ARCTIC BANDING OF MID-CONTINENT SNOW GEESE, 1977-1987:

A TIME FOR DECISION

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ABSTRACT

Lesser Snow Geese are the most numerous geese in the world. Birds from the population breeding in the eastern Arctic of Canada migrate through mid-continent North America and form an important recreational resource for people in both Canada and the United States. They also provide an important food source and cultural component for native people of Canada. During the past seven years harvests in North America have approached 500,000 annually. Eastern Arctic Snow Geese have the potential to provide even more recreational opportunities. However, presently used data bases are soft and cannot be applied to innovative management strategies. Increased recreational benefits can only accrue from increased accuracy and precision in estimated population parameters. Failure to accede to needed improvements will be detrimental to the species and to the future of sport hunting.

To resolve problems associated with use of imprecise measures, a ten-year banding program is proposed. It addresses imperatives outlined in the Mid-continent Snow Goose Management Plan. Eleven objectives are presented. All seek to obtain statistically and biologically sound population attributes. The joint venture amongst the Canadian Wildlife Service; the U.S. Fish and Wildlife Service; the provinces of Manitoba, Ontario and Quebec and states of the Mississippi and Central Flyways will seek to fulfill those objectives by 1987.

In Arctic Canada, helicopter supported banding crews will capture, sex and band samples of each of 16 cohorts in 13 strata. These strata, located on West Hudson Bay, Southampton Island and Baffin Island contain 37, 15 and 42 percent, respectively, of the breeding birds in the mid-continent population.

A pilot banding study will be conducted on West Hudson Bay in 1977 and 1978. Annual estimated costs for the pilot program are $101,000 in 1977 and $111,000 in 1978. Commitments are required immediately for 1977. Analysis of results will form the planning and sampling basis for the comprehensive operational program in the above three regions between 1979 and 1985. A concurrent reward banding scheme will be initiated in 1979 to measure band reporting rates. Annual updates of results will be made to co-operating agencies. The final completion report will be published and distributed in 1987.

During the course of the operational program, annual estimated costs will rise from $413,000 in 1979 to $741,000 in 1985. Grand total costs of the banding, auxiliary breeding population census and recovery analyses will be $4,063,500. Any pooling of strata or cohorts and resultant reduction in banding samples required could reduce the grand total. An additional $250,000 to $1,500,000 will be required to fund the reward banding scheme. Firm estimates will be presented for the operational banding program and reward banding scheme after pilot program evaluation in March, 1979.

The large budget cannot be funded by a single resource agency. Costs will have to be apportioned to all North American users of the resource.

At present, non-integrated programs and fragmented resource allocation lead to distressing and wasteful management approaches. Proposed co-operative programs, designed to pool money and manpower will shift emphases to improving quality of the data base. The shift is mandatory if intelligent judgements and informed decisions are to be made. The degree to which goals, presented in the overall Management Plan, are achieved will be determined by the mix and strengths of all basic population attributes measured.

After a decade a practical and theoretical core of information will be available which applied in the aggregate can only lead to more enlightened management of migratory birds.

What prospects are open after completion of the decadal program? Provided reasonable estimators for all population attributes are determined and simulation models that adequately test the sensitivity of each parameter to goal achievement are constructed, less costly and much lower scale programs should suffice for future quality monitoring. Cost effective programs which either maximize harvests or optimize all recreational benefits will follow.

After thorough review, approval of the banding proposal and objectives contained therein is sought from all potential cooperating agencies. Thereafter, agreement on active participating and long-term commitment of funds should be made. A time for decision.

INTRODUCTION

Lesser Snow Geese (*Anser caerulescens caerulescens*) are the most numerous geese in the world. Several million birds nest in arctic colonies. Two major populations have been delineated. The Eastern Arctic population migrates through and winters in the Central and Mississippi Flyways, and the Western Arctic - Wrangel Island population winters in the Pacific Flyway. The eastern population is four times larger than the western (Figure 1).

Eastern Arctic Snow Geese are a major waterfowl resource within central North America, providing millions of recreation hours for naturalists and hunters. They also serve as an important food source and cultural component for native peoples of the Hudson Bay region. Both sport and subsistence harvests will certainly increase over the next decade. As populations are stressed through increased usage a concommitant need will arise for more precise measures of Snow Goose vital statistics. A better understanding of population parameters will be needed for future resource allocation.

Central and Mississippi Flyway winter inventories indicate that the number of Snow Geese equals the number of Canada Geese (*Branta canadensis* ssp.) and White-fronted Geese (*Anser albifrons*) combined (Table 1). Recently developed photographic inventories indicate an even higher proportion of Snow Geese to other geese, as visual estimates of Snow Geese are conservative. Curtis and Lumsden (Curtis, 1976) estimated 1,650,000 ± 131,000 on the Hudson Bay coast in May, 1973 vs. 1,037,000 enumerated in December, 1972. Similar counts in May 1974, showed 2,109,500 ± 73,000 vs. 1,202,000 in December, 1973. Kerbes (1975) using aerial photography, estimated 528,700 ± 43,600 nests on the breeding grounds in June, 1973 and calculated a July, 1973 population of 3,517,000 birds: 30% breeders, 25% non-breeders and 45% young. In short, visual estimates made on the wintering grounds underestimate numbers of Snow Geese by a factor of two.

Reported harvest estimates for the Mississippi and Central Flyways show annual variations in numbers of geese harvested and proportions of each species retrieved (Table 2). For the 1966-1975 interval, subspecies of Canada Geese composed 43.5 percent of the mean annual harvest while Snow Geese contributed 46.9 percent (Table 2). While Canada Geese remain the primary retrieved species in the Mississippi Flyway, Snow Geese are the leading harvested species in the Central Flyway. Snow Geese are the prime target species in the southern tier of states in both flyways viz., Louisiana and Texas. Proportionally more of the dark morph are harvested in the Mississippi Flyway than in the Central Flyway (Dzubin, Boyd and Stephen 1973; 1975). Overall, mid-continent Snow Geese are an important exploited resource amongst three Canadian provinces (Table 3), five Mississippi Flyway states (Table 4) and five Central Flyway states (Table 5, Figure 2).

Photographic inventories have revealed that the Central and Mississippi Flyways winter twice as many Snow Geese as all other geese combined. Snow Geese are an important target species in both flyways. Adequate management of this species should reflect a similarly high proportion of expenditure on research and surveys for the species. The reverse is true. At present, the effort being directed at Snow Goose management is only a fraction of that aimed at other geese.

The disproportionate expenditure has resulted in a data base that is not adequate for defensible management of Snow Geese. The Joint Mississippi/Central Flyway Snow Goose Subcommittee has recognized the problem and has formulated a Mid-continent Snow Goose Management Plan (Bateman, 1977). The proposed banding program forms an integral part of the Management Plan.

THE NEED FOR ACTION

The need to improve the biological data base for Lesser Snow Geese has been discussed in detail by Boyd (1975). Dzubin et al., (1975) after completing an indepth analysis of all available Lesser Snow Goose banding data from 1952-71, concluded "Knowledge of basic population parameters for blue and snow geese remain unsatisfactory for the formulation of sound management practices and rational exploitation policies". Analysis of 17,500 recoveries from 121,000 bandings defined apparent changes in temporal distribution of harvest but did not give firm answers to allegations that interrupted migrations in northern states were reducing recreational opportunities in Gulf states because historical banding:

1. samples were too small or not representative;
2. was not done for enough consecutive years at most of the large colonies;
3. was not done simultaneously at all major colonies;
4. techniques (massive ground drives) had harmful side-effects which may have increased mortality, disrupted family groups, and affected distribution.

There has been no significant Snow Goose banding on the major colonies since 1971. Should population or management crises arise in the future, questions to be answered will be more profound than those forwarded by the Joint Mississippi/Central Snow Goose Subcommittee in 1972 (Appendix I), yet waterfowl managers will have a paucity of information to work with. A pre-planned banding program would provide a significant portion of the required data base.

Good estimates of cohort mortality are required to monitor trends in harvest. Lesser Snow Geese are considered to be underharvested and efforts to increase kill in Canada have been successful. There are pressures to maximize recreational opportunity elsewhere. Continuation and projection of these trends must be accompanied by studies of mortality rates in order to adjust harvest strategies appropriately and safeguard this international resource.

The proposed banding program is designed to monitor population stability and results will be used to detect changes in survival of a variety of cohorts from a number of strata that may be altered by future environmental changes. Climatic cooling at Southampton and Baffin Islands, possible overgrazing at West Hudson Bay colonies, and oil and mineral exploration at all regions could have detrimental effects on Eastern Arctic Snow Geese. The direction of world climatic change has been widely debated in recent years and there remains disagreement whether long term trends are for cooler or warmer climate. A recent model of future climate, which ignores anthropogenic effects, has been proposed by Hays, Imbrie and Shackleton (1976). They predict that the long term trend is toward extensive Northern Hemisphere glaciation and cooler climate. Bradley and Miller (1972) provided evidence for a trend toward cooler and shorter summers in the Southampton and Baffin Island regions. This cooling trend could reduce or perhaps eliminate successful nesting on these regions. West Hudson Bay colonies are not presently threatened by deteriorating climate, however, they may be affected by over-population of Snow Geese. Kerbes (1975) calculated that the West Hudson Bay region was much closer to its theoretical carrying capacity than were the

Southampton or Baffin regions. Recent studies of Snow Geese and their nutritional sources at the McConnell River colony (Figure 1) suggest that geese may be over-grazing the available food supply (Lieff, 1973; MacInnes and Ankney, pers. comm.). Furthermore, there is indirect evidence suggesting that Lesser Snow Geese from one or more eastern Arctic colonies are operating on a reduced nutritional plane. Tail fans of immature and adult Blue and Snow Geese harvested in Manitoba during 1975 and 1976 had significantly shorter rectrices than Blue and Snow Geese shot in other prairie provinces (Brace, Smith and Dzubin, 1976; Smith, pers. comm.). Prior to 1975, plumage characteristics of Lesser Snow Geese shot in Manitoba were identical to those of Western Arctic Lesser Snow Geese shot in western Saskatchewan and Alberta (Dzubin, pers. comm.).

If cooling results in reduced gosling production on Southampton and Baffin Islands, more accurate population measures will be required to manage the remaining major West Hudson Bay region. Similarly, if the West Hudson Bay colonies crash, Southampton and Baffin Island regions will require close monitoring in order to safeguard remaining Snow Goose stocks.

All three regions are threatened by adverse environmental effects from human activities related to exploiting eastern Arctic petroleum and mineral resources. Banding and associated studies are required to monitor status of Snow Geese on a stratum, colony, and regional basis.

Information on temporal and geographic distribution of harvest is required to monitor harvest trends and to assess shifts in harvest patterns due to changes in Snow Goose distribution. Autumn distribution of migratory birds is regulated by climatic and other environmental factors, and recent man-made alterations to the environment have resulted in significant redistribution of Lesser Snow Geese. Current banding and harvest questionnaire data are not precise enough to evaluate apparent changes in harvest patterns associated with changes in autumn distribution of geese. A quality banding program is needed to assess changes in harvest patterns.

Unresolved native land claims circumscribe much of Arctic Canada. These claims may involve areas occupied by goose colonies. Furthermore, agreements which will guarantee specific levels of subsistence harvest of geese will be negotiated over the next decade. Native harvest estimates generated from questionnaire surveys could be biased or inaccurate. The proposed banding program would permit corroboration of harvest estimates derived from questionnaires. Data concerning hunting mortality and non-hunting mortality are needed to prevent granting of non-sustainable quotas that might be detrimental to the Snow Goose resource, and consequently detrimental to sport hunting in Canada and the United States.

Wildlife managers in the United States and Canada are accountable to anti-hunting groups. Current Snow Goose literature (Sherwood, 1970; Dzubin et al., 1975; Boyd, 1975; Boyd, 1976a) contains numerous statements which point out short comings in our understanding of Snow Goose population dynamics. Lack of knowledge endangers future sport hunting. The proposed banding study will provide part of the data required to measure the effects of sport hunting on Snow Goose populations. The development of good temporal and geographic harvest estimates will permit the formulation of rational and defendable Snow Goose hunting regulations. Techniques developed during the study can be applied to other species.

The proposed study will not only increase our knowledge of Lesser

Snow Geese, but will also address several fundamental and presently unresolved problems facing migratory bird management. The relationship between hunting and non-hunting mortality and the effectiveness of reward banding in measuring reporting rates will be studied. Techniques and programs developed during the Snow Goose study will increase the precision of migratory bird management as a whole.

An additional justification for the proposed study concerns the development of an avenue for cost-shared migratory bird programs involving Canada and the United States. Migratory birds are an international resource and their future well-being is dependent upon an enlightened approach to migratory bird management.

Expenditures of the magnitude proposed are not inconsistant with past funding levels. Canadians have spent $1.1 million on Snow Goose breeding ground research during the past decade (Boyd, 1975). Snow Goose management and research costs in the United States are unknown, however, they are known to exceed Canadian expenditures. The Canadian Wildlife Service has supported several significant graduate student research projects (Cooke and Mirsky, 1972; Finney, Cooke, Ryder and Seiger, 1972; Prevett, 1972; Lieff, 1973; Ankney, 1974; Harwood, 1974; Finney, 1975; Cooke, MacInnes and Prevett, 1975), and presently provides approximately $35,000 annually to breeding ground studies at La Pérouse Bay and McConnell River, however, Canadian programs for the most part have been piece-meal. Wintering ground and migration staging area programs funded by United States agencies are also of limited value and cannot solely be used to formulate the basis of long-term population management strategies. Wintering ground bandings are of questionable value as geese banded are of unknown origin and banded samples represent a mixture of geese from several colonies (Smithy, Martin and Walthers, 1972). Cooke et al., (1975) showed that the winter range of each breeding colony extends over a considerable expanse of Gulf coast, overlapping with those of other colonies. They also showed more genetic exchange between colonies, clarifying Cooch's (1961) earlier conclusions. Furthermore, winter inventories bear critical examination. Results of winter aerial surveys of Snow Geese have been proven to be misleading (Kerbes, 1975). Neither Canadian nor United States Snow Goose programs can be considered adequate for overall population management. Long-term goal oriented programs must be developed to determine and monitor Snow Goose status in order to identify the most sensitive population parameters. The costs appear substantial, however, considering current rates of inflation, the approximately four million dollars required for the proposed program represents less than the amounts spent by North American taxpayers on Snow Geese during the past decade. The proposed program will finally provide managers with precise measures of population characters essential for rational management of this migratory bird resource.

SNOW GEESE IN THE EASTERN CANADIAN ARCTIC

Cooch (1961; 1963) suggested that there had been no major changes in colony size or abundance of Snow Geese on Southampton and Baffin Islands between 1929 and 1960. These regions have remained relatively stable. However, since the early 1960's the more southern colonies at Wolf Creek, McConnell River and Cape Henrietta Maria have expanded significantly.

Kerbes (1975) used vertical aerial photography to obtain the first accurate baseline inventory of the distribution, numbers, and color ratios of Snow Geese nesting in the eastern Canadian Arctic (Table 6, Figure 1). He estimated a total of 1,057,400 nesting adult birds in the population in June, 1973, distributed as follows:

1. Baffin Island Region, containing 42% of the total population; in the large colonies at Bowman Bay and Koukdjuak River, connected by the smaller colony of Cape Dominion.
2. Southampton Island Region, containing 15% of the total; primarily in the large colony at Boas River.
3. West Hudson Bay Region, containing 37% of the total; mainly in the large colony at McConnell River.
4. South Hudson Bay Region, containing 6% of the total; mainly in the colony at Cape Henrietta Maria.

The colonies of Baffin Island and Cape Henrietta Maria had a color phase ratio of 80% to 40% blue, while the colonies of Southampton Island, West Hudson Bay, and La Pērouse Bay all had from 20% to 30% blue phase.

Dzubin et al., (1975) divided the population into an "eastern stock", consisting of Baffin Island and Cape Henrietta Maria and a "western stock" consisting of Southampton Island, West Hudson Bay and La Pērouse Bay. Since 1971, annual summer banding has been done only at La Pērouse Bay and Cape Henrietta Maria. Although those colonies are representative of the distribution patterns of the western and eastern "stocks" respectively (Dzubin, et al., 1975), they are too small and are located too far south to safely represent the annual mortality and natality or the growth of the entire stocks. La Pērouse Bay has one hundredth the population of West Hudson Bay and Southampton and it is almost 400 miles south of Southampton, while Cape Henrietta Maria has one tenth the population of Baffin and it is almost 800 miles south of Baffin (Kerbes, 1975). A significant banding program must operate in each of the three main regions - West Hudson Bay, Southampton Island, and Baffin Island (Figure 3). The ongoing banding program at La Pērouse Bay and Cape Henrietta Maria should continue during that period, so that further comparisons can be made to determine the representative validity of the southern colonies.

The sedge lowlands used for brood-rearing are vast, extending for 150 miles on Baffin Island (Kerbes, 1975). Brood movement is extensive, however, dispersal is not random and subpopulations may exist (Cooch, 1958; Prevett, 1972; Lieff, 1973; MacInnes and Ankney, pers. comm.). Banding will occur throughout major colonies in order to determine if subpopulations differ in migration patterns and survival rates. Colonies have been stratified (Figures 4, 5 and 6) and banding will be conducted in each stratum to test for inter-area variation.

BANDING OBJECTIVES

Desirable objectives:

1. To determine annual survival rates, within a precision of ± 5% for a maximum of 12 adult color and sex cohorts and ± 10% for a maximum of four immature color and sex cohorts in a maximum of 13 strata (Seber 1970; 1973).

2. To determine annual survival rates, using capture-recapture techniques, and to relate these to the above estimates (Brownie, Anderson, Burnham and Robson, 1976).

3. To determine temporal and geographical distribution patterns of band recoveries at a high level of precision, using standard leg bands in conjunction with reward bands, and to relate harvest patterns and harvested numbers.

4. To precisely relate major harvest areas with colony origins of banded birds, by plotting recoveries by latitude and longitude and weighting results with measured band reporting rates calculated from a reward banding study.

5. To measure the extent and magnitude of inter-colony movements of age and sex cohorts, using recapture techniques.

6. To attempt measures of the size of the mid-continent population, using band recovery and harvested numbers (Boyd, 1976b).

7. To determine direct band recovery rates and relate annual differences to harvest pressure and changes in regulations (Brownie *et al.*, 1976).

8. To calculate relative recovery rates between age and sex cohorts and dark and white morphs.

9. To determine the proportion of the annual mortality due to hunting and to non-hunting causes, using results of a reward banding scheme.

10. To document any shifts in migration corridors and to document any "abnormal" delays in temporal patterns of movement, by relating band recovery patterns to meterological and environmental factors.

11. To determine the proportion of the population that is harvested, i.e., recovery rate/reporting rate, using results of a reward banding scheme (Henny and Burnham, 1976).

Adjunct objectives:

12. To determine photographically abundance and distribution of nesting birds on each of 13 colonies in 1979, 1982 and 1985 and four colonies in 1977 and 1978.

13. To determine more precisely, crippling losses areally and temporally.

14. To estimate natality or recruitment rates annually from each colony, using visual or photographic surveys (Lynch and Singleton, 1964; Hanson, Lumsden, Lynch and Norton, 1972).

15. To mathematically model colony and population dynamics, using estimated attributes. Simple simulation models, incorporating components of weather, predation, abundance, age structure, physiological state, food availability, native harvest, sport harvest, survival, recruitment, and emmigration will be constructed.

Attainment of banding objectives will not fulfill all goals outlined in the Management Plan. Coincident improvements in harvest, recruitment and abundance estimators must follow. It becomes apparant that the complexities of mid-continent Snow Goose management can only be unravelled and addressed through constructing open-ended, dynamic systems models (Watt, 1968, Walters and Gross, 1972). Simulation studies which test the validity of presently applied practices and which explore consequences of innovative strategies on harvesting policy should be part and parcel of future thrusts. Parameters which are found to be most sensitive to creating oscillations or inducing positive changes in the model should be defined and pursued. Such sensitivity tests can only lead to optimizing allocation of funds for future management efforts and serve as guides to the precision required of each estimator.

PROTOCOL

1. The banding program is to be a co-operative joint venture of the Canadian Wildlife Service; the U.S. Fish and Wildlife Service; the provinces of Manitoba, Ontario, and Quebec and the states of the Mississippi and Central Flyways. Hereafter, the aforementioned agencies will be referred to as the co-operating agencies. The Northwest Territories Fish and Wildlife Division, Queen's University, the University of Western Ontario, James Bay Development Corporation, and Inuit Tapirisat of Canada will be associate co-operators.

2. Prior to, and during the arctic banding operations, close liason will be maintained with residents living near the banding regions. The Inuit will be fully advised of all plans and basic approval by Inuit representatives will be requested before any field operation begins.

3. All bands are to be assigned to the Surveys Coordinator, Research and Surveys Section, Western and Northern Region, Canadian Wildlife Service, Saskatoon, who will be designated chief permittee. All bands will be re-issued to leaders of banding crews who will be responsible as subpermittees for placing and recording the bands correctly and submitting appropriate forms.

4. A Canadian Wildlife Service representative is to lead each crew. Crews will be composed of knowledgeable biologists and technicians from co-operating agencies. Suitably qualified non-agency biologists or Inuit may be hired on contract to complete crews.

5. Funds to cover expenses of the field banding operations, analysis of recoveries, and the reward banding scheme, are to be provided by the co-operating agencies, according to a mutually acceptable pro rata agreement.

6. The Wildlife Management Institute, Washington, D.C., will be the designated institution for payment of invoices for expenses of banding and analyses incurred in Canada.

7. The Canadian Wildlife Service will be responsible for organizing the logistics of the banding operations, including the purchase and positioning of supplies, leasing of helicopters, etc.

8. The Canadian Wildlife Service will determine the details of equipment and techniques to be used in the field operations (see Methods).

9. A field operation committee, chaired by a member of the Canadian Wildlife Service and composed of representatives of the co-operating agencies, will be responsible for planning and reviewing field operations.

10. An analysis committee, chaired by the Surveys Coordinator, Canadian Wildlife Service and composed of representatives of the co-operating agencies plus contracted statistical experts, will be responsible for statistical planning and analyses of the banding and the resultant recoveries. The analysis committee will set annual strata and cohort quotas for banding, and be responsible for detailed annual reviews of the preliminary analyses and for final analyses and the publishing of a completion report. Any and all co-operating agencies will have free access to the banding and recovery results for use in their own analyses - but for management and administrative purposes only. Recapture results will reside with the analysis committee. Formal scientific publication of results will reside with the analysis committee and any designated authors.

11. The analysis committee will provide annual reports to the winter meetings of the Mississippi and Central Flyway Council Technical Committees.

PLANS, METHODS AND REQUIREMENTS

A two year pilot banding program will begin on the West Hudson Bay region in 1977. The major objective of the pilot program is to address and resolve logistical problems associated with banding large numbers of Snow Geese. Following the pilot program, a seven year operational banding program will begin at West Hudson Bay, Southampton Island and Baffin Island regions. The operational program will provide measures of population characteristics essential for sound management of Snow Geese.

Banding Sample Sizes

The banding sample sizes required to fulfill the study objectives are based on numbers of recoveries needed to use recently developed age-specific survival estimating programs. Two programs, the Brownie-Robson (1976) age-dependant program and the Johnson (1974a) survival rate estimating program were considered.

Dr. David R. Anderson (pers. comm.) recommended using the Brownie-Robson program and advised that banding should be conducted for seven years. Following his suggestions, required sample sizes were derived by

Newell and Butler (1977) from chapter 8, Brownie et al., (1976). Newell and Butler (loc. cit.) indicated that the number of bandings required varies with length of the banding program, survival rate, recovery rate and desired level of precision. Average adult survival rate (0.76), average immature survival rate (0.38), and average recovery rate (0.05), were calculated from previous Lesser Snow Goose bandings. Based on recoveries from those bandings, estimation of annual adult survival rates within confidence limits of ±5% (C.V. = 0.025) and annual immature survival rates within ±10% (C.V. = 0.05) at a 95% confidence level, will require banding 1,623 adults and 2,640 goslings annually for each color morph and sex class studied. Johnson (1974b; pers. comm.) examined preliminary Snow Goose banding sample size requirements and concluded that the proposed samples would be adequate to estimate survival using the Johnson method.

To test for differences in recovery patterns and survival rates between various color phases and age and sex classes, it will be necessary to band eight adult cohorts, four yearling cohorts and four gosling cohorts (Tables 6 and 7). Statistically, the number of required bandings then becomes 12,984 adults, 6,492 yearlings and 10,560 goslings annually. Testing for differences between 16 cohorts for five geographic strata identified on each of West Hudson Bay and Baffin Island regions and for three strata on the Southampton Island region will theoretically require banding 150,000, 150,000 and 90,000 geese, respectively during each year of the seven year operational program.

The above sample sizes, although statistically sound, are idealistic, and may not be physically attainable due to:

1. insufficient numbers or absence of certain cohorts in some strata:
2. inability to differentiate between successful and nonsuccessful adults;
3. limitations of available manpower;
4. unforeseen problems, such as long periods of inclement weather, mechanical problems with helicopters, etc.

The banding sample sizes proposed above are tentative and subject to change. They will be modified after preliminary results of the two year pilot program are analyzed and tested.

Pilot Program

The two year pilot study is designed to determine the most efficient methods of banding large numbers of geese, the maximum numbers of geese that can be banded by crews of various sizes, what cohorts can be successfully banded and where future banding effort should be directed. The two year banding study alone will not provide the data required to calculate mortality nor develop sound management practices.

Helicopter supported banding methods will be used exclusively as these techniques have proven to be the most efficient method of capturing representative samples of geese over wide expanses of breeding range. Methods and techniques for helicopter supported banding have been developed and improved by various workers in Canada (Pakulak, Heyland, Kerbes, MacInnes, Finney, Cooke, Barry, Caswell, *in litt.*) and in Alaska (Timm and Bromley, 1976). Equipment and techniques which have proven to be the most efficient in terms of maximizing sample sizes without causing any significant mortality to geese or crews will be used and an effort will be made to develop new and improved methods during the pilot study.

Twenty field-workers and two helicopters will be utilized during the pilot program. The 20 field-workers will be divided into five crews, however, experiments will be conducted to determine optimum crew size, and consequently the size and number of crews might be altered. Distance between captured geese and camp, and cost effectiveness related to shuttling additional crew members versus seeking other groups of geese will be considered in order to develop the most efficient banding situations.

It is estimated that a four man crew can capture, sex and band 1,000 to 1,500 geese per day. Over a 20 day period, five crews operating at West Hudson Bay could conceivably band up to 150,000 geese. The actual number of geese banded will probably fall well short of the statistically desirable 150,000 objective, however, this will not preclude using results of the two year pilot study for planning strategy for the seven year operational program. It must be stressed that the 150,000 number is only essential for precisely measuring survival for 16 cohorts from five different strata over a seven year banding study, and this value is not a minimum measure upon which the success or failure of the pilot program rests.

The pilot study will not only determine the number of bandings physically possible, but will demonstrate feasibility of capturing all cohorts. It may not be possible to capture some cohorts or their small numbers may create a potential for overbanding minor cohorts. The estimated size of each of 16 unique cohorts for each of five West Hudson Bay strata (Figure 4) is given in Table 7. Each stratum will be surveyed at the time of banding to verify the number of geese and proportion of each cohort present. No attempt will be made to band cohorts not adequately represented within a given stratum. For example, if yearling groups are not present on any strata, or if yearlings are not numerous enough to be treated separately, the total number of bandings would be reduced by 33,000. If nest-failed and nonproductive adults join productive groups, it may not be possible to identify the four nonproductive adult cohorts. This would reduce the total banding objective by 33,000.

The pilot project will indicate where future banding effort should be directed. Examination of direct recovery patterns may indicate that certain similar cohorts show no significant differences in temporal and geographic distribution of recoveries. Once the maximum number of bandings physically possible is determined, the above information will be used to pool similar cohorts. Furthermore, there is no published evidence to indicate great differences in distribution from adjacent strata. This assumption must be tested to reduce any biases associated with extrapolating results from localized banding. The pilot study may reveal that similar cohorts from neighbouring strata have identical temporal and geographic recovery patterns, inferring that such strata can be lumped. Pooling similar cohorts and/or lumping strata would greatly reduce the number of bandings required to measure survival during the seven year operational program.

Operational Program

Final banding requisites and improved banding techniques developed during the pilot program will govern the operational program that will be conducted at West Hudson Bay, Southampton Island and Baffin Island regions from 1979 to 1985.

Assuming that pooling of cohorts and strata will reduce required sample sizes, a minimum of 50,000 geese will be banded on each region during each of the seven years of the operational program. These large numbers of bandings will require two helicopters and four crews on each of the vast West Hudson Bay and Baffin Island regions and one helicopter and two crews on Southampton Island.

Banding operations will begin when adult geese enter the flightless period of their annual molt. Although goslings can be banded when they are two to three weeks of age, they will not be banded until three or four weeks of age to minimize potential mortality. On West Hudson Bay they reach that age about 25 July. Goslings begin to fly at about six weeks of age. This gives a three week potential banding period from 25 July to 15 August. The phenology on Southampton Island and Baffin Island is about five to ten days later, giving an equivalent banding period of 1 to 21 August for banding the adults and young. Banding of non-breeding geese can begin in all regions in early July, since they have a synchronous molt throughout the Arctic.

Reward banding

Reward banding is an effective tool used extensively to increase reporting rates in fish tagging programs (Brownie et al., 1976). More recently reward banding has been introduced into continental waterfowl banding studies. Henny and Burnham (1976) used reward bands in conjunction with standard leg bands to measure band reporting rates for mallards (*Anas platyrhynchos*). Boyd (1976a) discussed the urgent need for determining band reporting rates for Lesser Snow Geese.

Reward banding will be implemented in 1979. The number and distribution of reward bands to be applied at each colony will be determined following analysis of data collected during the two year pilot banding study at West Hudson Bay. Ratio of standard bands to reward bands will be based on recovery rates measured during the pilot study. Reward bands will be used to measure reporting rates for all age, sex, and color phase cohorts exhibiting unique recovery patterns.

Ten dollar reward bands were used during the previously mentioned mallard study (Henny and Burnham, loc. cit.). The actual reward to be paid for Snow Goose reward bands will depend upon the finances available for reward banding and determination of number of reward bands that need be applied. Estimated maximum and minimum costs for reward banding, and appropriate assumptions determining these costs are given in Table 8. These estimates range between $250,000 and $1,500,000.

It is acknowledged that reward banding will be expensive, however, it forms an essential component of the study. Five of 15 study objectives depend upon results obtained from the technique, including determination of:

1. temporal and geographic estimates of kill;
2. direct band recovery rates and relating annual differences to harvest pressures and changes in regulations;
3. band reporting rates areally and temporally;
4. annual hunting and non-hunting mortality;
5. the proportion of the population that is harvested (i.e., recovery rate/reporting rate).

Although estimates of reporting rate are not essential for new survival estimating programs, Brownie et al., (1976) pointed out that the use of reward bands with standard bands can result in increasing total number of recoveries by two or three fold, and hence the precision of parameters being estimated can be increased by utilizing reward bands with standard bands.

Capture - recapture methods

Capture - recapture techniques to determine dispersal and population estimators of animals have widespread use, especially within insect and fish groups (Jolly, 1965; Southwood, 1966; Cormack, 1968; Seber, 1973). Their application to the Anatidae has been restricted to survival estimators through leg marking and neck banding individuals on breeding areas and subsequent sightings on localized wintering grounds, e.g., geese, and to recaptures of leg banded ducks on specific molting lakes, e.g., pintails, *Anas acuta* (Anderson and Sterling, 1974). Applying Jolly-Seber methods, Anderson and Sterling (loc. cit.) used recaptures of molting pintails over three years to estimate survival rates and successfully compared those with estimators derived from band recovery data (after Seber, 1970). Although Jolly's methods have been extended by Arnason (1972) and Arnason and Kreger (1973) to stratified sampling operations, they do not include cases for both age - and year - dependant survival (Brownie et al., 1976). Development of new techniques to analyze annual recaptures of previously banded birds could be pursued with Dr. A.N. Arnason, Department of Computor Sciences, University of Manitoba, Winnipeg.

The seven year operational banding program (plus two year pilot at West Hudson Bay) will blanket the three major breeding areas of Snow Geese containing 94 percent of the breeders. Therefore, opportunities will exist to corroborate population, survival and mobility estimators from analyses of annual recapture data over six years.

A confounding factor, to any proposed analyses, is the magnitude of inter - and intra-colony mobility. Because of a historical lack of coincident bandings, the extent of colony interchange is difficult to measure. However, after examining all available recapture data, Cooke et al., (1975) concluded there were sex specific differences in interchange patterns. Generally, female goslings returned to their natal colonies to breed but few males did. Adult females persisted in their high homing rates over years while adult males tended to show higher rates of emigration to other colonies.

As pairing occurs prior to the nesting season and there is considerable overlap of wintering ranges and spring migration corridors of individual colonies, opportunities for inter-colony matings exist. In a heavily hunted population with high chance of pair break up, subsequent re-pairing occurs. Re-paired females show high philopatry and return to their previously used nesting grounds, whereas males accompany new mates to the colony where the female had nested. Cooke et al., (loc. cit.) suggested that in the large McConnell River colony, more widowed males could be expected to remate with McConnell River females. The authors present formulae which could be used to calculate survival rates of both sex cohorts from recapture data, provided certain assumptions were not violated.

Assuming a bare minimum of 50,000 geese are banded annually for seven years in a stable July population of one million (half of them adults) and, if population mortality approaches 40 percent annually, at the end of the seventh year one in eight to ten "adults" might hold leg bands. The number of recaptures in each banding region is, therefore, expected to be large. Such masses of recapture data can provide accurate and precise survival estimators provided that sampling procedures are planned, necessary assumptions evaluated, and sound theoretical techniques are developed.

Auxiliary surveys

Surveys supplementary to goose banding will improve the Snow Goose data base. Two independent surveys are required. A nesting ground photographic survey is needed to measure the size of the successful breeding population, and a recruitment survey is required to estimate the annual production of young in each colony.

At present, there are no survey techniques which provide recruitment data with confidence limits (±10%) comparable to those of the photographic nesting census (Kerbes, 1975). Hanson et al., (1972) have successfully used small format aerial photography to estimate a mean percent young and a mean brood size, however, they did not attempt to calculate confidence intervals for their estimates. It is difficult to measure recruitment on colonies. Gosling to adult ratios can be misleading as nonproductive adults, nest-failed adults, and yearlings sometimes join successful adult-gosling groups. Photographic images of non-breeders cannot be separated from those of successful adults, unless the successful adults and their young are photographed as isolated families.

Hanson et al., (loc. cit.) and Dzubin (in litt.) have demonstrated a relationship between mean brood size and percent young in Snow Goose populations. Hanson et al., (op. cit.) collected brood samples from photographs of limited numbers of isolated families. They also estimated a less useful "mean assumed brood size" from photographs of combined family flocks. The most accurate means of obtaining brood counts is by ground observation, which is impractical for all banding strata.

Methods of estimating recruitment by age-ratio appraisals and brood counts similar to those used on wintering grounds by Lynch and Singleton (1964) should be developed. A suitable technique might utilize helicopter support immediately before or after the banding operation or developed independently through contractual arrangements.

Nesting adults can be censused in June with an aerial photography technique developed by Kerbes (1975). Since the proportion of nesting adults can fluctuate dramatically between years, the photographic census should be conducted at each colony each year of banding. June photography is planned for the West Hudson Bay colonies for both years of the pilot study. Due to budget and manpower constraints, photographic surveys in all three regions will be done only in 1979, 1982, and 1985, during the operational program. Estimated costs for the photographic inventories vary between $60,000 to $100,000 (Table 11).

LOGISTICS AND COSTS

Field operations

Banding will be conducted from base camps containing food and shelter for the crew and fuel and maintainance for the helicopter. Establishing a base is relatively simple when it can be located in an existing village. Less convenient, is establishing a field camp in areas where semi-permanent field shelters presently occur. Least convenient is a tent camp set up in the field where no facilities exist. All three types of camps will be utilized. Each field camp will require a base radio for maintaining communciations amongst banding units and to the "outside". This will ensure operational efficiency and provide safety in case of accidents or grounding due to inclement weather.

Annual costs are given in Table 9 for a single banding unit (i.e., one helicopter and two crews) for each region. These vary from $51,000 on West Hudson Bay to $57,000 at Southampton Island, to $62,000 at Baffin

Island. It will be necessary to have two banding units (i.e., double the cost shown in Table 9) on West Hudson Bay and Baffin Island. The helicopter charter costs given in Table 9 are representative of four passenger jet helicopters such as the Bell 206 Jet Ranger, the Hughes 500, the Allouette II or the Hiller 1100. Helicopters will be chartered on a monthly basis to ensure their availability and to procure cheaper rates. A one-month helicopter charter requires a minimum of 110 flying hours. Since the actual drive trapping will probably not require that much time, any extra hours will be used to reposition fuel caches, collect information on recruitment and conduct population inventories. The greatest proportion of the total cost of banding is referrable to helicopter charter (Table 9).

Logistics become more complicated proceeding south to north. Costs also increase. On West Hudson Bay (Figure 4) the settlement of Eskimo Point is a convenient base located almost in the centre of the banding area. A University of Western Ontario camp at McConnell River could be used as a base for the southern strata. On Southampton Island (Figure 5) Coral Harbour will be used as a base for stratum three. A tent camp will be required for strata one and two (Boas River), some 100 miles west of Coral Harbour. It will be necessary to ferry helicopter fuel by chartered fixed-wing aircraft to the Boas River camp. Fuel repositioning problems are even greater and costlier for Baffin Island as the banding area is approximately 200 miles from Frobisher Bay and 150 miles from Cape Dorset (Figure 6). A building and small airstrip at a Northwest Territories Wildlife Division camp on Niko Island will be used as a base for the northern strata but a tent camp will be required for the southern strata.

Only limited labour costs are given in Table 9, assuming that most banding personnel will be supplied and funded by the participating wildlife agencies.

Band recovery analyses

The detailed logistics of analysis, including computer programming, drafting and publication will be organized by the analysis committee. Annual costs for analysis vary and total $379,500 for the 10 year period (Table 10). Statistical consultation and contractual arrangements with biomathematicians to develop new recapture analysis techniques will be required (Column 7, Table 10). Certain costs can be decreased or eliminated through offers or commitments from participating agencies (see footnotes, Table 10).

Total costs

Total and annual costs for the program, 1977 to 1987, including costs of banding, auxiliary nest census and analyses are summarized in Table 11. The grand total cost is $4,063,500; 84 percent of which is made up of northern banding expenditures. Actual expenditures will be determined by results of the pilot program. Firm estimates will be available in March, 1979.

The estimated costs of reward banding vary from a minimum of $250,000 to a maximum of $1,500,000 (Table 8). These costs will be additional to the grand total of $4,063,500 found in Table 11. The reward band scheme, an integral component of the overall program, will be initiated in July, 1979. Again firm estimates will be available by March, 1979.

CONCLUSIONS

Lesser Snow Geese form an important recreational resource throughout mid-continent North America. Their numbers exceed those of other goose species and the population has the potential of providing increased recreational opportunities. However, statistically and biologically sound baseline data on annual distribution, mortality and mobility are presently lacking for implementation of effective conservation and management strategies. Managers are now unable to react sensitively to annual perturbations in the "system" viz., fluctuating cohort sizes, changes in colony abundance, shifts in distribution, migration interruptions, overharvest or underharvest in local areas. The imprecision in the data base can be partially remedied through a ten-year monitor banding program conducted in the eastern Arctic of Canada between 1977 and 1987. Such a program will be guided by imperatives set out in the Mid-continent Snow Goose Management Plan.

Meaningful banding programs designed to gain statistically sound measures are acknowledged to be expensive, requiring long term commitments of staff and funds. Under present spending constraints no single resource agency could possibly fund this large scale program. A need exists for a co-operative and coordinated venture with sharing of costs to be apportioned to most if not all North American users of the resource.

In all, the overriding problem is the dearth of precise estimates of the population attributes of various colony components of the mid-continent Snow Goose population. Part of the proposed solution is a decadal banding program which will improve precision of estimates of the survival and distribution parameters of Snow Geese from all the major eastern Arctic colonies. A concurrent thrust to improve measures of abundance, harvest and recruitment parameters should be made. Used in the aggregate the more precise attributes will lead to increased powers of predictability and optimization of recreational benefits.

Agreement in principle, active involvement and commitment of funds for the seven year operational banding program is sought from all resource agencies by March, 1978.

In the interim, the two year pilot banding program should proceed. To ensure its initiation in summer 1977, immediate needs for banding funds are $101,000 in 1977 and $111,000 in 1978. A suggested apportionment is 25 percent to each of the Canadian Wildlife Service, U.S. Fish and Wildlife Service, Mississippi Flyway Council and Central Flyway Council. Tentative approval has been gained from the two federal agencies. Therefore, a request is hereby made for approval and commitment of expenditures of $25,000 by each Flyway Council in 1977 and $28,000 in 1978. Furthermore, three experienced biologists-technicians are sought from each of the Councils to aid in the field operations, July 15 to August 15, in both 1977 and 1978. A time for decision.

TABLE 1. Population estimates (in thousands) of Canada, White-fronted and Snow Geese Wintering in the Mississippi and Central Flyways. (after U.S.F.&W.S. January and December visual estimates.)

Flyway	MISSISSIPPI			CENTRAL			
Goose Species	CANADA	WHITE-FRONT	BLUE SNOW	CANADA	WHITE-FRONT	BLUE SNOW	TOTAL GEESE (thousands)
1967	482	46	380	226	14	262	1,410
1968	445	24	363	275	12	270	1,389
1969	555	21	275	262	17	454	1,584
1970*	501	51	425	373	22	401	1,773
1971	588	39	655	378	21	422	2,103
1972	594	46	937	443	32	404	2,456
1973	609	43	532	412	30	505	2,131
1974	663	43	529	457	49	674	2,415
1975	650	40	441	389	40	682	2,242
1976	665	53	692	585	55	894	2,944
Average 1967-76	575	41	523	380	29	497	2,045

* December counts utilized since 1969.

Mean Population Levels 1967-76 for both flyways combined

	CANADA	WHITE-FRONT	BLUE & SNOW	TOTAL
Mean No.	955	70	1,020	2,045
% of Total	46.7	3.4	49.9	100.0

TABLE 2. Retrieved* harvest estimates (in thousands) of Canada, White-fronted and Snow Geese the Mississippi and Central Flyways. (after U.S.F.&W.S. Administrative Reports)

Flyway	MISSISSIPPI			CENTRAL			TOTAL
Goose Species	CANADA	WHITE-FRONT	BLUE & SNOW	CANADA	WHITE-FRONT	BLUE & SNOW	Retrieved* Harvest (thousands)
1966	152	41	156	194	34	191	768
1967	190	22	124	110	24	143	613
1968	160	7	81	85	20	80	433
1969	194	45	222	117	29	188	795
1970	197	42	291	221	27	284	1,062
1971	195	20	166	193	40	180	794
1972	168	11	108	117	41	150	595
1973	225	38	155	177	51	245	891
1974	283	10	170	137	36	247	883
1975	317	25	161	142	52	354	1,051
Average 1966-75	208	26	163	149	35	206	787

*Unretrieved harvest varies between 12-15% annually.

Mean retrieved Harvest level 1966-75 for both flyways combined

Species	CANADA	WHITE-FRONT	BLUE & SNOW	TOTAL
Mean No.	357	61	369	787
% of Total	43.5	7.8	46.9	100.0

TABLE 3. Estimated retrieved harvest of Lesser Snow (+ Blue) Geese in 3 Canadian Provinces. (after National Harvest Survey - Canadian Wildlife Service Progress Notes)

	1969	1970	1971	1972	1973	1974	1975	7 Year Average
MANITOBA	11,900	9,600	8,600	15,500	21,500	25,200	47,200	19,900
ONTARIO	21,600	12,600	12,300	6,300	12,500	13,800	19,600	14,100
QUEBEC	7,600	6,400	7,000	2,300	4,700	1,700	6,800	5,200
TOTALS	41,100	28,600	27,900	24,100	38,700	40,700	73,600	39,200

Estimates refer to purchasers of Canada Migratory Bird Permits in the populated portions of each province and do not include (1) unretrieved kill, (2) autumn kill of geese by natives, (3) spring kill of geese by natives and (4) autumn kill by non-resident alien hunters in hunting camps around Hudson and James Bays.

NOTE: (1) Estimated annual numbers of Lesser Snow Geese harvested by native peoples in the province of Ontario and Quebec, along coastal Hudson and James Bays, is approximately 50,000±.

(2) Sport hunters using "goose camps"harvest another 10,000± annually.

(3) Minor "Egging" at goose colonies creates only trivial impacts.

TABLE 4. Calculated retrieved harvest (in thousands) of Lesser Snow (+Blue) Geese in states of the MISSISSIPPI FLYWAY. (Applying goose species composition of tail-fans to reported harvests from U.S.F.&W.S. Administrative Reports.)

Year (in thousands)

State	1969	1970	1971	1972	1973	1974	1975	7-Year Average
Alabama	-	2.0	.1	-	.4	.3	.3	400
Arkansas	.9	-	1.9	3.5	3.0	2.5	3.4	2,200
Illinois	4.6	4.0	3.2	2.2	5.0	5.9	3.1	4,000
Indiana	4.0	.8	.6	.3	.9	-	.3	1,000
Iowa	45.0	45.0	44.6	31.0	28.2	34.0	35.5	37,600
Kentucky	.6	-	-	.1	-	.1	-	100
Louisiana	71.8	186.7	47.0	33.8	77.1	41.5	57.1	73,600
Michigan	17.4	1.3	3.0	1.2	2.6	3.0	.3	4,100
Minnesota	33.5	21.9	33.0	18.9	12.4	42.1	15.5	25,300
Mississippi	3.8	1.8	-	1.6	1.3	2.5	2.1	1,900
Missouri	17.9	22.5	24.0	12.9	18.7	28.2	36.9	23,000
Ohio	4.7	.3	.1	-	.5	.5	.6	1,000
Tennessee	-	.2	-	0	.7	.6	.6	300
Wisconsin	17.8	4.4	8.5	2.2	4.3	8.8	5.2	7,300
Flyway Total (thousands)	222	291	166	108	155	170	161	181,800

Adjusted for response bias and includes kill by junior hunters.

NOTE: Individual state estimates to be used with caution.

TABLE 5. Calculated retrieved harvest (in thousands) of Lesser Snow (+Blue) Geese in states of the CENTRAL FLYWAY. (Applying goose species composition of the tail-fans to reported harvest from U.S.F.&W.S. Administrative Reports.)

Year (in thousands)

State	1969	1970	1971	1972	1973	1974	1975	7-Year Average
Colorado*	.2	.2	-	-	.3	-	(?)	100*
Kansas	7.0	16.9	4.9	4.4	10.3	23.5	7.6	10,700
Montana*	-	-	-	-	-	-	.1	tr*
Nebraska	8.3	8.5	9.3	6.7	18.9	18.6	16.5	12,400
New Mexico*	.2	.8	1.7	.1	.9	.1	2.1	800*
North Dakota	43.6	48.9	61.9	36.6	69.4	94.7	138.8	70,600
Oklahoma	3.3	3.8	1.4	3.3	.6	3.4	5.7	3,100
South Dakota	55.6	43.1	41.4	28.0	34.4	27.5	39.0	38,400
Texas	69.9	161.5	59.2	71.1	109.6	79.0	126.0	96,600
Wyoming*	-	-	-	-	.2	-	-	tr*
Flyway Total (thousands)	188	284	180	150	245	247	336	232,700

*Harvest primarily from Western Arctic Populations.

Adjusted for response bias and includes kill by junior hunter.

NOTE: Individual State estimates to be used with caution.

Table 6. Expected numbers and cohort proportions in late July at three banding regions and in four classes of production years.

Production year classification	Mean brood	% Ad. succ.	Cohort proportions[1]				Total number of geese			
			S.A.	Im.	U.A.	Ylg.	W. Hudson Bay	South-ampton Is.	Baffin Island	Total
Excellent	3.5	70	28	48	12	12	1,414,300	564,900	1,619,100	3,598,300
Average	2.5	50	26	32	26	16	1,080,500	431,300	1,236,700	2,748,500
Poor	2.0	30	19	19	43	19	898,800	360,000	1,028,900	2,287,700
Failure	-	0	0	0	76	24	731,600	292,200	837,500	1,861,300

[1] S.A. = Successful Adult, Im. = Immature, U.A. = Unsuccessful Adult, Ylg. = Yearling; Each cohort expressed as a percentage of total birds

(see following page for explanations and assumptions)

Table 6. Definitions and assumptions used in estimating the size and apportionment of cohorts and strata (see Table 7).

1. Adults are birds two or more years of age and they are potentially capable of breeding. Successful Adults are those which succeed in raising Immatures (or young of the year). Unsuccessful Adults are those which have not attempted to breed or have failed in the attempt. Yearlings are one year old and they are not yet capable of breeding.
2. Reproductive success for a given year is classified into four types of production years as defined by brood size and percentage of adults successful in producing progeny (Table 6).
3. Population sizes and color ratios are derived from the photographic inventory of Successful Adults accomplished in 1973 (Kerbes, 1975). That year was considered to have been an excellent production year with 70% of the adults successful. The total number of adults thus derived was used to calculate the numbers of Successful and Unsuccessful Adults in each of the other three classes of production years.
4. The number of Yearlings present each year is one half the total number of Immatures produced in an average production year (i.e., first year mortality of 50% is assumed).
5. Sex ratio of all cohorts is 50:50.
6. Size and apportionment of strata recognizes the movement of Successful Adults and Immatures away from hatching sites and the tendency for some strata to have higher proportions of Unsuccessful Adults and Yearlings relative to other strata.
7. All banding regions and strata will not necessarily have the same class of production in any one year. West Hudson Bay is more likely to have a more successful season than are Southampton or Baffin Island. The latter two areas can be expected to suffer failures as often as once every three or four years, whereas West Hudson Bay has no recorded failure.

Table 7. Expected number of Lesser Snow Geese in late July during three possible production years. Pilot Program - West Hudson Bay Banding Region - Five strata - 16 Cohorts.

Percent Blue morph = 24%

Number of birds x 100

Production Success	Stratum (Fig. 4)	Cohort Proportions S.A.	Imm	U.A.	Ylg	Blue Succes. Ad. ♂♂	♀♀	Blue Immature ♂♂	♀♀	Blue Unsucc. Ad. ♂♂	♀♀	Blue Yearling ♂♂	♀♀	White Success. Ad. ♂♂	♀♀	White Immature ♂♂	♀♀	White Unsucc. Ad. ♂♂	♀♀	White Yearling ♂♂	♀♀	Total
Excellent	1	23	41	15	21	80.5	80.5	141	141	50	50	73	73	255	255	446	446	159	159	232	232	2873
	2	31	53	9	7	98	98	171	171	30	30	21	21	309.5	309.5	542	542	95.5	95.5	66	66	2666
	3	31	53	9	7	98	98	171	171	30	30	21	21	309.5	309.5	542	542	95.5	95.5	66	66	2666
	4	31	53	9	7	98	98	171	171	30	30	21	21	309.5	309.5	542	542	95.5	95.5	66	66	2666
	5	24	42	15	19	94	94	165	165	60	60	73	73	299	299	522.5	522.5	190.5	190.5	232	232	3272
	Total	28	48	12	12	468.5	468.5	819	819	200	200	209	209	1482.5	1482.5	2594.5	2594.5	636	636	662	662	14143
Average	1	20	25	29	26	58	58	72	72	84	84	73	73	182	182	228	228	264.5	264.5	232	232	2387
	2	31	38	22	9	70	70	87	87	50	50	21	21	221	221	277	277	159	159	66	66	1902
	3	31	38	22	9	70	70	87	87	50	50	21	21	221	221	277	277	159	159	66	66	1902
	4	31	38	22	9	70	70	87	87	50	50	21	21	221	221	277	277	159	159	66	66	1902
	5	21	26	31	22	67	67	84	84	100.5	100.5	73	73	214	214	267.5	267.5	318	318	232	232	2712
	Total	26	32	26	16	335	335	417	417	334.5	334.5	209	209	1059	1059	1326.5	1326.5	1059.5	1059.5	662	662	10805
Poor	1	13	13	45	29	34.5	34.5	34.5	34.5	117	117	73	73	109.5	109.5	109.5	109.5	371	371	232	232	2162
	2	24	24	40	12	42	42	42	42	110	110	21	21	132.5	132.5	132.5	132.5	182.5	182.5	66	66	1457
	3	24	24	40	12	42	42	42	42	110	110	21	21	132.5	132.5	132.5	132.5	182.5	182.5	66	66	1457
	4	24	24	40	12	42	42	42	42	110	110	21	21	132.5	132.5	132.5	132.5	182.5	182.5	66	66	1457
	5	14	14	47	25	40.5	40.5	40.5	40.5	140.5	140.5	73	73	128	128	128	128	445	445	232	232	2455
	Total	19	19	43	19	201	201	201	201	587.5	587.5	209	209	635	635	635	635	1363.5	1363.5	662	662	8988

Table 8. Estimated minimum and maximum costs for Reward Band Scheme, 1979-2005.

Banding Region	Number Standard Bands/Year	Number Reward Bands/Year	Reward Bands Recovered over 20 Years (50% Rec. Rate)	Total Cost ($10/band x 7 years)
MAXIMUM COSTS				
West Hudson Bay	75,000	15,000	7,500	$ 525,000
Southampton Island	40,000	8,000	4,000	280,000
Baffin Island	75,000	15,000	7,500	525,000
TOTALS	190,000	38,000	19,000	$1,330,000
	Recovery Analyses Costs			170,000
			TOTAL	$1,500,000
MINIMUM COSTS				
West Hudson Bay	6,600	1,320	660	$ 46,200
Southampton Island	6,600	1,320	660	46,200
Baffin Island	6,600	1,320	660	46,200
TOTALS	19,800	3,960	1,980	$ 138,600
	Recovery Analyses Costs			111,400
			TOTAL	$ 250,000

See following page for assumptions and explanations.

Table 8. Assumptions

Estimated costs will be based on analysis of results of the pilot banding program in 1977-1978.

Assumptions:

1. Direct recovery rate of standard leg-banded adults is 0.05 and over a 20-year span the total direct and indirect recovery rate will be 0.20. For immatures, the direct recovery rate will be 0.08 and over a 20-year period will total 0.20.

2. Reporting rates will be approximately 2.5 times higher on reward bands than on standard leg bands (based on reporting rates of neckbanded vs. normal birds - Appendix J, Dzubin, 1974; Brownie *et al.*, 1976).

Maximum Costs:

3. There are statistically significant differences in distribution patterns between:

   a. each of the 13 strata
   b. adults and immatures
   c. sexes for adults and immatures
   d. color phases, i.e., snow and blue

Minimum Costs:

4. There are statistically significant differences in distribution patterns between:

   a. adults and immatures
   b. color phases, i.e., snow and blue

   but not between strata or sexes.

Table 9. Estimated per unit (one helicopter plus 10 personnel) costs for banding Lesser Snow Geese in the eastern Canadian Arctic. (Based on 1977 costs.)

Banding region (Figure 3)	Helicopter charter[1]	Helicopter fuel[2]	Positioning of fuel	Crew wages[8]	Crew expenses[9]	Field equipment and supplies[10]	Total cost per unit	Number of banding units required/year
W. Hudson Bay	$26,000	$4,000[3]	$3,000[5]	$3,000	10,000	$5,000	$51,000	2
South-ampton Is.	28,000	4,000[3]	5,000[6]	3,000	10,000	7,000	57,000	1
Baffin Is.	32,000	3,000[4]	7,000[7]	3,000	10,000	7,000	62,000	2

1. One month; 4-passenger jet-turbine type; includes pilot, servicing and positioning.
2. For one month (approx. 110 hours flying time), includes deposit on drums.
3. F.O.B. Churchill, Manitoba.
4. F.O.B. Montreal, Quebec.
5. Airlift to Eskimo Point, N.W.T. (sealift cost would be similar).
6. Sealift to Coral Harbour, followed by airlift to Boas River.
7. Sealift to Frobisher, followed by airlift to Great Plain of the Koukdjuak.
8. Three man-months at $1,000; technical aid and Inuit help.
9. Six persons: commercial airfare from Winnipeg or Montreal, transit accommodations, field rations, etc.
10. For camping and banding, includes freight, storage, etc.

Table 10. Estimated annual costs for band recovery analyses, annual updates of results and final completion report publication.

Year	Computor[1] Time	Technical[2] Aid and Drafting	Typing and[3] Secretarial Help	Photography[4] Figure Reduction	Printing[5]	Subcommittee[6] Travel	Demographers,[7] Statisticians Consultants	Totals
1978	$12,000	$2,000	$1,000	$1,000	$ 500	$5,000	$5,000	$26,500
1979	3,000	3,000	1,000	1,000	1,000	3,000	3,000	15,000
1980	4,000	5,000	1,000	2,000	1,000	3,000	3,000	19,000
1981	5,000	5,000	1,000	2,000	1,000	3,000	3,000	20,000
1982	5,000	7,500	1,500	3,000	1,000	3,000	3,000	24,000
1983	6,000	7,500	1,500	3,000	1,000	3,000	6,000	28,000
1984	6,000	10,000	1,500	4,000	1,000	4,000	6,000	32,500
1985	7,000	10,000	2,000	4,000	1,000	4,000	12,000	40,000
1986	7,000	15,000	2,000	5,000	1,000	5,000	12,000	47,000
1987	20,000	30,000	10,000	7,500	40,000	8,000	12,000	127,500
Totals	75,000	95,000	22,500	32,500	48,500	41,000	65,000	379,500

[1] Funding committed by CWS Headquarters, Ottawa, by Dr. F.G. Cooch.
[2],[3],[4],[5] and [6]. Funding committed by CWS, Western and Northern Region, Saskatoon, by Dr. J.H. Patterson.
[7] Contractual arrangements for new analysis techniques .

Table 11. Estimated total maximum costs for banding Snow Geese in the eastern Canadian Arctic, 1977-1987, plus estimated expenditures for auxiliary nest census and total annual costs for band analyses.

Year	Banding regions[1]	No. of banding units[2]	Total cost of banding[3]	Auxiliary nest census[4]	Total Band Analyses Costs (Table 10)	Total Annual Costs
1977	WHB	2	$ 101,000	$ 10,000	$ -	$ 111,000
1978	WHB	2	111,000	15,000	26,500	152,500
1979	WHB, SI, BI	5	338,000	60,000	15,000	413,000
1980	WHB, SI, BI	5	372,000	-	19,000	391,000
1981	WHB, SI, BI	5	409,000	-	20,000	429,000
1982	WHB, SI, BI	5	450,000	75,000	24,000	549,000
1983	WHB, SI, BI	5	496,000	-	28,000	524,000
1984	WHB, SI, BI	5	546,000	-	32,500	578,500
1985	WHB, SI, BI	5	601,000	100,000	40,000	741,000
1986					47,000	47,000
1987					127,500	127,500
TOTALS			3,424,000	260,000	379,500	4,063,500[5]

1. WHB = West Hudson Bay, SI = Southampton Island, BI = Baffin Island.
2. One banding unit = 1 helicopter plus 2 crews at 4 people each.
3. Assumes 10% per year inflation rate.
4. June aerial photography (per Kerbes, 1975).
5. Not including Reward Band Scheme (Table 8).

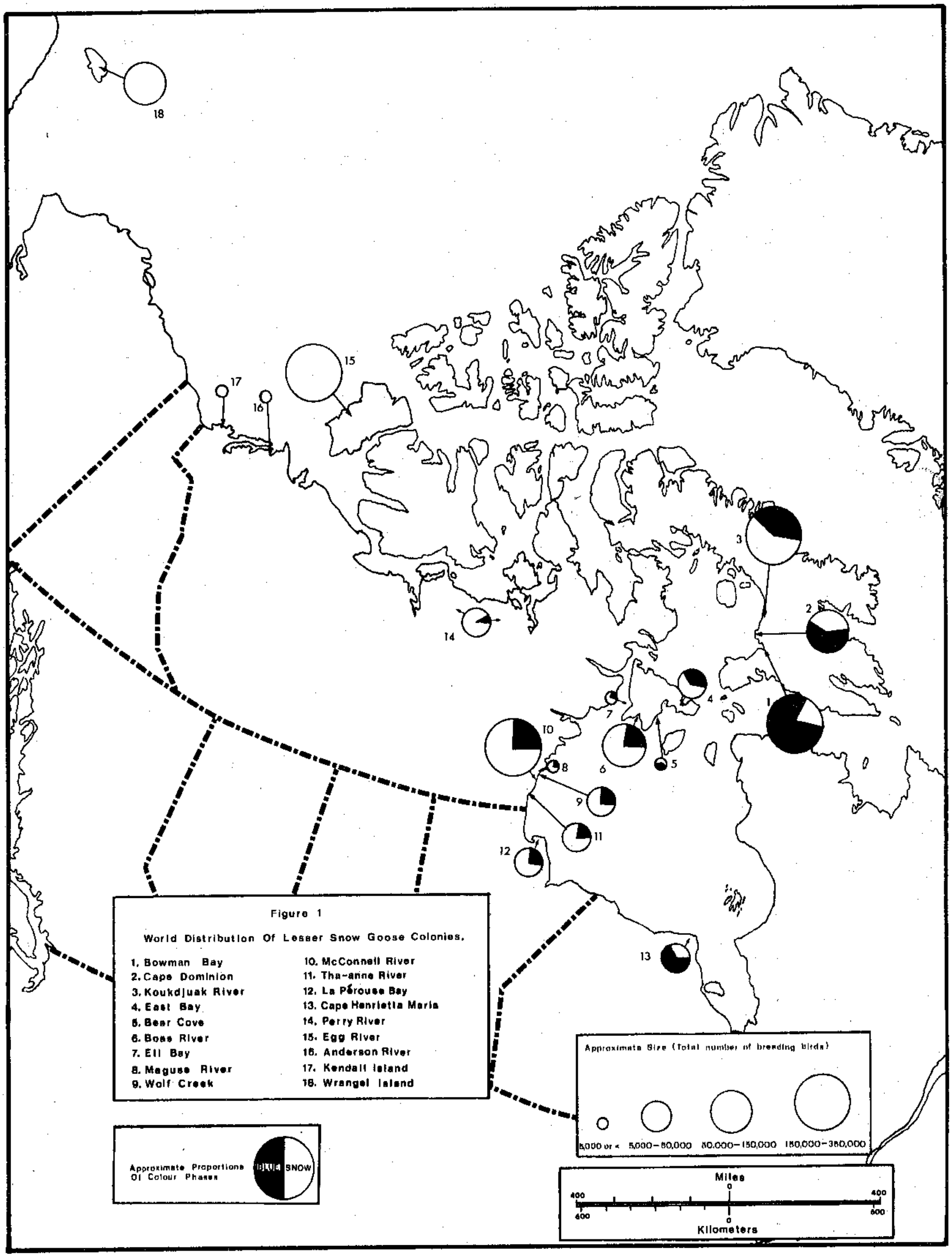
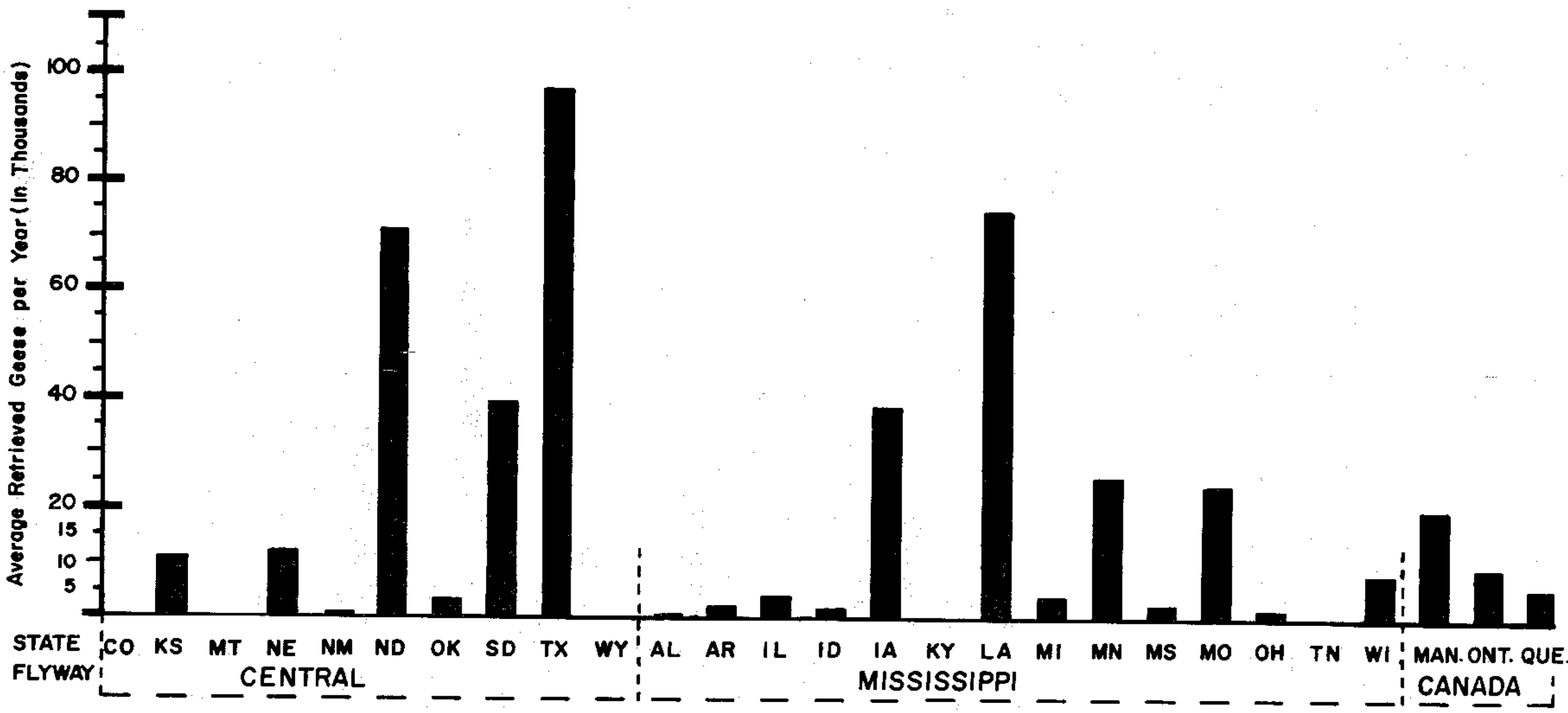


Figure 1

World Distribution Of Lesser Snow Goose Colonies.

1. Bowman Bay
2. Cape Dominion
3. Koukdjuak River
4. East Bay
5. Bear Cove
6. Boas River
7. Ell Bay
8. Maguse River
9. Wolf Creek
10. McConnell River
11. Tha-anne River
12. La Pérouse Bay
13. Cape Henrietta Maria
14. Perry River
15. Egg River
16. Anderson River
17. Kendall Island
18. Wrangel Island

Figure 2 Average annual, retrieved harvest (in thousands) of Lesser Snow (+Blue) Geese in States of the CENTRAL and MISSISSIPPI FLYWAYS plus three CANADIAN PROVINCES, 1969-1975.



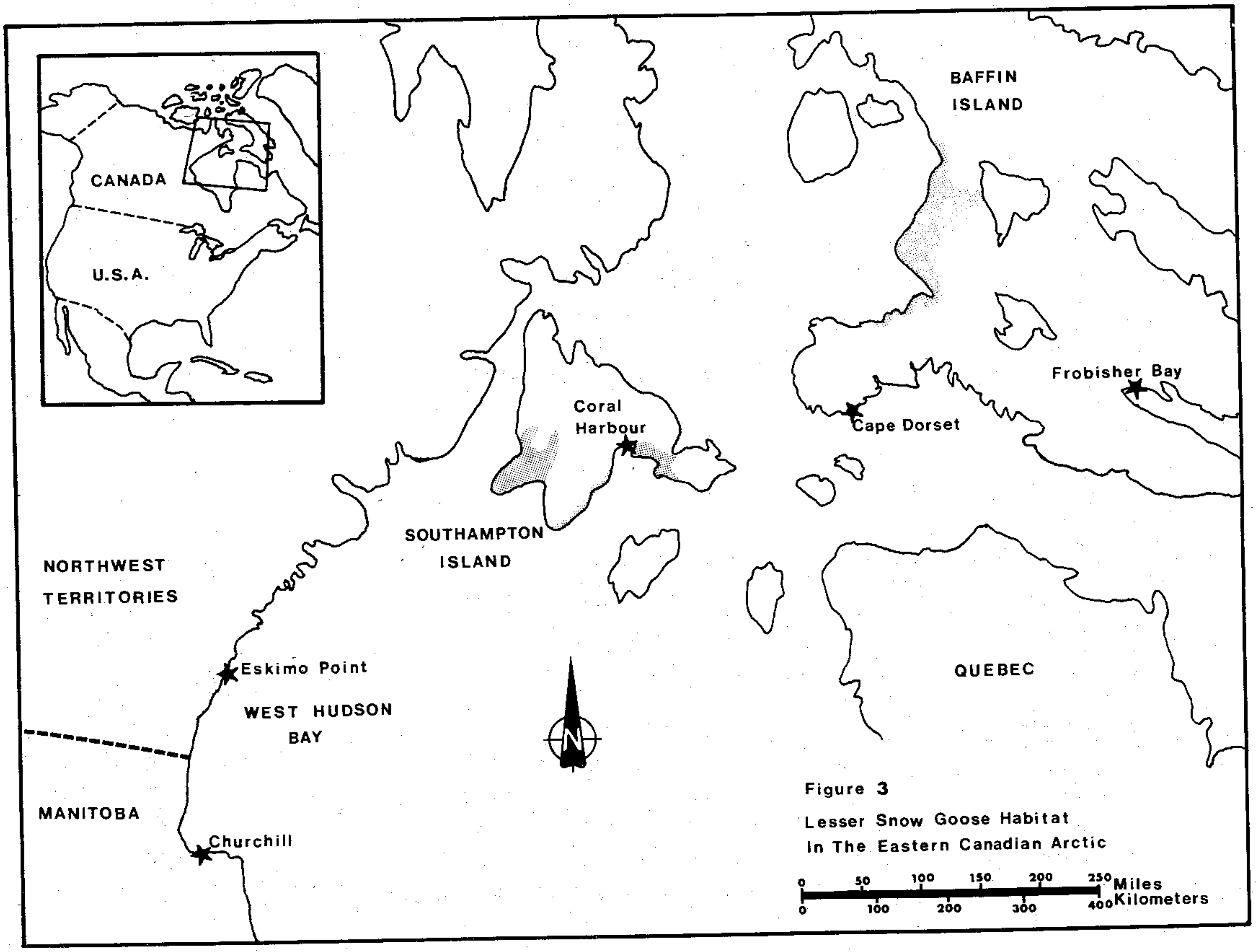


Figure 3

Lesser Snow Goose Habitat
In The Eastern Canadian Arctic

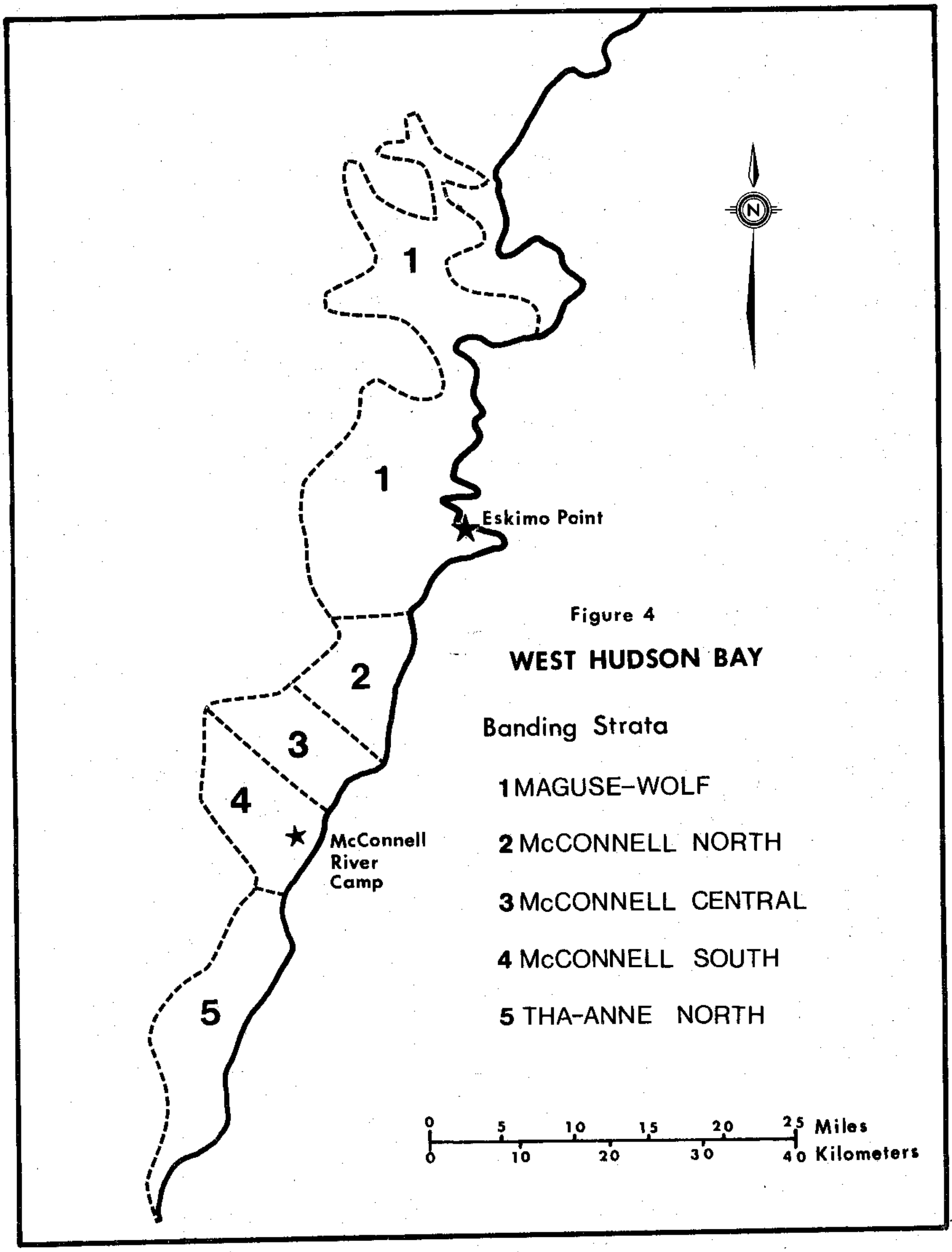


Figure 4

WEST HUDSON BAY

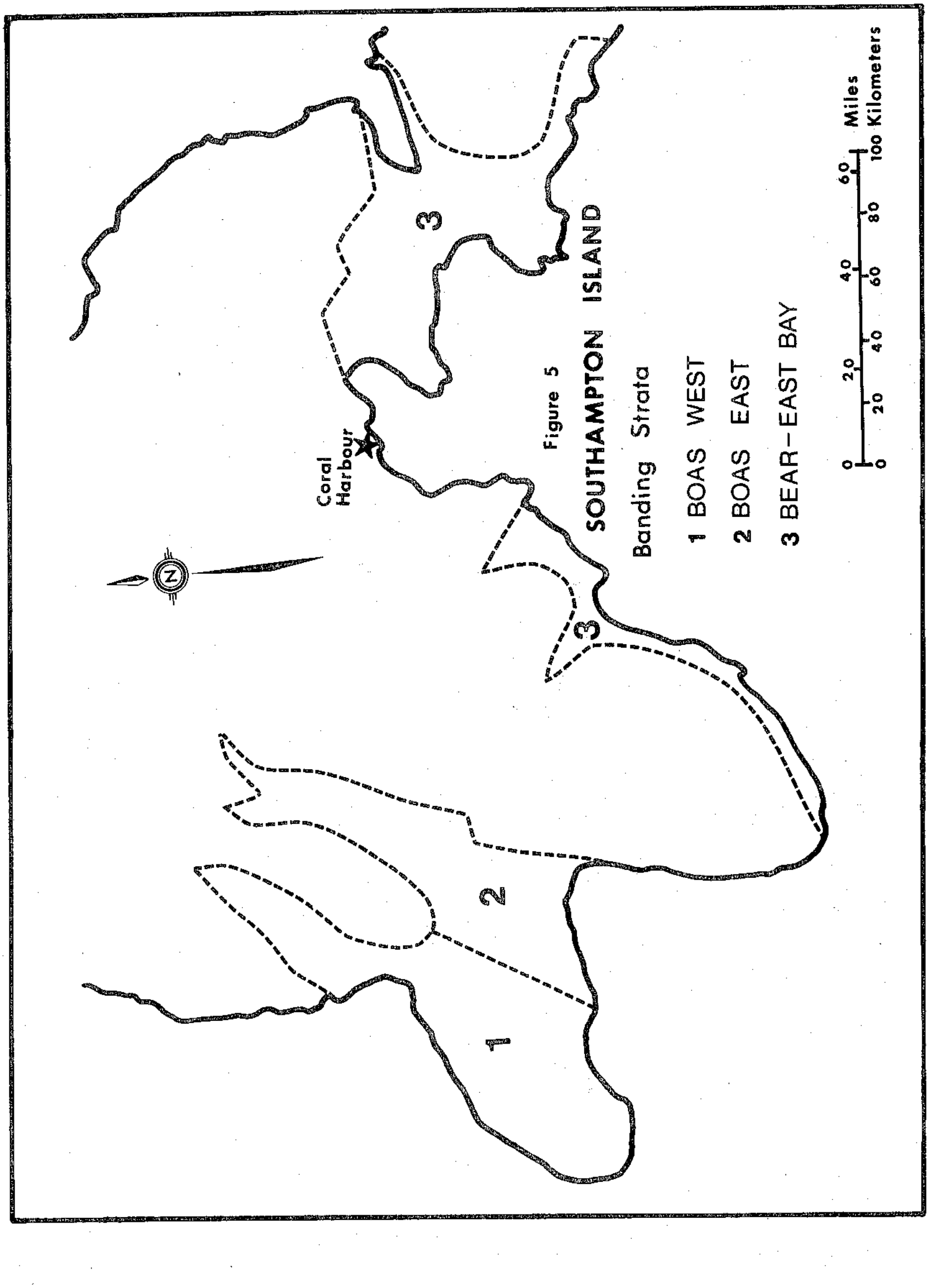


Figure 5
SOUTHAMPTON ISLAND
Banding Strata
1 BOAS WEST
2 BOAS EAST
3 BEAR-EAST BAY
Coral Harbour
Miles
Kilometers

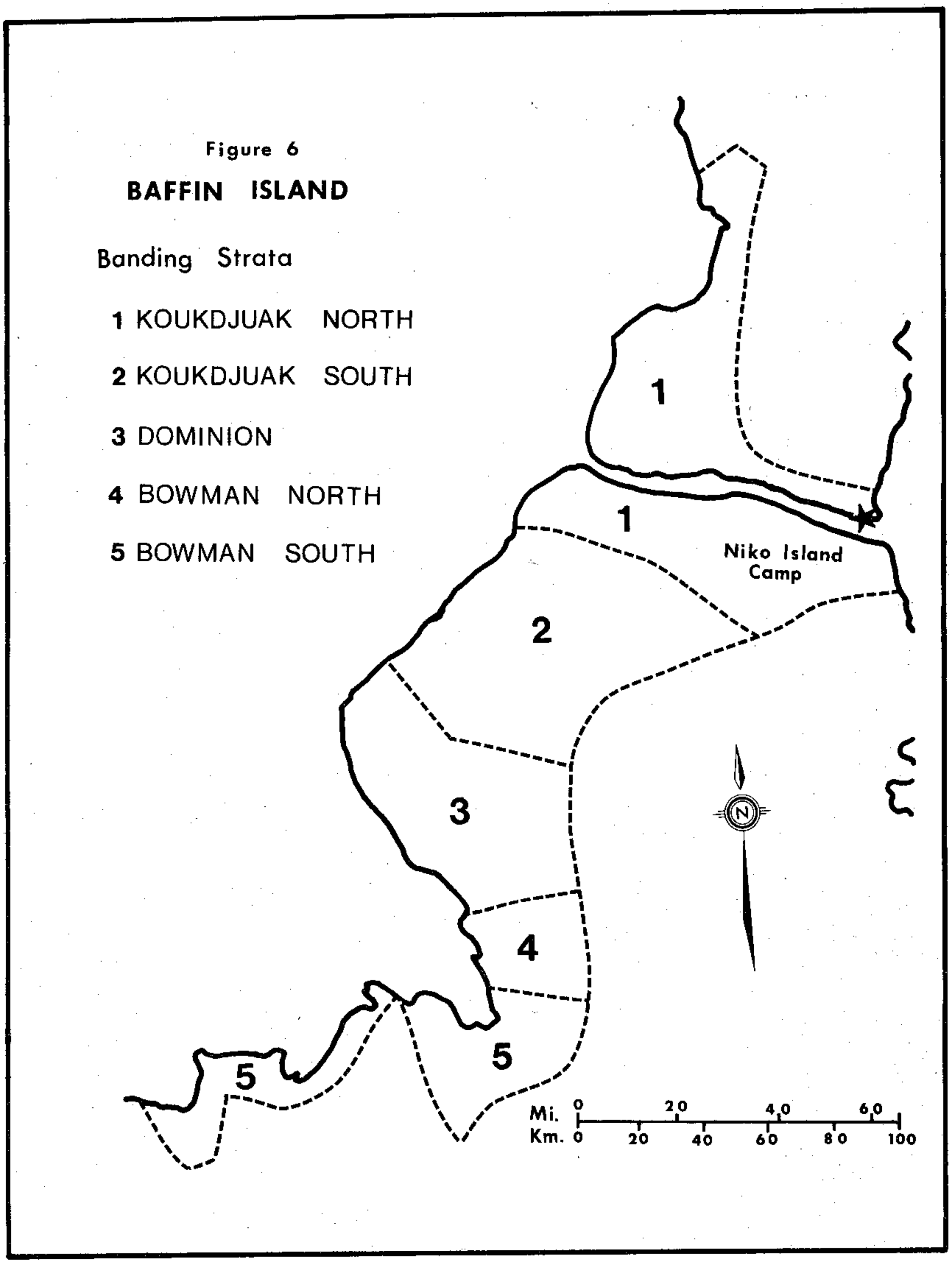
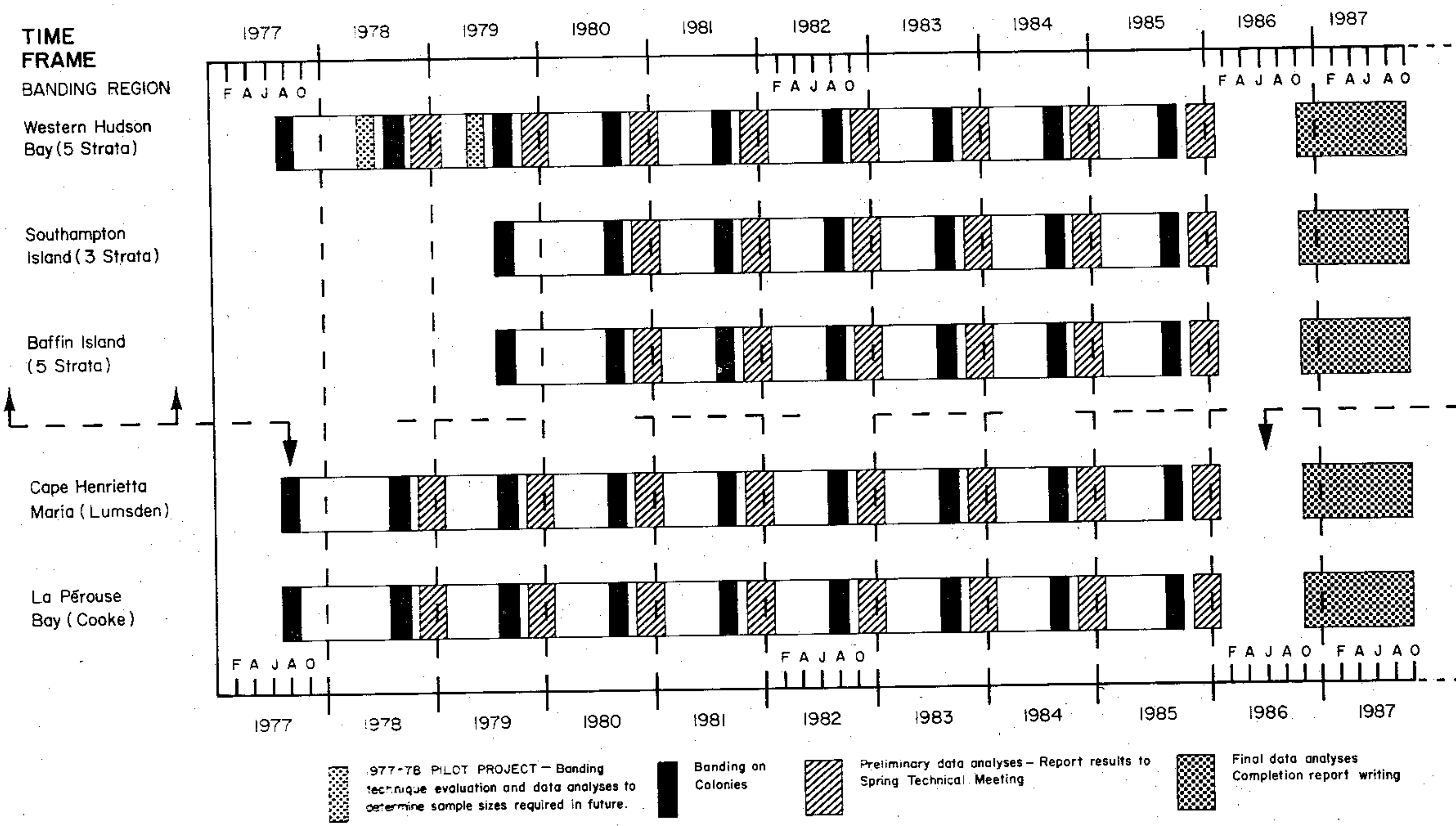


Figure 6
BAFFIN ISLAND
Banding Strata
1 KOUKDJUAK NORTH
2 KOUKDJUAK SOUTH
3 DOMINION
4 BOWMAN NORTH
5 BOWMAN SOUTH
1
1
2
3
4
5
5
Niko Island Camp
N
Mi. 0 20 40 60
Km. 0 20 40 60 80 100

FIGURE 7. PROPOSED SNOW GOOSE BANDING PROGRAM AND DATA ANALYSES



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Frequent communications were entertained with Mr. H. Bateman, Louisiana Wildlife and Fisheries Commission, in order to mesh the objectives of the banding program into the goals of the overall Mid-Continent Snow Goose Management Plan. Close liason has been maintained with the Joint Mississippi/Central Flyway Snow Goose Subcommittee to ensure a coordinated and cooperative approach to problem solving.

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APPENDIX I

Questions posed for Canadian Wildlife Service
band recovery anaysis by
Joint Blue-Snow Committee of the Central-Mississippi
Flyway Technical Sections
June 7, 1972 Kansas City, Missouri

Primary Questions:

1. Has there been a change in distribution of harvest over the last five years compared to previously?

2. Has the timing of recoveries in Canada; the two Dakotas; Missouri, Iowa, Kansas and Nebraska; Texas and Louisiana changed over the last five years compared to the previous five years?

3. Has the direct recovery rate and mortality rate changed over the past five years compared to previously?

Supplementary questions to be answered if possible:

4. Are immatures more vulnerable to harvest?

5. Do colour phases have different vulnerability?

6. What is the total population size? (To be determined by extrapolation from mortality and harvest data).

7. Are recovery rates of colour marked birds the same as normal birds?

8. Do different populations migrate southward in similar manners (analyzed by banding location of breeding population)?

9. To what extent do western Arctic snow goose populations contribute to hunting in Louisiana and Texas?

Additional questions posed by H. Lumsden, Chairman, Miss. Flyway Blue-Snow Subcommittee:

10. Are the early migrants to Texas the same population each year or are they subadults and nest-failed adults?

11. How much exchange between breeding colonies is there indicated by retrap data?

APPENDIX I (Dzubin, Boyd, and Stephen, 1973)

"All problems are divided into two classes, soluble questions which are trivial and important questions which are insoluble".

G. Santayana