AUTO ISO Exposure

Introduction

During a recent seminar on photography by Joe Edelman, “Abstract Photography”, Joe suggests a different way to do exposure than the normal setting of camera modes to Program, Time, Aperture, or Manual. The approach allows freedom to select the normal variables of shutter speed, and aperture a bit independently. The approach allows the photographer to focus on the shot and not the mechanical aspects of exposure so much. He indicates the approach fully blooms when using a mirrorless camera.

Background

The **shutter speed** sets how motion is handed in the image. The **aperture** sets the depth of field captured. In film days, the ISO or ASA was fixed by the film emulsion, so shutter and aperture were on a balance beam. Change one, the other must be changed to get an acceptable exposure. Digital cameras can change the ISO used for the capture. So, exposure has aperture and shutter speed and a third component, the ISO setting in digital cameras.

Using camera modes of Program, Time Priority or Aperture Priority serves little purpose with AUTO ISO setting since the photographer can set but one variable or none in the case of Program mode. But switch to MANUAL mode and the photographer can select aperture and shutter speed independently of the other. The camera then selects an ISO setting to achieve proper exposure.

Concept

- Choose shutter speed to handle motion, freeze the motion or increase exposure time to see the motion in the image.
- Choose aperture to select depth of field desired.
- Camera selects ISO setting to achieve proper exposure.

Issues

- Low ISO values are best for quality, so there is some limit to how high ISO can be set to achieve a near noiseless image.
- Understand, a proper exposure when selecting aperture and shutter speed independently can result in an **unachievable demand** on the ISO setting.
- Most cameras have a setting to how high the ISO can go using the “AUTO ISO” setting. Most also have a setting for shutter speed, below which the camera will not fall when using this feature. But the camera manuals do not state how high of an ISO setting should be used for this function.

The rest of the discussion is to determine what setting to use for 5 Nikon camera bodies for ISO limit under AUTO ISO and still get low noise images.

ASA versus ISO

Film speed was measured using an ASA standard. Digital cameras do not use film, so a standard was developed for digital cameras for proper exposure. This is ISO which has a number like 200. Changing the ISO setting in the camera DOES NOT change the actual exposure. So a manual setting of f4 at 1/200 is the same light volume at ISO 200 or ISO 20,000. Changing the ISO changes how the internal processing treats the data. In the second case, the data is UP SCALED 100 times!

Practical Use

Doing bird photography, one likely uses a big telephoto lens. The aperture needs to be set near wide open like f/2.8, f/4.0 or f/5.6. You want a blurred background. The shutter needs to be at a very short exposure like 1/8000 of second to stop motion. Program mode is out of the question. Aperture priority could be used but the shutter needs to remain short. Shutter speed priority could also be used but you want to use the lens wide open. What you do is set the camera mode to manual mode setting. Then the aperture is set as desired, and the shutter speed is set as desired. Now you likely don't have proper exposure, so AUTO ISO comes in to give you the proper exposure and allows variations in light in the scene.

Adjust the Exposure

The exposure as set in the above approach may not get you what you want in image rendition. To achieve a different interpretation on capture, you use exposure compensation. Set one of the command dials to exposure compensation. This allows a speedy way to change the image to a rendition of your desirers.

Adjustment to Taste

The only thing left is to determine what ISO limit should be used for this approach. This is highly personal, so you just go shoot all the ISO settings and determine where noise is objectionable to you.

Testing

Each camera was set to Program mode without AUTO ISO. Then each ISO was used to make an exposure. You get 13 to 19 images from each camera to compare. Here is the key, view the images at **ONLY at 100%** to determine how far the ISO can be increased without noise. I know, you want to see the noise, so you turn up the zoom to 800%. We all do this wanting to see the pixels. If you make the first pass of the images at 100%, you will make the right decision. When

you go back and look at the images at 800%, you will find noise in every image, but the point is to set the limit of ISO limit under AUTO ISO is what you see at 100%.

All the cameras have a small increasing slope to the noise level versus ISO setting to a point. What you want is **this point**. After this point, the noise rises faster than the ISO increase. The D2x data was so obvious. Using just the preview images you could pick this point. All digital cameras this noise gets worse with increase of ISO. Each increase of ISO just means the actual data is multiplied.

On capture, the sensor gets the number of protons reflected times the amount of time the shutter is open by the diameter of the lens or aperture. ISO just corrects the scene to what the "data capture says", there is **NO increase in light volume captured!** All **digital sensors have only one exposure level**.

SKIP THIS EXPLANATION TO JUST USE THE TECHNIQUE

Each pixel can only hold so many photons. Too many photons in one pixel site (well) and the photons "SPILL" out into joining pixels. This is called "blooming". That is why you cannot get to say ISO 1. If you get into the scientific details, you can figure out how many photons fit each pixel "well". Changing the ISO does NOT change this value!

Less photons in a pixel, then the electronics adjust the data to achieve an image. When the photons drop to some level, the electronic noise of the circuits are near the values of the photon count read in dark scene pixels. The magic of electronic pixels is that total photon count is a LINEAR voltage that the electronics reads. So, 2,000 photons are 2000 times one photon voltage. Very small values by the way. RAW files are all linear data from this fact. But images need to be in log scale for human eyes. The RAW converters take the linear data and makes the data logarithmic. Just what the eyes wants.

You could ignore all for the above issues of noise if the electronics were perfect. They are not. Most sensors have what is called dual gain. The electronics start with using very highly precise amplifiers. But as some point, the values are too small, the electronics switches to higher gain amplifiers. These are less precise. With such a high level of gain, the error levels increase. Plus, the electronics have an issue called "Thermal noise". The electronics make electronic noise related to the temperature.

Modern sensors measure down to 1 to 4 photons in each pixel well. This is the level of the electronic noise. Even worse, light is not linear. Standing at a pixel well you get very uneven rate of light arrival. This measurement is called "SHOT NOISE". The photons arrive very randomly.

Statements

For this technique, one needs to understand only a very few statements.

1. From starting low ISO, you really can NOT exposure the sensor below this level. At this level, ALL the pixels are full, and the image turns white!
2. From the lowest ISO to some point, noise rises but very slowly. The sensor is using the highly precise amplifiers.
3. From this point and above the sensor has switched to higher gain amplifiers for higher ISO.

You might think you need to fine this point of the amplifier switch. Do not need to know the amplifier switch point. JUST what level of noise you will accept in your image. The actual electronics could have other functions being switched in or out being applied to the data values. **Set the ISO limit to what you accept!**

Equipment Tested

- Nikon D2x
  - 2004 released date.
  - ISO settings 100 to 3200
  - This item converted to full spectrum.
- D700
  - 2008 release date.
  - Based on the D3 sensor & Multi-Cam 3500FX
  - ISO settings 100 to 12,800
- D800e
  - 2012 release date
  - ISO settings 50 to 25,600
- D850
  - 2017 Release date
  - ISO settings 32 to 102,400
- Z9
  - 2021 Release date
  - ISO setting 32 to 102,400

Results

- D2x
  - Limit @ **ISO 400**
  - Much worse at all ISO setting than all the rest of the cameras
- D700
  - Limit @ **ISO 800**
- D800e
  - Limit @ **ISO 2500**
- D850
  - Limit @ **ISO 4000**
- Z9
  - Limit @ **ISO 8000**

Technology improves over time. The Z9 and D850 are nearly the same sensor but the noise levels are reduced at the same ISO settings in the Z9. The level of noise in the D2x is huge versus the Z9 that is 17 years later!