THE INCREASE IN WINTERING HOODED MERGANSERS IN NEW ENGLAND:

Some Statistical Inquiries

Stephen Davis
211 Hornbine Road
Swansea, Massachussets 02777
(email abunoah@aol.com)

Abstract

In New England during the past decade, there has clearly been an increase in the number of wintering Hooded Mergansers (*Lophodytes cucullatus*). The present paper summarizes a statistical investigation of that increase based on New England Christmas Bird Count (C.B.C.) data (archived electronically and accessible on the World Wide Web at http //www.audubon.org/bird/cbc). Specifically, the paper provides a comparative analysis of the numbers of Hooded Mergansers counted on New England C.B,C.s during the 86th, 87th, 88th, and 89th and the 97th, 98th, and 99th counts. For comparative analysis, the data from the four counts from the 1980s were averaged, and the three counts from the 1990s were averaged. Variables used in the analyses were the latitude and longitude of the count; the presence or absence of coastline in the count's circles; the numbers of mergansers counted per each count's number of party-hours; and the air temperatures reported on the count day

Significant differences were discovered in the numbers of Hooded Mergansers reported between the two decades, in the numbers of mergansers by latitude, and in the reported temperatures from the 1980s to the 1990s. Correlates for these changes in values are also discussed herein.

This increase in wintering mergansers raises questions than cannot be answered by a limited study based on C.B.C. data. Such questions include whether this increase betokens a general trend for Hooded Merganser across its range or whether it indicates a more local geographic shift in wintering areas, and whether the apparent increase in temperature has a causal role in such changes.

Methods

I compared the average number of Hooded Mergansers reported on the 1985-1988 New England C.B.C.s with the average number reported from the same C.B.C.s in 1996-1998. I used a total of 87 counts, all of which had an adequate number of years reported (at least six of the seven years had reports).

Data from the counts as reported in *American Birds* for the above years were entered into a statistical program. The number of Hooded Mergansers counted per party-hour (HMs/P-Hr) for each count was calculated. An average count per party-hour was calculated for each C B C. area for each decade grouping. Comparisons could then be made between the decades for each count. Comparisons between the decades by latitude-longitude (Lat-Long) units were also made for the 23 Lat-Long units in New England where counts occurred.

Inasmuch as there has been a warming trend for the past decade, a secondary analysis and comparison were made for the temperatures on the count days as reported for the counts for the same years. Both the high and low temperatures were recorded, and an average temperature for the day was calculated. The average temperatures from the late 1980s were compared to the average temperatures from the 1990s. These temperature changes were also compared by individual count to the changes in the numbers of Hooded Mergansers.

Results

The number of counts that reported Hooded Mergansers (HMs) out of the total C.B.C. counts made in the region clearly increased over the period investigated (Table 1). Likewise, the total number of HMs counted on all of the New England counts shows an increase between the decades (Table 2). The large increase for 1998 is particularly noticeable

The number of HMs/P-Hr ranged from a low of zero on many counts in all the years to a high of 4.34 on the Buzzards Bay, Massachusetts count in 1998. Interestingly, the second highest individual count was 4.30 in 1985, also on the Buzzards Bay count. These high numbers compare surprisingly well to the continent's peak of 2.80 HMs/P-Hr as cal-

Table 1. Number of CBCs Each Year That Included Hooded Mergansers

1985	35 out of 83 or 42%
1986	34 out of 84 or 40%
1987	38 out of 87 or 44%
1988	40 out of 87 or 46%
1996	57 out of 87 or 66%
1997	60 out of 87 or 69%
1998	64 out of 86 or 74%

**The data analyzed are available from the author on a Statview 512 program for the Macintosh.*

Table 2. Total Number of Hooded Mergansers on New England Counts by Year

1985	1074
1986	1152
1987	1580
1988	1189
1996	2430
1997	2844
1998	3980

culated by Root (1988). That peak calculation, however, was an average for the ten years reported on individual counts from 1962-1963 to 1971-1972 and did not include the top one percent of counts for a species; this was for reasons peculiar to Root's graphics needs. Consequently, the values are not strictly comparable.

The average number of Hooded Mergansers per party-hour for the count years appear in Table 3. Not surprisingly, there was a very strong positive correlation between the average number of mergansers per party-hour for each count in the 1980s correlated with itself in the 1990s (Table 3). Although expected, the extremely high correlation (r=0.90) is in part produced by about one-sixth of the counts having an average count of zero for all the years and hence a zero average for both decades.

When the aggregate average counts from the late 1980s were compared to those from the late 1990s, the difference was significant: the 1980s average of 0.174 (±0.43) Hooded Mergansers per party-hour and the 1990s average of 0.387 (±0.67) produced a paired t-test with t= -6 056. (The difference is negative, as it expresses the values for the 1980s *minus* the values for the 1990s.)

Table 3. Average Number of Hooded Mergansers per Party Hour by Year

1985	0.15
1986	0.15
1987	0.21
1988	0.17
1996	0.32
1997	0.36
1998	0.5

The Buzzards Bay count had the highest average for its four counts from the 1980s (2.97 HMs/P-Hr) and also the highest average for the three years in the 1990s (4.04). The New London, Connecticut count was second in both of these averages: 2.20 for the 1980s counts and 3.38 for the 1990s.

For each count, the average Hooded Mergansers counted per party-hour in the 1980s was compared to the average counted from the 1990s. There were 15 counts on which none were counted in any of the 7 years. There were 66 counts on which the average count number increased. There were 6 counts where the average decreased from the 1980s to 1990s: Athol, Massachusetts (HMs/P-Hr decrease= -0.74: 0.87 to 0.13), Old Lyme, Connecticut (-0.18: 0.35 to 0.17)), Hartford, Connecticut (- 0 018: 0.025 to 0.007), Errol/Umbagog, New Hampshire (-0.010: 0 018 to 0.009), Biddeford/Kenebunkport, Maine (-0.006: 0.017 to 0 011), and Storrs, Connecticut (-0.003: 0.045 to 0.042). Interestingly, three of these counts—Old Lyme, Hartford, and Storrs—are in the same Lat-Long block (41°, 72°). A sign test reveals that 66 counts' Hms/P-Hr increased, 6 decreased, and 15 stayed the same (P<0.01).

The greatest increases in count averages between the four counts in the 1980s and the three counts in the 1990s occurred in New London (+1 18), Plymouth, Massachusetts (+1.13, from 0.75 to 1.88), South Kingstown, Rhode Island (+1.13, from 0.26 to 1.39), Worcester, Massachusetts (+1.08, from 0.13 to 1.21), and Buzzards Bay (+1.07).

Changes in count averages from decade to decade were compared to the latitude and longitude of the counts (decimalized). Interestingly, there was not a significant correlation with the longitude of the count and the magnitude of the increase in numbers (r=0.005), but there was a significant relationship between the count latitude and the increase in numbers (r=0.40, P>0.001). This result suggests that that the more southerly counts had larger increases but that the longitude of the count had relatively little bearing. When direction variables were run as a multiple regression on merganser numbers, a similar effect was determined the north-south direction had a significant result; the east-west direction did not.

Temperature Changes

There were statistically significant changes in the average temperatures reported (in Fahrenheit degrees) for the New England C.B.C.s between the two decades. These changes were similar for all three factors considered: high temperature, low temperature, and mean temperature The aggregate mean temperatures for the count years appear in Table 4

When each count's mean temperatures for the 1980s were compared to its means for the 1990s, there are also significant differences (Table 5) Again, the differences are similar for each temperature value. The results of paired t-tests' average high, average low, and average mean for the 1980s compared to those for the 1990s are presented in Table 5. Changes in temperatures were not, however, significantly correlated with latitude (r=0.06) or longitude (r=0.10).

More importantly, there is not a significant relationship between the average temperature changes between the decades and the changes in the average counts of HMs (r=0.02). This is in spite of the observation that both the average temperature and the average numbers of HMs increased for nearly all the counts. These temperatures, naturally, are single-day temperatures from each count for each year, and, as such, may not be representative of the actual "climate" or average temperature change. It would be worthwhile to attempt to correlate the change in numbers of HMs with the actual average climatological data.

Table 4. Average High, Low, and Mean Temperatures on Count Days by Year

YEAR	AVE. HIGH	AVE. LOW	AVE. MEAN
1985	27.3	12.0	19.7
1986	35.7	24.0	29.8
1987	32.3	18.0	25.2
1988	26.7	11.8	19.3
1996	36.0	23.0	29.4
1997	37.2	24.7	30.9
1998	35.4	20.1	27.7

Table 5. Average Temperature Changes From the 80s to 90s

	AVE. LOW	AVE. HIGH	AVE. MEAN
TEMPERATURE DIFFERENCE	+6.1	+5.6	+5.8
PAIRED -t VALUE	7.62	9.13	9.11
p value	<0.0001	<0.0001	<0.0001

When the analysis of temperature change between the decades and change in numbers of HMs is done by individual C.B.C. with a regression, the statistical values are as follows: r=0.02, F=0 041, and P=0.84. When the same comparison is made by Lat-Long blocks, there is also no significant relationship (r=0.08, F=0.131, and P=0.72). For both of these analyses, similar results were obtained for all three temperature values (Table 6).

Coastal Factor

Also entered into the data set was whether or not each count circle included the Atlantic coast. Hooded Mergansers winter on both salt water and fresh water. In New England winters, the fresh water is often frozen. Whether or not the local fresh water was frozen was not included in this analysis. Of the 87 counts considered, 34 or 39% included the coast. When the coastal variable was considered in the changes in Hooded Merganser numbers, it was independently correlated with higher count numbers and with increases between the decades. The coastal counts in the 1980s recorded an average of 0.352 HMs/P-Hr versus an average of 0.057 for the non-coastal counts (P<0 01). For the 1990s, the averages were 0.717 for the coastal counts and 0.181 for the non-coastal (P<0 001). The calculated increase in HMs/P-Hr per count was also significant on this variable: the increase for the coastal counts was 0.379 versus 0 128 for the noncoastal counts (p<0.001). This difference is not just the difference between the averages for the 1980s and those for the 1990s, as it includes the differences for each count, not simply the differences by decade.

To determine if the coastal variable was independently related to merganser increases, it was run in multiple regressions with latitude, longitude, and temperature. More of the eastern counts and more of the southern counts were coastal; similarly, both in the 1980s and 1990s, the coastal counts had warmer temperatures than the counts in the interior, but the temperature changes between the 1980s and 1990s did not differ significantly between the coastal and noncoastal counts (Table 7).

Table 6. CHANGE IN NEW ENGLAND WINTERING HOODED MERGANSER AND CHANGE IN AVERAGE TEMPERATURE BY LATITUDE-LONGITUDE BLOCKS

	73°	72°	71°	70°	69°	68°	67°	66°
44°	2	2	2	2	3	3	3	1
	0.18	0.0	0.01	0.16	0.18	-0.01	0.17	0.38
	3.4	8.3	2.6	10.8	5.4	2.3	12.1	7.1
43°	1	5	3	4	1	1		
	0.0	0.05	0.41	0.03	0.50	0.01		
	4.3	1.5	4.6	6.5	8.8	1.8		
42°	3	6	8	5				
	0.06	-0.04	0.24	0.14				
	6.2	6.3	4.1	7.1				
41°	7	8	5	7	1			1
	0.39	0.39	0.55	0.65	0.21	also 45°-71°:		0.01
	6.7	5.7	0.0	8.1	11.6			7.8

KEY: # of counts in the Lat-Long block
change in HM/P-Hr for the counts in that block
change in temp in degrees Fahrenheit for the counts in that block

The multiple regression analysis for the variables COASTAL, LATITUDE, and LONGITUDE as correlates with TEMPERATURE CHANGE, however, both clarified and obscured the effects: none of the three variables was significantly correlated with the temperature change between decades (r=0.106, F=0.289, and P=0.833 for the multiple regression).

Table 7. Average Temperature Changes for Coastal and Non-Coastal Counts

	COASTAL	NON-COASTAL	p-VALUE
80s AVE. TEMP.	26.9	21.3	<0.0001
90s AVE. TEMP.	33.0	26.9	<0.0001
TEMP. CHANGE (from 80s to 90s)	+6.2	+5.5	NS (P=0.61)

On the other hand, those variables were definitely related to the average temperatures for both the 1980s and the 1990s. For the 1980s, both coastal and lower latitude counts had significantly higher temperatures (Table 8). Actually, the three variables accounted for 70% of the temperature variation between counts; the coastal and latitude variables taken alone account for 69% of the variation.

Similar results are obtained for the 1990s (Table 9), although the coastal variable is only marginally significant (P<0.10). Clearly, latitude is by far the most important variable related to temperature; longitude does not matter much at all; and the coastal variable is intermediately important. When all of these variables are used in a combined analysis to tease out their independent relationships with the increase in numbers of Hooded Mergansers, the results are not surprising given the above analyses. The four-variable model (LATITUDE, LONGITUDE, TEMPERATURE, COASTAL) is not as good a predictor as the three-variable model (LATITUDE, LONGITUDE, COASTAL), and the three-variable model is not as good as the two-variable model (LATITUDE, COASTAL; Table 10). The temperature change is the least correlated variable, so that variable is left out in the next multiple regression (Table 11) As shown before, the longitude is not a very influential component, so it is dropped in the next analysis (Table 12).

Table 8. Average Temperature for the Counts in the 80s Correlated With Latitude, Longitude, and Coastal Variables

r=0.836 R^2= 0.699 F= 60.26 p< 0.0001

VARIABLE	p-VALUE	partial-F
COASTAL	0.0128	6.486
LATITUDE	0.0001	68.7
LONGITUDE	0.7312	0.119

Discussion

This study demonstrates an increase in the numbers of Hooded Mergansers reported on the New England C.B.C.s over the past decade. Counts that are farther south not only had larger merganser counts in the 1980s and 1990s on average, but also had larger increases in merganser numbers between decades. New England C.B.C. areas that include the coast have higher numbers of Hooded Mergansers.

A subanalysis demonstrates an increase in the temperatures (high, low, and mean) reported for the count days. These temperature changes are not correlated with the increase in the counts of Hooded Mergansers. I could not determine whether there actually has been a warming trend over the past decade, or whether some nuance of the C B.C. dates chosen (e.g., earlier dates) accounts for the temperature increases.

Table 9. Average Temperatures for the 90s Counts Correlated With the Latitude, Longitude, and Coastal Variables

r=0.688 R^2= 0.473 F= 24.55 p< 0.0001

VARIABLE	p-VALUE	partial-F
COASTAL	0.0515	3.905
LATITUDE	0.0001	28.8
LONGITUDE	0.5460	0.367

An increase in wintering Hooded Mergansers in New England was clearly demonstrated by this analysis; however, no explanation for the increase, other than a possible association with warmer temperatures, is feasible within the scope of this paper. Further analysis would be needed to assess whether other regions of the country have had corresponding increases (in which case the total numbers are increasing) or rather decreases (in which case there may be a shift in wintering range for the species). The recent availability of C.B.C. data online should aid such analyses. If the continental population has increased, an investigation of potential reasons for this increase could also prove interesting

Table 10. Four-variable Model: Change in Hooded Mergansers per P-Hr by Latitude, Longitude, Temp. Change, and Coastal Variables

r= 0.482 F= 5.743 p= 0.0004

Variable	partial-F	p-value
COASTAL	.36	0.129
LATITUDE	6.65	0.012
LONGITUDE	0.25	0.622
TEMP. CHANGE	0.05	0.827

Table 11. Three-variable model: Change in Hooded Mergansers per P-Hr by Latitude, Longitude, and Coastal Variables

r= 0.483 F= 7.914 p< 0.0001

Variable	partial-F	p-value
LATITUDE	6.75	0.011
LONGITUDE	0.23	0.632
COASTAL	2.54	0.115

Table 12. Two-variable model: Change in Hooded Mergansers by Latitude and Coastal Variables

r= 0.481 F=11.87 p< 0.0001

Variable	partial-F	p-value
LATITUDE	10.12	0.002
COASTAL	7.02	0.010

Further evaluation of the relationship of increasing numbers with increased temperature would also be in order: temperature changes, if indeed fully demonstrable, could be a causal factor or simply coincidental. If Hooded Mergansers appear to seek out a specific temperature range, it might prove fruitful to investigate whether numbers of other mergansers and of other ducks underwent similar changes in wintering for the same period. On a more basic statistical level, the degree to which the temperatures recorded for the Christmas Bird Counts represent the actual climatological data trends might likewise be an object of research.

Literature cited

Root, Terry. 1988. *Atlas of Wintering North American Birds.* University of Chicago Press, Chicago, Illinois.

—Received 12 November 2000; accepted 15 June 2001.