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Blue and Snow Goose distribution in the Mississippi and Central Flyways, 1951–71

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Abstract

Approximately 17,500 recoveries from summer bandings of Blue and Snow Geese (*Anser caerulescens caerulescens*) conducted in Arctic Canada between 1952 and 1971 form the principal basis of a review of recent patterns of distribution and movements. These were supplemented by a limited study of 4,500 recoveries from autumn bandings on US refuges. The numbers of recoveries appear comprehensive but the lack of long-run annual bandings at all colonies limits the inferences that can be drawn.

There are now 10 major and 6 minor colonies in Arctic Canada. Their locations and estimated sizes are described. Substantial changes in some colony sizes have occurred in the past 20 years, most notably a 20-fold increase in the McConnell River colony from 1954 to 1972, when it included 120,000 nests. Colonies lying north of 62°N latitude on Southampton Island and Baffin Island have not increased correspondingly. Numbers of nesting pairs have fluctuated greatly from year to year. A small decrease in the proportion of the predominant blue morphs in the Bowman Bay and Cape Dominion colonies on Baffin Island has occurred since 1955.

Snow Geese from the large but apparently decreasing Wrangel Island population, off the north coast of eastern Siberia, winter primarily in California where they mix with birds from the western Arctic populations of Canada. The colonies on Banks Island, Anderson River delta, and Kendall Island contain few blue morphs and have apparently stabilized their growth. The Snow Geese from these colonies winter in the Pacific Flyway and the state of Chihuahua in northern Mexico. Central Arctic colonies are small and not well known. Their inhabitants winter primarily in northern interior Mexico, the southern Central Flyway states, and, to a lesser extent, California. None of these colonies contributes significant numbers to the annual harvest in the Central and Mississippi Flyways. These two flyways receive virtually all their Blue and Snow Geese from colonies located around the periphery of Hudson Bay, including Southampton and Baffin islands.

An analysis of mean longitudinal line of recovery, using the axial line technique, shows no statistical difference in autumn distribution patterns south of the Canadian border among geese from various Hudson Bay colonies or among colour morphs. Thus for purposes of discussion all Blue and Snow Geese originating in the Hudson Bay colonies are treated as a mixed, homogeneous population, with the caveat that harvest and winter distribution data show definite tendencies for the blue morph to occur proportionately more often in the eastern parts of the winter range and the autumn migration corridors.

The numerical stability recorded in mid-winter inventories between 1950 and 1969, with estimates varying from 0.53 to 1.0 million, is not consistent with higher estimates of fall flights, increased breeding colony sizes, and recent spring estimates. Wintering ground assessments have probably been underestimating the size of the Hudson Bay population.

Total harvest estimates show significant increases over the past decade. Their wide annual fluctuations preclude any firm conclusions about changes on a geographic basis. Significant delays in migration through the Northern and Central States are made evident by comparing patterns of band recoveries during 1964–66 and 1967–71; these patterns, however, were also affected by changes in the timing and length of hunting seasons. Proportionally more band recoveries were made in the interval October 21 to November 20 in the years 1967–71. In the Gulf States, significantly more recoveries were reported in the interval January 1 to February 20 in 1967–71. This period is associated with an extension of the Louisiana hunting season into February.

Productivity indices tended to decrease over the 5-year-period ending in 1971, though there is no statistically significant downward trend over the past two decades. Comparison of mean annual mortality rates of banded geese from pooled samples for the early 1950's with those of the last 5 years suggests that mean rates for adults have increased while those for immatures have remained relatively stable.

Knowledge of basic population parameters for Blue and Snow Geese remains unsatisfactory for the formulation of sound management practices and rational exploitation policies. The unreliability of existing data does not allow a firm answer to the allegation that artificially interrupted migration in the Northern and Central States is reducing recreational opportunity in the Gulf States; but on the basis of the information now available, concern over the insecurity of future harvest apportionments does not seem to be justified.

Résumé

Les données fournies par quelque 17,500 récupérations d'Oies blanches et bleues (*Anser caerulescens caerulescens*) baguées l'été dans le Canada arctique entre 1952 et 1971 constituent le fondement principal d'un réexamen des structures récentes de la distribution et des déplacements de ces oiseaux. S'y ajoute l'apport d'une étude restreinte de 4,500 récupérations d'oiseaux bagués l'automne dans des sanctuaires des États-Unis. Le nombre des récupérations peut sembler exhaustif, mais les inférences qu'on en peut tirer sont limitées faute de baguages annuels à long terme dans toutes les colonies.

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Le Canada arctique compte maintenant 10 grandes et 6 petites colonies de ces oiseaux. Nous en décrivons tant les sites que l'évaluation des dimensions de ces dernières. Des changements substantiels sont survenus au cours des vingt dernières années dans les dimensions de certaines colonies, notamment la multiplication par 20 de l'effectif de la colonie de la rivière McConnell de 1954 à 1972, moment où elle comptait 120,000 nids. La population des colonies situées au nord de 62° N., sur l'île Southampton et la terre de Baffin, n'a pas augmenté à proportion. Le nombre des couples nicheurs a beaucoup fluctué d'une année à l'autre. Une légère diminution de la proportion des sujets de la forme bleue, prépondérante aux colonies de la baie Bowman et du cap Dominion, sur la terre de Baffin, est survenue depuis 1955.

Les Oies blanches de la population nombreuse—mais, apparemment en déclin—de l'île Wrangel, au large de la côte nord de la Sibérie orientale, hivernent surtout en Californie où elles se mêlent aux oiseaux des populations de l'Arctique occidental canadien. Les colonies de l'île Banks, du delta de la rivière Anderson et de l'île Kendall comportent peu de représentants de la forme bleue et semblent avoir stabilisé leur croissance. Les Oies blanches de ces colonies hivernent dans l'Aire de vol migratoire de la côte du Pacifique des États-Unis, ainsi que dans l'État de Chihuahua, dans le nord-ouest du Mexique. Les colonies de l'Arctique central sont petites et mal connues. Leurs habitants hivernent surtout dans le nord de l'intérieur du Mexique, les États du sud de l'aire centrale de vol migratoire des États-Unis, ainsi que, dans une moindre mesure, en Californie. Aucune de ces colonies ne fournit d'apport numériquement significatif aux prises annuelles effectuées dans les Aires centrale et du Mississipi. À peu près toutes les Oies bleues et blanches qu'accueillent ces deux Aires proviennent de colonies situées le long de la périphérie de la baie d'Hudson, y compris de l'île Southampton et de la terre de Baffin.

Une analyse de l'axe longitudinal moyen des sites de récupération, au moyen de la méthode des axes de moindre dispersion, ne révèle aucune différence statistique dans les structures de distribution automnale au sud de la frontière du Canada entre les oies des diverses colonies de la baie d'Hudson non plus qu'entre les porteurs des deux formes chromatiques. C'est pourquoi, aux fins de discussion, on traite de toutes les Oies bleues et blanches originaires des colonies de la baie d'Hudson comme d'une population homogène dans sa mixité, compte tenu d'une mise en garde comme quoi les données des prises et de la distribution hivernale montrent de nettes tendances de la forme bleue à survenir proportionnellement plus souvent dans les parties orientales tant de l'habitat hivernal que des corridors de migration automnale.

La stabilité numérique enregistrée lors des inventaires de la mi-hiver entre 1950 et 1969, avec des nombres estimatifs variant de 0.53 à 1.0 million, est en contradiction avec les nombres estimatifs plus élevés des vols d'automne, les dimensions accrues des colonies de nidation et les nombres estimatifs récents du printemps. Les évaluations des terrains d'hivernage ont probablement sous-estimé les dimensions de la population de la baie d'Hudson.

Les nombres estimatifs du total des prises ont manifesté des accroissements significatifs au cours de la dernière décennie. L'amplitude de leurs fluctuations annuelles empêche d'en arriver à des conclusions fermes au sujet des changements survenus en fonction de la variable géographique. La comparaison des structures de récupération de bagues au cours des périodes 1964—1966 et 1967—1971 manifeste à l'évidence des retards significatifs des migrations à travers les États du nord et du centre des États-Unis; ces structures, cependant, étaient affectées en outre par des changements apportés au moment et à la durée des saisons de chasse. Les bagues ont été récupérées en nombre proportionnellement plus élevé dans l'intervalle du 21 octobre au 20 novembre pendant la période 1967—1971. Dans les États riverains du Golfe du Mexique, on rapportait un nombre significativement plus élevé de récupérations dans l'intervalle du 1er janvier au 20 février lors de la période 1967—1971. Cette période coïncide avec l'extension jusqu'en février de la saison de chasse en Louisiane.

Les indices de productivité ont tendu à décroître à travers la période de cinq ans qui a pris fin en 1971, encore qu'il n'y ait pas de tendance statistiquement significative à la décroissance à travers les deux dernières décennies. La comparaison des taux de mortalité annuels moyens des oies baguées d'une somme d'échantillons de 1950 et des quelques années suivantes, avec ceux des cinq dernières années, donne à penser que les taux moyens ont augmenté pour ce qui est des adultes tandis qu'ils demeuraient relativement stables chez les oiseaux qui n'avaient pas encore atteint la maturité.

La connaissance qu'on a des paramètres démographiques fondamentaux des Oies bleues et blanches reste inadéquate à la formulation de saines pratiques de gestion et de politiques d'exploitation rationnelles. Le manque de fiabilité des données existantes ne permet pas d'apporter une réponse ferme à l'allégation que l'interruption artificielle de la migration dans les États du nord et du centre réduit la quantité de gibier disponible dans les États du Golfe; néanmoins, en fonction des renseignements dont nous disposons actuellement, pareille crainte de voir compromises les futures allocations de prises ne semble pas justifiée.

Introduction

During a Joint General-Mississippi Flyway Council and Technical Committee Meeting held at Kansas City, Missouri, June 6 and 7, 1972, an offer was made by representatives of the Canadian Wildlife Service (CWS) to analyse recoveries of banded Blue and Snow Geese in order to help solve recent management problems. The Councils and Technical Committees accepted the offer. A Joint Central-Mississippi Flyway Technical Committee was formed, composed of Mr. Tom Kuck (Chairman), South Dakota Department of Game, Fish and Parks, and members Mr. C. Stutzenbaker, Texas Parks and Wildlife Department, Mr. K. Babcock, Missouri Department of Conservation, and Mr. R. Bishop, Iowa State Conservation Commission. The Committee established guidelines for the banding analyses by posing nine questions, with additional questions from Mr. H. G. Lumsden, Chairman of the Mississippi Flyway Blue and Snow Goose Committee (see Dzubin, Boyd and Stephen 1973: Appendix I).

The main objectives of the CWS study were to clarify apparent changes in autumn distribution patterns of Blue and Snow Geese, and to answer the questions posed by the Joint Committee by examining patterns of band recoveries and ancillary data on other population parameters.

A second meeting between the Joint Committee and CWS staff was held at Denver, Colorado, on March 4, 1973, in which progress to that date was reviewed. The Joint Committee asked for an extended analysis to include determination of mean longitudinal lines of band recoveries (using the axial line method of Bellrose and Crompton (1970)), and mortality estimates. This paper is a revised version of a mimeographed report prepared at the request of the Central and Mississippi Flyway Councils and Technical Committees in August 1973.

Although not explicitly defined by the Joint Committee, a number of alleged problem components are reviewed in popular articles by Stutzenbaker (1970*a*) and Bateman (1971) and also in unpublished but public documents circulated since 1968; e.g. Blue/Snow Goose Workshop (1969), Hawkins (1971) and others noted below:

> North of the Gulf States, active management by state and federal agencies, through creation of refuges with associated feeding areas and implementation of half-day shooting regulations, has led to a delay in the traditional chronology of autumn migration. Late movements onto the Gulf State wintering grounds were also attributed to extended warm periods in autumn. Lack of freezing weather in the more northern states did not force geese southward until late November or December (Stutzenbaker 1970*b*, Bishop 1971).

> More geese (a higher proportion of the total harvest) are being killed in the Northern and Central States. Hunters in Texas and Louisiana have traditionally taken about 50% of the total harvest in each flyway and would prefer to continue harvesting that proportion (Stutzenbaker 1970*b*, Bishop 1971).

> Geese are wintering further north than previously. New impoundments in the Central States have the potential for holding geese for longer periods into the late autumn. Catastrophic losses from weather or stress-induced diseases could occur as a result (Stutzenbaker 1970*b*, Bishop 1971).

> Peak autumn populations on refuges in the Northern and Central States have continued to increase since 1963. Blue and Snow Geese are being "short-stopped" there much like populations of Canada Geese were in the recent past. Wintering ground "traditions" will be broken, new terminal wintering areas will be established and a loss of recreational opportunity will ensue in the Gulf States (Stutzenbaker 1970*b*, Lumsden 1972).

> Depredation by geese on improved pastures and rice crops is severe in Louisiana. Since the late 1950's geese have shown a preference for feeding on cultivated lands rather than in native marshes. Delayed hunting seasons help alleviate the depredation problem (Bishop 1971, Buller 1972).

In short, the main management problems centre on the possibility that both natural phenomena (*i.e.* changing weather patterns) and artificial land-water manipulations occurring in the Northern and Central states are reducing recreational opportunity in the Gulf States, or are liable to do so.

Methods

Preliminary searches for available recovery data indicated that most bandings of Blue and Snow Geese have been conducted in Canada, between 1952 and 1971, in eight colonies along the periphery of Hudson Bay, a series of small colonies in the Central Arctic, and two colonies in the Western Arctic. The following procedures for analysis of the recoveries from the Canadian bandings were agreed to by the principal banders involved in August, 1972 and January, 1973:

(1) After receipt of an updated recovery tape on September 15, 1972 from the US Bureau of Sport Fisheries and Wildlife, all electronic data processing would be conducted by the CWS Banding Section, Ottawa, under Ms. Laurie Wight, programmer-biologist.

(2) Five analytical programs would be used to give summaries of space and time distribution patterns of recoveries from each colony banded. Compilation and collation of these summaries into tables and figures would be completed at the Prairie Migratory Bird Research Centre at Saskatoon.

(3) Banders, with "proprietary rights" over their data, were to be given the opportunity to prepare background papers on the results. These research papers would not necessarily contain systematic amplifications of the questions. They would be published if possible by the CWS. (After study of the manuscripts received, it was decided in November, 1973 that only some merited publication in permanent form, several of them being considered preliminary or ephemeral.)

(4) A synthesis, comprising conclusions of the above background papers, would be prepared for the use of game managers and administrators. Data and other information extracted from these manuscripts would show author references as "in prep." or "*in litt.*"

(5) A compendium of basic data, such as details of banded sample size, maps of geographic distribution from colonies, tables of distribution by state and harvest zone, charts of temporal distribution patterns, maps of axial lines, and a bibliography would be prepared and distributed to serve as a basis for discussion, and an aid in future program planning.[4]

The intermittent nature of bandings (Table 1) and doubts about the reliability of other data make it unlikely that trustworthy answers could yet be given to most of the questions posed. No bandings were conducted to answer these questions specifically. The tentative answers found must be considered "spin-offs" from research studies which dealt with a variety of biological problems, more often of academic interest than of obvious utility to managers.

The band recovery analyses were restricted to shot birds (Code 01) banded in breeding colonies. Results from in-season bandings on migration areas in western Saskatchewan, eastern Alberta, and refuges such as Sand Lake National Wildlife Refuge, Squaw Creek National Wildlife Refuge, Anahuac National Wildlife Refuge, and Sabine National Wildlife Refuge were examined but did not form a major component of the total analysis.

[4]Copies of this document were duplicated and distributed in June 1974.

We used only direct recoveries. A growing body of evidence suggests more interchange of geese between colonies than previously supposed, so that indirect recoveries, especially of males, may not be referrable to the original colony of banding. As most banders had not identified sex at capture, we pooled sexes for analysis. We tabulated recoveries separately from the two colour morphs, blue and white, and also those of adults and immatures (Dzubin 1974: Appendices B and E).

We made the following assumptions (reviews in Geis 1972; Anderson 1972) in utilizing band recovery data: (1) that the banded sample was truly representative of the colony and showed the same characteristics as the unbanded portion; (2) that minimal or consistent mortality occurred from time of banding to September 1, when birds become subject to hunting mortality; (3) that there were equal and unchanging reporting rates in different geographical areas and years. The last assumption in particular was accepted with reservations. Because estimates of colony size were not available for all years when banding was conducted, the proportion of the total Blue–Snow Goose population represented by each sample banding could be determined only grossly. Numbers of direct band recoveries were therefore used without any weighting for colony size.

The use of band recovery patterns based only on shot birds to infer distributions of the free-flying population may lead to serious bias. Prevett (1972, in prep.) has shown by observations of geese marked at the McConnell River colony that annual variations in relative numbers of neckbanded geese present in two regions in Texas, (Rice Prairies and East Texas), could not be statistically correlated with numbers of shot recoveries from the two areas. However, as visibly-marked geese from other colonies have not been available for study, it has been necessary to make use of recoveries of shot birds to depict distribution and relative abundance.

Preliminary determination of mortality rates of banded geese was made by using a method proposed by Ricker (1958), and estimated variance calculated after Hayne (1971).

For estimating the rates at which immatures and white phase geese were likely to be shot, direct recovery rates were calculated for banded samples which produced 20 or more recoveries. Direct recovery rates, based on these sample sizes for adult and immature cohorts of both colour morphs, were available only for the Boas River colony in 1952 and 1953, and the McConnell River colony in 1960, 1965 and 1970. Pooled direct recovery rates for those years were used to determine the best estimates of vulnerability rates. In order to estimate differences in reporting rates between normal and neckbanded geese, all direct recovery data for the 1964–71 period from the McConnell River colony were pooled.

Published and unpublished estimates of wintering numbers within the Central and Mississippi Flyways were accepted at face value, although such surveys lack estimates of reliability and descriptions of sampling variation, and their credibility has been publicly questioned by several biologists, most recently by Bishop (1971) and Lumsden (1972). No other winter population indices were available. Until 1969 counts were made in January, after the close of normal hunting. Since 1969 the counts have been made in December, while the hunting season was in progress, and therefore require reduction by the estimated harvest during the December to January interval to be comparable to earlier figures. The appropriate correction factors are not known at the time of writing.

For the purposes of this report, harvest included both retrieved and unretrieved kill. The validity of estimates of annual goose harvest from the US National Harvest Survey has been questioned, particularly since mathematical models showed a harvest rate for Blue and Snow Geese as high as 34.5% in the period 1962–67 (Bishop 1971). (Both in the US and Canada the National Harvest Survey is primarily intended to yield estimates for the kill of principal game ducks.) In the absence of tested alternative data covering the whole of the two flyways, however, we accepted the published figures as valid indices of harvest trends in flyways and harvest zones. Harvest estimates obtained through state surveys sometimes resemble, and elsewhere diverge widely from, those calculated for the state in the national survey. They could not readily be used in this analysis as not all states conduct their own surveys.

Field productivity appraisals on the Gulf Coast States, compiled since 1950 by J.J. Lynch (1972) of the Bureau of Sport Fisheries and Wildlife, were accepted as sound estimates of productivity. These counts are begun while the hunting season is in progress. Both adults and immatures are subject to hunting mortality losses before they reach the Gulf Coast. Thus the indices are biased due to seasonal variations in the proportion of young removed by hunting prior to field assessment. Lynch (1971:5) has acknowledged that field mensuration techniques do not "achieve the ultimate in precision". However, appraisals further north in the US, earlier in the autumn, are much less consistent and reliable, because many families are temporarily disrupted when in the large aggregates found at refuges in the Central States (Prevett 1972). Published flyway-weighted age-ratios in the estimated harvest, based on goose-tail collection surveys, were examined for the 1962–71 period.

Most historical estimates of colony sizes were based on visual assessments by individual fieldworkers, either from the ground or from light survey aircraft (Cooch 1961). Total counts of nesting birds were made from aerial photographs taken by R.H. Kerbes in 1972 at two colonies, McConnell River and La Pérouse Bay. The mission was extended in 1973, when photographs of all the colonies in the eastern Arctic were obtained. These will provide the first precise estimates of the breeding population to be published at the completion of counts from photographs and of statistical analysis. (For preliminary results see Lumsden 1973, and Schroeder 1974.) For comparative purposes historical figures published by Cooch (1961) and more recent unpublished assessments have been grouped for the periods 1954–61 and 1968–72 (Figs. 1 and 2). Prior to 1973, a lack of synchronous coverage of all colonies during any one year impaired estimates of the total breeding population. Previous estimates, presented in the figures, were the best obtainable from which orders of magnitude could be compared.

Because bandings from three colonies on Baffin Island (Bowman Bay, Cape Dominion, and Koukdjuak River) were infrequent and showed consistent patterns of recovery, they have been grouped as the Baffin Island colony. Geese from Baffin Island and Cape Henrietta Maria (Ontario) are referred to as the *eastern stock* and those from the remaining colonies on the west side of Hudson Bay and Southampton Island as the *western stock*.

For convenient summary of harvest and recovery data, Central Canada and the United States were arbitrarily divided into five major harvest and band recovery areas (Fig. 3, after Lumsden, in prep.). The zones approximate those defined by Lemieux and Heyland (1967) for band recovery analysis and those used by game managers in discussing recent changes in harvest distribution patterns. They are:

Zone 1 – Hudson Bay and James Bay. Ontario and Quebec, between 50°N and 60°N and west of 65°W longitude. Manitoba and Saskatchewan, north of the 53°N latitude and east of 104°W longitude.

Zone 2 – Southern Canada. South of Zone 1 to US Border.

Zone 3 – Northern States. North Dakota, South Dakota, Minnesota, Wisconsin and Michigan.

Zone 4 – Central States. Nebraska, Kansas, Oklahoma, Iowa, Missouri, Arkansas, Illinois, Indiana and Ohio.

Zone 5 – Gulf States. Louisiana and Texas.

States along the Cordillera, and four in the southeast Mississippi Flyway (Mississippi, Alabama, Tennessee and Kentucky) in which the numbers of band recoveries and the estimated harvests are low, have been excluded from the following discussion.

To detect possible changes in distribution during the hunting season the temporal patterns of band recoveries were determined for 10-day intervals during the period September 1 to February 20. Approximately 20 to 25% of recoveries had to be rejected from this analysis because of unknown or insufficiently precise dates of death (*e.g.* hunting season – code 94). Those few recoveries falling outside the legal hunting seasons were also rejected. Direct recoveries from all colonies, including adult and immatures and both white and blue morphs, were pooled for the periods 1964–66 and 1967–71 to test whether significant changes in harvest chronology had occurred in the three US zones.

To summarize conveniently the geographical distribution patterns of recoveries from banding at each colony, mean longitudinal lines of recovery were calculated for each latitude from 25°N to 60°N, and for recoveries obtained between the 75°W and 110°W longitudes. Such axial lines (Bellrose and Crompton 1970; Funk *et al.* 1971, Bellrose 1973) have the advantage of summarizing masses of data and are amenable to statistical testing at each latitude with associated computations of one standard deviation about the mean line, *i.e.* statistical boundaries which should contain about two thirds of all recoveries at one latitude. The most serious limitation of axial lines is that several widely spread migration corridors may be mathematically forced into one mean degree of longitude for each latitude. Anomalies of this kind are apparent in the axial lines computed for the 51°N latitude in Canada, which includes recoveries from both James Bay and the Interlake region of Manitoba, 1,000 km apart, and for the 28°N latitude which includes recoveries in both Louisiana and Texas.

On prepared maps (of which a selection is included in this report, Figs. 4 and 5) cumulative percentage of recoveries was shown only for three latitudes, 49°N, 43°N and 33°N. The percentage figures (accumulated from north to south) include those recoveries received south of the 60°N latitude and north of 25°N (*i.e.* north of the Republic of Mexico). So few recoveries occurred in Mexico and north of the 60°N parallel that they have been omitted from the calculations. (See Tables 3 and 4 for the low percentages of recoveries reported in Franklin, Keewatin and Mexico). Recoveries in Mexico usually lack precise latitude or longitude data.

Copies of listings which show sample recovery sizes at each latitude, mean longitudinal line of recovery, variance, and cumulative percentage of recoveries for each latitude, are available on loan from the Librarian, CWS, Prairie Migratory Bird Research Centre, University of Saskatchewan Campus, Saskatoon. They corroborate maps presented in the text but were too voluminous to include in this report.

Although the Thirty-second Supplement to the American Ornithologists' Union's *Checklist of North American Birds* (Eisenmann 1973) recommends naming the Lesser Snow Goose as *Chen caerulescens caerulescens*, we follow Delacour (1954), Scott (1957) and Johnsgard (1965) and accept the generic name *Anser*, first applied to this species by Pallas (1769). The dark morph is referred to as the Blue Goose and the white as the Snow Goose.

Standard tests for normal and non-parametric distributed data were used. The convention level of $p = 0.05$ was used as the criterion of statistical significance.

A number of reservations on the precision of the data are necessary. We used results from an unverified recovery tape. Cursory test listings contained 5 to 7% errors in punched codes (e.g., incompatibilities of latitude and longitude codes with state codes, errors in latitude or date codes of banding or of recovery, and "shot" recoveries made during closed periods of the season). Many of the errors or omissions, though leading to rejection of a record for one analysis, did not prevent its use in another. We sought to use as many records as possible. Time and lack of access to original recovery records prevented a "cleanup" of the tape.

Results and discussion

Nine major colonies of Lesser Snow Geese were identified. The geographic location of these colonies and their estimated sizes in the period 1954 to 1961 are shown in Figure 1. For those colonies situated around Hudson Bay the proportion of blue morphs during that period ranged from 97% at Bowman Bay to 14% at McConnell River. The Central Arctic colony at Perry River showed 10% Blue Geese; on Banks Island only a trace of the spring population was composed of Blue Geese (Barry 1960). The gradually diminishing percentages of Blue Geese in western colonies were described by Cooch (1963).

Sizes of colonies showed marked changes between the periods 1954–61 and 1968 – 1972 (Fig. 2) and at least two new minor colonies were reported, at Maguse River and La

Pérouse Bay. Major increases occurred in and around the McConnell River colony, where a 20-fold increase in the main breeding area was documented, from approximately 15,000 birds in 1954 (Cooch 1961) to about 300,000 in 1972 (Kerbes in press), and where several 'satellite' groups appeared. The major colonies on Baffin and Southampton islands have not shown comparable increases, though the number of breeding birds has fluctuated widely from year to year. A doubling of colony size occurred at Cape Henrietta Maria (Hanson *et al.* 1972; Lumsden *in litt.*) and in the Perry River colonies (Ryder in prep.). Small reductions (of up to 10%) in the proportion of Blue Geese were documented in the Bowman Bay, Cape Dominion and Perry River colonies. Increases and then a trend toward stabilization in the proportion of blue morphs was evident at other Hudson Bay colonies. Summaries of annual changes in blue morph components and detailed descriptions of recent annual changes in abundance in the Cape Henrietta Maria, McConnell River and La Pérouse Bay colonies are found in Hanson *et al.* (1972).

The Egg River colony on Banks Island showed a slow increase from an estimated 120,000 in 1953 (Manning Höhn and Macpherson 1956) to approximately 200,000 birds in 1971 but has since stabilized (Barry *in litt.*).

Changes in colony size and in the proportion of blue morphs reflect a whole spectrum of biotic and edaphic factors (Cooch 1958, 1961, 1963; Kerbes 1969; Hanson *et al.* 1972). The extent of snow cover on the lowlands at the time the geese return and the length of the potential breeding season both help to determine whether successful breeding can occur and whether the blue or white morphs are more successful in production of progeny. Low reproductive outputs of wintering ground flocks have been used as summer climatic indicators by Lynch (1964, 1972). Recent meteorological studies by Bradley and Miller (1972) on Baffin Island, where the three major colonies contain mostly blue morphs, show that in 1960–69 there was a trend toward more accumulation of snow and ice. Further work on Baffin Island by Bradley (1973*a*, 1973*b*) and Barry (in press) strongly suggests that there has been a general cooling during the ablation season (June, July, August) from 1950 onward, with the cooling "particularly accentuated in the last 10 years". It is unknown if these negative changes are short term, regional variations or are reflections of a more extensive global pattern toward climatic deterioration in the northern hemisphere (Lamb 1966; MIT 1971:44; Vasari, Hyvärinen and Hicks 1972; Starr and Oort 1973; Barry, Bradley and Andrews in press). There have been several poor breeding years for geese on Baffin and Southampton islands in the last decade, culminating in 1972 when few Blue and Snow Geese attempted to nest in those major haunts. A similarly widespread breeding failure occurred in 1974. However, no decisive shift of balance between Baffin Island and western Hudson Bay seems yet to have occurred: the proportion of blue morphs has varied annually but shows no consistent trend to increase at McConnell River (Hanson *et al.* 1972). In June 1973, R.H. Kerbes found large numbers of nesting Blue and Snow Geese at the principal sites on Baffin Island and many nesting in other less favourable areas, such as that between Cape Dominion and the Koukdjuak River (Kerbes in press).

Geographic patterns of band recoveries were used to determine the colony origins of harvests in the Central-Mississippi Flyways (Tables 2, 3, 4). Direct recoveries of banding conducted in the Western Arctic at Anderson River and Banks Island, plus associated autumn migration bandings in western Saskatchewan and eastern Alberta, show most recoveries in the Pacific Flyway. Only a small proportion of the recoveries was recorded in the states of Chihuahua and Durango in northern Mexico (Table 2). Excluding that portion of Montana lying within the Pacific Flyway, fewer than 3% of these recoveries are from Central Flyway States and only one recovery was obtained from the Mississippi Flyway. The few available direct recoveries from colonies in the Central Arctic show about half in the Central Flyway and one quarter in the states of Chihuahua and Durango, northern Mexico (Table 2). Only one recovery was received from the Pacific Flyway. Although blue morphs were historically uncommon in wintering flocks in Chihuahua (Leopold 1959; USDI 1958, 1962, 1970) they made up 1 – 3% of white morph flocks surveyed there during January, 1971 and 1973 (Drewien pers. comm.). The blue morph has also shown an increase in the recently larger wintering flocks in the state of New Mexico (Zahm 1974), and, since 1965, in autumn migrants passing through western Saskatchewan (Dzubin *in litt.*). Such increases suggest either colonization of new areas, a natural growth in the proportion of the blue morph in western Arctic colonies (Cooch 1963), or recent tendencies of flocks of more Eastern Arctic origin to mix with those from the Western Arctic.

No direct recoveries were reported from the Pacific Flyway of either Blue or Snow Geese from colony bandings around Hudson Bay (Tables 3 and 4). Nearly all recoveries are in the Central and Mississippi Flyways. There were significantly more recoveries of Snow Geese from pooled eastern stocks in Canada (Proportion Test, $Z = -4.22$, $p < 0.05$) and in the Mississippi Flyway ($Z = -8.71$, $p < 0.05$) than there were in the Central Flyway. Proportionally more white morph recoveries were reported from pooled western stocks in the Central Flyway ($Z = 9.53$, $p < 0.05$) than in either Canada or the Mississippi Flyway. Most of the recoveries in Canada occurred around the western and southern shoreline of Hudson Bay and around James Bay. The predominance of the blue morph in autumn congregations around James Bay has been discussed by Cooch (1961), Lemieux and Heyland (1967), and Hanson *et al.* (1972). Proportionally greater numbers of eastern stock Blue Geese recoveries were taken in Canada ($Z = -10.73$, $p < 0.05$) and the Mississippi Flyway ($Z = -9.02$, $p < 0.05$) than in the Central Flyway. Proportionally more western stock Blue Goose recoveries were reported from the Central Flyway ($Z = 16.14$, $p < 0.05$) than in the other two regions. Relatively few Hudson Bay Blue or Snow Goose recoveries were taken in Mexico and these were primarily confined to the states of Tamaulipas and Vera Cruz. No eastern stock geese were recovered in Mexico (Tables 3 and 4). Lynch (1971) and Prevett and MacInnes (1972) have both documented the gradient toward fewer blue morphs in wintering flocks westward from southeastern

Louisiana to southern Texas, while Smithey, Martin and Walther (1972), Cooke and Finney (*in litt.*) and Kerbes (*in litt.*) show wide mixing of wintering ground flocks apparently from different colonies.

Indirect recovery patterns from in-season bandings at Tule Lake and Sacramento National Wildlife Refuges published by Rienecker (1965), show that these migrants originate from Wrangel Island and from Banks Island (Fig. 6) confirming the results presented earlier by Kozlik, Miller and Rienecker (1959), and Cooch (1958:157, 1964). In the United States, recoveries east of the Rocky Mountains, from bandings in the Pacific Flyway, were infrequent except for those recorded in western Montana.

Recoveries of bandings from the Wrangel Island colony were largely in the Pacific Flyway (Fig. 7). The wintering grounds also include China, Korea and Japan (Rakhilin, 1972:167). Small numbers of recoveries in Utah, western Montana, Alberta and Saskatchewan also indicate some mixing with birds originating from the Egg River colony on Banks Island (Nagel 1969, 1970). No Central or Mississippi Flyway recoveries were recorded. The Wrangel Island colony has shown marked decreases over the past decade, from an estimated 400,000 in 1960 (Uspenski 1965; Portenko 1972) to 300,000 in 1964 (Chernyavskii 1967) and to 130,000 in 1971 (Syroetchkovski 1972; *in* Kistchinski 1973:89; Syroetchkovski 1974).

Although mixing is evident on the autumn migration and wintering grounds of the Pacific Flyway, the Western Arctic and Wrangel Island colonies form relatively closed populations with only small interchanges between them. They contribute insignificant numbers of geese to the Central-Mississippi Flyway states. The Central Arctic population is numerically small (24,000 according to Ryder 1971; *in litt.*), but contributes birds to the Central Flyway, western Canada, and, to a lesser extent, northern interior Mexico.

Geese from colonies situated around Hudson Bay are primarily oriented to the Central and Mississippi Flyways (Tables 3 and 4) and again form a relatively closed population. Further results and discussions will be restricted to the Hudson Bay colonies (Colony numbers 1-12, Figs. 1 and 2).

Using the axial line technique devised by Bellrose and Crompton (1970), mean longitudinal lines of direct band recovery distribution, from each of five major colonies, are depicted for both Snow and Blue Geese in Figures 4 and 5. Cumulative percentages of band recoveries to each latitude indicate differences between colonies and stocks (Tables 3 and 4). Corroborative statistical listings, which showed ±1 SD at each latitude, show that for any latitude lying between 25° and 48°N in the continental United States there is no significant difference ($p < 0.05$) between direct and indirect, pooled adult and immature Snow Goose and Blue Goose recoveries. Axial lines for Blue Goose recoveries from all colonies tend to be more easterly, *i.e.*, within the Mississippi Flyway (Fig. 5), and show wider variability at most latitudes than those for Snow Geese. There being no statistically significant colony or colour morph differences in the mean longitudinal lines of recoveries in the US, we conclude that all Hudson Bay colonies can be treated as a mixed, homogeneous population while on autumn migration in the US.

Estimated annual harvest of Blue and Snow Geese for Zone 3 (Northern States), Zone 4 (Central States), Zone 5 (Gulf States), and the three zones combined, was regressed against time, 1962–71 (Fig. 8; Table 5). A statistically significant increase in harvest is demonstrated in the Northern States, Central States, and total Central-Mississippi Flyways (all $p < 0.05$), but not in the Gulf States ($p > 0.05$). A Spearman Rank Correlation (R_S) for the harvests in Northern and Central States over time also showed significant increases ($R_S = 0.68$ and 0.87 respectively; for both, $p > 0.05$). The wide variance associated with major annual fluctuations in harvest (viz. 1966, 1970) precludes definitive inferences on zonal harvests. Overall, there is an apparent trend to increased annual harvest in all zones.

To test relationships between estimated zonal harvests (Table 5) and numbers of direct recoveries in each zone (Table 6), a regression line was calculated for each zone for the 1964–71 period. There was no significant difference from zero slope for the regression of recovery numbers on harvest in the Northern and Central States ($Y = 0.30x + 59.1$, $r = 0.43$; and $Y = 0.31x + 54.0$, $r = 0.38$; for both $p > 0.05$) but a significant relationship existed in the Gulf States ($Y = 1.14x + 17.1$, $r = 0.87$, $p < 0.05$). That is, in the Gulf States, but not further north, as harvest increased the number of direct band recoveries also increased proportionally. For all zones combined there was no significant correlation between annual harvests and annual numbers of direct recoveries (Spearman Rank Correlation, $R_S = 0.62$, $p > 0.05$).

Annual estimated harvests of the two colour morphs in each of the Central and Mississippi Flyways (Table 7) were tested to determine if changes in proportions of colour phases harvested had occurred between the periods 1962–66 and 1967–71. Mean ratios of Blue and Snow Geese in the Central Flyway harvest increased from 0.40 Blue:1.0 Snow for 1962–66 to 0.54 Blue:1.0 Snow in 1967–71. Comparable figures for the Mississippi Flyway show a decrease from 2.00 Blue:1.0 Snow to 1.90 Blue:1.0 Snow. For both flyways combined the ratio changed from 0.81 Blue: 1.0 Snow to 1.02 Blue:1.0 Snow. Using a Proportion Test, it was determined that, in both flyways combined, significantly higher numbers of Snow Geese (and conversely fewer Blue Geese) were harvested in the earlier period ($Z = 99.82$, $p < 0.05$) than in 1967–71. In the Central Flyway significantly higher proportions of Snow Geese were also harvested in the 1962–66 interval ($Z = 90.19$, $p < 0.05$). However, the situation was reversed in the Mississippi Flyway with more Snow Geese harvested in the 1967–71 period than previously ($Z = -15.11$, $p < 0.05$). This suggests that the proportion of Blue Geese in the Mississippi Flyway harvest has decreased over the past 5 years. The inference was in part substantiated by lower proportions of Blue Geese in Baffin Island colonies (Fig. 2) with their prime orientation to the Mississippi Flyway (Table 4). (These conclusions should be considered tentative since the methodology and results of the US National Harvest Survey and applied Species Composition Survey have come under question (Bishop 1971; Lumsden 1972)).

Dates and approximate lengths of hunting seasons in the three zones are shown in Figure 9. Comparisons of temporal band recovery patterns for 10-day periods in the intervals

1964–66 and 1967–71, were made using the Kolmogorov-Smirnov goodness of fit test. For each of the three zones, significant differences in distribution patterns of band recoveries between the two periods were apparent, *i.e.* Northern States $d = 0.28$, $N = 8$, $p < 0.05$; Central States $d = 0.39$, $N = 11$, $p < 0.05$; Gulf States $d = 0.15$, $N = 13$, $p < 0.05$. Shifts to later band recovery peaks were confirmed in each zone through use of a Proportion Test. In the Northern States significantly more bands were recovered in the period October 21 to November 30 in 1967–71 than in 1964–66 ($Z = -4.99$, $p < 0.05$). In the Central States proportionally more bands were recovered in the period October 21 to November 30 in 1967–71 than in 1964–66 ($Z = -7.16$, $p < 0.05$). Lengths of goose seasons and opening and closing dates varied somewhat in both the Northern and Central States in the period 1964–71 (Dzubin 1974: Tables 2–5) but during these 8 years all states in the two zones were open to hunting between October 21 and November 30. However, in the Gulf States proportionally more bands were recovered in the periods October 21 to November 30, and December 1 to 31, in 1964–66 than in 1967–71 ($Z = 1.98$, $p < 0.05$, $Z = 2.62$, $p < 0.05$). Paralleling an extension of the Louisiana hunting season into the month of February in 1970–1972, a significant increase was evident in the proportion of bands recovered in the Gulf States between January 1 and February 20 in 1967–71 compared with 1964–66, when the season closed before January 15 ($Z = -4.62$, $p < 0.05$).

The data therefore confirm that in recent seasons more geese were being harvested in the Northern and Central States (Fig. 8; Table 5) and that the peak band recovery intervals had shifted to later periods (Fig. 9). Deleterious effects upon the Hudson Bay population were not readily apparent. Any inferred increase in harvest in the Northern and Central States might be accommodated by the much larger population suggested in Figure 2.

We computed trend analysis of wintering populations from 1952 through 1969 (Table 8) for annual totals of Blue and Snow Geese found in January in both the Mississippi and Central Flyways combined. A slight tendency toward decrease was apparent but the slope showed no significant difference from zero ($Y = -2.79x + 749$, $p > 0.05$). For the entire time period, no significant decrease or increase was noted for the Mississippi Flyway January counts ($Y = -1.11x + 421$, $p > 0.05$). In both flyways, the January counts indicate a trend toward stability, with annual fluctuations of a maximum factor of two.

The seeming population stability over the 18-year period suggested by the winter inventories was not corroborated by the apparent increases in colony population estimates (Figs. 1 and 2) nor by fall flight estimates ranging from 1.60 to 3.57 million birds obtained by Boyd (in prep.) using a Lincoln Index calculation with annual banding totals, estimates of harvest and band recovery rates. Total population estimates from an aerial survey conducted in late May, 1973 along the Hudson–James Bay coasts were about 1.65 million birds (S.G. Curtis *in litt.*) compared with an estimate of 1.04 million on migration and wintering grounds in December, 1972 (Table 8). This indication that winter assessments may be well below the size of the post-hunting season population is consistent with views expressed by Bishop (1971), Lumsden (1972) and Lynch (1973). The winter survey may also have been detecting a changing proportion of the surviving stock.

Trend analysis of three parameters, percentage of young, field productivity (ratio of parents to all adult-plumaged birds), and December brood size for the 1952 through 1971 period (Fig. 10; Table 9), showed only a slight decline in indicated productivity. No significant differences in slope of the regression lines from zero could be detected for any of the parameters ($p > 0.05$). Spearman Rank Correlations for the three parameters over 1952–71 also show non-significant differences for average December brood size and field productivity ($R_s = 0.41$, 0.42 respectively, $p > 0.05$), but a significant reduction in percentage of young ($R_s = 0.46$, $p > 0.05$).

To confirm results of the December field appraisals, we calculated trend lines of blue and white morph age ratios in the retrieved harvest of both the Mississippi and Central Flyways for 1962 through 1971 (Table 10). No statistically significant increase or decrease could be demonstrated over the decade for either morph, in either of the two flyways (all $p > 0.05$). Only the immature to adult ratios of Snow Geese in the Mississippi Flyway showed some tendency toward decrease ($Y = -0.03x + 1.23$, $r = 0.23$). The wide annual changes in progeny output and resultant variance (e.g. Blue Geese in Central Flyway, immatures per adult, 0.23 (1968) and 1.65 (1969)), the varying annual and colony vulnerability rates of immatures (Table 11) and the annually varying proportion of non-breeding yearlings and 2-year-olds, which have attained adult plumage but are unproductive, make uncorrected age ratios from the harvest a poor parameter on which to weight population productivity.

Should the apparent tendency toward decreasing productivity, as measured in the Gulf States by Lynch (1972), be real and not due to wide variance caused by the outlying points in years of poor or excellent productivity, it could be a reflection of the effects of climatic deterioration on reproductive output of colonies lying north of 61°N latitude. Increased hunting effort evidenced by increasing harvests in the Northern and Central States (Fig. 8) may cause more juvenile mortality. There may be real changes in the age structure of the population, or of other demographic characteristics or some combination of all those factors.

Prevett (1972, in prep.) has documented the negative effects of massive fall congregations on family cohesion of geese on refuges in the Northern and Central States. Hunting and other disturbances (e.g. eagles, airplanes) lead to greater loss of family integrity in Northern and Central States than in the Gulf States. More families remain intact in the Gulf States where average flock size is smaller and more widely dispersed than on refuges further north where flock sizes are larger and more confined, and where natural and artificial disturbances are much greater. Young of the year separated from parents may be more vulnerable to hunters. Massive autumn congregations may therefore enhance vulnerability of immatures and lead to higher harvests.

The chance that immature geese were more likely to be shot than adults varied between years and between colonies

(Table 11; see also Dzubin 1974, Tables 9a, 9b, 9c; Appendix). Vulnerability rates of immature Snow Geese ranged from a low of 0.79 for geese from the Boas River colony in 1961 to a high of 2.53 for Boas River birds in 1953 (Table 11). Blue morph rates ranged from 0.80 for McConnell River geese in 1965 to 2.55 for Boas River in 1953. For pooled samples from these two colonies, but excluding 1961, the average immature vulnerability rate was 1.93 for Snow Geese and 1.35 for Blue Geese.

To gain insight into the effects of neckbanding on recovery and reporting rates, we made a comparison of pooled direct recovery rates from normal wild and from neckbanded Blue and Snow Geese (Table 12, after MacInnes in prep.) For geese from the McConnell River colony, immature neckbanded Snow Geese were 2.17 times more likely to be shot and reported than normal legbanded Snow Geese. "Reporting" rates for immature neckbanded Blue Geese, adult neckbanded Snow Geese and adult neckbanded Blue Geese were 2.64, 1.40 and 1.17, respectively. Although the method of calculation of "reporting" here is the same as in the comparison of immature to adult vulnerability described in the preceding section, the results may be due to a different cause.

It seems likely that much of the enhancement of direct recovery rates of neckbanded birds results from a higher reporting rate for them by hunters. MacInnes (in prep.) is investigating this point thoroughly. It has important implications for the planning of future monitoring and research.

Boyd (in prep.) found a linear relationship between direct recovery rates and mortality rates of first year (immature) birds from western Hudson Bay stocks, i.e., Boas River, McConnell River, and La Pérouse Bay colonies, but concluded that direct recovery rate did not seem to be a satisfactory index to *adult* mortality.

Estimated mean mortality rates among immature samples for the 1952 to 1970 period have shown greater stability than among adult samples (Table 13). Mean mortality rates have tended to be higher during recent years (Table 13).

Conclusions

If a problem exists relating to artifically induced delays in Blue and Snow Goose migration chronology in the Northern and Central tier of states, leading to reduced recreational opportunity in the Gulf States, that problem has not been substantiated by the harvest, colony size or band recovery data used in this study.

During the past decade annual harvests in both the Central and Mississippi Flyways have significantly increased, a trend statistically evident in both the Northern and Central States. The winter population indices from the Gulf States have shown no downward trend. Summer colony estimates show no major decreases on Southampton or Baffin islands in spite of several years with unsuitable conditions for nesting. Growth has occurred in the last 10 years in the McConnell River colony and the Cape Henrietta Maria colony, significantly increasing the breeding population. Production indices tended to decrease over the 5 years ending in 1972, but the decreases are not significant at conventional statistical levels.

If the problems resulting from changing patterns of migration are deemed serious, it will be necessary to go to another level of precision in the collection of data, to measure reliably any harmful effects upon Blue and Snow Geese of recent changes in harvest and in autumn distribution patterns. The problem of reduced recreational opportunity propounded by the Gulf States appears to be more anticipatory than established.

A seemingly irreconcilable conflict of management objectives has developed over distribution of harvest in the Northern-Central States and Gulf States. The stance of the latter (in June, 1970) was: (1) "We will be satisfied with nothing less than a restoration of the traditional migration to the coastal wintering area and arrival there on schedule comparable to that of the fifties and before; and (2) We will not object to half the harvest occurring north of the Gulf States, as it does at present" (Bishop 1971:8). These wishes remain incompatible. The Northern and Central States have aspired to an increased harvest by active land management and regulatory practices. However, it is far from clear that the continuous changes in the distribution of geese and other birds, which changes are a fact of biological life, can be brought under control by interested agencies, whatever political pressures may be involved. Geese, reacting to various stimuli, decide how and when they will distribute themselves.

The desires of Canadians are alluded to but rarely considered seriously in debate. Canadians also want their fair share of the Blue–Snow Goose resource, and such a desire can only lead to future changes in harvest apportionments. The wishes of Mexicans have yet to be ascertained.

Within Canada, natural changes may greatly affect the growth, size, and distribution of colonies, and oil, gas, and mineral exploitation in the Arctic and in and around Hudson Bay could disturb colonies and migration areas. Major hydro developments are already underway on the east shore of James Bay and others may take place within a few years. Their effects are not easy to predict, but even the initial construction of a road and other preparatory works has had a great impact on the way of life of the Indians who have long used geese as an important source of food and, more recently, as the principal attraction of camps for visiting hunters. The distribution of geese on migration areas will probably also change as a result.

Rational conservation and exploitation policies can be formulated and followed only if concerted efforts are made to improve the precision of the data base for estimating abundance, production, mortality, harvest and emigration. More formal but flexible agreements may soon be required on how the annual surplus is to be divided among states and provinces and among Canada, the United States and Mexico.

There is a clear need for preliminary agreement on priorities, on how much additional research and operation effort is called for, on how much money should profitably be spent, and on the allocation of responsibilities among the pertinent agencies.

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Table 1
Summary of years and colonies where Snow and Blue Geese were banded in northern Canada, 1952–71. X denotes banded samples available for that year.

Colony	McConnell River	Boas River	East Bay	Baffin Island	La Pérouse Bay	Cape Henrietta Maria	Perry River
Lat.			63-081	65-073			67-102
Long.	60-094	63-085	64-081	66-073	58-093	55-082	67-100
1952		X					
1953		X					
1954	X						
1955							
1956		X					
1957			X				
1958							
1959	X						
1960	X	X					
1961	X	X	X	X			
1962							X
1963							X
1964	X						
1965	X	X	X				X
1966	X						X
1967	X			X			X
1968	X			X			X
1969	X				X	X	
1970	X				X	X	
1971	X				X	X	
No. banded normal	29,192	27,035	12,000	20,642		10,599	580
(Neckbanded	15,631)		(Colour leg banded		5,895)		
No. recoveries*	3,978	4,657	2,067	2,160		808	64
(Neckbanded	2,155)				(563)		

Total: Hudson Bay Colonies (excluding Perry River), 120,994 Blue and Snows banded; 16,388 recoveries.

*Received to Feb. 1972. Totals include both direct and indirect recoveries.

Table 2
Percentage of direct adult and immature Snow Geese recovery for western and central arctic colony banding locations and autumn migrants

	Arctic populations						
	Western						Central
Banded in:							
Degree block	69-129	72-124	72-125	72-124	51-109	51-111	67-100 67-102
Year(s)	59,63,66	53	55	61	60-70	60,62	62-68
Location	Anderson	Banks	Banks	Banks	W. Sask.*	E. Alta.*	Perry
Recovered: Flyway and area							
Canada							
Yukon			7.1				
Mackenzie							
Franklin							
Keewatin							
Alberta	21.9	20.0	7.1	35.7	0.8	23.1	13.6
Saskatchewan	4.3			1.8	17.4		9.1
Subtotal	26.2	20.0	14.2	37.5	18.2	23.1	22.7
Pacific							
Idaho					1.1		
Oregon	7.7		21.5	5.4	2.3		
Washington							
California	55.9	80.0	43.0	48.1	64.6	61.5	4.5
Nevada	2.2		7.1		3.1		
Utah					1.1		
Arizona					0.8		
Subtotal	65.8	80.0	71.6	53.5	73.1	61.5	4.5
Central							
Montana	3.7		7.1	3.6	1.1	7.7	
North Dakota					0.4		4.5
Nebraska					1.1		4.5
Colorado	0.3				0.8		
Texas							18.3
Subtotal	4.0		7.1	3.6	3.4	7.7	45.4†‡
Mississippi							
Minnesota							
Missouri							
Subtotal					0.8§		
Mexico	4.0		7.1	5.4	4.6	7.7	27.4
Alaska							
No. recoveries	324	5	14	56	258	13	22

*Autumn migrants.
†Includes South Dakota (3) recoveries 13.6%.
‡Includes Kansas (1) recovery 4.5%.
§Includes Michigan (1) recovery 0.8%.

Table 3
Percent recovery distribution of direct adult and immature Snow Geese for Hudson Bay colony banding locations

	Hudson Bay population						
	Western					Eastern	
Banded in: Degree block	63-085	63-081 64-081	60-094	60-094*	58-093†	55-082	65-073 66-073
Year(s)	52-65	57-65	54-71	64-71	69-71	69-71	61-68
Location	Boas R.	East B.	McC.R.*	McC.R.*	L.P.B.*	C.H.M.*	Baffin
Recovered: Flyway and area							
Canada							
Keewatin	0.1		0.1				
Saskatchewan	0.3			0.1	0.6		
Manitoba	3.0		3.8	3.5	7.2	3.0	
Ontario	7.7	13.4	2.3	2.0	1.2	10.0	11.4
Quebec	0.3	0.7					4.2
Subtotal	11.4	14.1	6.2	5.6	9.0	13.0	15.6
Central							
North Dakota	3.4	10.3	15.2	26.1	27.0	4.0	5.1
South Dakota	11.7	15.8	19.7	12.3	16.0	9.0	12.6
Nebraska	2.5	4.8	1.4	2.1	1.7	2.0	1.3
Kansas	1.3	1.0	1.4	0.5	0.6		2.6
Oklahoma	1.3	0.7	1.1	0.5	0.3		1.3
Texas	53.2	32.0	37.2	32.7	25.3	34.0	26.5
Subtotal	73.6‡	64.6	76.0	74.2	70.9	49.0	49.4
Mississippi							
Minnesota	6.9	9.4	6.1	3.7	2.0	2.0	9.3
Wisconsin	0.4	0.3	0.6	0.4			3.0
Michigan	0.1			0.1			0.4
Iowa	2.0	5.8	4.1	4.8	7.9	12.0	12.6
Illinois	0.3	0.3		0.1		2.0	1.3
Indiana				0.1			
Missouri	1.8	2.4	2.7	5.8	4.7	9.0	4.2
Arkansas	0.1		0.1		0.1		
Kentucky							
Louisiana	2.9	2.4	3.9	4.9	5.5	13.0	4.2
Subtotal	14.5	20.6	17.5	19.9	20.1	38.0	35.0
Mexico	0.5	0.7	0.2	0.3			
Pacific							
Atlantic			0.1				
No. recoveries	1,189	291	1,101	948	344	100	237

*Neckbanded only.
†Colour legbanded.
‡Includes three New Mexico recoveries 0.2%
*McC.R., McConnell River; L.P.B., La Pérouse Bay; C.H.M., Cape Henrietta Maria.

Table 4
Percent recovery distribution of direct adult and immature Blue Geese for Hudson Bay colony banding locations

	Hudson Bay population						
	Western					Eastern	
Banded in: Degree block	63-085	63-081 64-081	60-094	60-094*	58-093†	55-082	64-073 66-073
Year(s)	52-65	57-65	54-71	64-71	69-71	69-71	61-68
Location	Boas R.	East B.	McC.R.	McC.R.	L.P.B.	C.H.M.	Baffin
Recovered: Flyway and area							
Canada							
Keewatin			0.5				
Saskatchewan	0.2						
Manitoba	3.2	0.6	3.4	4.1	5.3	1.1	
Ontario	10.0	12.1	3.4	3.8	2.3	10.6	26.3
Quebec		2.3		0.3		4.6	10.9
Subtotal	13.4	15.0	7.3	8.2	7.6	16.3	37.2
Central							
North Dakota	1.8	8.7	12.7	23.6	23.5	5.3	2.4
South Dakota	10.0	13.8	16.4	12.3	15.2	7.8	4.0
Nebraska	1.8	0.6	0.8	0.8	0.7	3.9	0.8
Kansas	1.1	1.2	1.1	0.3		1.8	1.3
Oklahoma	1.4	0.6	0.3	2.2			0.5
Texas	43.9	24.8	32.2	26.8	22.7	13.5	8.5
Subtotal	60.0	49.7	63.5	66.0	62.1	32.3	17.5
Mississippi							
Minnesota	4.5	8.1	5.8	4.4	0.7	4.6	6.1
Wisconsin	0.5	1.2	0.5	0.3		0.7	2.1
Michigan	0.2	0.6	0.5		0.7	0.4	2.1
Iowa	3.6	5.2	2.6	3.6	9.2	10.5	8.8
Illinois	0.5	1.2	0.5	0.3		0.4	1.3
Indiana	0.2	1.2					0.5
Missouri	2.0	4.6	5.0	4.9	3.8	6.0	3.2
Arkansas	0.5		0.3				0.3
Mississippi				0.3		0.4	0.5
Alabama							0.5
Louisiana	14.4	12.6	14.0	11.7	15.9	27.6	19.9
Subtotal	26.4	34.7	29.2	25.5	30.3	51.4‡	45.3
Mexico		0.6		0.3			
Pacific							
Atlantic	0.2						
No. recoveries	440	173	379	365	132	282	377

*Neckbanded only.
†Colour legbanded.
‡Includes one Kentucky recovery 0.4% and one Ohio recovery 0.4%.

Table 5
Estimated Blue and Snow Goose harvest* by three zones in US (after USBSFW Admin. Reports. Recalculated by G.W. Kaiser)

Year	Zone III†	Zone IV	Zone V	Other zones‡	Total
1962	55,370	27,460	62,020	3,820	148,670
1963	62,320	35,580	112,580	4,990	215,470
1964	65,480	32,730	126,940	2,170	227,320
1965	79,420	55,190	101,200	2,220	238,030
1966	65,780	66,470	269,750	1,380	403,380
1967	78,660	56,910	151,110	2,440	289,120
1968	46,600	41,700	100,630	5,070	194,000
1969	194,630	111,860	164,740	5,850	477,080
1970	138,450	119,330	411,930	5,790	675,500
1971	168,590	103,070	118,710	1,900	392,270
Totals	995,300	650,300	1,619,610	35,630	3,260,840

*Includes adjustment for unretrieved birds.
†See Figure 3.
‡Alabama, Mississippi, Kentucky, Tennessee, New Mexico, Colorado, Wyoming, Montana.

Table 6
Zonal distribution of direct recovery numbers of Blue and Snow Goose adults and immatures from six Hudson Bay colonies

Zone	1964	1965	1966	1967	1968	1969	1970	1971	Totals
I Hudson and James Bays	3	46	7	31	67	27	44	21	246
II Southern Canada	2	4	0	11	2	28	13	23	83
III Northern states	34	238	145	155	65	209	249	107	1,202
IV Central states	7	69	52	71	78	31	150	45	503
V Gulf states	36	126	175	158	132	112	317	85	1,141
Pooled U.S. states	77	433	372	384	275	352	716	237	2,846

Table 7
Total estimated Blue and Snow Goose harvest* in Mississippi and Central Flyways (after USBSFW Admin. Reports. Recalculated by G.W. Kaiser)

	Blue Geese		Snow Geese		
Year	Central	Mississippi	Central	Mississippi	Total
1962	29,340	37,300	70,980	11,050	148,670
1963	38,770	54,430	100,530	21,740	215,470
1964	29,670	76,630	94,230	26,790	227,320
1965	41,820	63,120	83,550	49,540	238,030
1966	63,930	118,150	156,000	65,300	403,380
1967	58,350	81,100	106,530	43,140	289,120
1968	26,200	61,020	64,070	42,710	194,000
1969	82,980	175,020	133,030	86,050	477,080
1970	118,940	222,080	213,510	120,970	675,500
1971	66,920	132,830	131,410	61,110	392,270
Totals	556,920	1,021,680	1,153,840	528,400	3,260,840

*Includes unretrieved birds.

Table 8
Mid-winter and December inventory of Blue and Snow Geese (in thousands) in the Mississippi and Central Flyways, 1950–1973 (after USBSFW Reports, A. Brazda and A. Hawkins)

Year	Mississippi Flyway	Central Flyway	Total
1950 January	392	600	1,000*
1951	387	350	750*
1952	301	200	525*
1953	406	327	733
1954	515	500	1,015
1955	368	325	693
1956	450	477	927
1957	365	283	648
1958	415	306	721
1959	363	164	527
1950–59 mean	396	353	754
1960	492	300	792
1961	529	268	797
1962	369	207	576
1963	442	357	799
1964	457	300	757
1965	411	385	796
1966	484	214	698
1967	380	262	642
1968	363	270	633
1969 January	275	454	729
1960–69 mean	420	302	722
1950–69 mean	408	327	738
1969 December†	425	401	826
1970 "	655	422	1,077
1971 "	937	404	1,341
1972 "	532	505	1,037
1973 "	529	674	1,202

*1950–52 totals also include estimated number of Blue Geese.
†Mid-December surveys, in hunting season, not strictly comparable to previous January counts after hunting season.

Table 9
Brood averages and field productivity of Blue and Snow Geese on the Gulf Coast, 1952–71 (after Lynch 1972, Table 2)

Year	Goslings per average brood in December	% young	Field productivity (ratio of parents to all adult plumaged birds)
1952	2.39	48.2	68.6
1953	2.18	42.7	59.9
1954	1.80	6.0	5.7
1955	2.78	54.2	73.6
1956	2.03	35.4	38.8
Unweighted average	2.24	37.3	49.3
1957	2.14	43.7	58.6
1958	1.59	24.2	29.5
1959	2.49	50.9	73.6
1960	2.25	36.9	44.6
1961	1.67	13.2	13.3
Unweighted average	2.03	33.8	43.9
1962	1.93	31.1	40.1
1963	2.12	22.4	24.7
1964	2.09	25.8	30.8
1965	2.11	33.7	43.2
1966	2.49	42.7	55.9
Unweighted average	2.15	31.4	38.9
1967	1.92	20.2	24.2
1968	1.88	12.7	14.1
1969	1.98	29.1	37.0
1970	1.84	26.7	34.6
1971	1.58	17.2	22.4
Unweighted average	1.84	21.2	26.5

Table 10
Flyway-weighted age ratios in the goose kill based on the goose-tail collection surveys, 1962–1971 (after USBSFW Admin. Repts. 112, 136, 151, 173, 184, 202, 217 and Rept. dated 07/05/73)

	Immatures per adult							
	Blue Geese				Snow Geese			
Year	Central		Mississippi		Central		Mississippi	
1962 (N)†	0.78	256	0.77	180	0.82‡	617	0.88	113
1963 (N)	0.77	263	0.67	226	1.00‡	621	1.84	114
1964 (N)	0.80	261	1.07	344	0.90‡	812	1.16	242
1965 (N)	1.25	312	0.95	263	0.84	640	0.99	215
1966 (N)	1.22	247	1.55	328	1.17	634	1.05	243
1967 (N)	0.75	346	0.98	218	0.75	599	0.66	112
1968 (N)	0.23	129	0.26	192	0.55	266	0.38	112
1969 (N)	1.65	437	1.55	613	1.32	781	1.22	326
1970 (N)	1.03	432	0.90	479	1.27	897	1.59	437
1971 (N)	0.55	270	0.69	401	0.52	530	0.69	218

*Flyway weighted age ratios are calculated from State results of the Species Composition Survey weighted by the goose harvest in each state (as determined from the Mail Questionnaire Survey).
†N, tabulated number of goose tail-fans in Flyway sample.
‡Includes small sample from Montana-Pacific Flyway portion.

Table 11
Calculated vulnerability rates of immatures and snow morphs using direct recovery rates from bandings at Boas River and McConnell River colonies (after Cooch *in litt.*, MacInnes *in litt.*). Values in parentheses indicate numbers of recoveries.)

		% direct recovery rates				Vulnerability rates			
		Snow		Blue					
Year	Colony	Adult	Imm.	Adult	Imm.	Imm. snow / Ad. snow	Imm. blue / Ad. blue	Imm. snow / Imm. blue	Ad. snow / Ad. blue
1952	Boas River	6.12 (20)	8.11 (241)	4.89 (27)	5.66 (65)	1.33	1.16	1.43	1.25
1953	"	4.19 (143)	10.61 (296)	3.34 (40)	8.52 (86)	2.53	2.55	1.25	1.25
(1961)*	"	5.16 (43)	4.05 (37)			0.79			
1960	McConnell River	2.54 (49)	5.28 (117)	3.30 (24)	5.23 (47)	2.08	1.58	1.01	0.77
1965	"	3.03 (53)	5.06 (138)	3.72 (30)	2.98 (40)	1.67	0.80	1.70	0.82
1970	"	6.82 (55)	9.15 (61)	7.66 (34)	7.78 (29)	1.34	1.01	1.18	0.89

*1961 data not used in the calculations of means in text.

Table 12
Estimates of reporting rates for normal and neckbanded Blue and Snow Geese banded at McConnell River, NWT, 1964–71 (after MacInnes in prep.)

	% normal direct recovery rates				% neckbanded direct recovery rates				Reporting rates*,†			
	Snow		Blue		Snow		Blue					
Year	Adult	Imm.	Adult	Imm.	Adult	Imm.	Adult	Imm.	Imm.nb.sn. / Imm.nb.sn.	Ad.nb.sn. / Ad.nb.sn.	Imm.nb.bl. / Imm.nb.bl.	Ad.nb.bl. / Ad.nb.bl.
1965	3.03		3.72		6.24		14.89			2.06		4.00
No. recovered	53		30		72		21					
1966		4.04		3.42		11.80		10.48	2.92		3.06	
No. recovered		50		17		201		64				
1964–67 Pooled	3.08	4.59	4.37	2.98	7.04	11.47	6.92	9.99	2.50	2.29	3.35	1.58
No. recovered	86	212	53	64	174	394	51	138				
1968–71 Pooled	6.92	8.16	7.66	7.61	4.44	11.47	5.73	11.08	1.41	0.64	1.46	0.75
No. recovered	56	93	34	43	153	225	75	101				
1964–71 Pooled	3.94	5.29	5.25	3.94	5.53	11.47	6.16	10.43	2.17	1.40	2.64	1.17
No. recovered	142	305	87	107	327	619	126	239				

*Calculated reporting rates from pooled data should be considered indices only, as banded samples varied between years (or were nonexistent).
†Nb, neckbanded; sn, snow; bl, blue.

Table 13
Estimates of percentage annual mortality rates (m = 1-s) for banded Blue and Snow Geese in some years from 1952 to 1970 (after Boyd, in prep.)

	Adults when banded		Locals when banded	
Year	m%	S.E.	m%	S.E.
Western stock*				
1952	8.2	7.42	52.0	2.65
1953	7.2	8.31	62.6	3.32
Pooled (1952–53)	15.1	3.46	55.6	3.46
1956	47.2	3.00	–	–
1959	24.1	6.16	51.4	5.10
1965(n)	34.0	8.49	–	–
1966(n)	45.7	8.83	66.3†	3.74
1967(n)	29.2	8.43	77.5†	3.16
1968(n)	33.4	8.00	65.0†	4.24
1969	58.5	29.55	67.2	6.93
1970	51.3	14.73	70.6	5.00
Pooled (1967–70)	30.0	10.15	63.0	2.12
Eastern stock‡				
1967	(-41.7)§	(15.81)	70.1	7.42
1968	54.0	2.24	68.6	10.15
1969	(-18.1)§	(28.78)	59.9	9.43
1970	58.1	10.58	–	–
Pooled (1967–70)	25.7	4.36	72.2	3.46

*Western stock, comprising McConnell River, La Pérouse Bay, and Boas River colonies.
†Based on samples carrying neck-collars as well as legbands.
‡Eastern stock, comprising Bowman Bay, Cape Dominion, Koukdjuak River and Cape Henrietta Maria colonies.
§Parentheses denote inadmissible values.

Figure 1
Estimated size and location of breeding colonies in Arctic Canada, 1954–61

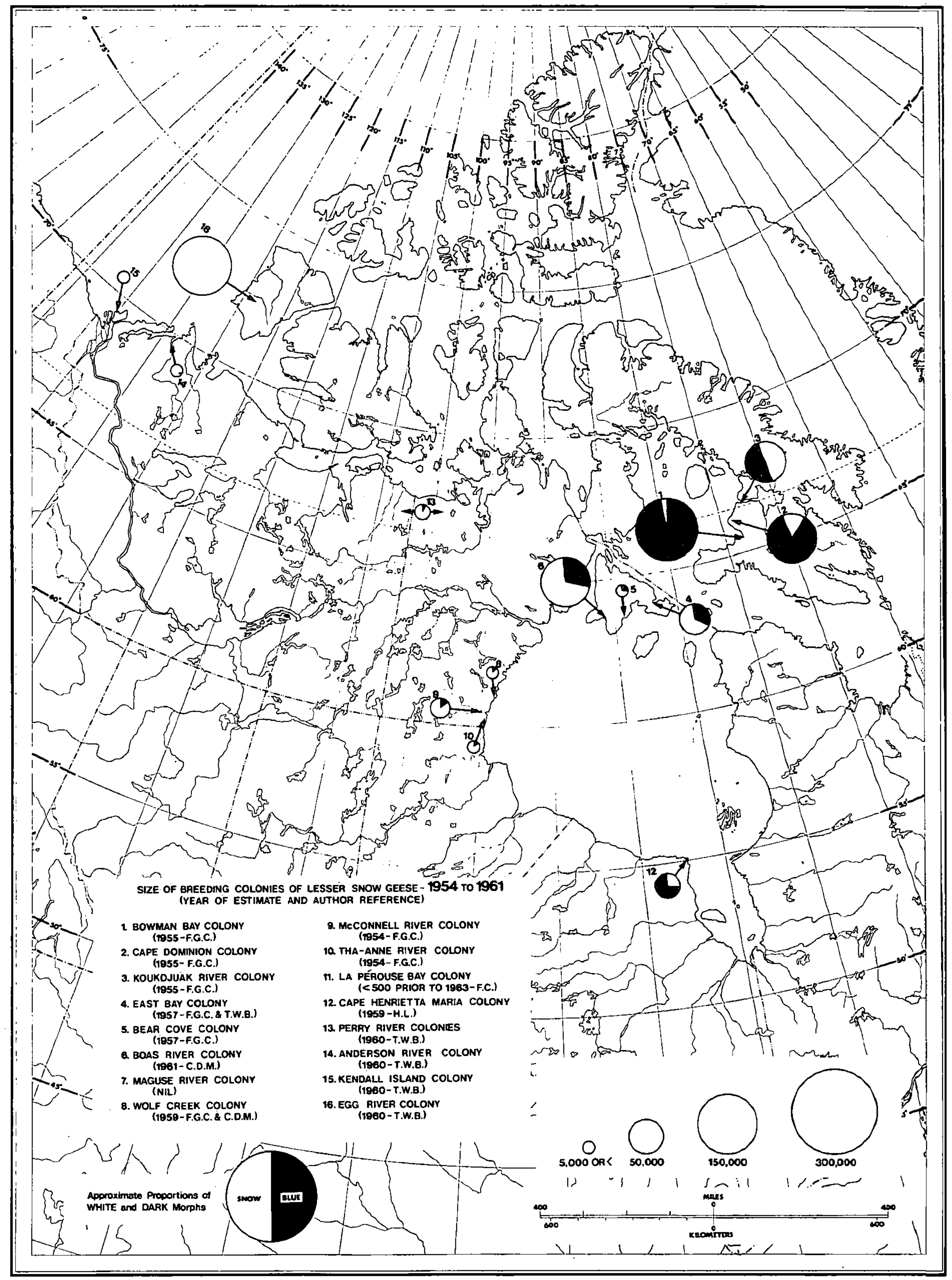

Figure 2
Estimated size and location of breeding colonies in Arctic Canada, 1968–72

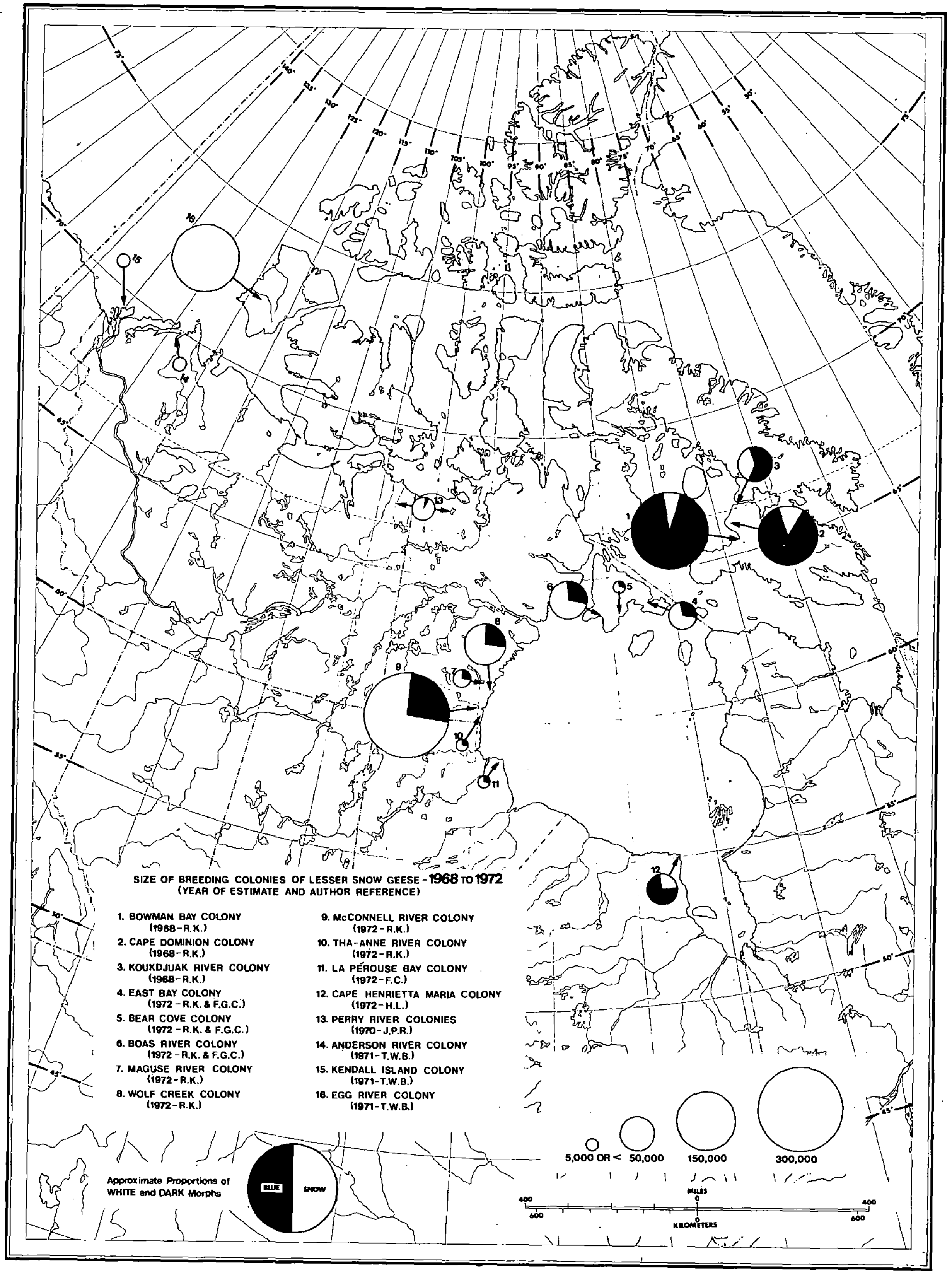

Figure 3
Boundaries of five band recovery zones (areas) in central North America (after Lumsden in prep.)

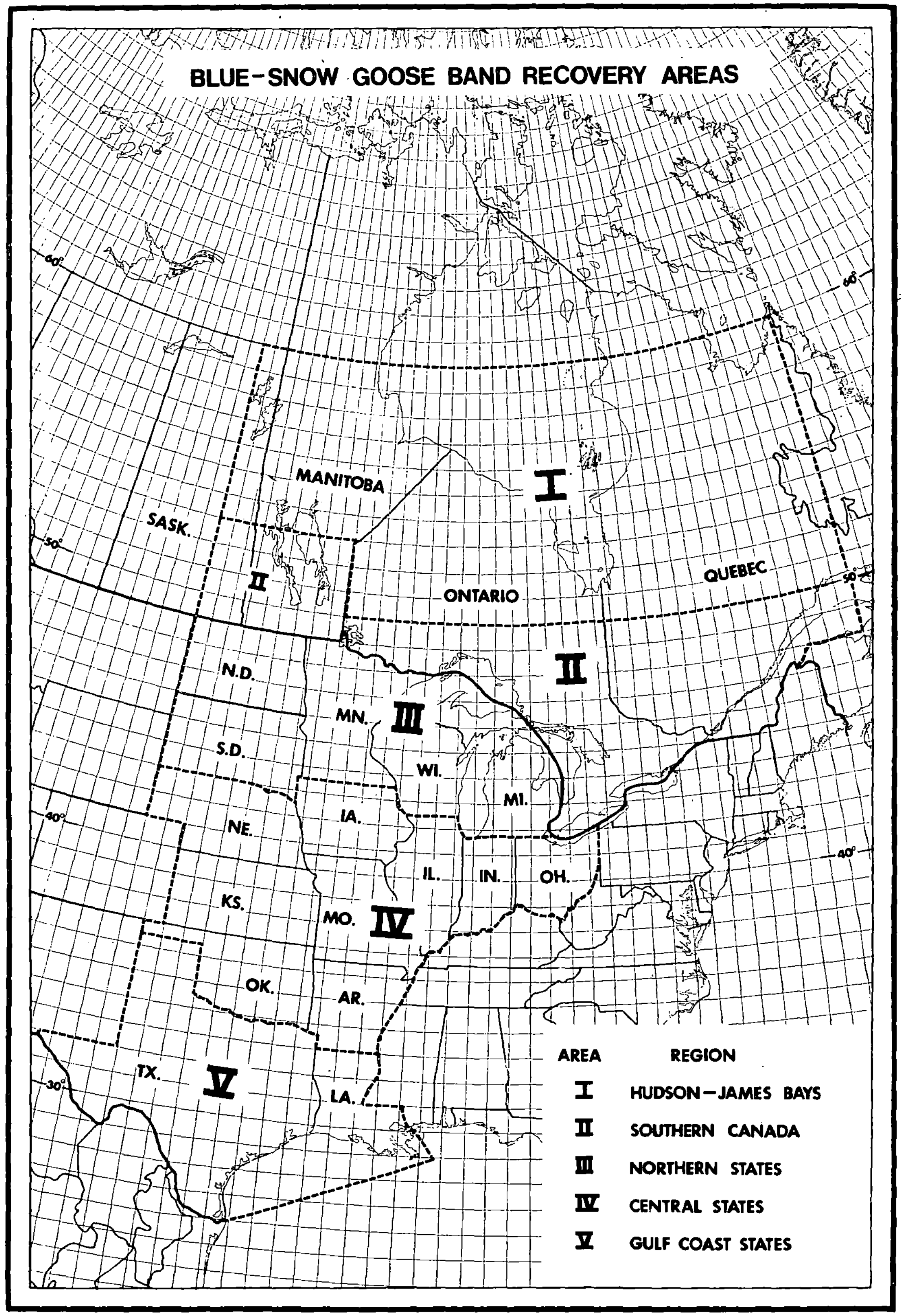

Figure 4
Comparison of the mean longitudinal distribution of direct Snow Goose recoveries from five Hudson Bay colonies

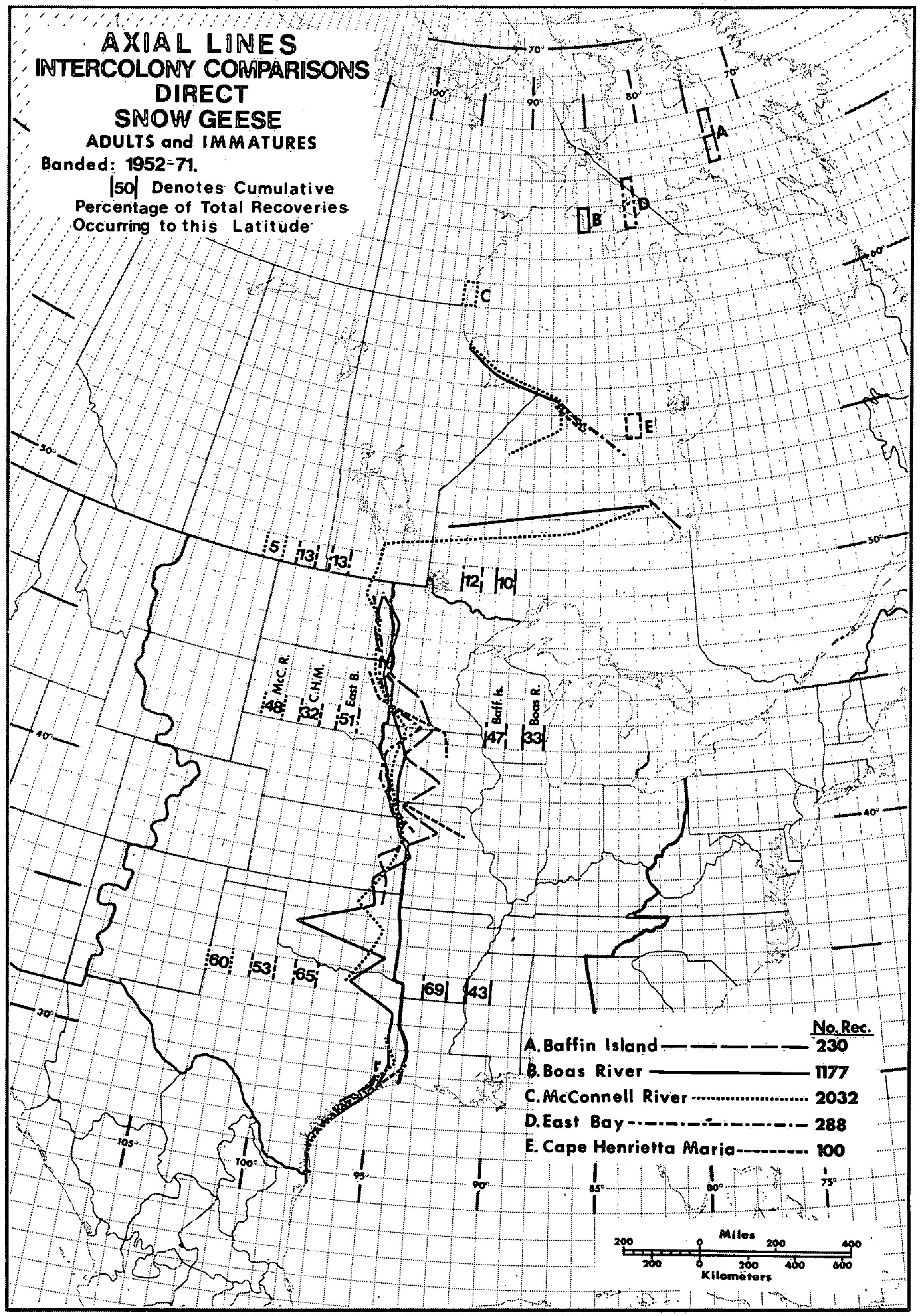

Figure 5
Comparison of the mean longitudinal distribution of direct Blue Goose recoveries from five Hudson Bay colonies

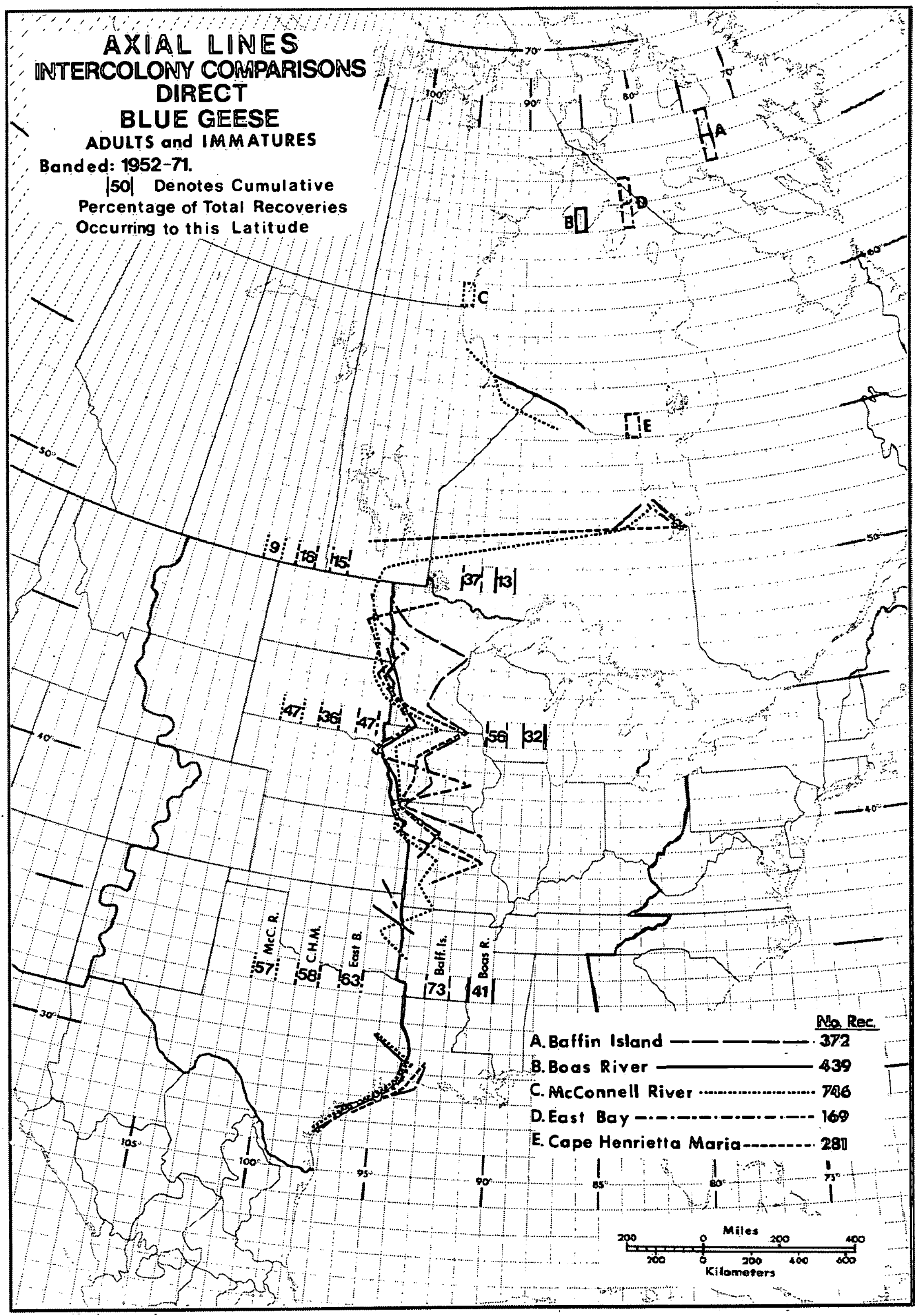

Figure 6
Geographical distribution of indirect recoveries from autumn and winter bandings at Tule Lake and Sacramento National Wildlife Refuges, 1952–62 (note lack of recoveries in eastern Central Flyway)

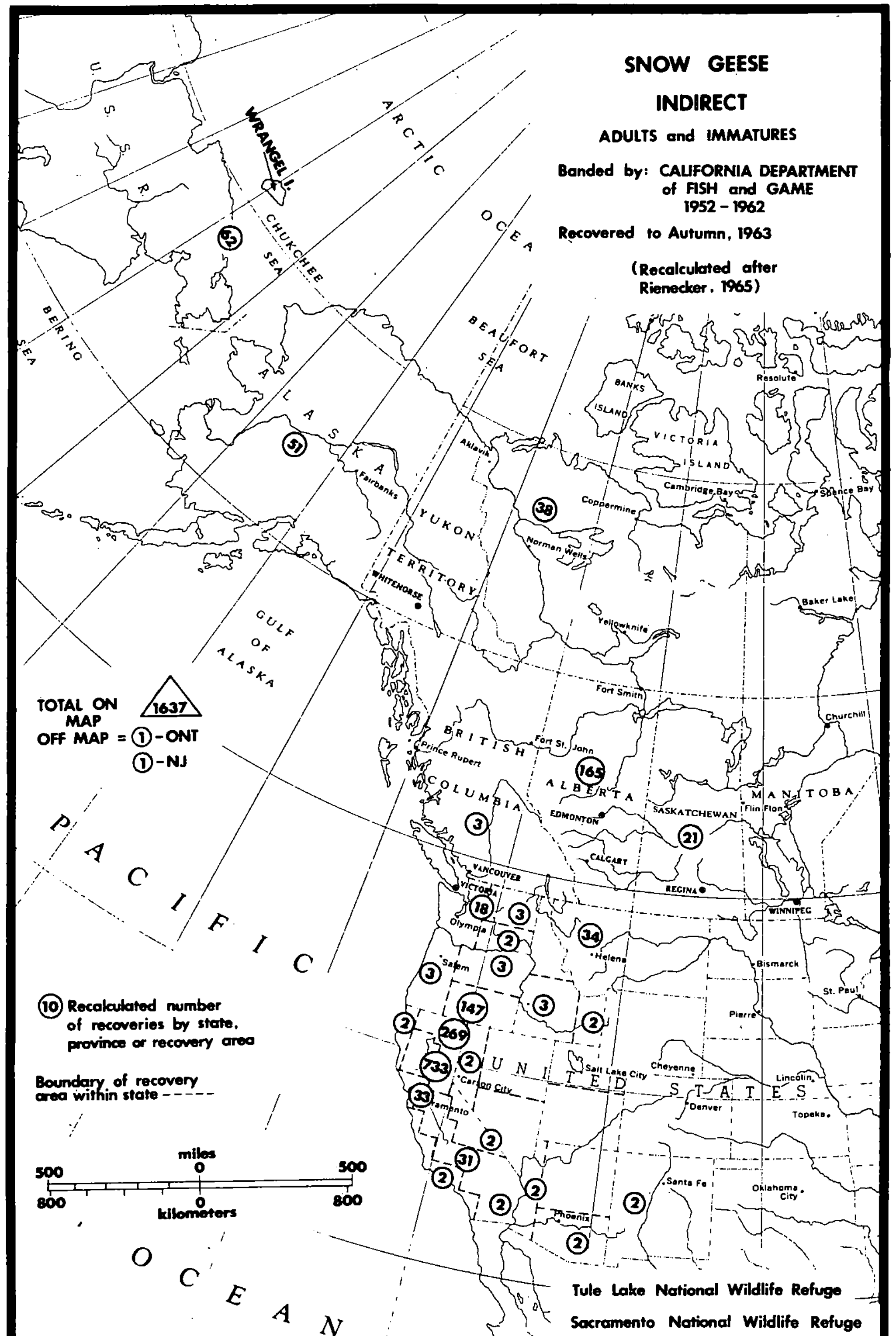

Figure 7
Geographical distribution of direct and indirect band recoveries from summer bandings on Wrangel Island, USSR (note few recoveries east of the continental divide)

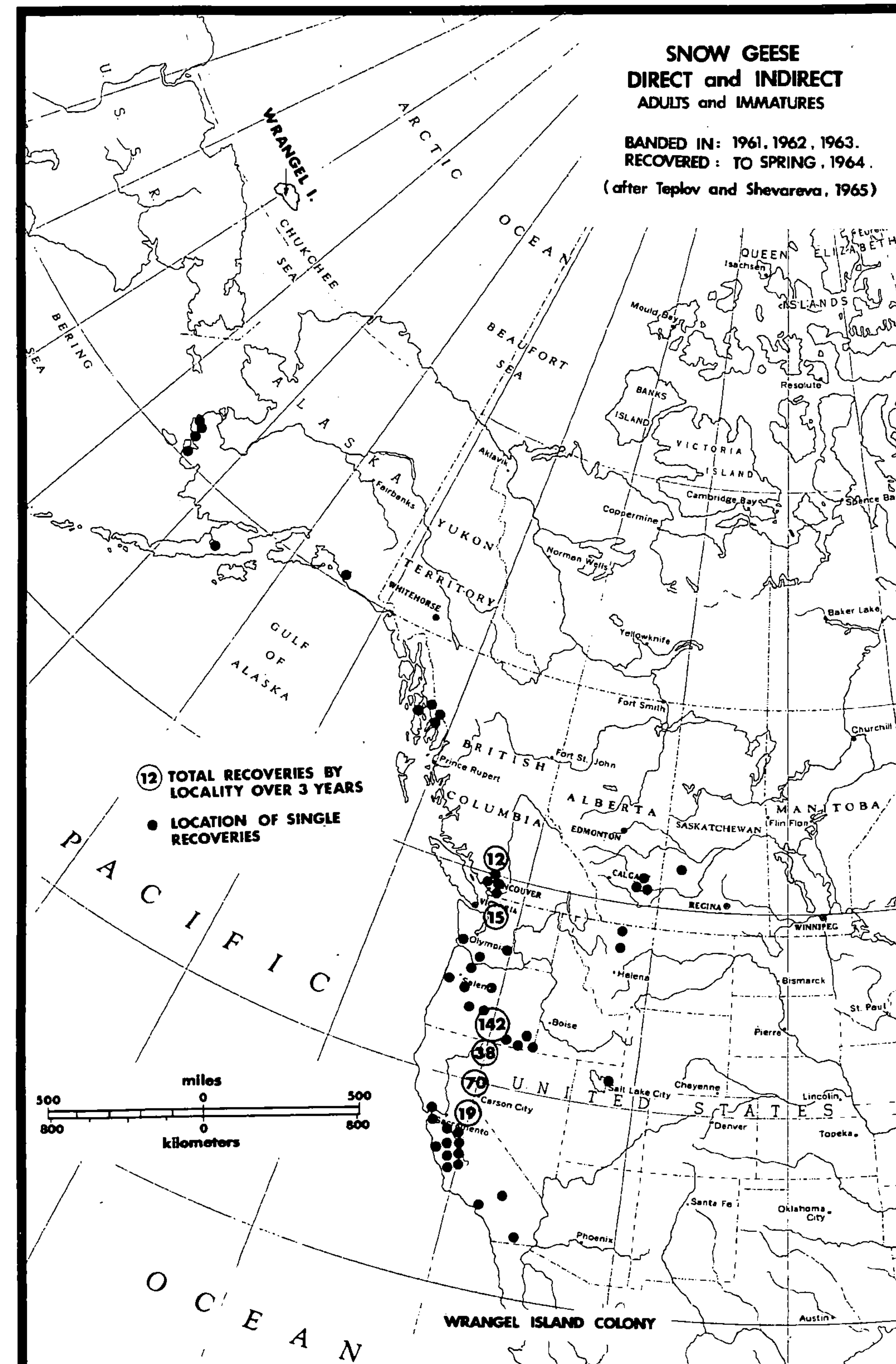

Figure 8
Trends in the estimated Blue and Snow Goose harvest in three US zones and in the Central-Mississippi Flyways, 1962–71

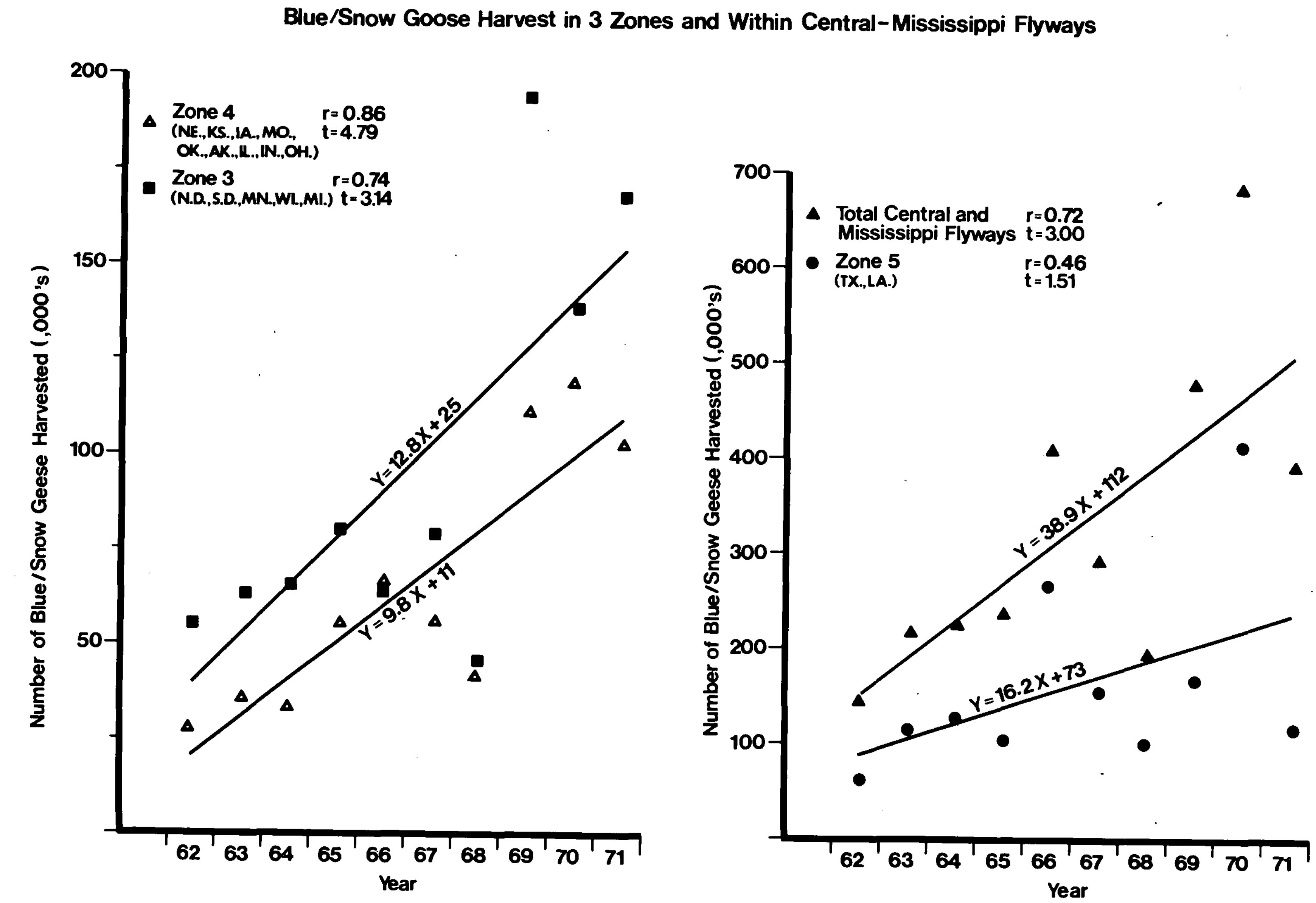

Figure 9
Comparison of the chronology of direct band recoveries from six Hudson Bay colonies for 1964–66 and 1967–71. (Numbers above bars indicate number of total recoveries for the specified 10-day period while circled numbers are zone totals)

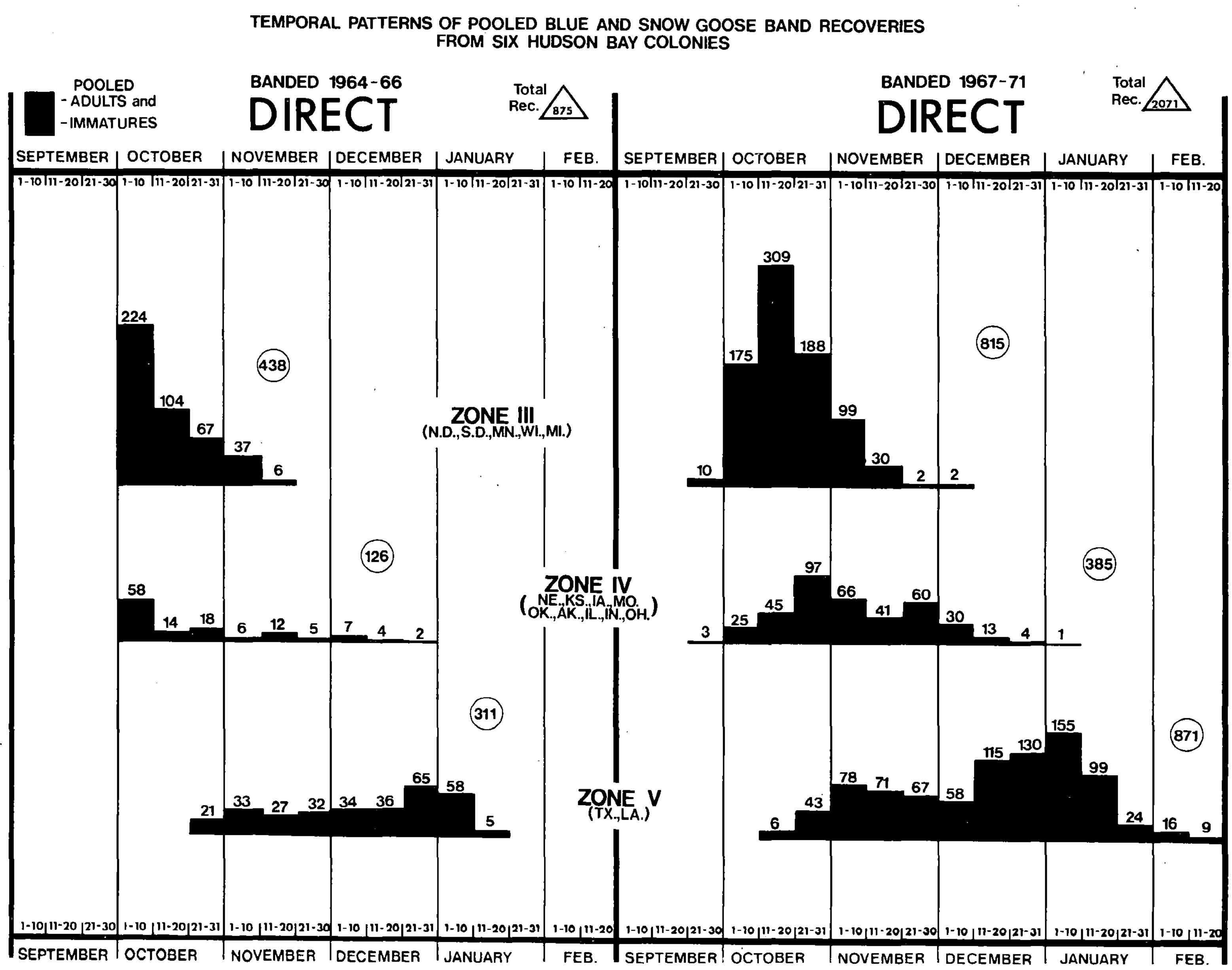

Figure 10
Trends in productivity indices of Blue and Snow Geese 1952–71 (after Lynch 1972)