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ON THE PLUMAGE OF NESTING RING-BILLED GULLS OF DIFFERENT AGES

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The change from immature to adult plumage in Ring-billed Gulls (*Larus delawarensis*) has been described by Dwight (1901, 1925), Bent (1921), and Grant (1973, 1979, 1982). In general Ring-billed Gulls attain adult plumage in their third winter. However, immature plumage may disappear as early as the end of the second year or persist for as long as 5 years (Ludwig 1974). The extent of immature plumage in birds of presumably the same age can show substantial variation (Grant 1973, Ludwig 1974, Cade 1982). These observations led Ludwig to state that Ring-billed Gulls "cannot be aged accurately by plumage criteria." Dwight (1901) believed the size of white spots on the outer primaries probably continues to increase even after adult plumage has been reached.

Ryder (1975) found that in pairs of Ring-billed Gulls consisting of one immature-plumaged bird and one mature-plumaged bird, the immature-plumaged bird was always a male. One hypothesis for this skewed sex ratio in immature-plumaged birds is that there is a sexual difference in time of plumage maturation. We trapped banded, nesting, 2- and 3-year-old birds to learn more about the plumage development in young gulls. In addition, we used those data to determine if nesting 2- and 3-year-olds can be aged using plumage characters.

We also trapped many unbanded nesting adult-plumaged birds which provided data on their plumage variability and allowed comparisons with the 3-year-olds. The trapped birds were banded and several were retrapped in following years. Retrapped birds provided data on year-to-year variation in plumage. That information was used to address the question whether individual adult Ring-billed Gulls can be identified by plumage characters in different years.

Our specific goals were: (1) to quantitatively describe Ring-billed Gull plumage by age and sex, (2) to determine whether plumage characters can be used to discriminate between 2-year-olds and 3-year-olds, and (3) to quantitatively describe the year-to-year variation in individual adult-plumaged gulls in order to see if plumage changes occur once adult plumage is reached.

METHODS

The study area at the Eastern Headland of the Toronto Outer Harbour on Lake Ontario is described by Blokpoel and Fetterolf (1978). The breeding population has been expanding rapidly in recent years and immature-plumaged birds nest at the periphery of the colonies.

Birds were trapped using walk-in traps placed over their nests during 1980, 1981, and 1982. Plumage characters of the right wing and tail

were recorded and both wings of most birds were photographed to show the dorsal surface of the primaries. When taking the pictures, we held the spread-out wings parallel to the lens surface. Banding date and age at the time of banding were obtained from the Bird Banding Laboratory, allowing calculation of a known age for 55 of the gulls trapped at the Headland (2- and 3-year-olds).

Plumages of 276 unknown-age adult-plumaged birds were also recorded in order to obtain information on plumage variability. Adult-plumaged birds were those with no black spots on the rectrices and no brown or dusky color on the wing. All gulls were sexed by bill length and depth measurements, as described by Ryder (1978).

Description of plumage.—We used descendent numbering of the 10 primaries. The progression from immature to adult plumage in Ring-billed Gulls involves loss of black spots on rectrices, loss of brown color from the wing, appearance of white spots on primaries 9 and 10, appearance of white tips on primaries 5 to 9, and reduction in black on greater primary coverts and outer primaries.

Presence/absence of characters.—Plumage characters were quantified for each individual as follows:

(a) Spots on rectrices: rectrices with any trace of black were counted (range 0–12).

(b) Wing color: the presence of brown or dusky was noted for each of 7 areas of the wing: dorsal surface—alula, leading edge, secondaries, coverts (other than greater primary coverts); ventral surface—leading edge, primary coverts, secondary coverts. An arbitrary decision was made to use the right wing for wing color and the following wing characters.

(c) Color of greater primary coverts: greater primary coverts with brown or black were counted (range 0–9). This character was treated separately from other wing color characters since many adults retained black on greater primary coverts whereas dark color disappeared from other areas of the wing.

(d) Primary spots: the presence or absence of white spots on each vane (proximal and distal) of primaries 9 and 10 was noted. In addition, note was made of whether the two spots on a primary met at the shaft.

(e) Primary tips: the presence of a white tip on primaries 5 through 9 was recorded.

(f) Black bands on primaries 4 and 5: the presence of black subterminal bands on the vanes and at the shafts of primaries 4 and 5 was recorded in the same manner as primary spots above.

The presence of brownish-black on the primaries is characteristic of immature plumage but was not considered in this study due to difficulty distinguishing brownish-black from the black of adult plumage. Body plumage characteristics were also not considered. Forty-four 2-year-olds (32 males, 12 females), 11 3-year-olds (6 males, 5 females), and 276 unknown-age adult-plumaged birds (133 males, 143 females) were used in this analysis. Since all 2-year-olds showed some immature color on

either the wing or tail, and since some 3-year-olds had no such markings of immaturity, the "adult" classification probably includes gulls 3 years of age and older.

Measurement of characters.—We also measured relative size of several plumage characters on the primaries of each wing. This was accomplished by projecting a slide of each wing onto graph paper. The distance from the tip of primary 10 to the tip of the greater primary covert covering the proximal vane of primary 10 (Fig. 1) was standardized at 250 units on the graph paper. The slide projector was moved in order to standardize the measurements for different slides. Thus all other measures were relative to this measure of the length of exposed 10th primary. Variables measured included: maximum length of the spot on each vane and along the shaft of primaries 9 and 10; maximum length of white tips on primaries 6–9; and length of the subterminal black bands measured along the shaft of primaries 5–8 (see Fig. 1). Both wings of 36 2-year-olds (26 males, 10 females), 8 3-year-olds (4 males, 4 females), and 196 adult-plumaged birds (96 males, 100 females) were analyzed in this manner.

Discriminant function analysis.—Discriminant function analyses (DFA) were used to separate 2-year-olds from 3-year-olds on the basis of either presence/absence data or measurement data. Presence/absence data were first grouped into 6 values: number of spots present (counting each vane and shaft as one) on primaries 9 and 10, number of the outermost primary with a white tip, number of brown areas on the wing, number of spotted rectrices, number of black greater primary coverts, and number of subterminal bands present (vanes and shafts) on primaries 4 and 5. Analyses were run using the Statistical Analysis System (SAS Institute Inc. 1982) on an IBM 4341 computer. A stepwise discriminant analysis (STEPDISC) was used to select the variables with the greatest discriminatory power, as measured by Wilks' lambda. A linear discriminant function was then calculated from the variables chosen (using the DISCRIM procedure).

Year-to-year variation in plumage of individual "adults."—Nested analyses of variance were run on each measurement variable in order to quantify the amount of variation attributable to differences among birds, differences among years for the same bird, and left-right differences between wings of the same bird in the same year. Eight adults with measurement data from both wings in each year 1980–1982, and 27 adults caught in both 1980 and 1981 were used in the analyses.

These birds also allowed a test of the hypothesis that plumage characters continue to change in a predictable direction once adult plumage is reached (i.e., that white primary tips and spots continue to increase in size, while the black subterminal bands continue to decrease in size). This was tested by pairwise comparisons of each measurement variable among birds caught in consecutive years (62 gulls with measurements for at least one wing) and among birds caught in 1980 and again in 1982 (15 gulls).

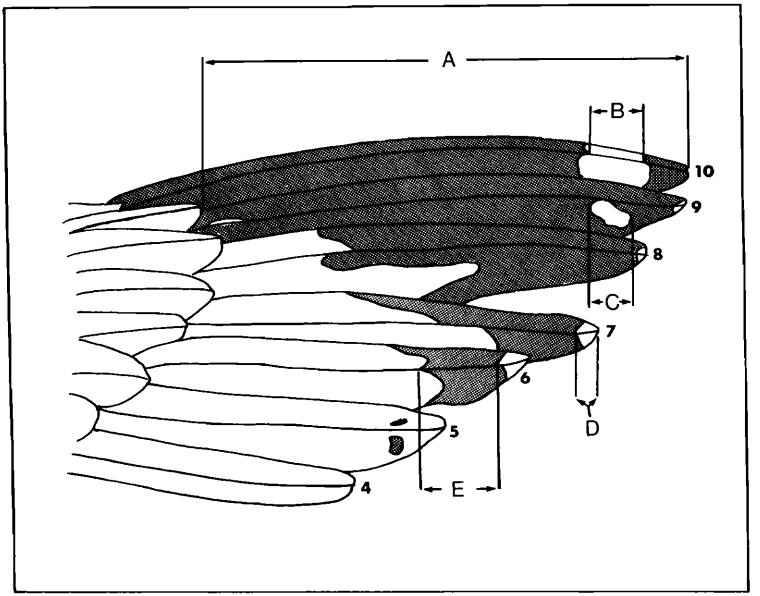

FIGURE 1. Wingtip of Ring-billed Gull showing examples of how measurements were taken. A. length of exposed primary 10, measured from outer tip of the greater primary covert covering the proximal vane of the 10th primary, to the outermost tip of primary 10. This distance was standardized at 250 graph units for all wings. B. length of white spot measured along the shaft of primary 10. C. spot length measured on the proximal vane of primary 9. D. length of white tip on primary 7. E. length of subterminal black band on primary 6, measured along the shaft.

RESULTS

Plumage description.—There were no differences for adult gulls in the presence or absence of plumage characters among the 3 years of study (using G-tests). Similarly, Student's *t*-tests on measurements of primary spots, primary tips, and bands on primaries 5–8 indicated that 1980–1982 adult birds did not differ in plumage with the exception that the subterminal black band on primary 7 was slightly shorter in 1982 (42.9 graph units) than in 1980 (47.1 units) or 1981 (46.6 units) ($P < 0.05$). Because of this similarity, data for adult birds from the 3 years were pooled. Small samples in one or more years prevented analysis of inter-year differences in the immature-plumaged gulls. Data for 2- and 3-year-olds from the 3 years were also pooled on the assumption that there were no inter-year differences.

The data for 2-year-olds and adults were then analyzed for sexual differences (the 3-year-old sample was too small to split). Among 2-year-olds, there were no sexual differences in the presence of plumage characters. Only one difference was found in measurement data, subterminal bands on primary 8 being slightly shorter in males (221 units) than in

females (231 units) ($P < 0.05$). (As all character measurements are relative to the length of the exposed 10th primary, our results do not necessarily imply that absolute lengths of spots, tips, and bands are the same in each sex.)

Among adults, two presence/absence traits showed significant differences between the sexes: males were more likely than females to have a white spot on the distal vane of primary 9 ($P < 0.05$), and a black subterminal band on the distal vane of primary 5 ($P < 0.01$). These differences are inconsistent with a difference in plumage maturity of the sexes, since females resemble immature birds more closely for the former trait, while males resemble immatures more closely in the latter. Only one difference was apparent among the measured variables: males had a shorter subterminal band on primary 5 (10.9 units) than did females (13.5 units) ($P < 0.05$). Due to overall similarity of the sexes in both age groups tested, data from each sex were pooled.

In contrast to the lack of large differences by year and sex, differences due to age were marked. Typically, 2-year-olds had a single white spot on the proximal vane of primary 10, a single white tip on primary 5, brown or dusky color on the secondaries, alula, upper wing coverts, and leading edges of the wing, and black spots on several rectrices (Fig. 2). Most 3-year-olds had lost all traces of black on the tail and brown from the wing (with the exception of the greater primary coverts). They most frequently had white spots on both vanes and the shaft of primary 10 and on the proximal vane of primary 9, as well as white tips on primaries 6 through 9. Length of the subterminal bands had decreased on primaries 5–8. Adults were similar to 3-year-olds (some probably were 3 years old) but tended to have more white and less black on the primaries. The number of dark-colored greater primary coverts decreased from age 2 to adult, although many adults still retained some black coverts.

The differences between 2- and 3-year-olds were for the most part statistically significant, especially for the frequency of occurrence of primary spots, white primary tips, and wing and tail color (Table 1). The lengths of the subterminal bands were all significantly shorter in 3-year-olds (Table 2). There were fewer significant differences between 3-year-olds and adults, with most of these differences in measurement data rather than in presence/absence data (Tables 1 and 2). Differences were spread among primary spots, black bands, and primary tips, with the greatest statistical difference being an increase in the length of the primary spot on the distal vane of primary 10 ($P < 0.001$).

Despite the large differences between 2- and 3-year-olds, there was substantial variation in most of the traits within age classes. For instance, 2-year-olds had 0–12 spotted rectrices, while adults had 0–6 black greater primary coverts. No trait was consistently present in one age group and absent in another. However, age differences were more clearcut after grouping of the presence/absence data for discriminant analysis, as explained in the Methods.

Ageing of nesting gulls based on plumage characters.—We were able to

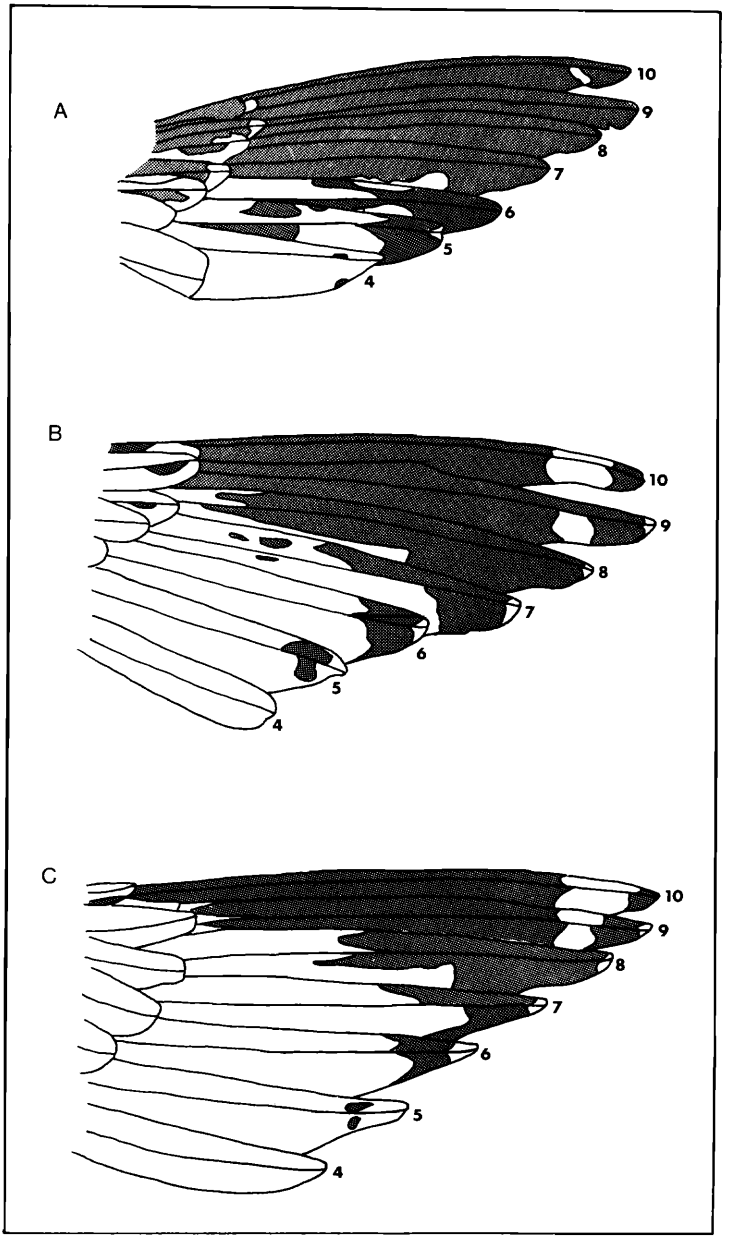

FIGURE 2. Examples of "typical" wingtip plumage for Ring-billed Gulls of different age classes. Drawings show primaries 4 to 10 and the tips of the greater primary coverts. A. 2-year-old; B. 3-year-old; C. adult of unknown age. Dark shading indicates brown in figure A, dark brownish-black in B, and black in C.

TABLE 1. Percent frequency of occurrence of various plumage characters on the right wing of Ring-billed Gulls of different age. Significant differences are indicated by asterisks (*G*-tests: * $P = <0.05$, *** $P = <0.001$).

Character	Age of gull				
	2 Years (n = 44)		3 Years (n = 11)		Adult (n = 276)
Spots on rectrices:	84.1	***	9		0.0
Wing color:					
Dorsal secondaries	79.1	***	0		0.0
Dorsal alula	86.4	***	9		0.0
Dorsal coverts[a]	93.2	***	18		0.0
Dorsal leading edge	75.0	***	9		0.0
Ventral primary coverts	43.2	*	0		0.0
Ventral secondary coverts	22.7		0		0.0
Ventral leading edge	63.6	***	9		0.0
Color of greater primary coverts:	100.0	*	82		63.6
Primary spots:					
Primary 10 distal vane	22.7	***	100		99.6
Primary 10 proximal vane	95.5		100		100.0
Primary 10 shaft	20.5	***	100		98.2
Primary 9 distal vane	0.0	*	27		49.6
Primary 9 proximal vane	2.3	***	55		73.9
Primary 9 shaft	0.0		9	*	39.9
Primary tips:					
Primary 9	0.0	***	55		77.2
Primary 8	0.0	***	82		98.2
Primary 7	0.0	***	91		99.6
Primary 6	15.9	***	100		99.6
Black bands:					
Primary 5 distal vane	97.7		100		77.5
Primary 5 proximal vane	97.7		91		85.1
Primary 5 shaft	93.2		82	*	49.6
Primary 4 distal vane	45.2	*	0		2.5
Primary 4 proximal vane	7.1		0		0.4
Primary 4 shaft	7.1		0		0.0

[a] Except the greater primary coverts.

classify correctly all fifty-five 2- and 3-year-olds using only the number of the outermost primary with a white tip. All 3-year-olds had at least one white tip on any of primaries 7–9, whereas white tips were either not present at all, or present only on primaries 5 or 6 in 2-year-olds. The 95% confidence interval for the percent of gulls correctly classified using this technique was 95.2–100% (confidence limits for percentages, Rohlf and Sokal 1981:156).

In order to further test this separation technique, we used 12 known-age birds trapped in 1979 (eleven 2-year-olds, one 3-year-old). These

TABLE 2. Comparison of measurements of primary characters by age of Ring-billed Gulls. All measurements are relative to the length of exposed primary 10 which was standardized at 250 units in length for all gulls. Only non-zero values have been included (sample size of non-zero measures is in brackets). Statistically significant differences are indicated by asterisks (*t*-tests: * $P = <0.05$, ** $P = <0.01$, *** $P = <0.001$).

Character	Age of gull				
	2 Years		3 Years		Adult
Primary spots:					
Primary 10 distal vane	27.7 (6)		31.4 (8)	***	42.7 (196)
Primary 10 proximal vane	20.8 (35)	***	39.0 (8)		43.3 (196)
Primary 10 shaft	14.8 (5)		20.9 (8)	**	32.3 (195)
Primary 9 distal vane	— (0)		16.5 (2)		22.7 (106)
Primary 9 proximal vane	10.0 (1)		21.3 (4)		21.7 (150)
Primary 9 shaft	— (0)		5.0 (1)		12.7 (86)
Primary tips:					
Primary 9	— (0)		2.4 (5)		2.4 (165)
Primary 8	— (0)		4.4 (7)		5.6 (188)
Primary 7	— (0)		8.3 (8)		9.6 (192)
Primary 6	2.7 (6)	**	9.5 (4)	*	13.1 (177)
Black Bands:					
Primary 8	224.1 (36)	**	157.3 (8)	*	131.1 (196)
Primary 7	158.1 (36)	***	52.3 (8)		46.2 (196)
Primary 6	75.3 (36)	***	35.3 (8)	**	29.4 (196)
Primary 5	35.3 (35)	***	14.0 (6)		12.1 (93)

birds were not included in previous analyses due to incomplete plumage descriptions, but the presence/absence of white on the primaries was known. All 12 birds were correctly classified by the presence/absence of white tips on primaries 5–9.

For measurement data, stepwise discriminant analysis identified the length of the subterminal black band on primary 7 and the length of the white spot on the proximal vane of primary 10 as most important in discriminating 2- and 3-year-olds. However, these 2 variables incorrectly classified 14% (5 of 36) of the 2-year-old gulls as 3-year-olds. Clearly, the use of white tips on primaries 5–9 for separating 2- and 3-year-olds is both the simplest and most reliable method.

Year-to-year plumage variation in individual adults.—Nested analyses of variance were carried out on measurement data from gulls caught in all 3 years of study, and those caught in both 1980 and 1981. Differences between individual gulls accounted for the bulk of the variance in all measures. Differences between years for individual gulls also added a significant component of variation, though much less than between-bird differences. Calculated variance components were similar in the 3-year sample and the 2-year sample. The spot length variables showed the following variance components: between individuals—73% (average for

all primaries), between years—15%, and between left and right wings—13%. Subterminal band lengths had similar variance components (69%, 21%, and 11%). Measurements of white tips on the primaries showed more intra-individual variation, with only 37% of variance between individuals, 34% between years, and 29% between wings.

The 5 measurements which showed significant differences between 3-year-olds and adults (see Table 2) were tested for directional change in adults in consecutive years. In a paired sample of 62 adults, none of the variables showed a significant change between years. Furthermore, no directional changes were found in paired comparisons of gulls caught 2 years apart (15 adults trapped in 1980 and 1982). Intra-individual variation between years accounted for an average of 31% of total measurement variation for the consecutive year sample, and 24% of variation in the 1980–82 sample. However less than 1% of variation was attributable to directional change between years.

Changes in the length of the spot on the distal vane of primary 10 were also examined relative to the average size of the spot. Those individuals having spots smaller than average over the two consecutive years tended to have an increased length (by 6% of original length) in the second year, but this difference was not statistically significant. (Similarly there was no consistent change in length of spot for individuals which had larger than average spot lengths.)

DISCUSSION

The plumages of 2-year-old, 3-year-old, and adult Ring-billed Gulls in this study were similar to descriptions in the literature which have been based on unbanded birds (e.g., Dwight 1901, 1925, Bent 1921, Grant 1973, 1979). Variability in immature plumage which has been documented by Grant (1973), Ludwig (1974), and Cade (1982) was also evident in our data. This variability has also been observed in other gull species (e.g., Poor 1946, Grant 1979, Monaghan and Duncan 1979, Cade 1982, Catley 1982, Coulson et al. 1982). Contrary to Ludwig's statement concerning the difficulty in using plumage to age Ring-billed Gulls, however, we did find that 2- and 3-year-old breeding gulls could be distinguished on the basis of presence/absence of white tips on primaries 5–9. It is likely that our estimate of the percent successful separation is biased in favor of success by our search for variables with best discriminating power (Ryder 1978). Nevertheless this character is a useful one because of the high success (100%) for the original sample and for the small 1979 sample, and the high confidence interval (95.2–100%) for the original sample.

One problem with ageing gulls on the basis of the presence of white primary tips is that they are very susceptible to wear (Grant 1979, 1982, our observations). This, combined with the small size of the white tips on some primaries, necessitates close examination of the feathers. The technique is thus restricted to birds in the hand, or at least to those very

close to the observer. Once in the hand, however, the presence of white tips can be determined more objectively than the color of the wings or of other parts of the body such as the iris or feet.

The lack of directional change in plumage characteristics of adults and the large component of inter-individual variation suggest that much of the variation in adult plumage is not age-related. It does appear that gulls gain some white and lose some black from the primaries after having reached age 3, but it does not appear that much further change occurs, as was suggested by Dwight (1925). At the same time, there is enough random variation within gulls between years to negate the use of wing patterns for individual recognition from one year to the next (which might have been useful to researchers). Length of white tips has the highest component of intra-individual variation, likely due to wear of these primary tips.

The virtual lack of sexual differences in plumage, especially in 2-year-old gulls, negates the hypothesis that differences in the rate of plumage maturation by sex accounts for the skewed sex ratio of nesting immature-plumaged birds. The sex ratio of 2-year-old birds in our sample was skewed towards males (32:12), as was Ryder's (1975) sample of immature birds (41:7). This suggests earlier breeding by males or higher male survival. However, it is also possible that males were trapped more readily than females at the nest. In addition, our known-age sample relied to a large extent on gulls which returned to their natal colony to breed (many had been banded as nestlings at the Eastern Headland). Thus a tendency for males to show more more fidelity to natal colonies than females (cf. Greenwood 1980) would produce a bias in favor of males.

SUMMARY

During 1980–1982, 55 nesting, banded, 2- and 3-year-old birds and 276 nesting, unbanded adult-plumaged birds were trapped. The plumages of all trapped birds were described quantitatively. The 3 years of data were pooled as there were no notable differences among years. The plumage of males and females was similar within the 2-year-old and adult age classes, so data for the sexes were pooled.

Wing and tail plumage of known-age 2- and 3-year-old gulls was similar to descriptions in the literature. Three-year-olds differed significantly from 2-year-olds in most plumage characters, having less brown or black on the wings and tail, and a greater presence of white on the wings (either in primary spots or primary tips). Despite large variance in many plumage characters, all 55 birds were correctly classified on the basis of the number of the outermost primary with a white tip: all 3-year-olds had a white tip on at least one of primaries 7–9, while none of the 2-year-olds did.

The unknown-age, adult-plumaged birds showed some plumage differences compared to 3-year-old birds, primarily in the measured lengths

of characters on the primaries (white primary spots, white primary tips, and black subterminal bands), suggesting some change in plumage after the third summer. However, these changes were not present among adults caught in successive years, suggesting that directional change in plumage does not occur throughout the life of the gull. Most variation in measurements of spots, tips, and bands was attributable to inter-individual differences. Inter-year differences within the same gulls also accounted for a significant proportion of the variance, and even the same bird showed random differences between right and left wings. This intra-individual variation makes plumage a poor criterion for recognition (at least by field workers) of individual birds in consecutive years.

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