The Ultimate Photography Guide to Depth of Field (DoF)

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Introduction

You've heard the advice a million times:

"Master depth of field, and your photos will magically look much better."

Just to mention one example. Photography master and author, Harold Davis, in his great book, Creative Composition: Digital Photography Tips and Techniques, mantains:

"Depth of field is a key compositional element in many, if not most, photographs. It is one of the most important tools a photographer can use to create striking images."

And it's true – using depth of field the right way is very powerful. It can radically transform good photos into images that win hearts and minds.

It sounds so simple.

The only problem?

You aren't sure how to really put depth of field into practical use.

How can you shoot shallow depth of field? Or deep depth of field? When should you use one approach or the other? Where should you focus the lens? What camera settings should you use?

Because while many experts preach the virtues of strategic use of depth of field, almost nobody tells you how to do it.

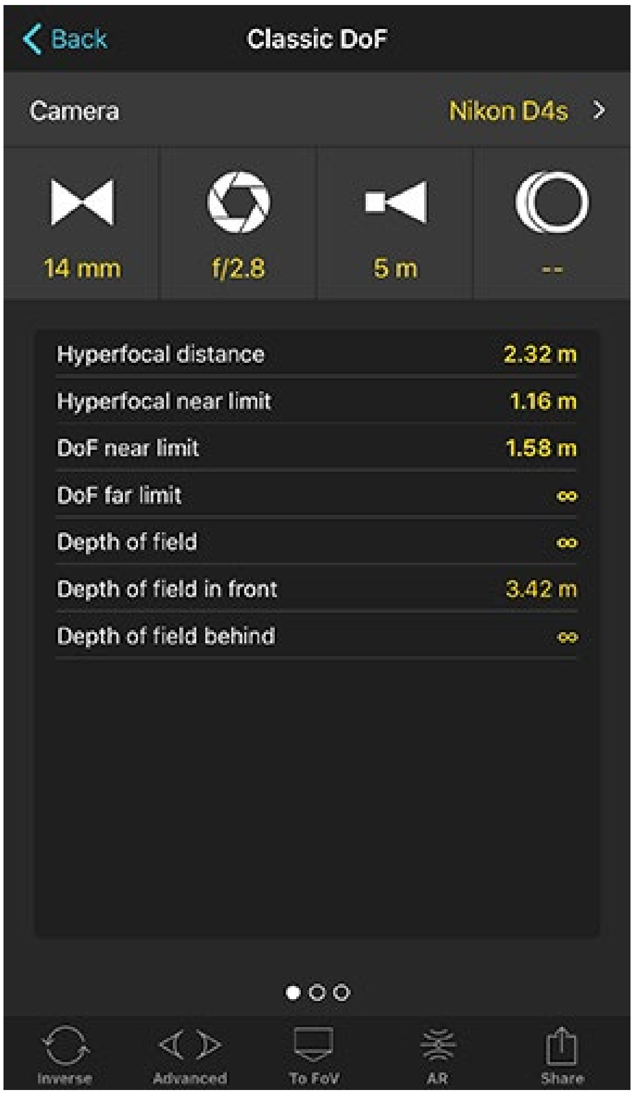
As a result, many well-intentioned photographers are spending their precious time trying to apply depth of field without even completely understanding the concept itself nor knowing how to properly use it.

If that's your case, don't worry! You're not the only one...

In my courses, I explain depth of field together with camera aperture, just after the exposure triangle (aperture-shutter speed-ISO). I support the theory class with many examples and online tools, including the PhotoPill's on-line depth of field calculator, to help students visualize which settings come into play when shooting both shallow and deep depths of field.

One of the moments students love is when I take my iPhone and use the augmented reality view of PhotoPills' DoF calculator app to answer one of the most common questions:

"That's very cool… but, where do I focus exactly?"



PhotoPills' DoF Calculator - results in a table.

PhotoPills' Dof Calculator - results in Augmented Reality. Surprisingly enough, I don't get many questions during the theory class. It seems that everyone has properly assimilated the concept. Unfortunately, nothing could be further from the truth.

It’s not until the following day, while I’m heldig the practical class, that problems quickly arise. These obstacles fill the atmosphere with frustration and despair, reminding me exactly what I felt when I first started studying and using depth of field.

Most of the students start to realize how their creativity is limited by the incapacity of shooting the desired level of depth of field. This is mainly due to two causes:

- They have not properly internalized the concept.
- The limitations of their own equipment, in most cases a basic DSLR camera with a 18-55mm f/3.5-5.6 kit.

Usually, the top six problems with depth of field are:

- When shooting portraits, most students fail to separate the subject from the background. They cannot blur enough the background elements to get the desired shallow depth of field.
- When shooting landscapes, they typically fail to get everything sharp. “Why do I get the mountains (or the stars) blurred?” - they ask. They are reluctant to use the hyperfocal distance, so they pick small apertures (f/16, f/22) to maximize depth of field. Neglecting that, when shooting with a wide angle lens (10mm to 35mm), focusing at the hyperfocal distance is the easiest way to maximize depth of field.
- Also, most students don’t know how to focus at the hyperfocal distance. They try to focus the lens at the exact number the hyperfocal table pops out, falling short most of the time. Keep this in mind, don’t fall short otherwise you’ll get an image with the subjects on the horizon out of focus. Make sure you focus at a slightly longer distance than the hyperfocal distance and you’ll get background elements (e.g. the stars) in sharp focus. It will work every time you try it!
- Students realize that their basic equipment puts a limit to their creative mind, not allowing them to turn their ideas into real photos.
- Some clearly show that the concept wasn’t understood, mixing up depth of field with focal length, and even with the minimum focus distance. Others mix up the focus distance (subject distance) with the hyperfocal distance.

- Intermediate and advanced photographers don't understand the meaning and practical use of the circle of confusion.

My goal with this step-by-step depth of field tutorial is to help you easily overcome all the difficulties you'll come across when shooting for a desired depth of field, regardless of your level of expertise (beginner, advanced or professional).

After reading it, you will quickly get the creative control over what is in sharp focus in your images, and what is not.

To do so, I'll give you everything you need, from theoretical concepts (depth of field, hyperfocal distance, circle of confusion, etc) to practical tools like PhotoPills app and its free online tools (DoF calculator, hyperfocal distance chart, circle of confusion calculator, diffraction calculator, etc), together with a large number of inspiring images and tips.

In other words, you're about to gain the power to decide how much depth of field you want and where you want it, so you can reach the highest level of self expression through photography. Or like the Masters say, your photos will begin to have a great depth of feeling.

"Look and think before opening the shutter. The heart and mind are the true lens of the camera." - **Yousuf Karsh**

1

Quick answers to depth of field questions

Before I get into detail explaining depth of field, I thought that, for those of you that are looking for fast answers, it would be more useful to start with this question-answer summary:

What's depth of field?

Depth of field (DoF) is the distance between the nearest and furthest elements in a scene that appear to be "acceptably sharp" in an image.

Why should I care?

Mastering depth of field will give you the creative control over what's in sharp focus in your images, turning you into a better storyteller.

Recommend me a few Masters to inspire me

I love the work of theses photographers: Bill Gekas, Utah Barth, Clyde Butcher and Jose B. Ruíz.

What affects depth of field?

Depth of field depends on aperture, focus distance, focal length and circle of confusion (CoC). The latter depends on camera sensor size, final image print size, image viewing distance and viewer's visual acuity.

Produce more DoF: small apertures (f/8-f/22), short focal lengths (10-35mm), longer focus distances, smaller camera sensors (crop).

Produce less DoF: wide apertures (f/1.4-f/5.6), long focal lengths (70-600mm), short focus distances, larger camera sensors (full frame).

Are there any depth of field calculators?

Yes! Feel free to use PhotoPill's online free depth of field charts and calculators. And, if you prefer a depth of field app, check our app PhotoPills. It includes everything you need as a photographer or filmmaker ;)

What’s the circle of confusion (CoC)?

It’s a convention used to establish what we consider to be acceptably sharp in a photo. It’s the maximum diameter (mm) that a blur spot on the camera sensor will be seen as a point (in focus) in the final printed photo. You need to decide its value to calculate depth of field values.

What’s the hyperfocal distance?

When focusing at the hyperfocal distance, everything falling from half of this distance to infinity will be in focus. It depends on aperture, focal length and circle of confusion. It does not depend on focus distance (subject distance).

What’s the practical use of the hyperfocal distance?

The hyperfocal distance is commonly used in landscape and night photography to maximize depth of field when shooting with a wide angle lens (10-35mm).

How to focus at the hyperfocal distance?

Focusing the lens at exactly the hyperfocal distance is very difficult. Sometimes, it’s not even necessary. Once you’ve calculated the hyperfocal distance, make sure you focus the lens at a distance that is a little bit longer (2-3ft - 0.5-1m) than the hyperfocal distance. If you focus at a shorter distance than the hyperfocal distance, even by an inch (2.5cm), the subjects at the horizon (e.g. stars) won’t be in focus!

What’s the setting most commonly used to control depth of field?

Aperture! Why? Because it’s the easiest way to achieve the depth of field you need. Use wider apertures to reduce DoF and smaller ones to increase it. But, it’s not always possible to choose an aperture based on a depth of field criteria.

Depending on the photo, there will be other factors that will limit your aperture choice. For example, in wildlife photography, when shooting an animal in motion, you’ll need to take into account shutter speed and ISO, if you want to freeze the movement and get an image correctly exposed.

How to shoot for deep depth of field when using a wide angle lens (10-35mm)?

Once you've decided the focal length and aperture, focus the lens at the hyperfocal distance, always making sure that you're not falling short. It's better to focus a little bit further than the hyperfocal distance. This will ensure that everything at the horizon is in focus. Falling short will blur all the elements at the horizon (mountains, stars, etc).

How to shoot for deep depth of field when using a long focal length (70mm or larger)?

Get further from the subject, use small apertures (f/8, f/11, f/16) and focus the lens about a third of the way into the frame.

How to shoot for shallow depth of field?

Decide the amount of depth of field you need and get close to the subject, use wide apertures (f/1.4-f/5.6) and long focal lengths (from 70mm or larger). Finally, focus the lens on the part of the subject you want to direct the viewer's attention.

Shooting with a full frame camera will also produce a shallower depth of field than shooting with a cropped one.

Should I always shoot with small apertures (f/11-f/22) to maximize depth of field?

No! Why? Because diffraction will decrease the resolution of your photography and thus will reduce sharpness. Diffraction puts a limit to the aperture choice.

What is diffraction?

Diffraction is the result of light dispersion caused by the edges of the diaphragm blades in the lens. The smaller the aperture the more light rays are scattered, and more negatively will the photo be affected.

What's the depth of field preview button?

It's the camera button that reduces the lens aperture to the set value giving you a preview of the image area(s) that will be sharp. I don't really use it!

Does the typical DoF calculator work for macro photography?

No! You need to take into account magnification. Use our macro depth of field calculator.

What lenses do you recommend for macro photography?

The following ones are great: Nikon Micro-60mm f/2.8G, Tamron Macro 90mm f/2.8, Canon Macro 100m f/2.8L, Olympus Macro 60mm f/2.8, Nikon Micro 105mm f/2.8G, Sigma Macro 150mm f/2.8 and Nikon Micro 200mm f/4D.

What's bokeh?

Bokeh is the Japanese word for "blur". In photography, it is used to describe the quality of the blur produced in the out of focus areas of an image produced by a lens. Bokeh and shallow depth of field are not the same.

What lenses give me a good bokeh?

Lenses that will give you great bokeh: Nikon 85mm f/1.4, Canon 24-70mm f/2.8, Nikon 28-70mm f/2.8 and the Nikon 24-70mm f/2.8, Nikon 135mm f/2 DC, Nikon 200mm f/2 VR and the Canon 200mm f/2 IS.

Lenses that will give you bad bokeh: Nikon 50mm f/1.4 AF-D, Canon 50mm f/1.4, Nikon 18-105mm f/3.5-5.6 and Canon 24-105mm f/4.

How do I shoot a nice bokeh?

Use a long focal length (50mm or more). Select a wide aperture (f/1.4, f/1.8, f/2.8). Get close to the subject. Focus the lens on the subject you want to be sharp. Put your subject far from the background that you want blurred out. Make sure that there are small background highlights, such as specular reflections or light sources (artificial or natural).

If you don't find an answer here, you'll find it in the following sections. But if you still have a question, please, feel free to use the "Comments" area at the bottom of this article to ask us!

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Inspiring depth of field examples

Nikon D4s | 85mm | f/1.4 |1/60s | ISO 100 | 2350K | Focus on Mar's fingertips: 4.92ft (1.5 m) | In Focus from 4.88ft (1.49m) to 4.95ft (1.51m) | Total DoF: 0.07ft (0.02m) | DoF in front: 50% (0.035ft - 0.01m) | DoF behind: 50% (0.035ft - 0.01m)

"What uses having a great depth of field, if there is not an adequate depth of feeling?" - **William Eugene Smith**

It's all about depth of feeling! William Eugene Smith wisely reminds us that depth of field by itself is just another tool more at our service.

However, it can be a pretty useless one if you don't know how to put it to creative use. Let's face it, at the end of the day, what will really make your photos stand out from the crowd is your creative mind: the idea, the message, the story you're willing to tell.

So, depth of field is a great tool that you can use to turn your thoughts into real stunning pictures. Internalize the concept, learn it and I promise that by controlling the area(s) of your images that are sharp you'll become a great storyteller and, thus, a better communicator.

But, before we plunge ourselves into the exciting universe of depth of field, let me share a few examples with you... seeking inspiration.

By having a closer look at these depth of field examples, you'll get an idea of both "where to focus" and "what settings to use" depending on the type of photography and goal you have in mind.

Deep depth of field examples

Sometimes, you'll want to maximize depth of field in order to keep everything sharp. A classic example is when you're photographing the Milky Way, where you typically want to capture detail from the foreground to the horizon while capturing stars as big bright spots. Commonly, you'll use deep depth of field when photographing landscapes (daytime and at night), seascapes, cityscapes and architecture.

The good news is that, as I'll explain in detail in this tutorial, if you're shooting with a wide angle lens (10-35 mm), you just need to focus at the hyperfocal distance to maximize depth of field.

On the contrary, in landscape photography, when you're using a telephoto lens (200mm, 300mm, 500mm), the hyperfocal distance is so large that you cannot focus at it. Since you'll be using small apertures (f/11, f/16, etc) to maximize depth of field, the rule of the thumb is to focus about a third of the way into the frame. This trick works because when you are using these small apertures and long focal lengths, depth of field usually is distributed 1/3 (33.33%) in front of the focus point and 2/3 (66.66%) behind it. Make sure you're not focusing at infinity, because you'll get blur in the foreground.

Nikon D700 | 14mm | f/2.8 | 30s | ISO 3200 | 3500K | Focus at hyperfocal distance: 7.6ft (2.32 m) | In Focus from 3.8ft (1.16m) to ∞ | Total DoF: ∞ | DoF in front: 3.8ft (1.16m) | DoF behind: ∞

This photo is related to seamen stories and legends. I tried to connect Heaven and Hell with a stair made of stars. Focusing at the hyperfocal distance was essential to maximize depth of field. If you want to know what inspired me and how I took it, take a look at the article "How To Shoot Truly Contagious Milky Way Pictures".

Later on in this tutorial, I'll explain that focusing at a distance larger than the hyperfocal distance ensures that the depth of field far limit stays at infinity. Thus, all the elements in the horizon or further away will be in sharp focus (e.g. stars). The only downside is that you lose depth of field in front of the focus plane.

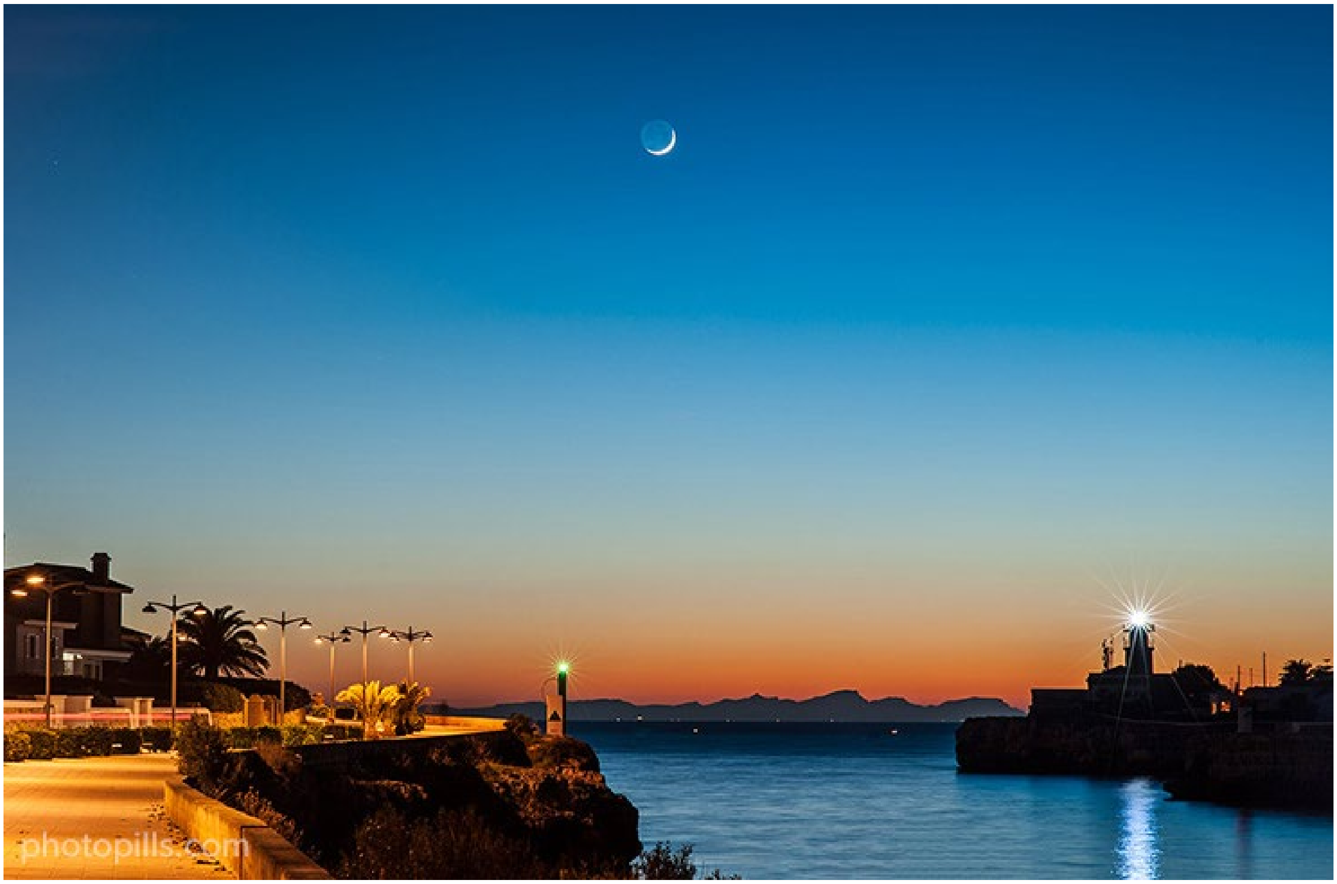
Fujifilm X100 | 23mm | f/11 | 1/80s | ISO 200 | 3500K | Focus at hyperfocal distance: 7.74ft (2.36 m) | In Focus from 3.87ft (1.18m) to ∞ | Total DoF: ∞ | DoF in front: 3.87ft (1.18m) | DoF behind: ∞

In 2012, a very rare phenomenon took place in Menorca: it snowed! This photo shows the white landscape and, in the background, El Toro – our highest hill.

Nikon D700 | 35mm | f/8 | 110s | ISO 200 | 5000K | Focus on the main rock: 65.6ft (20 mts) | In Focus from 13.35ft (4.07m) to ∞ | Total DoF: ∞ | DoF in front: 52.25ft (15.93m) | DoF behind: ∞

This image was taken during a photographic session with my friend and master José Benito Ruiz. Twenty minutes prior to this shot, the sky was flat with no clouds. Nothing presaged the twilight of lights and colors that we enjoyed minutes later. Once again, Ansel Adams was on our side.

The reason I didn't focus at the hyperfocal distance is because I didn't have any interesting foreground or background elements in the frame. Since the rocks were at a distance larger than the hyperfocal distance (16.86 ft - 5.14m), the easiest thing to do in this case was to directly focus on the main rock.



Nikon D700 | 85mm | f/13 | 30s | ISO 200 | 3550K | Focus at hyperfocal distance: 62.5ft (19.05m) | In Focus from 31.25ft (9.52m) to ∞ | Total DoF: ∞ | DoF in front: 31.25ft (9.52m) | DoF behind: ∞

Ciutadella de Menorca, the village where I live is pure magic. The image above includes streetlights, lighthouses, the moon and, at the horizon, Mallorca, the biggest piece of land in the Balearic Islands, to complete a great scene during the blue hour.

Nikon D700 | 24mm | f/11 | 1/125s | ISO 200 | 4600K | Focus at hyperfocal distance: 5.64ft (1.72m) | In Focus from 2.82ft (0.86m) to ∞ | Total DoF: ∞ | DoF in front: 2.82ft (0.86m) | DoF behind: ∞

The roof of the Cathedral of Ciutadella is a unique place. As it is unique to live a sunset from such a privileged position above the village. Again, focusing at the hyperfocal distance allowed me to have everything in focus, from the roof adornment located in the foreground to the sun.

Nikon D700 | 14mm | f/2.8 | 30s | ISO 3200 | 3050K | Focus at hyperfocal distance: 7.6ft (2.32 m) | In Focus from 3.8ft (1.16m) to ∞ | Total DoF: ∞ | DoF in front: 3.8ft (1.16m) | DoF behind: ∞

After a PhotoPills' nightscape, It's always a good idea to take a photo of the team: Germán (the Architect), Joan (the Rock Star), Rafael (the Bard) and myself with the glorious Milky Way crossing the sky. For obvious reasons, you'll notice that it was taken after shooting a Star Wars Tribute.

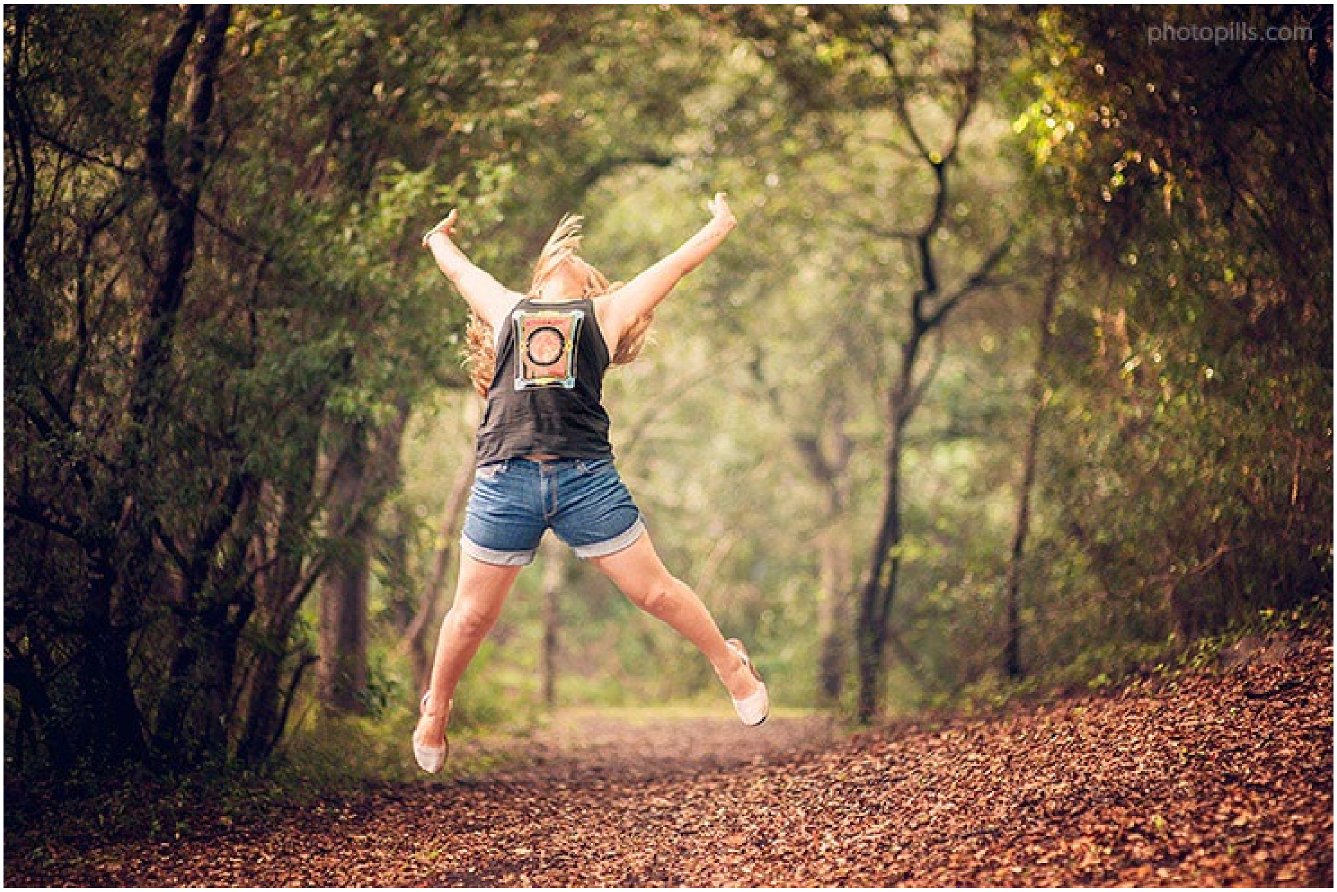
Shallow depth of field examples

Sometimes, you'd rather to use a shallow depth of field to direct the viewer's attention to a specific area in order to separate your subject from a busy background. This is very common in portraits. But it also comes very handy when shooting landscapes, street photography, products, events, close-ups and macro photography.

To obtain a shallow depth of field you'll generally get closer to the subject, focus on the part of the subject that you want to be perfectly sharp and use large focal lengths (from 70mm) with wide apertures (f/1.4-f/5.6).

Nikon D700 | 85mm | f/1.4 | 1/350s | ISO 200 | 4113K | Focus on Júlia's left eye: 6.56ft (2m) | In Focus from 6.49ft (1.98m) to 6.63ft (2.02m) | Total DoF: 0.14ft (0.04m) | DoF in front: 50% (0.07ft - 0.02m) | DoF behind: 50% (0.07ft - 0.02m)

I shot this picture outside, where the light was enhanced with a golden reflector. The focus is precisely placed on Júlia's left eye (on my right hand side). Consequently, all the attention is directed to the eye, which is placed right in the center of the image. I didn't follow any rule, but I made sure sure the eye's line was placed at one third from the top of the frame.



Nikon D700 | 85mm | f/1.4 | 1/125s | ISO 1250 | 3000K | Focus on Anna's chest: 26.24ft (8m) | In Focus from 25.06ft (7.64m) to 27.52ft (8.39m) | Total DoF: 2.46ft (0.75m) | DoF in front: 47.68% (1.18ft - 0.36m) | DoF behind: 52.32% (1.28ft - 0.39m)

Both, happiness and the beautiful background bokeh seems to hold Anna in the air. The forest brings so many fantastic opportunities to shoot portraits. Take advantage of it!

Nikon D700 | 85mm | f/2 | 1/10s | ISO 400 | 5627K | Focus on a person in the middle of the group: 26.24ft (8m) | In Focus from 24.64ft (7.51m) to 28.08ft (8.56m) | Total DoF: 3.44ft (1.06m) | DoF in front: 47% (1.60ft - 0.49m) | DoF behind: 53% (1.84ft - 0.56m)

A rainy forest and my brave students. What else can you ask for?

Nikon D700 | 500mm | f/8 | 1/500s | ISO 200 | 5700K | Focus on the eye of the bee-eater: 32.80ft (10m) | In Focus from 32.51ft (9.91m) to 33.10ft (10.09m) | Total DoF: 0.59ft (0.18m) | DoF in front: 50% (0.29ft - 0.09m) | DoF behind: 50% (0.29ft - 0.09m)

This image is the result of a great photo session with the bee-eater (Merops apiaster) in one of Menorca's breeding colonies. In wildlife photography, you must focus very precisely because long focal lengths produce a very shallow depth of field. The photo was taken from inside a hide. The colors and beauty of the plumage of these birds makes photography an art.

I was able to close the aperture because the bee-eater was staying still, which in turn allowed me to have the whole bird in focus!

Nikon D700 | 500mm | f/5.6 | 1/1500s | ISO 800| 5700K | Focus on the eye of the Buzzard: 65.51ft (20m) | In Focus from 64.76ft (19.74m) to 66.50ft (20.27m) | Total DoF: 1.74ft (0.53m) | DoF in front: 49.34% (0.75ft - 0.26m) | DoF behind: 50.66% (0.99ft - 0.27m)

As opposed to the previous picture, this one was taken while the Buzzard (Buteo buteo) was in motion. I had to widen the aperture a little bit to reduce shutter speed and, thus, freeze the bird. A few seconds before I was shooting with my Nikon D300s with a 1.4x teleconverter attached to my 500mm lens. As I saw that the bird was approaching me, I decided to switch to my Nikon D700 and 500mm lens. Notice that I didn't crop the photo, so changing the gear was a great decision. I was pretty lucky!

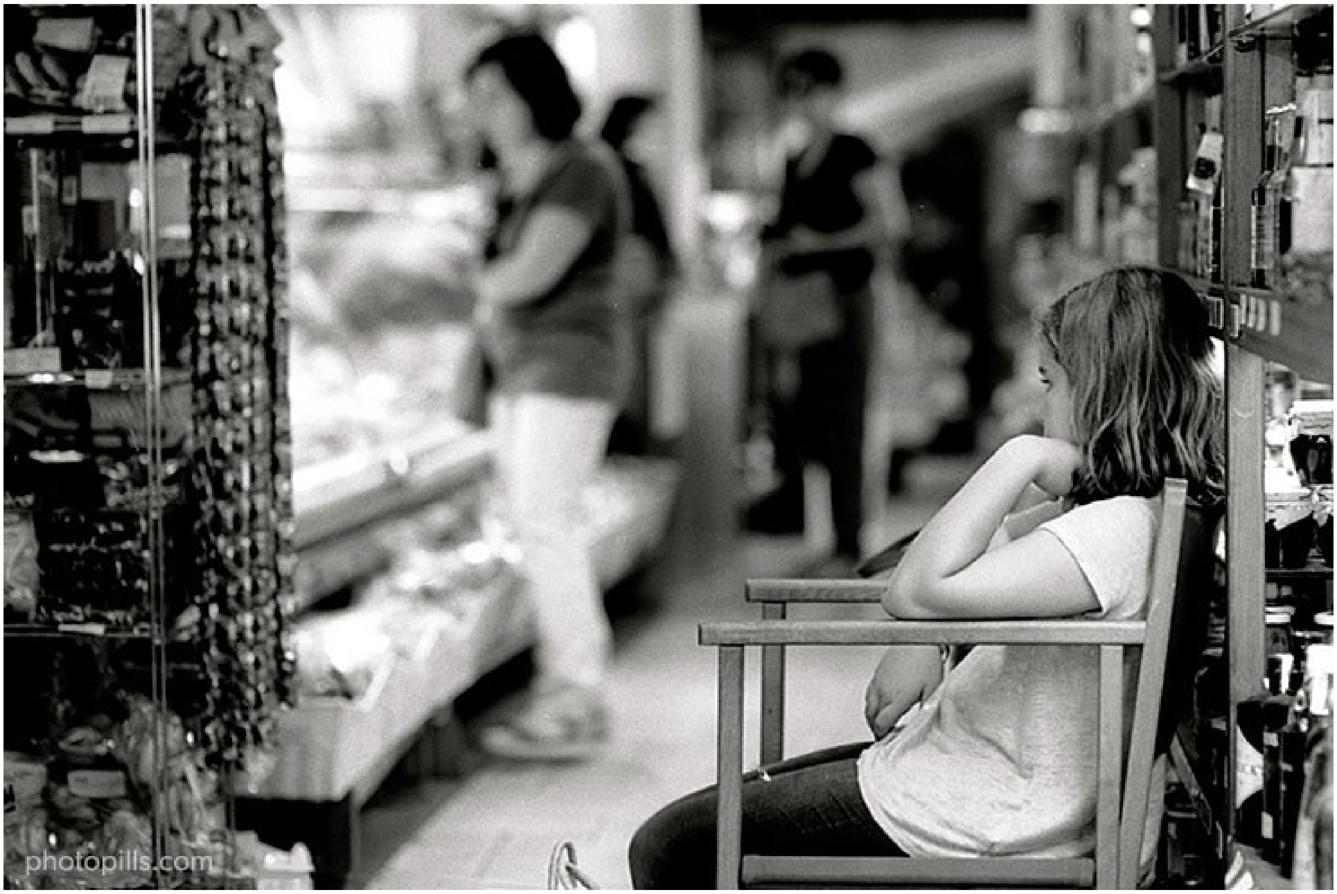
Nikon D7100 | 500mm | f/8 | 1/40s | ISO 200 | 6850K | Panorama of 11 pictures (portrait). In every picture, the lens was focused on the rocks to keep them in focus.

By stitching 11 pictures with little depth of field, you can create a panorama where the overall depth of field is quite considerable. Using the technique of focus stacking to create beautiful panoramas is another way to control the areas of the image you want to be sharp.

Nikon D700 | 85mm | f/1.4 | 1/125s | ISO 200 | 5000K | Focus on Aina's eyes: 13.12ft (4m) | In Focus from 12.82ft (3.91m) to 13.42ft (4.09m) | Total DoF: 0.60ft (0.18m) | DoF in front: 50% (0.30ft - 0.09m) | DoF behind: 50% (0.30ft - 0.09m)

You should try sometime the Brenizer method (Ryan Brenizer). This method consists in creating portraits by shooting several pictures with the same depth of field using a fast telephoto lens to finally build a panorama.

As you look at it, you have the impression that the image had been taken using a wide angle lens but with little depth of field. This photo is the result of 57 frames stitched together with the software PTGui Pro. The hardest part of the job was for Aina, my little daughter, who had to stay the whole session without moving.



Nikon Fm2n | 85mm | f/2 | 1/350s | ISO 400 | Kodak Tri-X 400 film | Focus on Aina's head: 9.84ft (3m) | In Focus from 9.59ft (2.925m) to 10.08ft (3.075m) | Total DoF: 0.49ft (0.15m) | DoF in front: 50% (0.245ft - 0.075m) | DoF behind: 50% (0.245ft - 0.075m)

From time to time, I like to detox from the digital system using my film cameras. I still keep in perfect conditions my first Olympus OM-10, a Yashica mat 124-G, a few Polaroid Land and my preferred Fm2n. All of them still work perfectly well! In the picture you see, Aina is sitting on a chair, waiting for her mother while she's shopping. Without a doubt, the grain from analogic cameras is unbeatable, artistically speaking.

Nikon D700 | 85mm | f/2.0 | 1/500s | ISO 200 | 5700K | Focus on the bottle: 13.12ft (4m) In Focus from 12.71ft (3.87m) to 13.56ft (4.13m) | Total DoF: 0.85ft (0.26m) | DoF in front: 48.37% (0.41ft - 0.13m) | DoF behind: 56.31% (0.44ft - 0.13m)

This picture was taken during a traditional slaughter of pigs in a small village in Mallorca. A raging backlight of the rising sun impacted the scene outlining the butcher’s silhouette. The product in the foreground is a typical spirit from Mallorca.

Nikon D700 | 500mm | f/5.6 | 1/10s | ISO 400| 5600K | Focus on the head of the first racing horse: 442ft (135m) | In Focus from 405ft (127.71m) to 486ft (148.56m) | Total DoF: 81.22ft (24.86m) | DoF in front: 45% (36.91ft - 11.29m) | DoF behind: 54% (44.31ft - 13.56m)

Sant Joan is one of the best traditional festivals in the world. Celebrated in Ciutadella at the end of June, it includes the popular horse races. The horses and riders run among the crowd, making it an incredibly dangerous moment for both the riders and spectators. Here, I shaked the camera to give a sense of speed to the image. Learn more about this great festival reading "**Dreaming of Sant Joan**".

Nikon D300s | 200mm | f/4.0 | 1/500s | ISO 200 | 6600K | Focus on the statue: 49ft (15 m)| In Focus from 47.60ft (14.57m) to 50.49ft (15.46m) | Total DoF: 2.89ft (0.89m) | DoF in front: 48.53% (1.40ft - 0.43m) | DoF behind: 51.47% (1.49ft - 0.46m)

Two emblematic buildings of my village gave me the opportunity to play with my 80-200mm lens. In this image the façade of the City Hall is blurred becoming the ideal background for the famous statue placed on top of the manor house Torre-Saura. Both details melt together in the frame.

Nikon D4s | 105mm | f/4.0 | 1/500s | ISO 800 | 5500K | Extension rings 20mm + 36mm | Focus on the eyes of the water snake: 4 metres

Occasionally, when you least expect it, nature offers you a great scene. This water snake was quietly resting in a cattle trough in a nearby oak grove. After 10 minutes of "trial and error", it allowed me to focus on its eyes and I managed take this picture.

Nikon D700 | 24mm inverted| f/8.0 | 1/20s | ISO 400 | 5500K | Focus on the right-hand side stamen

Shooting macro photography with the reverse lens technique can become an addiction: abstraction to create art. In this case, I was able to reach a rate of magnification of 4:1 using a Cosina wide-angle with a lens reversing ring.

Of course, these are just a few examples of depth of field practical use. Feel free to apply it to any type of photography and situation you desire… Just be as much creative as possible!

Now that you have an idea about the results you can get applying depth of field, it's time to dig deeper into the concept itself.

Are you ready? Take a deep breath and dive deep.

3

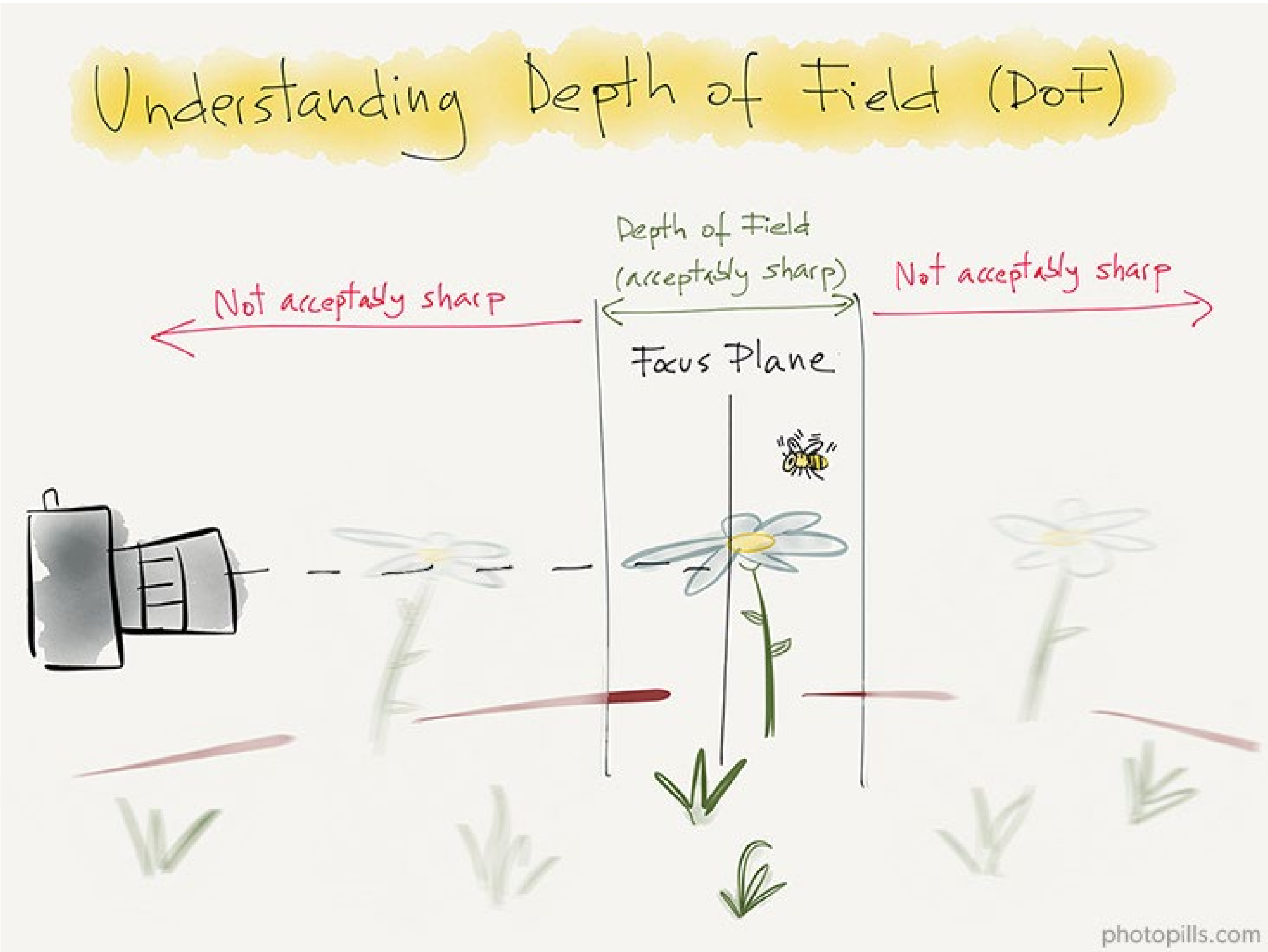
What is depth of field?

Nikon D300s | 105mm | f/3 | 1/6000s | ISO 200 | 4700K | Focus on the eyes of the hoverfly: 1ft (0.30 m)

Due to the fact that a camera can precisely focus the lens at only one distance at a time, sharpness gradually decreases on each side of the focused distance or, if you prefer, the plane of focus (PoF).

Depth of field definition

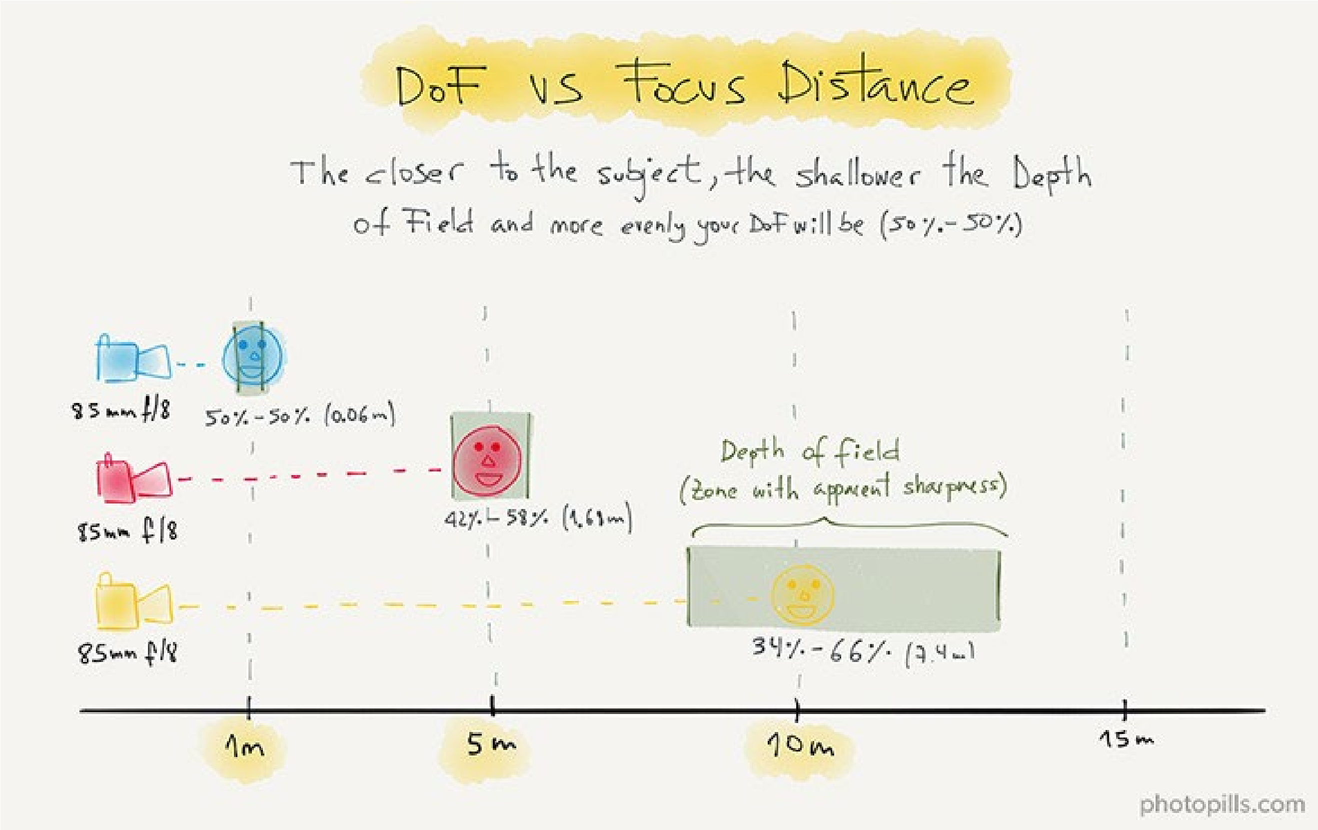
As a result, depth of field (DoF) is the distance between the nearest and furthest elements in a scene that appear to be "acceptably sharp" in an image.



The distance between the camera and the first element that is considered to be acceptably sharp is called DoF near limit. Similarly, the distance between the camera and the furthest element that is considered to be acceptably sharp is called DoF far limit. Notice that the limits of depth of field are not hard boundaries between sharp and unsharp since defocus is produced gradually.

Depth of field is not equally distributed in front (near) and behind (far) your focus point. Usually, the far DoF is larger than the near DoF.

For a given focal length, the nearer you focus the more evenly distributed your DoF will be (50%-50%). On the contrary, the furthest you focus the less evenly distributed.



In similar fashion, for a given focus distance, a telephoto lens will give you a more evenly distributed DoF than a wide angle lens.

Depending on the settings used for the shot, the area that is considered to be acceptably sharp in your image can go from less than a millimeter (Macro Photography) to kilometers, and even to infinity (Landscape or Astrophotography).

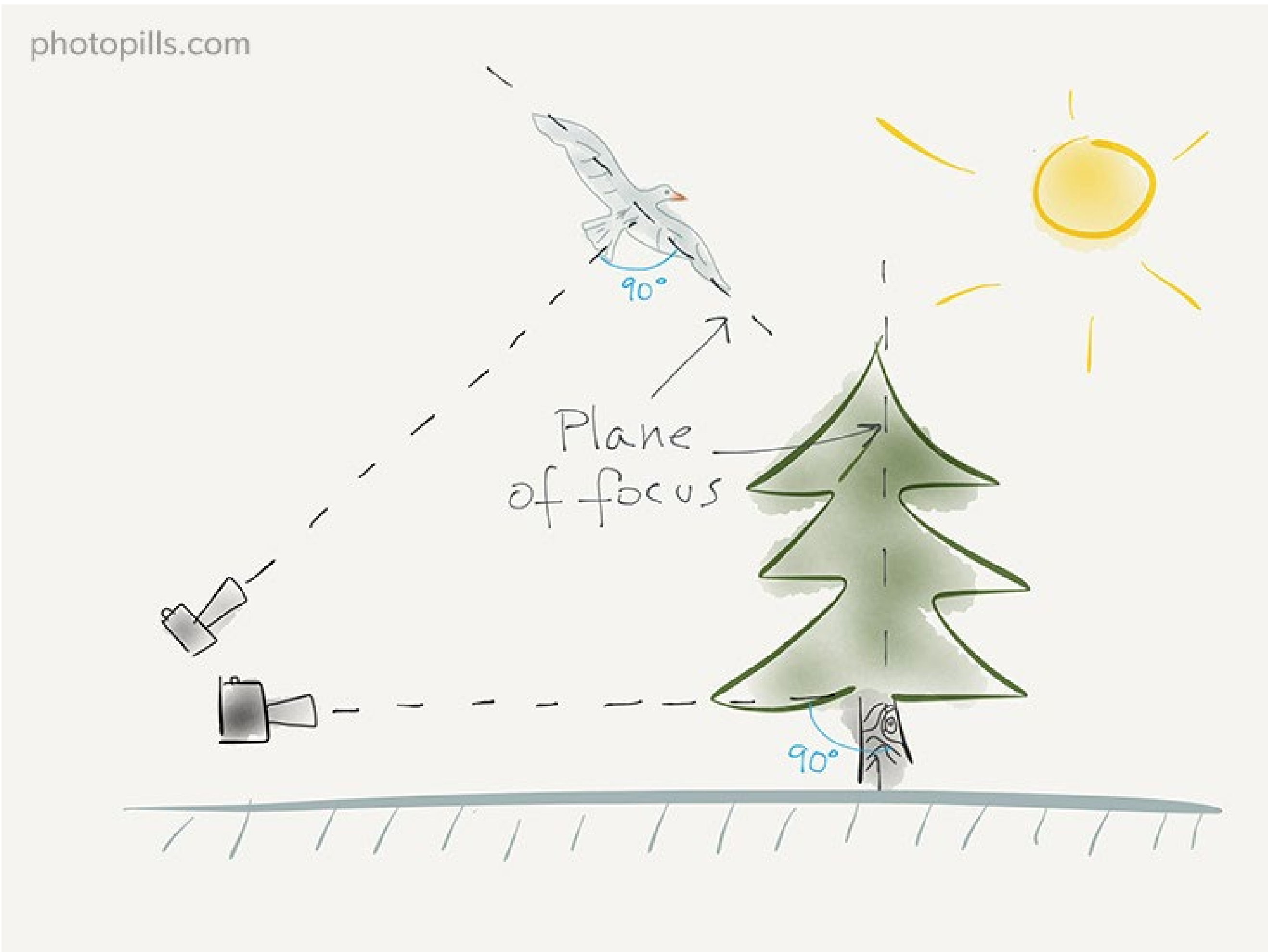
This last infinite depth of field situation occurs when you focus the lens at what is called the hyperfocal distance or at any distance larger than the hyperfocal distance.

In section 4, I'll explain in detail the hyperfocal distance and its applications. You'll see that knowing the hyperfocal distance is very useful to maximize depth of field when shooting a landscape with a wide angle lens (14mm-35mm).

An interesting depth of field fact

There is a DoF fact to which I specially want you to pay attention. I believe that it'll help you better understand depth of field and its creative use:

"The plane of focus is perpendicular to the shooting direction"



Ok, Ok... I know, this seems obvious, but you can take advantage of it in a creative way.

Have a look at the following portrait. It belongs to one of my personal projects called "Woman, Mixed Emotions".

Nikon D4s | 85mm | f/1.4 | 1/500s | ISO 320 | 3951K | Focused on Maria's eyes: 4.92ft (1.5m) | In Focus from 4.88ft (1.49m) to 4.96ft (1.52m) | Total DoF: 0.08ft (0.02m) | DoF in front: 49% (0.04ft - 0.01m) | DoF behind: 50% (0.04ft - 0.01m)

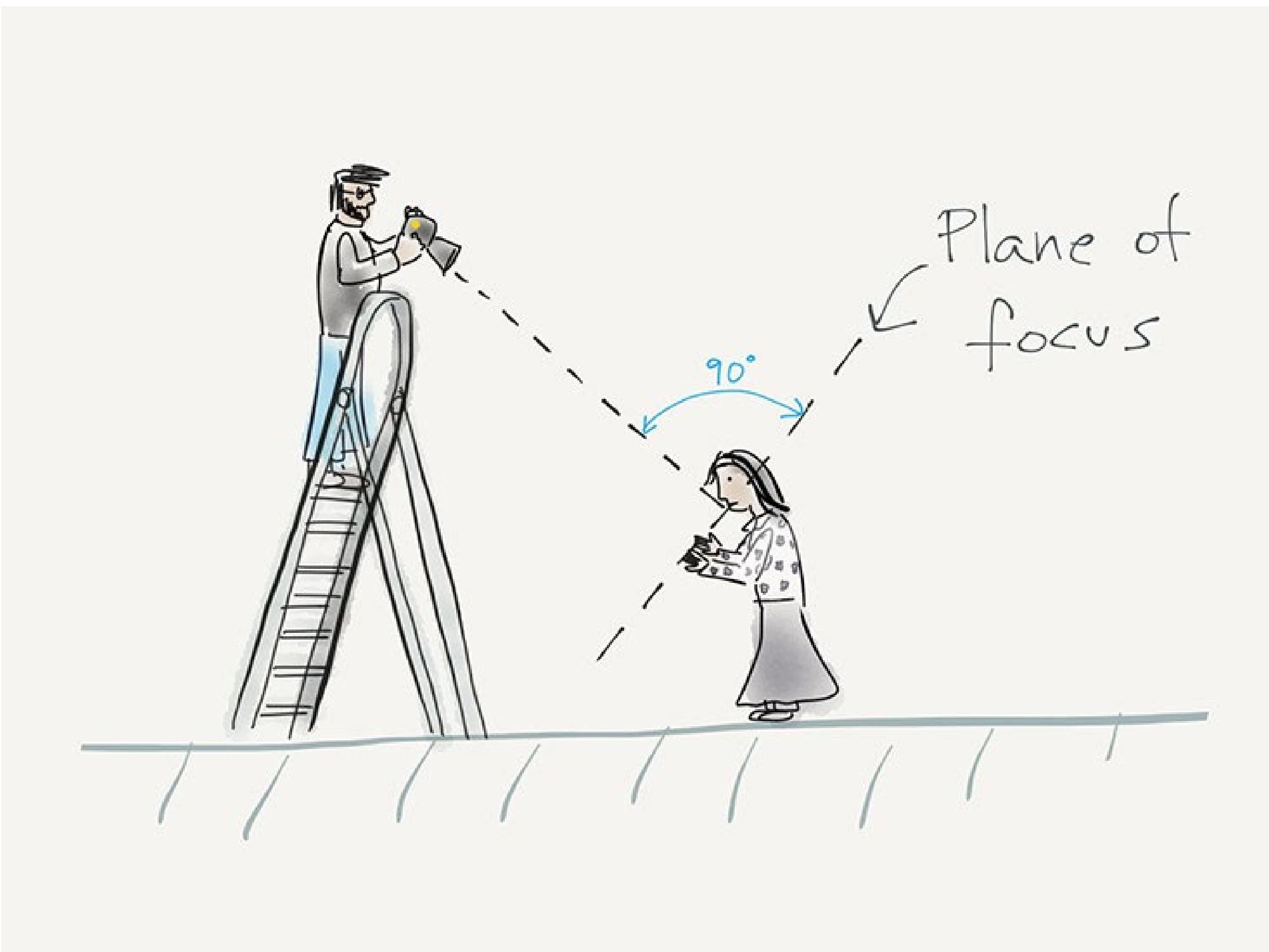
This work goes far beyond any historical moment, any geographical spot and any role that has been attributed to women by society. The viewer is lead through a visual intimate path to finally discover the deepest emotions that dwell in our women.

This picture represents the beginning of a terrible disease: cancer. It immortalizes the very first moment Maria, now totally recovered, looked at her falling hair and realized that her life would turn into a real nightmare. She was suffering but also pulling all her strength and energy to fight back the disease.

To tell Maria's story, the challenge was that I needed both Maria's face and hands to be in the plane of focus (in sharp focus). At the same time I wanted the body, where her cancer was growing, completely out of focus. How did I take it?

First, I used a subject distance (focus distance) of 4.92 ft (1.5m), a focal length of 85mm and an aperture of f/1.4 to minimize my depth of field. Then, I asked Maria to separate her hands from the body. I climbed on top of a ladder and focused the lens on Maria's eyes. Finally, I shot in a direction perpendicular to the plane formed by Maria's face and hands, getting both in sharp focus (in the plane of focus).

The following picture is the illustration of how depth of field worked for me that day.



The Focus plane is perpendicular to the shooting direction. Take advantage of it in a creative way.

With this simple example, I also want to point out that:

"The photo is where it is, not where you are"

So go, move around and find the right shooting position. The right spot is where everything makes sense and where all the elements you need come together in a superb image.

Let's move on!

Depth of field calculator

Depth of field is a function of the camera type (sensor size or film), aperture, focus distance, focal length and the subjective assumptions behind what is considered to be "acceptably sharp", which I'll explain in section 5 (circle of confusion). Depending on the settings and assumptions you use, you'll get a depth of field or another.

The aperture is the setting that beginners typically use to control depth of field. The wider the aperture (smaller f-number f/1.4 to f/4), the shallower the depth of field. On the contrary, the smaller the aperture (large f-number: f/11 to f/22), the deeper the depth of field. However, as you read through this article, you'll find out that other options allow you to make the most out of your depth of field creative decisions, not only by changing the aperture.

Finally, before I explain in detail how each one of these settings influences depth of field and how you can take advantage of it, let me share the link to PhotoPills' depth of field calculator. It'll help you assess which camera settings you require to achieve a desired level of sharpness.

Note: this DoF calculator considers the following hypothesis to define what's "acceptably sharp": given the sensor size, the circle of confusion is calculated assuming a print size of 8"×10" (20cm x 25cm), a viewing distance of 10" (25cm) and the manufacturers standard visual acuity. PhotoPills *includes a depth of field chart and an advanced DoF calculator where you can change these hypothesis to adjust the circle of confusion you need.*

If you prefer to work with a table, here you have PhotoPills' online depth of field chart.

TIPS

- When using this DoF calculator, many of my students mix up the subject distance and the hyperfocal distance. These two distances are the same only when you want to focus at the hyperfocal distance.
- The hyperfocal distance only depends on aperture, focal length, camera sensor and circle of confusion. It does not depend on subject distance (focus distance). So, subject distance is not a field you need to introduce when calculating the hyperfocal distance.
- Just to make it clear, use the calculator to fill in the hyperfocal distance in the subject distance field. You'll see that the far DoF limit is situated at infinity and the near DoF limit is situated at half the hyperfocal distance.

4

How to use the hyperfocal distance

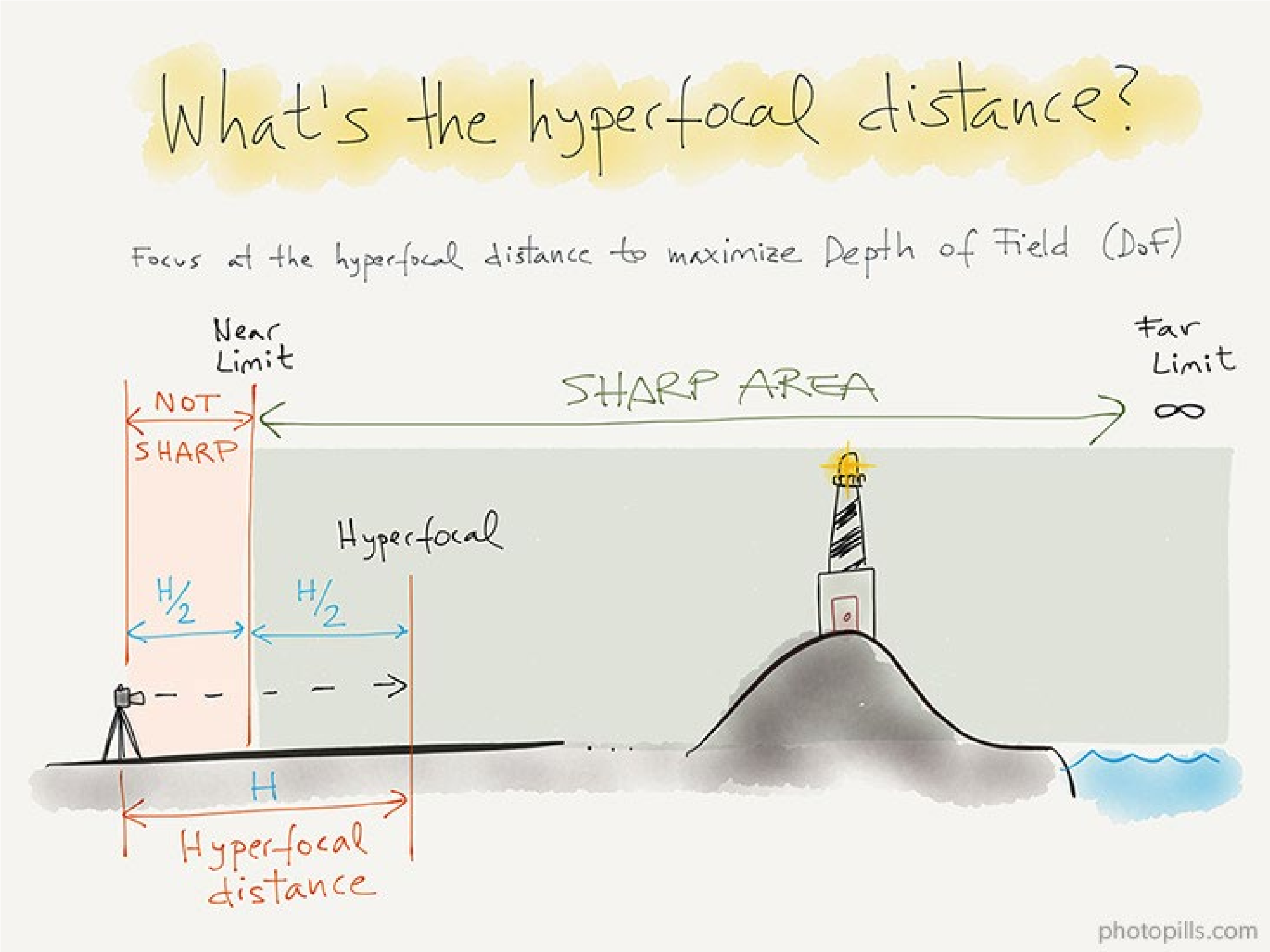
Nikon D4s | 24mm | f/2.8 | 20s | ISO 6400 | 3050 K | Panorama 11 photos | Focus at hyperfocal distance: 22.34ft (6.81m) | In Focus from 11.17ft (3.41m) to infinite | Total DoF: infinite | DoF in front: 11.17ft (3.41m) | DoF behind: infinite

No matter the type of photo you're shooting (landscape, night, seascapes, cityscapes, architecture…), when your goal is to maximize depth of field shooting with a wide angle lens (under 35mm), you just need to follow these steps:

- Use the automatic focus system of your camera to focus at the hyperfocal distance.
- Set back the camera to manual focus.
- Point and shot… that simple!

Hyperfocal distance definition

In other words, when the lens is focused at the hyperfocal distance, everything that falls at any given distance from half of this distance out to infinity will be acceptably sharp, which is the maximum depth of field you can have. Therefore, calculating the hyperfocal distance is a "must" in landscape and night photography essentially.



Notice that if you focus at a distance that is shorter than the hyperfocal distance, the depth of field far limit will not be at infinite. This will result into blurring the elements at the horizon (or furthest background elements like mountains or stars).

In practice, as I explain in the article "**How to shoot truly contagious Milky Way pictures**", focusing exactly at the hyperfocal distance is very difficult. So you need to make sure that you're focusing at a distance that is a bit larger than the hyperfocal. Actually, not much larger, one foot (30cm) will do the job. It's better to have a little bit less depth of field in front of the focus point rather than blurring the background elements.

For example, in night photography, if you focus at a shorter distance than the hyperfocal, the depth of field far limit will not be at infinite, which will blur the stars. By focusing at a slightly larger distance, the depth of field near limit will be a bit further from the camera, but the stars will be perfectly in focus.

Hyperfocal distance table: calculating the hyperfocal distance

The hyperfocal distance depends on the selected aperture, focal length, camera sensor size and circle of confusion assumptions, or what is considered to be "acceptably sharp" (explained in detail in section 5).

"Hey Toni, that's great but, how do you calculate the hyperfocal distance?"

Don't worry about calculations, you don't have to work out the numbers with the hyperfocal distance equations, just use PhotoPills or the following Hyperfocal Distance Chart that works for Nikon, Canon and any other brand (35mm and cropped sensors).

Note: this calculator considers the following hypothesis to define what's "acceptably sharp": given the sensor size, the circle of confusion is calculated assuming a print size of 8"×10" (20cm x 25cm) , a viewing distance of 10" (25cm) and the manufacturers standard visual acuity.

By having a quick look at the hyperfocal distance table we can conclude that:

The shortest the focal length, the shorter the hyperfocal distance and, thus, the more DoF.

The longest the focal length, the larger the hyperfocal distance and, thus, the less DoF.

The smaller the aperture (large f-numbers), the shorter the hyperfocal distance and, thus, the more DoF.

The wider the aperture (small f-numbers), the larger the hyperfocal distance and, thus, the less DoF.

How to focus at the Hyperfocal distance

One of the questions I get the most when shooting the Milky Way with my students is:

"How do I focus at the hyperfocal distance? The hyperfocal distance for my shot is 7.62 ft (2.32 m). I believe that I'm focusing at it, but I don't get the stars in sharp focus. What am I doing wrong?"

It seems that photographers know how to calculate the hyperfocal distance using a DoF calculator or a hyperfocal table, but when it's time to put it to practical use, they fail to get the background elements in focus (for example, the stars).

If this is happening to you, you're surely focusing your lens at a distance slightly shorter than the hyperfocal... Numbers don't lie!

For a full frame Camera, focal length 14mm and aperture f/2.8 the hyperfocal distance is 7.62ft (2.32m). Let's see what happens with depth of field when you focus at a slightly shorter distance 7.12ft (2.17m), at just the hyperfocal distance 7.62ft (2.32m) and at a slightly longer distance 8.12ft (2.47m). Plug the numbers in the DoF calculator to get the following results:

Focus distance	DoF near limit	DoF far limit	Total DoF
7.12ft (2.17m)	3.68ft (1.12m)	107ft (32.57m)	103.32ft (31.45m)
7.62ft (2.32m) Hyperfocal distance	3.81ft (1.16m)	∞	∞
8.12ft (2.47m)	3.93ft (1.20m)	∞	∞

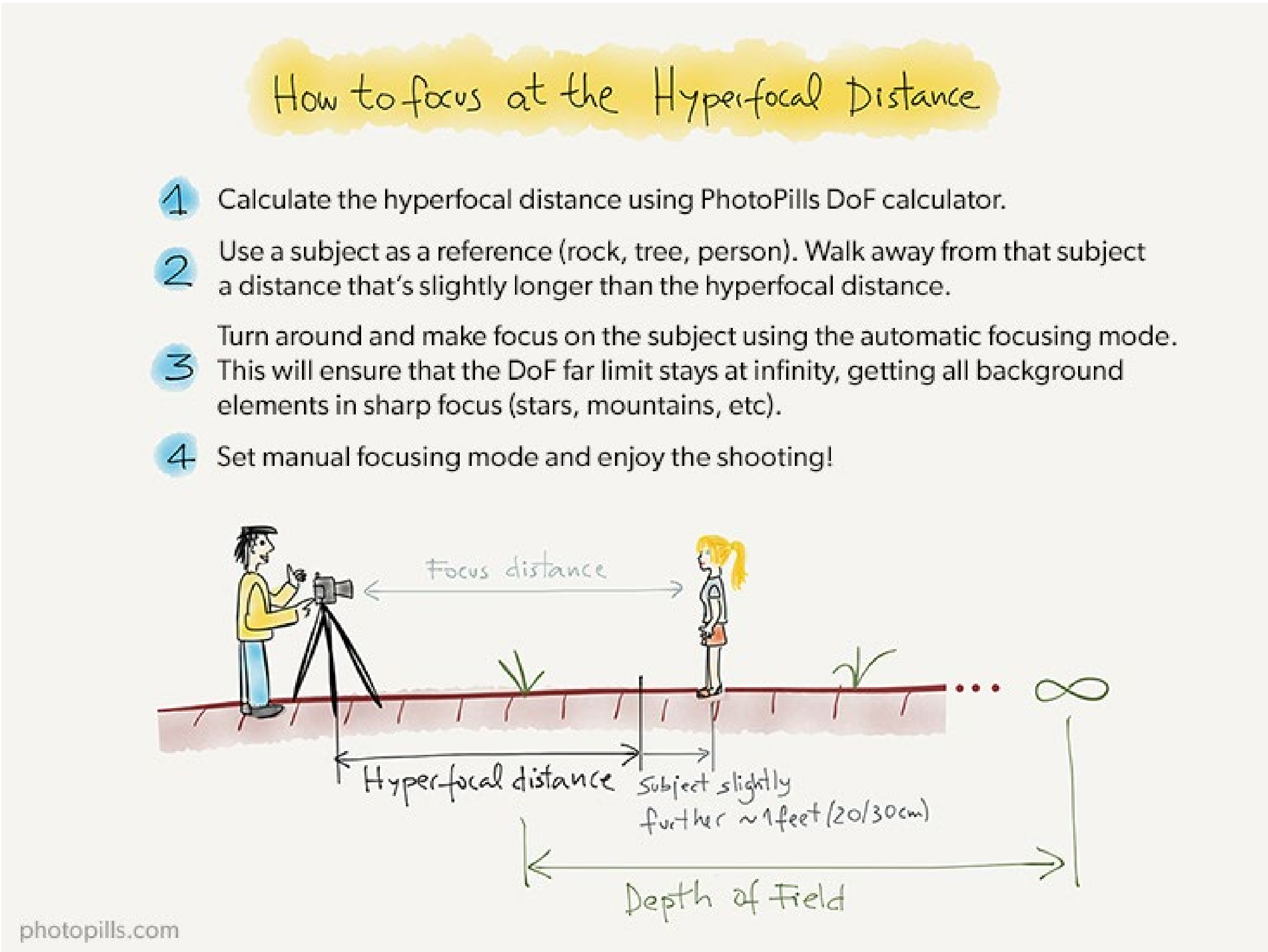
When you're shooting outdoors, focusing exactly at the hyperfocal distance is very difficult. You don't usually measure distances with a ruler when you're in the field. Actually, you don't have to!

The figures from the table above state that if you fall short when focusing at the hyperfocal distance, even by a few inches (a few cm), your DoF far limit will not be at infinity, it'll be much closer. Therefore, you won't get the furthest background elements (stars) in sharp focus.

In this case, when focusing at 7.12ft (2.17m) the DoF far limit is just 107ft (32.57m) away from the camera. Anything beyond this distance will appear to be out of focus in the photo.

On the contrary, if you focus the lens at a distance slightly longer than the hyperfocal distance 8.12ft (2.47m), the DoF far limit will stay at infinity. In other words, you'll get the background elements (e.g. stars) in focus.

In conclusion, if you fail to focus at exactly the hyperfocal distance, make sure you're failing in excess.

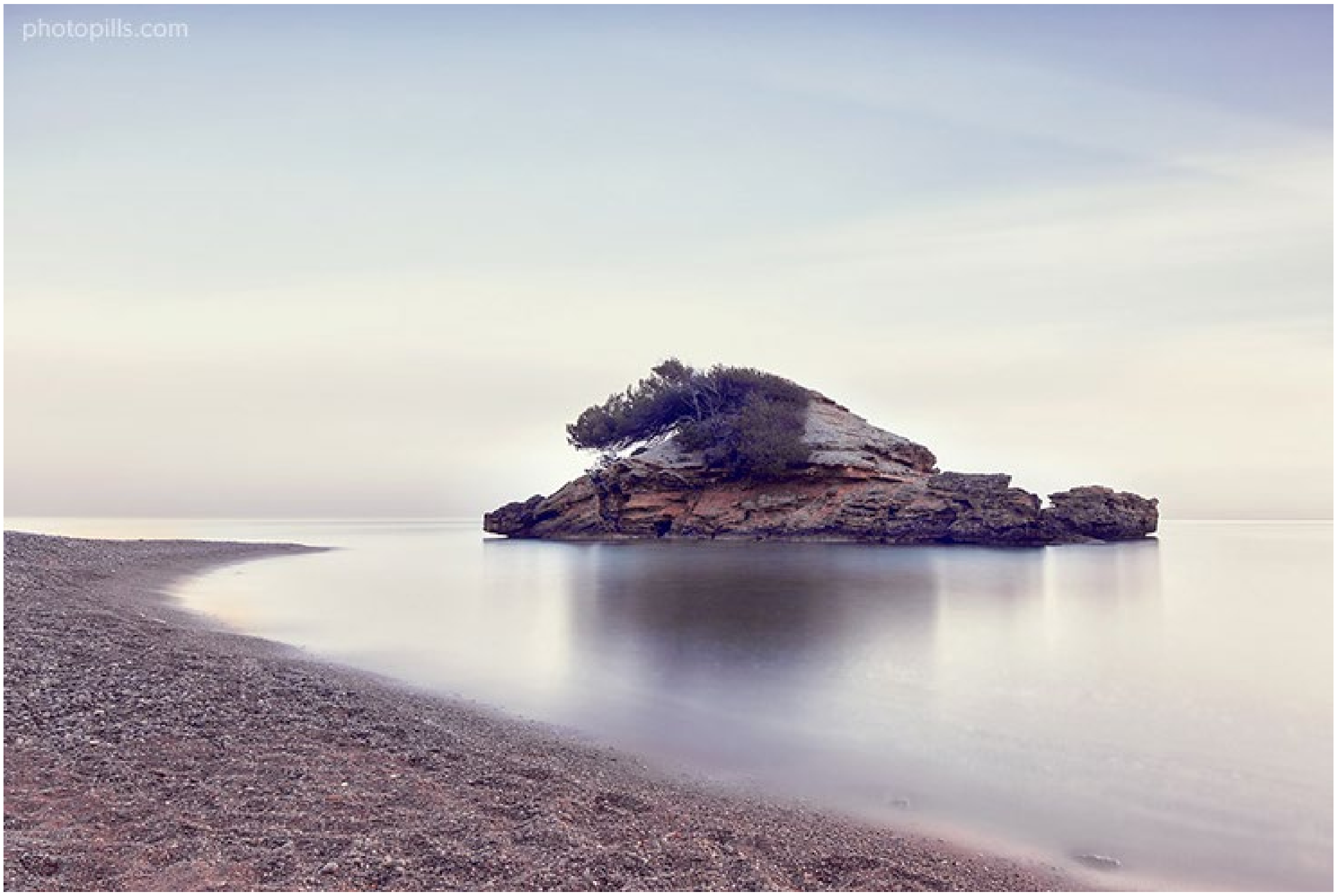


How to focus at the hyperfocal distance, just make sure you're not falling short. Focus at a slightly larger distance!

Have a look at the following video where you can see me focusing at the hyperfocal distance, step by step.

An example: applying the hyperfocal distance

Have a look at the following photo I took using a focal length of 22mm, an aperture of f/11 and my Nikon D4s (full frame). To shoot it, I used the DoF calculator to figure out the hyperfocal distance, which resulted to be 4.75ft (1.45m). Then, I used the automatic focus system of the camera to focus a little bit further than the hyperfocal distance, let's say at 5.24ft (1.60m). Finally, I set back the camera to manual focus, pointed and shot.



Nikon D4s | 22mm | f/11 | 1/216s | ISO 100 | 8046K | Focus a bit further than the hyperfocal distance: 5.24ft (1.60m) | In Focus from 2.62ft (0.76m) to infinite | Total DoF: infinite | DoF in front: 2.62ft (0.76m) | DoF behind: infinite

Here, the augmented reality of PhotoPills' DoF calculator comes in very handy to visualize where the hyperfocal distance lays.

TIPS

- When using the DoF calculator, many of my students mix up the subject distance (focus distance) and the hyperfocal distance. These two distances are the same only when you want to focus at the hyperfocal distance.
- Hyperfocal distance depends on aperture, focal length, camera sensor and circle of confusion only. It does not depend on subject distance. So, subject distance is not a field you need to fill in when calculating the hyperfocal distance.
- Just to make it clear, use the calculator to fill in the hyperfocal distance in the subject distance field. You'll see that the far DoF limit is situated at infinity and the near DoF limit is situated at half the hyperfocal distance.

5

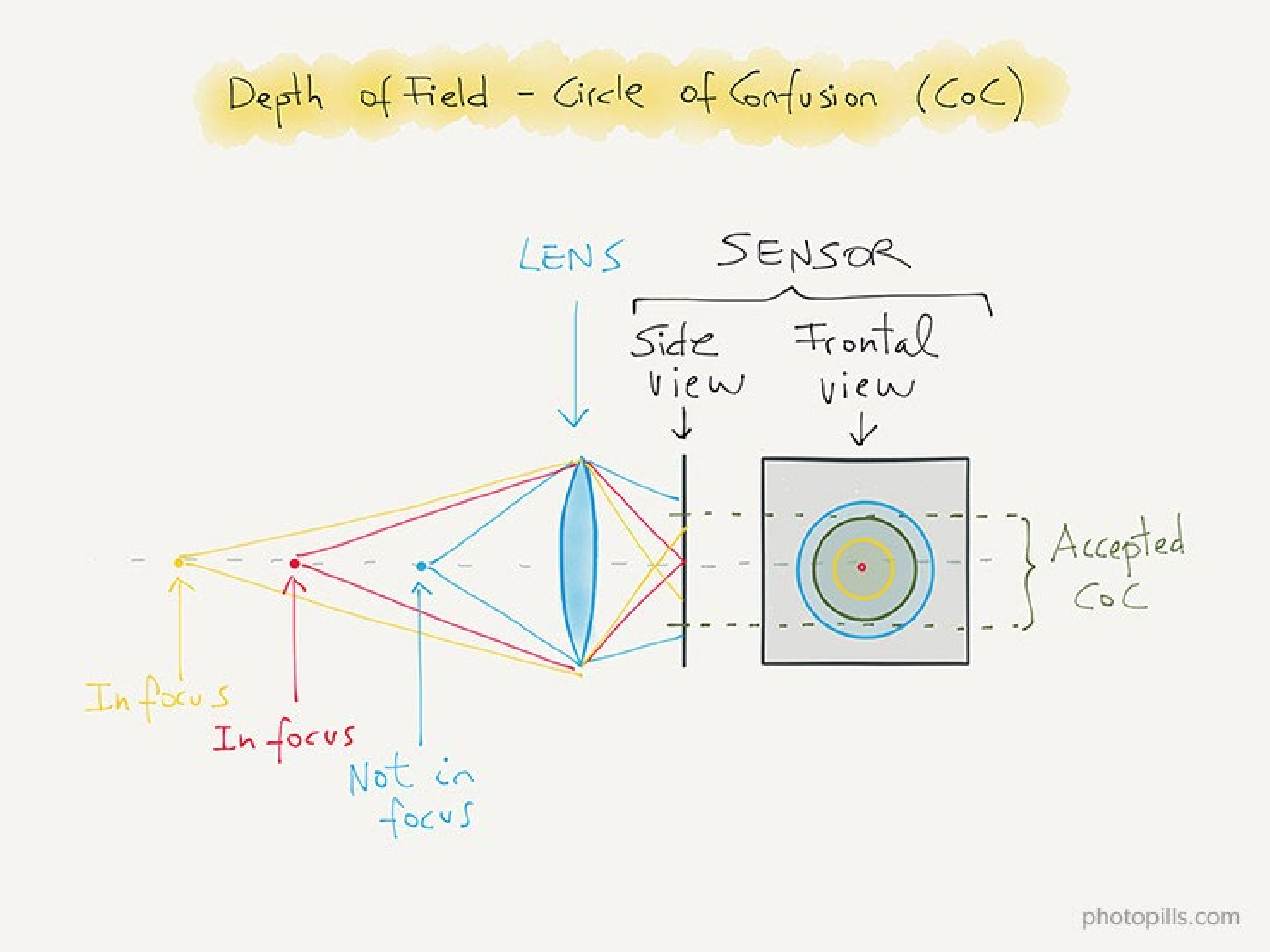
What is the Circle of Confusion?

"If you misbehave, the CoC will get you"

When learning depth of field, the circle of confusion (CoC) is the particular photographer's Bogeyman. Like the imaginary monster that is used to frighten children, the CoC has no specific form or shape, and the idea of it varies dramatically from photographer to photographer. In many cases, it has no set appearance in the photographer's mind – it's just a non-specific embodiment of terror.

Circle of confusion definition

The truth is that there is no reason to fear the circle of confusion. The CoC is simply the maximum size that a blur spot, on the image captured by the camera sensor, will be seen as a point in the final image by a viewer for a given viewing conditions (print size, viewing distance and viewer's visual acuity).



The green circle represents the circle of confusion (CoC). This is the maximum size of a blur spot that will appear to be acceptably sharp in the final image. Any blur spot larger than the accepted CoC will appear to be out of focus.This is the case of the blue circle.

In other words, it's the size (diameter) of the largest blur spot in the camera sensor that is indistinguishable from a point on the final image. It's a parameter that defines what's considered to be acceptably sharp in a photo.

Notice that without determining the value of the circle of confusion (what you consider to be acceptably sharp), you cannot calculate the depth of field you'll have in your image, because you won't know the maximum size that a blur spot can have to be perceived as a point.

Therefore, as you are going through your depth of field calculations, you need to know and use the diameter of the circle of confusion together with the other shooting settings that affect DoF (aperture, focal length and focus distance).

Usually, most depth of field calculators use a circle of confusion that is the result of assuming a print size of 8’’×10’’ (20cm x 25cm), a viewing distance of 10” (25cm) and the manufacturers standard visual acuity. That’s the reason you don’t need to plug it when using the typical DoF calculator.

In general, these assumptions work pretty well. But if you need to change them (print size, viewing distance and visual acuity), use an adjusted value of the circle of confusion (CoC) when doing your DoF calculations. The typical example is when you want to print an image in large format.

A different view of Circle of Confusion: paintings

Let me give you a different example. I’ll assume that you have good visual acuity, that you’re seeing perfectly well. Now, go to a gallery in your town and stand in front of any of the paintings.

Let’s have a look at this masterpiece by Carles Gomila: Kitsune.

When you look at it from a certain distance, the painting appears to be in sharp focus. But, as you get closer, the image turns blurry. If you get close enough, you'll be able to see the detail of the traces or "blur spots" forming the painting.

Imagine that the diameter of the blur spots forming the painting is 0.039 inches (1mm). Walk away from the painting. There'll be a distance from where you'll start to see it perfectly in focus, without noticing the traces. Let's assume that this distance is 16ft (5m).

Then, I can confirm that, for this given viewing conditions (viewing distance 16ft, painting size and your visual acuity), the circle of confusion of the painting is 0.039 inches (1mm) because you'd see any blur spot bigger than 0.039 inches (1mm) to be out of focus.

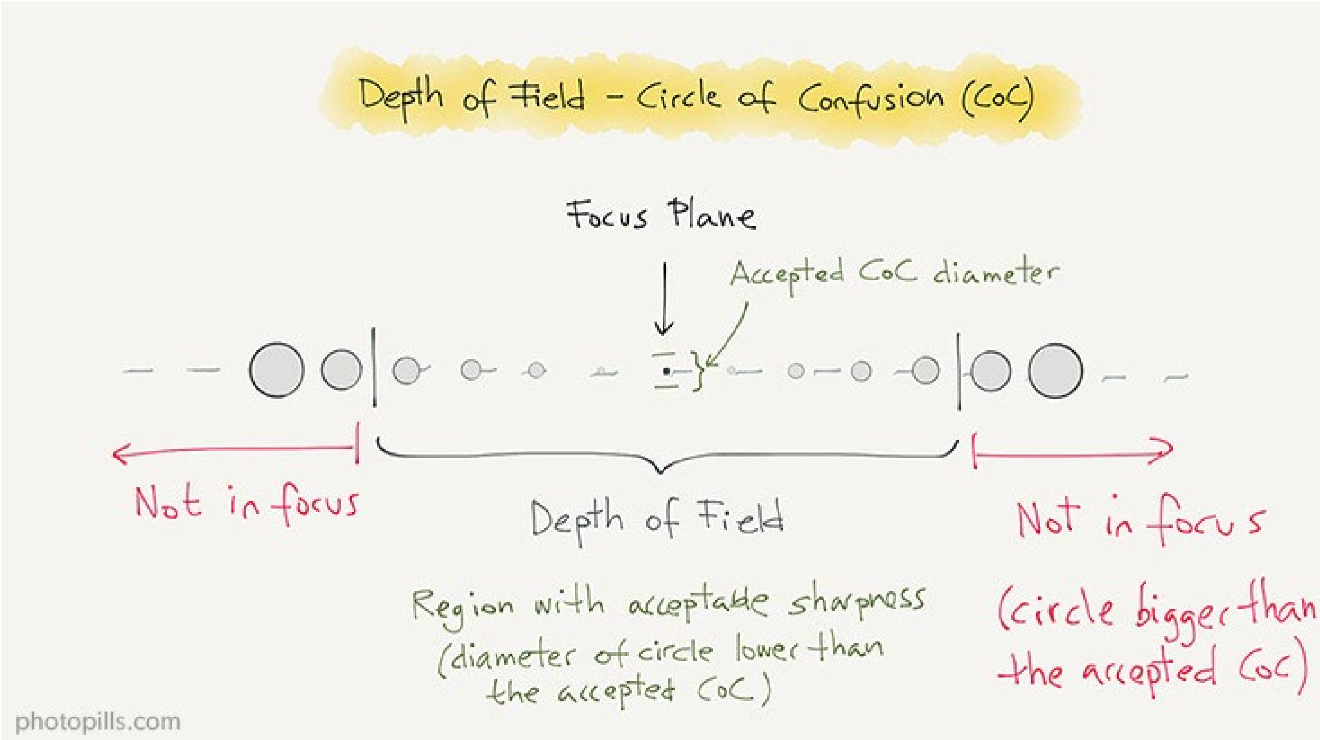
Therefore, if you want to see the painting in sharp focus from a closer distance, you need the traces or blur spots forming it to be smaller. This means that the acceptable circle of confusion needs to be smaller too.

In photography, the blur spots you see in the image are an enlargement of the blur spots captured by the sensor of the camera. This enlargement is given by the proportion between the sensor size and the final image size (print size). From now on, every time I'll use the term circle of confusion, I'm referring to the size of a blur spot on the camera sensor, not of the final printed image.

A third way of explaining the Circle of Confusion

Let me explain it in a different way.

You know that only at the focus distance, a point object will be reproduced as a point image on the sensor. And, as you move away from the plane of focus, any point object will be defocused, producing a blur spot in the image. The "diameter" of this blur spot or blur circle increases with distance from the point of focus.



For a given camera sensor and viewing conditions (print size, viewing distance, viewer's visual acuity), when this blur spot is small enough, we see it as a point in the image and it appears to be in focus. So we say that it is rendered as "acceptably sharp". On the contrary, when this blur spot surpases a certain size, it appears to be out of focus to us.

Usually, the maximum size that a blur spot on an image will be seen as a point (in focus), is generally accepted to be the largest on-film/sensor circle (blur spot) that a person with good vision would see as a well defined point on an 8''×10'' (20cm x 25cm) print when viewed from a "normal" viewing distance of 10" (25 cm). This point in focus is commonly known as the acceptable circle of confusion, or simply the circle of confusion (CoC). Anything larger would be seen as a small circle, not as a point, and would be therefore perceived as out of focus.

Of course, talking about circles is a simplification. In reality, the circle of confusion is not a circle. It has the same shape as the lens aperture, normally rendered as a polygonal shape. To keep things simple it is typically assumed to be circular, which is accurate when it is very small.

Factors that influence the circle of confusion

The acceptable circle of confusion is influenced by sensor/film size, viewer's visual acuity, viewing distance and print size. Camera manufacturers assume the diameter of the circle of confusion to be 0.01 inch (0.254 mm) when providing lens depth of field markers (shown below for a Zuiko 50mm f/1.8 lens). But, in fact, a person with 20/20 vision can distinguish objects 1/3 this size, and so the circle of confusion has to be even smaller than this to achieve an acceptable sharpness. Thus, the better visual acuity you have the smaller the circle of confusion should be.

Zuiko 50mm f/1.8 lens depth of field markers

Additionally, as you increase viewing distance you're missing detail in the image. So the circle of confusion could be larger and you'd still appreciate the same level of sharpness. On the contrary, when print size (image enlargement compared with the camera sensor) increases, the circle of confusion needs to be smaller in order to keep the image perceived as sharp.

In conclusion, the circle of confusion is just a variable used to reach consensus on how much a point needs to be blurred in order to be perceived as unsharp for a given camera sensor and viewing conditions (print size, viewing distance and visual acuity). Its value is not a dogma, it's just a convention.

Circle of confusion calculator

How do you calculate the circle of confusion? This calculator will help with the math for any given combination of sensor/film size, visual acuity, viewing distance, and print size.

Also, the following table will help you visualize how print size and viewing distance influence CoC values, when using a full frame camera (sensor size of 36x24mm) like the Nikon D4s, and the viewer is assumed to have the manufacturer's visual acuity.

Coc (mm)				
Viewing distance (m)	Print Size 2:3 (cmxcm)			
	10x15	**20x30**	**30x45**	**66x100**
0.25	0.050	0.025	0.017	0.008
0.5	0.100	0.050	0.033	0.015
1	0.200	0.100	0.067	0.030
2	0.400	0.200	0.133	0.060
4	0.800	0.400	0.266	0.120

What we learn from the table is:

- For a given viewing distance, the larger the print size, the smaller the CoC must to be to keep the same depth of field, because of the image enlargement.
- For a given print size, the shorter the viewing distance, the smaller the CoC must be to keep the same depth of field, because you're viewing more detail.

Calculating the circle of confusion

Let's work with an example. Imagine that your mother's birthday is approaching and you want to surprise her. What about giving her a large format picture of her favourite landscape as birthday present? You know that she loves a little hut in the bay of Fornells (Menorca). A print size of 2.29x4.92ft (70x150cm) would made for an amazing present!

Your mother's vision is perfect, she's still young. So you want the main subjects in the printed photo to be sharp, even from a viewing distance of 10" (25cm). This means that you need the fisherman and the hut to be in focus.

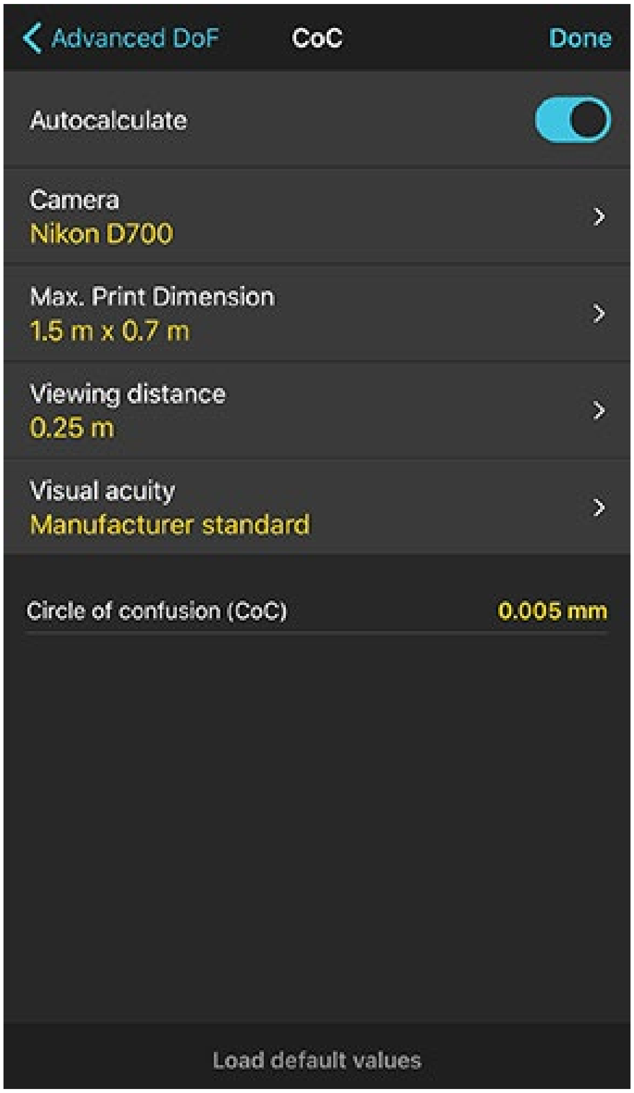
Since you'd be focusing at the hut, you need the total depth of field to be larger than the size of the hut, which is 16.4ft (5m) wide.

What's the acceptable circle of confusion you need to use when doing your depth of field calculations (total DoF) before the shot, if you're using your full frame camera (in my case a Nikon D700)?

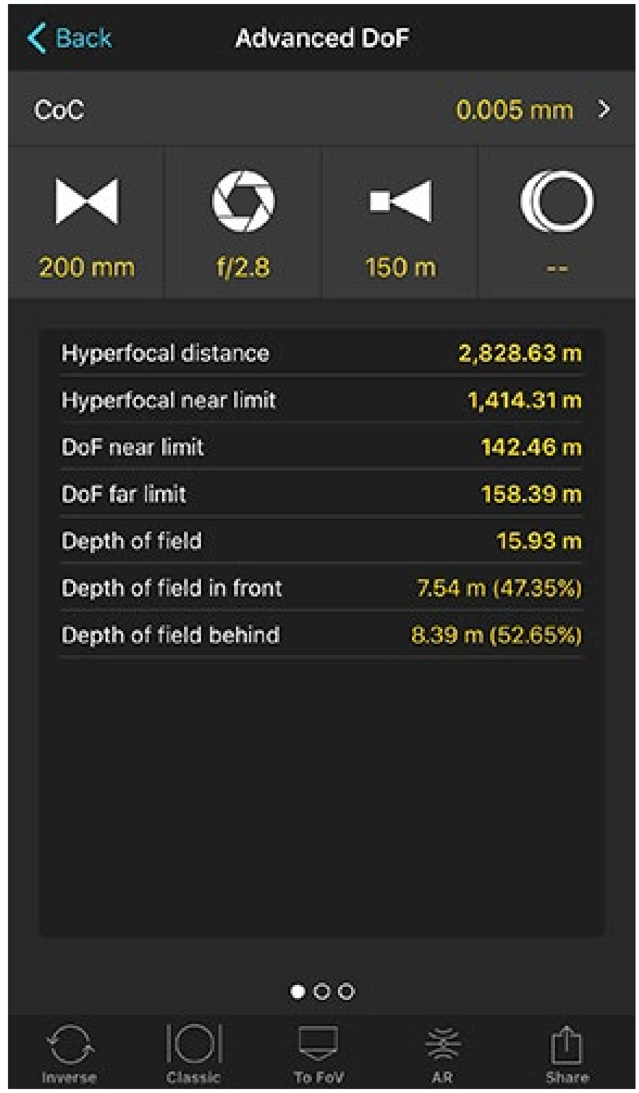
If you plug all these settings in the Circle of Confusion Calculator, you'll find out that only blur spots with size under 0.005mm will be seen as points in the final printed image. So you must use this specific CoC or a smaller one when doing your depth of field calculations.

This way, the calculated depth of field information will tell you if you'll get the hut in focus.

Now, let me use PhotoPills' Advanced Depth of Field calculator to figure out the total depth of field. I took the fisherman photo with my Nikon D700, focusing at the fisherman (492ft - 150m), using a focal length of 200mm and an aperture of f/2.8. Introducing also a circle of confusion of 0.005mm in the calculator, I get a total DoF of 52.26ft (15.93 m), larger than 16.4ft (5m). Therefore, now, I'm sure that, with this settings, I'll get both the fisherman and the hut in focus.



PhotoPills' Advanced DoF calculator - calculating the circle of confusion.



PhotoPills' Advanced DoF calculator - depth of field results in a table.

Similarly, if you want to maximize depth of field depending on the print size, viewing distance and visual acuity, you'll need to use an adjusted circle of confusion when calculating the hyperfocal distance, so you know where to focus exactly. Using the wrong CoC can lead you to have a blurry image when printed.

How circle of confusion influences depth of field

How does the circle of confusion affect depth of field? Or in other words, how does the convention of what's considered to be "acceptably sharp" affects depth of field values? Have a look at the following numbers. They have been calculated by only changing the CoC and keeping the rest of settings constant (focus distance 3 m, focal length 85 mm, aperture f/1.4).

CoC (mm)					
	0.030	**0.060**	**0.120**	**0.240**	**0.480**
DoF near limit (m)	2.95	2.90	2.81	2.64	2.36
DoF far limit (m)	3.05	3.11	3.22	3.48	4.13
Total DoF (m)	0.10	0.21	0.41	0.84	1.78
DoF in front	49.14%	48.29%	46.58%	43.15%	36.31%
Dof behind	50.86%	51.71%	53.42%	56.85%	63.69%
Hyperfocal distance (m)	170.38	85.23	42.66	21.37	10.73

Common sense says that if we accept larger defocused spots to be acceptably sharp (larger CoC), then, we'll see in focus a larger area of the image and, therefore, depth of field will increase too. The numbers in the table don't lie:

"The larger the accepted circle of confusion, the deeper the depth of field"

The ultimate circle of confusion tricky question

Finally, to conclude, I'd like you to answer the following question, just to check if you understood the meaning of the circle of confusion:

"What's the optimal CoC in photography?"

Answer: it depends!

There is not such a good or bad CoC in general, it depends on the sensor size of your camera, the print size you're going to use, the viewing distance you want people to look at the image and the viewer's visual acuity. Depending on these conditions, you'll need the blur spots forming the image to be smaller or, on the contrary, you'll accept them to be larger.

All these assumptions need to be taken into account when doing the depth of field calculations.

So, when your photography mentor asks you "Is a 0.025 mm CoC a good CoC to have a sharp image?", your answer must be:

"It depends Sir! What's the sensor size? What's the printing size of the photo? How far will people be viewing it from? What's people visual acuity assumed to be?"

TIPS

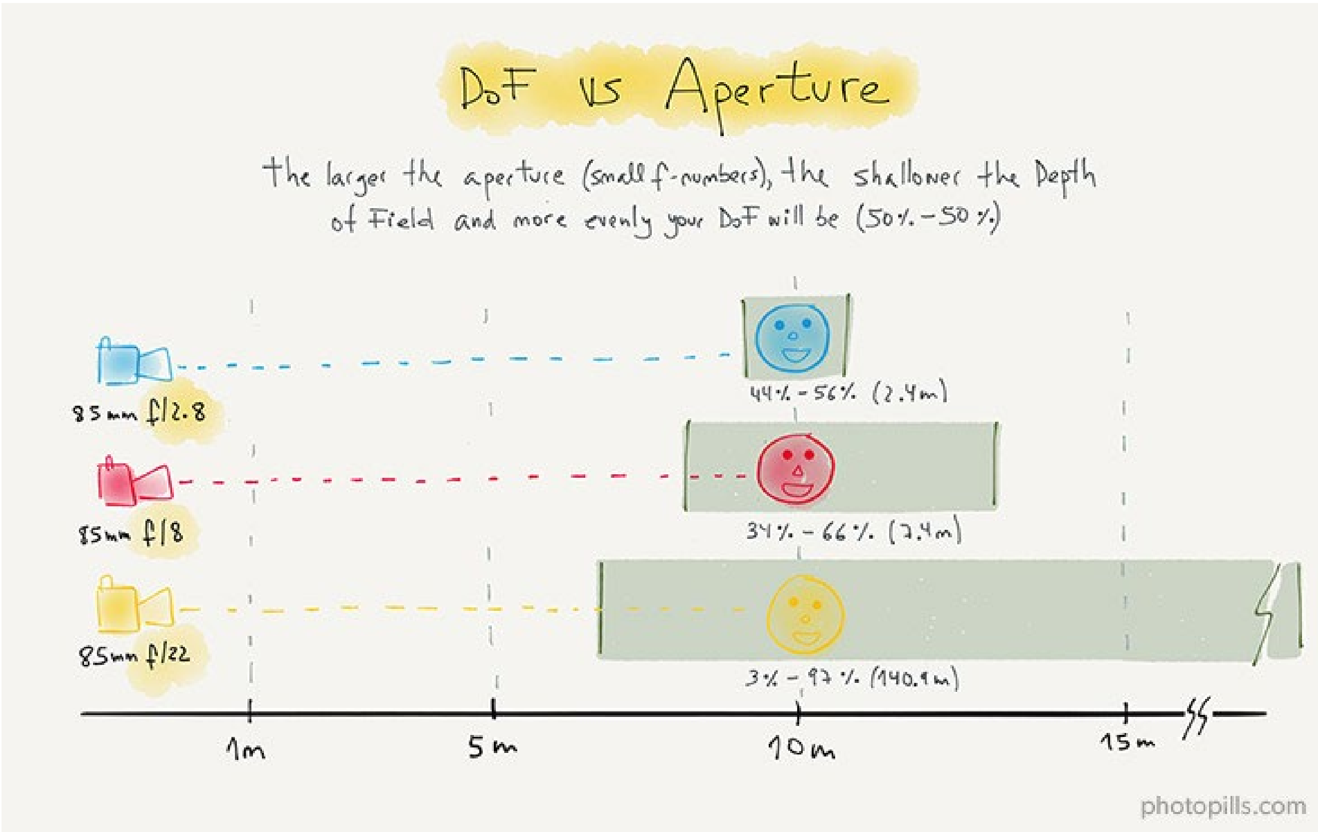
For a desired level of acceptable focus in a photo, you get these relationships:

- The larger the print size, the smaller the blur spots forming the image need to be (smaller CoC) so they are perceived as points in focus.
- The smaller the camera sensor, the more enlargement will be between the image on the sensor and the final printed image, and the smaller the blur spots forming the image need to be (smaller CoC) so they are perceived as points in focus.
- The closer the viewing distance, the smaller the blur spots forming the image need to be (smaller CoC) so they are perceived as points in focus.
- The better visual acuity, the smaller the blur spots forming the image need to be (smaller CoC) so they are perceived as points in focus.

6

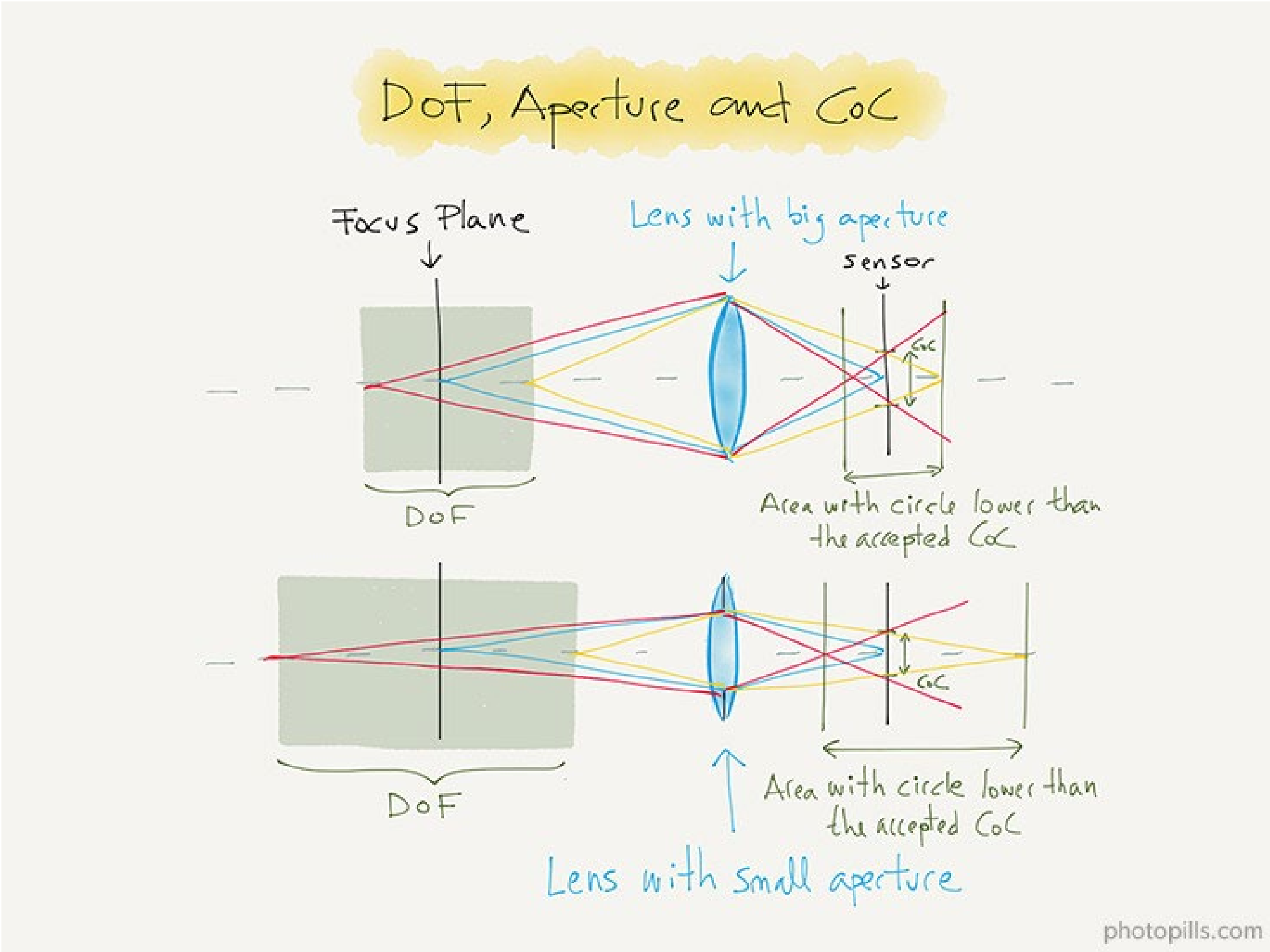
Depth of field vs aperture

"For a given subject framing and focus distance, depth of field is controlled by aperture size: the smaller the aperture (large f-numbers), the deeper the depth of field."



Many photographers use the aperture to get the desired depth of field because it can be easily controlled by simply changing the aperture. Subject distance (focus distance) and focal length are more influenced by the image composition choice.

On the one hand, when you close the aperture (large f-number: f/11 to f/22, etc.) the rays of light are forced to get through a smaller hole, narrowing the light beam. This increases the distance between the last two points that are considered to be acceptable sharp in front and behind the plane of focus, thus, allowing you to get a deeper depth of field.



The smaller the aperture, the larger area will produce blur spots smaller than the CoC and, thus, the deeper the depth of field.

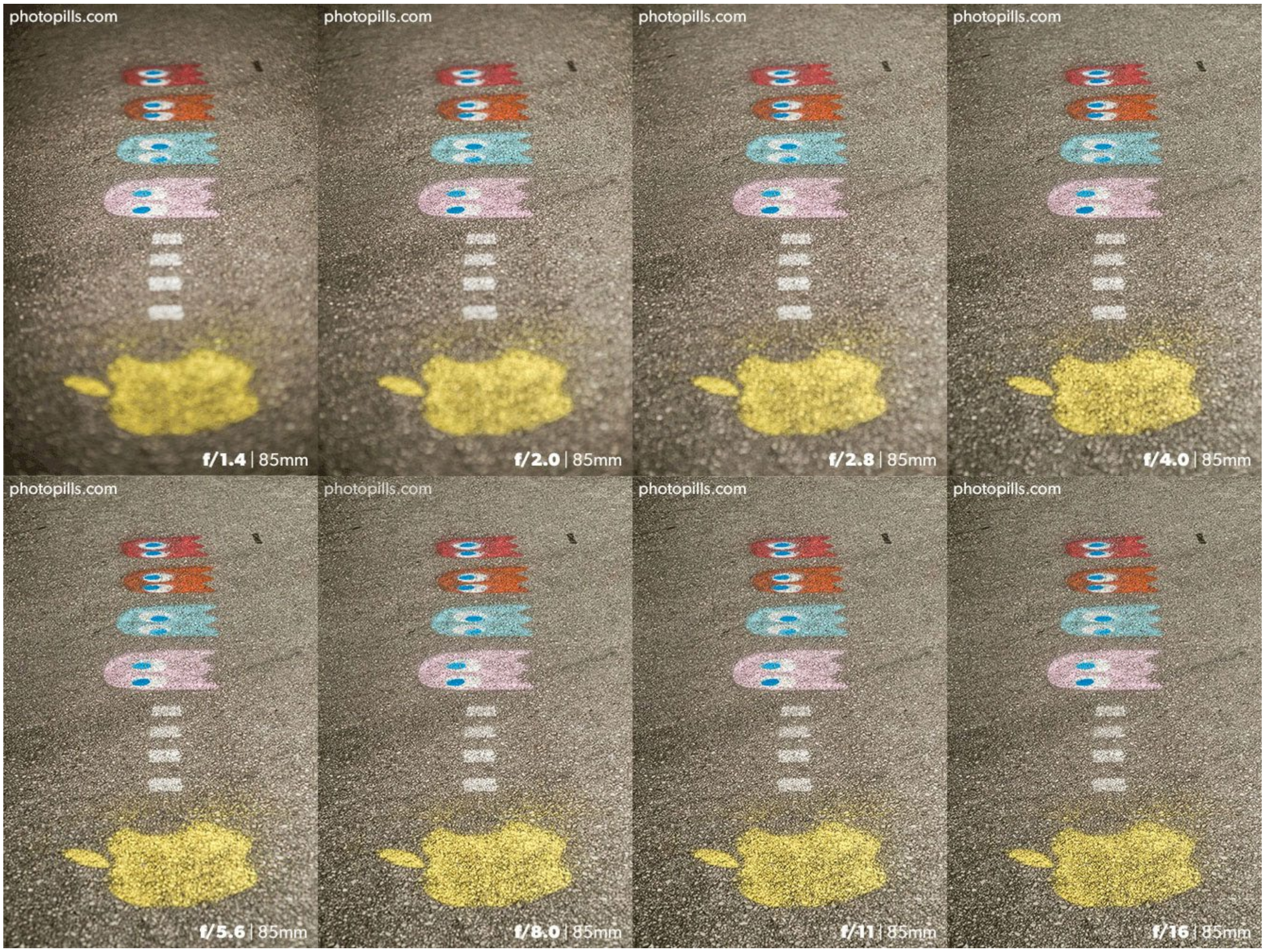
On the other hand, the wider the aperture (small f-number: f/1.4, f/2.8, etc), the shallower the depth of field, resulting into a smaller portion of your image completely sharp.

Take a look at the following two images shot with a full frame camera (Nikon D4s in this case). Focus distance is kept constant at 8.2ft (2.5m) and focal length at 85mm, while aperture is changed from f/1.4 to f/16. Notice how depth of field increases as aperture decreases.

Nikon D4s | 85mm | f/1.4 | 1/6400s | ISO 100 | 5650K | Focus at 8.2ft (2.5m) | In Focus from 8.09ft (2.47m) to 8.32ft (2.54m) | Total DoF: 0.23ft (0.07m) | DoF in front: 49.29% (0.11ft - 0.03m) | DoF behind: 50.71% (0.12ft - 0.04m)

Nikon D4s | 85mm | f/16 | 1/6400s | ISO 2800 | 5650K | Focus at 8.2ft (2.5m) | In Focus from 7.07ft (2.15m) to 9.77ft (2.98m) | Total DoF: 2.70ft (0.83m) | DoF in front: 41.98% (1.13ft - 0.35m) | DoF behind: 58.02% (1.57ft - 0.48m)

Similarly, the following animated gif shows how depth of field increases when aperture is progressively decreased, while camera type (Nikon D4s), focus distance (8.2ft - 2.5m) and focal length (85mm) are kept constant.



Additionally, I'd like to show you the relationship between depth of field and aperture numerically. If you use PhotoPills' DoF calculator to work out the depth of field for different apertures, the numbers will also show that depth of field increases as you decrease the aperture.

Aperture								
	f/1.4	f/2.0	f/2.8	f/4.0	f/5.6	f/8.0	f/11	f/16
DoF near limit (m)	2.47	2.45	2.43	2.40	2.37	2.31	2.25	2.15
DoF far limit (m)	2.54	2.55	2.57	2.60	2.65	2.72	2.82	2.98
Total DoF (m)	0.07	0.10	0.14	0.2	0.28	0.41	0.57	0.83
Dof in front	49.29%	49%	48.58%	47.99%	47.16%	45.99%	44.33%	41.98%
Dof behind	50.71%	51%	51.42%	52.01%	52.84%	54.01%	55.67%	58.02%
Hyperfocal distance (m)	170.38	120.5	85.23	60.29	42.66	30.19	21.37	15.14

Notice that, for a given focus distance, the percentage of depth of field in front of the focus point decreases and increases behind it as you close the aperture.

Since using small apertures increases depth of field, one of the most common questions I get in my classes and workshops is:

"Why not using the smallest aperture to obtain as much sharpness as possible?"

Actually you can't. Two practical facts limit your aperture choice.

The first limitation is the exposure triangle. While you choose the aperture, you also need to take into account shutter speed and ISO in order to get a photo correctly exposed. Small apertures reduce the amount of light collected by the sensor. Consequently, you need to reduce shutter speed (select a longer exposure time) to maintain a consistent exposure, forcing you to use a tripod to prevent motion blur. The best solution here is increasing ISO instead of decreasing shutter speed.

The second limitation is diffraction. As you stop down the aperture, the light passing through the lens tends to diffract more and more, decreasing the resolution of your photography and thus losing sharpness. I'll talk a little bit more about diffraction in section 7.

TIPS

- The wider the aperture (small f-number: f/1.4, 2.8, etc) the less depth of field (shallower).
- The smaller the aperture (large f-number: f/16, f/22, etc) the more depth of field (deeper).
- Pay attention to diffraction when using small apertures (f/16, f/22), because diffraction will make your images look more softened and less sharp.

Aperture in macro photography

In macro photography, the aperture choice is conditioned by subject distance and focal length choices.

On the one hand, you'll need to get pretty close to the subject, from an inch (2.5cm) to one or two feet (30-50cm) depending on the focal length you use. On the other hand, you'll be using a macro lens (50-60mm, 90-105mm, 150-200mm). Both settings will lead you to get a very shallow depth of field.

Consequently, small apertures like f/11, f/14, f/16 and f/22 are a great choice to try to maximize depth of field considering the short leeway determined by the compulsory subject distance (short) and focal length (long) choice.

Aperture in portrait photography

In portrait photography, your aperture choice will depend on the desired level of shallow depth of field, combined with the focal length choice (usually more than 70mm).

For a shallow depth of field effect, wide apertures like f/2.8 and f/4 are great. Using them will help you keep your subject sharp while blurring all background elements.

Let's say you need more depth of field because you'd like include interesting background elements that are close to the subject. Here, an aperture of f/8 would be a fantastic choice.

Finally, if you want to go for a deep depth of field, use smaller apertures like f/11, f/16 or less. Don't forget to always keep an eye to avoid diffraction.

On the contrary, if you're using a wide angle lens (8-35mm), you can maximize depth of field by focusing at the hyperfocal distance. In most cases however, these focal lengths are not a good choice for portraits because its large field of view will force you to get too close to the subject, which might deform it. For example, if the subject fills the frame when shooting with a wide angle lens, the nose and the forehead might appear disproportionate and unreal.

The Bard

Aperture in wildlife photography

Getting close to capture animals is very difficult. Wildlife photographers generally use telephoto lenses (300-600mm), whose depth of field is extremely shallow.

To increase depth of field and capture the whole animal in focus, you may be tempted to use small apertures (f/8, f/11). In practice, the truth is that the aperture choice will depend on whether the animal is in motion or staying still.

Small apertures might work when animals stay still, because you'll be able to freeze them and maintain a correct exposure by slowing the shutter speed (increasing exposure time).

But when animals move, you need a fast shutter speed (exposure times under 1/1000s) to freeze most movements and avoid blur. As a consequence, you are forced to use the widest aperture possible in your lens if you want to get a correctly exposed photo.

Therefore, you need to find the right balance between aperture (depth of field) and shutter speed (ability to freeze movement).

One possible workaround is to push the ISO up. Depending on the camera you have, it's a good idea to shoot with the ISO setting in auto mode. For example, shooting at 1/1000s, f/8 and ISO auto mode between 400 and 12800 will work perfectly well in many cases.

Aperture in landscape photography

Once you have decided the focal length you're going to use and the composition you want, select the aperture that will give you the desired level of sharpness. Usually, you'll want to maximize depth of field to keep the elements at the horizon in focus (mountains, trees...).

If you're using a wide angle lens (14-35mm), focusing at the hyperfocal distance will maximize depth of field no matter the aperture you use. In this case, depending on the effect you want to create, your aperture choice will be a trade-off with shutter speed in order to get an image exposed correctly. For example, you might want to use long exposures to capture the movement of running water, which will force you to close aperture, reducing the amount of light collected, to get the right exposure.

On the contrary, if you're using longer focal lengths (more than 70mm), and you still want to maximize depth of field, you must use smaller apertures (f/11, f/16) and focus about a third of the way into the frame.

Aperture in astrophotography

In most of your captures, you'll be looking to maximize depth of field in order to get stars in sharp focus. But you'll also want to capture as many stars as possible.

In this situation, the aperture choice doesn't involve depth of field. It's all about the amount of light collected. So, you'll need the widest aperture possible (f/1.4, f/2.8, etc.) and the longest exposure time possible to allow the sensor the collect the most light it can and, thus, capture the greatest number of stars.

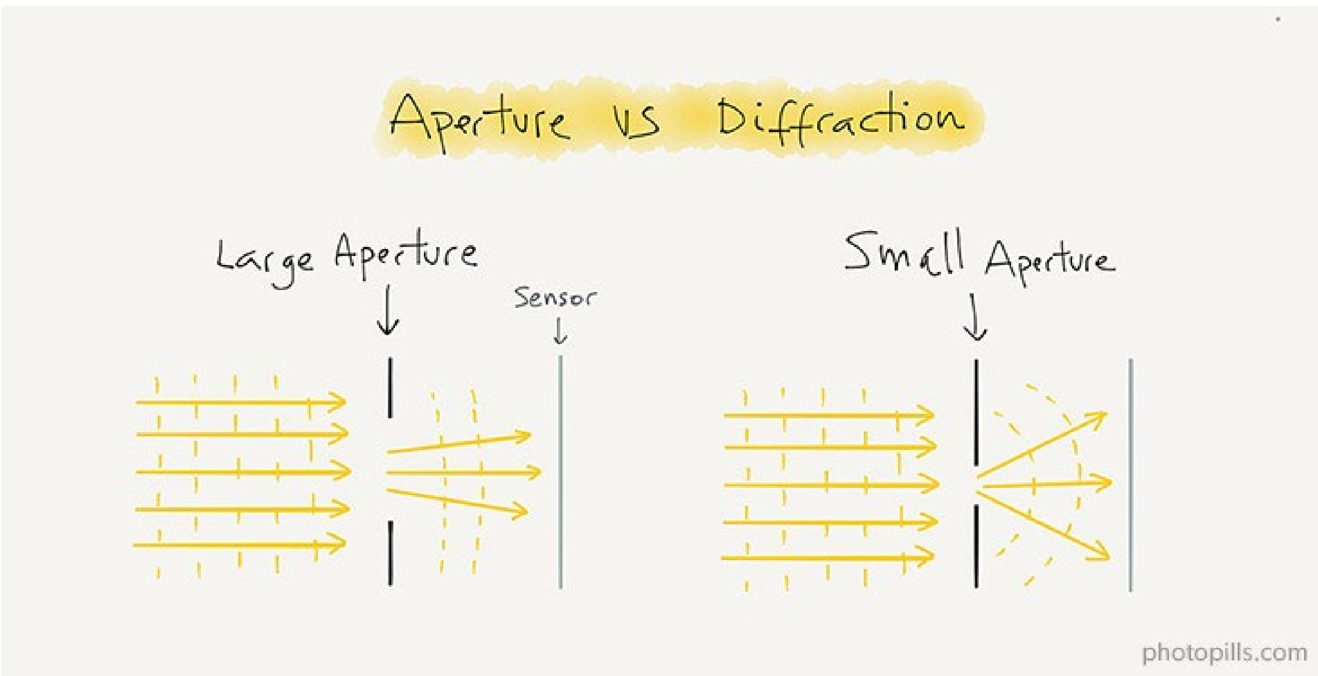
The question then is "Where to focus?". Again, since you want the stars in focus, and you'll be using a wide angle lens (14-35mm), focusing at the hyperfocal distance will maximize depth of field.

7

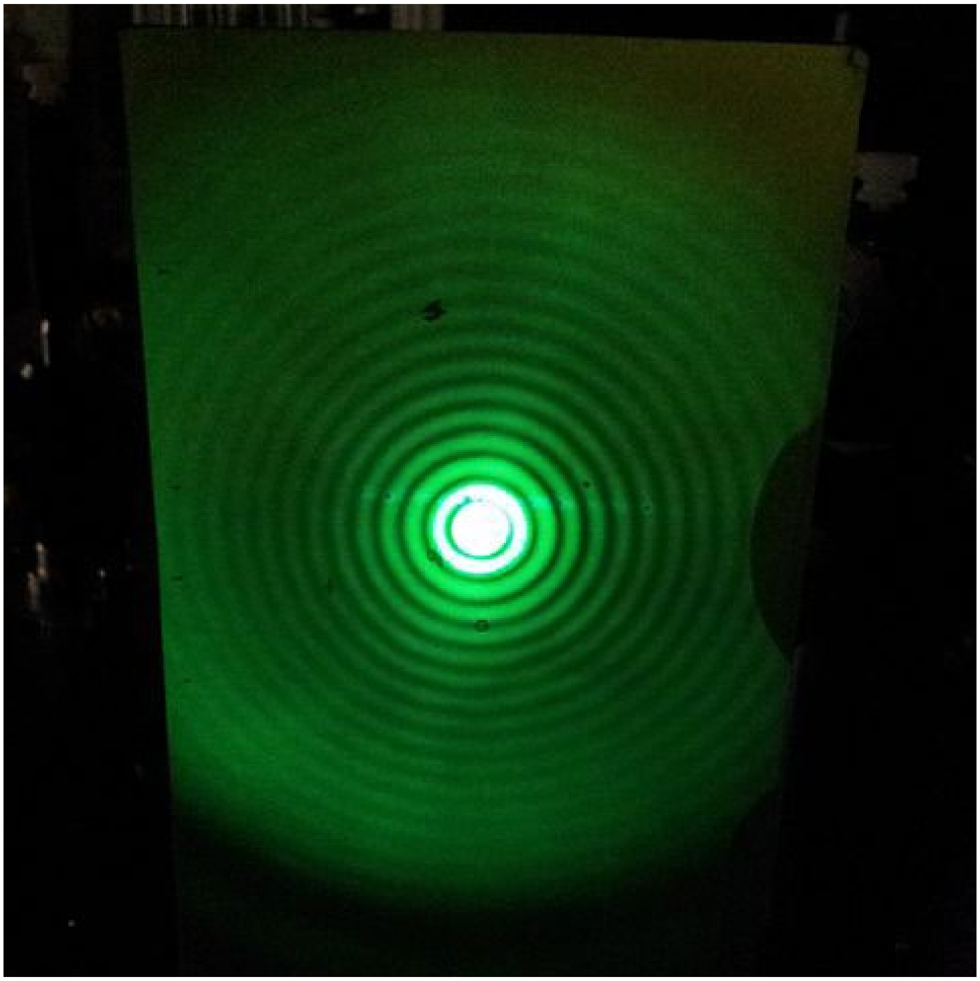
Depth of field vs diffraction

Diffraction is the result of light dispersion caused by the edges of the diaphragm blades in the lens. This causes the images to look more softened and less sharp, with less detail.

At larger apertures, only a small percentage of light is scattered. But as the aperture decreases, the percentage increases making the effect more visible – the size of the aperture gets roughly comparable to the light wavelength, increasing the amount of light rays scattered around the edges of the lens.



When light waves are scattered, they start to interact with each other, adding in some places and canceling out in others. These waves form a diffraction pattern known as the airy disk.



Real Airy disk created by passing a laser beam through a pinhole aperture (source: wikipedia)

The diameter of the airy disk determines the smallest point to which a lens can focus a beam of light. It defines the theoretical maximum resolution for a lens. When the airy disk is larger than the circle of confusion or 2.5 times the pixel size in the camera, your image will start to suffer from diffraction.

“Wait a minute Toni! All this information is great, but how does diffraction look like?”

Take a look at the following photos taken with a camera Nikon D4s. The first photo was shot with an aperture of f/8. I took the second one using an aperture of f/32. Can you see the effects of diffraction? Well, it’s not that easy.

The effects of diffraction are very soft. You'll see them better in the cropped images compared in the animated GIF below.

In the following animated GIF, you see the effect of diffraction produced inside the black square region shown in the images above. The photo taken with an aperture of f/32 looks more softened and less sharp. This is caused by diffraction.

In macro photography, diffraction can be used in a positive way to create beautiful shapes that produce different and authentic backgrounds.

In practice, what's important to keep in mind about diffraction is:

- Diffraction cannot be completely eliminated. Even the resolution of the finest lens is limited by diffraction. Actually, high quality lenses that have been designed to suffer only from diffraction are said to be "diffraction limited".

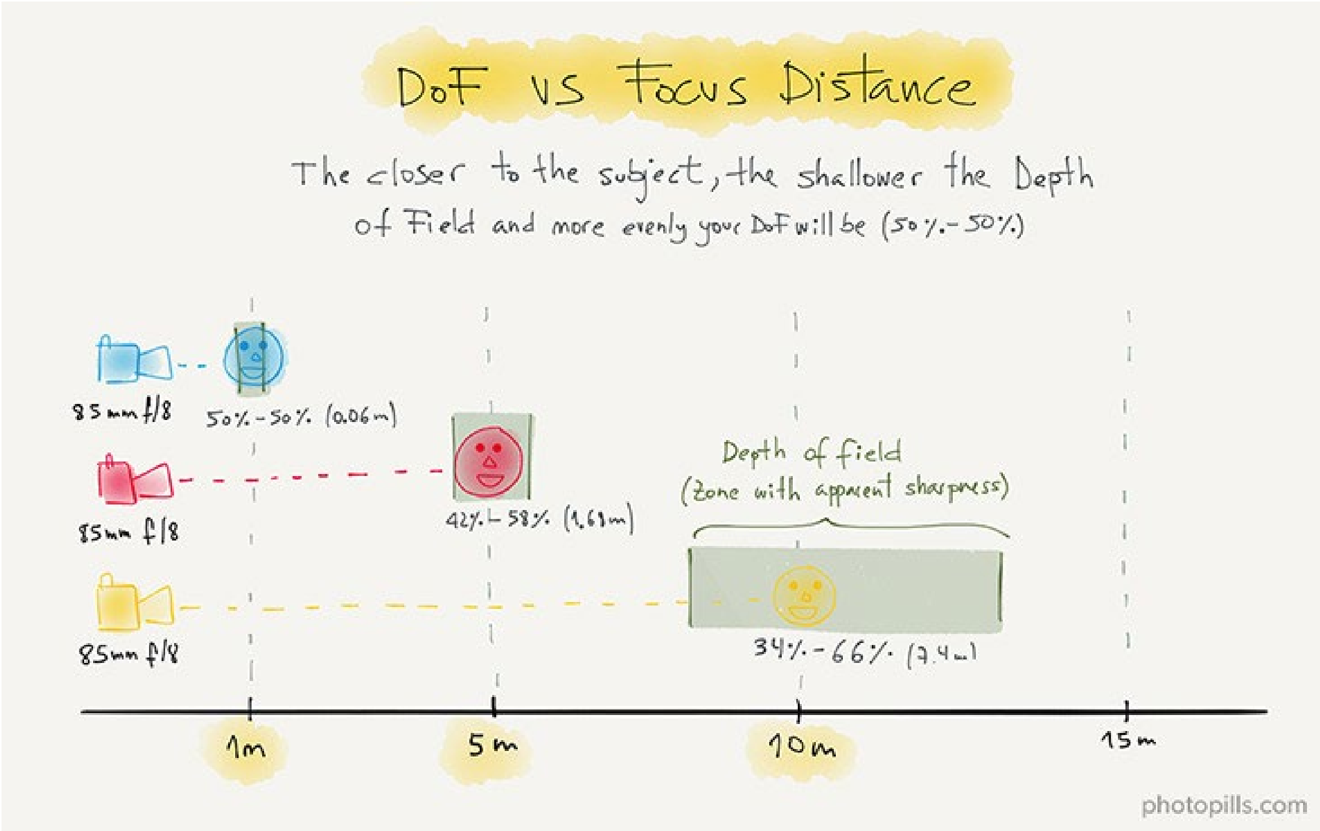
- You need to test each one of your lens on your camera to find the aperture that is visibly affected by diffraction. To run the test, just shoot pictures at different apertures and check the results thoroughly with an editing software, zooming at 100% or more (real pixels).

- Your aperture choice should be only limited by diffraction when it truly ruins your image. It's perfectly acceptable to have a little bit of diffraction when maximizing depth of field.

Finally, you can use our Diffraction Calculator to assess the aperture at which your camera starts to produce images affected by diffraction.

8

Depth of field vs subject distance

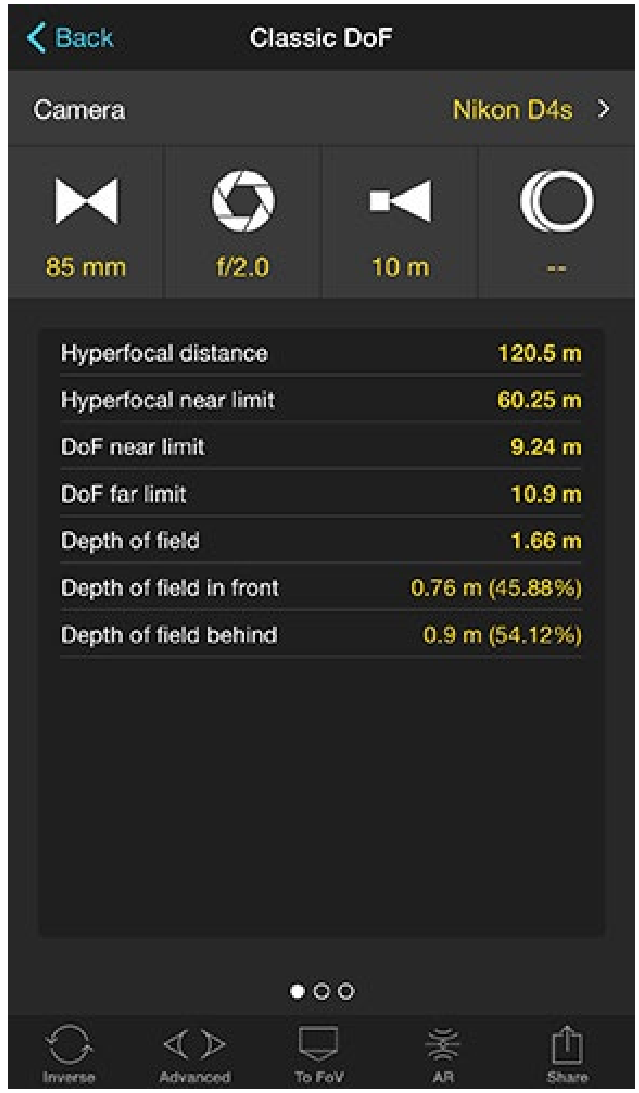


Subject distance, the distance at which you're focusing the lens, has a great impact on depth to field. The further you are from your subject the deeper the depth of field will be. Conversely, the closer the shallower.

Therefore, one way to reduce depth of field is by getting closer to your subject. That's what you would do while shooting a portrait. You want the subject to be in focus while blurring distracting elements in the foreground and background.

Let's see the numbers! Take a look at the following screenshots of PhotoPills' DoF calculator. In both cases, I'm using a 85mm focal length at f/2 on my Nikon D4s. In the first screenshot, I'm 6.56ft (2m) from my subject, getting a total DoF of 0.19ft (0.06m). Whereas, in the second screenshot, I'm 32.8ft (10m) from it, getting a total DoF of 5.44ft (1.66m).

Depth of field numbers using a 85mm lens at f/2 on a **Nikon D4s** (1.0x) and a focus distance of 6.56ft (2m).



Depth of field numbers using a 85mm lens at f/2 on a **Nikon D4s** (1.0x) and a focus distance of 32.8ft (10m).

Now, using the same camera (my Nikon D4s), focal length (85mm), and aperture (f/2), but changing the subject distance, I get the following depth of field table:

Subject Distance (m)							
	2	**4**	**6**	**10**	**20**	**50**	**100**
DoF near limit (m)	1.97	3.87	5.72	9.24	17.16	35.35	54.65
Dof far limit (m)	2.03	4.13	6.31	10.90	23.96	85.40	587.35
Total DoF (m)	0.06	0.25	0.59	1.66	6.80	50.05	532.7
DoF in front	49.20%	48.37%	47.54%	45.88%	41.73%	29.27%	8.51%
DoF behind	50.80%	51.53%	52.46%	54.12%	58.27%	70.73%	91.49%
Hyperfocal distance (m)	120.5	120.5	120.5	120.5	120.5	120.5	120.5

We can conclude from this table that the closer to the subject the shallower the depth of field.

In addition to this, when you're close to the subject, depth of field is rather evenly distributed around the focus point. But, as you move away from it, the percentage of depth of field in front of the focus point decreases while increases behind it.

Notice that the hyperfocal distance does not depend on subject distance. It remains equal when you change subject distance in the DoF calculator. Hyperfocal distance only depends on aperture, focal length, camera sensor and the hypothesis behind what is considered to be acceptable sharp.

Compare the photos I took with the settings I used in the PhotoPills' screenshots. Do you notice that I got a shallower depth of field when I got closer to the subject?

Nikon D4s | 85mm | f/2 | 1/640s | ISO 800 | 5650K | Focus on the hut: 6.56ft (2m) | In Focus from 6.46ft (1.97m) to 6.66ft (2.03m) | Total DoF: 0.20ft (0.06m) | DoF in front: 50% (0.10ft - 0.03m) | DoF behind: 50% (0.10ft - 0.03m)

Nikon D4s | 85mm | f/2 | 1/640s | ISO 800 | 5650K | Focus on the hut: 32.8ft (10m) | In Focus from 30.31ft (9.24m) to 35.75ft (10.90m) | Total DoF: 5.44ft (1.66m) | DoF in front: 45.88 % (2.50ft - 0.76m) | DoF behind: 54.12% (2.94ft - 0.90m)

In practice, the subject distance choice is not only based on the desired depth of field criteria. Depending on the type of photography, this choice is also influenced by other photography decisions like the elements you want in the frame when composing the image or whether it's possible to get close to the subject or not (e.g. when photographing wildlife).

For example, in macro photography, you need to be very close to the subject. The distance can go from just an inch (2.5cm) to one or two feet (30-50 cm) depending on your macro lens.

In portrait photography, where you are shooting static subjects, you'll be relatively close to the subject 10-20 ft (3-6m). In wildlife photography, you should get as close as you can! In this case, a telephoto lens becomes compulsory.

Finally, in landscape photography, you'll be using a wide angle lens focused at the hyperfocal distance in most cases. Composition will define the position of the subject in your frame, not depth of field.

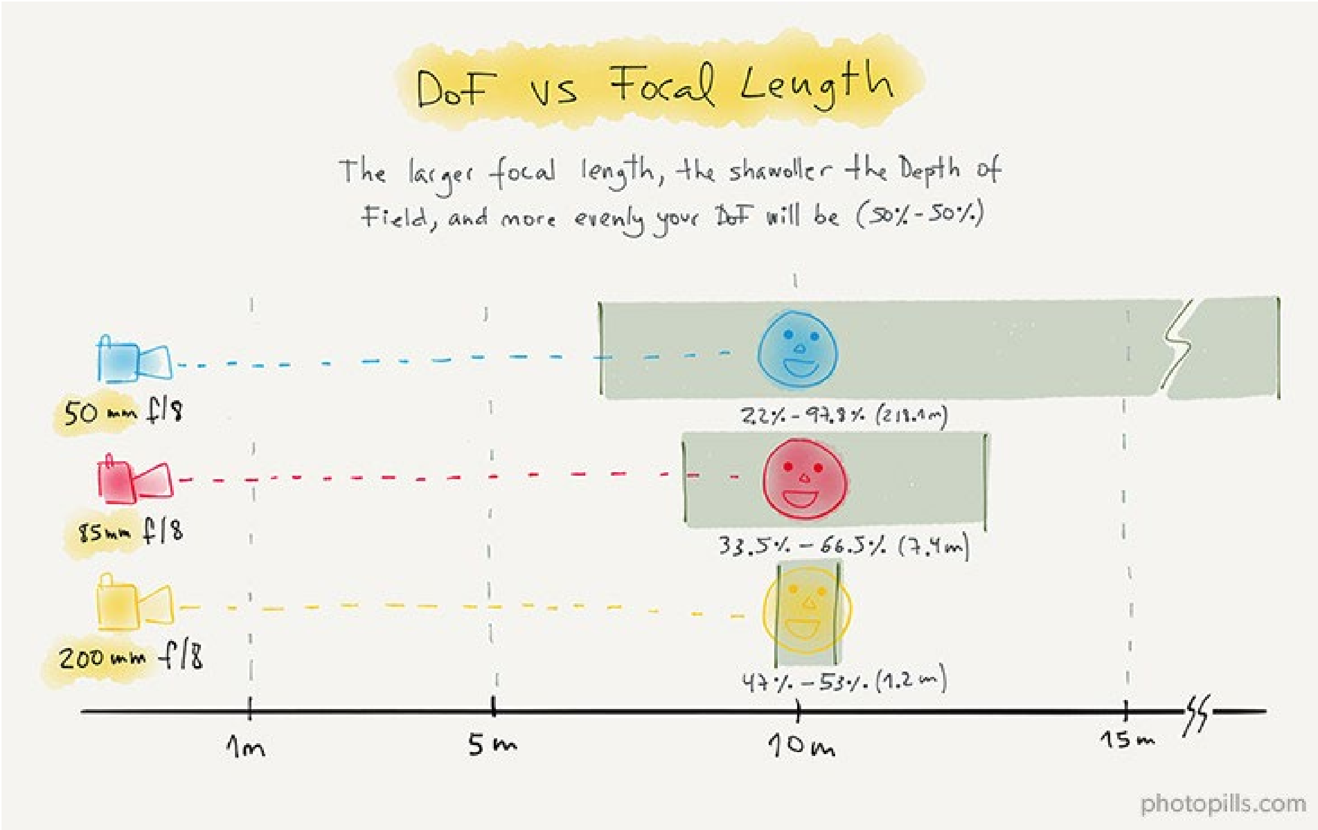
TIPS

- The closer to the subject, the shallower the depth of field. But as you get closer and closer to the subject, you'll find out that there is a distance from which your lens cannot focus. Thus, it's important to know the minimum focus distance of your lenses. This is the shortest distance at which a lens can focus measured from the sensor plane.

- Using a lens with a long "minimum focus distance" limits the options for composing a shot. Also, it forces you to change the lens every now and then, which is very annoying. Obviously, a lens that allows you to focus at short distances too is much better.

9

Depth of field vs focal length



Keeping all the settings equal (focus distance, aperture, sensor size, CoC), larger focal lengths produce a much shallower depth of field. For example, a 100mm lens focused at 20ft (6m) will have much less depth of field than a 24mm lens focused at 20ft (6m). Compare the depth of field values in the following images.

Nikon D4s | 100mm | f/8 | 1/320s | ISO 800 | 5650K | Focus at the hut: 19.68ft (6m) | In Focus from 17.24ft (5.26m) to 22.93ft (6.99m) | Total DoF: 5.69ft (1.73m) | DoF in front: 42.92 % (2.44ft - 0.74m) | DoF behind: 57.08% (3.25ft - 0.99m)

Nikon D4s | 24mm | f/8 | 1/320s | ISO 800 | 5650K | Focus at the hut: 19.68ft (6m) | In Focus from 5.64ft (1.72m) to ∞ | Total DoF: ∞

Again, let's have a look at the numbers! Keeping constant the camera (I'm still using my Nikon D4s), aperture (f/8) and focus distance (20ft - 6m), the following table shows us that long focal lengths produce shallower depth of field.

Focal length (mm)								
	14	**24**	**35**	**50**	**100**	**200**	**300**	**500**
DoF near limit (m)	0.72	1.72	2.77	3.82	5.26	5.80	5.91	5.97
Dof far limit (m)	∞	∞	∞	13.99	6.99	6.22	6.09	6.03
Total DoF (m)	∞	∞	∞	10.17	1.73	0.42	0.18	0.06
DoF in front	5.28	4.28	3.23	2.18	0.74	0.20	0.09	0.03
DoF behind	∞	∞	∞	7.99	0.99	0.22	0.09	0.03
Hyperfocal distance (m)	0.83	2.42	5.14	10.47	41.77	166.87	375.30	1,042.17

Hyperfocal distance increases dramatically with larger focal lengths. As a result it is impossible to precisely focus at such long distances. That's the reason you won't focus at the hyperfocal distance when using long focal lengths to maximize depth of field: the focus point defined by the hyperfocal distance is too far away!

Now, I'd like to explain you one interesting detail regarding focal length when focus distance is much shorter than hyperfocal distance but longer than what is considered a Macro distance (macro photography).

Since a different focal length produces a different frame and thus a different image, the question is:

What happens when the subject covers the same proportion in the frame?

In other words, what happens when you're shooting the "same" image (same frame or same field of view)?

When focus distance is adjusted to match field of view, total depth of field is virtually the same whether you're shooting with a wide-angle or a telephoto lens.

Here you have the numeric proof (Nikon D4s, aperture f/2.8):

Focal length (mm)	Focus distance (m)	Total DoF (m)
14	1	1.04
35	2.5	0.88
70	5	0.86
85	6	0.85
105	7.5	0.86
200	14.28	0.85
300	21.42	0.85
400	28.56	0.85

Ok! I know, there is a tiny variation for the smaller focal lengths, but it can be ignored compared to the effects of aperture and focus distance (subject distance).

Now, is depth of field distributed in the same way around the plane of focus?

The answer is NO!

Focal length does have an impact on the percentage of depth of field in front of and behind the plane of focus. Long focal lengths produce a more evenly distributed depth of field around the plane of focus than short focal lengths. Again, numbers don't lie (**Nikon D4s**, aperture f/2.8):

Focal length (mm)	Focus distance (m)	DoF in front	DoF behind
14	1	28.66%	71.34%
35	2.5	41.46%	58.54%
70	5	45.72%	54.27%
85	6	46.53%	53.47%
105	7.5	47.15%	52.85%
200	14.28	48.51%	51.49%
300	21.42	49%	51%
400	28.56	49.25%	50.75%

To sum up, what you really need to know is that for the same focus distance and aperture, long focal lengths (telephoto lenses) produce shallower depth of field than short focal lengths (wide angle lenses).

TIPS

- Compared to telephoto lenses, wide angle lenses provide a larger sharp area behind the focal plane, which is very useful in landscape photography.

- When focusing at short distances, the fact that long focal lengths produce a more evenly distributed depth of field around the point of focus (blurring both foreground and background) explains why they are extensively used in portrait photography.

10

Depth of field

vs

teleconverters

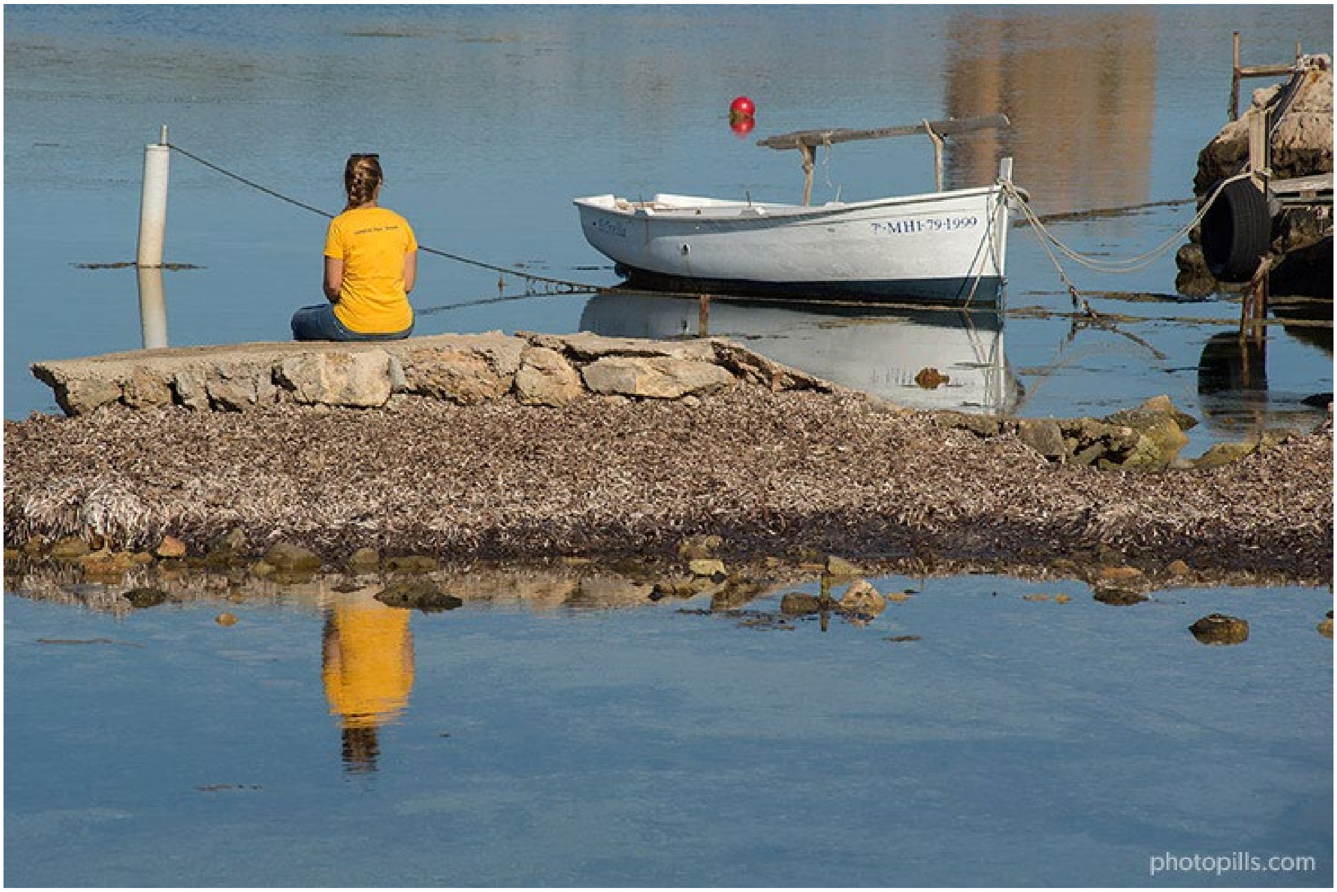
A teleconverter is a secondary lens mounted between the camera and the lens. Its job is to enlarge the central part of an image. Unfortunately, it also reduces the amount of light reaching the film or sensor in a camera.

As for depth of field, the effect is the same as if you were using a lens equivalent to the combination of the lens and the teleconverter.

In other words, if you're using a 2x converter on a 100mm lens (equalling 200mm) at f/5.6, the depth of field is the same as if you're using a straight 200mm lens at f/11.

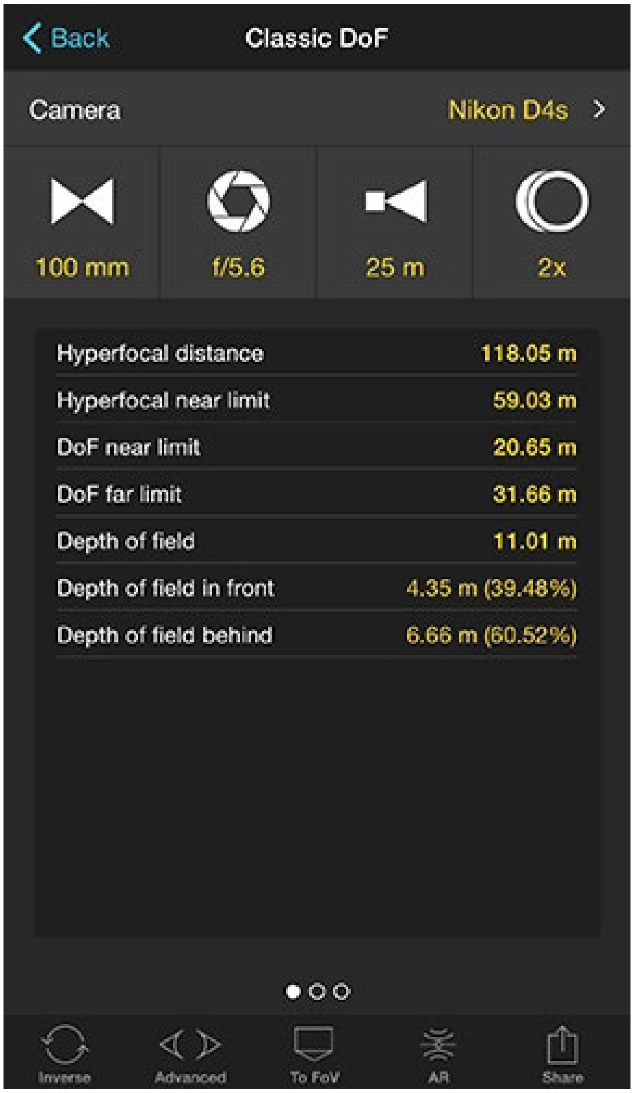
A 2x converter duplicates the focal length by 2, but it also reduces by 2 stops the light collected. For example, using an aperture of f/5.6 and a 2x converter, the sensor would capture the same light as if you were shooting with twice the focal length and an aperture of f/11. In both cases you'll get the same depth of field.

Nikon D4s | 100mm | Nikon Tc-2x converter | f/5.6 | 1/800s | ISO 320 | 5650K | Focus at 82ft (25m)| In Focus from 67.75 ft (20.65m) to 103.85ft (31.66m) | Total DoF: 36.10ft (11.01m) | DoF in front: 39.48% (14.25ft - 4.35m) | DoF behind: 60.52% (21.85ft - 6.66m)

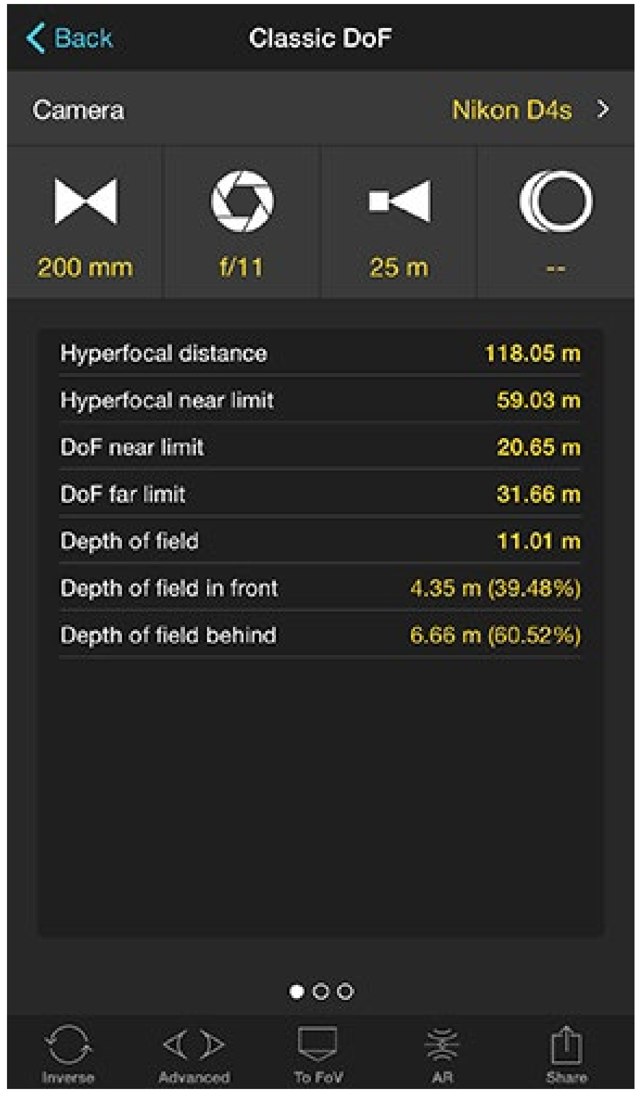


Nikon D4s | 200mm | f/11 | 1/800s | ISO 250 | 5650K | Without teleconverter | Focus at 82ft (25m) | In Focus from 67.75 ft (20.65m) to 103.85ft (31.66m) | Total DoF: 36.10ft (11.01m) | DoF in front: 39.48% (14.25ft - 4.35m) | DoF behind: 60.52% (21.85ft - 6.66m)

If you input these settings into PhotoPills' DoF calculator, you'll see that depth of field is the same.



Depth of field using a 2x converter on a 100mm focal length and an aperture of f/5.6 on a **Nikon D4s** (1x).



Depth of field using a 200mm lens at f/11 on a **Nikon D4s** (1x).

11

Depth of field vs sensor size

I'll begin by explaining two important concepts that will help you understand the relationship between sensor size and depth of field: crop factor and effective focal length.

Crop factor

The crop factor (CF) of a DSLR camera is the ratio of the diagonal of a 35mm frame to the diagonal of the image sensor of the camera. Remember that a 35mm frame has a size of 36x24mm, resulting into a diagonal of 43.3mm.

In the following image, sensor size is 23.5x15.6mm and the diagonal 28.21mm:

CF = Diagonal 35mm / Diagonal Sensor = 43.3mm/28.21mm = 1.5

Effective focal length

For a given sensor size and focal length, the effective focal length (also known as the 35mm equivalent focal length) is the focal length that would produce the same field of view on a 35mm camera. It's calculated by multiplying the actual focal length of the lens by the crop factor of the sensor.

effective focal length = focal length x crop factor

Imagine that you're shooting with a Nikon D7100 (sensor size 23.5x15.6mm, crop factor 1.5x), using a focal length of 35mm, an aperture of f/1.8 and a focus distance of 10ft (3m).

Since this camera has a crop factor of 1.5x, its effective focal length is 50mm (1.5x35mm). In other words, 50mm is the focal length you need to use on a full frame camera to get the same field of view than a focal length of 35mm on a camera with a crop factor of 1.5x.

The following images show the same field of view. The first one shot with a Nikon D7100 (1.5x) and focal length 35mm. The second one shot with a Nikon D4s (full frame) and focal length 50mm.

Nikon D7100 | 35mm | f/1.8 | 1/400s | ISO100 | 5650K | Focus at 10ft (3m)

Nikon D4s | 50mm | f/1.8 | 1/1000s | ISO100 | 5650K | Focus at 10ft (3m)

Sensor size vs DoF

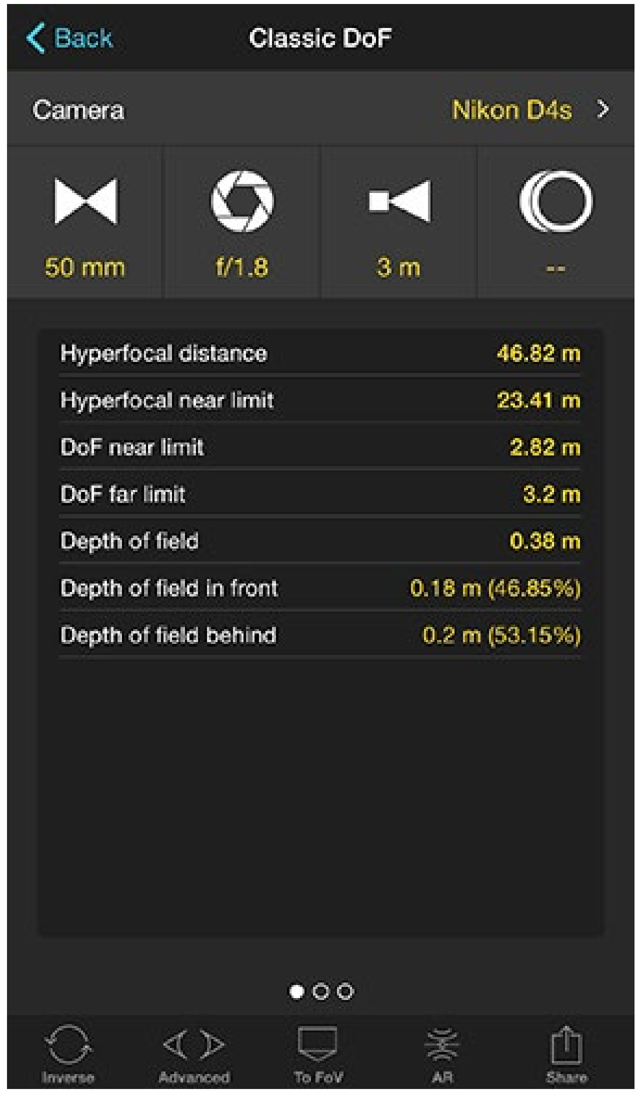
When it comes to sensor size vs depth of field, the rule is:

"For a given aperture and effective focal length, the larger the sensor, the shallower the depth of field."

Therefore, full frame cameras produce shallower depth of field than APS-C cameras at the same effective focal length and aperture. Shooting portraits using a full frame camera results in more pleasant images, since it gives you more control over shallow depth of field.

Let's type the numbers into PhotoPills' DoF calculator for both images and you'll see that given the same aperture and effective focal length, a full frame camera produces a shallower depth of field.

Depth of field numbers using a 35mm lens at f/1.8 on a **Nikon D7100** (1.5x) and a focus distance of 10ft (3m)



Depth of field numbers using a 50mm lens at f/1.8 on a **Nikon D4s** (1.0x) and a focus distance of 10ft (3m).

But, if you keep the same aperture, focal length (nominal, not effective) and focus distance and just change sensor size, depth of field won't be significantly affected. Let me prove it with a real example.

Have a look at the following images. I used a 85mm lens (not effective) at f/2 on both, my **Nikon D7100** (sensor size 23.5x15.6; 1.5x) and **Nikon D4s** (full frame). The subject is 10 ft (3m) away from the camera.

Can you appreciate any significant difference on depth of field?

Not really!

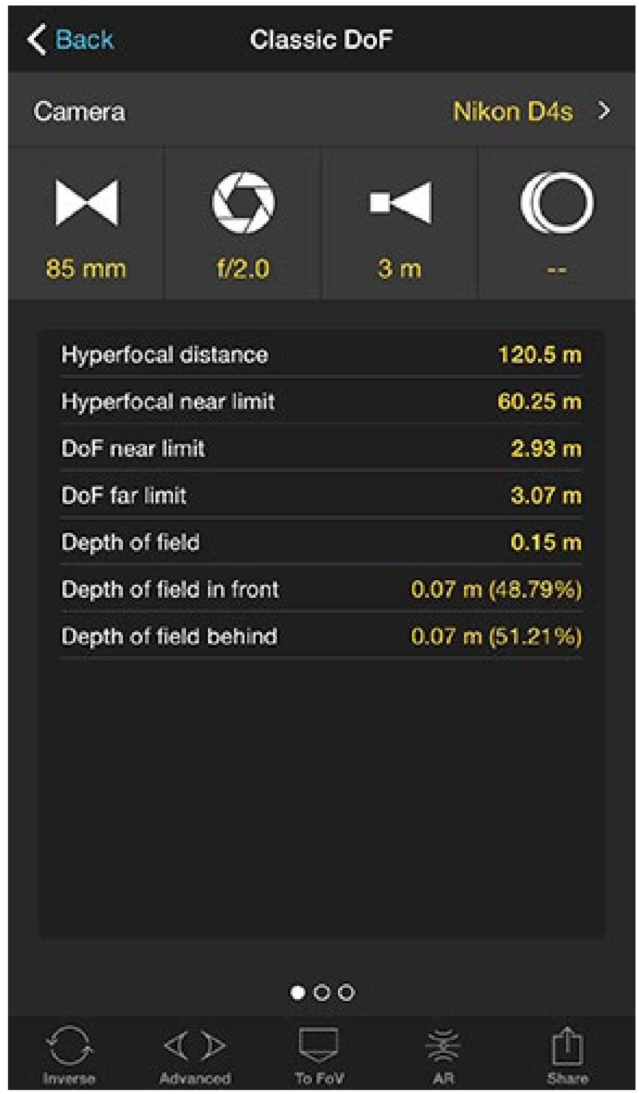
Nikon D7100 | 85mm | f/2 | 1/640s | ISO 800 | 5650K | Focus at 10ft (3m)| In Focus from 9.84ft (2.95m) to 10.17ft (3.05m) | Total DoF: 0.33ft (0.10m) | DoF in front: 49.18% (0.16ft - 0.05m) | DoF behind: 50.82% (0.17ft - 0.05m)

Nikon D4s | 85mm | f/2 | 1/2500s | ISO 800 | 5650K | Focus at 10ft (3m)| In Focus from 9.76ft (2.93m) to 10.25ft (3.07m) | Total DoF: 0.49ft (0.15m) | DoF in front: 48.79% (0.24ft - 0.07m) | DoF behind: 51.21% (0.25ft - 0.07 m)

What you see in the image is the crop effect. Place your tripod in a determined spot and take a photo with a crop sensor camera with the subject filling the frame. Then, take the same photo in exactly the same position with a full frame camera. You will have more space around the subject but depth of field variation is neglectable.

Again, If you input these settings into PhotoPills' Dof Calculator, the numbers show the tiny depth of field difference between both sensor sizes.

Depth of field numbers using a 85mm lens at f/2 on a **Nikon D7100** (1.5x) and a focus distance of 10ft (3m).



Depth of field numbers using a 85mm lens at f/2 on a **Nikon D4s** (1x) and a focus distance of 10ft (3m).

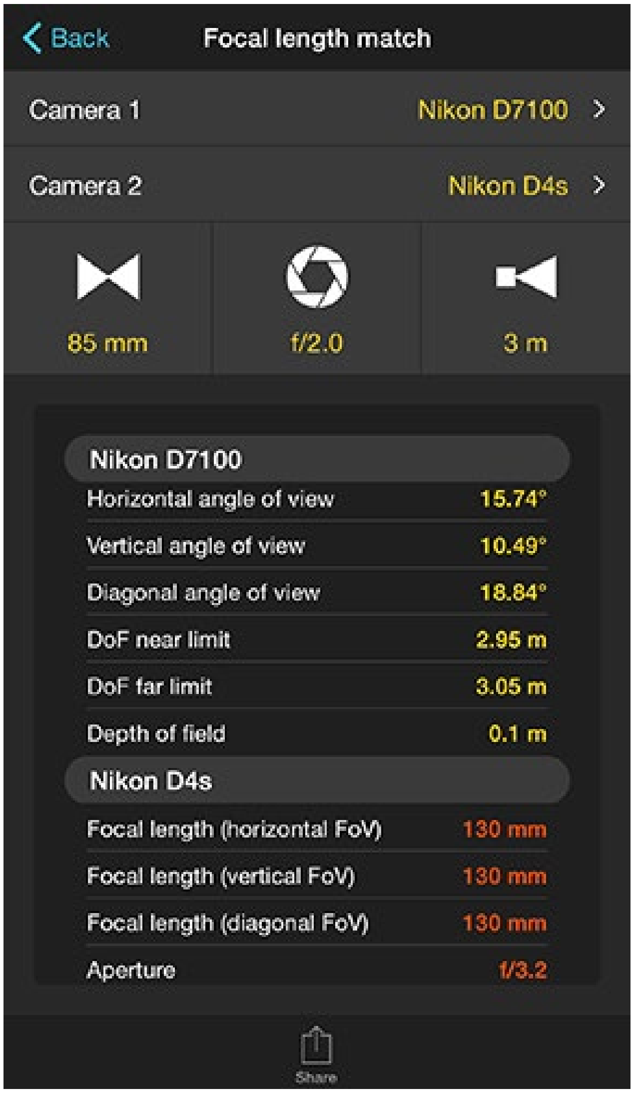
If you wish to achieve the same photo with both cameras, you will have to use a larger focal length (effective focal length) on the full frame camera or get closer to the subject, either of which will affect the depth of field.

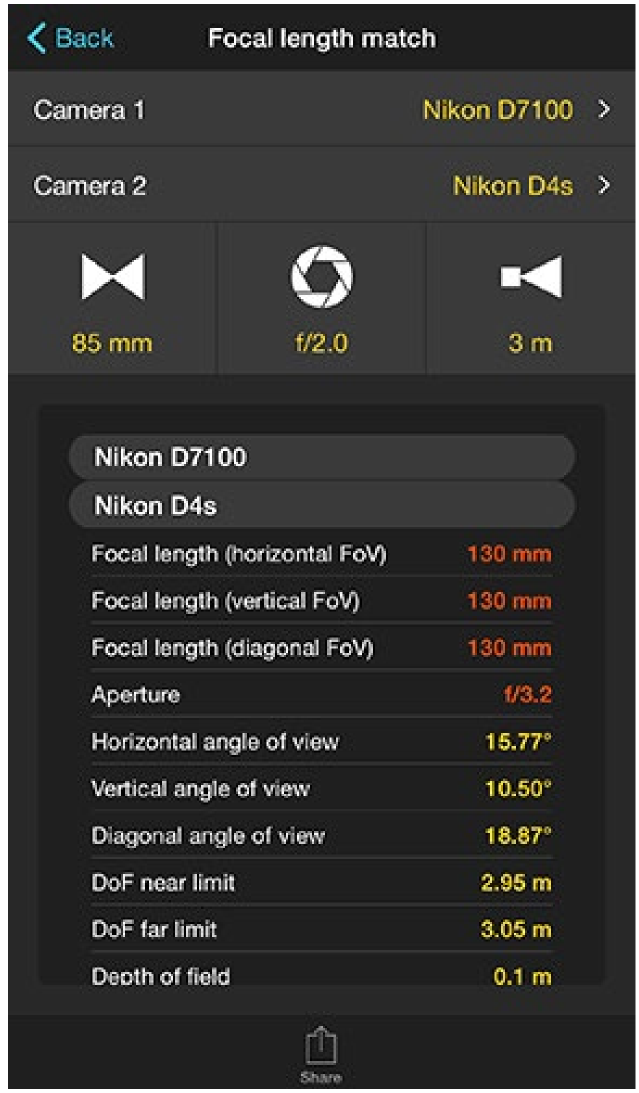
In other words, depth of field variations are due to the different fields of view produced by different sensor sizes. As the sensor gets larger, you need to get closer to the subject (changing perspective) or use a longer focal length in order to fill the frame with that subject. Therefore, if you want to keep the same depth of field on larger sensors than on cropped sensors, you'll need to use smaller aperture sizes.

Finally, imagine that you shot a portrait using a 85mm lens at f/2 on your **Nikon D7100** (crop sensor). And now you'd like to find out the aperture and focal length you need to use on a **Nikon D4s** (full frame) to replicate the same depth of field shooting from the same position (same perspective).

How do you calculate it?

Easy, use **PhotoPills**' focal length match calculator:





The calculator is telling you that, when shooting with a full frame camera (Nikon D4s), you need to use a 130mm lens and an aperture of f/3.2 to have the same DoF and FoV. Therefore, you need to increase focal length and close a little bit the aperture.

12

The preview depth of field button

Digital cameras allow us to quickly take a trial shot and check the depth of field directly on the image. That's why I don't really use the preview depth of field button of my digital camera. But I couldn't write an article about DoF without quickly mentioning it.

When you look through the viewfinder of your DSLR camera, you're actually looking through the lens at its widest aperture.

Yes, you've read correctly, the lens is not set at the one you've chosen for the picture. This aperture that you chose will only be set at the right moment of taking the picture. As a consequence, the depth of field you're observing is shallower than the one you'll get in the image. Obviously, the exception is when you're shooting at the maximum aperture.

Why most cameras keep the widest aperture until the shutter is pressed? Because it allows the camera to collect enough light for you to properly focus and frame the shot.

In order to help you better assess the depth of field you'll get in the final image, almost all DSLR cameras include what is called the depth of field preview button. This button reduces the lens aperture to the set value, giving you a preview of the parts of the image that will be in sharp focus. That way you can reduce the trial and error when adjusting the aperture according to the depth of field you have in mind. This is particularly useful when shooting in film, where the cost of wasting a photo is very high.

If you press the depth of field preview button and then look through the viewfinder, you'll see that the DoF has increased compared to when using the widest aperture. However, you'll also find out that the viewfinder image is darker, making very hard to accurately judge the depth of field.

This happens because you're stopping down the aperture and, thus, cutting down the light that's being collected. This is one of the main reasons why many photographers think that the depth of field preview button is useless.

One final word on how to use the DoF preview button. Pay attention on the out of focus areas of the composition. It's in this area that you'll see the big change as you set different apertures.

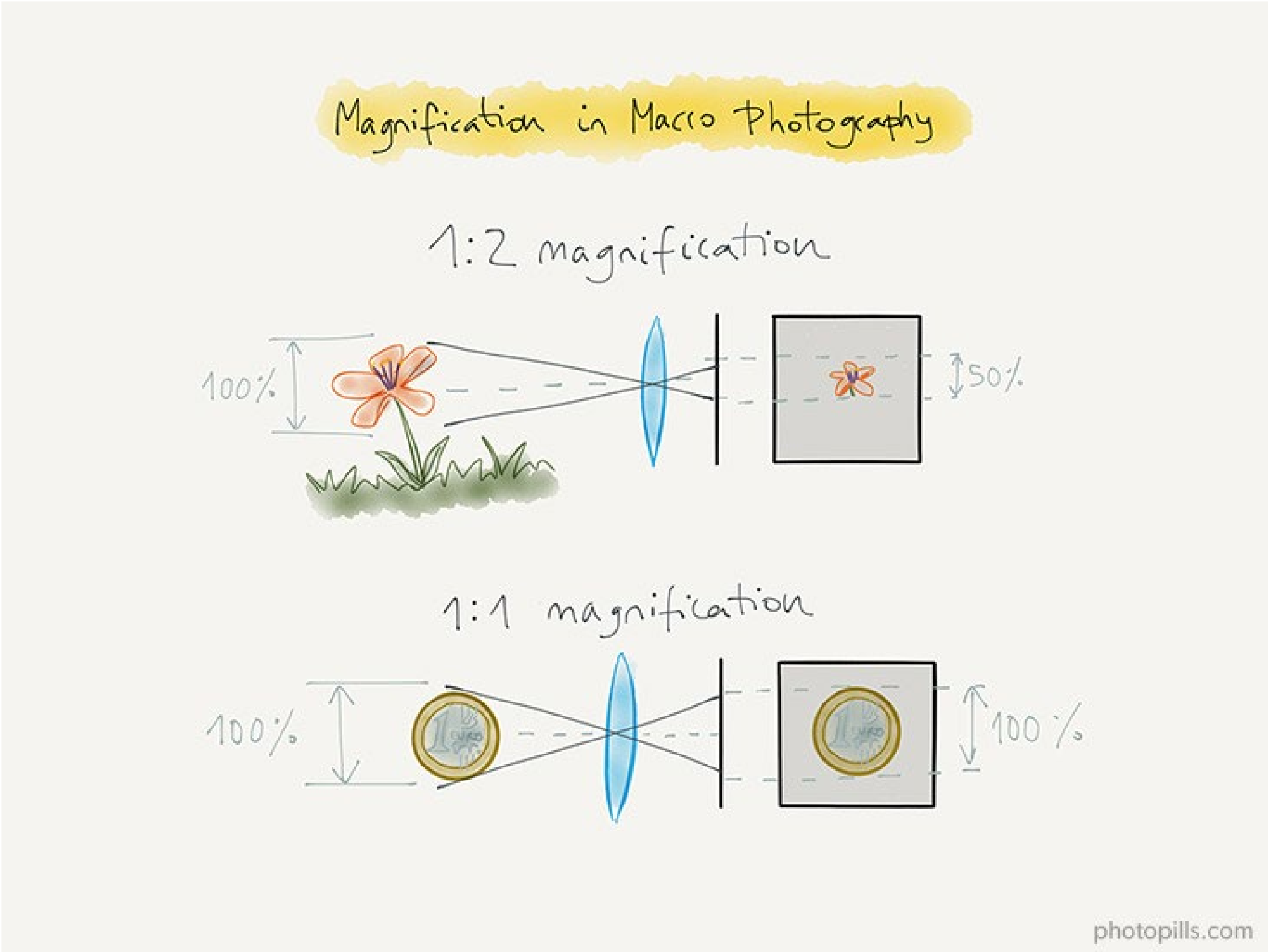
13

Macro photography and depth of field

Nikon D7100 | 105mm | Macro f/4 | 1/400s | ISO 100 | 5850K

Macro photography is about photographing at close distances small subjects whose image on the sensor or film is as large as, or larger than, the subjects themselves.

“Macro” refers to the magnification of the image as it appears on the sensor. For example, 1:1 magnification means that the image of a subject cast onto the image sensor will be the same size as the subject. If the image is 5 times the real size of the subject, then magnification is 5:1.



The ratio of the subject size on the sensor plane to the real subject size is called the reproduction ratio (1:1, 2:1, 3:1, etc). Lenses that are capable of reproduction ratios of 1:1 or greater are called macro lenses.

As a result, you'll need to get very close to the subject, from even less than an inch (<2.5 cm) to one or two feet (30-50cm) depending on the macro lens you use.

A good macro lens is key in macro photography because it is capable of focusing at amazingly short distances where non macro lenses fail.

Another way to get great magnifications is by using the reverse lens technique. Just turn the lens around so that the rear element points outwards, and the front element faces the camera body. Then, attach it to the camera using a special adapter. A lens has been designed to fit large subjects into the tiny sensor. So, if you reverse it, you can use it as a macro lens. For example, a 50mm lens will give you a magnification of 1:1. The wider the lens the larger the magnification.

Usually, beginners use a 50-60mm macro lens, amateurs a 90-105mm, and pros 150-200mm, which allows to comfortably shoot from a larger distance (30-50cm or even more).

If you're looking for a lens for macro photography, the following ones are great: **Nikon Micro-60mm f/2.8G**, **Tamron Macro 90mm f/2.8**, **Canon Macro 100m f/2.8L**, **Olympus Macro 60mm f/2.8**, **Nikon Micro 105mm f/2.8G**, **Sigma Macro 150mm f/2.8** and **Nikon Micro 200mm f/4D**.

It's important to point out that all macro lenses (50-60mm, 90-105mm and 150-200mm) have the same reproduction ratio of 1:1. What changes is the working distance. The longer the focal length, the longer the working distance can be allowing you to work more comfortably. As you have guessed, the price goes up as well!

This combination of short subject distance and long focal length produces a very shallow depth of field. Therefore, apertures of f/11, f/16, f/22 and even f/32 are great to try to maximize depth of field considering the short leeway determined by the compulsory subject distance (short) and focal length (long) choice.

In macro photography, depth of field is also influenced by a new variable: magnification. As you magnify a subject, depth of field becomes shallower (it can even reach less than 1mm!), which makes controlling depth of field very challenging.

Another new variable that affects depth of field is **pupil magnification**. This is the result of dividing the diameter of the exit pupil of a lens by its entrance pupil diameter.

Calculating macro depth of field

When the subject distance is so reduced that approaches focal length, for example shooting with a 100mm macro lens at a working distance of 4 inches (10cm), the classic depth of field calculator doesn't give correct values. This is due to not taking into account magnification and pupil magnification. If you want a good approximation to total depth of field you'll get in a macro shot, use the our **macro DoF calculator**.

TIPS

- Total depth of field does only depend on magnification, pupil magnification, camera sensor and aperture.
- For focal lengths around 50mm, not taking into account pupil magnification may work pretty well. But, when using long focal lengths, such as 105mm or 180mm, you should take into account pupil magnification to get more accurate results.
- For the same magnification and camera sensor size, doubling the f-stop also doubles the total depth of field. Use the calculator to set the apertures f/8 and f/16 and you'll see how total depth of field doubles too.

Diffraction limit aperture in macro

Since you'll be using small apertures to try to increase total depth of field (f/16, f/22, f/32), diffraction will make your photos look more softened and less sharp. It'll reduce the resolution of your images. In this case, you should look for the trade-off between your aperture choice and diffraction.

The aperture that causes the effects of diffraction is called the diffraction limited f-stop. But keep in mind that we're not talking about rigid boundaries here. The diffraction limited aperture gives you an approximation. It doesn't mean that larger apertures won't produce diffraction and smaller apertures will produce it. It only gives you an idea of what apertures are diffraction limited.

Keep in mind that diffraction is not always a bad thing to have. Do not sacrifice a great photo idea because of diffraction. The idea you want to get across, the story you wanna tell is more important than the "negative" effect of diffraction. So, push aperture, don't be afraid.

Our Macro Diffraction calculator will help you compute magnification and the diffraction limited aperture.

Tips to make the most of depth of field in macro photography

Take a look at the following picture. Notice that only the eye and part of one leg of the mantis is in focus, leaving out of focus other interesting parts of the insect (antennae, body, etc.).

I focused on the mantis' eye, the best choice when photographing insects (and people). As you can see, I got most of the mantis blurred, not due to poor focusing but because of shallow depth of field.

But, how can you have the whole insect in focus?

One option is to ignore depth of field and change the perspective. If you shoot the subject from a direction which allows you to fit most of the interesting parts of the insect along a single plane of focus, then you'll get all you need in sharp focus. You just need to make sure the focus plane is parallel to the insect body when shooting!

Nikon D700 | 105mm | Macro f/8 | 1/180s | ISO 400 | 7500K

Have a look at the following image of a hoverfly.

Another option is a technique called focus stacking, especially if you don't want to change the perspective. It consists in shooting a series of images with an identical composition, each one focused on a plane of different depth on the body of the insect. The goal is that all the parts you want in focus in the final image must be in sharp focus in at least one image of the series.

To do so, you'll need at least a basic manual focus slider to move the camera after each shot or to slowly turn the focus ring. Alternatively, if you're a more advanced photographer, I recommend you an automated system like the StakShot.

Once at home, you can use a software like Helicon Focus or PhotoShop stacking to automatically select the focused parts of each images and stack them together into the final image that displays.

In the following image, the whole orchid in sharp focus.

Nikon D300s | 105mm macro | f/6 | 1/125s | ISO 200 | 6600K

An Epipactis Microphylla orchid. The photo is the result of a 6 images staking. **Nikon D700** | 105mm | f/8 | 1/30s | ISO 200 | 5000K with extension tubes of 12 and 20mm

14

Bokeh

vs

depth of field

Nikon D300s | 125mm | f/2.8 | 1/180″ | ISO 3200 | 3650K

Bokeh is the Japanese word for “blur”. In photography, it is used to describe the quality of the blur produced in the out of focus areas of an image produced by a lens. Bokeh and shallow depth of field are not the same.

In other words, while shallow depth of field refers to the part of the image that is acceptably sharp, bokeh refers to the quality of the background and foreground blur, whether it is smooth or harsh.

Depending on the lens design, the blur in the image can be soft and pleasant or harsh and distracting to the eye. That’s the difference between good or bad bokeh. For example, compare the background blur of these two crops. Do you see the difference?

The **Nikon 18-105mm f/3.5-5.6** zoom lens produces poor bokeh.

The **Nikon 85mm f/1.4** lens produces beautiful bokeh.

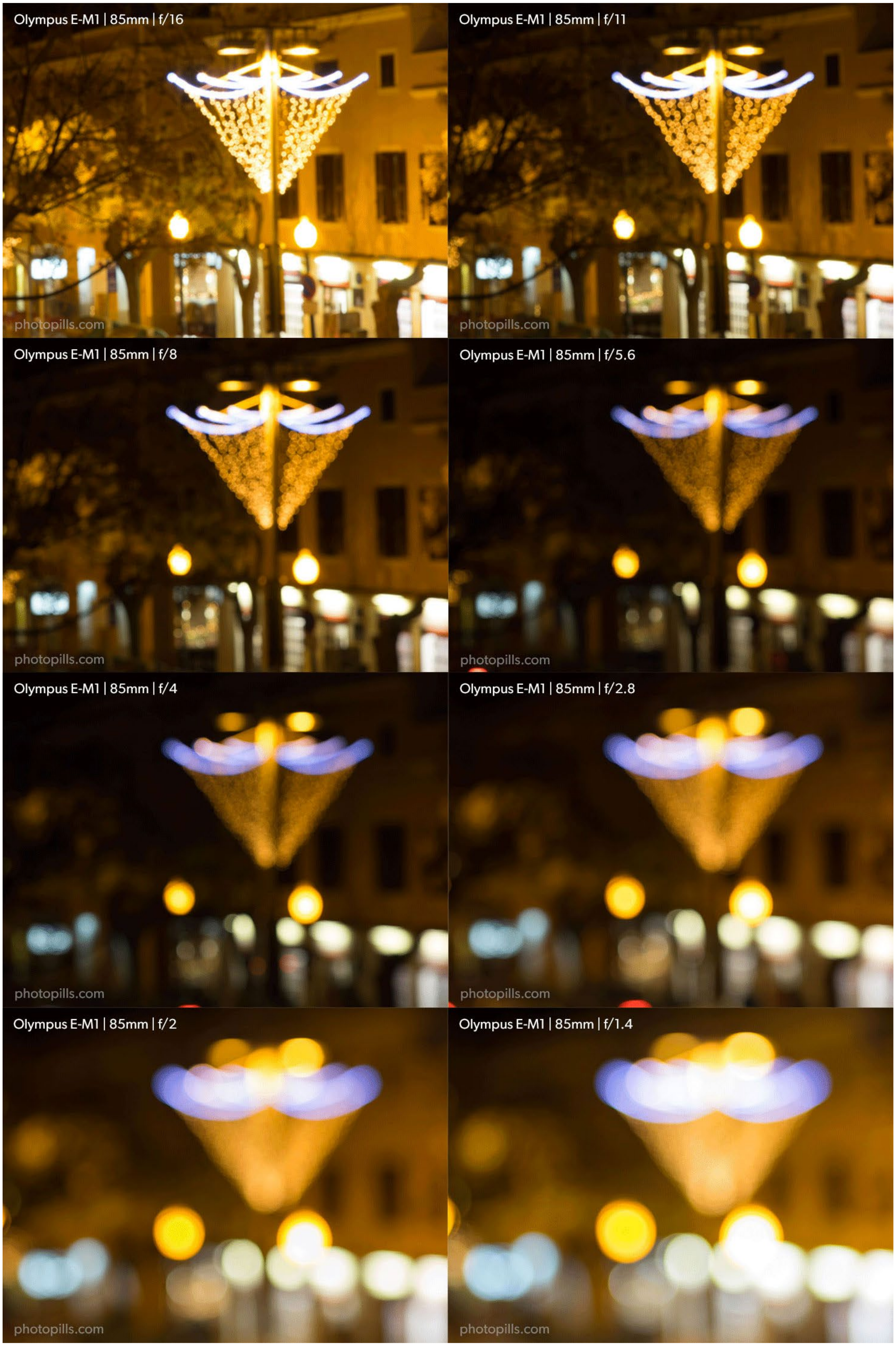
The Nikon 18-105mm f/3.5-5.6 zoom has a harsh bokeh, whereas the Nikon 85mm f/1.4 lens has a very smooth looking out of focus background.

I love using good bokeh as a way of making the backgrounds more interesting. When shooting at shallow depth of field, good bokeh is important so that the subject stands out sharply against a pleasantly blurred background.

If you choose a lens with the goal of achieving great bokeh, pay attention to its design. Look for lenses that have been corrected to compensate for optical aberrations, and that have aperture blades with curved edges to make the aperture more closely approximate a circle rather than a polygon.

The blades define the shape and size of your bokeh. The wider the aperture the wider your bokeh, and the more blades are used to produce the aperture the better. Expensive lenses may have 8 diaphragm blades whereas cheaper ones have only 5, producing a poorer bokeh.

Take a look to the bokeh changes as you increase the aperture.


Olympus E-M1 | 85mm | f/16
photopills.com
Olympus E-M1 | 85mm | f/11
photopills.com
Olympus E-M1 | 85mm | f/8
photopills.com
Olympus E-M1 | 85mm | f/5.6
photopills.com
Olympus E-M1 | 85mm | f/4
photopills.com
Olympus E-M1 | 85mm | f/2.8
photopills.com
Olympus E-M1 | 85mm | f/2
photopills.com
Olympus E-M1 | 85mm | f/1.4
photopills.com

Lenses producing great bokeh are the Nikon 85mm f/1.4, Canon 24-70mm f/2.8, Nikon 28-70mm f/2.8 and the Nikon 24-70mm f/2.8. If you're looking for an even more beautiful bokeh, I recommend you the Nikon 135mm f/2 DC, Nikon 200mm f/2 VR and the Canon 200mm f/2 IS.

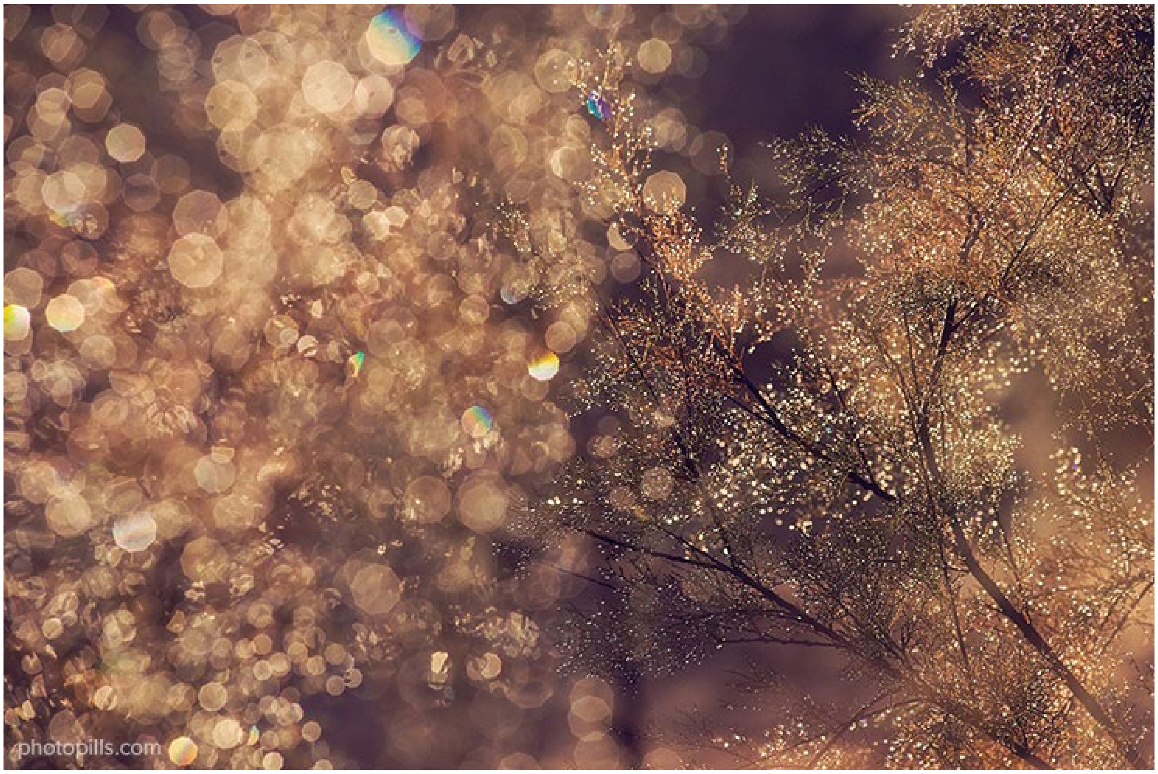
On the other hand, forget about the Nikon 50mm f/1.4 AF-D, Canon 50mm f/1.4, Nikon 18-105mm f/3.5-5.6 and Canon 24-105mm f/4, because they will give you very bad bokeh.

Now that you've chosen the right lens for your desired bokeh, here are a few tips to help you achieve nice bokeh:

- Choose a long focal length like 50 mm or more to get shallow depth of field.
- Select a wide aperture (f/1.4, f/1.8, f/2.8).
- Get close to the subject.
- Focus your lens on the area you want to be crisp and sharp.
- Put your subject far from the background that you want blurred out.
- Bokeh is most visible around small background highlights, such as specular reflections and light sources (e.g. stars).

Having a look at a few photos. and conclude if the bokeh is pleasant or not.

Nikon D7100 | 85mm | f/1.4 | 1/100s | ISO 800 | 3700K



Nikon D4s | 125mm | f/8 | 1/6400s | ISO 1600 | 3700K

Nikon D4s |200mm | f/1.4 | 1/640s | ISO 100 | 5650K

Nikon D700 | 500mm | f/5.6| 1/190s | ISO 400 | 5300K

Finally, I can't end this guide without talking a little bit about custom bokeh shapes.

That's right! You can artificially produce beautiful background blur effects by making a bokeh template for your lens. All you have to do is:

- Take a pencil and draw the circumference of your lens on a card. Place the lens on the card and draw around it.
- Draw the shape you want right in the middle of the circle. It's size should be pretty small, less than an inch (15-20mm) should be fine.
- Use a cutting blade to cut out the template. Make sure you cut following a larger circle outside the first one so that the template overlaps the front of the lens. Then, fasten the template over the lens with an elastic band.
- When shooting, make sure you have background highlights: candles, christmas lights, street lights, fireworks, stars, etc.

Another alternative is to buy already made templates.

Bokeh Shapes Masters Kit.

Finally, watch this Bokeh Master Kit video review by the guys at DigitalRev TV. It is a little bit crazy, but it's so fun. I love these guys!

15

The secret to improve

"There's a difference between knowing the path and walking the path". – Morpheus, The Matrix (1999)

Hey PhotoPiller! Congratulations!

You've made it! You're a hero!

Believe it or not, you've just gone through more than 17.000 words on depth of field. This is the kind of material that would destroy Superman, even worse than kryptonite. But look at you, here you are, safe and sound.

Amazing!

The good news is that now you know everything you need to put depth of field at your service. You are capable of shooting pictures that will surprise the world. You can capture images that will give goosebumps.

You know the path. Now, you just have to let your imagination fly.

But knowing the path is never enough. It won't help you improve your photography. It won't help you improve in life. The secret is to start walking it!

I used to be one of those people that believe knowledge is power. I was persuaded that, by mastering knowledge, I would be capable of achieving my goals in life. How wrong I was...

Throughout time, life has taught me that the only way to improve is by putting the theory into practice, by walking the path. It's only when you plunge into the real world that you realize you actually don't know how to apply it. You thought it was crystal clear, but it's far from it.

As soon as you feel this "aha" moment, take a deep breath, show character and say to yourself: "I'm going to do it, no matter what it takes. I'm not giving up!"

And guess what? You're not alone, we're here to walk the path with you. When you'll need us, you'll have us.

Just leave a comment below these lines or contact us via info@photopills.com. Your comments, questions and feedback will surely help both of us improve.

Life's too short to take it too seriously. A little bit of crazy fun is always more than welcome. So, for now, I'll leave you with the Bard.

The Bard impersonating Morpheus, **The Matrix**.

"This is your last chance. After this, there is no turning back. You take the Skull pill – the story ends, you wake up in your bed and believe whatever you want to believe. You take PhotoPills – you stay in Wonderland and I show you how deep the rabbit-hole goes. Remember: all I'm offering are Legendary Photos and Goosebumps, nothing more."

The making of: light painting with Germán (the Developer), Rafael (the Bard) and myself (the Photographer).

Keep imagination high!

Happy DoF!

Antoni Cladera is a landscape photographer with commitment to environment. Artist of the Spanish Confederation of Photography and member of the Spanish Association of Nature Photographers (**AEFONA**). He's a part of the PhotoPills Team.

Special thanks to **Sandra Vallaure**, a great photographer and friend, for her tremendous help in making this article possible.

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