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FIELD NOTE NO. 67

PREDICTIONS OF THE 1974 SPRING SNOW GOOSE MIGRATION AT WINNIPEG INTERNATIONAL AIRPORT

BY

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In the belief that rapid exchange of information is of the utmost importance to a solution of the bird problem, the Associate Committee on Bird Hazards to Aircraft has decided to release rough field notes as soon as they are produced, rather than to wait until these data would normally appear in formal reports.

These field notes are produced for information and will not usually receive the editorial care given to formal reports.

It is hoped that other groups will contribute similar notes on an exchange basis.

V. E. F. Solman

V.E.F. Solman, Chairman
Associate Committee on
Bird Hazards to Aircraft.

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ACKNOWLEDGEMENTS

This study was carried out at the request of the Ministry of Transport, and under the auspices of the Associate Committee on Bird Hazards to Aircraft of the National Research Council (NRC). The former organization provided financial assistance through the latter agency. Camera equipment and film were provided by the NRC.

The Air Traffic Control Centre at Winnipeg International Airport allowed us to film the master scope of the AASR-1 radar and co-operated in other ways as well. The Winnipeg Meteorological Office and the Atmospheric Environment Service, Toronto, provided weather data.

D.R.M. Hatch and R.W. Gemmell made frequent observations of staging and migrating geese. Volunteers, too numerous to mention here, provided us with records of their snow goose sightings.

A.D. Rutkus, Ottawa Meteorological Office, estimated geostrophic winds from 850 m B maps for periods that no pibal data were available.

Bird strike statistics for Winnipeg and vicinity in the first half of May 1974 were obtained from S. Hines, Ministry of Transport.

H. Boyd commented on an earlier draft of this report.

INTRODUCTION

The eastern populations of the Lesser Snow and Blue Goose, Anser c. caerulescens (snow geese), winter along the coast of the Gulf of Mexico. In spring, their north-northwesterly migration through the United States brings them into southern Manitoba. From their staging grounds in southern Manitoba, the geese fly northeasterly to the coasts of James and Hudson bays. In recent years, the main staging area in southern Manitoba has been between Cartwright and Windygates, with the largest concentrations near Pilot Mound, Crystal City and Snowflake (Blokpoel, 1974). The Terminal Control Area of Winnipeg International Airport is northeast of this staging area and thus in the direct line of flight of thousands of migrating snow geese each spring.

In spring 1969, a civil airliner was seriously damaged on striking a flock of migrating snow geese 12 n mi (22km) northeast of Winnipeg. The Associate Committee on Bird Hazards to Aircraft of the National Research Council was asked to (1) detect and warn of this spring migration and (2) develop techniques to predict it.

In 1970, 1971 and 1972 the Canadian Wildlife Service studied the snow goose migration over the Winnipeg area and developed a model to predict it (Blokpoel, 1974; Blokpoel and Gauthier, 1975).

The NRC also worked at Winnipeg Airport to develop a "bird radar" (Hunt, 1973, 1974; Hunt and Blokpoel, 1973).

In spring 1974, at the request of the Ministry of Transport, the migration prediction model was tested in real-time operations at Winnipeg International Airport. The results are reported here.

METHODS AND MATERIALS

A Preparation of the migration predictions

(1) The prediction model

According to our migration prediction model (Blokpoel and Gauthier, 1975) heavy snow goose migration over the Winnipeg area was to be expected if:

(a) the day was in the period 2-17 May

(b) the Winnipeg weather was as follows:

1) direction of surface wind - tail wind, side wind or a head wind of not more than 7 mph (11 km/hr)

2) direction of geostrophic wind - tail wind, side wind or a head wind of not more than 6mph (10 km/hr)

3) precipitation - less than normal

(c) the Pilot Mound weather, 2 hr previously, was as follows:

1) direction of surface wind - tail or southeast wind

2) precipitation - less than normal

The distance between Pilot Mound, in the centre of the main staging area, and Winnipeg was about 90 mi (144 km) or a 2-hr flight for the geese, assuming they flew with an average ground speed of 45 mph (72 km/hr). Tail wind included directions from W through S, head wind was from N through E, and all other directions comprised side wind.

Additional prediction guidelines were:

(d) Late in the season (16 May), intervals of not more than 4 hr of unfavourable northwesterly winds at the staging grounds during a period of favourable winds would not arrest major departures.

(e) In the middle of the season, intervals of not more than 3 hr of light (2.5 mph, 4km/hr) head winds at the staging grounds during a period of favourable winds would not arrest major departures.

(f) In normal years, the birds preferred to leave the staging grounds in the early morning and evening. When migration had been delayed by bad weather for a long time, massive departures could take place at any time of the day or night.

Three consecutive hourly readings of favourable weather comprised the minimum period for prediction of heavy migration. To allow time for weather changes to affect the whole Pilot Mound staging area, which covered about 40 by 15 mi (64 by 24 km), a migration prediction period began 1 hr before and ended 1 hr after any period of weather conditions favourable to migration.

(2) Application of the prediction model in an operational environment

The prediction model was largely based upon the relationships between various weather factors and the occurrence of heavy spring

snow goose migration. It was unknown which weather conditions were associated with light or no goose migration. Thus, the model could predict only periods of heavy migration and not periods with little or no migration. In practice, any period for which we did not predict heavy migration would have "non-heavy migration".

Less than normal precipitation was less than a trace. In practice, this meant non-heavy migration would be predicted when precipitation of more than 1 hr duration was forecast for either Pilot Mound or Winnipeg. Unfortunately, the weather forecaster was often unable to delimit periods of precipitation. A weather forecast including "occasional showers" could not be used without making some arbitarary decision. Similar problems arose when wind conditions were forecast as "light and variable". Such information was incompatible with the prediction model and arbitrary decisions had to be made, usually after further discussion with the weather forecaster.

One would obviously discontinue making migration predictions as soon as the geese had left their staging area. Thus, as suggested (Blokpoel and Gauthier, 1975), an air survey was made of the staging grounds on 15 May 1974 to determine the number of snow geese remaining.

Migration forecasts valid for 12 hr were issued daily at 0600 hr, 1200 hr and 1800 hr. Unlike the prediction model,

which was developed using values obtained from weather records, operational migration predictions were based on forecast weather. Forms were provided on which the personnel at the Winnipeg Meteorological Office recorded their 12 hr forecasts for each of the 5 critical weather factors.

A notice, indicating whether or not heavy migration was expected, was posted in both the Air Traffic Control Centre and the Winnipeg Meteorological Office, in the area where pilots received weather briefings. When the prediction criteria indicated a period of heavy migration, the supervisor of the Air Traffic Control Centre was advised and he issued a NOTAM, which was valid for 12 hours and indicated when heavy snow goose migration was predicted to occur.

B Determination of the accuracy of the migration predictions

1) Radar observations.

To determine if heavy migration indeed occurred during those periods for which it was forecast, we made time-lapse films of the screen of the 23-cm AASR-1 long range surveillance radar at the Air Traffic Control Centre at Winnipeg International Airport, 26 April through 16 May, 1974. The range was set at 60 n mi (111 km). The screen was fitted with a clock and data tab. The antenna made 6 revolutions per minute. Every second sweep was recorded on one film frame. Solman (1969) gave

details of the camera set-up and the manual of the Civil Aviation Branch (Can. Dept. of Transport, 1967) described the AASR-1 radar.

As snow geese migrate in spring in northeasterly directions, in large flocks and at altitudes of up to more than 5,000 ft (1520 m), the flocks would be expected to produce big, non-fluctuating echoes, moving at a constant speed, on a straight course in directions between north and east and visible for many miles on the screen. As in previous years, all echoes with these characteristics were considered "goose echoes".

The numbers of snow goose flocks over Winnipeg were obtained by hourly counts of the "goose echoes" crossing a straight line, the length and position of which were varied to best fit the direction, spread and visibility of the echoes during that hour and thus intercept the greatest number of echoes. Although we were predicting for the Winnipeg area (a circle with a radius of 69 mi (111 km) with its centre at Winnipeg Airport), we were particularly interested in the times that geese moved in large numbers over Winnipeg and its immediate vicinity. Thus, if a count was made 40 mi northeast of Winnipeg, we converted the time that the birds were counted to the time the birds had flown over Winnipeg or a straight line through Winnipeg perpendicular to the direction of their flight.

When making those conversions we assumed an average ground speed of 45 mph (72 km/hr) for the migrating geese.

We defined a period of heavy migration as any period during which a total of at least 200 "goose echoes" occurred, with a minimum of 20 echoes per hour.

(2) Visual observation

Visual observations were made from the Air Traffic Control Tower to confirm that the "goose echoes" were caused by flocks of migrating snow geese. In addition, we received many reports of snow goose migration from volunteers (bird watchers, RCMP detachments and meteorological stations had been provided with reporting forms).

In order to determine the distribution and chronology of the staging snow geese in southern Manitoba, road surveys were made in the period 20 April - 20 May, 1974 by D.R.M. Hatch. The records of these observations were stolen. Air surveys by light aircraft were made on 3, 12 and 15 May, 1974. We also received many reports of staging snow geese from volunteers.

(3) Weather data

Weather records were used to determine the accuracy of the weather forecasts and to determine the accuracy of the migration prediction model as it applied to the spring 1974 migration. Weather records for Winnipeg and Pilot Mound,

1 through 17 May 1974, were provided by the Winnipeg Meteorological Office and the Meteorological Applications Branch, Department of the Environment, Toronto. Winnipeg weather data included: 6-hourly geostrophic wind (3,200 ft above ground level, 975 m agl) speeds and directions, hourly surface wind speeds and directions, and continuous precipitation data. Pilot Mound weather data included: 6-hourly precipitation data and hourly surface wind speeds and directions.

C) Terminology

All directions are given in degrees True North. The direction of the wind indicates from where the wind blows; the direction of the birds, their apparent destination.

U.S. customary units are used in the tables and figures, but in the text the equivalent units of the Système International d'Unités (metric) are given as well.

All times are Central Standard Time.

RESULTS

A Synopsis

The results of the project were generally disappointing. The lack of success was due to several factors. The prediction model itself was inadequate because it produced some inaccurate migration predictions. In addition, some of the weather forecasts were incompatible with the model and a few were inaccurate.

Periods of validity for the migration predictions were a problem. Because forecasts issued at 0600 hr, 1200 hr and 1800 hr were valid for 12 hr periods, there resulted two 6-hr periods of overlap for 1200-1800 hr and 1800-2400 hr. When the updated forecast weather for these periods differed from the original, it sometimes also resulted in a change in the migration prediction. To eliminate this, beginning 8 May 0600 hr, migration prediction periods were reduced to 6 hr, except for the prediction at 1800 hr which continued to cover a 12 hr period.

The wording of the NOTAM's did not completely agree with the migration predictions. When a period of heavy snow goose migration was predicted for the Winnipeg area, a NOTAM was issued which stated "Heavy waterfowl migration predicted in Winnipeg Terminal Area from...to...". The Winnipeg Terminal Area covered an area within a 30 n mi (56 km) radius of Winnipeg,

while the prediction model forecast less specifically for the Winnipeg area, which encompassed that area within a 60 n mi (111 km) radius of Winnipeg. Thus, heavy migration could be correctly forecast for the Winnipeg area and not occur in the Winnipeg Terminal Area. This technicality was noted at too late a date to be rectified.

The weather forecast was often unsuitable for use in the migration prediction model and in such cases arbitrary decisions had to be made. This weakened our confidence in the migration forecasts. Furthermore, early in the season when heavy migration was predicted, usually no goose flocks were seen from the ATC tower, further undermining our confidance. On 8 May it was decided to discontinue issuing NOTAM's and from 9 May, no more migration predictions were provided. However, we continued to prepare migration predictions in order to evaluate the usefulness of the prediction model.

B Accuracy of migration predictions at the operational level

There were only 3 periods of heavy migration during spring 1974: 4 May 0300-1500 hr; 6 May 0700 hr - 7 May 0500 hr; and 14 May 2300 hr - 15 May, 2000 hr.

The predicted periods of both heavy migration and non-heavy migration were compared on an hourly basis to the actual migration determined by counts of "goose echoes" on

the radar films. Migration predictions were made continuously from 2 May 0000 hr to 17 May 1000 hr (a total of 370 hr). Of these 370 hr, a total of 294 hr (79%) were correctly predicted. Concerning periods of heavy migration, 32 hr (58%) of the 55 hr of actual heavy migration were correctly predicted, while these 32 hr comprised only 38% of the 85 hr for which heavy migration was predicted. Concerning periods during which non-heavy migration occurred, 262 hr (83%) of the 315 hr with non-heavy migration were correctly predicted. These 262 hr comprised 92% of the 285 hours predicted to have non-heavy migration (Fig.1).

Table 1 provides a breakdown of the 370 hr to show the extent to which our operations were hampered by the problems mentioned earlier.

C Accuracy of the weather forecasts

For our purpose, a weather forecast was considered correct only if the predicted migration based on the weather forecast was the same as that based on the weather records.

There was a total of 214 hr of weather records sufficiently detailed to fit the migration prediction model (Table 1, first two rows). Of these, the weather forecast was correct for 186 hr (87%).

There were an additional 116 hr (almost 1/3 of the period 2-17 May) for which the accuracy of the forecast weather could not be determined (Table 1, rows 3, 4 and 5). Of those, 57 hr

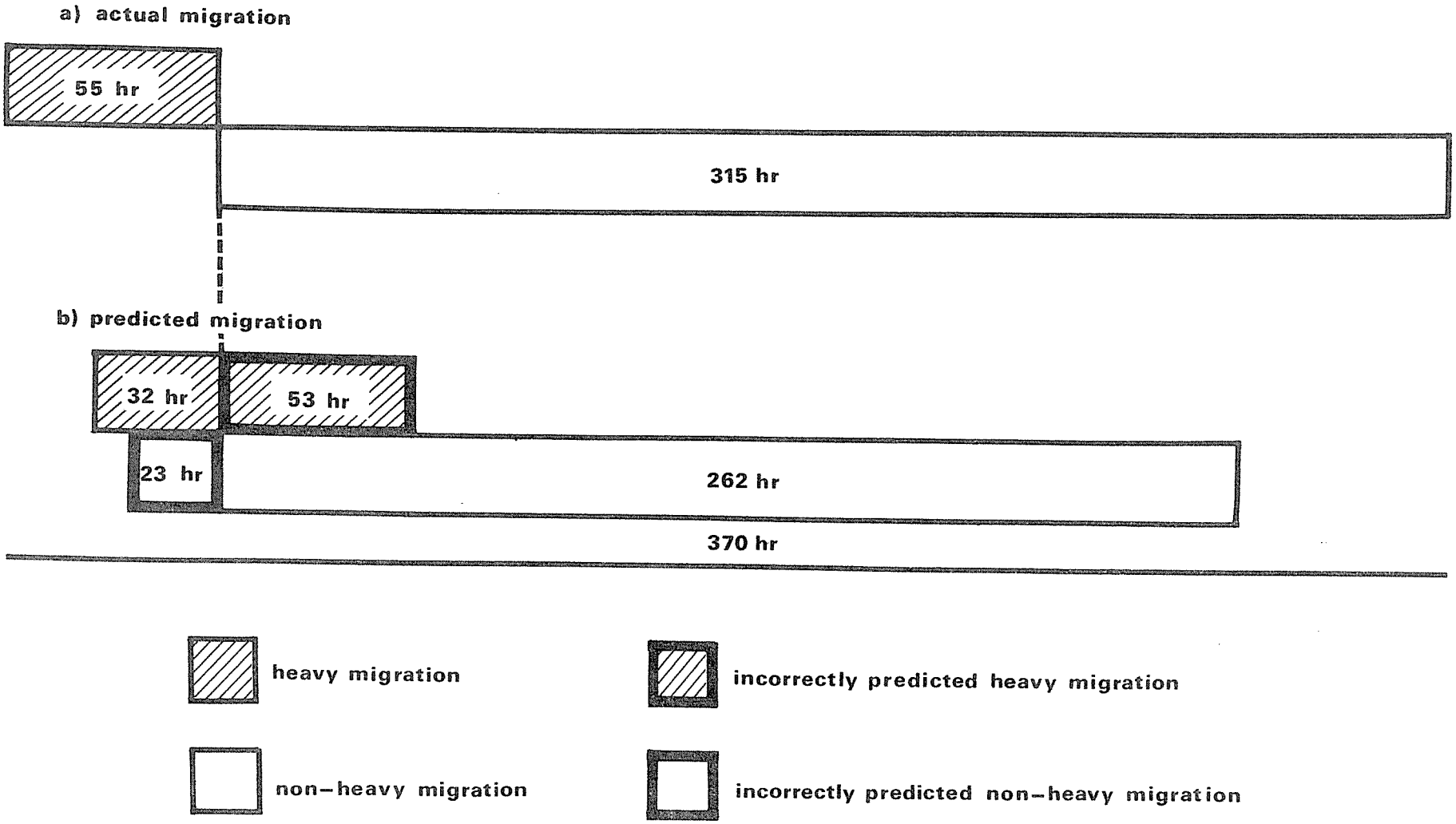

Figure 1. Comparison of (a) the actual snow goose migration during spring 1974 (based on radar films) with (b) the predicted migration for operational purposes (based on weather forcasts).

Table 1. Breakdown of the 370 hours for which snow goose migration predictions were made in spring 1974.

Migration forecasts based on:	Total hours (a)	Correct hours (b)	Accuracy (%) ($\frac{b}{a}$)
accurate weather forecasts	191	175	89
inaccurate weather forecasts	23	11	50
weather forecasts of unknown accuracy *	37	22	67
weather forecasts imcompatible with the prediction model	57	46	71
weather forecasts imcompatible with the prediction model and of unknown accuracy	22	2	14
air survey of the staging area	40	38	95
Total	370	294	79

* In 1974 the precipitation at Pilot Mound was reported as 6-hourly totals, which made it impossible to determine whether forecast precipitation had indeed occurred during certain hours

of forecast weather did not fit the prediction model ("light and variable" winds, "chance of" or "occasional" precipitation), 37 hr of weather records were unavailable or not detailed enough (duration of periods of precipitation at Pilot Mound were not recorded in 1974, unlike previous years), and during 22 hr both conditions prevailed (Table 1).

Thus, because precipitation was always forecast in terms that did not fit the prediction model and the weather records for Pilot Mound often did not provide the duration of precipitation, the determination of the accuracy of the weather forecast was based primarily on periods without forecast or actual precipitation.

D Accuracy of the prediction model

To determine the accuracy of the prediction model, migration predictions based on weather records were compared to the actual migration situation. Of the 314 hr for which weather records were available and/or of sufficient detail for use with the migration prediction model, 269 hr were correctly predicted, giving an accuracy of 86% (Fig. 2).

Concerning periods of heavy migration, 38 hr (78%) of the 49 hr of actual heavy migration were correctly predicted while these 38 hr comprised only 53% of the 72 hr for which heavy migration was predicted (Fig. 2). These values were considerably lower than those calculated for 1972, which were 85% and 74%, respectively (Blokpoel and Gauthier, 1975).

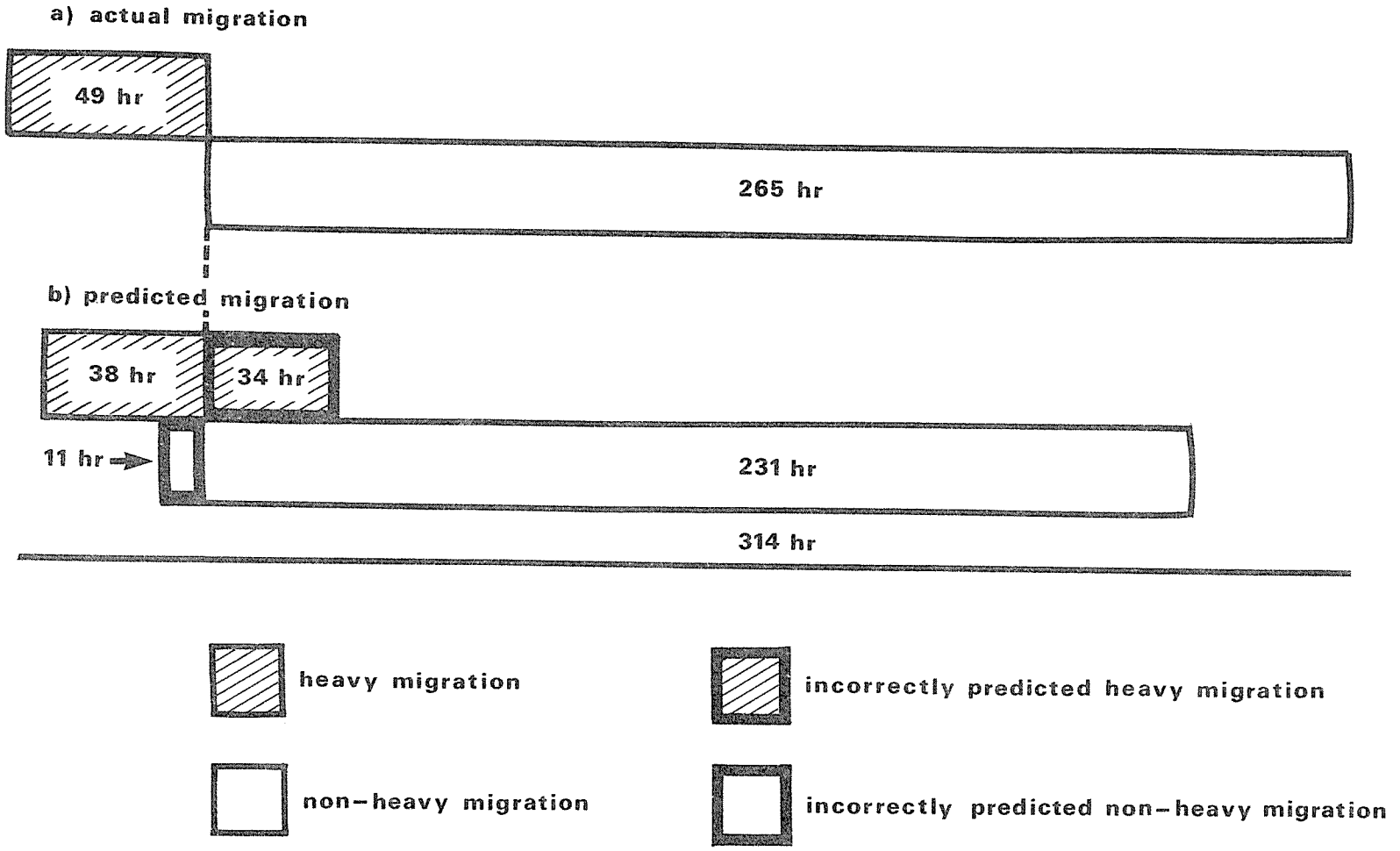

Figure 2. Comparison of (a) the actual snow goose migration during spring 1974 (based on radar films) with (b) the predicted migration (based on weather records).

There was a total of 45 hr for which either predicted heavy migration did not materialize or actual heavy migration was not predicted (Fig. 2 and Table 2).

Due to the very late spring on the prairies during 1974, snow geese first arrived at the Pilot Mound staging area on 29 April, rather than in mid-April, as is usual (Blokpoel and Gauthier, 1975). This may explain why no heavy migration occurred despite favourable weather conditions on 2 and 3 May.

The second major error in migration prediction occurred 6 May 2300 hr through 7 May 0500 hr. Even though the radar presentation for that period was extremely poor, we believe that heavy migration was occurring despite precipitation at both Winnipeg and Pilot Mound. We have no previous records of heavy migration during extensive periods of precipitation.

We are unable to explain the erroneous prediction on 8 May. It is possible that there were few geese in the Pilot Mound staging area ready to migrate at that time, however, all data on the routine surveys of the staging area collected by D.R.M. Hatch were stolen and records of observations collected from volunteers were few and inconclusive.

Heavy migration did not materialize for the predicted period 10 May 0100 - 0900 hr. Snow geese tend to depart during the first few hours after sunrise and the last few hours before sunset (Blokpoel and Gauthier 1975). The preferred departure time during the predicted period of migration

Table 2. Periods during which actual heavy migration (based on radar films) and predicted heavy migration (based on weather records) differed, 2-17 May 1974.

Period	Hours	Heavy migration		Conditions
		Actual	Predicted	
2 May,2100hr-3 May,0300hr	6	No	Yes	Favourable
3 May,2200hr-4 May,0300hr	5	No	Yes	Favourable
6 May,0500hr-0700hr	2	No	Yes	Favourable
6 May,2300hr-7 May,0500hr	6	Yes	No	Ligh drizzle and light rain at Pilot Mound; light and very light rain at Winnipeg
8 May,0200hr-1500hr	13	No	Yes	Favourable
10 May,0100hr-0900hr	8	No	Yes	Favourable
14 May,2300hr-15 May,0200hr	3	Yes	No	Very light head winds at Pilot Mound
15 May,1800hr-2000hr	2	Yes	No	Air and ground surveys indicated no snow geese remained in Pilot Mound staging area

corresponded to that during which fog was present at Pilot Mound. Fog at Pilot Mound was not one of the weather factors analysed during the development of the prediction model. It is quite likely that fog inhibited migratory departures on the morning of 10 May.

On 15 May, although both air and ground surveys indicated that all snow geese had left the Pilot Mound area, heavy migration continued 2 hr after it was predicted to end. That suggests that the heavy migration over the Winnipeg area consisted of geese from a staging area other than the Pilot Mound area. This explanation may also apply to the inaccurate migration predictions for 6/7 May and 14/15 May.

The prediction model was inadequate both because the geese appeared to depart from staging areas other than Pilot Mound and because factors in addition to, or other than, those thought favourable for heavy migration were of influence in spring 1974.

Concerning periods during which non-heavy migration occurred, 231 hr (87%) of the 265 hr with non-heavy migration were correctly predicted. The 231 hr comprised 95% of the 242 hr predicted to have non-heavy migration (Fig. 2). Although the prediction model was developed to predict periods of heavy migration only, the prediction of periods of non-heavy migration using the model proved to be more accurate.

BIRD STRIKES AND NEAR-MISSES DURING 2-17 MAY, 1974

During the first half of May, 4 "bird strike" forms were filed for the Winnipeg International Airport area (Table 3). Of these, two were near-misses which occurred during a period of unpredicted heavy snow goose migration. In both cases, the species involved were not reported to be snow geese, however the species description as "100 ducks" could possibly indicate a flock of snow geese, particularly since ducks do not usually migrate in such large aggregations in spring.

On 5 and 6 May, bird strikes were reported. The strike on 5 May occurred during a period of very light snow goose migration. The species involved was unknown. The strike on 6 May occurred during a predicted period of heavy snow gosse migration. "Two geese" was recorded as the species involved and it is likely that they were snow geese.

On 9 and 15 May, bird strikes or near-misses occurred, although reports were not filed. The incident on 9 May took place during a period of heavy NW migration by unknown species (as shown on the radar film). That of 15 May was during a period of predicted heavy snow goose migration. The species involved was "duck size" and could well have been snow geese.

Half of the species involved in these known bird strikes and near-misses were probably snow geese and 4 out of the 6

Table 3: Bird strikes and near-misses during the first half of May, 1974 in the vicinity of Winnipeg International Airport.

Date	Time	Aircraft	Company Flight	Flight Data				Strike Data		
				phase, location	height (ft. ag)	speed (kts)	lights in use	species	area struck	remarks
May 4	1055	DC-8	Air Can. #211	final	600	130	landing beacon wing	"starling size"	(near-miss)	
May 4	1110	B-727	CP Air #073	approach 6 mi S of airport	1200	150	landing beacon strobe nav.	"100 ducks"	(near-miss)	
May 5	2120	B-727	CP Air #075	climb 6 mi SE of airport	2700	180	landing beacon strobe nav.	unknown	windshield & nose	feathers & down on wiper blades and windshield; returned to airport
May 6	2033	B-727	CP Air #075	climb	2400	215	landing beacon wing strobe nav.	"2 geese"[a]	engine #3	impact very noticeable to crew and passengers, engine performance dropped; returned to airport
May 9	1640	-	CP Air	-	-	-	-	"sparrow size"	-	no written report[b]
May 15	0240	DC-8	Air Can. #571	13 mi NE of airport	-	-	-	"duck size"	-	no written report[b]

[a] A white feather was noted by airport personnel on engine #3, but was not collected.

[b] Data from Air Traffic Control Centre personnel at Winnipeg International Airport.

aircraft/bird incidents occurred during periods of heavy snow goose migration. The remaining 2 were during periods of light snow goose migration (determined from radar films).

These few statistics suggest that (a) during heavy snow goose migration the actual chance of a collision between an aircraft and a goose flock is fairly great, (b) in the first half of May, collisions with other bird species do occur and (c) the use of existing strobe lights on aircraft is not always effective in dispersing airborne birds and thus preventing collisions.

DISCUSSION

A Theoretical shortcomings of the migration predictions

The migration prediction model was based, for the most part, on correlations between weather factors and heavy migration. No investigation had been made to determine relationships between weather factors and periods of non-heavy migration.

The migration prediction model could predict heavy migration over the Winnipeg area only for flights originating in the Pilot Mound staging area. Any extensive changes in the staging distribution of the geese would make it impossible to predict, using this migration prediction model, when heavy migration would occur over the Winnipeg area.

Over the past 10 years, there have been increasing numbers of geese staging in south western Manitoba, particularly in the Boissevain-Hartney-Souris area west of the Pilot Mound staging area (Blokpoel, 1974). This trend continued in 1974 when, for the first time, more snow geese were observed in staging areas west of Pilot Mound than in the Pilot Mound staging area itself.

A further change in the staging distribution was noted during spring 1973, when approximately 30, 000 geese

were observed in the Oak Hammock area, 20 mi N of Winnipeg (Hatch, pers. comm.). Oak Hammock, recently developed as a waterfowl refuge, was opened in early 1973. During the dry spring of that year, it provided staging geese with an extra sheet water area, such areas being scarce in the remainder of southern Manitoba. In 1974, the spring melt was delayed and accompanied by extensive flooding and thus only limited use was made of the Oak Hammock area by the geese.

The migration prediction model was based on a simple univariate analysis (heavy migration was correlated with one weather factor at a time). The influence of the individual weather factors was not quantified, nor did we know the effect of the combined weather factors. In addition, the effects of the following factors were poorly understood: 1) progression of the migration season 2) the timing of the onset of spring "early" or "late" spring), 3) the apparent tendency for migration departures to occur in the early morning and early evening, 4) the volume of migration that had already taken place at any particular date, and 5) shifts in the staging areas and/or migration routes.

B. Practical shortcomings of the migration predictions

The migration predictions were based upon, and thus limited by, the accuracy of the weather forecasts. In addition,

weather forecasts were not as detailed as weather record data and, in some instances, did not fit the prediction model. Redesign of the prediction model to cope with weather forecast terminology would likely be accompanied by a reduction in the migration prediction accuracy.

When designing and testing the prediction model (Blokpoel and Gauthier, 1975), the exact duration of precipitation at Pilot Mound was available. The 1974 weather records for Pilot Mound usually gave the total precipitation on a 6 hr basis with no information on duration. That type of data made it impossible to calculate the accuracies for certain periods.

Inaccuracies in the wording of NOTAM's and overlapping migration prediction periods might have been eliminated by more elaborate preparation.

C. Usefulness of migration predictions in general

The theoretical migration prediction model showed several shortcomings when applied in the operational environment of Winnipeg International Airport. The accuracy of the operational migration predictions was limited. It is likely

that multivariate analysis of the migration data would result in a migration prediction model of improved accuracy. Even an improved model would provide only a general warning, to alert pilots and air traffic controllers, but it would not give information on the exact numbers, locations, and heights of the migrating flocks. An operational migration prediction system should, ideally, provide the bird strke probability for anysspecified time, altitude and distance from the airport. The difficulties in developing such a prediction system and the unsuitability of the present migration prediction model for calculations of bird strike probabilities were discussed by Blokpoel and Gauthier (1975).

Not only snow geese, but also a host of other spring migrants such as swans, pelicans, cormorants, and several species of geese and ducks present a hazard to flight safety in the vicinity of Winnipeg International Airport. It would obviously be a massive undertaking to predict the timing and volume of migration for all those species.

A warning system providing detailed information on any hazardous situation created by airborne birds is needed. Studies have been conducted (Hunt, 1973, 1974; Hunt and Blokpoel, 1973), and research is presently underway to develop a system based on radar which would provide the bird strike probability for aircraft taking off or landing (Hunt, in prep.).

SUMMARY

1- A theoretical migration prediction model was used operationally for flight safety to predict the Lesser Snow and Blue Goose migration situation over the Winnipeg area, 2-17 May 1974.

2- Periods of actual heavy migration were determined from films taken of the master scope of the 23-cm AASR-1 radar at Winnipeg International Airport, 26 April through 17 May, 1974.

3- Migration predictions, based upon specially prepared weather forecasts, were issued daily at 0600 hr, 1200 hr and 1800 hr. The overall accuracy of those predictions was 79%, but was much lower when only heavy migration was considered.

4- The accuracy of the prediction model for the spring 1974 migration was determined using weather records. Of the 49 hr of heavy migration, 38 hr (78%) were predicted while of the 72 hr of predicted heavy migration, 38 hr (53%) materialized. The accuracy of the prediction model for the spring migration of 1974 was lower than that for 1972, using the same migration prediction model.

5- Inherent shortcomings of the migration prediction model and difficulties in using the model with the terminology of weather forecasts make it advisable to revise the prediction model prior to further use.

6- Operational usefulness of migration predictions for flight safety is discussed. An improved migration prediction model with greater accuracy would only warn or alert pilots and air traffic controllers in a general way. An automatic system, based largely on radar, would provide information on all actual hazardous situations created by airborne birds of any species in sufficient detail to estimate bird strike probabilities. Further research and development work on such a "bird radar" is recommended.

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