the wet oxidation procedure. Although instruments based on the Dumas combustion method are considered to be accurate, precise and simple to use in general (Nelson and Sommers, 1980), higher N values than expected have been obtained with organic soils. This has been attributed mainly to incomplete oxidation of C-rich samples (Bremner, 1965) with formation of some CO gas as well as CO_2. The CO will not be removed by the CO_2 trap prior to N_2 analysis. Thus instead of measuring N_2 gas the instrument measures a mixture of N_2 and CO (both of which have a molecular weight of 28) and this gives an overestimate of the N content of the original sample.

Dry combustion methods are usually acknowledged to be more accurate than wet oxidation for determination of organic C (Charles and Simmons, 1986). A small proportion of C incompletely oxidized may not significantly affect the determination of C but may have a more pronounced effect on N, which is present in peat in much lower concentrations. The organic C results found in the present work had a relatively low coefficient of variation, but both analysis methods for N had much higher coefficients. This lower precision of N values could be ascribed to sub-sampling error (Bremner and Mulvaney, 1982) and greater spatial variation of N in the peat. Subsampling errors could be reduced by developing techniques in which larger subsamples are used (Kirsten and Jansson, 1986), but the C content of peat is so large that suitable methods would be difficult to devise. The overestimation of N content by dry combustion implies that this method has lower accuracy than does wet oxidation. The higher coefficient of variation using combustion shows that this method also has lower precision than does wet oxidation. Thus although the elemental analyser appears to be suitable for analysis of organic C in Antarctic peat samples, the wet oxidation procedure provides more accurate and more precise determination of total N content.

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NEW OR NOTEWORTHY MOSSES FROM THE ANTARCTIC PENINSULA REGION

P. J. LIGHTOWLERS

Institute of Terrestrial Ecology, Natural Environment Research Council, Bush Estate, Penicuik, Midlothian EH26 0QB, Scotland

ABSTRACT. *Brachythecium glaciale* B.S.G. and *B. majusculum* M. E. Newton are reported from the Antarctic Peninsula for the first time. Three new collections of *Orthotrichum rupestre* Schwaegr. from the Danco Coast are noted and specimens of *Pterygoneurum* from Signy Island, South Orkney Islands, are referred to *Pterygoneurum ovatum* (Hedw.) Dix.

During the Antarctic summer of 1980–1, Dr R. I. Lewis Smith added to his extensive botanical collections from the maritime Antarctic (the Antarctic Peninsula and its offshore islands). The following records represent some of the most interesting moss taxa he collected during that season. However, a significant number of mosses from this area cannot be satisfactorily identified because of the lack of taxonomic revision, particularly in the genus *Bryum* for example, or in the families Dicranaceae and Ditrichaceae. Further taxonomic work will thus be needed before the full importance of Smith's collections can be appreciated.

The R. I. Lewis Smith collection, along with others made by British Antarctic Survey (BAS) personnel, is maintained in the BAS Herbarium (AAS) and is fully documented in the BAS Herbarium Database. This is available for consultation and any enquiries about access to it or loans of bryophyte material are welcomed by the author. The bryophyte section of the herbarium is currently on loan to and maintained by the Institute of Terrrestrial Ecology.

Brachythecium glaciale B.S.G.

B. glaciale was first reported in the southern hemisphere by Newton (1979) during a revision of South Georgian *Brachythecium* species. *B. glaciale* is common in South Georgia and Tierra del Fuego, and its occurrence in the Antarctic Peninsula is thus a small but significant southward extension to its range. On Andrée Island (Danco Coast) it was collected from a moist basaltic rock ledge at *c.* 25 m a.s.l. In addition to this specimen, four collections made by R. Ochyra from the South Shetland Islands have been determined as *B. glaciale* by Dr M. E. Newton. These were previously identified as *B. subpilosum* (Hook f. *et* Wils.) Jaeg. (Ochyra and others, 1986) but the specimens in AAS have non-plicate leaves with broadly recurved lower margins, and serrate upper margins. These characters are typical of *B. glaciale* and distinguish this species from *B. subpilosum* (Newton, 1979).

Specimens examined. R. I. L. Smith 4015, Andrée Island, Charlotte Bay, Danco Coast, (64° 31′ S, 61° 31′ W) (AAS, BM, KRAM). R. Ochyra 5078/79, 478/80, 636/80, 1725/80, Admiralty Bay, King George Island, South Shetland Islands (62° 07′ S, 58° 27′ W) (AAS).

Brachythecium majusculum M. E. Newton

A single specimen of this species was collected from a moist rock ledge (close to the specimen of *B. glaciale* above) on Andrée Island in Charlotte Bay and determined by M. E. Newton. This species is otherwise known only from Tierra del Fuego and South Georgia, so this record is a considerable extension to its range.

Specimen examined. R. I. L. Smith 4011, Andrée Island, Charlotte Bay, Danco Coast (64° 31′ S, 61° 31′ W) (AAS, PC).

The total number of *Brachythecium* species now reported from the Antarctic Peninsula is five. These are: *B. majusculum* and *B. glaciale; B. austro-glareosum* (C. Muell.) Kindb. (Cardot, 1906*b*); *B. austro-salebrosum* (C. Muell.) Kindb. (Cardot, 1900, as *B. antarcticum* Card.); *B. subpilosum* (Cardot, 1906*a*). A further species, *B. turquetii* Card. (Cardot, 1906*b*), is known only from a single gathering and was reduced to synonymy with *Calliergidium austro-stramineum* (C. Muell.) Bartr. by Robinson (1972), but the remaining species of *Brachythecium* have all been revised for South Georgia by Newton (1979) and were confirmed as distinct species. There appears to be only one record of *B. subpilosum* from the Antarctic (Cardot, 1906*a*) and *B. austro-glareosum* is also rare. The most common and widespread species in the Antarctic Peninsula region is *B. austro-salebrosum*.

Calliergidium austro-stramineum (C. Muell.) Bartr. is also an abundant moss in the northern Antarctic Peninsula region. Ochyra and others (1986) transferred it to the genus *Brachythecium* but Bartram (1946) considered that it was related to *Drepanocladus*, so its taxonomic position appears to be uncertain.

Orthotrichum rupestre Schwaegr.

O. rupestre was first reported from the Antarctic Peninsula as *O. antarcticum* Card. by Cardot (1900). However, Ochyra (1985) reduced the latter species to synonymy with the cosmopolitan *O. rupestre*. Until now, *O. rupestre* was known in the Antarctic only from the type collection of *O. antarcticum* in Brussels (BR), and one other specimen, also collected during the Belgian Antarctic Expedition of 1897–9. Both of these specimens were collected from near Cape Anna (64° 35′ S, 62° 26′ W) (Cardot, 1901). Three specimens have recently been collected by R. I. Lewis Smith from the nearby Cuverville Island. *O. rupestre* thus appears to be a rare and very local component of the Antarctic moss flora.

Specimens examined. R. I. L. Smith 4170, south-east end of Cuverville Island, Gerlache Strait, Danco Coast, (64° 41′ S, 62° 38′ W) (AAS); R. I. L. Smith 4180 (as above) (BM, KRAM); R. I. L. Smith 4181 (as above) (AAS, ALTA, B, BA, CHR, H, LE, MEL, NIPR, NY).

Pterygoneurum ovatum (Hedw.) Dix.

Pterygoneurum cf. *ovatum* was first reported from the Antarctic by Smith (1985) as a major component of a pioneer community on Signy Island, South Orkney Islands. Some specimens of this species from the same locality had previously been reported as *Stegonia latifolia* (Schwaegr.) Vent. (Smith, 1972). It is now clear that the latter belong to *Pterygoneurum* and they are here referred to the widespread and variable species *Pt. ovatum*.

Pterygoneurum plants are similar in habitat and appearance to those of the genus *Pottia*, but the leaves differ in having secondary photosynthetic lamellae on the adaxial surface of the nerve. These form two (or more) wings of cells, one cell thick, projecting from the upper surface of the nerve. In Antarctic material, these wings are often much reduced, and this, together with the crenulate–denticulate upper leaf margin, may have led to the confusion with *Stegonia*.

There are slight differences between Antarctic *Pt. ovatum* specimens and those from other areas. Antarctic plants have short stems, 1–2 mm high, often bearing sporophytes, with imbricate, usually piliferous leaves. Compared with European and Australian material, the leaves of Antarctic specimens have rather small lamellae which are often reduced to only one or two rows of cells. The leaf cells of Antarctic plants are also relatively large, averaging 18–20 μm wide, and the upper leaf margin is crenulate–denticulate, rather than entire or almost entire. However, the Antarctic plants agree well with European and Australian specimens in sporophyte characters, having exserted, ellipsoid shortly, cylindrical capsules with no peristome. The seta is 2.5–3.5 mm long and the spores are 25–40 μm in diameter.

The minor differences in gametophyte characters shown by the Antarctic specimens do not appear to merit taxonomic recognition as a separate variety. The size of the lamellae and the degree of denticulation of the upper leaf margin are variable between stems and between specimens, and it would be difficult to distinguish a taxon on the basis of these characters alone. Enlarged leaf cells occur in Antarctic specimens of *Tortula princeps* De Not., as well as in *Pt. ovatum*, and it appears that this may be a characteristic response of mosses in the Pottiaceae to severe Antarctic conditions.

In the Antarctic, *Pt. ovatum* is at present known only from Signy Island, where it grows on base-rich glacial till (Smith, 1985) at an altitude of 5–25 m. The species has not been recorded in the sub-Antarctic region and, elsewhere in the southern hemisphere, it has been reported only from Australia (Catcheside, 1980) and South America (Mitten, 1869, as *Tortula pusilla* Mitt.). Unfortunately, no South American material has been traced during this study, but Australian specimens examined seem more similar to the Antarctic specimens than to those from Europe, particularly in the large number of rhomboidal cells at the leaf apices.

Specimens examined. R. I. L. Smith 546, clay soil on new moraine below Orwell Glacier, Moraine Valley, Signy Island, South Orkney Islands (60° 43′ S, 45° 37′ W) (BA, BM, LE, O). R. I. L. Smith 673, Marble Knolls, north of Elephant Flats, Signy Island (AAS). R. I. L. Smith 3155, north end of Orwell Glacier moraine system, Signy Island (AAS, ALTA, BA, BM, CHR, KRAM, MEL, NIPR, PC, NY). R. I. L. Smith 3164, between Marble Knolls and Knob Lake, Signy Island (AAS, B, H).

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FURTHER RANGE EXPANSION OF INTRODUCED REINDEER *RANGIFER TARANDUS* ON SOUTH GEORGIA

T. S. McCann

British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, UK

Introduction

Reindeer were introduced to South Georgia from Norway on three occasions (Leader-Williams, 1978). The first introduction of ten deer was made to the Barff Peninsula in November 1911. By 1973 this herd occupied all vegetated areas on the Barff Peninsula and had expanded its range by circumventing the Cook and Heaney glaciers to form another herd in the Royal Bay area (Lindsay, 1973). A second introduction of five deer was made to the Busen Peninsula (Fig. 1) in 1911–12 but this herd was lost in a snowslide (Olstad, 1930). The third introduction of seven deer in 1925 was also to the Busen Peninsula. When studied extensively in 1973–76, this herd was observed not to occupy all the vegetated areas available within its potential range bounded by the Neumayer and Fortuna glaciers (Leader-Williams, 1980). This included Fortuna Bay, where reindeer tracks had been noted by Shackleton (1919) and which must therefore have been occupied by the first Busen herd. This note describes range expansion that has occurred between 1976 and 1986 in the Busen herd.

Methods

Several areas on the Busen Peninsula unoccupied by reindeer in 1976 were visited during October and November 1986. Sightings of reindeer and indirect signs of occupancy (cast antlers and droppings) from these visits and from visits by other field parties were collated to identify areas that have been occupied since 1976.

Results

Observations of reindeer and reindeer presence in previously unoccupied areas of the Busen Peninsula are summarized in Table I.

On 17 October 1986 12 deer were seen from a distance grazing in Enten Bay. On 18 and 22 October visits were made to Fortuna Bay without seeing reindeer but on [?] October 14 deer (11 males, 3 females) were seen on the south-eastern shore of the bay. On 5 November the same group, but with two more males, was seen on the south-eastern slopes of the bay. On 14 November a group of 13 deer comprising four females each with a young calf, four yearlings and one adult male was seen in Hercules Bay.

The available data suggest that the reindeer expanded their range to these new areas between 1981 and 1986, with the expansion to Fortuna Bay probably occurring in 1986.

Discussion

Emigration of *Rangifer* to new areas is a feature of their behaviour. Dispersion commonly occurs as continental herds reach peak densities and large segments of a herd transfer to another area where population pressure is lower (Bergerud, 1980; Haber and Walters, 1980). On South Georgia, introduced reindeer from the Barff

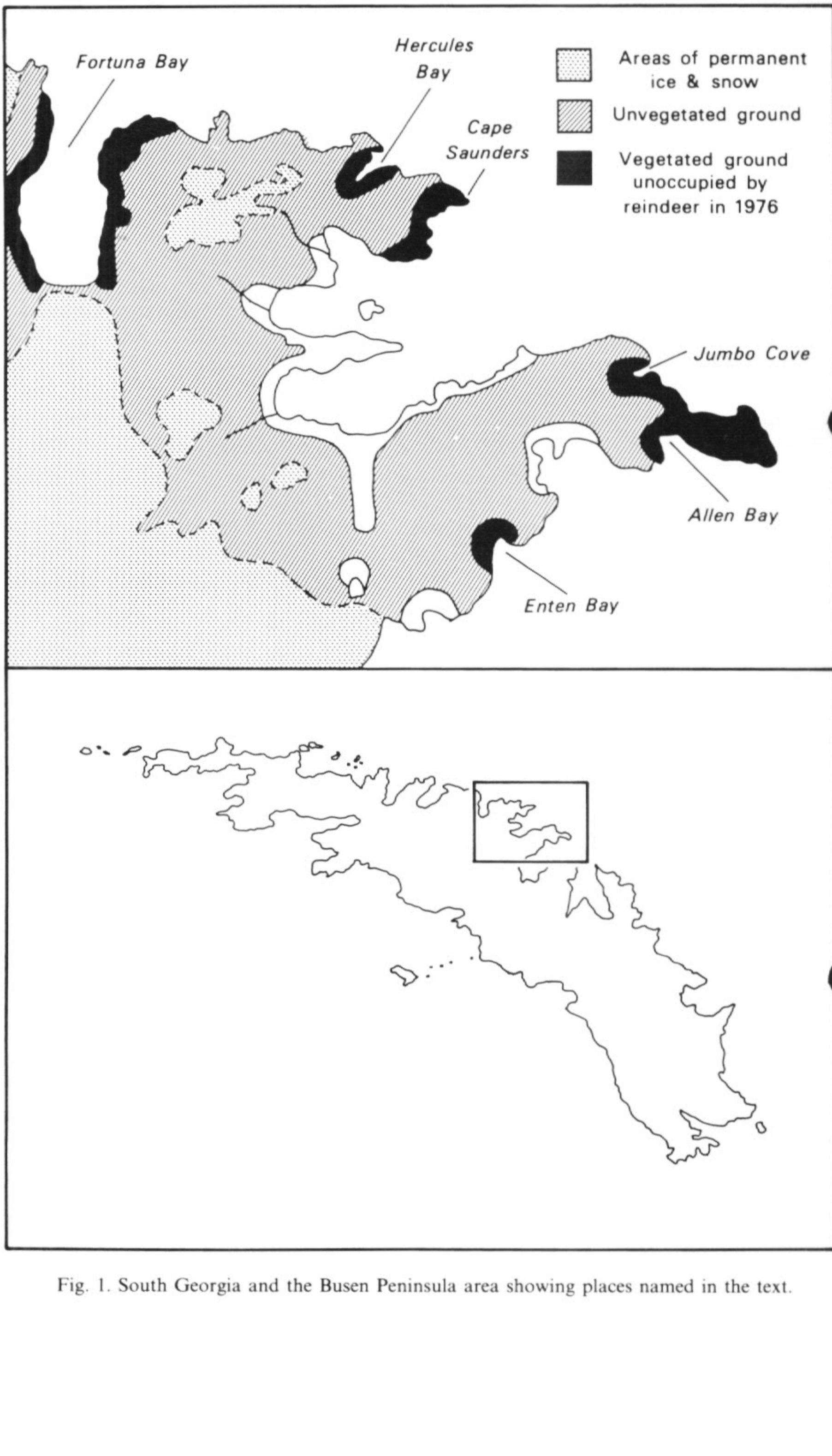

Fig. 1. South Georgia and the Busen Peninsula area showing places named in the text.

Table I. Areas of the Busen Peninsula unoccupied by reindeer in 1976 with more recent records of range occupancy.

Area previously unoccupied	Date last visited without signs of reindeer	Recent occupancy by reindeer: Date	Cast antlers	Sightings	Source
Allen Bay	Aug. 1979	—	–	–	Headland, 1980
Cape Saunders	Aug. 1979	—	–	–	Headland, 1980
Enten Bay	Aug. 1979	Oct. 1986	–	+	this paper
Fortuna Bay	Mar. 1981	—	–	–	Heilbronn, 1981
		Oct. 1986	–	+	this paper
Hercules Bay	Aug. 1979	—	–	–	Headland, 1980
		Dec. 1985	–	+	S. & J. Poncet, pers. comm.
		Nov. 1986	+	+	this paper
Jumbo Cove	Aug. 1979	—	–	–	Headland, 1980

rd expanded their range between 1961 and 1965 to form the Royal Bay herd (Lindsay, 1973). This range expansion occurred after the Barff herd had reached peak numbers, and as vegetation was starting to become overgrazed (Leader-Williams, 1980). It was made possible by the retreat of the Cook Glacier snout, which formerly had formed the southern boundary to the range of the Barff herd (Lindsay, 1973).

The range expansion noted here has both similarities to and differences from the spread to Royal Bay. The Busen herd derived from different genetic stock and is more sedentary than the Barff herd (Leader-Williams, 1980) and the areas of range unoccupied on the Busen Peninsula in 1976 were separated from the occupied areas only by steep mountain passes rather than by glaciers (Leader-Williams, 1980). The Busen herd had reached peak numbers in the 1970s and overgrazing of the areas of occupied range was evident (Leader-Williams, in press). The spread of reindeer to Enten Bay, Fortuna Bay and Hercules Bay will, if left unchecked, relieve pressure on the overgrazed areas. However, the range expansion recorded here will also have consequences for the vegetation communities of those areas. Elimination of macro-lichens and dwarf shrub swards will probably occur within a decade, and the productivity of tussock grassland will be reduced over several decades (Leader-Williams and others, in press). This will be particularly unfortunate for Fortuna Bay which surveys have shown to be a botanically rich area (D. W. H. Walton, pers. comm.).

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RIGHT WHALE SIGHTINGS AROUND SOUTH GEORGIA

W. N. Bonner

British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, UK

During the 1958–59 Antarctic whaling season the gunners of the seven Compañia Argentina de Pesca whale catchers operating out of Grytviken, South Georgia, were asked to keep records of any southern right whales (*Balaena glacialis*) that they sighted while searching for the fin and sei whales that made up most of the commercial catch at that time. They were asked particularly to note the occurrence of any females accompanied by calves.

Methods

Sightings were recorded as distance and bearing from a few principal sea marks used by the whalers. They are probably accurate to within 5 nautical miles.

Unfortunately, no details were recorded of the effort involved in terms of the numbers of hours searching, nor was any note taken of areas searched with negative results. However, it is believed that all the whale catchers were hunting in the area from which the right whales were recorded at that time. All seven catchers recorded seeing some right whales.

Results

Figs 1 and 2 show the position and group size of sightings by date for February (Fig. 1, including one sighting on 29 January) and March (Fig. 2). Between 29 January and 30 March 111 sightings of right whales were recorded. Only one pair (40 n miles east of Cape Charlotte on 26 February) was recorded as a female with calf. Over two-thirds of the whales were found in groups of two or more. The most common sightings were of single individuals (31 whales), or pairs (26 pairs or 52 whales). Two groups of 3, two groups of 4 and one group each of 6 and 8 whales were recorded. More whales were seen in March (63) then in February (37, including one sighted on 29 January). Most of the sightings were made in water deeper than 200 fathoms. This may reflect optimum conditions for hunting fin and sei whales.

Discussion

Because of the unsystematic way in which these data were collected, it is unfortunately not possible to draw useful conclusions about right whale abundance from them.

Sightings of whales from similar positions on the same date by different catchers may refer to the same individuals. In Table I an attempt has been made to eliminate what are believed to be duplicate records. It is still possible that groups of whales, e.g. the eight sighted together 35 n miles north-east of Jason Island, might have been separately recorded by other catchers. Furthermore, it is almost certain that the same whales may have been sighted on different dates.

The greatest number of right whales sighted on a single day was 12 on 19 March. These were made up of a group of 8 and a group of 2 60 n miles apart and two

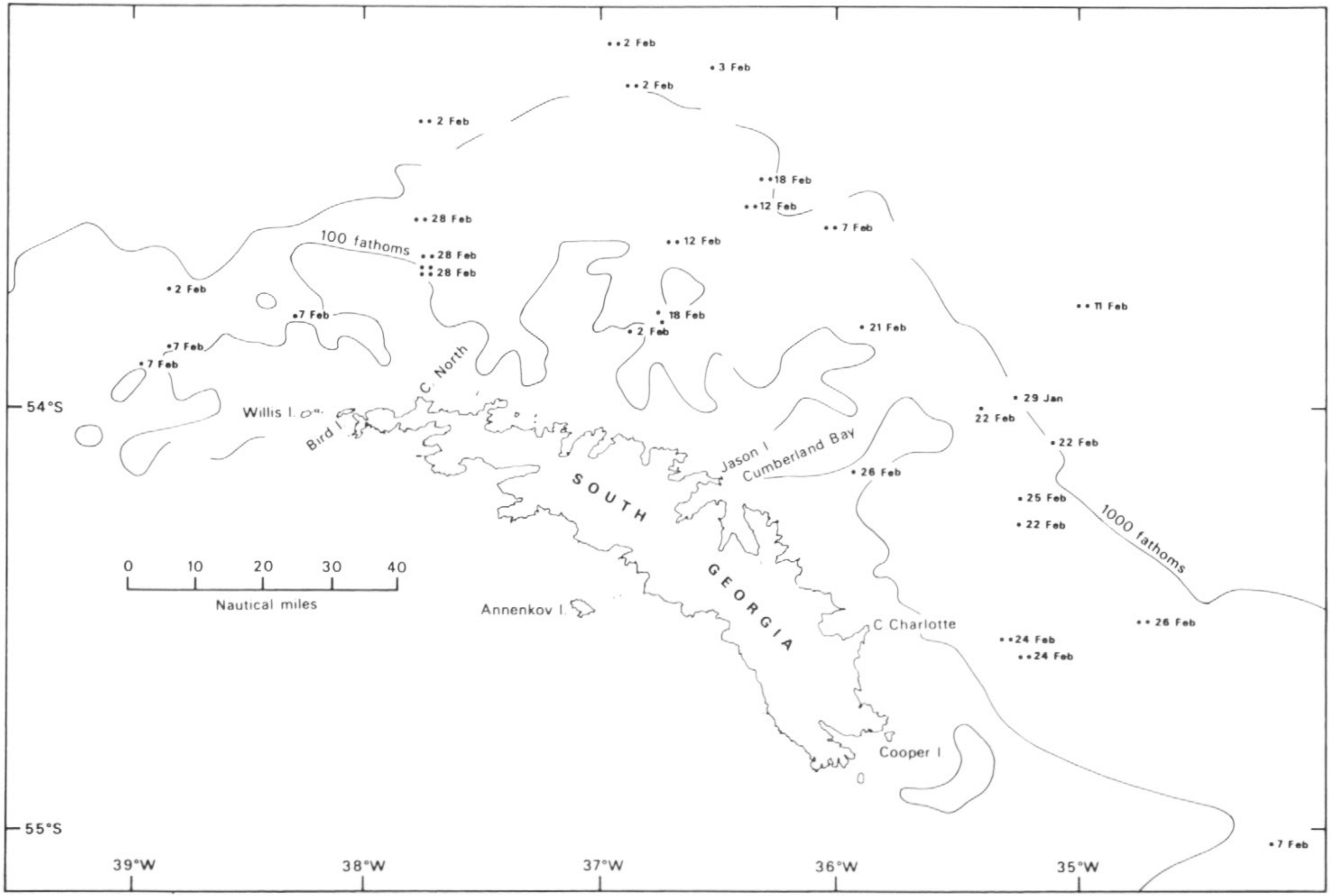

Fig. 1. Observations [illegible]right whales around South Georgia, February 1959. (One sigh[illegible] of two whales not plotted.)

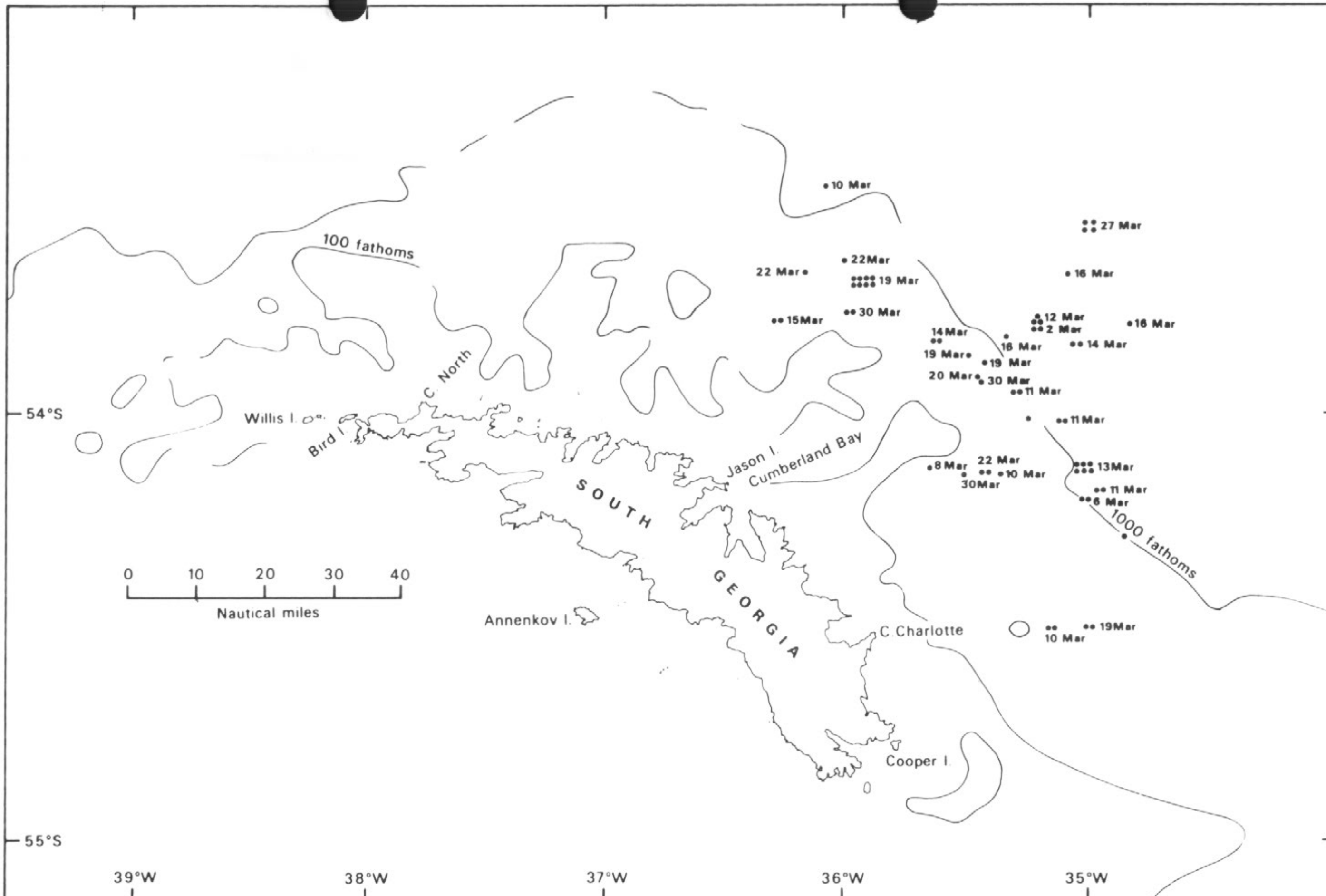

Fig. 2. Observations of right whales around South Georgia, March 1959. (One sighting of three whales not plotted.)

Table I. Sightings of right whales off South Georgia in 1959 adjusted for probable multiple sightings

	No. of occasions whales sighted	*Total no. of whales*		*Group size* 1		2		3		4		5		6		7		8	
		*a**	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
February (including 29 January)	31	48	37	16	15	28	18	0	—	4	4	0	—	0	—	0	—	0	—
March	32	63	56	15	14	24	18	6	6	4	4	0	—	6	6	0	—	8	8
Total	63	111	93	31	29	52	36	6	6	8	8	0	—	6	6	0	—	8	8

* *a*, Total recorded; *b*, total adjusted.

individual sightings (which may have been of the same whales) between them. Hence, it is reasonably certain that there were at least 11 right whales off the north-east coast of South Georgia on that date.

Right whales were familiar enough to whalers off South Georgia in the 1950s, though they were rarely seen close to shore. Modern records are of whales seen within a few hundred metres of land, and have mostly been made from the British Antarctic Survey research station at Bird Island, which lies just to the north-west of the main island of South Georgia.

Sightings from Bird Island have been recorded from mid-December to April, with one record on 2 May 1983. 1983 was the first year in recent times that Bird Island had been occupied during the austral winter. Most sightings are between the latter half of January and March. A remarkable record was of at least 7 adult right whales seen together on 30 January 1980 (British Antarctic Survey internal reports). On 17 December 1981, a right whale was seen feeding in Cumberland Bay (pers. obs.).

Limited opportunities exist for sighting right whales at sea off South Georgia during movements of British Antarctic Survey ships, and particularly during the Offshore Biological Programme. The absence of records probably reflects the inefficiency of unskilled observers working from ships of opportunity compared with trained whalers working from catching boats, rather than the absence of whales.

The incomplete and anecdotal nature of the information presented here is regretted. It is offered not for its own sake, but in the hope that it may serve as a background for more systematic studies which will provide useful information on the habits of southern right whales.

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