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Blue and Snow Goose distribution in the Mississippi and Central Flyways: a preliminary report.

by

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Volume I

A report prepared at request of the Central and Mississippi Flyway Councils and Technical Committees by the Canadian Wildlife Service.

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Blue and Snow goose distribution in the Mississippi and Central Flyways: a preliminary report.

Abstract: Analyses of geographical and temporal patterns of approximately 17,500 recoveries from summer bandings of blue and snow geese in Arctic Canada and 4,500 recoveries from autumn bandings on U.S. refuges were made to answer relevant management questions. Although the numbers of recoveries appear formidable, the lack of long-run bandings at colonies (with one exception) precludes many definitive statements. Fifteen background papers have been prepared by the original banders and will be circulated later (as Volume III of this report). A compendium of all tabular and graphic materials will be made available as a working and planning document.

Location and estimated sizes of 10 major and 6 minor colonies in Arctic Canada are described. Substantial changes in colony sizes have occurred in the last 30 years, including a twenty-fold increase in the McConnell River colony from 1954 to 1972. Colonies lying north of 62°N latitude on Southampton Island and Baffin Island have probably not increased correspondingly; numbers of breeding pairs have fluctuated greatly from year to year. A decrease of 5 to 10% in the blue morph component in the Bowman Bay and Cape Dominion colonies on Baffin Island has occurred since 1955.

Western Arctic colonies, on Banks Island and Anderson River Delta, contain few blue geese and show primary orientation to the Pacific Flyway and a secondary one to the state of Chihuahua in northern Mexico. Central Arctic colonies are small and show equal orientation toward northern, interior Mexico and to Central Flyway States. Snow geese from the Wrangel Island colony, off the coast of eastern Siberia, winter primarily in California where they intermix with birds from the Western Arctic colonies. None of the aforementioned colonies contribute significant numbers to the annual harvest in the Central-Mississippi Flyways. These two flyways receive virtually all of their blue and snow geese from colonies located around the periphery of Hudson Bay including Southampton Island and Baffin Island. In total, the latter colonies form a relatively closed unit, as do the Western Arctic and Wrangel Island populations.

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 between geese from different colonies or between 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.

The available population data from harvest surveys and winter counts have been accepted at face value. Indications of relative stability in numbers on the wintering grounds between 1950 and 1969, with estimates varying from 0.53 to 1.0 million, are 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 on a zonal basis. Significant delays in the timing of migration through the Northern and Central States are evident from comparison of patterns of band recoveries from periods 1964-66 and 1967-71. More geese were being harvested in the interval October 21-November 30 in the years 1967-71. In the Gulf States extension of season into February led to significantly more recoveries in the interval January 1 to February 20 in 1967-71. Productivity indices have shown a tendency to decrease over the past two decades, though the tendency is not statistically significant. Comparison of mean annual mortality rates from pooled banded samples for the early 1950's with those of the last 5 years suggest that mean rates for adults have increased significantly, while those for immatures have remained relatively stable.

Our knowledge of basic population parameters remains unsatisfactory for sound management practices and formulation of rational exploitation policies. The unreliability of the data base does not allow firm conclusions in reference to the allegation that artificially interrupted migration in the Northern and Central States is reducing recreational opportunity in the Gulf States. On the basis of the information now available, concern over the insecurity of future harvest apportionments is deemed more anticipatory than justified by events so far.

Introduction: During a Joint Central-Mississippi Flyway Council and Technical Committee Meeting held at Kansas City, Missouri, June 6 and 7, 1972, representatives of the Canadian Wildlife Service offered to conduct an updated band recovery analyses of blue and snow goose (*Chen caerulescens caerulescens*) bandings in order to elucidate recent management problems (Buller, 1972). The two Councils and Technical Committees accepted the offer. A Joint Central-Mississippi Flyway Technical Committee was formed, composed of chairman, Mr. Tom Kuck, 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 (Appendix I). Additional questions were posed by Mr. H. Lumsden, chairman of the Mississippi Flyway Blue and Snow Committee, of which two were added to the list in Appendix I.

The main objectives of the Canadian Wildlife Service study were to:

(1) Analyze available band recovery information and attempt to clarify purported changes in autumn distribution patterns of blue and snow geese.

(2) Answer the questions posed by the Joint Committee by examination of patterns of band recoveries and ancillary data on other population parameters (Provisional answers are given in Appendix II).

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. A request from the Joint Committee for an extended analysis to include determination of mean longitudinal lines of band recoveries, i.e., the axial line method of Bellrose and Crompton (1970) and mortality estimates was acceded to, although the Joint Committee recognized that this would result in a two month delay in receipt of the final report.

THE PROBLEM

The Joint Committee did not explicitly define the overriding problem but a number of alleged problem components are reviewed in documents circulated since 1968: Stutzenbaker (1970), Bishop (1971), Lumsden (1972), and Buller (1972). These are:

1. 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.

2. More geese (a higher proportion of the total harvest) are being killed in the Northern and Central States. Texas and Louisiana have traditionally taken about 50% of the total harvest in each flyway and would prefer to continue harvesting that proportion.

3. 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.

4. 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.

5. 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 regulations help alleviate the depredation problem.

In short, the main management problems revolve about the observation that both natural phenomena and artificial land-water manipulations occurring in the Northern and Central States are, or have the potential of, reducing recreational opportunity in the Gulf States.

METHODS AND DATA BASE

Preliminary searches for available recovery data indicated that most pre-season bandings had been conducted in Arctic Canada, from 1952-1971, in: (a) eight colonies along the periphery of Hudson Bay, (b) a series of small colonies in the Central Arctic and, (c) two colonies in the Western Arctic. A meeting of the principal banders of snow geese was convened at Ottawa, Ontario, on August 17 and 18, 1972, and again on January 12 and 13, 1973. The following conclusions were reached:

(1) After receipt of an updated recovery tape on September 15, 1972 from the U.S. Bureau of Sport Fisheries and Wildlife all electronic data processing was to be conducted by the Canadian Wildlife Service Bird Banding Section, Ottawa, under Mrs. Laurie Wight, programmer-biologist.

(2) Three existing and two new programs were to be used to give summaries of geographical and temporal patterns from each colony of banding. Compilation and collation of machine runs into tabular and graphic data was to be completed at the Prairie Migratory Bird Research Centre at Saskatoon, under the co-ordination of A. Dzubin.

(3) Original banders, who held proprietary rights over their recoveries, were to be given opportunity to prepare background papers

on the results of their colony bandings. These research papers need not contain systematic amplifications of the questions. They would be published by the Canadian Wildlife Service. The intention is for those papers to form Volume III of the Administrative Report, after editing to journal standard.

(4) A synthesis which drew on the conclusions of the above background papers was to be prepared for use by managers and administrators (Volume I). Extracted material from the yet unpublished papers would show author reference in the form "(Lumsden, in press)".

(5) A compendium of the tabular and graphic results, e.g., banded samples, maps of geographical distribution from colonies, tables of distribution by state and harvest zone, charts of temporal distribution patterns, maps of axial lines and a bibliography was to be prepared and distributed. This document would update band recovery results, serve as a catalyst for discussion and aid in future program planning (Volume II).

Because of the intermittent nature of bandings (Appendix III) it was readily acknowledged that trustworthy answers could not yet be given to most of the questions posed in Appendix I. In no colony had bandings been conducted to answer those questions specifically. The tentative answers offered in Appendix II must be considered "spin-offs" from the primary objectives of the research studies in colonies, which dealt with a variety of biological problems, often of more academic interest than of obvious utility to managers.

Data constraints: The band recovery analyses were restricted to shot birds (Code 01) which had originated from preseason, summer bandings in known Arctic breeding colonies. Results from in-season bandings on migration areas and refuges in western Saskatchewan, eastern Alberta, Sand Lake National Wildlife Refuge, Squaw Creek National Wildlife Refuge and Sabine National Wildlife Refuge were alluded to but did not form a major component. Reference was made to published banding recovery studies in the Pacific Flyway (Rienecker, 1965) and the Soviet Union (Teplov and Shevareva, 1965).

Only direct first hunting season recoveries (this and other technical terms are defined in Appendix IV) were utilized. 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. Since most banders did not separate sexes, they were pooled for analysis. Recoveries from the two colour morphs, blue and white, were tabulated separately, as were those of adults and immatures.

Assumptions (reviews in Geis, 1972; Anderson, 1972) inherent in utilizing band recovery data include: (1) the banded sample was truly representative of the colony and showed the same characteristics as the unbanded portion, (2) minimal or consistent mortality occurred from time of banding to September 1, when birds become subject to hunting mortality, (3) equal reporting rates between geographical areas and years. The latter assumption in particular was accepted with reservations. Because colony size estimates were not available for all years when banding was conducted, the proportion of the total blue-snow goose population represented by individual colony bandings could be only grossly determined. 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 press) 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, (i.e., Rice Prairies and East Texas), could not be statistically correlated with numbers of shot recoveries from the two areas. However, since visibly-marked geese from other colonies have not been available for study, it has been necessary to make use in the first instance of recoveries of shot birds to depict distribution and relative abundance.

Mean annual mortality rates: Preliminary determination of mortality rates was made using a method proposed by Ricker (1945; 1958) and estimated variance calculated after Hayne (1971).

Vulnerability rates: For comparing the rate at which immatures and white phase geese were likely to be shot, direct recovery rates were calculated for those banded samples which produced 20 or more recoveries. Direct recovery rates based on adequate samples, 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 these 5 years were utilized to determine the best estimates of vulnerability rates (Appendix II, Questions 4 and 5).

In order to estimate differences in vulnerability between normal and neckbanded geese, all direct recovery data for the 1964-71 period from the McConnell River colony were pooled (Appendix II, Question 7).

Wintering abundance: For discussion purposes published and unpublished estimates of wintering numbers within the Central and Mississippi Flyways were referred to and accepted at face value. It was recognized that such surveys lack estimates of reliability and descriptions of sampling variation. Their credibility has been questioned by many biologists (Bishop, 1971; Lumsden, 1972;

Lynch, repeatedly). 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. Such assessments were taken while the hunting season was in progress and require correction by the estimated remaining harvest to be comparable to earlier figures. (The appropriate correction factors are not known at the time of writing.)

Harvest: The validity of estimates of annual harvest from the U. S. National Harvest Survey has also been questioned, particularly since mathematical models showed a harvest rate of 34.5% in the 1962-1967 period (Bishop, 1971). Again we accepted the published figures as valid indices of harvest trends in flyways and harvest zones. For the purposes of this report, harvest included both retrieved and unretrieved kill. Harvest estimates obtained through state surveys sometimes resemble and elsewhere diverge widely from the national survey. They could not readily be utilized in this preliminary analysis as not all states conduct their own surveys.

Productivity: Field productivity appraisals on the Gulf coast states, compiled since 1950 by J. J. Lynch of the Bureau of Sport Fisheries and Wildlife were accepted as sound estimates of productivity (run of data summarized in Lynch, 1972). 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 liable to bias due to seasonal variations in the proportion of young removed by hunting prior to field assessment. However, appraisals 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).

Colony sizes: In 1972 at two colonies, McConnell River and La Perouse Bay, total counts of nesting birds were made from aerial photographs (Kerbes, in press). Otherwise, sizes of colonies have been determined almost solely by subjective methods. Published historical (Cooch, 1961) and more recent unpublished assessments provided by authors were grouped into two time periods for comparison, i.e., 1954-1961 and 1968-1972. Lack of synchronous coverage of all colonies during one year confers an untidiness upon the figures in relation to estimates of total population on the breeding grounds. Except as noted above, exact colony sizes are unavailable. Estimates are presented as the best obtainable from which orders of magnitude of change can be visually compared. (In June, 1973 R.H. Kerbes was successful in obtaining photographs of all the colonies in the Eastern Arctic. But it will be some months before precise estimates of the breeding populations can be arrived at.)

Because bandings from 3 colonies on Baffin Island, i.e., Bowman Bay, Cape Dominion and Koukdjuak River were infrequent and showed consistent patterns of recovery, they have been grouped as the Baffin Island colony. For discussion purposes geese from Baffin Island and Cape Henrietta Maria (Ontario) are termed the eastern stock and those from the remaining colonies on the west side of Hudson Bay and Southampton Island as the western stock.

Harvest zones: For convenient summarization of harvest and recovery data, Central North America was arbitrarily divided into five major harvest zones and band recovery areas, in a north-south gradient by tiers of states (Figure 1, after Lumsden, in press). These zones approximate those defined by Lemieux and Heyland (1967) for band recovery analysis and those utilized by managers (See Appendix I, Question 2) 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 latitude and west of 65°W longitude. Manitoba and Saskatchewan north of the 53°N parallel and east of 104°W longitude.

Zone 2: Southern Canada. South of Zone 1 to the U.S. Border.

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

Zone 4: Central states. Comprising Nebraska, Kansas, Oklahoma, Iowa, Missouri, Arkansas, Illinois, Indiana and Ohio.

Zone 5: Gulf states. Comprising Louisiana and Texas.

Central Flyway states along the Cordillera and those in the southeast Mississippi Flyway, i.e., Mississippi, Alabama, Tennessee and Kentucky were excluded. Both numbers of band recoveries and estimated harvests are low in these states.

Temporal patterns: The chronology of band recovery distribution was determined by 10 day groupings for the period September 1 to February 20, for all states and provinces and for all colony bandings. Approximately 20 to 25% of recoveries were rejected from this analysis because of unknown or insufficiently precise date codes, e.g., hunting season - code 94. Those few recoveries falling outside the published season framework were also rejected. Direct recoveries from all colonies, representing 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 3 zones (Appendix I, Question 2).

Axial lines: In order to summarize conveniently the geographical distribution patterns from bandings at each colony, mean longitudinal lines of recovery, for each latitude from 25°N to 60°N and for recoveries obtained between the $75^{\circ}W$ and $110^{\circ}W$ longitudes, were machine calculated. Such axial lines (Bellrose and Crompton, 1970; Funk et al, 1971), contain some inherent weaknesses, in that several longitudinally spread migration corridors may be averaged into one mean degree of recovery for each latitude. Certain anomalies were apparent in the axial lines computed for the $51^{\circ}N$ parallel in Canada (i. e., recoveries in both James Bay and the Interlake region of Manitoba) and the $28^{\circ}N$ parallel (with recoveries in both Louisiana and Texas). Axial lines have the advantage of summarizing masses of data and are amenable to statistical testing at each latitude with associated computations of 1 standard deviation about the mean line, i. e., statistical boundaries which should contain about two thirds of all recoveries at one latitude.

On prepared maps (of which a selection are included in this report) cumulative percentage of recoveries were shown only for 3 latitudes, $49^{\circ}N$, $43^{\circ}N$ and $33^{\circ}N$. The percentage figures (accumulated from north to south) include those recoveries received south of the $60^{\circ}N$ latitude and north of $25^{\circ}N$ (i. e., north of the Republic of Mexico). The few recoveries occurring in Mexico and north of the $60^{\circ}N$ parallel were rejected in calculations.

Copies of listings which show sample recovery numbers at each latitude, mean longitudinal line of recovery, variance, and cumulative percentage of recoveries for each latitude are available on loan from

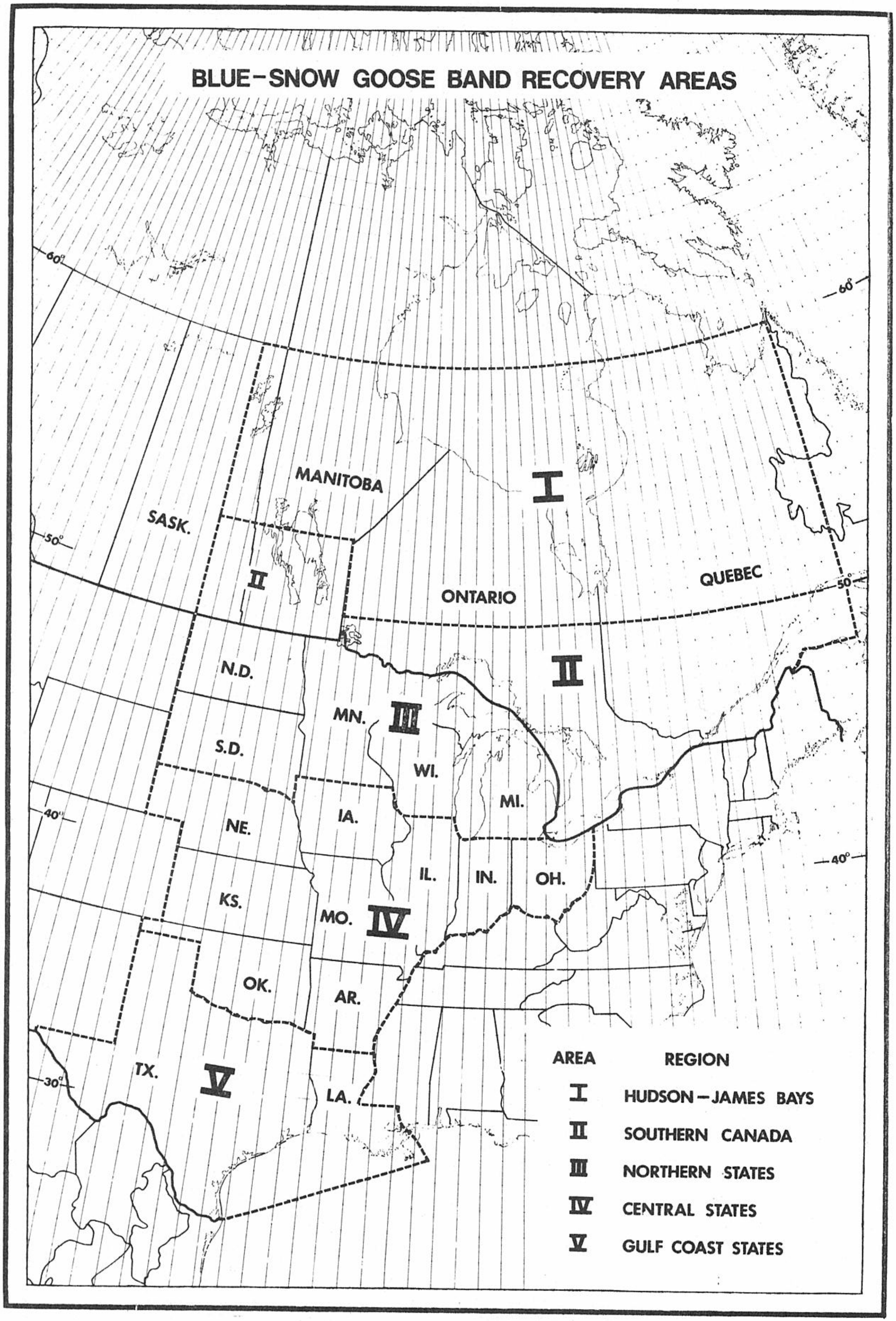

Figure 1. Boundaries of five band recovery zones (areas) in central North America (after Lumsden, in press).

the Librarian, Prairie Migratory Bird Research Centre, Univ. of Saskatchewan Campus, Saskatoon. They corroborate maps presented in the text but were too voluminous to include in this report.

Taxonomy: Scientific nomenclature conforms to the Thirty-second Supplement to the American Ornithologists' Union Checklist of North American Birds (Eisenmann, 1973) in considering the Lesser Snow Goose as *Chen caerulescens caerulescens*. The dark morph is referred to as the Blue Goose and the white as the Snow Goose. We recognize that many waterfowl biologists reject *Chen* and accept the generic name *Anser* first applied to this species by Pallas (1769).

Statistical Tests: Standard tests for normal and non-parametric distributed data, i.e., linear regression, Spearman rank correlation, Chi-square, and Kolmogorov-Smirnov, were taken from Steel and Torrie (1960) and Sokal and Rohlf (1969), and the Proportion test from Maksoudian (1969: 250). Reference was made to the statistical tables of Owen (1962). Statistical significance was inferred at the conventional level of $p = .05$.

This report is labelled "preliminary" because a number of reservations on the precision of the data base are evident. We accepted results from an unverified recovery tape, cursory listings from which contained about 5 to 7% errors in punched codes, e.g., incompatabilities of latitude and longitude codes with state codes, errors in latitude or date codes of banding or of recovery, recoveries made during closed periods of the season, etc. Time and lack of access to original recovery records prevented a "cleanup" of the tape. We had either to concede that the available recovery data were sufficiently precise for argument or to reject them in total. We chose to proceed.

RESULTS AND DISCUSSION

A substantial body of literature exists in reference to Arctic habitats and the goose populations breeding on them. Much of our discussion will impinge on questions posed by the Joint Committee. Readers are referred to the following key references for background material on each of the major populations of blue and snow geese especially for information on biology, history, habitats, abundance and migration corridors.

Population	Reference
Wrangel Island	Kebbe, 1960; 1961.
	Portenko, 1972.
	Uspenski, 1963; 1965a; 1965b; 1967; 1970a; 1970b.
	Uspenski, Beme and Velizhanin, 1963.
Western Arctic	Barry, 1960; 1967.
	Kozlik, Miller and Rienecker, 1959.
	Manning, Hohn and Macpherson, 1956.
	McEwan, 1958.
	Rienecker, 1965.
Central Arctic	Gavin, 1947.
	Hanson, Queneau and Scott, 1956.
	Macpherson and Manning, 1959.
	Parmelee, Stephens and Schmidt, 1967.
	Ryder, 1971; 1972a; 1972b.

Hudson Bay	Beals and Shenstone, 1968. Bellrose, 1968. Bird, 1967. Cooch, 1958; 1961; 1963; 1964. Cooke, 1969. Hanson, Lumsden, Lynch and Norton, 1972. Harvey, 1970; 1971. Kerbes, 1969. Lemieux and Heyland, 1967. Lumsden, 1957; 1958. Manning, 1942. Soper, 1942. Sutton, 1931; 1932.

Colony locations and sizes: The geographical distribution of colonies and their estimated sizes in the period 1954 to 1961 are shown in Figure 2. (See Appendix IV, for co-ordinate locations.) Nine major colonies were delineated. For those colonies situated around Hudson Bay the proportion of blue morphs during that period ranged from 14% at McConnell River to 97% at Bowman Bay. The Central Arctic colony at Perry River showed 10% blue geese while on Banks Island only a trace of the spring population was composed of blue geese. The gradually diminishing percentages of blue geese in western colonies have been described by Cooch (1963).

Sizes of colonies showed marked changes in the period 1968 to 1972 (Figure 3) 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 twenty-fold increase in the main breeding area was documented from approximately 15,000 birds in 1954 (Cooch, 1961) to well over 300,000 in 1972 (Kerbes, in press) and several 'satellite' groups appeared. The major colonies on Baffin Island and Southampton Island have not shown comparable increases, though number of breeding birds have fluctuated widely from year to year. A doubling of colony size occurred at Cape Henrietta Maria (Lumsden, in press) and in the Perry River colonies (Ryder, in press). The Egg River colony on Banks Island showed a slow increase to approximately 200,000 birds in 1971 but has since stabilized (Barry, in press). Small reductions (of up to 10%) in the proportion of blue geese were documented in the Bowman Bay, Cape Dominion and Perry River colonies while increases and then a trend toward stabilization in 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 and La Pérouse Bay colonies are found in Hanson _et al_ (1972).

Changes in colony size and in the proportion of blue morphs reflect a whole spectrum of biotic and edaphic factors (see Cooch, 1961, 1963; Hanson et al, 1972). Of particular concern to goose management is the recent work of Bradley and Miller (1972) showing that in 1960-69 there was a trend towards the accumulation of snow and ice on Baffin Island. 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. There have been several poor breeding years for geese on Baffin and Southampton Islands in the last decade, culminating in 1972 when very few snow geese attempted to nest in those major haunts. However, no decisive shift of balance seems yet to have occurred because in June 1973, R.H. Kerbes found very large numbers of nesting snow geese at the principal sites on the islands and many nesting in other less favourable areas, such as that between Cape Dominion and the Koukdjuak River (Kerbes, personal communication).

Referent population: Geographical patterns of band recoveries were utilized to determine the colony origins of harvests in the Central-Mississippi Flyways (Tables 1, 2, 3). Direct recoveries of bandings conducted in the Western Arctic at Anderson River and Banks Island plus associated autumn migration bandings in Western Saskatchewan

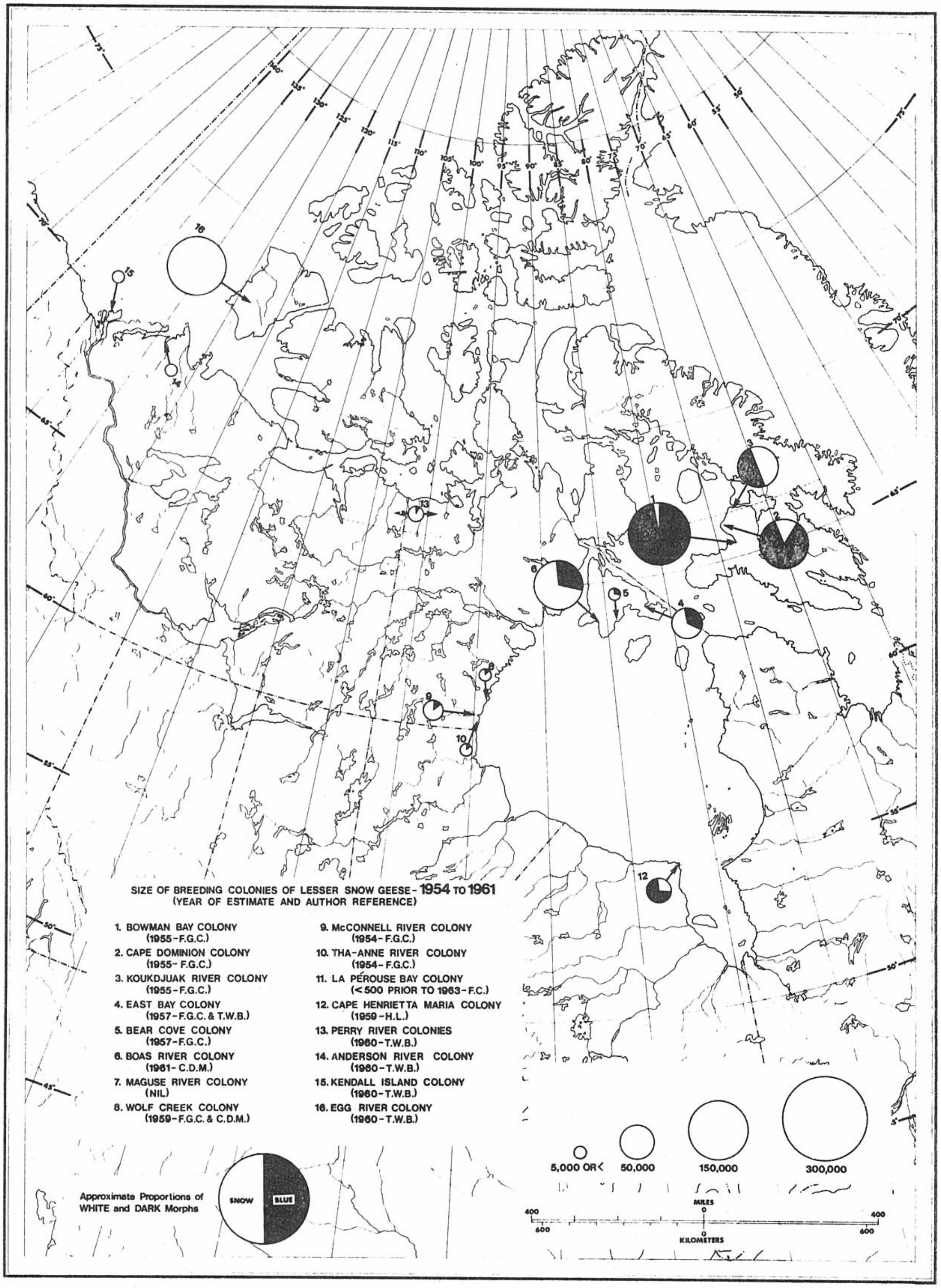

Figure 2. Estimated size and location of breeding colonies in Arctic Canada, 1954-1961.

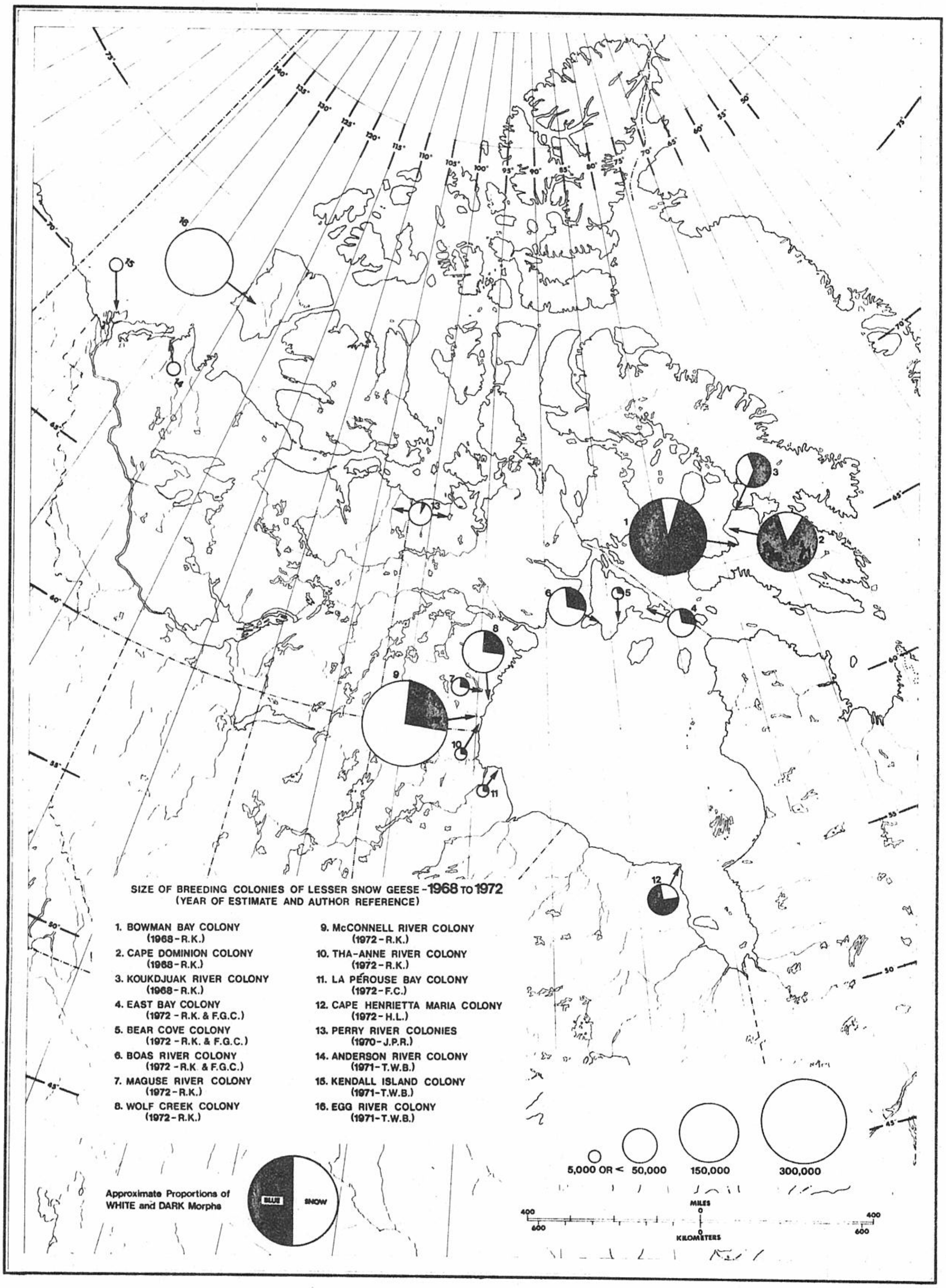

Figure 3. Estimated size and location of breeding colonies in Arctic Canada, 1968-1972.

and Eastern Alberta show primary orientation to the Pacific Flyway and a secondary one to the state of Chihuahua in northern Mexico (Table 1). Excluding that portion of Montana lying within the Pacific Flyway, fewer than 3% of the recoveries are from Central Flyway States and only 1 recovery was obtained from the Mississippi Flyway.

Direct recoveries from the Perry River colonies in the Central Arctic show approximately equal orientation to the Central Flyway and the state of Chihuahua in northern Mexico (Table 1).

No direct recoveries were reported from the Pacific Flyway of either blue or snow geese from colony bandings around Hudson Bay (Tables 2 and 3). Nearly all recoveries are in the Central and Mississippi Flyways. For snow geese (white morphs), there were significantly more recoveries (and inferred harvest) 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 snow geese 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 in James Bay. The predominance of the blue morph in autumn congregations in James Bay has been discussed by Cooch (1961), Lemieux and Heyland (1967) and Hanson et al (1972).

Table 1. Percent recovery distribution of DIRECT ADULT and IMMATURE SNOW GEESE for colony banding locations and autumn migrants.

	Western Arctic Population						Central Arctic
Banded in:							67-100
Degree block	69-129	72-124	72-125	72-124	51-109	51-111	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:	Barry	McEwan	Höhn	Barry	Dzubin	Grieb	Ryder &
Flyway & area		(Bander Reference, *in litt.*)					MacInnes
CANADA							
Yukon			7.1				
Mackenzie							
Franklin							
Keewatin							
Alberta	21.9	20.	7.1	35.7	.8	23.1	13.6
Saskatchewan	4.3			1.8	17.4		9.1
Subtotal	26.2	20.	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.	43.0	48.1	64.6	61.5	4.5
Nevada	2.2		7.1		3.1		
Utah					1.1		
Arizona					.8		
Subtotal	65.8	80.	71.6	53.5	73.1	61.5	4.5
CENTRAL							
Montana	3.7		7.1	3.6	1.1	7.7	
North Dakota					.4		4.5
Nebraska					1.1		4.5
Colorado	.3				.8		
Texas							18.3
Subtotal	4.0		7.1	3.6	3.4	7.7	45.4
MISSISSIPPI							b,c
Minnesota							
Missouri							
Subtotal					.8[a]		
MEXICO	4.0		7.1	5.4	4.6	7.7	27.4
ALASKA							
Total	100.0	100.	100.0	100.0	100.0	100.0	100.0
No. recoveries	324	5	14	56	258	13	22

[a] Includes Michigan (1) recovery - .8%.
[b] Includes South Dakota (3) recoveries - 13.6%.
[c] Includes Kansas (1) recovery - 4.5%.

Table 2. Percent recovery distribution of DIRECT ADULT and IMMATURE SNOW GEESE for colony banding locations.

Banded in:	Hudson Bay Population - Western					Eastern	
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 & area	Cooch Kerbes	Cooch Kerbes	MacInnes Cooch	MacInnes	Cooke	Lumsden	Lemieux Kerbes
	(Bander Reference, *in litt.*)						
CANADA							
Keewatin	.1		.1				
Saskatchewan	.3			.1	.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	.3	.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	.5	.6		2.6
Oklahoma	1.3	.7	1.1	.5	.3		1.3
Texas	53.2	32.0	37.2	32.7	25.3	34.0	26.5
Subtotal	73.6[a]	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	.4	.3	.6	.4			3.0
Michigan	.1			.1			.4
Iowa	2.0	5.8	4.1	4.8	7.9	12.0	12.6
Illinois	.3	.3		.1		2.0	1.3
Indiana				.1			
Missouri	1.8	2.4	2.7	5.8	4.7	9.0	4.2
Arkansas	.1		.1		.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	.5	.7	.2	.3			
PACIFIC							
ATLANTIC			.1				
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. recoveries	1,189	291	1,101	948	344	100	237

[a] Includes three New Mexico recoveries - .2%.
* Neckbanded.
** Color legbanded.

Table 3. Percent recovery distribution of DIRECT ADULT and IMMATURE BLUE GEESE for colony banding locations.

Banded in:	Hudson Bay Population - Western					Eastern	
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 & area	Cooch Kerbes	Cooch Kerbes (Bander Reference, <u>in litt.</u>)	MacInnes Cooch	MacInnes	Cooke	Lumsden	Lemieux Kerbes
CANADA							
Keewatin			.5				
Saskatchewan	.2						
Manitoba	3.2	.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		.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	.6	.8	.8	.7	3.9	.8
Kansas	1.1	1.2	1.1	.3		1.8	1.3
Oklahoma	1.4	.6	.3	2.2			.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	.7	4.6	6.1
Wisconsin	.5	1.2	.5	.3		.7	2.1
Michigan	.2	.6	.5		.7	.4	2.1
Iowa	3.6	5.2	2.6	3.6	9.2	10.5	8.8
Illinois	.5	1.2	.5	.3		.4	1.3
Indiana	.2	1.2					.5
Missouri	2.0	4.6	5.0	4.9	3.8	6.0	3.2
Arkansas	.5		.3				.3
Mississippi				.3		.4	.5
Alabama							.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 [a]	45.3
MEXICO		.6		.3			
PACIFIC							
ATLANTIC	.2						
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. recoveries	440	173	379	365	132	282	377

[a] Includes one Kentucky recovery - .4% and one Ohio recovery - .4%.
* Neckbanded.
** Colour legbanded.

For eastern stock blue geese proportionally greater numbers of 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 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 2 and 3).

Indirect recovery patterns from inseason bandings at Tule Lake and Sacramento National Wildlife Refuges show that these migrants originate from Wrangel Island, U.S.S.R. and from Banks Island (Figure 4; after Rienecker, 1965), confirming the results presented earlier by Kozlik, Miller and Rienecker (1959). In the United States, recoveries east of the Rocky Mountains were infrequent from bandings in the Pacific Flyway.

Recoveries of bandings from the Wrangel Island Colony, which in 1960 contained 400,000 nesting geese (Uspenski, 1965b), showed primary orientation to the Pacific Flyway, (Figure 5; after Teplov and Shevareva, 1965). A small scattering of recoveries in Montana, Alberta and Saskatchewan indicates some mixing with birds originating in the Egg River colony on Banks Island. No Central or Mississippi Flyway recoveries were recorded.

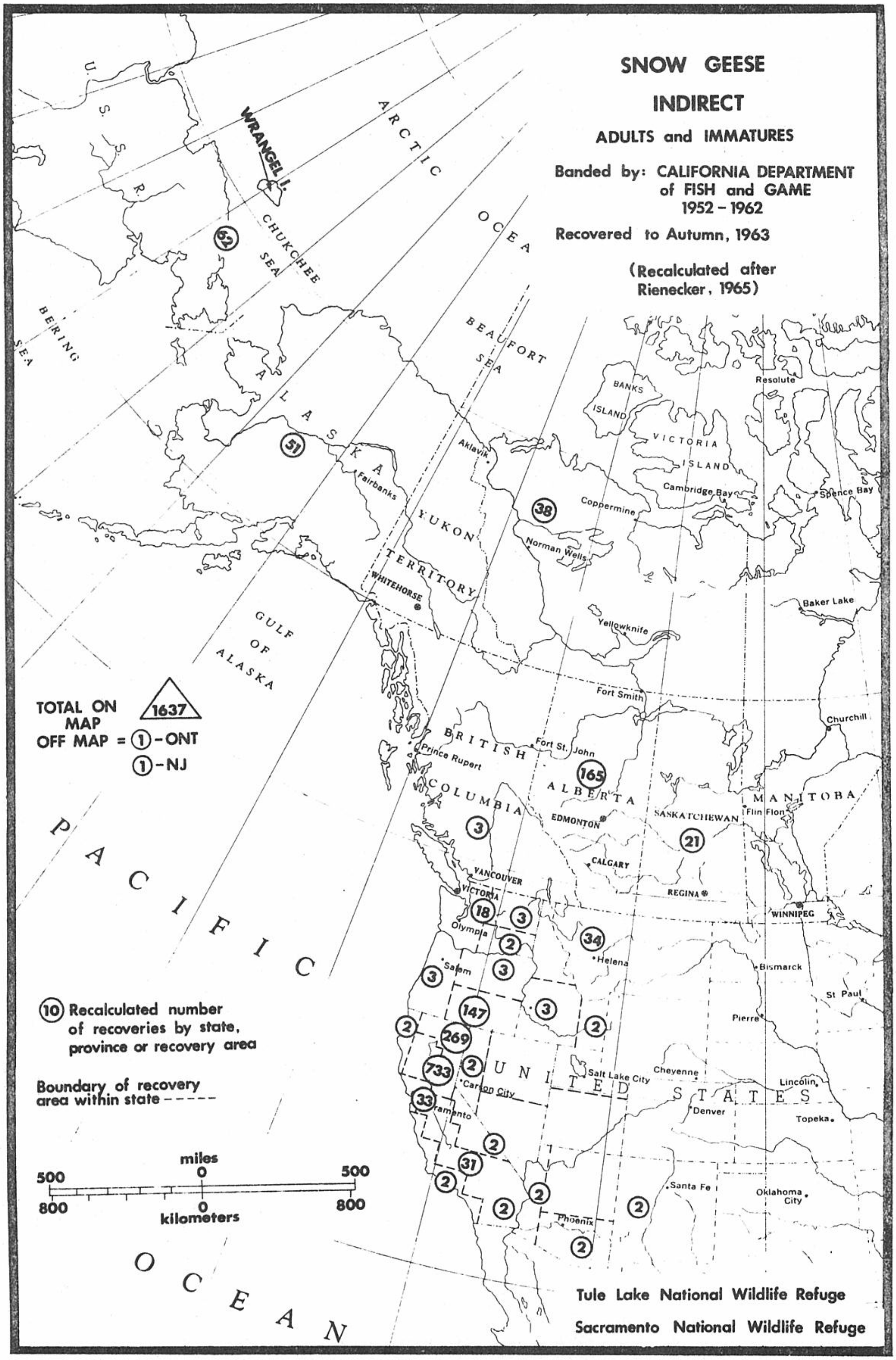

Figure 4. Geographical distribution of number of indirect recoveries from autumn and winter bandings at Tule Lake and Sacramento National Wildlife Refuges, 1952-1962 (note lack of recoveries in eastern Central Flyway).

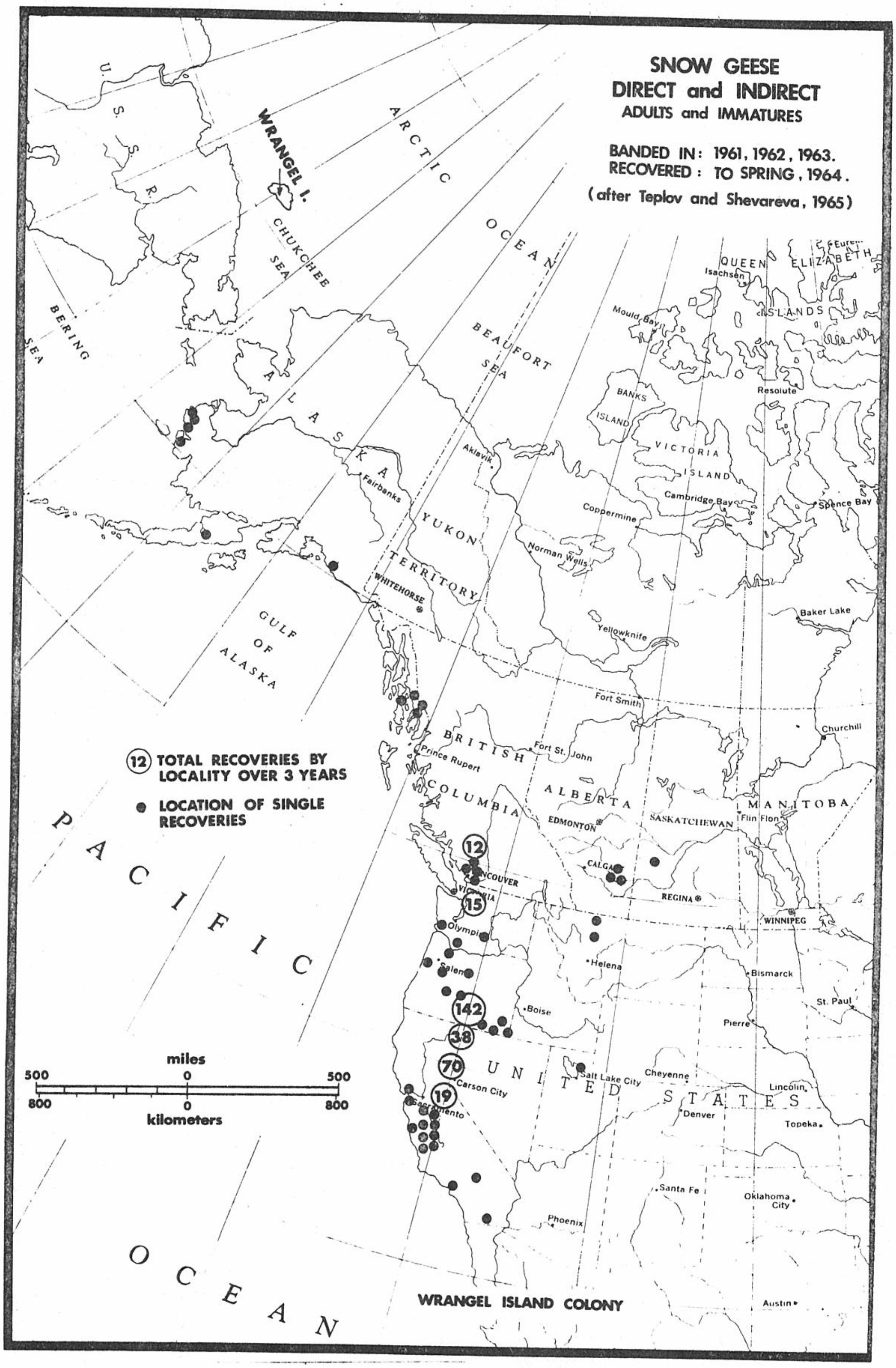

Figure 5. Geographical distribution of numbers of direct and indirect band recoveries from summer bandings on Wrangel Island, U.S.S.R. (Note few recoveries east of the continental divide.)

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) but contributes birds to the Central Flyway, western Canada and northern Mexico. Birds from Central Arctic colonies mix with those from the Western Arctic in western Canada and in northern Mexico.

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

<u>Axial lines:</u> Based on axial line analysis (Bellrose and Crompton, 1970) geographical patterns of direct band recovery distribution from each of 5 major colonies are depicted for both snow and blue geese in Figures 6 and 7. Cumulative percentage of band recoveries to each latitude indicate differences between colonies and stocks (as previously shown in Tables 2 and 3). Corroborative statistical listings, which showed ±1 S.D. at each latitude (available on loan - see Methods Section), show

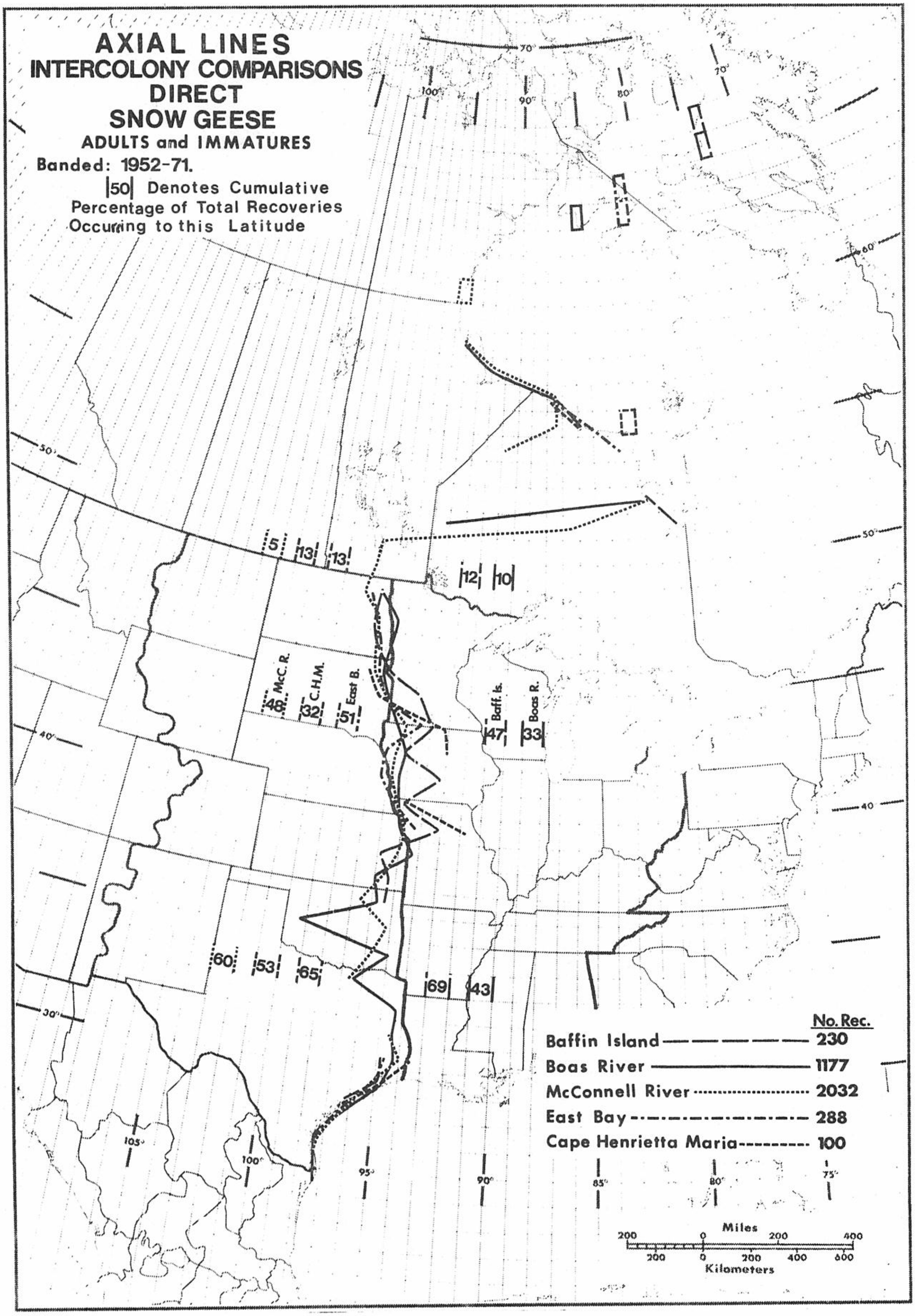

Figure 6. Comparison of the mean longitundinal distribution of direct snow goose recoveries from five Hudson Bay colonies.

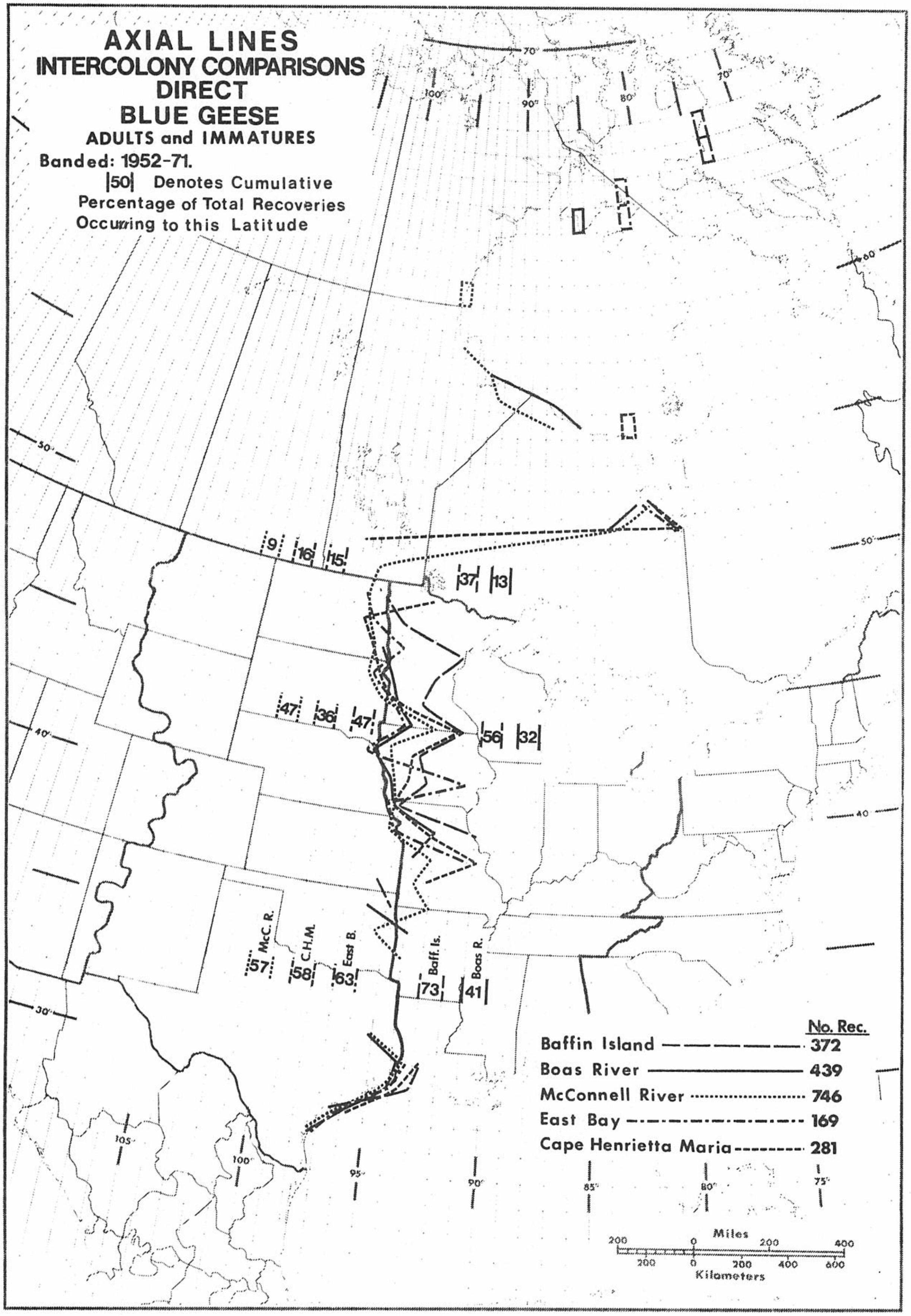

Figure 7. Comparison of the mean longitudinal distribution of direct blue goose recoveries from five Hudson Bay colonies.

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 geese or blue goose recoveries at any latitude. Axial lines for blue goose recoveries from all colonies tend to be more easterly, i.e., within the Mississippi Flyway (Figure 7), and show wider variability at most latitudes than those for snow geese. Since no statistically significant colony or colour morph differences in the mean longitudinal lines of recoveries in the United States could be determined, we conclude that all Hudson Bay colonies can be treated for the purposes of this preliminary analysis as a mixed, homogenous population while on autumn migration in the United States.

Total harvest: 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, 1962-1971 (Figure 8; Table A - Appendix V). 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 for the harvests in Northern and Central States over time also showed significant increases ($R_s = 0.68$ and 0.87 respectively; for both, $p<0.05$) but again no significant increase in the Gulf States ($Rs = 0.51$, $p>0.05$). The wide variance associated with major annual fluctuations in harvest precludes definitive inferences on zonal harvests. Overall, there is an apparent trend to increased harvest.

To test relationships between estimated zonal harvests (Table A - Appendix V) and numbers of direct recoveries in each zone (Table G - Appendix V) 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 band 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, 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, $Rs = 0.62$, $p>0.05$).

Annual estimated harvests of the two colour morphs in each of the Central and Mississippi Flyways (Table B - Appendix V) 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 to 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.

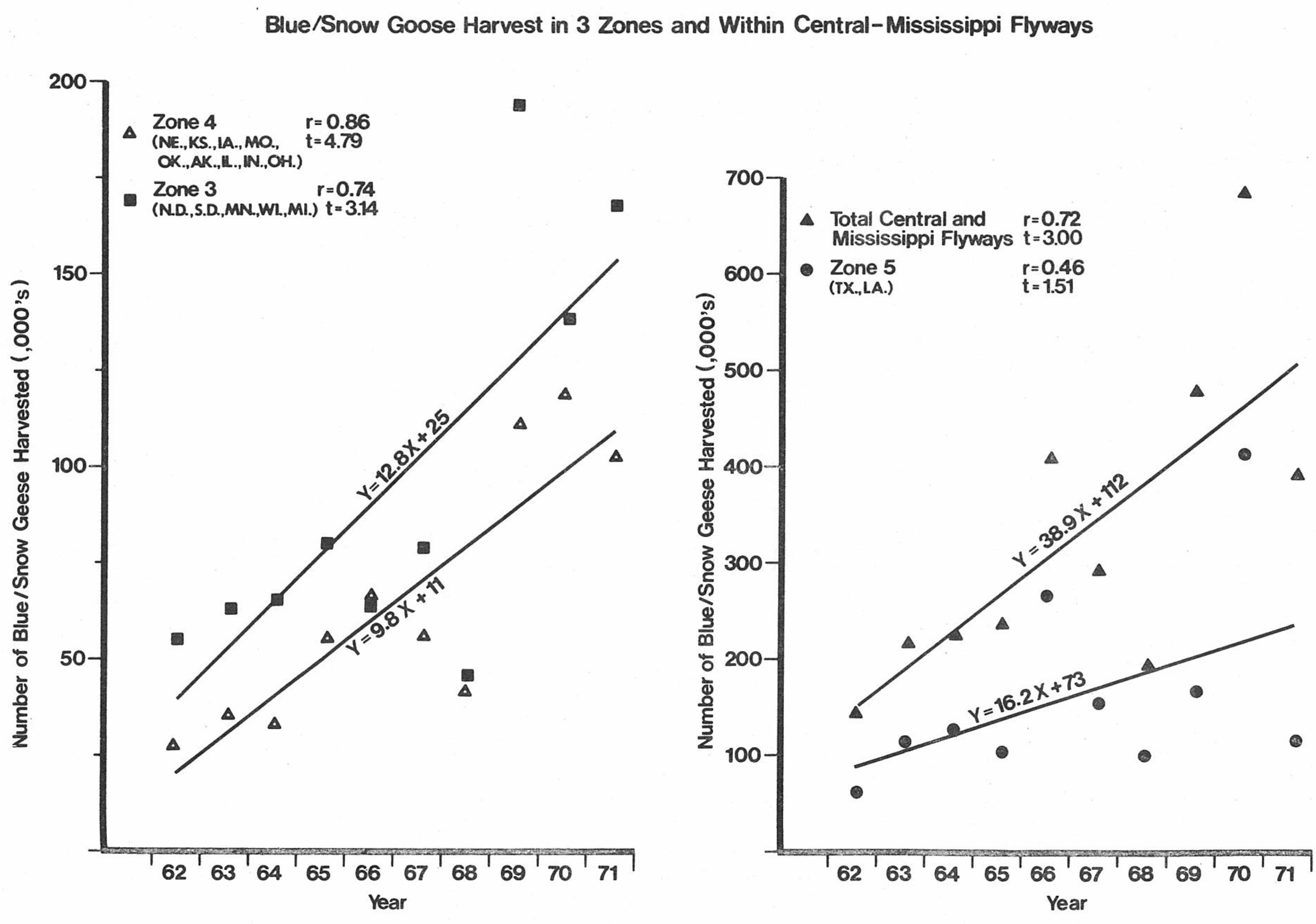

Figure 8. Trends in the estimated blue and snow goose harvest in three U.S. zones and in the Central-Mississippi Flyways, 1962-1971.

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 the Baffin Island colonies (Figure 3) with their prime orientation to the Mississippi Flyway (Table 3). These conclusions should be considered tentative as the methodology and results of the U.S. National Harvest Survey and applied Species Composition Survey have come under question (Bishop, 1971; Lumsden, 1972).

National Harvest estimates in Canada, conducted since 1967, do not sample hunters along the coasts of Hudson Bay and James Bay but do sample hunters in Southern Canada (Figure 1). Estimated annual harvests of blue and snow geese in Southern Manitoba and Southern Ontario have varied between 10,000 - 40,000. For Hudson Bay and James Bay the combined native kill in spring and the kill by native and tourist hunters in autumn have been estimated to range from 35,000 to 75,000 blue and snow geese (Hanson and Currie, 1957; Lumsden, in litt.).

Harvest Chronology: Comparisons of temporal band recovery patterns for 10-day periods, 1964-66 vs. 1967-71, (Figure 9) were made using a Kolmogorov-Smirnov goodness of fit test. For each of the 3 zones, significant differences in temporal distribution patterns of band recoveries (and inferred harvest) 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 $d = 0.16$, $N = 13$, $p<0.05$. Shifts to later harvest 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 again recovered in the period October 21 to November 30 in 1967-71 than in 1964-66 ($Z = -7.16$, $p<0.05$). In the Gulf States proportionally more bands were recovered in December in 1967-71 than in 1964-66 ($Z = 2.70$, $p<0.05$); and a similar significant increase ($Z = -4.80$, $p<0.05$)

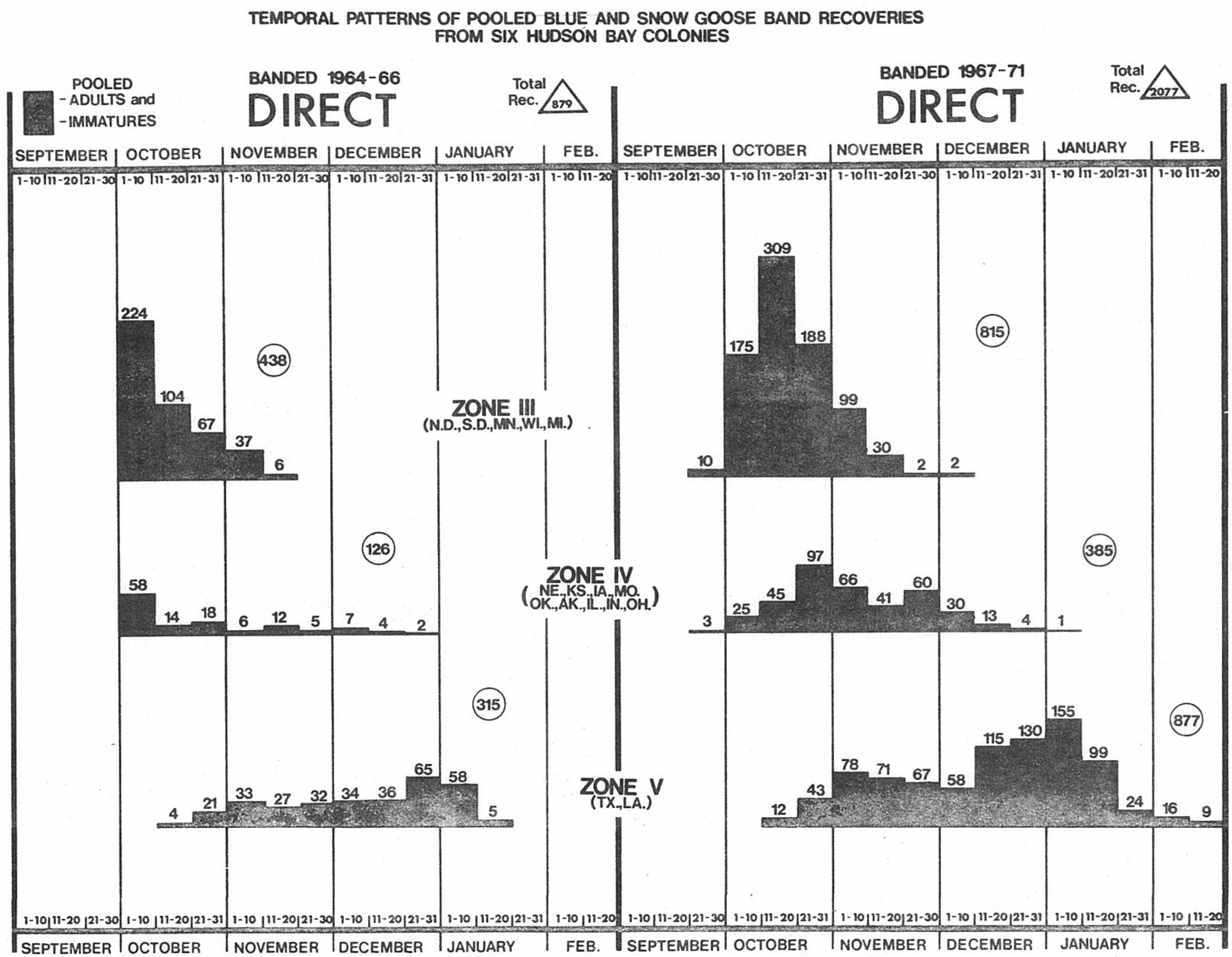

Figure 9. Comparison of the chronology of direct band recoveries from six Hudson Bay colonies for two time periods. (Numbers above bars indicate number of total recoveries for the specified 10-day period while circled numbers are zone totals).

was evident in the proportion of bands recovered between January 1 and February 20 in 1967-71, when extended season regulations were in force, than in 1964-66 when the season closed by January 15th.

The data therefore confirm that in recent seasons more geese were being harvested in the Northern and Central States (Figure 8; Table A - Appendix V) and that the peak harvest had shifted to later periods (Figure 9). Deleterious effects upon the Hudson Bay Population were not readily apparent. Such increased harvest in the Northern and Central States might be accommodated by the much larger population, as evidenced from Figure 3.

Wintering populations: A regression of estimates over time (1952-1969) (Appendix V, Table C) was computed for annual totals of blue and snow geese found in January in both Mississippi and Central Flyways. A slight tendency toward decrease was evident but the slope showed no significant difference from zero ($Y = -2.79x + 749$, $p > 0.05$). For the time period, no significant decrease or increase was noted for the Mississippi Flyway January counts ($Y = -1.11x + 421$, $p = >0.05$), or for those in the Central Flyway ($Y = -1.24x + 323$, $p = >0.05$). 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 estimates (Figures 2 and 3) nor by fall flight estimates ranging from 1.60 to 3.57 million birds obtained by Boyd (in press) by a Lincoln Index calculation using 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 in excess of 1.6 million birds (S.G. Curtis, in litt., preliminary calculation only) compared with an estimate of 1.04 million on the migration and wintering grounds in December, 1972 (Appendix V, Table C). Winter assessments may be seriously underestimating the size of the post-hunting season population, (a view previously expressed by Bishop, 1971; Lumsden, 1972 and Lynch, 1973) and may also have been detecting a changing proportion of the surviving stock.

Productivity indices: Three parameters: per cent young, field productivity and December brood size were regressed against time over the 1952-1971 period (Figure 10; Appendix V, Table D). Although a slight decline in productivity is apparent, there is no significant differences in slope of the regression lines from zero for each of the parameters ($p = >0.05$). Spearman rank correlations for the 3 parameters over years also show non-significant differences for field

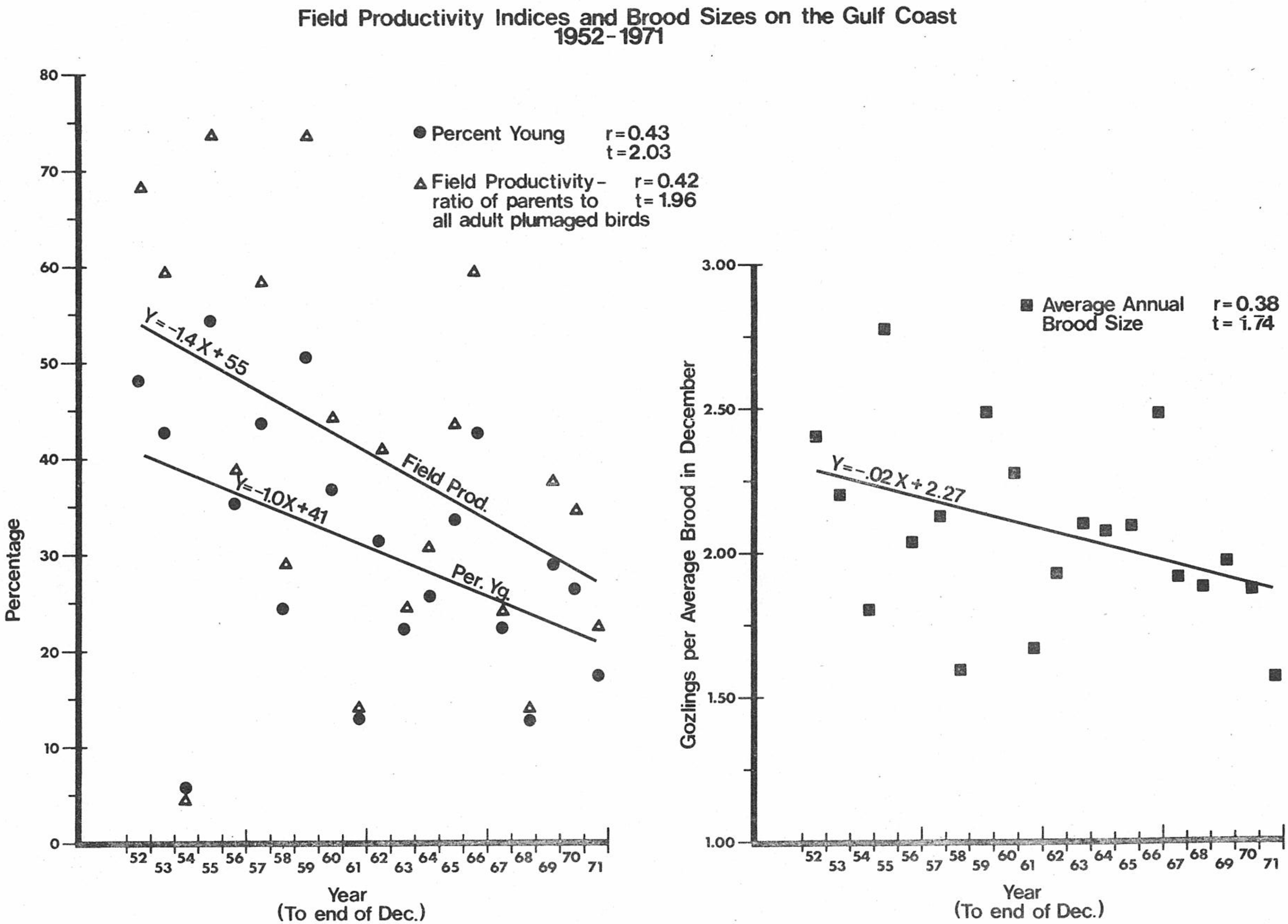

Figure 10. Trends in productivity indices of Blue and Snow Geese 1952-1971, (after Lynch 1972).

productivity and per cent young ($R_s = 0.41$; 0.42 respectively, $p>0.05$) but a significant reduction of average December brood size ($R_s = 0.46$, $p<0.05$).

Should the apparent tendency toward decreasing productivity 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 (1) the effects of climatic deterioration on reproductive output of colonies north of 60^{o}N latitude, (discussed under Colony location) or (2) of increased hunting pressure as evidenced by increasing harvests (Figure 8), or (3) changes in the age structure of the population, or other demographic characteristics.

Prevett (in press) has documented the negative effects of massive fall congregations on family cohesion in Northern and Central refuges. Hunter activity and natural disruptions lead to a higher breakdown of family integrity in Northern and Central States than in Gulf States. Young of the year separated from parents may be more vulnerable (see following section) to hunters. Massive congregations may therefore enhance vulnerability of immatures and lead to higher harvests.

Vulnerability rates: The chance that immature geese were more likely to be shot than adults varied between years and between colonies (Tables 4a, 4b, 4c). 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. Blue goose rates ranged from 0.80 for McConnell River geese in 1965 to 2.55 for Boas River in 1953. For pooled colonies with samples of more than 20 recoveries received for each age and colour cohort, the average immature vulnerability rate was 1.93 for snow geese and 1.35 for blue geese.

Comparison of direct recovery rates from normal wild and from neckbanded blue and snow geese (Table 5) showed that for geese from the McConnell River colony immature neckbanded snow geese were 2.17 more likely to be shot and reported than normal leg-banded snow geese. Vulnerability (or reporting) rates for adult neckbanded snow geese, immature neckbanded blue geese and adult neckbanded blue geese were 2.64, 1.40 and 1.17, respectively.

Table 4a. Vulnerability rates of immatures and snow color phases using direct recovery rates.

Year	Colony	Direct recovery rates - %				Vulnerability rates			
		Snow		Blue					
		Adult	Imm.	Adult	Imm.	Imm. Sn. / Ad. Sn.	Imm. Bl. / Ad. Bl.	Imm. Sn. / Imm. Bl.	Ad. Sn. / Ad. Bl.
1952* (N.rec.)	Boas River	6.116 (20)	8.106 (241)	4.891 (27)	5.662 (65)	1.33	1.16	1.43	1.25
1953* (N.rec.)	Boas River	4.189 (143)	10.613 (296)	3.344 (40)	8.515 (86)	2.53	2.55	1.25	1.25
1956	Boas River	6.146 (225)		8.083 (97)					.76
1960	Boas River	2.250 (36)	5.611 (101)		6.344 (59)	2.49		.88	
1961	Boas River	5.162 (43)	4.053 (37)			.79			
1954	McConnell River	6.231 (20)	11.989 (88)		8.116 (28)	1.92		1.48	
1959	McConnell River	4.227 (50)	9.650 (102)		5.785 (21)	2.28		1.67	
1960*	McConnell River	2.535 (49)	5.275 (117)	3.301 (24)	5.228 (47)	2.08	1.58	1.01	.77
1961	Koukdj. River	4.394 (157)	1.197 (21)	4.229 (144)	2.066 (44)	.27	.48	.58	1.04

Table 4b. Continued.

Year	Colony	Direct recovery rates - %				Vulnerability rates			
		Snow		Blue					
		Adult	Imm.	Adult	Imm.	Imm. Sn. / Ad. Sn.	Imm. Bl. / Ad. Bl.	Imm. Sn. / Imm. Bl.	Ad. Sn. / Ad. Bl.
1968	Cape Dom.- Koukdj. R.	2.335 (23)		2.179 (43)					1.07
1957	East Bay	3.826 (111)		3.294 (56)					1.16
1961	East Bay	4.594 (147)		4.778 (86)					.96
1965 (N.rec.)	East Bay	2.70 (27)		2.70 (27)					1.00
1967	Bowman Bay			2.707 (32)	3.277 (31)		1.21		
1968	Bowman Bay	3.258 (23)		1.948 (65)					
1969	Cape H. Maria	4.553 (26)		3.500 (51)					1.30
1970	Cape H. Maria		6.806 (49)	2.954 (42)	6.710 (165)		2.27	1.01	
1970**	La Pérouse Bay	4.441 (33)	10.370 (196)		9.101 (81)	2.34		1.14	
1971**	La Pérouse Bay		7.843 (48)		3.197 (20)			2.45	

**Colour leg-banded.

Table 4c. Vulnerability rates of immatures and snow color phases using direct recovery rates.

		Direct recovery rates - %				Vulnerability rates			
		Snow		Blue					
Year	Colony	Adult	Imm.	Adult	Imm.	Imm. Sn. / Ad. Sn.	Imm. Bl. / Ad. Bl.	Imm. Sn. / Imm. Bl.	Ad. Sn. / Ad. Bl.
1964	McConnell River	3.164 (33)	3.653 (24)	5.250 (21)		1.15			.60
1965*	McConnell River	3.032 (53)	5.064 (138)	3.717 (30)	2.983 (40)	1.67	.80	1.70	.82
1970*	McConnell River	6.824 (55)	9.154 (61)	7.658 (34)	7.775 (29)	1.34	1.01	1.18	.89
1960	Anderson River	5.642 (29)	5.682 (60)			1.01			
1961	Banks Island	4.299 (23)	6.226 (33)			1.45			
1964	Western Sask.	4.322 (29)	9.728 (25)			2.25			
1967	Western Sask.	4.003 (48)	11.798 (21)			2.95			
1968	Western Sask.	3.253 (27)	6.181 (28)			1.90			
(Inseason bandings.)									

*Colonies and years used for determining best estimates of vulnerability rates.

Table 5. Estimates of vulnerability rates for "normal" and neckbanded blue and snow phase geese banded at McConnell River, N.W.T., 1964-1971 (after MacInnes, in press).

	Normal direct recovery rates - %				Neckbanded direct recovery rates - %				Vulnerability rates			
	Snow		Blue		Snow		Blue					
Year	Adult	Imm.	Adult	Imm.	Adult	Imm.	Adult	Imm.	Imm.Nb.Sn. / Imm. N.Sn.	Ad.Nb.Sn. / Ad. N.Sn.	Imm.Nb.Bl. / Imm. N.Bl.	Ad. Nb.Bl. / Ad. N.Bl.
1965	3.032		3.717		6.239		14.894			2.06		4.00
(N.rec.)	(53)		(30)		(72)		(21)					
1966		4.036		3.421		11.796		10.476	2.92		3.06	
(N.rec.)		(50)		(17)		(201)		(64)				
1964-67 Pooled	3.081	4.588	4.366	2.980	7.042	11.467	6.920	9.993	2.50	2.29	3.35	1.58
(N.rec.)	(86)	(212)	(53)	(64)	(174)	(394)	(51)	(138)				
1968-71 Pooled	6.922	8.158	7.658	7.611	4.444	11.468	5.730	11.075	1.41	.64	1.46	.75
(N.rec.)	(56)	(93)	(34)	(43)	(153)	(225)	(75)	(101)				
1964-71 Pooled	3.944	5.294	5.247	3.944	5.529	11.467	6.158	10.427	2.17	1.40	2.64	1.17
(N.rec.)	(142)	(305)	(87)	(107)	(327)	(619)	(126)	(239)				

Note: Calculated vulnerability rates from pooled data should be considered indices only, as banded samples varied between years (or were nonexistent).

MAJOR CONCLUSIONS

If a problem exists relating to artificially 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, it was not substantiated by presently available harvest, colony size or banding recovery data. During the past decade annual harvests in both the Central and Mississippi Flyways have shown a significant upward trend, a trend statistically evident in both the Northern and Central states. Although recognized as imprecise, the winter population indices 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. Massive increases have occurred in the last ten years in the McConnell River colony, and the Cape Henrietta Maria colony. Production indices have tended to decrease over the past 5 years, but not significantly.

If an interrupted migration problem exists then managers must go to another level of precision in the collection of data, in order to validate any harmful effects upon the blue-snow goose resource from recent changes in harvest and in autumn distribution patterns. In short, the problem of reduced recreational opportunity as designated by the Gulf States is deemed to be more anticipatory than an established fact.

QUESTIONS FOR ADMINISTRATORS

A seemingly irreconcilable conflict of management objectives has developed vis-à-vis distribution of harvest in the North-Central States vs. 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 those 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 views remain incompatible with those of the Northern and Central States who have aspired to a wider apportionment of the harvest by active land and regulatory practices. Further, the desires of Canadians are alluded to but rarely considered in debate. Canadians also aspire to their fair and equitable share of the blue-snow resource and such appetency can only lead to future changes in harvest apportionments. The aspirations of Mexicans have yet to be ascertained.

Within Canada natural changes, may greatly affect the growth, size and distribution of colonies while 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 is bound to 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 between states and provinces and among the 3 nations involved; 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 can profitably be spent and on the allocation of responsibilities among agencies.

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APPENDIX I

Questions posed for Canadian Wildlife Service band recovery analysis
by Joint Blue-Snow Committee of the Central-Mississippi
Flyways 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)?

Appendix I (continued).

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 II

Tentative answers to questions posed in Appendix I

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1. The total estimated harvest in the Central and Mississippi Flyways has increased from 1962 to 1971 and has shown 200 per cent annual variations (Figure 8, Table A and B - Appendix V). A major harvest peak occurred in 1970. Such wide annual variations in estimated harvest preclude definitive or statistically significant conclusions regarding changes in harvest distribution within and among Northern, Central and Gulf States.

Comparison of annual numbers of direct band recoveries (unweighted by colony size) in Northern, Central and Gulf State zones for the period 1964-71 showed no significant upward or downward trends (Table G - Appendix V). Also, no statistically significant increase or decrease in direct recovery rates during 1964-71 could be found for pooled adults and immatures (both blue and snow morphs), in any of the three zones (Appendix III; Table G - Appendix V).

2. Comparisons of chronology of harvests during 1964-66 and 1967-71 by grouping direct band recoveries in 10-day periods, have shown statistically significant shifts to later harvest peaks in the last 5 years in all three zones (Figure 9).

Appendix II (continued).

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3. Boyd (in press) 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 (Figure F - Appendix V). Estimated mean mortality rates among these immature samples have shown greater stability than among adult samples (Table E). Mean mortality rates have tended to be higher during recent years (Table E).

4. Immature, blue and snow goose vulnerability rates showed wide variation between years. Those of immature snow geese ranged from 0.79 at Boas River in 1961 to 2.53 at Boas River in 1953 (Table 4d). Blue goose rates ranged from 0.80 at McConnell River in 1965 to 2.55 at Boas River in 1953 (Tables 4a, 4c). Pooled direct recovery rates for large banded samples (marked *) for Boas River and McConnell River colonies (Tables 4a, 4b, 4c) showed that immature snow geese were 1.93 times more likely to be shot than adults and immature blue geese were 1.35 times more likely to be shot than adults.

5. Utilizing the same large banded samples as in (4) above (marked *) immature snow geese were 1.34 times more likely to be shot

than immature blue geese. However, adult snow geese were only 0.94 times as likely to be shot as blue geese (Tables 4a, 4b, 4c).

6. Estimated fall flight of blue and snow geese in the Central-Mississippi Flyways during the period 1962 to 1970 based on harvest (retrieved and unretrieved) plus the mid-winter inventory figures, have ranged between 0.92 and 1.2 million birds (Tables B and C - Appendix V). A Lincoln Index (which is dependent on accurate estimates of total kill and the assumption that direct adult and immature recovery rates are a consistent measure of the number of banded geese killed in the U.S.) provides another set of estimates of fall flight. Assuming that band reporting rate was constant at 33%, Boyd (in press) estimated fall flights in 1964-71 to have varied from a low of 1.60 million geese in 1967 to a high of 3.57 in 1970, with a mean of 2.28 million.

7. Comparison of direct recovery rates of normal with neckbanded geese from the McConnell River colony for the period 1964-71 showed that immature neckbanded snow geese were 2.17 times more likely to be shot and reported than normal legbanded snow geese (Table 5). Comparable figures for neckbanded immature blue geese were 2.64, for adult neckbanded snow geese 1.40, and for adult neckbanded blue geese 1.17.

Appendix II (continued).

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8. Axial line analyses (Bellrose and Crompton, 1970) for each of five major Hudson Bay colonies (Baffin Island, Boas River, East Bay, McConnell River, and Cape Henrietta Maria), led to the following conclusions (figure 6 and 7). For any latitude lying between 25^{o} and 48^{o}N, there was no significant difference in mean longitude of recovery (± 2 S. D.) between direct and indirect, adult and immature snow geese or direct and indirect adult and immature blue geese. There was no significant difference between mean degree of longitude of recovery (± 2 S. D.) between pooled adult and immature snow geese and pooled adult and immature blue geese. Blue geese were more easterly orientated and showed wider variability at most latitudes than snow geese, but statistically significant colony or colour morph differences in distribution in the U. S. could not be demonstrated.

9. No direct recoveries of bandings conducted in western Arctic snow goose populations at Egg River on Banks Island or the Anderson River Delta were received from Texas or Louisiana. Corroborative evidence from western Saskatchewan bandings also show no direct recoveries from these two states and fewer than 3% in other Central Flyway states.

Appendix II (continued).

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10. Based on a comparison of temporal patterns of recoveries of yearling vs. adult birds in Texas and Louisiana, no significant differences exist between these two cohorts (Lumsden, in press). Yearlings do not migrate earlier than successful breeding adults.

11. Considerable mixing of populations from different breeding colonies around Hudson Bay occurs both on the migrating and wintering areas (Cooke and Finney, in press; Kerbes, in press). Exchange of birds between colonies is higher than was previously documented and involves principally males. Females, both yearlings and adults, return more frequently to their natal colonies than do males. Therefore, colonies are not reproductively isolated.

APPENDIX III

Years and colonies where Snow and Blue Geese were banded in Northern Canada, 1952-1971.

Colony	McConnell River	Boas River	East Bay	Baffin Island	La Pérouse Bay	Cape Henrietta Maria	Perry River
LAT-LONG	60-094	63-085	63-081 64-081	65-073 66-073	58-093	55-082	67-102- 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	
Banders	Cooch MacInnes	Cooch Kerbes	Cooch Kerbes	Lemieux Kerbes	Cooke	Lumsden	Ryder MacInnes
No. Banded Normal	29,192	27,035	12,000	20,642		10,599	580
(Neckbanded	15,631)		(color	legbanded	5,895)		
No. Recoveries*	3,978	4,657	2,067	2,160		808	63
	(2,155 NB)				(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.

APPENDIX IV

Definitions

Direct recovery. A band reported during the first hunting season after banding. For preseason summer bandings in colonies, recoveries were considered "direct" from September 1 of the calendar year of banding to February 20 of the next calendar year. Only shot recoveries were considered.

Indirect recovery. A band reported during the second and all subsequent hunting seasons again delineated from September 1 of one calendar year to February 20 of the next.

Immatures. Applied to all birds of the year which were banded as locals, i.e., incapable of flight, or which could be distinguished as hatched in the calendar year of banding.

Adults. All birds which were hatched in a previous calendar year, i.e., all yearlings, two-year-old, and 3+ year old, breeding or non-breeding individuals.

Mortality rate. The percentage of the population estimated to have died between September 1 of one calendar year and August 31 of the following year. It includes both hunting and natural mortality.

Direct Recovery rate. Percentages of banded birds which were shot and recovered between September 1 and February 20 (first hunting season) after banding.

Appendix IV (continued).

Reporting rate. The percentage of all the bands recovered by hunters that were reported to the U.S.B.S.F. & W. Bird Banding Laboratory at Laurel, Maryland.

Relative recovery rate. A comparison of the direct band recovery rates of adults and immatures, or blue and snow morphs to determine any differences between such groupings in their likelihood of being shot. The rate is expressed as a vulnerability index, either greater or less than 1.

Colony. A local subdivision of breeding and non-breeding individuals delineated by the geographical unit which they occupy in any one breeding season. They are imperfectly isolated from other breeding localities over years. A colony was considered major if it contained $\geq$20,000 birds in the spring of the year and minor if it contained $\leq$10,000. The approximate center of each colony during the 1968-1972 period was located at:

Appendix IV (continued).

Major Colony	Lat. °N	Long. °W	Minor Colony	Lat. °N	Long. °W
Bowman Bay	65°30'	73°30'	Bear Cove	63°40'	85°45'
Cape Dominion	66°10'	74°00'	Maguse River	61°20'	94°10'
Koukdjuak River	66°40'	73°00'	Tha-anne River	60°30'	94°40'
East Bay	64°00'	82°10'	La Pérouse Bay	58°40'	93°10'
Boas River	63°40'	85°45'	Anderson River	69°45'	129°30'
Wolf Creek	61°05'	94°15'	Kendall Island	69°30'	135°15'
Cape Henrietta Maria	55°10'	82°30'			
Perry River (sub-colonies)	67°00'	100°-102°			
Egg River	72°30'	124°50'			

(Reference map locations on Figure 3)

APPENDIX V

Table A . Blue and Snow Goose Harvest[1] by 3 Zones in U.S. (After U.S.B.S.F. and W. Administrative Reports. Recalc. by G. Kaiser, C.W.S. - Ottawa).

	ZONES				
YEAR	III	IV	V	OTHERS*	TOTAL
1971	168,590	103,070	118,710	1,900	392,270
1970	138,450	119,330	411,930	5,790	675,500
1969	194,630	111,860	164,740	5,850	477,080
1968	46,600	41,700	100,630	5,070	194,000
1967	78,660	56,910	151,110	2,440	289,120
1966	65,780	66,470	269,750	1,380	403,380
1965	79,420	55,190	101,200	2,220	238,030
1964	65,480	32,730	126,940	2,170	227,320
1963	62,320	35,580	112,580	4,990	215,470
1962	55,370	27,460	62,020	3,820	148,670
TOTALS	955,300	650,300	1,619,610	35,630	3,260,840

*Alabama, Mississippi, Kentucky, Tennessee, New Mexico, Colorado, Wyoming, Montana.

[1] includes UNRETRIEVED birds.

APPENDIX V

Table B . Total Blue and Snow Goose Harvest[1] in Mississippi and Central Flyways. (After U.S.B.S.F. and W. Administrative Reports, Recalc. by G. Kaiser, C.W.S. Ottawa).

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

[1] includes UNRETRIEVED birds.

APPENDIX V

Table C . Mid-Winter and December Inventory of Blue/Snow Geese in Mississippi and Central Flyways, 1950-72. (after U.S.B.S.F.W. Reports and A. Hawkins)

(in thousands)

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 Average:	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 Average:	420	302	722
1950-69 Average:	408	327	738
1969 December**	425	401	826
1970 December	655	422	1,077
1971 December	937	404	1,341
1972 December	505	532	1,037

*1950-52 totals also include estimated number of Blue Geese.

**Mid-December, in hunting season surveys, not strictly comparable to previous post hunting season, January counts.

APPENDIX V

Table D . Brood averages and field productivity of blue and snow geese on the Gulf Coast, 1952-1971 (after Lynch, 1972; Table 2).

Year	Goslings per average brood in December	Percent 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

APPENDIX V

Table E. Estimates of annual mortality rates ($m = 1-\hat{s}$) and their 95% limits (± 1.96 S.E. ($\hat{s}$)) for banded blue and snow geese in some years from 1952 to 1970 (after Boyd, in press).

	Adults when banded				Locals when banded			
Year	m %	S.E.	Limits		m %	S.E.	Limits	
WESTERN STOCK*								
1952	8.2	7.42	0	22.8	52.0	2.65	46.8	57.2
1953	7.2	8.31	0	23.5	62.6	3.32	54.1	69.1
Pooled	15.1	3.46	3.3	21.8	55.6	3.46	48.8	62.4
1956	47.2	3.00	41.4	53.1	-			
1959	24.1	6.16	12.0	36.2	51.4	5.10	41.4	61.4
1965 (n)	34.0	8.49	17.4	50.6	-			
1966 (n)	45.7	8.83	28.4	63.0	(n)66.3	3.74	59.0	73.6
1967 (n)	29.2	8.43	12.7	45.7	(n)77.5	3.16	71.3	83.7
1968 (n)	33.4	8.00	17.8	49.1	(n)65.0	4.24	56.7	73.3
1969	58.5	29.55	0.7	100.0	67.2	6.93	53.6	80.8
1970	51.3	14.73	22.4	80.1	70.6	5.00	60.7	80.4
Pooled (67-70)	30.0	10.15	10.1	49.9	63.0	2.12	58.9	67.1
EASTERN STOCK**								
1967	-41.7	15.81			70.1	7.42	55.6	84.6
1968	54.0	2.24	49.7	58.4	68.6	10.15	48.7	87.6
1969	-18.1	28.78			59.9	9.43	41.4	78.4
1970	58.1	10.58	37.4	78.8	-			
Pooled (67-70)	25.7	4.36	17.2	34.3	72.2	3.46	65.4	79.0

(n) based on samples carrying neck-collars as well as legbands.

*Western stock - comprising McConnell River, La Pérouse Bay, and Boas River colonies.

**Eastern stock - comprising Bowman Bay, Cape Dominion, Koukdjuak River and Cape Henrietta Maria colonies.

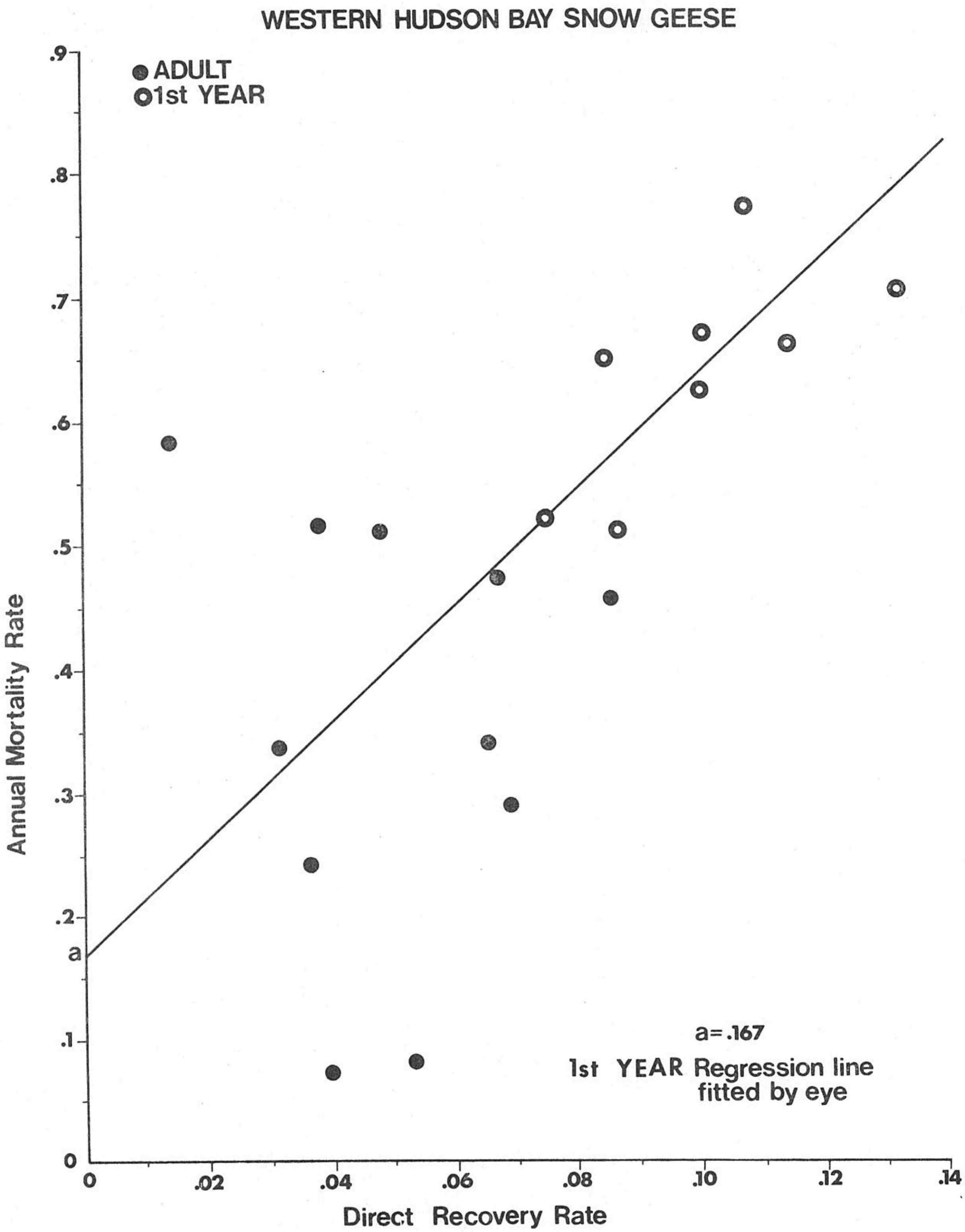

Figure F. Relation between direct recovery rates and mortality rates of adult and first-year Blue and Snow Geese from western Hudson Bay stocks (after Boyd, in press).

APPENDIX V

Table G. 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-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

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