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Shotgun noise and implications for duck hunting

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Introduction

In recent years, small-gauge shotguns, especially 20 gauges, have grown in popularity among North American duck hunters. Part of this is due to the improved nontoxic ammunition now available from several manufacturers. Other aficionados praise the lighter guns for their fast, responsive handling.

Many contend that shooting a small-gauge gun is simply more fun, and that smaller guns and lighter cartridges discourage unethical long-range shooting. Within limits, they find the 20-gauge shotgun adequate for all waterfowl.

A common argument in favor of the 20 gauge is the perception that it is quieter than 12- and 10-gauge shotguns and therefore is less likely to scare away ducks. Some private hunting clubs have mandated 20 gauges for that reason, and others have considered it. Yet there are few, if any, scientific studies measuring noise levels of various waterfowl cartridges— meaning that most opinions about relative noise are subjective rather than factual.

The Max McGraw Wildlife Foundation of Dundee, Illinois, designed a study to measure noise levels generated by multiple types of waterfowl shotshells. Pattern testing of several of the shells followed, as well as a shooting test to determine whether typical hunters might shoot a heavier gun better than a lighter one. In short, the testers found no clear advantages to the 20 gauge – and 20-gauge shells proved to be about as loud as 12-gauge ammunition.

The results suggest that hunters who want to reduce shotgun noise in hopes of putting less pressure on nearby ducks may want to consider other factors before choosing a particular gauge or gun. It is more important for hunters to choose a gun that they shoot well, resulting in fewer wounded/crippled birds, and to pattern their guns and practice to understand the limits of their abilities and equipment. If hunters believe noise is a detriment to sustained hunting in a given location, it might be more effective to shoot the most efficient shell/gun combination possible regardless of gauge, potentially reducing the overall number of shells fired during a hunt.

SUMMARY

Noise differences between 12 and 20 gauge shotgun shells are minimal to nonexistent.

Limited patterning tests showed that 12-gauge loads consistently put more pellets in an 18-inch circle than any 20- or 28-gauge load, though most of the smaller gauges would be lethal at 35 yards.

Shooting tests were inconclusive, though a slight majority of participants scored higher with a 12 gauge than with a 20.

Hunters who wish to practice good conservation should pattern and practice with their shotguns to find the gun/shell combination that patterns well and they shoot most effectively, regardless of gauge. Noise is virtually irrelevant as many shells produce nearly identical sound profiles.

Sound test methodology

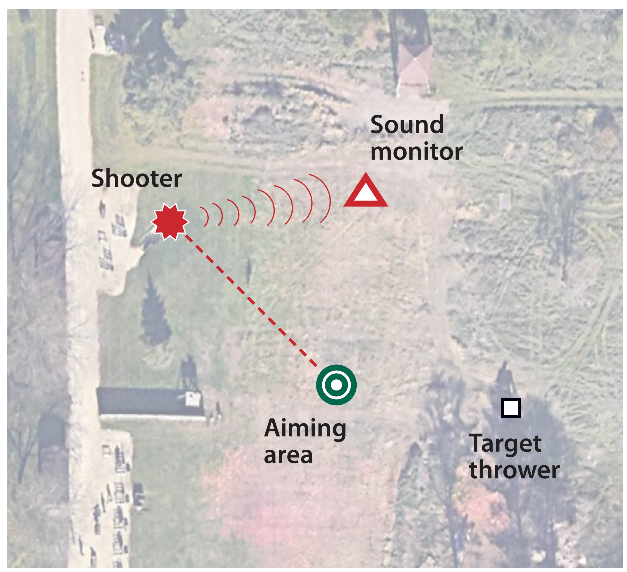
Sound testing took place on June 13, 2022 at McGraw's Slawek Family Clay Target Center. The morning was dry and calm, minimizing weather's impact on the testing. McGraw closed its other shooting ranges, eliminating the possibility of other noises affecting the results.

A senior scientist from GZA GeoEnvironmental performed the testing using a Brüel & Kjær Type 2250L sound level meter, set on a five-foot-tall tripod. The meter was placed 30 yards from the shooting position and slightly less than 90 degrees from the direction of the gunshot *(see diagram at right)*.

The study tested 20 shotgun loads in 10, 12, 20, and 28 gauges. Shooters fired five shells of each load at an incoming clay target to ensure that the shotguns always fired in the same direction and at approximately the same angle, minimizing another potential variable.

McGraw team members assigned each shell a letter code for identification and provided no other information to GZA until testing concluded, ensuring that results were recorded "blind."

After each shot, the shooter paused to confirm that the noise had registered and that the GZA scientist and the monitor were prepared for the next shot. After five shots, the results were evaluated for consistency. If the difference between the loudest and the quietest shots approached two decibels (dBA), the testers fired five additional shots.



GZA analyzed the results and reported on them in a memo (included as an appendix to this report). Results were reported in two noise metrics, Leq and LAleq. For the purposes of this summary, we will use the LAleq measurements, as they better reflect the quick, impulse-like nature of a shotgun report.

While this experiment did not measure bird reactions to the noise, other studies have shown that birds do not hear as well as humans. Therefore, if the human ear cannot reasonably distinguish changes in noise differences, it is plausible to expect that birds will not. That said, humans do not readily distinguish noise differences of less than three decibels. A five-decibel difference is perceived easily, and a ten-decibel increase represents a doubling of noise.

Results

The study revealed no significant differences in noise among the 10, 12, and 20 gauges. The loudest shell tested—a 3½-inch 12 gauge propelling 1½ ounces of shot at 1,500 feet per second—was only two to three decibels louder than the three loudest 20-gauge shells tested, a difference that is not perceivable to the human ear. It was somewhat louder than the two quietest 20-gauge shells, which many duck hunters would consider marginal: 2¾-inch loads containing ⅞ and ¾ ounces of shot, respectively.

When 3-inch and 2¾-inch 12-gauge shells were compared to more common 20-gauge waterfowl loads, the results were especially surprising. The loudest 3-inch 12-gauge tested, a 1⅛-oz load, was only 1.3 decibels louder than the loudest 20 gauge—meaning the difference would not be perceived by the human ear, and likely not by a bird. A few 12-gauge loads were quieter than the loudest 20s, though the difference was minimal.

The tested 10-gauge loads—the largest allowed for waterfowl hunting in North America—were quieter than more than half of the 12-gauge loads and one of the 20-gauge loads, though the differences were below the perceptible threshold.

The only shells that were appreciably quieter were the two 28-gauge loads. Both loadings were more than five decibels softer than the loudest 12- and 20-gauge loads, a recognizable difference. Yet many waterfowl hunters consider the 28 gauge to be marginal at all but the closest ranges, given its relatively low payload compared to typical 20-, 12-, and 10-gauge ammunition.

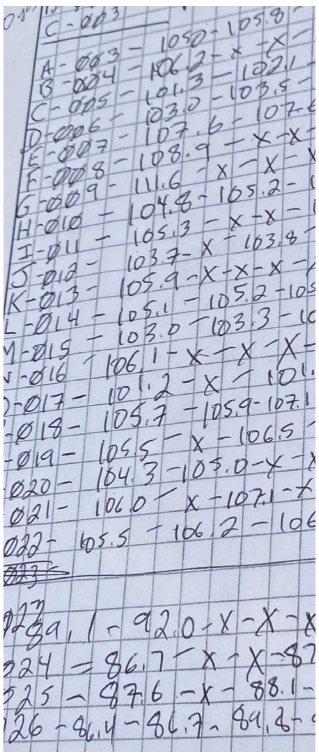
OTHER FACTORS

- There was no perceptible noise difference among shells of different lengths.
- There was little correlation between payload and noise. The loudest 20-gauge cartridge tested holds just ⅞ oz. of shot, while the heaviest 3-inch 12-gauge load, 1⅜ ounces of shot traveling at 1,300 feet per second, was among the quietest tested in that gauge.

- The loudest shells measured all exceeded 1,500 feet per second, though the difference between those shells and slower loads generally was not perceptible.

This test included only a sampling of current ammunition offerings. Other small-gauge shells may be significantly quieter than the tested 12 gauges, and noise levels of a given shell could theoretically change if a manufacturer changes components such as gunpowder or primers. Yet given the results, it is accurate to say that one cannot automatically conclude that a 20-gauge shotgun is noticeably quieter than a 12 gauge.

Of course, a given cartridge's noise is unrelated to its effectiveness. McGraw followed up with patterning and shooting tests to compare the small gauges to the 12 gauge.



NOISE LEVEL RESULTS BY LOAD TYPE

Manufacturer	Gauge	Velocity (fps)	Payload (oz)	Length (inches)	LAIeq (dBA)
Winchester	10	1450	$1\frac{3}{8}$	$3\frac{1}{2}$	108.8
Remington	10	1260	$1\frac{3}{4}$	$3\frac{1}{2}$	108.4
Remington	12	1500	$1\frac{1}{2}$	$3\frac{1}{2}$	111.2
Field & Stream	12	1500	$1\frac{1}{8}$	3	110.3
Federal	12	1500	$1\frac{1}{8}$	$2\frac{3}{4}$	109.3
Kent	12	1550	$1\frac{1}{16}$	$2\frac{3}{4}$	109.1
Winchester	12	1350	$1\frac{1}{4}$	$2\frac{3}{4}$	108.7
Kent	12	1400	1	$2\frac{3}{4}$	108.0
Kent	12	1300	$1\frac{3}{8}$	3	107.8
Remington	12	1450	$1\frac{1}{4}$	3	107.7
Kent	20	1550	$\frac{7}{8}$	3	109.0
Remington	20	1400	1	3	108.3
Hevi Bismuth	20	1400	$1\frac{1}{8}$	3	108.1
Boss	20	1300	$1\frac{1}{8}$	3	107.6
Fiocchi	20	1470	$\frac{3}{4}$	$2\frac{3}{4}$	107.8
Hevi XII	20	1350	$1\frac{1}{4}$	3	107.6
Kent	20	1500	$\frac{7}{8}$	$2\frac{3}{4}$	106.4
Winchester	20	1325	$\frac{3}{4}$	$2\frac{3}{4}$	106.3
Winchester	28	1300	$\frac{3}{4}$	$2\frac{3}{4}$	104.2
Boss	28	1350	$\frac{7}{8}$	$2\frac{3}{4}$	103.8

Patterning tests

McGraw team members shot patterns with nine of the tested loads, covering 12, 20, and 28 gauges. They used life-size images of a mallard duck for the tests, hoping to compare the lethality of each load.

Standard practice for patterning involves shooting patterns at 40 yards and determining the percentage of pellets within a 30-inch circle at that distance. Because the estimated pellet count for the nine shells tested varied widely due to varying shot sizes and payload weights, the testers chose to count only the number of pellet strikes on the mallard's image, as well as the number of strikes in an 18-inch circle surrounding the image. In addition, McGraw calculated average strikes using the densest patterns for each load, reducing potential variations due to aiming error.

Team members mounted the targets 35 yards from the shooting position, representing a likely effective limit for most duck hunters. The testers used Beretta A400 shotguns in 12, 20, and 28 gauge, all with 28-inch barrels and with modified chokes installed.

The shooters used a rest to ensure consistency in shot placement. They fired five shells of each load, aiming at a different target each time. Weather conditions were warm and calm.

AMMUNITION IN PATTERNING TEST

Manufacturer	Gauge	Velocity (fps)	Payload (oz)	Pellet size	Pellet count (approx.)
Kent	12	1550	1 1/16	4	204
Remington	12	1450	1 1/4	3	197
Boss	20	1300	1 1/8	3	138
Hevi Bismuth	20	1400	1 1/8	3	138
Hevi XII	20	1350	1 1/4	6	297
Kent	20	1550	7/8	4	168
Remington	20	1400	1	4	192
Boss	28	1350	7/8	5	315
Winchester	28	1300	3/4	6	236

Results

No 20-gauge shell in steel, bismuth, or Hevi-XII put as many pellets into the 18-inch circle or the mallard image as the two 12-gauge steel loads tested. In part, this is because the 12 gauges held more pellets than most 20-gauge loads, but the difference was significant.

The Remington Nitro Steel 12-gauge load (1¼ ounces of No. 3 shot, 1400 fps) put an average of 40.6 pellets into the 18-inch circle, and an average of 16 pellets in the mallard body. Dropping the worst performing pattern raised the average pellet strikes to more than 41 in the 18-inch circle, 16.5 on the mallard. In addition, an average of 1.75 pellets struck the neck/head of the mallard image.

The Kent Fasteel 2.0 12-gauge load (1 1/16 ounces of No. 4 shot at 1550 fps) produced the second most strikes on average—0 in the 18-inch circle, 15 in the mallard body, and one in the neck/head. Throwing out one pattern raised the average only slightly (31.75 in the circle, 15.75 in the body).

By contrast, the best performing 20-gauge load in terms of pellet strikes was Kent Fasteel (7/8 ounce of No. 4 shot, again at 1550 fps). It averaged 28.8 strikes in the circle and 12.4 in the mallard. Dropping the worst pattern boosted its averages significantly, to 32 and 13.75 strikes, respectively.

The Hevi-XII 20 gauge (1¼ ounces of No. 6 shot at 1350 fps) averaged 27.8 strikes in the circle and 12 in the body—surely lethal but not unexpected given that the load contained nearly 300 pellets, compared to 168 in the Kent 20 gauge shell. Bismuth shells in 20 gauge did not perform well overall—both examples averaged just 15.4 strikes in the 18-inch circle.

The Boss 28 gauge bismuth load (7/8 ounce of No. 5 shot at 1350 fps) performed surprisingly well, averaging 18 pellets in the circle and 7.6 shots in the body. Averaging the four best patterns raised that number to 22 hits in the circle and 10 in the body.

AVERAGE PERFORMANCE BY GAUGE

	Circle hits	Body + head hits
12 gauge	35.3	16.7
20 gauge	21.8	10.64
28 gauge	20.1	9.2

This is not to imply that 20- and 28-gauge loads are inadequate. Every load with the probable exception of the 28-gauge Winchester shell threw patterns that would be lethal at 35 yards (the Winchester's No. 6 steel pellets likely would not retain sufficient energy at that distance). In addition, further experimentation with different choke constrictions could increase pattern density for some shells. If shots were limited to 30 yards, any differences in field performance among the tested shells would likely be theoretical, not practical.

Yet in this test under these circumstances, the 12-gauge shells clearly put the most pellets on target—even their weakest patterns put 12 or more pellets into the bird image. By contrast, all of the smaller gauge shells had at least one pattern that put eight pellets or fewer into the mallard, and in some cases, the number dropped to two or three, potentially crippling an actual bird.

The final equation in choosing a waterfowl gun and load is how effective the combinations are in a shooter's hands. Some hunters believe that they shoot light, fast-handling guns better and therefore are more effective with them, while others maintain that weight is a key factor in shooting a shotgun accurately, especially at longer distances. Further experiments at McGraw sought to compare a light 20-gauge shotgun to a heavier 12 gauge in head-to-head shooting tests.

Shooting tests

McGraw team members set up a pair of crossing targets at a measured 35 yards—one flying right to left, the other left to right. Again, the distance was chosen to simulate a shot at the edge of an average hunter's ability.

Participants took 10 shots with a 12-gauge Beretta A400 and 10 shots with a similar 20 gauge, each with a 28-inch barrel and a Modified choke tube installed. McGraw supplied Kent steel target loads with No. 7 shot in both gauges.

The 12 gauge weighed 7 pounds, 4 ounces, while the 20 gauge weighed 5 pounds, 10 ounces. For some shooters, the 20-gauge gun was equipped with a magazine cap weight bringing it up to a whisker over 6 pounds, allowing an assessment of the gauge's performance in a heavier gun. About half of the shooters started with the 12 gauge; the rest began with the 20.

Two dozen shooters participated in the testing. The following trends emerged:

- 35 yards is a challenging test. Only 12 of the 24 shooters broke 50 percent or more with either gauge. The highest score for both gauges was an 8x10
- Ten shooters scored better with a 12 gauge, nine with a 20, and one shooter broke six with each

- On average, the weighted 20 gauge performed better than the unweighted 20 gauge. Eight out of 18 shooters who shot the weighted 20 gauge scored 50 percent or better, while only two of the eight shooters who attempted the test with the unweighted gun scored 50 percent

Because the shooters' abilities varied widely, it is difficult to make definitive statements about the results. Yet it is clear that the lighter guns did not create a significant advantage for shooters.

This corresponds with an earlier test conducted by one of the study participants for Field & Stream magazine (*click here to see study*). That test found that a heavy gun was easier to shoot faster and more accurately than a lighter gun of the same model. Therefore, shooters who want to shoot a 20 gauge in the field may wish to experiment by adding weight to their guns.

Conclusions

This study is not an indictment of the 20 gauge for waterfowl hunting. Both the 20 gauge and the 12 gauge are effective at normal ranges, and the study did not test effectiveness or lethality at longer distances, especially with the super-premium ammunition now available. Yet it does strongly suggest that one of the most common arguments in favor of the 20 gauge—that it is quieter than the 12—is not necessarily valid.

Therefore, ***hunters should choose the gun, gauge, choke, and ammunition combination that they shoot best,*** if it consistently throws a lethal pattern at the distances at which they are likely to shoot. *(Click here for ballistics expert Tom Roster's shot lethality table for scientifically derived recommendations.)*

By doing so, hunters should minimize crippling and the number of birds that are wounded but go unrecovered, a conservation ethic to which we all should aspire.

APPENDIX

Max McGraw Wildlife Foundation Waterfowl Ammunition Study

GZA

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MEMORANDUM

To: Mr. Kerry Luft, Executive Vice President, The Max McGraw Wildlife Foundation

From: Timothy Kelly, P.E. & Gerry Trzupek, GZA GeoEnvironmental

Date: Wednesday, August 11, 2022

Re: Waterfowl Loads Noise Study

OVERVIEW

The Max McGraw Wildlife Foundation (McGraw WF), located in Dundee Township, Illinois, conducted a waterfowl shotgun loads noise study in conjunction with GZA GeoEnvironmental (GZA) at the McGraw WF facility. The study monitored the noise levels associated with 20 different types of shotgun shells. The study's intent was to evaluate which characteristics of waterfowl shotgun loads could have a perceivable effect upon resultant noise levels.

This memo presents basic information on noise and noise monitoring, the results of noise monitoring conducted by GZA, and findings derived from the resulting noise data.

1. BACKGROUND INFORMATION

NOISE METRICS

Sound is caused by the vibration of air molecules, and its loudness is measured on a logarithmic scale using units of decibels (dB). Sound is composed of a wide range of frequencies; however, the human ear is not uniformly sensitive to all frequencies. Therefore, the "A" weighted scale was devised to correspond with the ear's sensitivity. The A-weighting generally weighs noise levels in the humanly audible range more heavily and screens out noise levels that cannot be heard but are still generated, such as a high frequency dog whistle.

To determine noise levels in the A-weighted scale, the monitor differentiated noise levels at nine different frequencies for each reading, ranging from 31.5 hertz to 8 kilohertz.

The noise metric measured for the study was Leq, which is the steady-state sound level that contains the same amount of acoustic energy as the actual, time-varying sound level over a specified period. For this study, due to the quick, impulsive nature of firing a shotgun, the time period considered was one second.

NOISE MONITOR

A Brüel & Kjær Type 2250L sound level meter was used for monitoring the noise levels. The instrument was calibrated prior to use and set up on a tripod approximately five (5) feet above the ground. The monitor was set up 30 yards from the shooter and slightly less than 90 degrees from the direction the shooter was firing. Figure 1 presents an overhead view of the equipment and personnel in the study area.

LIMITED LITERATURE REVIEW

A brief and limited literature review was completed to assess the current understanding of firearm noise on birds. The available literature on the topic was limited and does not appear to directly relate to the concerns of McGraw WF, as it lacks specific noise levels that are associated with the noise characteristics of varying waterfowl ammunition loads.

The Illinois Natural History Survey conducted a literature review in 1994 on the "Effects of Military Noise on Wildlife: a Literature Review" (Larkin 1994). While the literature review noted that "[f]lying waterfowl may also respond to noise" and that "when presented with gas compressor station noise, individual snow geese will alter their flight direction (61% by more than 90 degrees)" (Larkin Page 26), the literature review did not indicate the noise levels of the compressors, or the waterfowl sensitivity to variances in noise levels.

A 2016 technical guidance manual by CalTrans was released in June 2016. This technical guidance is titled "Technical Guidance for Assessment and Mitigation of the Effects of Traffic Noise and Road Construction Noise on Birds." While this study was developed for transportation-related noise, there is some applicability to the McGraw WF concerns, as the document addresses impulse sound related to construction noise.

While the applicability of this guidance manual is limited, the manual did note that "[n]oise types and levels that appear to increase stress and adverse physiological reactions in humans may also have similar consequences in birds" and that "[t]hese extensive data show that birds are much more resistant to hearing loss and auditory damage from acoustic overexposure than are humans and other mammals. Traffic and construction noise, even at extreme levels, is unlikely to cause threshold shift, hearing loss, auditory damage, or damage to other organ systems in birds and, therefore, interim guidelines for hearing damage in birds from traffic and construction noise are probably not needed" (CalTrans Page 7).

This manual notes that "human auditory thresholds in quiet and in noise are about 6 dB better than that of the typical bird," from which they draw the conclusion that "[w]hen estimating whether a bird might be disturbed by hearing traffic or construction noise from a distant site, this 6 dB difference in masked thresholds means that if a human can barely hear traffic or construction noise from a distant site, a bird certainly cannot hear the noise and therefore can't be disturbed by it. The rule that 'if a human can't hear it, a bird can't either' thus proves a handy rule of thumb for estimate whether a distant noise from construction equipment might be disturbing" (CalTrans Page 31).

Based on the above information and the lack of alternate direction provided by the literature review, the Leq was analyzed as the noise metric for this study. The Leq is a typical noise descriptor for environmental studies. Additionally, the perceived relative difference between various noise levels by humans was used in lieu of waterfowl-specific information, as this information was unavailable in the studies reviewed.

FIGURE 1 – STUDY AREA

2. NOISE MONITORING PLAN

Monitoring occurred on the morning of Monday, June 13, 2022. The other shooting ranges at McGraw WF were not in use during this period, eliminating one possible source of interfering noise. The morning was dry and reasonably calm, minimizing these weather-based potential sources of noise level variability.

For each of the 20 types of waterfowl ammunition loads, the shooter fired at five targets. As the noise profile of a shotgun blast has a directional element, the clay target provided a set area to aim. The shooter paused after each shot to confirm that the previous noise level reading had been registered and that GZA personnel and monitor were prepared for the next shot. After five shots, GZA personnel evaluated whether the five readings were consistent enough to constitute a “set” or if another five shots using the same ammunition load were needed to increase sample size due to noise level variability. Typically, if the difference from the quietest to the loudest shot in a group of five approached 2 dBA, another five shots were fired.

The 20 types of waterfowl ammunition loads varied in multiple aspects: gauge, shell length, payload, velocity, and manufacturer. The data was recorded blind in the field blind; i.e., each shell was given a letter code for documentation, and no other identifying information was conveyed to GZA personnel. A list of the various load parameters and assigned codes is presented below:

Manufacturer	Remington	Remington	Boss	Kent	Federal	Remington	Field & Stream	Kent	Hevi Bismuth	Hevi XII	Remington	Kent	Winchester	Boss	Winchester	Winchester	Kent	Fiocchi	Kent	Winchester
Velocity (fps)	1450	1260	1350	1500	1500	1500	1500	1300	1400	1350	1400	1400	1325	1300	1300	1450	1550	1470	1550	1350
Payload (oz)	1 1/4	1 3/4	7/8	7/8	1 1/8	1 1/2	1 1/8	1 3/8	1 1/8	1 1/4	1	1	3/4	1 1/8	3/4	1 3/8	7/8	3/4	1 1/16	1 1/4
Length (inches)	3	3 1/2	2 3/4	2 3/4	2 3/4	3 1/2	3	3	3	3	3	2 3/4	2 3/4	3	2 3/4	3 1/2	3	2 3/4	2 3/4	2 3/4
Gauge	12	10	28	20	12	12	12	12	20	20	20	12	20	20	28	10	20	20	12	12
Statistical Metric	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T

3. NOISE MONITORING RESULTS

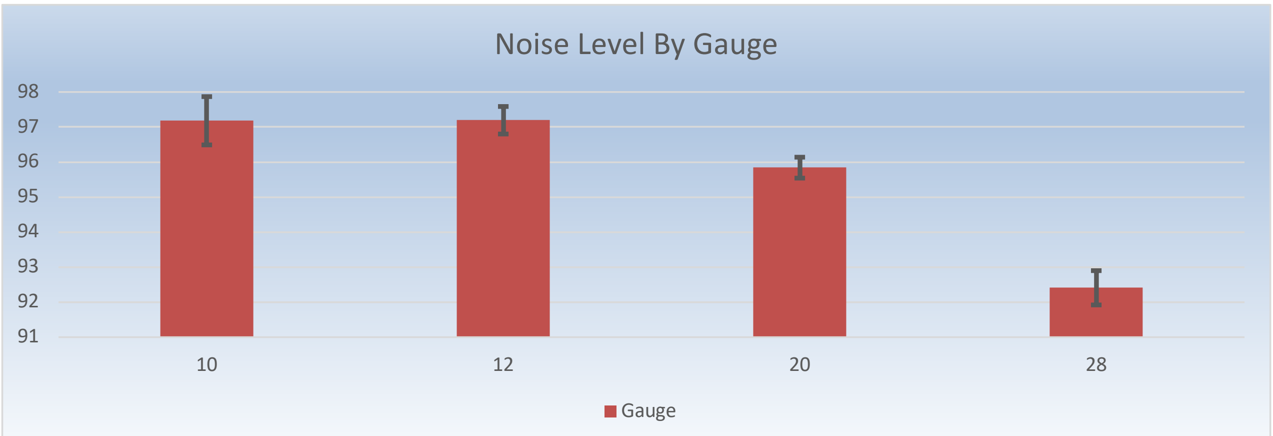
The table below presents the average Leq for each type of load and the standard deviation of each load's data set. The standard deviation is a measure of the variability of the data set relative to the mean. The smaller the standard deviation, the more consistent the data in the data set.

TABLE 1 – NOISE LEVEL RESULTS BY LOAD TYPE

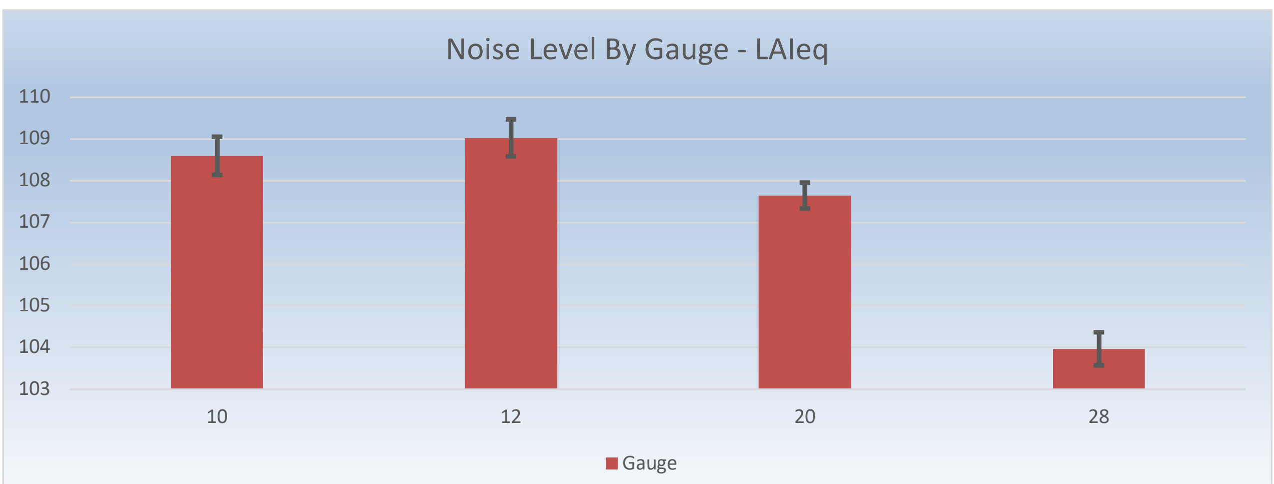
Manufacturer	Gauge	Velocity (fps)	Payload (oz)	Length (inches)	LAeq (dBA)	LAIeq (dBA)
Winchester	10	1450	1.375	3.5	97.6	108.8
Remington	10	1260	1.75	3.5	96.7	108.4
Remington	12	1500	1.5	3.5	99.3	111.2
Field & Stream	12	1500	1.125	3	98.3	110.3
Federal	12	1500	1.125	2.75	97.2	109.3
Kent	12	1550	1.0625	2.75	97.2	109.1
Winchester	12	1350	1.25	2.75	97.0	108.7
Kent	12	1400	1	2.75	96.5	108.0
Remington	12	1450	1.25	3	96.0	107.7
Kent	12	1300	1.375	3	95.9	107.8
Kent	20	1550	0.875	3	97.0	109.0
Hevi Bismuth	20	1400	1.125	3	96.8	108.1
Boss	20	1300	1.125	3	96.1	107.6
Fiocchi	20	1470	0.75	2.75	96.1	107.8
Remington	20	1400	1	3	96.0	108.3
Hevi XII	20	1350	1.25	3	95.8	107.6
Kent	20	1500	0.875	2.75	94.6	106.4
Winchester	20	1325	0.75	2.75	94.2	106.3
Winchester	28	1300	0.75	2.75	92.4	104.2
Boss	28	1350	0.875	2.75	92.4	103.8

Below are graphical results by the various groups of waterfowl loads studied, arranged by gauge, length, payload, and velocity, respectively. For each graph, the vertical bar represents the average Leq of the grouping, and the error bar demonstrates the 95% confidence level. Based on the data sets for each group, 95% of the Leq data fall between the upper and lower confidence levels presented. This demonstrates the reasonable limits of the data's variability.

FIGURE 2

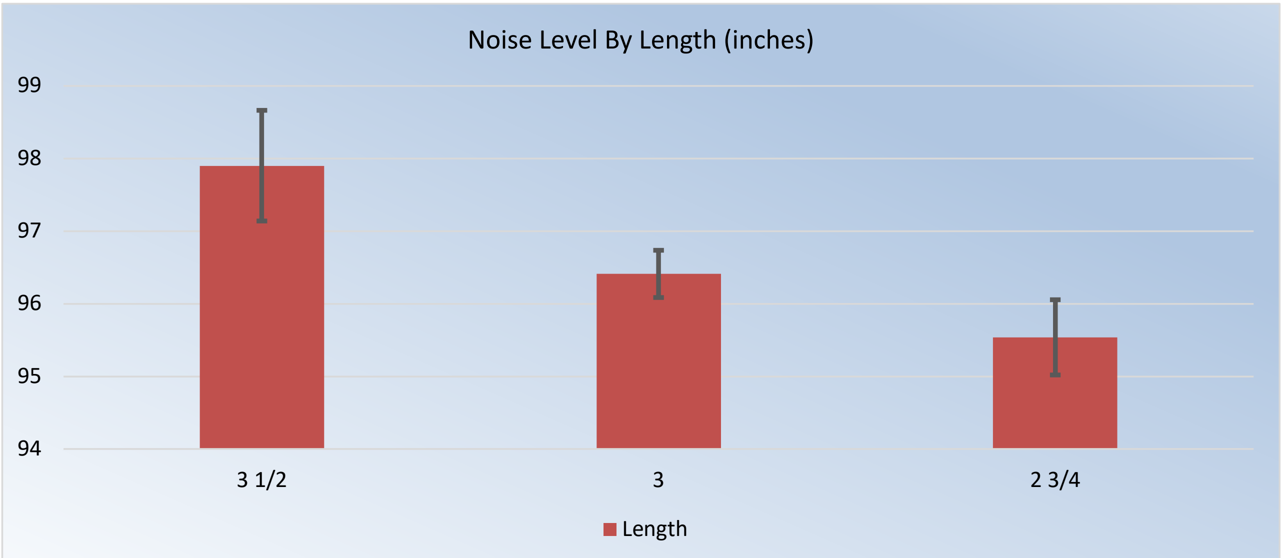


Gauge	10	12	20	28
LAeq (dBA)	97.18	97.19	95.84	92.41
Confidence Level (95.0%)	0.69	0.39	0.30	0.49

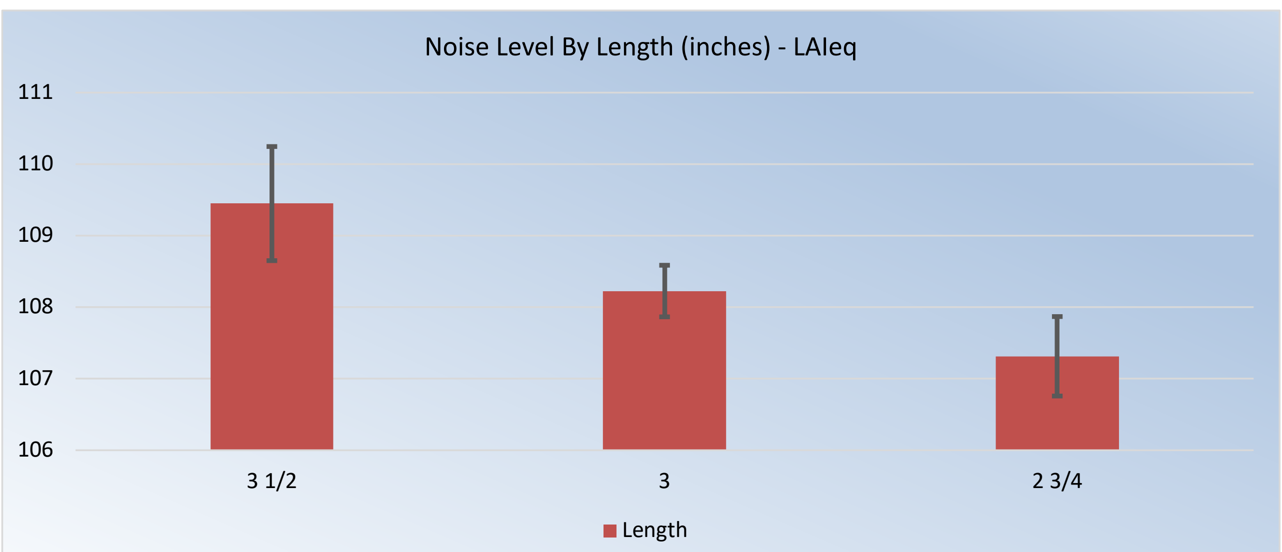


Gauge	10	12	20	28
LAIeq (dBA)	108.60	109.03	107.64	103.97
Confidence Level (95.0%)	0.46	0.44	0.31	0.40

FIGURE 3

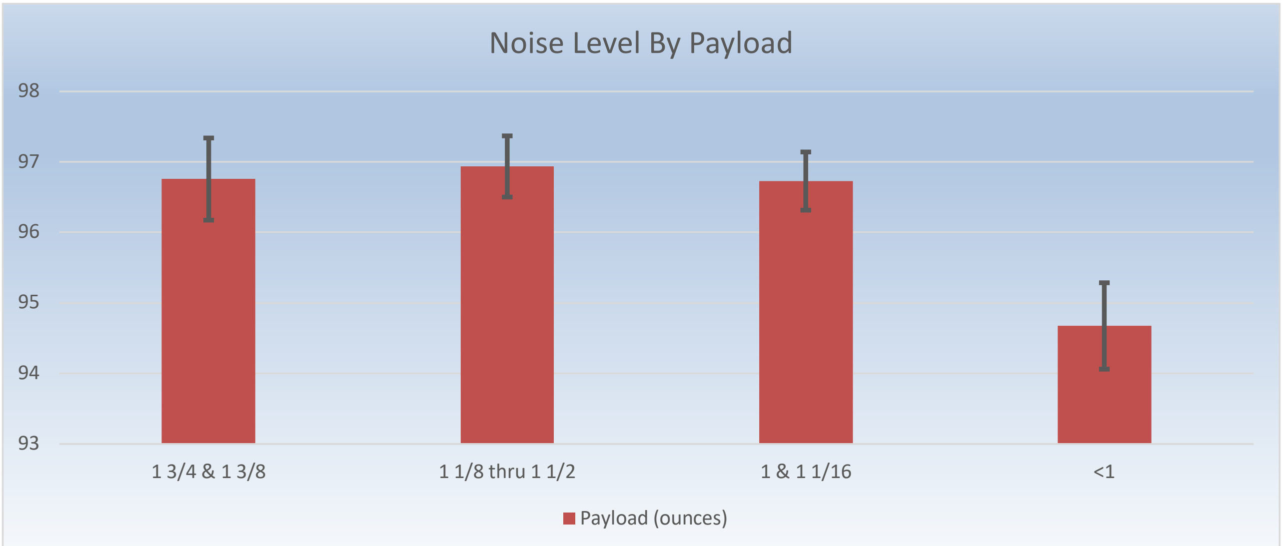


Length (inches)	3 1/2	3	2 3/4
AVERAGE (dBA)	97.90	96.41	95.54
Confidence Level (95.0%)	0.76	0.33	0.52

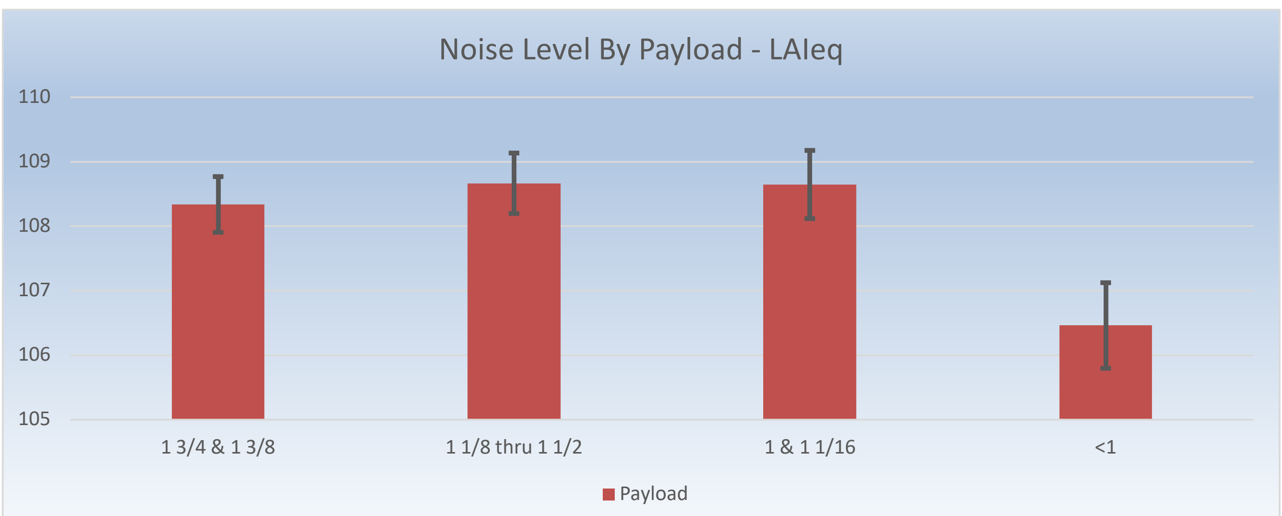


Length (inches)	3 1/2	3	2 3/4
LAIeq (dBA)	109.45	108.23	107.31
Confidence Level (95.0%)	0.80	0.36	0.56

FIGURE 4

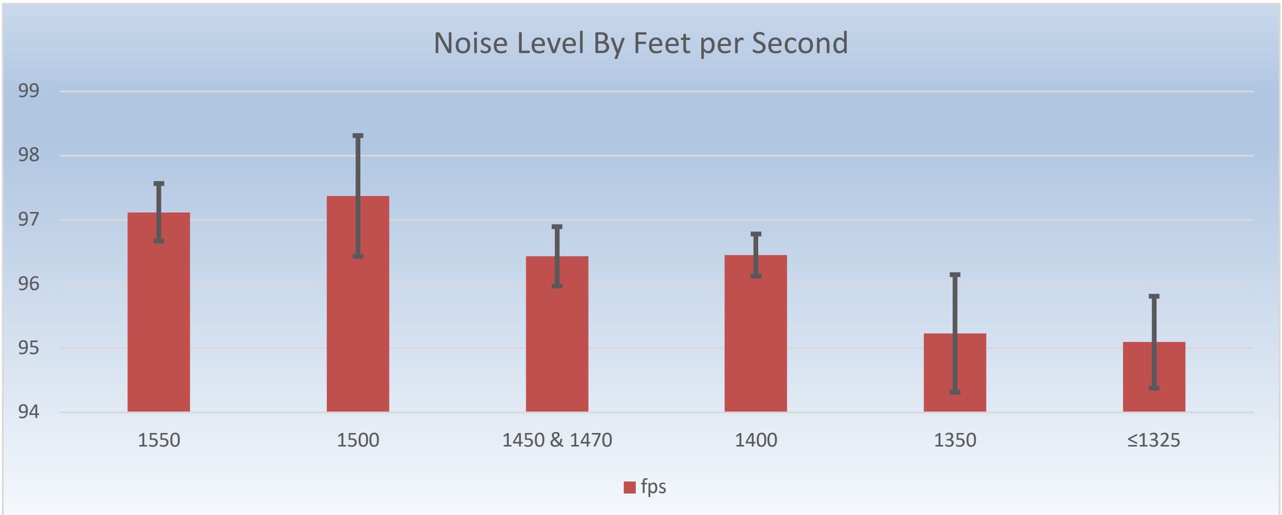


Payload (ounces)	1 3/4 & 1 3/8	1 1/8 thru 1 1/2	1 & 1 1/16	<1
AVERAGE (dBA)	96.76	96.94	96.73	94.67
Confidence Level (95.0%)	0.58	0.43	0.41	0.61

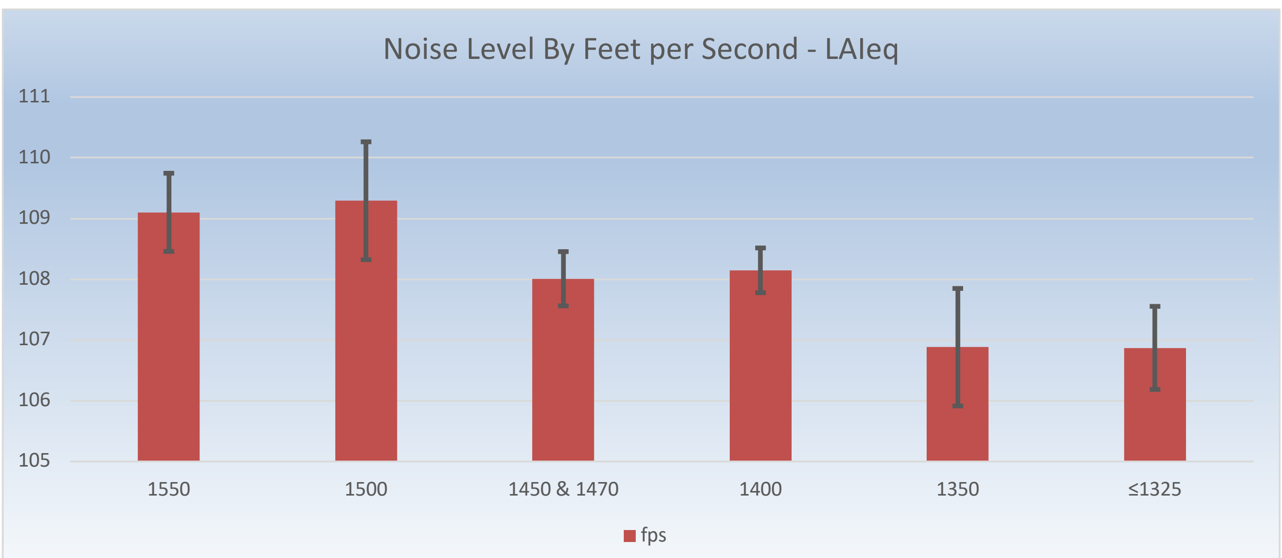


Payload (ounces)	1 3/4 & 1 3/8	1 1/8 thru 1 1/2	1 & 1 1/16	<1
AVERAGE (dBA)	108.34	108.67	108.65	106.46
Confidence Level (95.0%)	0.43	0.47	0.53	0.66

FIGURE 5

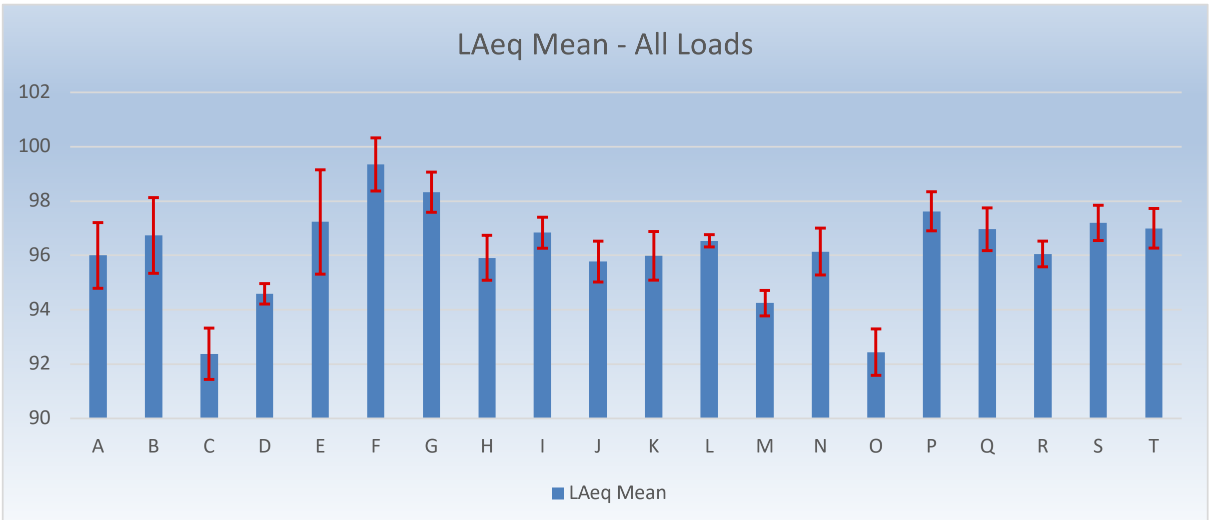


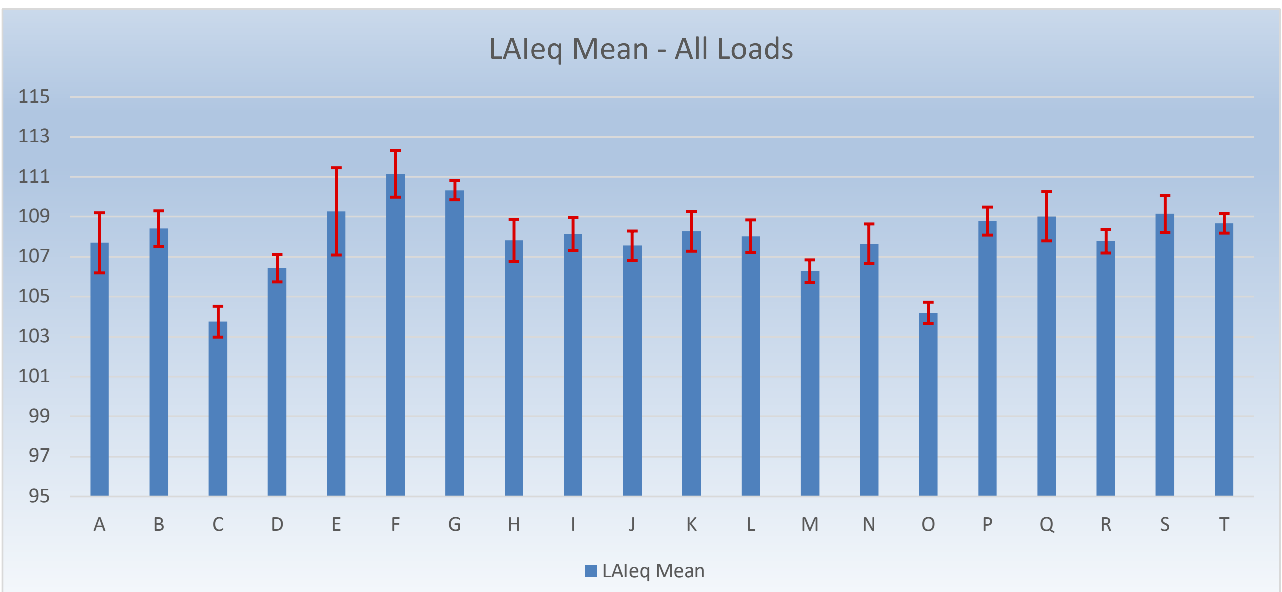
Velocity (fps)	1550	1500	1450 & 1470	1400	1350	≤1325
AVERAGE (dBA)	97.12	97.37	96.43	96.45	95.23	95.09
Confidence Level (95.0%)	0.45	0.94	0.46	0.33	0.92	0.72



Velocity (fps)	1550	1500	1450 & 1470	1400	1350	≤1325
AVERAGE (dBA)	109.10	109.29	108.01	108.15	106.88	106.87
Confidence Level (95.0%)	0.64	0.97	0.45	0.37	0.97	0.68

FIGURE 6





4. SUMMARY

As a point of reference while comparing results, the human ear cannot typically distinguish noise changes of less than three decibels. Typically, changes in decibel levels are perceived as follows:

Increase in decibels	Perceived as
Three decibels	Minimum perceivable change
Five decibels	Readily perceptible increase
Ten decibels	Twice as loud

From this study, the load with the highest Leq, the Remington 3 ½-inch 12 gauge, was approximately 7 dBA louder than the loads with the lowest Leq/LAIeq, the two 28 gauge shells (Winchester and Boss). That 7 dBA variation constitutes a perceptible noise difference. As presented on Figure 2, the 28 gauge load noise levels, in general, are perceptibly quieter to the human ear than the other three gauges studied. Accounting for the Confidence Intervals, the noise difference from the 28 gauge load to the other loads ranged from 5.95 dBA to 3.14 dBA for the Leq and from 5.90 dBA to 2.96 dBA for the LAIeq. No perceptible noise difference was calculated between the 10, 12, and 20 gauge loads; the change in noise level from highest to lowest Leq/LAIeq was less than three dBA.

Load length demonstrated no perceptible noise level difference between the three sizes studied; the change from the largest to smallest load length was less than three dBA.

Variations in payload showed little noise level difference, with the exception of loads that were less than one ounce. However, these smallest load shells were still less than three dBA quieter, attributing no perceivable difference.

Noise levels based on load velocity demonstrated the greatest amount of variability based on standard deviation and 95% confidence levels. This is likely due to smaller sample set sizes compared to other groupings. However, the mean values of these groupings demonstrated less than a three dBA noise level difference.

The results presented are limited to the events observed in the field and are meant to present in-field use of the studied ammunition loads. Data collected was limited due to the overall scope of the study and is not meant to replace existing studies on the topic. The primary focus of the study was the relative difference in noise levels between the various ammunition loads, and the study-observed noise levels for each type presented should not be extrapolated or used for any other purposes. As presented in Section 1 of this document, the above results present human sensitivity to relative noise level differences as a surrogate sensitivity for waterfowl. Additional research would be needed to evaluate the sensitivity to relative noise level differences in various bird species.

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About the Max McGraw Wildlife Foundation

The Max McGraw Wildlife Foundation is the nation's leading advocate for creative and entrepreneurial thought in conservation. It was created more than 60 years ago by the visionary conservationist Max McGraw, founder of McGraw-Edison Co.

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