

XXIX. INFLUENCE OF TEMPERATURE ON ARCTIC-NESTING GEESE

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For the purpose of contributing to a symposium largely devoted to geese in the western Palearctic, it seems appropriate to avoid reporting solely North American events and take a more general view, made possible by the very recent publication of sets of seasonal (*Jones and Wigley, 1980a-d; Kelly and Jones, 1981a-b*). The ways in which those indices are derived from station records are described in those publications. The published estimates are expressed as anomalies (i.e., departures from the datum of the mean values from the years 1941-1960). I have recalculated them as deviations from the mean for 1950-1980, the period in which the goose data are available.

I have brought together the results of monitoring the numbers and breeding success of several goose populations from Eurasia as well as North America, updating the data assembled by *Ogilvie (1980)*. A few runs of records extend as far back as 1950. The other records all cover at least ten years. Instead of considering one species or one subpopulation at a time, I have pooled the data by regions and then for the Arctic as a whole. The boundaries of the four regions were determined as much by the availability of records as by geography. The regional collections are: (1) *Alaska* (in which I have also included *Ostrov Vrangelya* and the northwest of the Northwest Territories); (2) *northeastern Canada*, extending from the Queen Elizabeth Islands to James Bay and from Queen Maud Gulf and the western coast of Hudson Bay east to southern Baffin Island and the west coast of Greenland; (3) the *Greenland Sea* states, i.e., east Greenland, Iceland and Spitzbergen; and (4) *northern U.S.S.R.* from the Kola Peninsula east to the Taymyr Peninsula, including *Novaya Zemlya* and other offshore islands. I have found no suitable data for northeastern Asia, from 100°E to the Bering Strait, apart from the Lesser Snow Geese breeding on *Ostrov Vrangelya*.

Three kinds of data are used wherever possible: (1) annual census or index numbers (N); (2) field observations on the proportion of first-winter birds in flocks in autumn or early winter (J); and (3) annual means of observed brood sizes (B). As a supplement in some cases, the proportion of first-winter goose tails found in the samples returned by hunters selected to take part in the U.S. and Canadian species composition surveys are used. Canada Geese have been left out of this analysis as they pose special problems. It is difficult to identify young Canada Geese in the field from September onwards. There are also difficulties in dissecting the information on numbers in winter, usually published state-by-state, so as to correspond with what

is known about the segregation of different populations that overlap in their winter quarters.

This approach to population analysis was pioneered by *Lebret* (1948) in Europe and by *Lynch* in North America (*Lynch and Singleton*, 1964, and many unpublished reports to the U.S. Fish and Wildlife Service). There are several ways in which the available data may be biased and in only a few cases have large samples been obtained to reflect the composition of very large populations. Seemingly inconsistent results have led several investigators to spend more effort on reconciling regional data, or deploring their use, than in seeing whether the data can be used effectively, despite their obvious limitations.

The notion of pooling results from different species and subpopulations exposed to different local climates will doubtless seem improper to such critics; and the results which follow are sufficiently inconclusive to give grounds for scepticism. Yet it is important to look at large sketches as well as at small, detailed pictures. National agencies must be more concerned with continental than with local fluctuations in the numbers and distribution of geese and their possible causes.

I have combined inventories and observations on family size and the proportion of young geese into two sets of index numbers. The first, a success index (SI), was obtained by assigning annual scores to each constituent and then summing them. Values less than the period mean minus one standard error ($m-s$) were scored as "1"; those exceeding the mean plus one standard error ($m+s$) were scored as "3"; and the remainder, grouped about the mean, were scored "2". For brood size and % first-winter the means of the whole run of years were used. Nearly all the populations concerned increased substantially during the period 1950–1980. In those cases where there were clear trends throughout the period the deviations from the expected population size were used. Where the fluctuations were irregular 5- or 10-year mean population sizes were used to score the year-to-year changes. A complete data set for any population results in an integer score ranging from 3 to 9. Where one of the pieces of information is missing for an entire run (e.g., brood sizes for Atlantic Brent Geese), no entry has been made so that the score could not exceed 6. Occasional missing values have been dealt with by inserting a score of 2. For those early years in which few populations were being monitored, no index number was inserted unless at least three statistics derived from 3 populations, in at least 2 regions, were available.

The annual indices from all available data (total success index or TSI) are displayed in Figure 1. There were no significant regional trends extending over the entire period. The TSI show a significant decrease, its correlation with years yielding $R = -0.421$ ($0.02 > p > 0.01$). The mean annual decrement (-0.01) is much less than most of the year-to-year changes. The most important characteristic of the TSI series is that there are no long runs of high or low scores. The wide fluctuations are somewhat surprising given that the method of rating ensures that about 2/3 of the scores for each elements will be "2".

The second indicator shown in Figure 1 is the ratio parents/geese in adult plumage (P/A), *Lynch's* "field productivity" (*Lynch and Singleton*, 1964). This is obtained from the proportion of the first-winter geese observed (j)

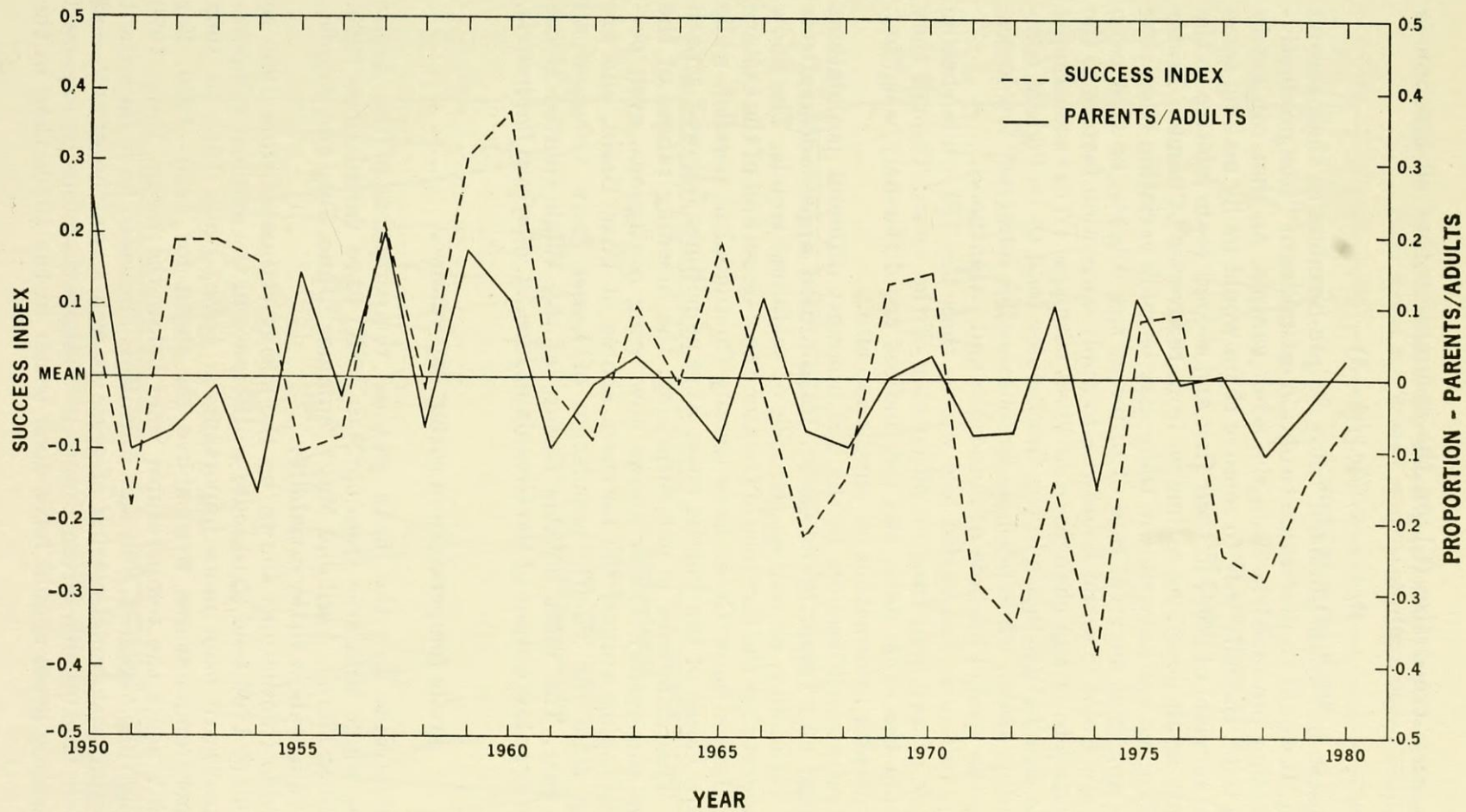


Figure XXIX/1: Variations in annual indices of goose population success and on the parent/adult ratio, derived from field observations in fall and winter, 1950 - 1980

and from the mean brood size (\bar{b}), on the assumption that all the broods were accompanied by two adults:

$$P/A = 2/\bar{b} \times J/(1-J)$$

Many of the geese in "adult plumage" may be pre-breeders in their second or third winter. It would be preferable to obtain estimates of "true productivity" by subtracting pre-breeders from the adult sample. As that can rarely be done in the field, the only way to remove them would be by making some estimate of the survival of geese in their first and second years relative to the survival of truly adult geese. As estimates from recoveries of banded Lesser Snow Geese of known age have shown, there may be wide variation from year to year in the apparent survival rate of different age cohorts, so that even from Lesser Snow Geese it would be unwise to apply correction factors to the observed age ratios to reflect changes in survival with age. (What seems most often to be the case is that losses in the first winter tend to be high in comparison with adult losses, while pre-breeders may suffer relatively few losses, as they escape the special hazards of innocence and parenthood.)

The parent/adult ratio has varied less widely than the TSI while sharing with it the lack of any long runs on either side of the mean. Though they are derived from the same data, the two indices are differently weighted. The TSI incorporates information on population size.

Figure 2 illustrates differences in the TSI amongst different populations of White-fronted and Lesser Snow Geese. Its confused appearance reflects the extent of variability, as well as the lack of sustained trends. The Snow Goose plots suggest that the fortunes of Greater Snow Geese and of the eastern populations of Lesser Snow Geese have usually fluctuated in parallel, while the Lesser Snow Geese of the Pacific coast have sometimes followed a path of their own. This difference is not surprising, the breeding ranges of the Greater Snows and eastern Lesser Snows now being contiguous, even perhaps now overlapping around the northern shores of Foxe Basin, and are well separated from the Pacific population of Lesser Snow Geese at all times of the year. The most notable feature of the White-fronted Goose diagram is the very low output of the Greenland race, *A. albifrons flavirostris*.

Arctic temperature in spring and summer

Figure 3 illustrates how the mean seasonal temperatures of the Arctic (defined as the whole land area from 65°N to 85°N) have varied since 1950. "Spring" includes March, April and May; "summer" June, July and August. The summer values show little variability.

The very wide fluctuations shown by the spring estimates from 1950 to 1955, from 1962 to 1968 tend to obscure a difference in the summer temperatures that may have been more important to geese. From 1950 to 1963 all the summer temperatures were above the mean for 1950-1980. For 6 of the next 7 years the temperatures were below the mean. From 1970 to 1980 no long runs occurred. Summer warmth is known to have important effects on nesting and brood-rearing of geese as well as on the growth and quality of their food plants. From Figure 3 it might therefore be expected that Arctic-nesting geese should have done better in the 1950s than in the

Figure 2 Annual indices of the breeding success of different populations of Snow Geese and White-fronted Geese, 1950-1980.

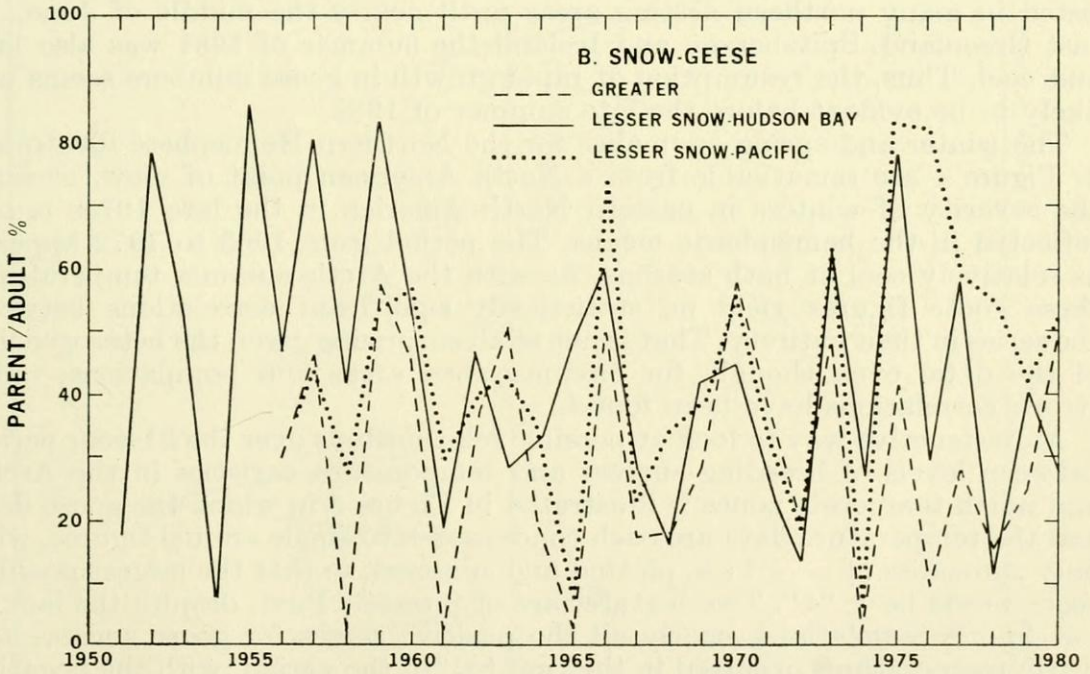
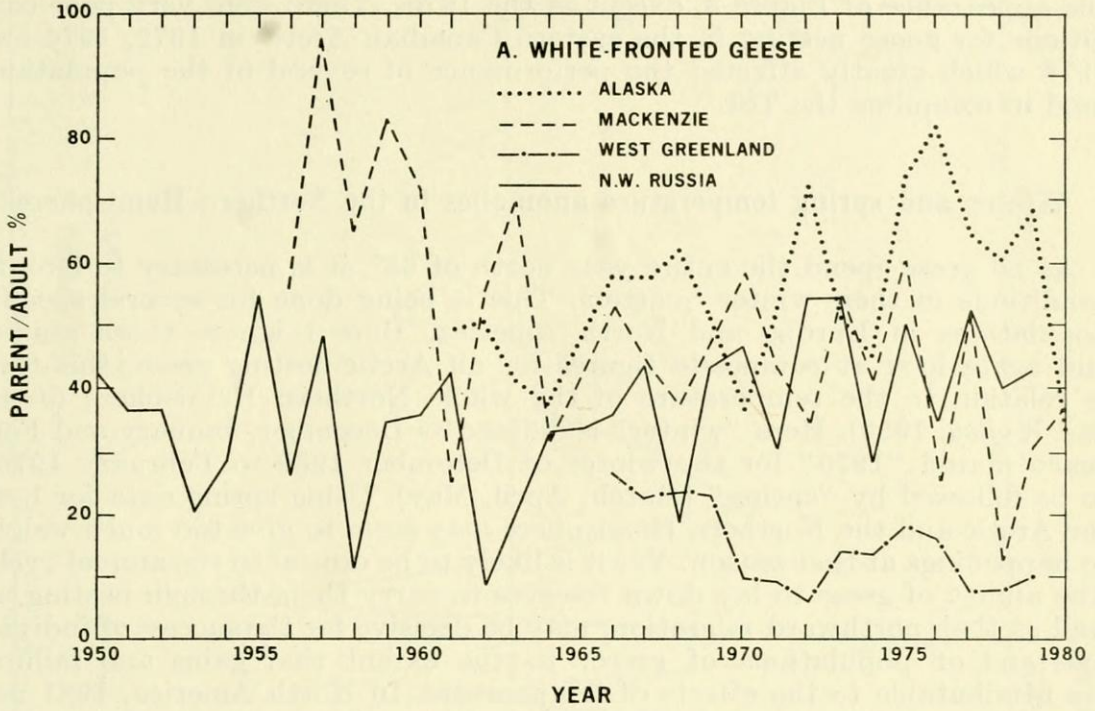


Figure XXIX/2: Annual indices of the breeding success of different populations of Snow Geese and White fronted Geese 1950 - 1980.

1960s, with their performance in the 1970s being intermediate. The variation in goose success illustrated in Figure 1 conforms in a general way with the appearance of Figure 3, except in the 1970s. There were very poor conditions for goose nesting in the eastern Canadian Arctic in 1972, 1974 and 1978 which greatly affected the performance of several of the populations used in compiling the TSI.

Winter and spring temperature anomalies in the Northern Hemisphere

As no geese spend the entire year north of 65° , it is necessary to look at conditions in their winter quarters. This is being done for several specific populations in Europe and North America. Here I ignore those studies and again look at composite figures for all Arctic-nesting geese, this time in relation to the temperature of the whole Northern Hemisphere (*Jones and Wigley, 1980*). Here "winter" is defined as December, January and February (dated "1970" for the winter of December 1969 to February 1970), to be followed by "spring" (March, April, May). Using spring data for both the Arctic and the Northern Hemisphere may seem to give too much weight to happenings at that season. Yet it is likely to be crucial to the annual cycle. The ability of geese to lay down reserves to carry them through nesting, as well as their northward migration, may be decisive for the success of individuals and of populations of geese, to the extent that gains and failures are attributable to the effects of temperature. In North America, 1981 was a poor year for goose production. First, those geese staging in the prairies in April and early May encountered severe drought. Then snow cover persisted in many northern nesting areas until nearly the middle of June. In east Greenland, Spitzbergen and Iceland the summer of 1981 was also late and cool. Thus, the resumption of rapid growth in goose numbers seems unlikely to be evident before the late summer of 1982.

The winter and spring anomalies for the Northern Hemisphere illustrated in Figure 4 are remarkable from a North American point of view, because the severity of winters in eastern North America in the late 1970s is not reflected in the hemispheric means. The period from 1963 to 1972 appears as relatively cool at both seasons. As with the Arctic summer temperatures these goose figures yield no statistically significant correlations between the series in their entirety. That is not at all surprising given the heterogeneity of the data, even though, for circumscribed areas and populations, quite strong correlations have been found.

An instructive way to look at possible relationships over the 31-year period between levels of breeding success and temperature varieties in the Arctic and north temperate zones is illustrated in Figure 5 in which the goose data and the temperature data are each condensed into single annual figures, with only anomalies of $> \pm 1$ s.e. plotted and summed, so that the largest possible score would be ± 4 . Two features are of interest. First, despite the lack of one-to-one correlations, nearly all the positive scores for goose success and warm temperatures occurred in the first half of the period, with the negative scores similarly concentrated in the second half.

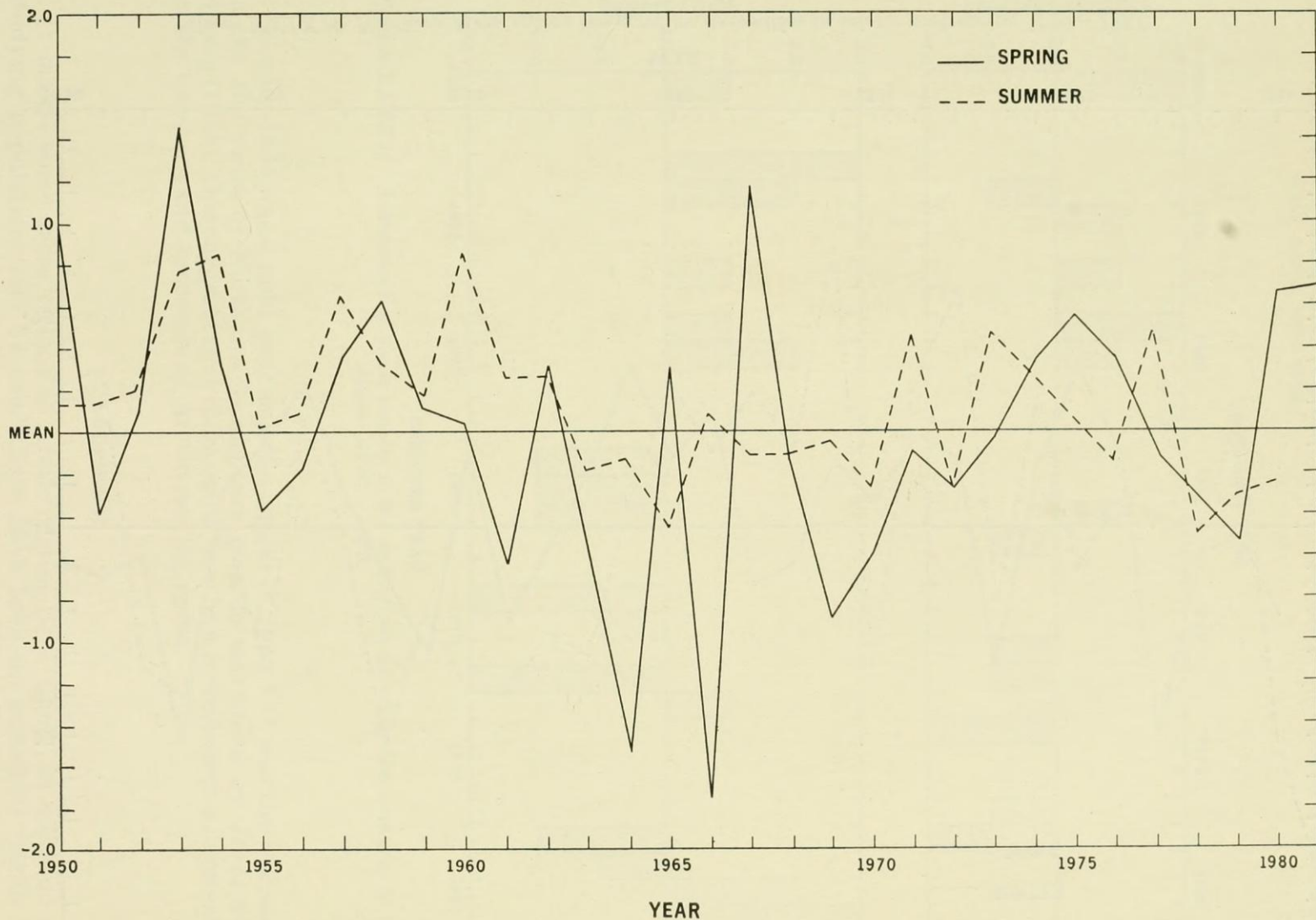


Figure XXIX/3: Arctic temperature anomalies in spring and summer 1950 – 1980.

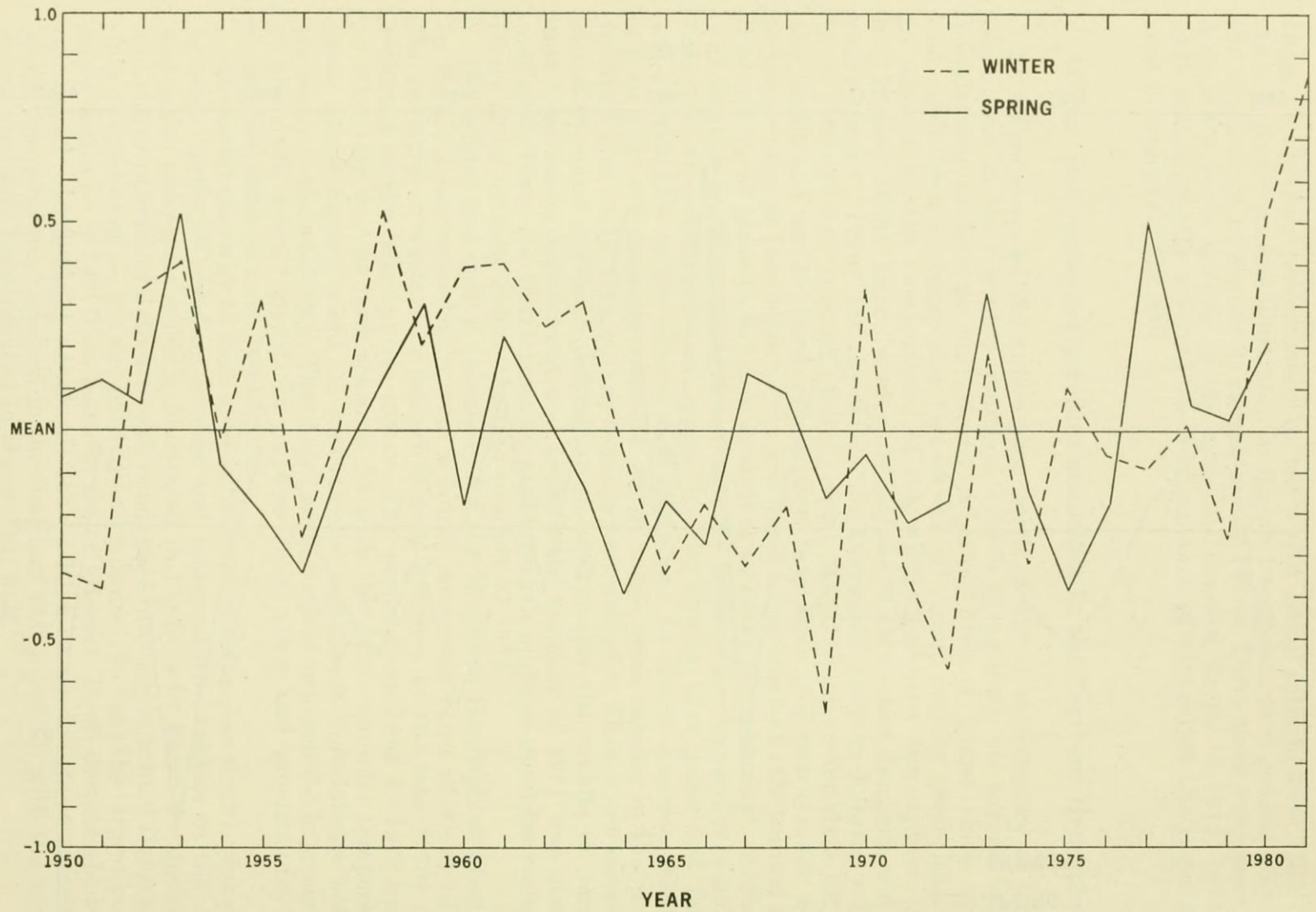


Figure XXIX/4: Northern Hemisphere temperature anomalies in winter and spring 1950 – 1981.

Figure 5 Anomalous values of goose success index and of pre-breeding temperatures in the Arctic, 1950-1980.

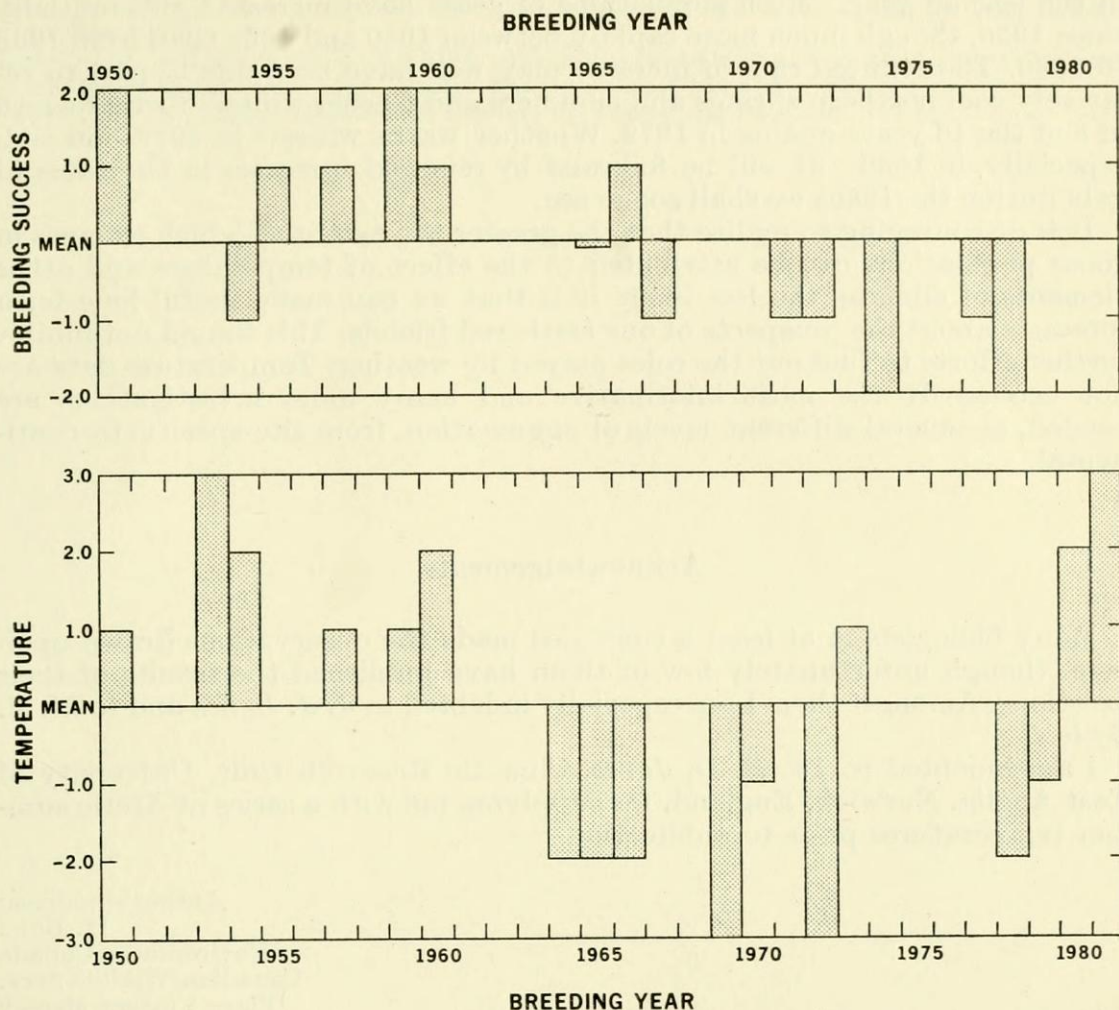


Figure XXIX/5: Anomalous of goose success index and of pre-breeding temperatures in the Arctic, 1950 - 1980.

Second, 1980 was a mild year and the winter of 1980 - 81 was the warmest in the 100 years of Northern Hemisphere records assembled by *Jones and Wigley* (1980). This suggests that there could now be a reemergence of growth in the numbers and successes of Arctic-nesting geese.

Conclusion

It makes some sense to look at Arctic nesting as a whole, in addition to studying populations one by one. There have been no persistent trends in spring and summer temperatures in the Arctic. Temperatures in summer have varied much less than temperatures in autumn, winter and spring. This

may help to explain why there has been poor year-by-year correspondence between northern temperature anomalies and fluctuations in breeding success in the last 30 years. Most populations of geese have increased substantially since 1950, though much more rapidly between 1950 and 1965 than from 1965 to 1980. The reduced rate of increase may well have been due in part to relatively cool northern springs and summers and to cool winters further south in 8 of the 16 years ending in 1979. Whether warm winters in 1979–80 and, especially, in 1980–81 will be followed by renewed increases in the rates of gain during the 1980s we shall soon see.

It is discouraging to realize that the greater the extent to which changes in goose populations can be attributed to the effect of temperature and other elements of climate, the less likely it is that we can make useful long-term forecasts about the prospects of our feathered friends. This should not inhibit further efforts to find out the roles played by weather. Temperature data are not necessarily the most informative and many more investigations are needed, at several different levels of aggregation, from site-specific to continental.

Acknowledgements

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