Body Size and Hematological Values for Herring Gulls *(Larus argentatus)* Breeding in the Northeastern United States

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Abstract: With a substantial number of herring gulls (*Larus argentatus*) being seen each year at wildlife clinics and wildlife rehabilitation facilities, it is clear that there is a need for hematological reference values for this species. Being able to compare values from gulls in these settings to reference ranges available from healthy, actively breeding gulls will provide useful information regarding their health. Surprisingly, there are very few published studies with hematological data specific to herring gulls. In this study, serum chemistry values and body size measurements were obtained from approximately 20 incubating herring gulls at two breeding islands—Appledore Island, Maine, USA and Kent Island, New Brunswick, Canada. The values found were compared to those in the published literature obtained from a number of similar species. This comparison indicated that the hematological values from the herring gulls sampled on Appledore and Kent Islands are similar to those found in other gull species. Therefore, the data collected in this study represent ranges of normal hematological values for healthy, breeding herring gulls.

Key words: Herring gulls, *Larus argentatus*, seabirds, hematology, serum chemistry, body size, breeding gulls

INTRODUCTION

Gulls are commonly seen at rehabilitation centers throughout the Northeast US and Canada. For instance, the Wildlife Clinic at Tufts Cummings School of Veterinary Medicine admitted 36 herring (*Larus argentatus*) and 7 ring–billed gulls (*Larus delawarensis*) in 2006, 41 herring and 12 ring–billed gulls in 2007, and 7 herring and 6 ring–billed gulls as of the 24th of April 2008. Accurate diagnosis and successful treatment of these birds depends on the availability of hematological reference values and size and weight measurements (Young 1994). Having reference values for comparison also can help to determine the prognosis and chance of survival for these birds earlier in the rehabilitation process by revealing underlying problems such as anemia, malnutrition, or liver and renal pathology that may not be obvious at the time of presentation (Porter 1992).

The scarcity of published hematological values from healthy herring gulls poses a challenge for wildlife rehabilitators encountering this species. In general, most avian blood chemistry reference values are limited to groups of birds that are handled intensively in production and clinical situations, such as poultry, psittacines, and raptors (Work 1996; Newman et al 1997). The lack of serum biochemistry reference ranges for herring gulls also limits the ability to monitor the health status of wild populations. Usually, the health of wild populations is assessed by examining population size and reproductive success of individuals. Evaluating blood biochemistry results, however, provides clearer and earlier evidence of changes in health status (Newman et al 1997).

Analysis of blood biochemistry provides an informative method for assessing wildlife health and is a technique that has been used in other studies to monitor the health and nutritional status of birds (Newman et al 1997; Hollmen et al 2001; Averbeck 1992; Villegas et al 2004; Grasman et al 2000a; Grasman et al 2000b). Serum biochemistry analysis yields information about liver and kidney function and electrolyte levels (such as sodium, potassium, calcium, and phosphorus) as well as nutritional and metabolic parameters such as cholesterol, trigylcerides, and glucose. Serum biochemical analysis not only allows for the assessment of an individual's general health but also

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permits the detection of organopathies and infectious diseases (Newman et al 1997; Hollmen et al 2001).

The main objectives of this study were to quantify masses and body sizes and to obtain serum samples from healthy, breeding gulls from two populations in the Northeast. Serum samples were collected to measure concentrations of variables related to protein metabolism (total protein, albumin, and uric acid), carbohydrate metabolism (glucose), fat (triglycerides and cholesterol), muscle degradation (creatine kinase and aspartate aminotransferase), dehydration (sodium and potassium), inflammatory conditions (alpha, beta, and gamma globulins), liver and heart conditions (aspartate aminotransferase, lactate dehydrogenase, and alkaline phosphatase), renal function (blood urea nitrogen, uric acid, and phosphorus) and general nutritional deficiencies (calcium and phosphorus) (Hollmen et al 2001; Villegas et al 2004).

Materials and Methods

Study Sites. Herring gulls were sampled from two islands—Appledore Island, ME, USA (42°59'N; 70°36'W) and Kent Island, New Brunswick, Canada (44°35'N; 66°45'W). Appledore Island is part of the Isles of Shoals, a nine–island archipelago located approximately 10 km (6.2 mi) from the coast of Portsmouth, NH. Approximately 709 pairs of herring gulls and 483 pairs of great black–backed gulls (*Larus marinus*) nested on Appledore Island in 2006 (Ellis, unpublished data). Kent Island is located approximately 9 km (5.6 mi) south of Grand Manan Island, Canada, in the Bay of Fundy, and had an estimated 5,926 pairs of herring gulls in 2001 (Ronconi and Wong 2003). Grand Manan is approximately 35 km (21.7 mi) from the New Brunswick coast.

Sample Collection. Twenty incubating herring gulls were trapped and captured at each site during the months of May and June 2006 using one of two methods. The first method was a 'walk–in–nest trap' placed over the nest. This trap consisted of a chicken wire cage with a single opening on one side, through which the gull enters in order to sit on its eggs. Once the gull sat on the eggs a string attached to the overhanging door of the cage was pulled to close the door to the trap and contain the gull. The second method was a chicken wire 'drop–down nest trap' (Mills and Ryder 1979) placed over the nest. This trap was propped up on one side with a wooden stake, which was attached to a monofilament line. Once a gull walked under the trap and settled on its eggs, the trap was tripped quickly by pulling the monofilament line. Once the gull was trapped (by either method), it was carefully removed from its nest and placed in a cloth cone for restraint. Each bird was then weighed to the nearest gram using a Pesola® (Pesola AG, Baar, Switzerland) spring scale and sliding calipers were used to obtain tarsus length, head and bill length, and bill depth in millimeters.

Blood was collected from each bird using standard avian blood collection protocol. Blood was extracted from the alar vein located at the humeral–radial–ulnar junction on the ventral aspect of the wing. Blood samples were obtained by using 23–gauge needles and 6 cc syringes to draw 1 to 3 ml of blood per bird. Samples of whole blood were transferred into serum separator tubes and stored in coolers with ice for a maximum of 2 hours until the samples were centrifuged for 10 minutes at 7100 rpm to separate the serum. Serum samples were transferred to fresh serum separator tubes via pipette and then stored in a standard freezer (–12°C [10.4°F]) at either the Shoals Marine Laboratory on Appledore Island or at the Bowdoin Scientific Station on Kent Island. Samples were transferred on ice to Tufts Cummings School of Veterinary Medicine where they were stored in ultracold freezers (–80°C [–112°F]). These samples then were transported to IDEXX Laboratories (Grafton, MA) for analyses within one month of collection.

Blood was analyzed from 20 herring gulls from Appledore Island and 18 from Kent Island. Serum concentrations of the following analytes were measured: albumin, albumin/globulin ratio, alkaline phosphatase (ALP), aspartate aminotransferase (AST), calcium, cholesterol, creatine kinase (CK), globulin, glucose, lactate dehydrogenase (LDH), phosphorus, potassium, sodium, total protein, and uric acid. Triglyceride levels also were measured, and samples underwent protein electrophoresis (albumin, total protein, globulin, albumin/globulin ratio, alpha 1, alpha 2, beta 1, and gamma 1 fractions).

Statistical Analyses. The serum biochemistry and protein electrophoresis data were first evaluated to determine basic descriptive statistics (mean, median, standard error). After testing for assumptions of ANOVA, we compared serum biochemical values between the two populations using Mann–Whitney U tests (SPSS, version 15.0). Data on mass and body sizes were transformed (log + 0.5), then used in separate univariate ANOVA tests to compare the two populations. It was not possible to accurately assign gender to all of the gulls sampled; therefore, the data were combined for all individuals from each population for analysis.

Table 1. Serum Biochemistry and Triglyceride Values for Incubating Herring Gulls Sampled at Kent Island, New Brunswick, Canada and Appledore Island, Maine, USA.

	Kent Island				Appledore Island			
Variable	N	Mean ± SE	Median	Range	N	Mean ± SE	Median	Range
AlkPhos (u/l)	18	327.9 ± 56.7	261	72-959	20	171.8 ± 24.1	155	0-378
AST (u/l)	18	265.6 ± 22.5	264.5	63-447	20	209.9 ± 9.76	204.5	137-290
CK (u/l)	18	638.2 ± 123.4	518.5	222-2455	20	388.5 ± 47.8	360	111-1085
LDH (iu/l)	18	216.6 ± 23.2	193.5	76-389	20	488.7 ± 93.8	315.5	99-1946
Amylase (u/l)	18	1362.3 ± 77.0	1398	625-1725	20	1355.5 ± 52.2	1351	822-1830
Albumin (g/dl)	18	1.73 ± 0.08	1.6	1.2-2.4	20	1.83 ± 0.07	1.8	1.4-2.5
Total Protein (g/dl)	18	4.2 ± 0.17	4.05	3-5.7	20	3.92 ± 0.12	3.9	3.1-4.8
Globulin (g/dl)	18	2.47 ± 0.13	2.4	1.8-3.6	20	2.09 ± 0.08	2.2	1.4-2.6
Cholesterol (mg/dl)	18	328.2 ± 15.6	315	230-525	20	325.9 ± 10.6	325.5	244-403
Glucose (mg/dl)	18	348.3 ± 7.38	354.5	294-402	20	325.4 ± 11.3	323.5	237-412
Calcium (mg/dl)	18	9.73 ± 0.21	9.6	8.4-11.7	20	9.2 ± 0.25	9.05	7.4-11.5
Phosphorus (mg/dl)	18	2.74 ± 0.24	2.6	1.4-5.3	20	3.13 ± 0.26	3.15	0.6-4.9
Potassium (mEq/L)	14*	2.39 ± 0.16	2.15	1.8-3.7	20	3.38 ± 0.22	3.3	2-4.9
Sodium (mEq/L)	14*	154.6 ± 0.64	154.5	151-158	20	150.3 ± 0.76	149.5	145-157
A/G ratio	18	0.72 ± 0.05	0.7	0.5-1.3	20	0.89 ± 0.04	0.9	0.6-1.2
Uric Acid (mg/dl)	18	11.4 ± 1.04	11.6	3.6-17.4	20	10.5 ± 0.94	8.75	5.3-17.9
Trigylceride (mg/dl)	18	333.4 ± 142.9	147	53-2615	20	160.4 ± 14.9	138	76-279

* *Not enough serum was available from four individuals to run sodium and potassium analysis.*

Table 2. Protein Electrophoresis Values for Incubating Herring Gulls Sampled at Kent Island, New Brunswick, Canada, and Appledore Island, Maine, USA.

	Kent Island (n=18)			Appledore Island (n=20)		
Variable	Mean ± SE	Median	Range	Mean ± SE	Median	Range
Albumin (g/dl)	1.88 ± 0.08	1.8	1.4-2.9	1.79 ± 0.07	1.8	1.4-2.3
Total Protein (g/dl)	3.84 ± 0.12	3.85	2.7-4.8	3.92 ± 0.12	3.9	3.1-4.8
Globulin (eph) (g/dl)	2.47 ± 0.13	2.4	1.8-3.6	2.09 ± 0.08	2.2	1.4-2.6
A/G ratio (eph)	0.76 ± 0.08	0.625	0.25-1.38	0.56 ± 0.03	0.525	0.38-0.84
Albumin (eph) (g/dl)	1.56 ± 0.08	1.44	1.04-2.26	1.38 ± 0.04	1.39	1.08-1.64
Alpha 1 (g/dl)	0.57± 0.08	0.6	0.09-1.11	0.77 ± 0.05	0.76	0.33-1.12
Alpha 2 (g/dl)	0.39 ± 0.04	0.35	0.16-0.84	0.42 ± 0.04	0.36	0.25-0.92
Beta 1 (g/dl)	0.6 ± 0.05	0.56	0.35-1.17	0.5 ± 0.05	0.415	0.18-1.0
Gamma 1 (g/dl)	0.55 ± 0.06	0.57	0.22-1.13	0.85 ± 0.08	0.905	0.3-1.45

Results

Serum Biochemistry. Eight of the 26 serum parameters evaluated differed significantly ($p<0.05$) between Kent Island and Appledore Island populations (Tables 1 & 2). Of these eight, six were serum chemistry values (alkaline phosphatase, AST, LDH, globulin, potassium, and sodium). The remaining two were protein electrophoresis results (globulin and gamma 1 proteins). Alkaline phosphatase, AST, globulin, and sodium were higher in the Kent Island gulls. LDH, potassium, and gamma 1 proteins were higher in the Appledore Island population compared to the Kent Island population.

Values obtained from Kent Island and Appledore Island populations were compared to findings from previous studies of seabirds (Table 3). Mean levels of albumin, globulin, and the A/G ratio of gulls from both Kent and Appledore Islands fell within the ranges reported for gull species in published literature. The mean and median values for alkaline phosphatase were higher in gulls from both islands when compared to the mean value from a study of western gulls (*Larus occidentalis*) (Newman et al 1996). The mean and median creatine kinase levels were elevated in the Kent Island gulls compared to those found in the Appledore Island gulls and gulls from other studies (Newman and Zinkl 1996; Newman et al 1997). CK values for gulls at Appledore Island were similar to those found in western gulls (Newman et al 1996). The mean values of gamma 1 proteins in Kent Island and Appledore Island gulls both were higher than those found in western gulls. For both populations, potassium levels were comparable to those reported in other gulls; however, Kent Island levels were slightly low compared to those in western gulls (Newman and Zinkl 1996). The opposite occurred with sodium levels, which were similar to findings from other studies for both populations but were slightly low in Appledore gulls. Of the 16 other parameters, all levels were within the ranges reported for gulls in other studies, with the exception of triglycerides, which were slightly elevated in the Kent Island population when compared to other populations.

There was a large degree of individual variation in blood values in the Appledore and Kent Island gull populations, which created outliers in the data. Therefore, medians for all parameters also were compared between the two populations. For most analytes, means and medians were approximately equivalent in both the Kent and Appledore Island populations. The mean for triglycerides in gulls on Kent Island was high compared to previous studies, but the median was approximately the same as the median and mean

Table 3. Serum Biochemistry and Protein Electrophoresis Results for Herring Gulls and Related Species of Seabirds from Previous Studies.

Author	Jeffrey et al (1985)			Newman et al (1996)			Alonso-Alvarez (2005)			Fox et al (2007)			Work (1996)		
	Species	*n*	mean	Species	*n*	mean	Species	*n*	mean	Species	*n*	median	Species	*n*	mean
Biochemistry															
AlkPhos (iu/L)				WG	26	97									
AST (iu/L)				WG	25	207				HG	151	202	ST	12	522
CK (iu/L)				WG	25	360							ST	9	65
Amylase (iu/L)										HG	120	1475			
Albumin (g/dl)				WG	26	1.4				HG	152	1.60	ST	11	1.5
TP (g/dl)	HG		2.8	WG	26	3.5	YG	64	2.99	HG	155	4.2	ST	11	3.3
Globulin (g/dl)				WG	26	2.2				HG	152	2.5	ST	11	1.8
CHOL (mg/dl)	HG		410.2	WG	26	309	YG	64	293						
GLUC (mg/dl)	HG		445.2	WG	26	366				HG	139	468	ST	11	267
Calcium (mg/dl)				WG	26	9				HG	155	9.4	ST	12	9.4
Phosphorus (mg/dl)				WG	26	2.7				HG	154	1.35	ST	12	3.9
Potassium (MEQ/L)				WG	24	3.4									
Sodium (MEQ/L)				WG	25	155									
A:G ratio				WG	26	0.7				HG	152	0.63			
Triglycerides (mg/dl)	HG		144.4				YG	64	77.4	HG	143	102			
Uric Acid (mg/dl)	HG		5.5	WG	26	12.1	YG	64	6.16	HG	144	9.7	ST	12	12.3
Electrophoresis															
Alpha 1 (g/dl)				WG	17	0.7									
Alpha 2 (g/dl)				WG	17	0.4									
Beta 1 (g/dl)				WG	17	0.4									
Gamma 1 (g/dl)				WG	16	0.4									
Albumin eph (g/dl)				WG	17	1.3									

HG=Herring Gull (*Larus argentatus*)
WG=Western Gull (*Larus occidentalis*)
YG=Yellow-legged Gull (*Larus cachinnans*)
ST=Sooty Tern (*Sterna fuscata*)

Table 4. Weight and Measurement Ranges for Gulls Sampled from Appledore and Kent Islands.

	Mean ± SE	Median	Range
	Kent Island (n=18)		
Weight	1003 g (35.4 oz) ± 25.7 g (0.91 oz)	980 g (34.6 oz)	870 g (30.7 oz) - 1200 g (43.3 oz)
Tarsus length	66 mm (2.60 in) ± 0.85 mm (0.03 in)	65 mm (2.56 in)	61.5 mm (2.4in) - 71.4 mm (2.8in)
Head & bill length	122 mm (4.80 in) ± 1.75 mm (0.07 in)	119 mm (4.68 in)	114.7 mm (4.5in) - 137.5 mm (5.4in)
Bill depth	19.9 mm (0.78 in) ± 0.37 mm (0.01 in)	19.2 mm (0.76 in)	18.0 mm (0.71in) - 23.2 mm (0.91in)
	Appledore Island (n=20)		
Weight	1250 g (44.1 oz) ± 23.3 g (0.82 oz)	1280 g (45.1 oz)	1100 g (38.8 oz) - 1400 g (49.4 oz)
Tarsus length	68.9 mm (2.71 in) ± 0.73 mm (0.03 in)	69.4 mm (2.73 in)	63.4 mm (2.5in) - 73.8 mm (2.9in)
Head & bill length	130 mm (5.12 in) ± 1.32 mm (0.05 in)	131.8 mm (5.19 in)	119.9 mm (4.7in) - 137.4 mm (5.4in)
Bill depth	22 mm (0.87 in) ± 0.33 mm (0.01 in)	22.2 mm (0.87 in)	19.9 mm (0.78in) - 24.5 mm (0.96in)

of triglycerides in Appledore gulls. Likewise, the mean for creatine kinase on Kent Island was higher than that found in Appledore Island gulls and in previous studies, but the median fell within the ranges described in the literature.

Weights and Measurements. Herring gulls on Appledore Island generally were larger than those on Kent Island (Table 4). Gulls sampled at Appledore Island had significantly greater bill depths ($F_{1,43}$ = 15.93, P<0.0001), head + bill lengths ($F_{1,43}$ = 11.56, P=0.001), and tarsus measurements ($F_{1,43}$ = 9.30, P=0.004) than did gulls from Kent Island. Body masses of gulls on Appledore Island also were significantly greater than those at Kent Island ($F_{1,43}$ = 55.33, P<0.0001).

Discussion

The mean lactate dehydrogenase (LDH) value was slightly higher in the Appledore gulls than that measured in previous studies; however, the difference was so small that it probably does not indicate abnormal health. Alkaline phosphatase values in Kent and in Appledore Island gulls were higher than those measured in previous studies. This enzyme can increase with egg–laying (Newman et al 1997) and higher levels can be attributed to females being in a breeding state (Villegas et al 2004). Both the Appledore and Kent Island populations were in the breeding state at the time of blood sampling; therefore, the breeding state may be the most probable explanation for the high alkaline phosphatase levels. Creatine kinase levels were higher in the Kent Island gulls than in the Appledore gulls and higher than that found in other studies. High creatine kinase levels can indicate muscle abnormalities; however, exercise also has the potential to elevate this enzyme (Hollmen et al 2000). The high levels found in the Kent Island population compared to the Appledore population is most likely due to a slight difference between trapping methods used on each island. On Appledore Island, it was possible to occasionally capture birds right off their nests by hand whereas on Kent Island the drop–down traps were used in every case. Gulls in the traps may have struggled more rigorously prior to capture than gulls captured quickly and directly from the nest without cage trapping.

Gulls on Kent Island had a mean triglyceride level slightly higher than that found in other studies. Triglyceride concentrations are regulated by lipid metabolism as well as dietary intake (Newman et al 1997), consequently its elevation in the Kent Island gulls may simply be the result of ingestion of a high–

fat meal just prior to blood sampling. However, because the median for triglycerides in gulls from Kent Island is nearly equivalent to that of gulls at Appledore Island, the elevated mean for triglycerides on Kent Island may result from extreme variation among the individuals sampled there, and thus the median may be more accurate. One or two of the blood samples collected from gulls on Kent Island were noted to be highly lipemic compared to the rest. These samples were outliers and may have inaccurately elevated the mean triglyceride levels on Kent Island.

Of the protein electrophoresis results, the globulin and A/G ratio were higher in the Kent Island gulls, although both were similar to ranges seen in other studies. Globulin levels can be elevated by infection and inflammation, but levels also vary depending on an animal's nutritional and physiological status (Grasman 2000b). Gulls at Appledore Island also exhibited an A/G ratio similar to previous studies; however, gamma 1 globulins were higher than values found in the literature and significantly higher than the value found in the Kent Island gulls. Antibody responses may increase gamma globulins, and thus increases in gamma globulins may demonstrate the presence of an active infection (Grasman et al 2000b). The increase here, however, was so minor that it most likely does not indicate abnormal health.

There was a difference in body size and mass between the Kent Island and Appledore Island populations. The mass of herring gulls on Appledore Island ranged from 1100 g (38.8 oz) to 1400 g (49.4 oz), while gulls on Kent Island weighed from 870 g (30.7 oz) to 1200 g (42.3 oz). These ranges for both populations fell within the scope of herring gull weights measured in previous studies (Monaghan and Metcalfe 1986; Fox et al 1981; Newman and Zinkl 1996). Body size measurements from both gull populations were also similar to measurements of herring gulls from other studies (Fox et al 1981). The difference in mass between gulls on Appledore and Kent Islands may result from differences in diet during the breeding season. Several previous studies indicate that garbage (including chicken, hot dogs, and hamburgers) is an important source of food for gulls on Appledore Island (Pierotti and Good 1994; Rome and Ellis 2004; Ellis et al 2005). In contrast, herring gulls on Kent Island primarily eat marine invertebrates and fish with garbage virtually absent from their diet during the breeding season (Fox et al 2002). Consumption of garbage might increase mass of herring gulls because it is a reliable and consistent source of food compared to unpredictable marine prey such as fish. However, as it was not possible to assign genders to individual gulls, it is possible that the differences in mass and body size are a result of variation in the proportion of males and females in the two populations.

Conclusion

Accessible hematological reference values would aid in diagnosis and treatment of gulls in rehabilitation and would provide a way to monitor population health. Additional hematological studies are necessary to fully evaluate the range of values for herring gulls; however, the information obtained from this study provides a useful baseline. Future studies should evaluate a larger number of gulls from multiple populations at different times of the year and should include both complete blood counts (CBCs) and blood biochemical values.

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Literature Cited

Alonso–Alvarez, C. 2005. Age–dependent Changes in Plasma Biochemistry of Yellow–legged Gulls (*Larus cachinnans*). *Comparative Biochemistry and Physiology*. 140: 512–518.

Averbeck, C. 1992. Haematology and Blood Chemistry of Healthy and Clinically Abnormal Great Black–backed Gulls (*Larus marinus*) and Herring Gulls (*Larus argentatus*). *Avian Pathology*. 21: 215–223.

Belant, J. L., S. K. Ickes, and T. W. Seamans. 1998. Importance of Landfills to Urban–nesting Herring and Ring–billed Gulls. *Landscape and Urban Planning*. 43: 11–19.

Ellis, J. C., W. Chen, B. O'Keefe, M. J. Shulman, and J. D. Witman. 2005. Predation by Gulls on Crabs in Rocky Intertidal and Shallow Subtidal Zones of the Gulf of Maine. *Journal of Experimental Marine Biology and Ecology*. 324: 31–43.

Fox, G. A., C. R. Cooper, and J. P. Ryder. 1981. Predicting the Sex of Herring Gulls by Using External Measurements. *Journal of Field Ornithology*. 52(1): 1–9.

Fox, G. A., K. A. Grasman, K. A. Hobson, K. Williams, D. Jeffrey, and B. Hanbidge. 2002. Contaminant Residues in Tissues of Adult and Prefledged Herring Gulls from the Great Lakes Region in Relation to Diet in the Early 1990s. *Journal of Great Lakes Research.* 28: 643–663.

Fox, G. A., D. A. Jeffrey, K. S. Williams, S. W. Kennedy, and K. A. Grasman. 2007. Health of Herring Gulls (*Larus argentatus*) in relation to Breeding Location in the Early1990s, I. Biochemical Measures. *Journal of Toxicology and Environmental Health.* Part A. 70(17): 1443–1470.

Grasman, K. A., P. F. Scanlon, and G. A. Fox. 2000a. Geographic Variation in Hematological Variables in Adult and Prefledgling Herring Gulls (*Larus argentatus*) and Possible Associations with Organochlorine Exposure. *Archives of Environmental Contamination and Toxicology*. 38: 244–253.

Grasman, K. A., M. Armstrong, D. L. Hammersley, P. F. Scanlon, and G. A. Fox. 2000b. Geographic Variation in Blood Plasma Protein Concentrations of Young Herring Gulls (*Larsus argentatus*) and Caspian Terns (*Sterna caspia*) from the Great Lakes and Lake Winnipeg. *Comparative Biochemistry and Physiology*. 125: 365–375.

Hollmen, T., J. C. Franson, M. Hario, S. Sankari, M. Kilpi, and K. Lindstrom. 2001. Use of Serum Biochemistry to Evaluate Nutritional Status and Health of Incubating Common Eiders (*Somateria mollissima*) in Finland. *Phyiological and Biochemical Zoology*. 74(3): 333–342.

Jeffrey, D. A., D. B. Peakall, D. S. Miller, and G. R. Herzberg. 1985. Blood Chemistry Changes in Food–deprived Herring Gulls. *Comparative Biochemistry and Physiology.* 81(4): 911–913.

Kilpi, M., and M. Ost. 1998. Reduced Availability of Refuse and Breeding Output in a Herring Gull (*Larus argentatus*) Colony. *Annales Zoologici Fennici*. 35: 37–42. Finnish Zoological and Botanical Publishing Board: Helsinki, Finland.

Monaghan, P., and N. B. Metcalfe. 1986. On Being the Right Size: Natural Selection and Body Size in the Herring Gull. *Evolution*. 40(5): 1096–1099.

Newman, S., and J. Zinkl. 1996. Baseline Marine Bird Project: Contract FG 3460–OS Final Report: Establishment of Hematological, Serum Biochemical, and Electrophoretogram Reference Intervals for Species of Marine Birds Likely to be Impacted by Oil Spill Incidents in the State of California. CA Fish & Game Contract.

Newman, S. H., J. F. Piatt, and J. White. 1997. Hematological and Plasma Biochemical Reference Ranges of Alaskan Seabirds: Their Ecological Significance and Clinical Importance. *Colonial Waterbirds.* 20(3): 492–504.

Patton, S.R. 1988. Abundance of Gulls at Tampa Bay Landfills. *Wilson Bulletin*. 100(3): 431–442.

Pierotti, R. J., and T. P. Good. 1994. Herring Gull (*Larus argentatus*). *The Birds of North America*. No. 124. The American Ornithologist's Union, Washington, DC. The Academy of Natural Sciences: Philadelphia, PA.

Porter, S. L. 1992. Laboratory Diagnostic Testing in Wildlife Rehabilitation. Pp. 167–172 in *Wildlife Rehabilitation*, volume 10 (D. R. Ludwig, ed.). National Wildlife Rehabilitators Association: St. Cloud, MN.

Rome, M. S., and J. C. Ellis. 2004. Foraging Ecology and Interactions between Herring Gulls and Great Black–backed Gulls in New England. *Waterbirds*. 27(2): 200–210.

Ronconi, R. A., and S. N. P. Wong. 2003. Estimates of Changes in Seabird Numbers in the Grand Manan Archipelago, New Brunswick, Canada. *Waterbirds.* 26: 462–472.

Villegas, A., J. M. Sanchez Guzman, C. Corbacho, P. Corbacho, and J. M. Vargas. 2004. Blood Values of Bald Ibis (*Geronticus eremita*) in Captivity: Comparative Ranges and Variability with Age, Sex and Physical Condition. *Journal of Ornithology*. 145: 98–104.

Work, T.M. 1996.Weights, Hematology, and Serum Chemistry of Seven Species of Free–ranging Tropical Pelagic Seabirds. *Journal of Wildlife Diseases.* 32(4): 643–657.

Young, J. S. 1994. Problems Associated with Establishing Avian Clinical Chemistry Reference Intervals. Pp. 13–20 in *Wildlife Rehabilitation*, volume 12 (D. R. Ludwig, ed.). National Wildlife Rehabilitators Association: St. Cloud, MN.