PROGRESS AND PROSPECTS OF ORNITHOLOGICAL RESEARCH WITHIN BIOMASS

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Abstract: Orinithological research in the Antarctic and sub-Antarctic regions is carried out at sea and on land. This research is constrained by a number of factors. These constraints are examined in relation to the objectives of the BIOMASS programme. More particularly, the aims and scope of BIOMASS-related avian research are reviewed, and an assessment is made of accomplishments during 1977–1981. Prospects for BIOMASS-related ornithological research in 1982–1986 (the second half of the BIOMASS period) are examined.

1. Introduction

Seabirds play important ecological roles in the functioning of terrestrial and marine ecosystems in the Southern Ocean region (SIEGFRIED, 1982; CROXALL, 1983). They constitute a major class of predators potentially or actually competing with man and certain other animals, such as whales, for food resources. For instance, the sum of direct and indirect consumption of krill (*Euphausia superba*) by seabirds may reach 115 million t, which is slightly larger than the consumption by whales and two-thirds the consumption of seals calculated by similar methods (CROXALL, 1983).

The need for more refined assessments of the impacts of seabirds on the main potentially exploitable resources (krill, squid and fish) of the Southern Ocean, and the influences that the distribution and abundance of these resources exert on the dispersion and demography of their avian predators is very relevant to the aims of the BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) research programme. Thus, in 1978 the BIOMASS Working Party on Bird Ecology was constituted with the following terms of reference:

1) To organize an international survey of Antarctic seabirds (ISAS), aimed principally at krill-eating Adélie (*Pygoscelis adélie*) and Royal/Macaroni (*Eudyptes chrysolophus*) penguins;

2) To recommend ecological studies and long-term monitoring (including population dynamics and trophodynamics) of selected Antarctic seabirds at certain locations;

3) To recommend standard observational and experimental procedures for studies of Antarctic seabirds; and,

4) To advise on the conduct of ornithological activities related to the objectives of BIOMASS.

This report summarizes general progress of BIOMASS-related ornithological research during the last five years, and reviews prospects for the remaining five years (1982–1986) of BIOMASS.

It should be noted that the BIOMASS Working Party on Bird Ecology does not direct research projects. Rather, it functions to initiate, plan and stimulate avian research programmes within the scope of BIOMASS (see BIOMASS Report Series 8, 18 and 21). The actual research work is directed by individual national organizations participating in BIOMASS with the assistance of the Working Party's advice on coordination of effort, involving mainly standardization of observations and analyses of data. In this context, the Working Party's services to the BIOMASS community include three handbooks on field methods (BIOMASS Handbook, 18, 19 and 20) and a report on preliminary data analysis of observations of seabirds at sea during FIBEX (First International BIOMASS Experiment) (BIOMASS Report Series, 22). Major compilations currently in production deal with: distribution and abundance of Antarctic and sub-Antarctic penguins–a synthesis of knowledge; inventories of standard body-weight data for Antarctic and sub-Antarctic seabirds; and, bibliographies of scientific literature on penguins and other Antarctic seabirds.

The main objectives of present research programmes are:

1) Assessment of the impacts of seabirds on the main resources (krill, squid and fish) for the Southern Ocean generally and for certain local areas in particular;

2) Investigation of the extent to which seabirds at sea can be used as indicators (predictors) of the distribution and abundance of the main resources; and,

3) Assessment of the extent to which data on breeding numbers and success of selected species of seabirds at chosen sites may be used to indicate changes in the abundance of marine resources and especially those resulting from commercial exploitation.

The approaches to these objectives involve a variety of research projects, based both on land and at sea and combining both intensive and extensive studies, which are reviewed briefly below.

2. Impact of Seabirds on Marine Resources

Although preliminary attempts have been made to assess this for the Southern Ocean generally (MOUGIN and PRÉVOST, 1980; PRÉVOST, 1981), it is clear that parts of the data base and some of the methods used were inappropriate. Fresh attempts should be based on clearly identified and referenced empirical foundations and ideally should commence with smaller well-known areas before making broad generalizations and extrapolations.

In estimating the impact (*i.e.* the food consumption) of seabird populations certain information is fundamental.

2.1. *Numbers and biomass*

Information is best for breeding populations of surface-nesting colonial species, although their wide distribution in often inaccessible areas creates substantial problems in assessing population sizes. Although scientists have given strong support to ISAS, logistical backing (in particular the need to use helicopters and aircraft for photographic surveys) has been inadequate. The outcome is likely to be good to adequate coverage in some areas, but substantial gaps in others. Breeding population estimates for important species (Adélie, Chinstrap (*Pygoscelis antarctica*) and Macaroni/Royal penguins) for the Southern Ocean as a whole are not likely to be of high accuracy, but for some local areas (*e.g.* Prince Edward Islands, South Georgia, South Shetland Islands, Ross Sea) there is a reasonable expectation of good results.

From existing ISAS findings, it is clear that previous assessments of Adélie penguin populations were considerable overestimates and the total breeding population is unlikely to exceed 10 million pairs. In the Scotia Sea, Chinstrap penguins considerably outnumber Adélie penguins and are undoubtedly the single most important avian consumer of krill there.

There is little reliable information for population sizes of burrow-nesting seabirds. For sub-Antarctic islands, even estimates of the area covered by each main habitat and the determination of breeding densities of the burrowing petrel species in these habitats would represent a major advance, and programmes of this nature are under way at Iles Crozet, Prince Edward Islands and South Georgia. Farther south, where cliff and crevice nesters predominate, the problem is even more intractable and compilation of inventories of known breeding sites, together with any information on colony size, is an essential first step.

Most Antarctic seabirds are long-lived and show considerably deferred sexual maturity. Thus, non-breeding birds form an important part of the whole population. Their numbers can really only be estimated from the demography of the population, as expressed in the form of life tables. Such information is only presently available for Emperor (*Aptenodytes forsteri*) and Adélie penguins and three albatross species. Some demographic information is now available for most Antarctic seabirds (see CROXALL, 1982a) and rough approximations of non-breeding stocks could be made for some of these. However, results from many long-term studies have never been published, and data on at least age of first breeding, survival to this age and survival of breeding adults should be provided as soon as possible.

Data on body weight are being compiled by the Working Party on Bird Ecology, and mean values for the Southern Ocean and regions thereof for each species will be published in the near future.

2.2. *Diet*

Published results of detailed quantitative analyses of the stomach contents of an adequate sample of specimens are only available for 13 species (CROXALL, 1983). All but two of these relate to studies in the Scotia Sea, and all refer to birds sampled at their breeding sites. Further detailed information is required, especially for the Indian Ocean and the Ross Sea, and also for petrels generally. Without accurate knowledge of diet composition, assessment of impact on prey stocks will be highly speculative. In addition, information on birds collected at sea, and in particular during the winter months, is urgently required.

A forthcoming report on Ross Sea seabirds (AINLEY and O'CONNOR, 1983) contains quantitative data on diets of seabirds taken at sea. There are, nevertheless, adequate samples (>20) for only three species. These show important differences from the same species in other areas, and emphasize the need for local studies of seabird impact to have dietary data from their own areas.

The very few determinations of assimilation efficiency of Antarctic seabirds conform to the generally accepted value of 75%.

2.3. Bio-energetics

No published empirical determinations of adult resting metabolic rate are available for petrels, and data for penguins are only just adequate. Fortunately, data from other sources (*e.g.* CROXALL, 1982b) indicate that theoretical equations are reasonably applicable to petrels and penguins, although further confirmation of this would be highly desirable.

Data on energy costs of flight and swimming are of crucial importance and published information is available only for the King penguin (*Aptenodytes patagonicus*) (KOOYMAN *et al.*, 1982), although two other pilot studies have been made. Now that techniques exist for estimating these costs, it is vital that studies should be undertaken. No studies on growth energetics of Antarctic seabird chicks have been published, although some field studies have been made. Fortunately, the amount of food delivered to chicks can be estimated if meal size and feeding frequency is known throughout the rearing period. Such data are available for several species from at least one site but further information of this type is needed, since these direct measures are probably more relevant to impact assessment than are metabolic data.

2.4. Activity budgets

Knowledge of the duration of attendance periods ashore is clearly basic to the construction of activity budgets, but for proper interpretation of at-sea bio-energetics, a more detailed breakdown of activities is also required. For most birds, time spent resting and flying (and ideally, flying sub-divided into gliding and flapping) is adequate, but resting, swimming and diving durations are required for penguins. Such studies are only just commencing, and would be greatly enhanced by the development of appropriate telemetric techniques and remote-recording devices.

2.5. Area of impact

Realistic assessment of the impact of birds as predators on marine resources depends on knowing where they feed. Without extensive deployment of telemetric equipment or extensive observations at sea of individuals of know status, this cannot easily be answered directly.

A maximum foraging range for breeding birds during incubation and chick-rearing can be defined by knowing the duration of trips to sea at these times. A more realistic estimate can be made, especially during chick-rearing, if the relationship between actual flight pattern and straight-line distance covered is known. So far, such data are only available for seven seabird species (PENNYCUICK, 1982). Only by using remote-recording devices or through direct observation are data on non-breeding birds and all birds in the non-breeding season likely to be acquired. Extensive information from pelagic observations, of species' distribution patterns at all times of the year, coupled with detailed information from the previous section, may be of considerable help in defining the limits of areas of the principal impact of particular seabird species and associations.

3. Pelagic Seabirds as Indicators of Distribution and Abundance of Marine Resources

Research is directed mainly at attempts to establish significant correlations between the dispersion of birds and particular oceanic biotopes and features (*e.g.* frontal systems). In theory, this should allow seabirds to be used as environmental integrators and predictors of certain resources. One major constraint, however, is the paucity of information on the diets of the birds during the non-breeding, pelagic, phase of their life-histories. A second problem is the difficulty of observing penguins (the main avian consumers of krill) in the open ocean away from their breeding sites. Although preliminary attempts at broad-scale correlations between seabird distributions and oceanic biotopes have not been particularly successful, there are indications that at smaller scales more predictable relationships may be detectable.

4. Environmental Monitoring Studies Using Seabirds

Data, collected over a series of years, on the breeding numbers and success of selected seabird species, may play an important part in monitoring environmental changes and especially those consequent on commercial exploitation of marine resources. The SCAR Bird Biology sub-Committee originally established the framework for a comprehensive monitoring scheme involving selected species and locations and outlines of suitable methodology. Currently, monitoring programmes involve seven species at seven sub-Antarctic and two Antarctic sites (see BIOMASS Report Series, 18), and work is in hand by the Working Party on Bird Ecology to improve techniques and methodology and, thus, enhance the accuracy of the records so that significant changes may be detected more easily.

5. SIBEX (Second International BIOMASS Experiment) Seabird Research

Despite the original BIOMASS objectives emphasizing energy flux through food chains and the contribution of krill to the dynamics of its predators, studies of predators have hitherto been subordinate to research on physical and biological oceanography and on the distribution and abundance of krill. If these priorities are maintained it is important to continue: to obtain detailed information on the spatial and temporal distribution of seabirds, their species diversity and biomass; to investigate what correlations exist between the distribution of birds at sea and features of the physical and biological environment; and, to determine whether seabirds can be used as indicators of the distribution and abundance of selected prey stocks, especially krill and cephalopods.

To acquire sufficient good-quality data to address these aims, it is essential to have continuous recording (by specialist ornithologists) of seabird data, concurrent with the recording of information on oceanographic conditions and plankton distribution and abundance. This will require two specialist ornithologists per cruise; and at least three ten-minute seabird observation cards should be completed per hour while detailed marine research is in progress. In addition, it is becoming increasingly important: to give particular attention to the above relationships for periods outside the breeding season of Southern Ocean seabirds; to obtain quantitative information on the composition of the diet of seabirds sampled while at sea; and, to assess the feeding range of seabirds foraging from their breeding islands.

The first of these requirements is important, because of suggestions that, amongst Antarctic seabirds, the greatest inter- and intra-specific competition for food may occur in winter, when resources are either reduced in abundance or are less available. It is also possible that at this time depredation by seabirds may have a more significant impact on the "over-wintering" populations of prey species, such as krill. The second requirement includes systematic collection of birds for analysis. This necessitates the use of inflatable boats. While sampling could be carried out while "stations" are being operated, it would not be compatible with, for example, acoustic transects and trawling. Thus, specific periods would need to be allocated to ornithological sampling.

Assessment of the feeding ranges of breeding seabirds by direct observation is only possible if there are available for observation at sea sufficient individuals which can be recognized as of known breeding status. This requires a substantial marking programme (use of dyes, colour rings, etc.) for a variety of species, to be developed at breeding sites within the appropriate vicinity of areas of SIBEX activity.

If research under the auspices of BIOMASS is expected to address questions of energy flux and predator-prey interactions in Southern Ocean marine systems, then, we feel that, a major programme like SIBEX should give a lead in these respects. There is a real need, and unrivalled opportunity, for a detailed study of physical and biological oceanographic dynamics within the foraging range (say 100 km) during their breeding seasons of the main avian and mammalian predators on krill. This should be complemented by simultaneous research at breeding colonies (and also at sea) on the diet of these species, incorporating detailed analyses of the size, frequency and sex of krill (and other main prey) for comparison with the results of net hauls. The objective of the research should be to investigate the dynamics of the most productive regions of the Southern Ocean system, with the emphasis on fairly fine-scale sampling permitting accurate assessments of standing stock and study of the rapid changes characteristic of such areas. Attention should, therefore, be directed to shelf-slope areas and major frontal systems, particularly the Antarctic Divergence. Research areas should be selected to complement existing or projected research at land-based sites and obvious candidates are the Bransfield Straits (near South Shetland Islands) and the Ross Sea and the vicinities of Elephant Island, South Orkney Islands, South Georgia, Prince Edward Islands, Crozet Islands and Prydz Bay.

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