

The impact of BIOMASS-related research on South African Antarctic science

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The impact of the international BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) Programme on South African science in the Antarctic is assessed. An analysis was undertaken of refereed papers, reports or theses containing BIOMASS-related research findings, published in indigenous or foreign literature. During the programme's 16-year existence (January 1975 to September 1991), a total of 163 South African scientists, or their associates, accounted for some 401 publications comprising in excess of 7 500 printed pages. This information was analysed further to assess the productivity of individual South African scientists involved with BIOMASS. Criteria used by the South African National Antarctic Programme (SANAP) to assess new research were applied to further evaluate BIOMASS's effect on the national Antarctic scientific effort. Results indicate that BIOMASS has significantly influenced the direction, extent and impact of recent South African research in the Antarctic, particularly in the marine-life sciences.

Die invloed van die internasionale BIOMASS (Biological Investigation of Marine Antarctic Systems and Stocks)-program word bepaal. 'n Ontleding is gedoen van beoordeelde manuskripte, verslae of tesesse in plaaslike en internationale literatuur wat BIOMASS-verwante navorsingsresultate bevat. Gedurende die program se sestienjarige bestaan (Januarie 1975 — September 1991) was 'n totaal van 163 Suid-Afrikaanse wetenskaplikes, of hulle medewerkers, verantwoordelik vir ongeveer 401 publikasies wat meer as 7 500 gedrukte bladsye beslaan. Hierdie inligting is verder ontleed om die produktiwiteit van die individuele wetenskaplikes betrokke by BIOMASS te bepaal. Kriteria wat deur SANAP (South African National Antarctic Programme) gebruik word om nuwe navorsing te bepaal is toegepas om die invloed van BIOMASS op die nasionale Antarktiese poging verder te evalueer. Resultate dui daarop dat BIOMASS die rigting, omvang en invloed van resente SA navorsing in Antarktika, spesifiek die mariene-lewewetenskappe, betekenisvol beïnvloed het.

INTRODUCTION

A well-known quotation from the Omar Kahyim reads:

"the moving finger writes; and, having writ, moves on: nor all your piety nor wit shall lure it back to cancel half a line, nor all your tears wash out a word of it".

In this context, there is little doubt that the impact of the international BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) Programme is indelibly etched in the recent history of South African (SA) Antarctic science. The question to be asked, however, is not so much as to what extent

BIOMASS has influenced SA scientific endeavour in the Antarctic, but how the programme's influence may be objectively assessed?

To address this question, the publication record of SA scientists, or their collaborators, active in research considered relevant to BIOMASS's primary objectives is documented. The achievements and productivity of these scientists in their respective research fields are also assessed.

The somewhat more subjective criteria used by the South African National Antarctic Programme (SANAP) to evaluate new research were applied to the above information. The impact of BIOMASS-associated initiatives on SA Antarctic research is thus evaluated in terms of national relevance, practical feasibility and local benefit.

METHODS

Any review of this kind involves arbitrary judgements and some degree of personal bias. First, it is based exclusively on the natural sciences most specifically related to the objectives of BIOMASS, namely the life and marine sciences. Only SA research undertaken during BIOMASS's 16-year existence (1975 to 1991) has been considered and it must be stressed that all research on whales has been excluded. The reason for this is that such research clearly pre-empted and has to a large extent continued independently of BIOMASS. Secondly, although several national research projects have been undertaken independently of BIOMASS (especially at Marion Island) these have been included in the analysis on the basis of their perceived relevance to BIOMASS's overall objectives (see Table 1). Such relevance has also impacted on the geographical scope of the analysis and research carried out north of the Polar Front (approximately 50° S) has only been included if perceived as directly applicable to BIOMASS's objectives or to species that BIOMASS has identified as important. Finally, the review is limited to scientists resident in South Africa alone, with the exception of the products of joint collaboration between foreign-based scientists and those residing in the Republic.

The production of reports in the technical literature is the most frequently used index of scientific productivity (Underwood 1985). This review is therefore based on scientific reports produced by SA scientists working in the Antarctic or closely adjacent regions from 1 January 1975 until 1 September 1991 (i.e. for the duration of BIOMASS) and subject to the provisions already outlined above. South Africa's annual reports to SCAR (Scientific Committee for Antarctic Research), as well as the annual reports of a variety of national institutes/museums, judged as likely to contribute to the analysis, were examined for listings of relevant publications produced during the stipulated review period.

Some difficulty was experienced in selecting relevant, as opposed to irrelevant, reports. All research reports containing information either directly or indirectly applicable to BIOMASS's objectives, as set out in Table 1, were initially selected. Only reports published in the primary scientific literature (i.e. peer-refereed papers in open, scientifically edited, technical, printed

TABLE 1. THE PRINCIPAL AND SUBSIDIARY OBJECTIVES OF THE BIOMASS PROGRAMME (FROM ANON 1977)

PRINCIPAL OBJECTIVE

To gain a deeper understanding of the structure and dynamic functioning of the Antarctic marine ecosystem as a basis for the future management of potential living resources

SUBSIDIARY OBJECTIVES

- 1 Study of the physical/chemical environment influencing krill and its food base
- 2 Study of the variability between years and regions in the concentration and composition of phytoplankton
- 3 Autecological studies of key organisms of the Antarctic ecosystem and assessment of their standing stocks/biomass and production in selected areas of the Southern Ocean
- 4 Description of the major food chains in Antarctic waters with emphasis on the flux of energy and material between the various trophic levels in selected small areas
- 5 Development of models to improve our understanding of the quantitative interaction between different elements of the ecosystem and the effects of climate, whaling and krill fishing on structure and efficiency of the food chain
- 6 Compilation and analysis of data from exploratory and commercial fishing
- 7 Provision of scientific information on the Antarctic ecosystem to the scientific community, governments, industries and other concerned bodies

periodicals and books or those qualifying for the science citation index system — Siegfried and Bosman 1987) were analysed. Furthermore, special books, conference/workshop proceedings and Selected Scientific Papers presented to the C-CAMLR (Commission for the Conservation of Antarctic Marine Living Resources) were included, provided they had been subject to peer review and editing. Although purely "in-house", semi-popular or popular articles were not taken into account, postgraduate theses at recognised universities were.

In an attempt to assess the particular spheres of South Africa's Antarctic research efforts where the effect of BIOMASS-related research has been most felt, the publication record of SA scientists associated with BIOMASS was considered in the context of the five basic criteria by which new research is evaluated within SANAP (Table 2).

For a variety of reasons, a review of this type is never complete or comprehensive and cannot ever hope to fully reflect BIOMASS's impact, either direct or indirect, on SA Antarctic science. Nevertheless, I am confident that the survey encompassed at least 90% of the primary scientific publications and probably all of the scientifically important work relevant to BIOMASS produced by scientists active in SANAP.

RESULTS

A total of 401 reports, including 10 papers currently in press, embracing in excess of 7 500 printed pages, was published in 85 individual books, periodicals or theses between January 1975 and September 1991. Of these, 114 (28%) reports arose directly out of BIOMASS initiatives, while the balance addressed BIOMASS objectives in one way or another. A total of 157 (39%) reports

was published outside SA. Two noticeable peaks (1981 and 1985) in the incidence of publications were apparent (Fig 1).

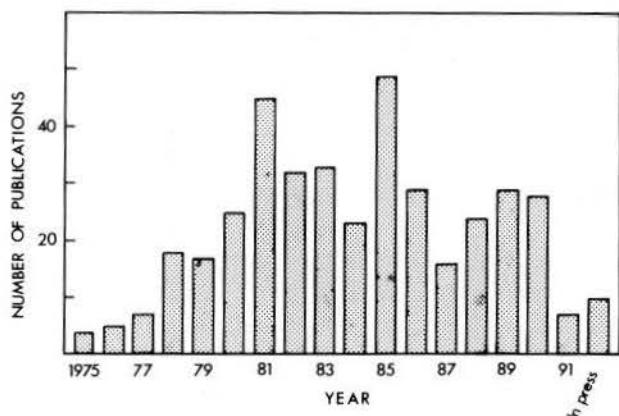


Fig 1 Number of BIOMASS-related reports produced by South African scientists between January 1975 and September 1991

The publications were produced by 163 individual scientists of whom 41 (25%) were based outside South Africa. Fifty-seven (67%) of the 85 books, theses and serial titles were published outside South Africa (in Australia, France, Germany, Japan, the Netherlands, the United Kingdom and the United States). Thirty-two (43%) of the books and journals qualified for inclusion in the core list of the science citation index system; 84% of these being published outside South Africa. Moreover, 54 (73%) of the serial titles and books appeared in foreign publications, 27 (50%) of these in science citation index listed publications.

These statistics are directly comparable to those reported by Siegfried (1987) for SA marine scientists as a whole. Taken together, they clearly demonstrate that the bulk of published material forthcoming from SA BIOMASS-related work has been acceptable for publication in internationally distributed journals and books of high scientific reputation.

The incidence of collaboration between scientists in the production of co-authored reports involved 149 (37%) of the total number of reports being co-authored. Of these, 28 (19%) were produced in conjunction with colleagues resident outside South Africa.

Subjects

It was possible to classify all the papers produced by nine subject headings, namely: Birds, Krill, Oceanography, Plankton (including primary production), Seals, Fish, Technical, Management-related and Other. By topic, papers were dominated by birds (178 papers, 44% of the total), krill (58 papers, 14% of the total), seals (52 papers, 13% of the total) and oceanography (50 papers, 12% of the total) in that order (Fig 2). Peaks in the publication

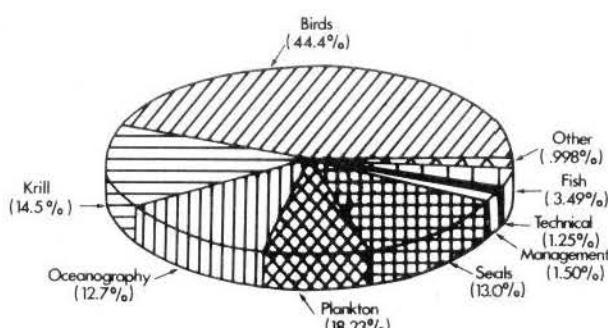


Fig 2 Pie-chart of BIOMASS-related reports produced by South African scientists by subject

of bird reports are apparent in 1981, 1985 and 1989, whereas discernible peaks in both oceanographic and krill reports occurred in 1985 (Fig 3). The 1985 peaks coincided with publication of the *Proceedings of the Fourth SCAR Symposium on Antarctic Biology* (Siegfried *et al* 1985) held in South Africa during 1983. By contrast, the 1981 peak in bird publications most probably arose from the publication of the *Proceedings of the Symposium on Birds of the Sea and Shore* (Cooper 1981) held in Cape Town during 1979.

A final point of interest to be noted from Fig 3 is the relatively recent emergence (from 1986 onwards) of papers dealing specifically with the management of Antarctic living, particularly marine, resources. This is a function of the prominent role that SA scientists have assumed within the C-CAMLR. Focusing attention on issues related to the management of Antarctic marine living resources certainly represents an important outcome of BIOMASS (Knox 1984) and one in which South Africa has shared. This can be attributed to the fact that BIOMASS has facilitated a relatively steady production of reports on Antarctic krill (*Euphausia superba*), a key CCAMLR species, by SA scientists. Consequently, these scientists have been well placed to actively contribute to the development of scientific advice on the management of the krill resource (Miller 1991).

Productivity

The bulk of the published reports described above was produced

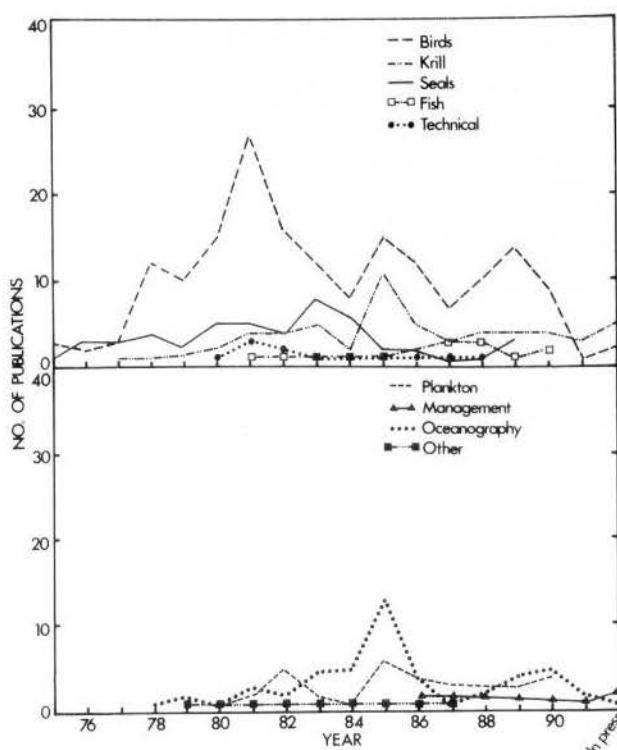


Fig 3 Number of BIOMASS-related reports produced by South African scientists by year and subject

by a relatively small number of scientists. Of all the reports (401), some 224 (56% of the total) were produced by only nine (5% of the total of 163) individuals. In turn, two of these individual scientists accounted for 64 (16% of the total number) papers. This trend is clearly illustrated in Fig 4. This small but productive core of individual scientists also produced the 91 (52%) reports appearing in the core list used by the science citation index system. As illustrated by Siegfried (1987), the general principle that SA marine scientists who publish most frequently also tend to produce relatively high-quality products appears to hold true. It is also interesting to note that one of these products was specifically commissioned by BIOMASS (Miller and Hampton 1989) and represents an attempt to consolidate that programme's research efforts on krill.

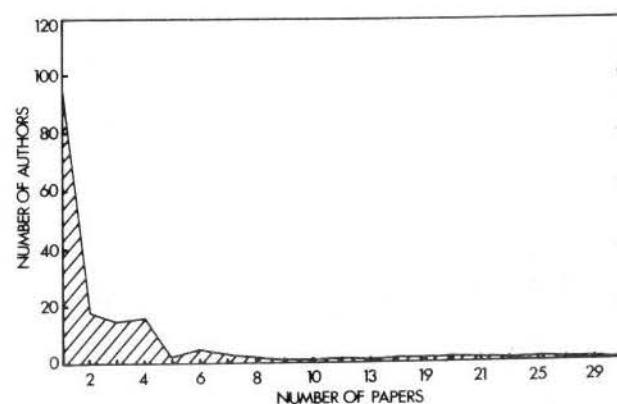


Fig 4 The relationship between number of authors and number of published reports, based on a overall total of 400 reports produced by 163 individual South African scientists or their collaborators between January 1975 and September 1991

The 163 individual scientists produced on average 2.46 reports (or 47.30 pages) during the course of the 16-year review period. This represents a mean of 0.16 reports (3.20 pages) per scientist per year. If, however, allowance is made for the fact that BIOMASS only really got underway in 1977 and that it can reasonably be assumed that a two-year "lag or lead" time accompanies each individual scientist's productivity, then mean production per scientist (from 1979) increases to 0.23 reports (4.66 pages) per annum. These values are somewhat lower than the 0.53 report and 7.40 page per year national average reported by Siegfried (1987) for SA marine scientists as a whole during the period 1980 to 1985. Considering senior authors alone for the period from 1979 onwards, however, produces a mean productivity level (0.45 reports, 6.23 pages) much closer to the national average. Furthermore, the nine most productive scientists (i.e. with 20 or more published reports each) exhibited an average of 2.25 reports per scientist per year. This is slightly in excess of the 1.93 report per year average obtained by Siegfried (1987) for senior South African marine scientists. Given the longer time period (12 years) of the current compared to Siegfried's review (5 years), then the levels of sustained productivity indicated above appear significant, particularly in view of the restricted group of publications on which they are based.

DISCUSSION

The results of this literature review clearly illustrate the profound effect that BIOMASS-related research has had on SA Antarctic science. There is little doubt that association with BIOMASS has promoted a sustained level of scientific productivity as evidenced by the number and publication rate of the scientists most closely involved (i.e. the provisions of Criterion A in Table 2 is met). Furthermore, the standard of a significant number of the publications produced, as exemplified by the number of papers appearing in science citation listed publications, is strong evidence for the "promotion of excellence in self-initiated research".

Secondly, BIOMASS-related initiatives have certainly been instrumental in the creation of new expertise nationally (Criterion B). In particular, this is demonstrated by the proportionately large number of published reports dealing with birds and krill. Not only can BIOMASS be seen to have markedly influenced the direction and scope of ornithological research in SA over the past 10 years or so (cf Siegfried and Bosman 1987), but it should also be noted that no national expertise on krill existed prior to the programme's inception.

The development of acoustic techniques by BIOMASS to as-

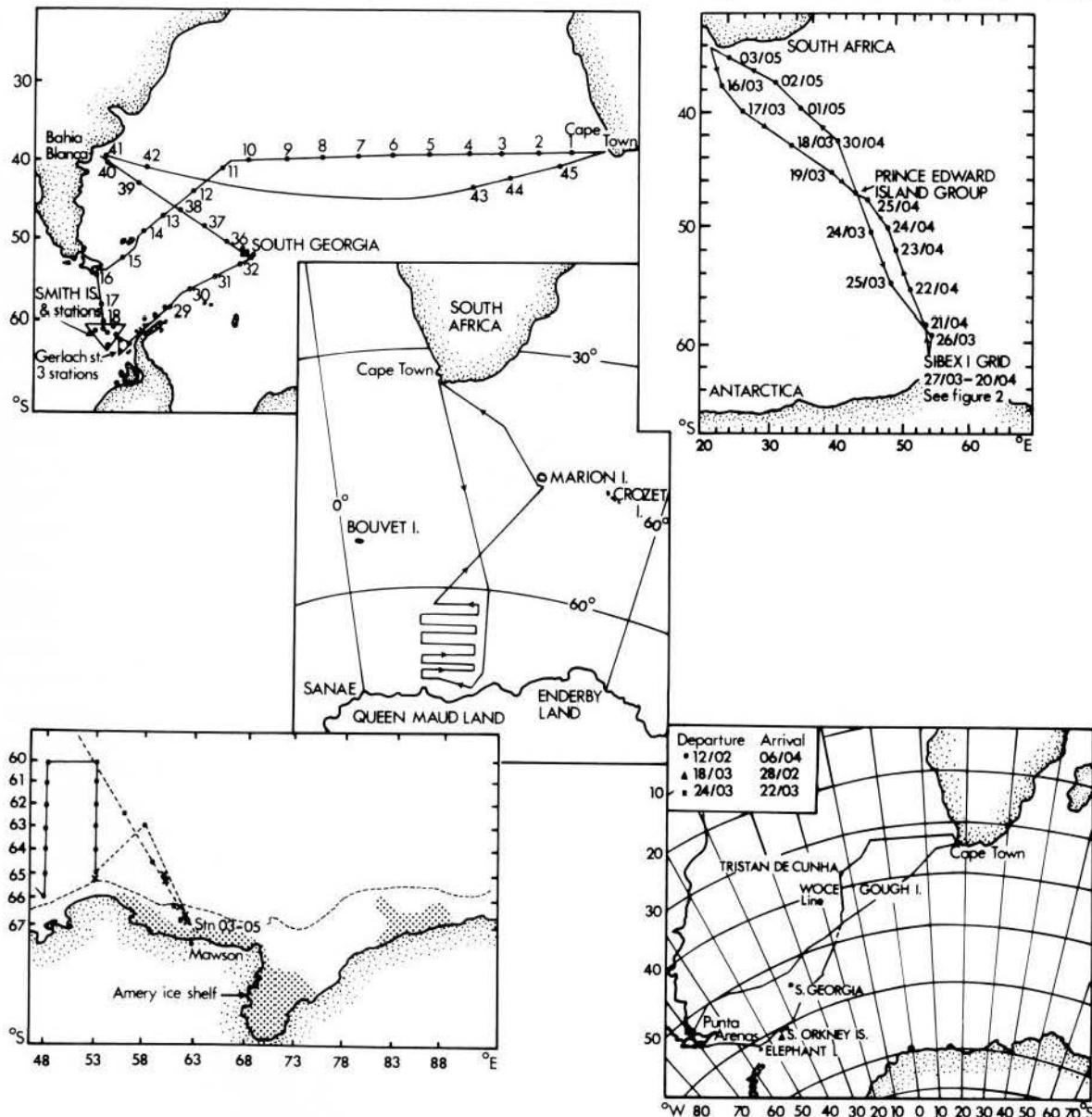


Fig 5 Tracks of five South African research cruises undertaken during national participation in BIOMASS

TABLE 2. CRITERIA APPLIED TO EVALUATE THE PERCEIVED BENEFITS OF RESEARCH ARISING FROM SOUTH AFRICA'S INVOLVEMENT IN BIOMASS, BASED ON SIMILAR CRITERIA USED BY THE SOUTH AFRICAN NATIONAL ANTARCTIC RESEARCH PROGRAMME (SANAP)(AFTER ANON 1987)

- A Perceived value of BIOMASS-initiated programmes within national research priorities, especially the promotion of excellence in self-initiated research;
- B Contribution of such programmes to the creation of new expertise, especially (i) the provision/maintenance of specialised facilities in national laboratories, and (ii) the development of trained manpower;
- C Fostering of both national and international liaison, through (i) the transfer of expertise/technology via national/international collaboration, (ii) ensuring relevance (both national and international) in research, and (iii) fostering national/international collaboration;
- D Facilitating the launching of special research programmes in neglected, emergent or strategically important fields, and
- E Serving decision-makers with the best possible scientific advice available.

sess krill abundance and distribution has also certainly impacted on local efforts to assess marine resources, especially pelagic species, using similar techniques (*cf* Cram *et al* 1979). Furthermore, BIOMASS's fundamental contribution to the setting up of the CCAMLR's principal objectives (*cf* Knox 1984) has meant that SA scientists have been well placed, as a result of their involvement in BIOMASS, to make a significant contribution to the development of a scientifically based management plan for Antarctic marine living resource exploitation (*cf* Miller 1991). In these terms, BIOMASS has undoubtedly facilitated research in both emergent and strategically important fields (Criterion D).

Finally, BIOMASS's collaborative nature has certainly facilitated the integration of SA research in the Antarctic Criterion C. There is no doubt that the combination of both fundamental scientific dialogue and enhanced organisational skills resulting from five specially designated cruises to various parts of the Antarctic (Fig 5) improved the standard of scientific advice on Antarctic issues provided to SA decision-makers in recent years. Not only has this resulted in the final SANARP criterion (Criterion E) being met, but it has provided a useful foundation on which strategic planning for future SA scientific endeavour in the Antarctic has come to be based (*cf* Anon 1987).

It must be concluded therefore that BIOMASS has had a profound influence on SA Antarctic science as a whole. Conversely, it is hoped that involvement by South Africans in BIOMASS's organisational structures and planning, its data collection and analyses and its logistic support has been equally beneficial. Given the prominent role that South Africans are perceived to have played in BIOMASS, the commissioned review published by Miller and Hampton (1989) being an obvious example, this would certainly appear to be true.

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