photo & video

A feeling of beauty is often an indicator of the presence of a golden spiral.

Text and photos
by Rico Besserdich

What makes an image a really good one is certainly a question that, at some point, troubles the mind of every image-maker. Is it the subject of the image, or is it the specific moment captured? Is it the colors in the photo, or the techniques used? Each of these aspects deserves consideration, and not every breathtaking image can be entirely explained by just following a checklist, marking the things that were done correctly with a green pen and using a red pen for the failures spotted. Yet, what most humans perceive as beautiful and aesthetically pleasing visually can surprisingly often be explained with math. Yes, math.

Fibonacci Numbers

— in Underwater Photography

It is not a new thing. It all began in Pisa, 817 years ago, when a very clever mathematician was thinking profoundly about numbers… and also about rabbits. His name was Leonardo Pisano Bigollo, better known as Fibonacci.

Fibonacci lived around 1170-1250 B.C. and was known to be the most talented mathematician of the Western world in the Middle Ages. As a member of an important trading family in Pisa, he traveled extensively throughout the Middle East as a youth and discovered the mathematical advantages of the Indian number system, which made its way to the West through the Arabic countries. In his time, the Roman numeric system was the one used in Europe, making advanced mathematics difficult, if not impossible.

In Fibonacci's own words (from his book *Liber Abaci*, published in 1202): "…when I had been introduced to the art of the Indians' nine symbols through remarkable teaching, knowledge of the art

very soon pleased me above all else and I came to understand it, for whatever was studied by the art in Egypt, Syria, Greece, Sicily and Provence, in all its various forms."

Just imagine the year we are living in—2019—in Roman numerals. In Fibonacci's time, this number was written MMXIX. Tricky to do math with that.

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Statue of Fibonacci (1863) by Giovanni Paganucci, Camposanto di Pisa, Italy

A legendary formula

Around the year 1210, Fibonacci returned to Pisa, where he wrote several important texts and books. Copies of his works were extremely limited, as the great mathematician lived 200 years before print was even invented, so his texts and books were handwritten. One of his most well-known books survived the centuries: *Liber Abaci (The Book of Calculation)*. This book introduced the Hindu-Arabic decimal system and the use of Arabic numerals to Europe, an often forgotten but important fact. Forgotten perhaps because what is most often discussed is the problem about rabbits and the legendary mathematical formula resulting from it.

In his work, Fibonacci posed the following question: "A certain man puts a pair of rabbits in a place surrounded on all sides by a wall. How many pairs of rabbits can be produced from that pair in a year if it is supposed that every month each pair begets a new pair which from the second month on becomes productive?" (Fibonacci, *Liber Abaci*, third chapter)

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Find the golden ratio in human faces such as Grace Kelly's, the American actress who became Princess Grace of Monaco in 1956.

The resulting sequence, in which each number is the sum of the two preceding numbers, goes like this: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55… and so on.

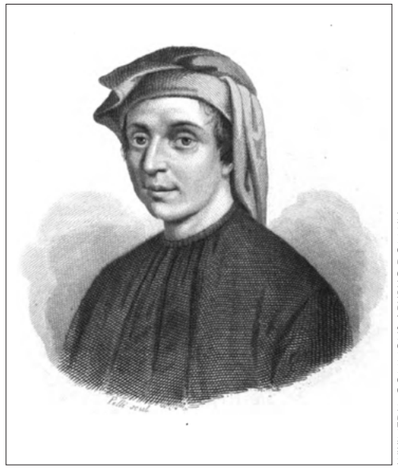
Behold, the world-renowned Fibonacci sequence, also known as the Fibonacci numbers. Please be patient, I will tell you in a short while what all this has to do with underwater photography.

An amazing proportion

Now Fibonacci himself actually had very practical matters and questions in mind when he studied and researched the deeper meanings of mathematics. Just take economy, accounting and population growth (rabbits!) as examples. Unbeknownst to Fibonacci at the time was that his sequence, or better to yet, the quotient of the adjacent terms, led to an amazing proportion—a proportion that can be found in tiny atoms, in DNA and in hurricanes, in small and large objects everywhere in nature, and even in distant galaxies.

This proportion is known by many names: the golden ratio, the golden mean, phi and the divine proportion, among others. Some even call it nature's secret code. It is a number that translates into a ratio, a ratio that defines beauty and aesthetics in nature and in the arts. The answer to the big question about (the meaning of) the universe, life and all the rest is not "42," it is 1.618. Nature's secret code—and yes, it is everywhere.

Nineteenth century engraved portrait of Leonardo Pisano Bigollo, (aka. Fibonacci) from 1850 by an unknown artist (right); Leonardo da Vinci's *Vitruvian Man* (c. 1490) is considered to be a masterpiece, utilizing the golden ratio (far right)



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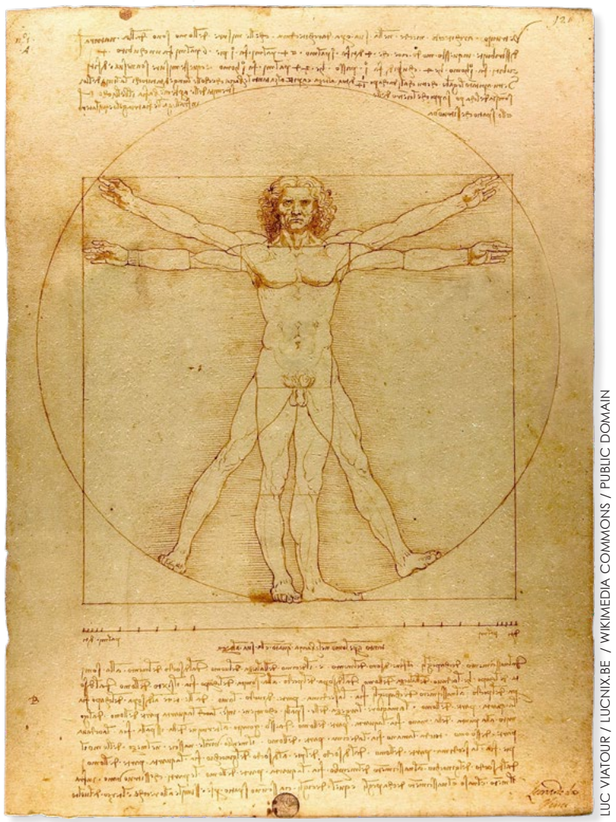

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Do you like honey bees? If you divide the female bees by the male bees in any given hive, you will get 1.618. How about sunflowers? Sunflowers, which have opposing spirals of seeds, have a 1.618 ratio between the diameters of each rotation. Neither bees nor sunflowers in sight? Try measuring from your shoulder to your fingertips, and then divide this number by the length from your elbow to your fingertips. Your result will be 1.618. Too difficult? Take the length of your leg and compare it to the length of your arm. This proportion should be near 1.618 in almost all cases. The golden ratio cannot be avoided.

Everything beautiful in nature (including beautiful humans) is based on the golden ratio. Or, as the German philosopher Carl Friedrich von Weizsäcker nailed it down when he said, "Perhaps the omnipresent hidden mathematics of nature is the ground of all beauty."

With nature as the greatest teacher, many artists used the golden ratio to create artworks that will stay beautiful forever. Just take Raffael, Leonardo da Vinci, Dali, Rembrandt and Albrecht Dürer as a few examples. In the world of architecture, the Pyramid of Cheops (Giza) in Egypt, the Parthenon in Greece, St. Peter's Basilica in Italy or Cologne Cathedral in Germany are perfect examples, utilizing the golden ratio, the divine number, the sacred ratio 1.618.

In the underwater world

Once we open our eyes and minds to

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The Parthenon in Athens, Greece

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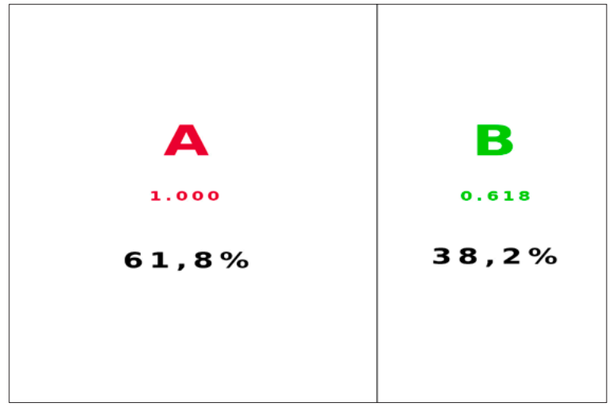


The simplest way to divide an image frame into two sections, utilizing the Fibonacci number 1.618 (right); "Minimalistic" version of image composition, frame divided in the 1.618 ratio (far right)

it, we can spot this divine ratio everywhere, even in the oceans. Seashells, nautilus, crinoids or even corals—everything we perceive as beautiful is based, in one way or another, on the Fibonacci sequence.

For photographers, this leads us to three options (assuming we want to create beautiful images with the divine number in mind): 1) We look out for marine life and subjects that fit into the golden ratio; 2) we compose our images according to the golden ratio; or 3) we combine the first two options above.

Well, not everyone likes math, and we are, at any rate, already overtasked with our diving, traveling, photo gear, and a million other things we need to keep in mind. So, let's start with something easy in terms of how to make use of the "magic number."

A very basic first step

Imagine your picture frame in your camera's viewfinder, LCD screen or on your computer screen in post-production. Divide this frame into two sections. Naturally, you might want to have two sections of the same size. But please don't... as it is not very Fibonacci!

If you want to utilize the golden ratio, the two sections of your picture frame should not be of equal size. To do it "Fibonacci-style": Create one section that covers roughly 61.8 percent, and another one that covers roughly 38.2 percent of the frame.

To separate the frame into two sections of equal size would mean you subdivide your frame at "50," or directly down the middle. This could come with the risk of creating a boring image composition.

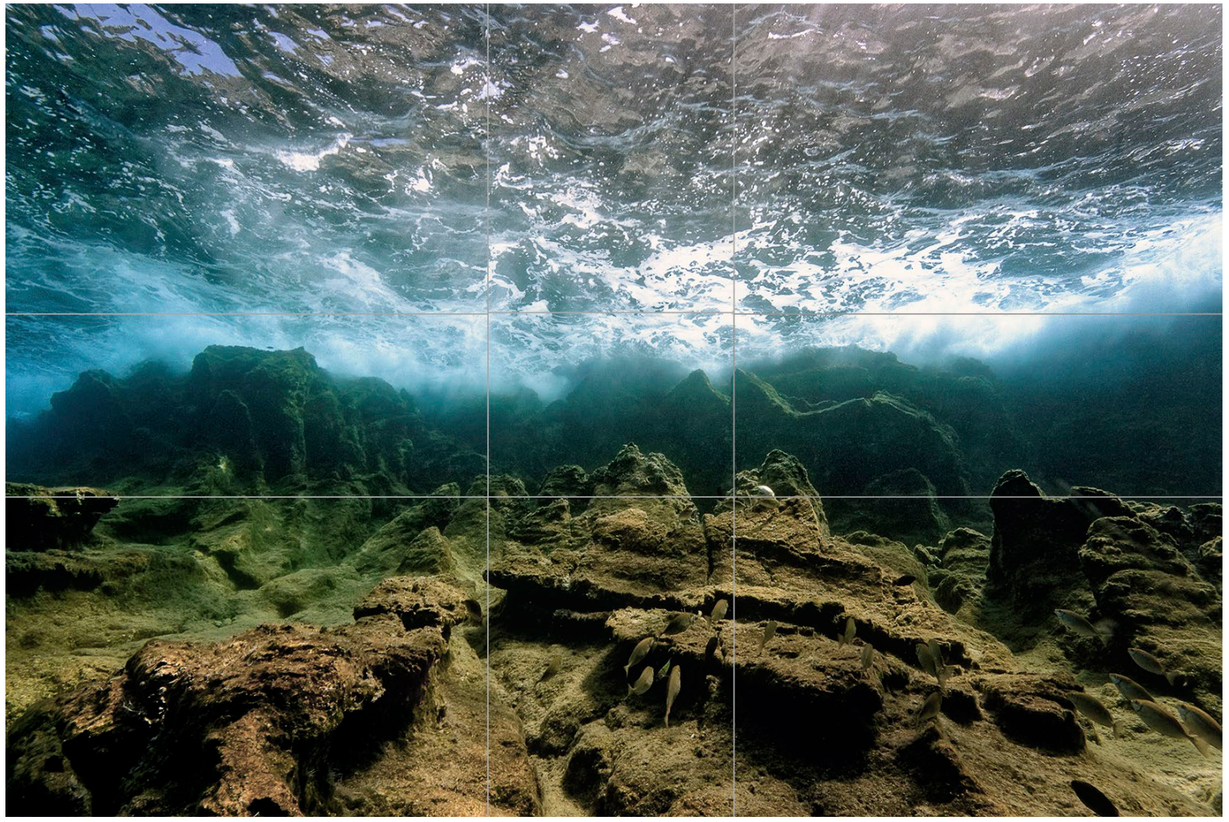
This works, by the way, with vertical and horizontal subdivisions alike. It also works with all kinds of different image aspect ratios (such as 4:3, 3:2, 1:1 and so on). What is important are the proportions of the sections (please see the image graphic top left).

Please note that the Fibonacci sequence and its effects on image composition is not the "rule of thirds" and should not be mistaken for it. Image composition using the Fibonacci sequence is a far more advanced thing than the rule of thirds.

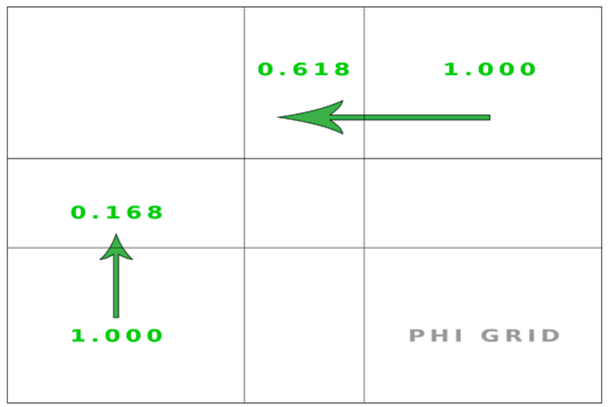
After that nice and smooth warm-up, let us proceed with the next step. It is called the phi grid, and again, it is a part of the Fibonacci numbers family.

Phi grid

Now, everyone knows the rule of thirds. It divides a frame into three rows and three columns of equal size, resulting in a 1:1:1 ratio vertically and a 1:1:1 ratio horizontally—a well-known basis of image composition. The phi grid, however, works slightly differently. It divides the frame in a similar way as the rule of thirds does but makes the middle row and



The phi grid in an underwater landscape photograph—the "action" happens in the three center sections.



The phi grid (above) is based on the "divine number," or ratio, and as such, is very different from the well-known rule of thirds grid.

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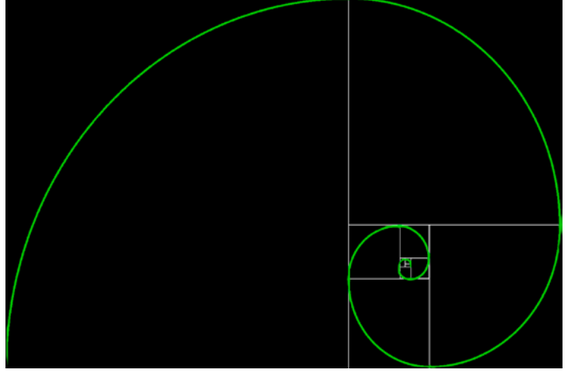
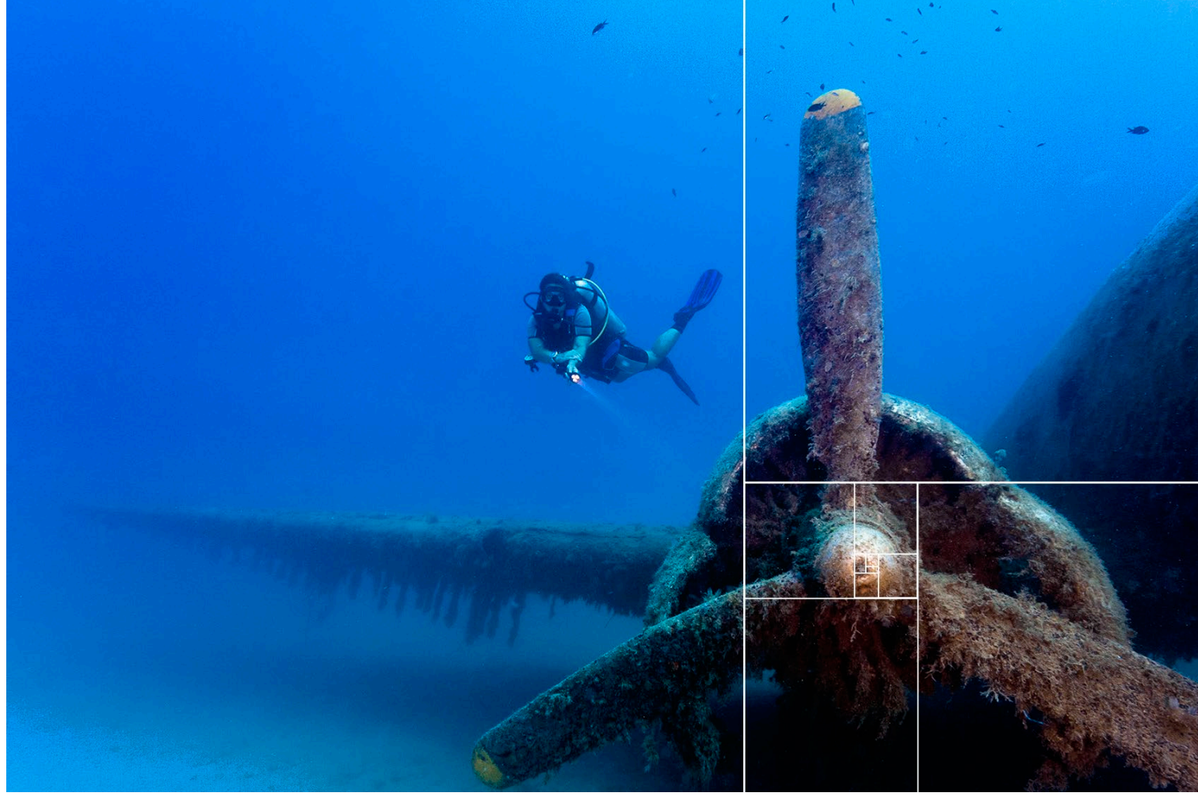
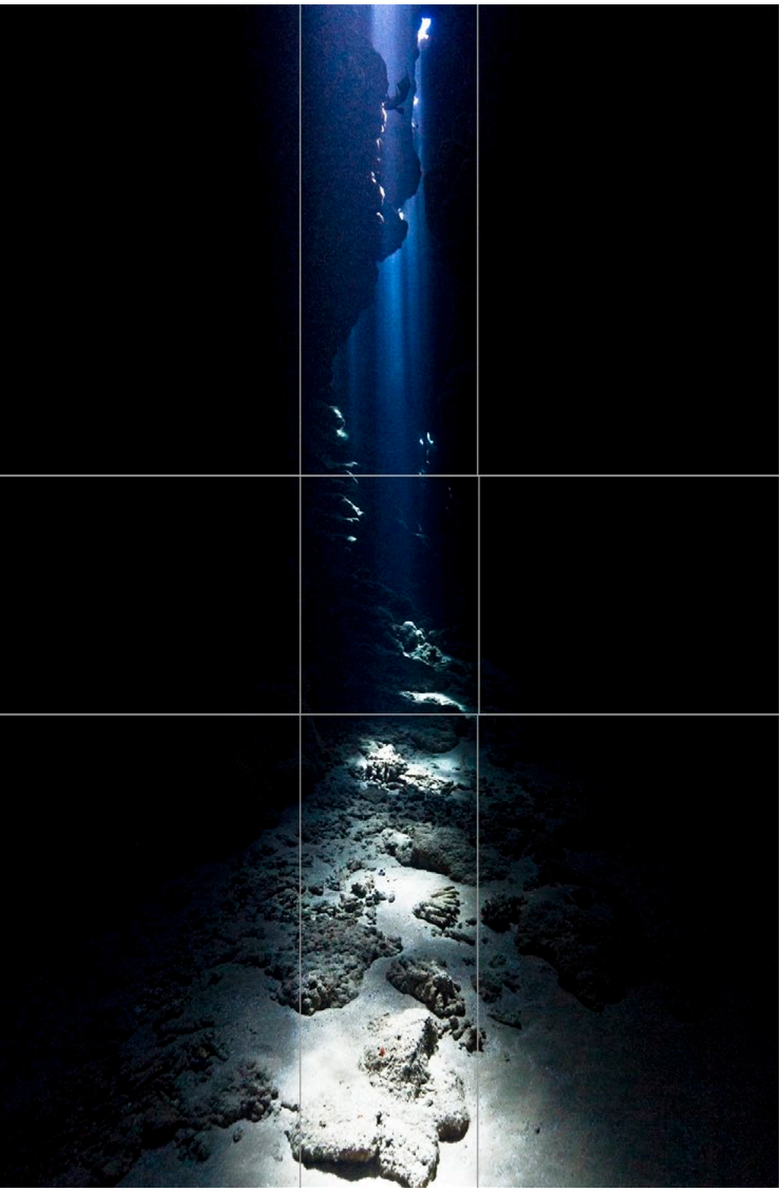
The source of the magical golden spiral (right); The golden rectangle in an underwater image (far right); The golden rectangle and golden spiral, combined. Everything of interest in this underwater image fits in this configuration (lower right).







The phi grid and all other patterns of the golden ratio can be utilized in horizontal and vertical images alike.

middle column smaller according to the golden ratio. This results in a 1:1.618:1 ratio vertically and a 1:1.618:1 ratio horizontally. Simply put, the phi grid gives more weight to the top left and right sections, and to the bottom left and right sections of the frame (please see center image graphic on the previous page).

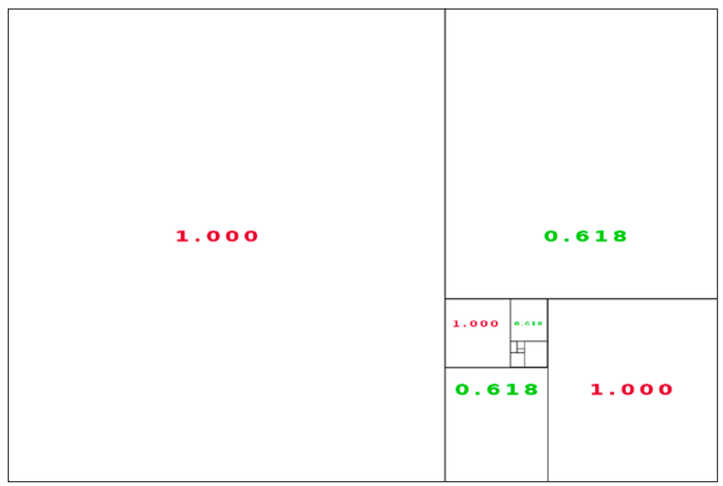
Golden rectangle

Whilst the first example was simple, because we divided a frame into only two sections; and the second example might have been easy to digest as well, since it reminded us somewhat of the rule of thirds; we will now go a little bit deeper into complexity with a third example.

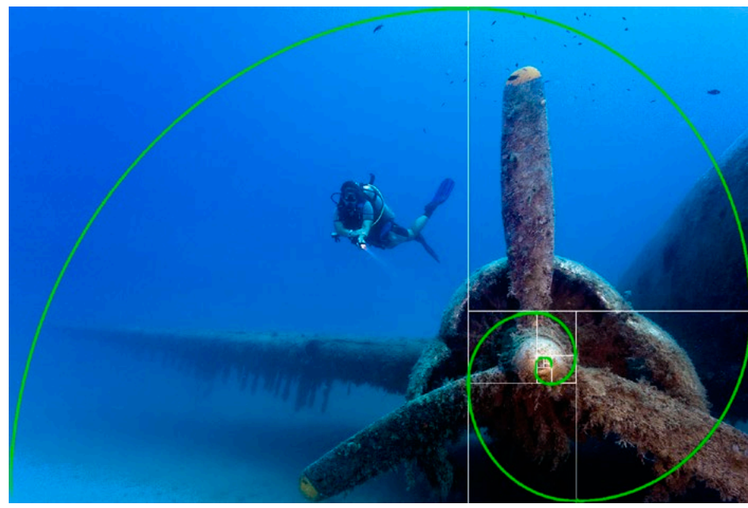
Following the Fibonacci sequence, an image frame can be subdivided into several sections of different dimensions, with each section and the sum of all of them fitting into the 1.618 ratio. Just remember the rabbits!

First, we divide the frame as in the first example, vertically dividing the frame into two sections, utilizing the 1.618 ratio. The larger section, we leave as it is; the smaller one, we divide into two sections horizontally, again in the 1.618 ratio.

The upper one stays as it is; the lower one we again divide horizontally into two sections. Again, we leave one of those new sections as it is and divide the next one. Logically, our sections are getting smaller and smaller. In the end, we have nine squares (outer frame border included) and a perfect Fibonacci sequence. Voila, the "golden rectangle." (See image left)



Dividing an image frame into several golden ratio sections. The proportion is always 1.618. This is the golden rectangle.



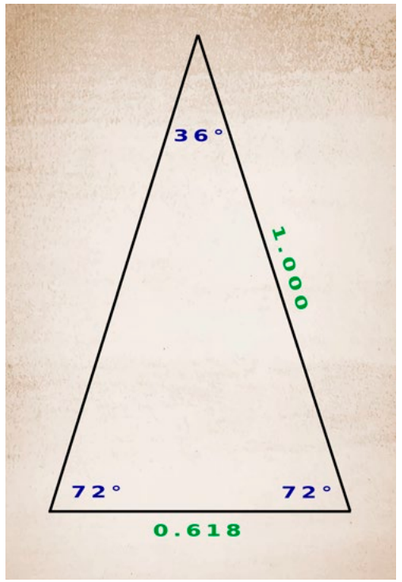
Golden spiral

This one is easy. Take the example above (our collection of different squares) and connect the vertices of these squares with a curved line. Result: The points of these vertices creates a (logarithmic) spiral. Voila, the "golden spiral"—Mother Nature's code of beauty. (See top left image)

The golden spiral is, one could say, a logical result of the Fibonacci sequence. And yes, it is everywhere.

Golden triangle

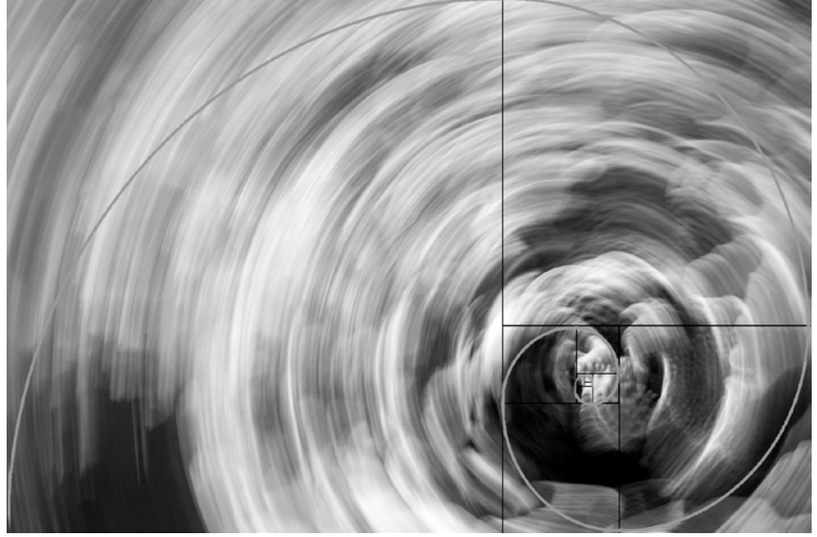
What works with squares works with triangles as well. The "golden triangle" is an isosceles triangle with a vertex angle of 36 degrees and base angles of 72 degrees. The legs are in a golden ratio (1.618 proportion) with the base. A penta-



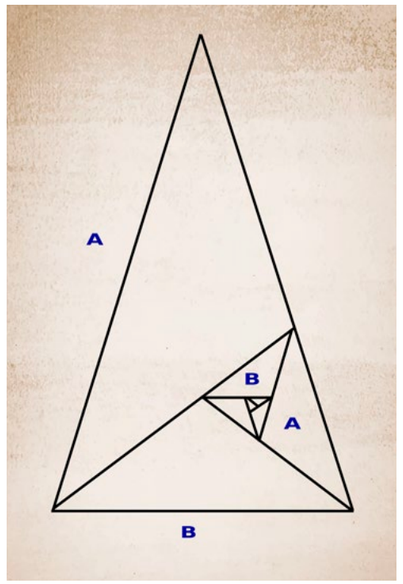
gram, for instance, is a perfect example of a combination of golden triangles.

Such a triangle can then be divided into smaller sections, with each section having a "golden number relation" to its neighbor. Connect the vertices of these squares in a curved line and you will have another golden spiral.

Any square-shaped image can be divided into golden triangles to help image composition. Just imagine (or draw) a horizontal line from one corner of the frame to the next. Consider this line to have the value of 1.618. Find a starting point (in your line) that is more or less equal to 1.000 (or at 68.2 percent of the line). From this point, draw another line that ends up in one of the two remaining empty frame corners. You do not have to, but you could draw a last line,



The golden rectangle and golden spiral image overlays are also useful to improve image composition (above); Beauty and the golden spiral, they are always together (right); The golden triangle, in its most basic version (left); The golden triangle, in a more advanced version—1.618 is the number! (below center); Wherever Fibonacci is, there is a golden spiral (lower right)

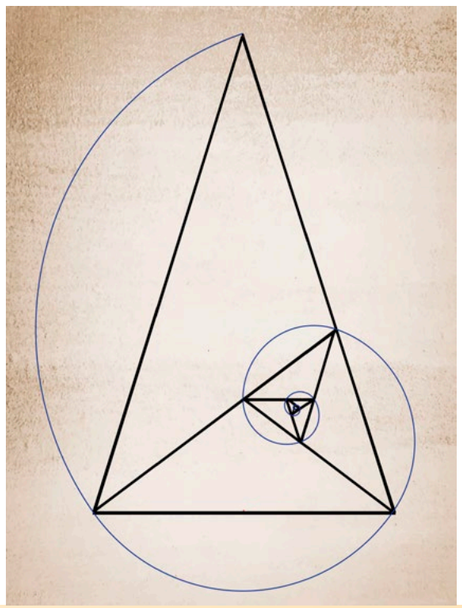


starting at 0.618 (or roughly 32.8 percent) of your "main" line, and reaching the last remaining corner of the image frame.

If the composition works according to the Fibonacci numbers, your main subjects will be oriented to the line(s) and/or fit nicely into the golden triangle sections, which your lines create in the image. (See lower images on next page).

Software

In case you find all this far too complicated to do, you can use Adobe Lightroom or Adobe Photoshop (version CC or later). Both provide the option to adjust or crop your image, utilizing the golden ratio. That does not mean you must crop, but it is a useful visual tool to find out if your image matches the golden ratio or not.



In Adobe Lightroom: When you are using the crop tool, you can cycle through the different options/grids by pressing O (for overlay). You cannot see or access this option unless you are actually using the crop tool. Which overlays (help grids) Adobe Lightroom makes available for you is something you can select by entering: Crop Guide Overlay > Choose Overlays to Cycle.

In Adobe Photoshop: First, the crop tool must be activated. To cycle through the different crop overlays/grids (including the golden ratio, of course), you can use the same keyboard shortcut (O).

Plan B: Just do a search online for "Fibonacci overlays," and you will find various websites of which some do offer free downloadable overlays with plenty of different golden ratio variations. For example: http://parksphotos.com/goldenoverlays/.

These tools are very useful when you want to check if your images are already proud members of the golden ratio, or golden number family, or perhaps could use a slight correction to improve their composition. After a little practice, you will easily memorize Mother Nature's special code as it has always been with you… even in your very own DNA.

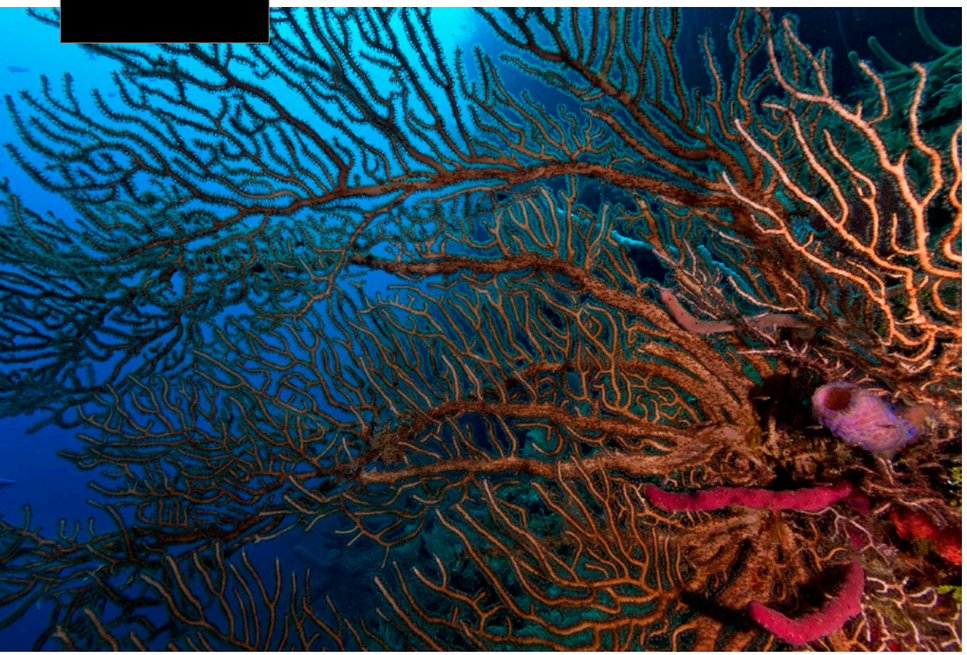
Composing & selecting

However, utilizing the Fibonacci numbers in underwater photography in terms of image composition might not always be easy if one thinks too much about ratios, numbers and math (especially while diving). But then again, many camera user manuals are actually more complicated than the Fibonacci sequence ever was, at least in terms of photography.

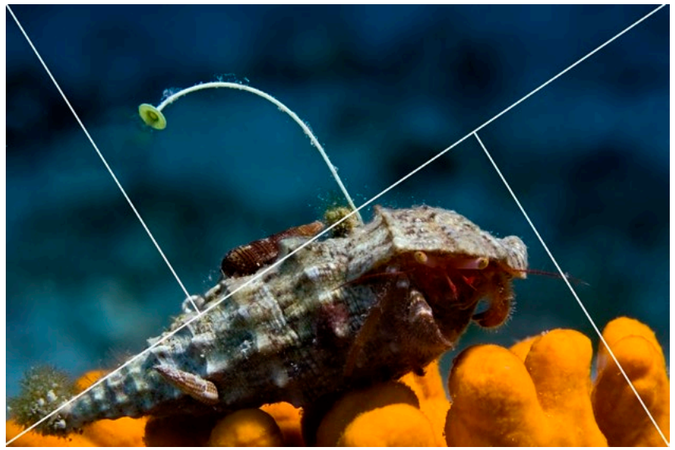
Going back to the question posed at the beginning of this article, which was: "What makes an image a really good one?" Perhaps, when selecting your images for a magazine, a contest, an exhibition or just for yourself, have a little dialogue with yourself: "This is so beautiful. I like it! But why is it beautiful? Is it the subject, the light, the colors or something else?"

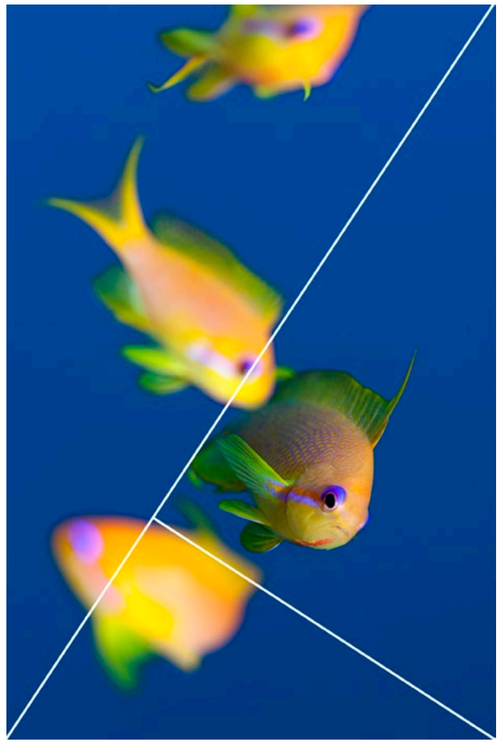
It could be that the answer to your questions is 1.618, nature's divine code of beauty, the Fibonacci code. This has nothing to do with the camera model used or specific photography techniques applied (not that they are useless, but they are not everything); it has a lot to do with

The Fibonacci code is present everywhere in nature, even in tube-worms (right); "Mother Nature's secret number" is present in corals as well. The 1.618 ratio can be found in many marine animals (below).



Utilizing the golden triangle (the most basic option) in an underwater image composition (right); When working with one (or more) golden triangles in image composition, it always helps if the main subjects of the image follow the line and/or nicely fill one or more of the triangle sections (lower left)





Beauty

Beauty is a universal language. Wise philosophers and scientists in Greece, Egypt and India pondered and studied the "key of beauty" long before Fibonacci was even born. But it was Fibonacci who, by using math as a universal language, paved a way for making some mysteries of life and nature understandable to humankind.

He did it at a time when the Fourth and Fifth Crusades took place, the Mongolian Gengis Khan ruled an empire and invaded China, truth (what is right and what is wrong) was dictated by religion, and everyone on the planet believed without a doubt that Earth was a disc and the center of the universe. ■

an understanding of what defines beauty. The knowledge of this will certainly help you on your way as a photographer, as it will give you the power to be able to explain why your images are good (beyond subject and technique) and beautiful.

Are you a Fibonacci fan? Learn more about the Fibonacci number sequence and related mathematical topics in The Fibonacci Quarterly *(fq.math.ca), a journal published four times a year since 1963, by the Fibonacci Association.*

Rico Besserdich is a widely published German photographer, journalist and artist based in Turkey. For more information, visit: ***Maviphoto.com****. See his latest book at:* ***Songofsilence.com****.*

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Tip of the Day

by Peter Symes

Read... the... manual!

Ideally, your camera rig should be an extension of yourself and second nature to operate. When you get a new piece of kit, say a camera, read the manual thoroughly with the camera in hand.

Then read it again while familiarising yourself with all the knobs and buttons and going through all the settings in the menus. It is unlikely you will ever use them all, or even most of them, as modern cameras have become very capable at the price of added complexity. But you should know which different functions are hiding in the menus as one day you may need them. Or you may later develop your technique and decide to go in a different direction—for example, from stills to video.

Practice makes perfect

But most importantly, practice and play until you can set and switch between your preferred modes of operation or settings, without taking your eyes off the viewfinder. It should be like driving a stick shift.

Technology is just a tool

Taking great pictures is not about having the latest and best equipment around but about knowing how to use what we have in an optimal way. Consider this: The classical masters of photography like Ansel Adams, Robert Capa, Henri Carter Bresson and Dorothea Lange had only rather rudimentary mechanical film cameras, with none of the many features and fancy technology that is now available in even basic consumer cameras and smartphones.

Technology makes many things a lot easier, but only if we know how to use it properly. It does not make us good photographers on its own. It is just a tool, and we have to understand how it works if we are to be in control of the creative process. ■

Contrary to popular belief, flash photography does not appear to damage seahorses' eyes. Flashes had no observable impact on foraging behaviour or feeding success rates. Still, touching the animals—perhaps to position them for the ideal snapshot—can trigger strong stress responses.

Impact of flash photography on fish

Text and photos by Peter Symes

With the advent of still more affordable and easier-to-use solutions for underwater photography such as waterproof action cameras and housings for cell phones and tablets, an estimated one in four divers is now also some sort of underwater photographer. On popular dive sites, flashes can be seen going off all the time. Yet, despite all these interactions, the impacts of photographer behaviour and photographic flashes on animals are quite poorly understood.

While taking pictures, divers spend more time close to marine life, causing damage to the substrate and often touching animals. It has been a long-standing contentious issue that some underwater photographers cause damage to reefs by either not being mindful, lacking sufficient buoyancy skills or simply just being unscrupulous in their pursuit of the desired image, never mind the damage caused to delicate corals.

Another prevailing concern is stressing or, worse still, molesting animals, say, by moving them to other locations in the misguided pursuit of a better composition. Divers will occasionally carry "muck sticks" to coax animals into a better position for taking photographs. For the same reason, most underwater competitions, exhibits and, indeed, magazines like ours will refuse images created under such circumstances.

What about flash?

Just taking photos is believed to cause harm in some cases. As a result, flash photography is banned in many aquariums. The bright photographic strobes used in underwater photography frequently raise questions about potential impacts on animals' behaviour and/or their visual systems, i.e. do they cause eye damage or even blindness?

Yet, thus far, no significant effect of flash photography has been detected on the behaviour of teleost fishes, according to a new study published in *Scientific Reports*, which investigated the matter.

To assess the impact of photographer behaviour and photographic flashes on animals, a study was conducted on 14 benthic fish species that are important for scuba diving tourism and aquarium displays.

Seahorses and frogfishes are highly popular with underwater photographers. Cryptic species such as these depend on camouflage to avoid predation. Many are slow swimmers, not capable of fleeing from scuba diving photographers. Species like seahorses are visual predators that rely on accurate resolving power to catch prey. Any reduction in visual acuity or sensitivity is likely to reduce survivorship, and the high intensity light of photographic strobe lights could theoretically result in retinal damage.

Flash is OK

The study found that photographic flashes had no significant effect on the time seahorses spent hunting. The number of strikes at prey was not different, neither was the catch success rate. Even in the treatments that caused movement reactions, feeding rates were unchanged, indicating that despite potential distress, visual acuity was not impacted.

There is no evidence that photographic strobes result in changes to gross eye anatomy (shape or size of the eye and/or lens) or basic retinal morphology, defined here as the thickness of the whole retina or the thickness of each retinal cell layer. Caution remains necessary, as different species may well have different susceptibility to damage to their retinas.

Don't touch!

On the other hand, the results showed very clearly that touching fishes in the wild has a very strong effect on seahorses, frogfishes and ghost pipefishes. The fish moved much more, either by turning away from the diver, or by swimming away in an attempt to escape. Moreover, manipulation of animals by underwater photographers elicited very strong flight and stress responses.

In the wild, seahorses need to hunt almost nonstop due to their primitive digestive systems, so frequent interruptions by divers could lead to chronic stress or malnutrition. The highly significant increase in movement for frogfishes, species which rarely move if undisturbed, implies a considerable energy expenditure, which could lead to decreased fitness. ■

SOURCE: NATURE

Waterproof SSDs from Sony

It happens to us all—we drop stuff, or spill something. Underwater photographers, who often will find themselves transferring or editing images in moist environments or close to water, will be reassured that a bout of butterfingers need not have catastrophic consequences. Sony's new high-speed external SSD drives are both dust and waterproof, and the USB-C port does not even require a cover to maintain protection. The drives can withstand being submerged in one meter of water up to 30 minutes, take a drop from three meters, and withstand 13,227 pounds of pressure. The drives come in 500 GB, 1 TB and 2 TB storage configurations. Pricing has not been released yet, and the drives are expected to ship in summer 2019.
pro.Sony

Tablet Housing

Divepad from Italian manufacturer Easydive is a universal underwater housing for both iOS and Android tablets in sizes up to 10 inches. The tablet communicates with the housing via a Bluetooth connection. All you need is the application, downloadable from the App Store or Google Play. With an iPad, all the camera features are accessible via an app. On Android tablets, the control unit enters into keyboard mode to enable access to different applications. The housing is depth-rated to 60m.
Easydive.it

Aquatica Monitor 5HD

Do you also struggle a bit looking through the viewfinder or seeing what is displayed on the rear panel of your camera? If so, rescue may be at hand in the shape of Aquatica's external monitors, which provide a Full HD 1920x1080 resolution. The monitor supports focus peaking and false colour to assist in focusing and proper exposure. The colour temperature is adjustable. The sunshade can easily be detached without the use of tools. The monitor is compatible with housings from other manufacturers using a 16mm bulkhead. The aluminum housing is depth-rated to 100m. **Aquatica.ca**