c't Digital Photography

The in-depth quarterly for the photo enthusiast

Workshops

Nature Photography

Underwater Shooting

32-bit Editing
Ultimate Contrast, Tone Mapping

Free DVD

eBook: The Wild Side of Photography
Full Version Software
Video Tutorials

Smartphone Special

Camera Test
Shooting Tips
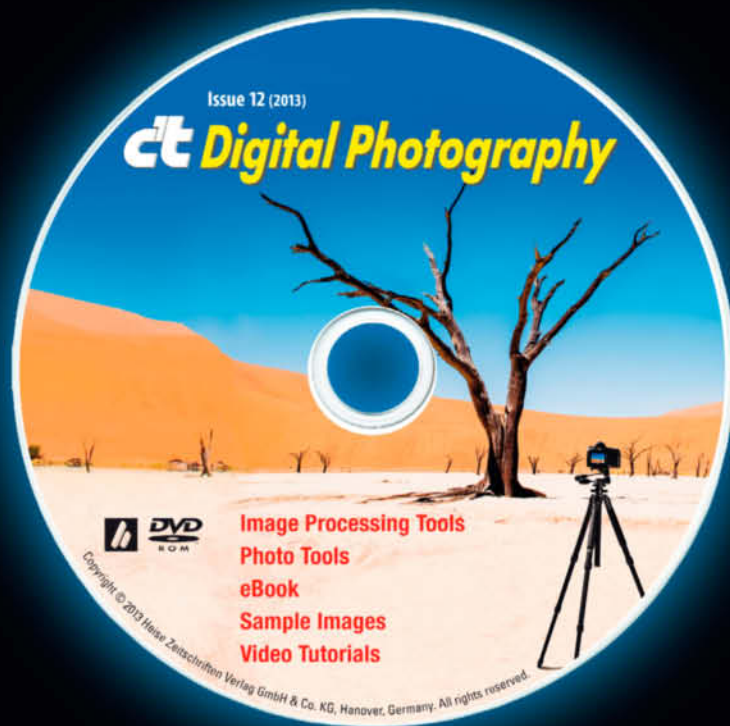## DSLR Remote Apps

Full-frame hits the Mainstream
Budget Large-sensor SLR and System Camera Test

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Issue 12 (2013)

c't Digital Photography

Image Processing Tools
Photo Tools
eBook
Sample Images
Video Tutorials

DVD
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provided with the premium edition of the
magazine is available for download at

www.ct-digiphoto.com/dvd122013

c't Digital Photography

The in-depth quarterly for the photo enthusiast

Every revolution has its good and bad sides, and the digital revolution is no exception. Until now, one of the unshakable rules of the digital photography game was that capturing images on sensors as large as 35mm negatives was an extremely expensive thing to do. Ten years ago, if you wanted to use all your prime lenses in their intended format, you probably had to spend as much on your camera as you would on a small car. The positive side of all this was the birth of a fantastic new photographic status symbol – the full-frame sensor.

Today, full-frame camera prices are finally starting to reach less stratospheric levels, and you can get your hands on Canon's EOS 6D or the Nikon D600 for a street price of around US$2,000. At last, photographers everywhere can mount a 28mm lens and shoot away without having to compensate for crop factors or annoying depth-of-field anomalies.

This issue's comprehensive camera test will help you decide for yourself whether it's worth investing in one of the new breed of full-frame DSLRs, while our nature photography workshop will help you to capture better images of the natural world whichever camera you use. On a different tack, but no less important in today's photographic world, our smartphone special tells you all about the best built-in cameras on today's market and reveals that, although they were initially dismissed as toys, phone cameras are rapidly establishing themselves as serious artists' tools.

Have fun with Issue 12 …

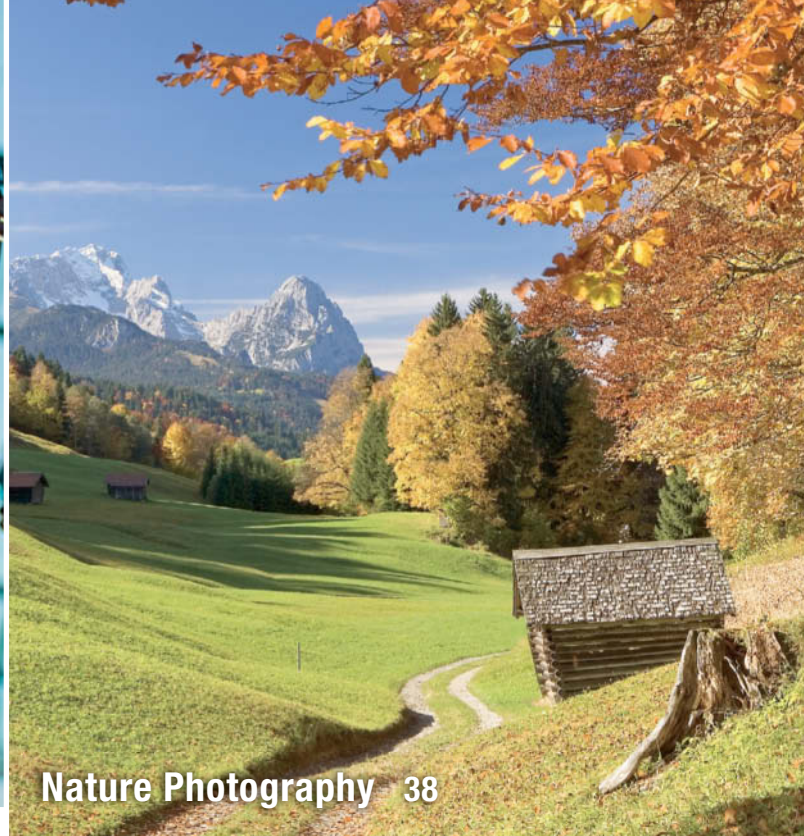*S. Arackal*

Sebastian Arackal

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Portfolio

Still lifes take pride of place in the work of Jessica Backhaus. Her 'painted feelings' compel us to take time to step back and think.

Camera Test

Cheap full-frame DSLRs are starting to hit the market and mirrorless system cameras are getting better all the time. Our test gives you the run-down on the best today's market has to offer.

Photographing Nature

Magnificent subjects are all around us in the great outdoors. This article gives you tips on how to spot them, as well as on how to choose your equipment and compose your pictures.

CameraBag

A lightweight, simple-to-use alternative to specialized applications such as Lightroom and Aperture, CameraBag is a low-price grab bag of effects for use on the road or on a home computer.

Smartphone Camera Test

Can the camera modules built into the latest smartphones really compete with purpose-built compact cameras? This test provides the answers, some of which may surprise you.

Smartphone Art

Smartphones free their users from the technical dictates of conventional photography and have quickly become the tool of choice for pro and amateur artists alike.

DSLR Remote Control Apps

Connecting cameras to mobile devices opens up a whole new range of creative opportunities for photographers. We take a look at some of the best apps currently on offer.

Underwater Workshop 90

32-bit Image Processing 108

Underwater Photography

Thanks to an increasingly broad range of affordable underwater gear, many divers are now turning their hand to photography. This article provides tips on choosing the right equipment and tells you how to go about taking your own subaquatic snaps.

32-bit Image Processing

32-bit processing techniques finally give us the chance to experiment with a virtually endless range of luminance values and contrast, while tone mapping techniques enable us to fine-tune our images within the highly flexible 32-bit color space.

Water Wigs

Tim Tadder's 'water wig' portraits aren't composited and are not created using multiple images. They are based on a simple, crazy idea that you can easily try out yourself.
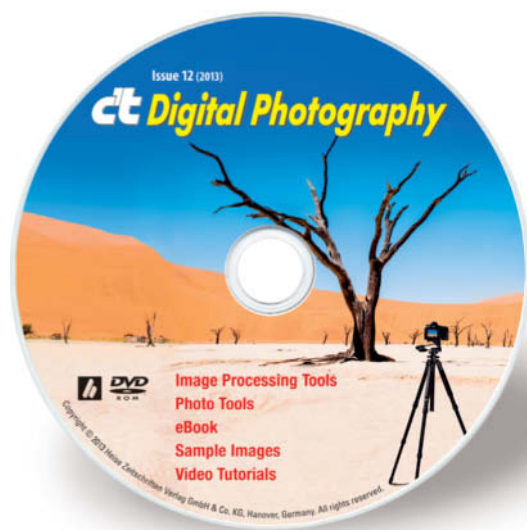
About Us

Free DVD

DVD Download

If your copy of the magazine contains no DVD, navigate to the URL on page 2 to download the DVD content for free

Readers' Letters

Open Source Applications

Issue 11 is wonderful – especially the fine art printing and photo project articles. I also want to commend your continuing coverage of open source photography software. I know of no other photo magazine that covers open source applications.

Richard

One of the Best Magazines, but Still Room for Improvement

I want to share with you all the problems your magazine has and some ideas for improvements. I read hundreds of magazines and yours is the first I bought because of the potential I saw in it. However, although you are one of the best magazines in my opinion, you have to improve in order to be THE best, and I really wish you will be best in near future, because you are already heading in that direction.

Full frame vs. medium format article (issue 10): In some places during comparison the author writes about choosing f10 on the Hasselblad vs. f8 in the Nikon (page 33), f16 vs. f4.4 (page 31), and so on. Why are the aperture comparisons not linear over the course of the tests? 10/8 isn't the same as 16/4.4. How to Combat Camera shake article (issue 10): On page 80 in the bottom corner "The nuts and Bolts of Camera shake" the author writes "Tests have shown …" who did this test the author talks about? Do I have to believe the author's words as is? I hope the magazine improves in coming issues as I see you're doing a great job.

Maxim Dupliy

The aperture settings vary between the cameras because we have to use settings that produce the same depth of field if we want to make a realistic comparison. Regarding "Tests have shown …", the symptoms described are a widely known phenomenon that has been well documented in too many places to name here.

Enjoyable Read

I am prompted to write to you after an enjoyable reading of the shootout between the D800E and the Hasselblad H4D-40 in issue 10. For that many thanks.

I have a D700 but few prime lenses. I am contemplating buying either the D800 or the D600 (but not the D800E as I do not consider it worth the extra hundreds of dollars). What concerns me is that diffraction could be a problem with the D800 whichever lens one has if the lens is stopped down beyond f11. And as one who likes the challenge of 1 to 1 or better this concerns me. Hence my attention has turned to the D600. What the shootout article did was to prompt me to reread the article entitled "High-end Lenses" in volume one, but that was a contest between Canon on the one hand and Zeiss and Leica on the other. Could we have another article substituting Nikon for Canon? In the meantime, can you let me have the sources of the comparisons.

Stanley Robinson

Thanks for your positive feedback on the shootout article. That's an interesting suggestion for our next big lens test – we will discuss the idea at our next editorial meeting.

Good and Thorough Comparison

I just wanted to respond to your article comparing Hasselblad H4D-40 to Nikon D800E. With very few objections, I thought it was a very good, thorough comparison. I work with both cameras and noticed just a few points that would have made the comparison more solid. First, the sensor technology is totally different; CCD in the Hasselblad, as opposed to CMOS in the Nikon, which really defines the strengths and limitations of each system, not to mention the price difference in the camera bodies. Second, the difference in shape of those sensors, which becomes significant when images are cropped, especially verticals from a horizontal shot. Lastly, you should have chosen Phocus as the converter for the Hasselblad. The Nikon got a step up with Lightroom, the Hasselblad a step down. In short, if a shooter has excellent lenses for the Nikon, the D800E is a great back up camera for the Hasselblad and takes the lead when size, weight, speed and high ISO are needed (not to mention cost). Once again: great article. I really enjoy the magazine.

Paul

A Very Short Letter

Great mag. Really. Talks to the artists – not down or up to. Great balance.

David Vaughan

Tell us what you think:

We are always happy to receive your comments and suggestions in a letter, an e-mail to editor@ct-digiphoto.com or at www.facebook.com/ct-digiphoto. We reserve the right to abbreviate your input for publication. Our comments are printed in italics.

DVD Contents & Highlights
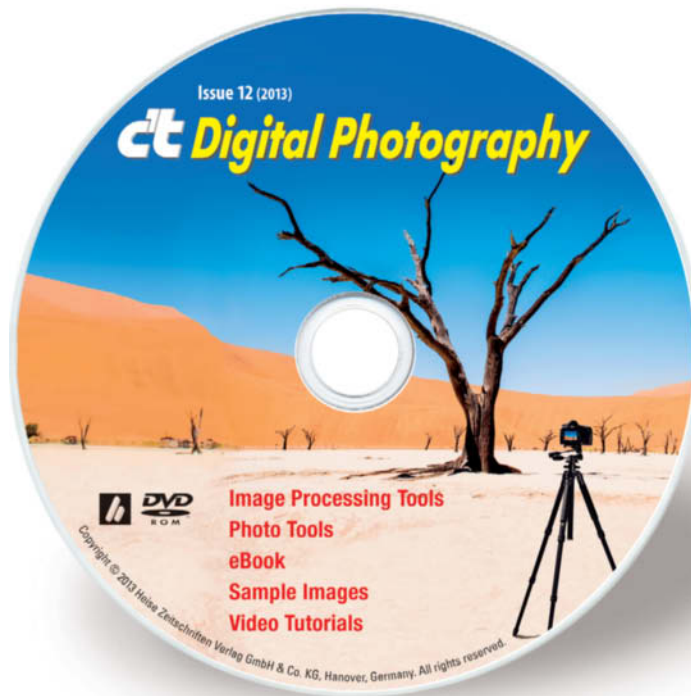
eBook

The Wild Side of Photography

Image Processing Tools

Windows

Chromagic 1.1

Fotomatic 1.4

GIMP 2.8.4

GIMP Portable 2.8.4

GREYC's Magic Image Converter
(G'MIC) 1.5.5.1

Harry's Filters 4.01

ImageJ 1.46

Inkscape 0.48.4

Inkscape Portable 0.48.4

Liquid Rescale 0.7.1

Liquid Rescale Portable 0.7.1

Luminance HDR 2.3.1

Normalmap 1.2.3

Perspective Transformations 8.0

PhotoZoom Express 4.0.2 *full version*

PSPI 1.0.7

StylePix 1.12.2

StylePix Portable 1.12.2

The Works 3.2

Mac OS

GIMP 2.8.4

GREYC's Magic Image Converter
(G'MIC) 1.5.5.1 for Lion

GREYC's Magic Image Converter
(G'MIC) 1.5.5.1 for Mountain Lion

ImageJ 1.46

Inkscape 0.48.2 for Snow Leopard

LiveQuartz 1.9

Luminance HDR 2.3.1

PhotoZoom Express 4.0.2 *full version*

Seashore 0.5.1

Linux

Luminance HDR 2.3.1

PSPI 1.0.5 for Ubuntu

PSPI 1.0.7 for SUSE 10

Photo Tools

Windows

AmoK Exif Sorter 2.56

GeoSetter 3.4.16

GeoSetter Portable 3.4.16

Geotag 0.082

GPSBabel 1.4.4

IrfanView 4.35

IrfanView PlugIns 4.35

IrfanView Portable 4.35

Plug-In Switch 1.3

Mac OS

AmoK Exif Sorter 2.56

GPSBabel 1.4.4

MacPorts 2.1.3 for Lion

MacPorts 2.1.3 for Mountain Lion

MacPorts 2.1.3 for Snow Leopard

Linux

AmoK Exif Sorter 2.56

GPSBabel 1.4.4

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32-bit Image Processing

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An Introduction to Composition 1

An Introduction to Composition 2

Composition Using Color Contrast

Under South African Skies

The Wild Side of Photography

eBook: This cult book by Cyrill Harnischmacher is your entry ticket to the fascinating world of experimental photography.
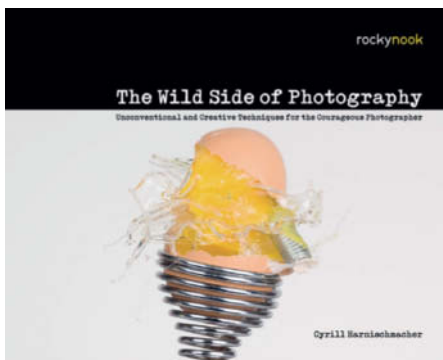
Forget all you know about conventional photographic techniques and take a look at the *Wild Side of Photography*. This fantastic photo guidebook includes contributions from 17 international photographers, all of whom have their own unique style and approach to taking photos. The ideas collected here range from the creative use of blur, through spherical panoramas, unorthodox shooting positions and the creative use of light, to printing on exotic materials and high-peed image capture using a photoelectric shutter trigger.

Author Niklas Plessing is an expert on 'graffiti made of light' and uses long exposures to capture fascinating optical sculptures with his camera. His technique involves moving either the camera or the light source during the exposure. Plessing tells us, "Although photographers around the world have been creating complex light 'paintings' for years now, this kind of photographic image has been enjoying a serious boom in the last two or three years. This is due in part to the increasing availability of cheap, portable LED lamps that provide bright light while using relatively little power". Plessing's chapter goes into detail on how he uses battery-powered, colored LED fairy lights, an LED workshop lamp masked with multicolored plastic gels and a powerful, varicolor LED flashlight to produce his wonderful 'lightwritings'. He describes with clear, step-by-step instructions how to develop ideas, choose the right equipment, find a location and plan your own lightwriting shoot.

Alain Briot contributes two chapters, the first of which is "Landscape Blurs", which talks about using blur as a compositional tool, presenting a real alternative to the 'maximum sharpness' approach taken by traditional landscape photographers. Briot says, "This approach can be used with any subject, be it trees, mountains, deserts, waterscapes or others. In fact, it can be used with subjects other than landscapes. Just because my personal preference is photographing landscapes does not mean that it has to be limited to this subject alone. You can only find out what can really be achieved using this technique by trying it out yourself with the subject of your choice. Don't be afraid to make mistakes. Mistakes are part of the creative process. And remember: what may at first seem like a mistake might just end up as a great photograph." And there is no better advice than that to take with you on your first trip to the 'wild side'. (sea)

Learn how to convert your prime lenses into a working microscope

Photo: Niklas Plessing

**'Lightwriting',
La Gomera
(Canary Islands)**
ISO 100 | f22 | 3 seconds

An Introduction to Composition

Video Tutorial: This two-part tutorial by Jose Ruiz gives you hands-on tips on the basics of photo composition.

Firming up your knowledge of the basic rules of composition will help you to shoot better photos. Pro nature and landscape photographer Jose Ruiz (josebruiz.com) uses this two-part tutorial to distill his comprehensive photographic know-how into easy-to-understand sections that will work wonders when applied to your everyday shooting workflow. Ruiz calls composition "The visual alphabet that a photographer needs to be able to understand to make a composition." This 25-minute video introduces you to the most important aspects of image composition.

The first part concentrates on the most important elements of an image: "Points, lines, shapes and colors make the difference between a snapshot and an aesthetically pleasing and sophisticated image." Carefully placed lines steer the viewer's attention to the subject, and the author uses examples of these and other key elements to demonstrate why some images are more attractive than others. He also talks about backgrounds, which need to be chosen carefully when framing a subject. The second part of the video concentrates on color and explains why a sunset, with its dominant red tones, is perceived as dramatic, while a largely blue seascape radiates meditative calm. Ruiz explains, "Color is not important for 'survival', but is important for emotions. It is the last compositional element to be added".   (sea)

Under South African Skies

Video Tutorial: South African pro photographer Heinrich van den Berg gives us the inside line on his thrilling wildlife photo portfolio.

You have to be sure of what you are doing if you give up your day job to become a full-time wildlife photographer. That is precisely what Heinrich van den Berg (www.heinrichvandenberg.com) did 15 years ago, and the results prove that he made the right decision. He has won many international prizes for his work, including the renowned Eric Hosking Award, and has published more than 20 wildlife photography books, including *Elephants* and *Kruger – Wildlife Icon of South Africa*, a homage to the world-famous Kruger National Park, South Africa's largest wildlife reserve.

In this video, van den Berg talks about his favorite photos and the wonderful light that makes photographing his country's wealth of fauna such a pleasure. His images of the 'big five' (lions, leopards, black rhinos, elephants and
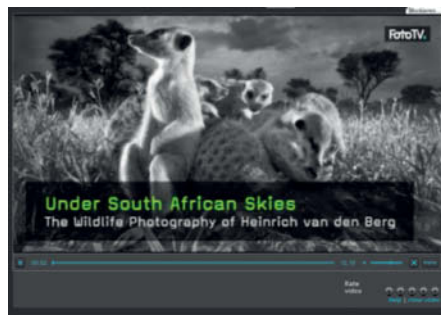
Cape buffalo) are extraordinary. But van den Berg is happy to take an unusual approach to wildlife photography too, and the photos of meerkats that he shot for the Discovery Animal Planet TV channel use wide-angle lenses, close-up shooting positions and fill flash to produce terrific results.   (sea)

PhotoZoom Express 4.0.2

Full Version Software: The simple way to resize your photos.
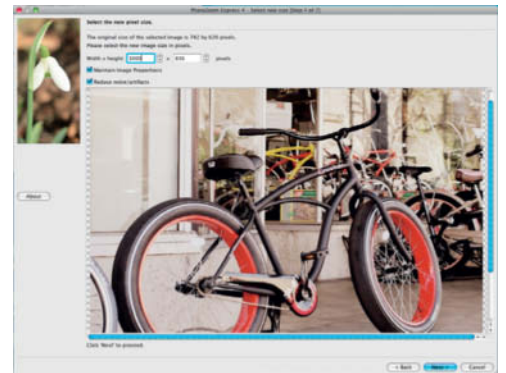
The name says it all: *PhotoZoom Express* is designed for quick, easy and error-free upsizing of low-resolution images. Photos shot for the Web or captured using smartphones are ideal for processing in *PhotoZoom*, and can be printed in large formats once the application has done its job. Many fine art print services require images with a minimum resolution of 768×768 pixels to produce even the smallest prints they offer.

Upsized images often look pixelated or blurred and lack detail, but *PhotoZoom Express* gets going where others give up, using patented 'S-Spline' interpolation technology to produced enlarged images without the unwanted artifacts that spoil other digital enlargements. Theoretically, images can be upsized to as large as $30,000 \times 30,000$ pixels, although the quality of the results does of course depend on the quality of the source material you use. Print resolution can be set to low (96 dpi), medium (150 dpi) or high (300 dpi) quality, and the Software supports IPTC, EXIF, XMP and ICC profiles in the RGB, CMYK, Grayscale and Lab color spaces. Other tools include batch processing functionality as well as multi-processor and 64-bit support.

This issue's DVD includes a free full version of *PhotoZoom Express 4.0.2*. Use of the software requires free online registration, and a licence key will be sent to your e-mail address once you have provided the required details.   (sea)

Portfolio
Jessica Backhaus

Still lifes take pride of place in the work of Jessica Backhaus. The internationally successful artist describes her photographs as 'painted feelings', but you would not know it at first glance. These images compel us to take the time to experience them.

In the *Symphony of Shadows* series, abstract, tightly cropped images of building exteriors with shadows cast by ledges or downpipes contain nothing that diverts our attention from the colors. This effect is particularly striking when the photos are displayed in groups on a wall. Viewers respond to the composition in different ways, depending on their mood and frame of mind at the time and how they interact with ideas and feelings.

Several features of *Symphony of Shadows* are distinctively 'Backhaus': depicting only parts of the subjects, the impact of color and the way interpretation is left to the viewer. Asking the age-old question, 'What is the photographer trying to tell us?' would send us down the wrong track, for these images contain their own intrinsic message. To find out what it is, you have to give them time.

The same is true for Backhaus' current series, *Once Still and Forever*, from which the rest of the photos in this article were taken. What does the photo of the tram tracks evoke for you – a life lived according to a predetermined path, or perhaps a sense of constriction? The glowing ball on the water – does it seem lost to you, or is it a colorful beacon of hope in the water, with a forbidding barrier behind it? Do the shards of glass on the wall threaten us, or are they just a hindrance? And what about the old mirror on the pink wall – has it gone blind because it has seen enough of the world, or is it a symbol of the past? Everyone sees things in their own way, and these photos give us feedback from the realm of our own feelings.
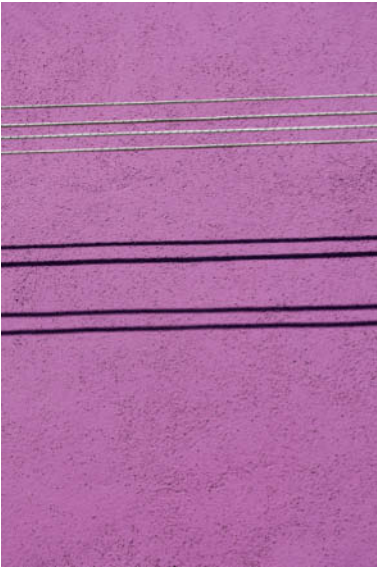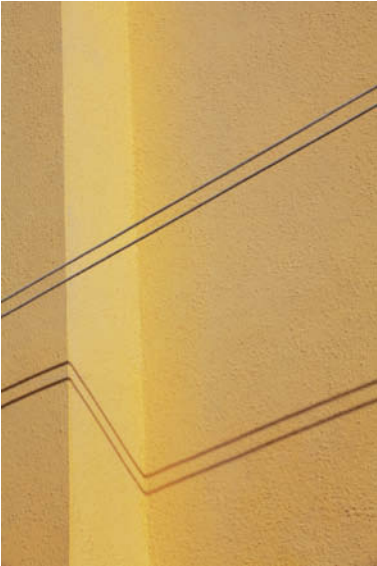
A New Road (2011)

Three years in the making, *Once Still and Forever* is Jessica Backhaus' most personal work so far. She travels extensively, always with here camera at the ready. Where and when the photos were taken is of no relevance; they are timeless. While shooting this series, Backhaus left 14 years of life in New York behind her and relocated to Berlin, where she spent part of her childhood. The freshness of starting again in Berlin is suggested in the photos, which show fleeting scenes of transition.

Backhaus' international career was launched in Paris when she was only 16. Happenstance brought her under the wing of the 'grande dame' of photography, the late Gisèle Freund, and their close friendship remains a great influence. At 25 she moved to New York, where she assisted various photographers (including David LaChapelle) while starting to build her own career. She also travelled with world-famous photographers Michel Comte and Francois Halard. For as long as she can remember, Backhaus has always loved to travel – even as a child she wanted to live in Paris, New York and Berlin.

She has certainly developed a unique visual style, and the six sequences she has released so far show that she still has plenty more ideas up her sleeve. The abstract parts of building exteriors in *Symphony of Shadows*, spots of color on water in the series *I wanted to see the world* (not shown here), and the numerous still lifes, notably in *Once Still and Forever*, make Jessica Backhaus a photographer well worth following.   (jr)

Jessica Backhaus
www.jessicabackhaus.net

Galerie Robert Morat (Hamburg, Berlin)
www.robertmorat.de

Galerie Robert Klein (Boston)
www.robertkleingallery.com

Again (2012)

Wondering (2012)
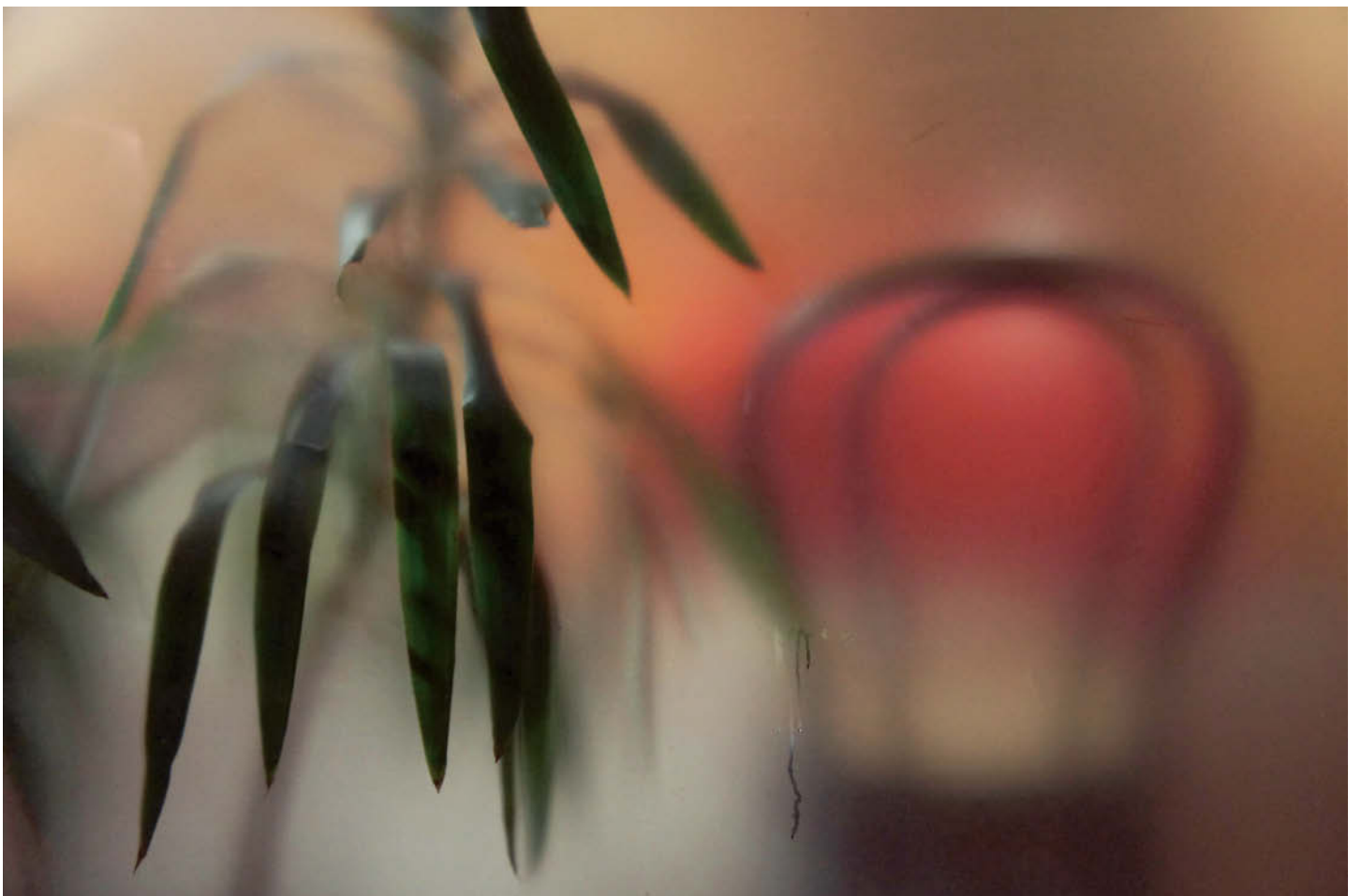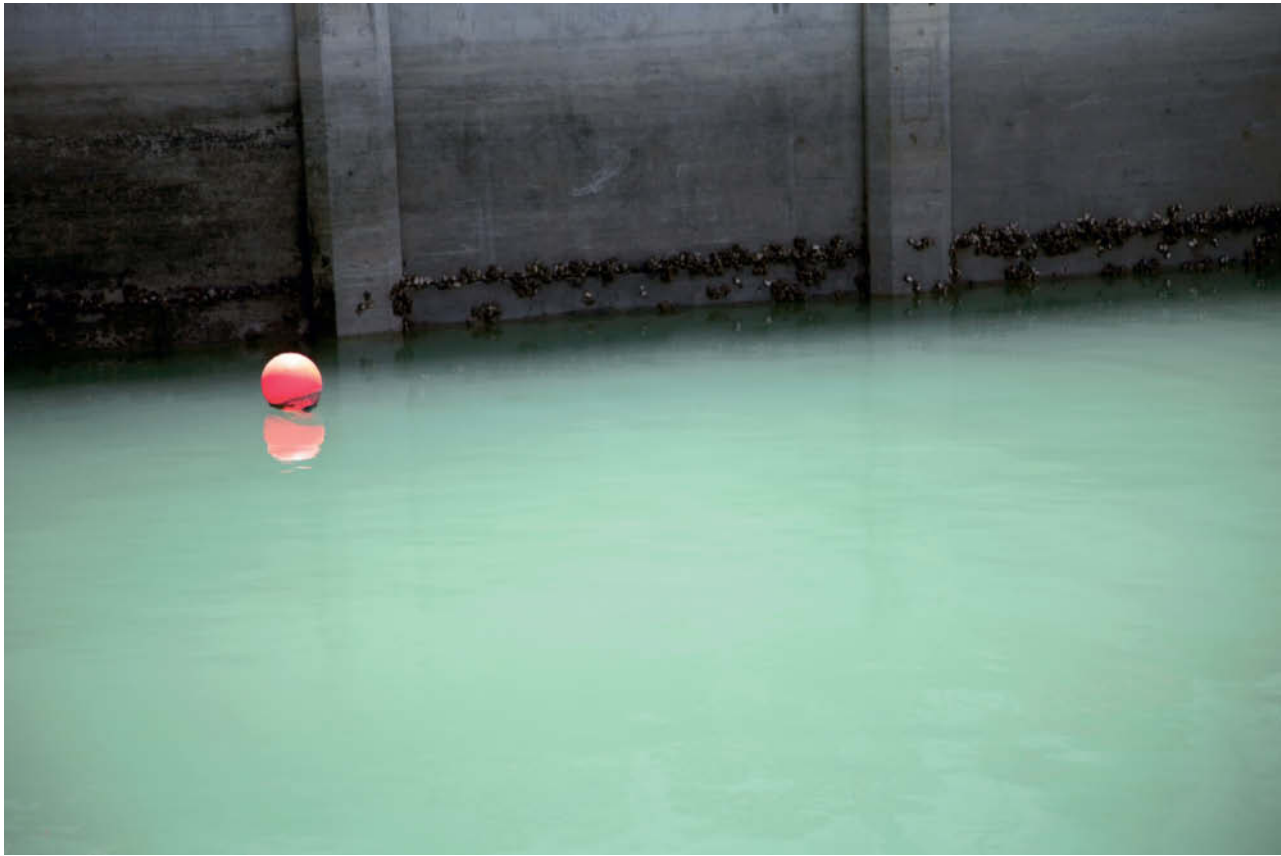
Harbor (2010)

Why (2011)

Maybe (2011)

Shades of Time (2011)

Beyond Seeing (2012)

Dr. Klaus Peeck

Full-frame and System Camera Test

Full-frame DSLRs are getting cheaper all the time and models without a low pass filter are no longer seen as exotic 'specials' for astronomers, but rather as high-resolution devices designed for everyday use by enthusiasts. Alongside a selection of the latest DSLRs, this issue's test lines up the high-speed E-PL5 from Olympus, the long-awaited mirrorless EOS M from Canon, the latest iteration of Nikon's 1 series and, last but not least, Sony's high-end DSC-RX1 full-frame compact.

Bringing affordable full-frame cameras to market seems to be the aim of many DSLR camera manufacturers for the model year 2013. Canon and Nikon are leading the way with their EOS 6D and D600 models, with body-only prices starting at around US$2,000. Sony has announced a cheaper full-frame DSLR body too, but sent us the high-end mirrorless compact Cyber-shot DSC-RX1 to test – a fine device with a full-frame sensor and a fixed 35mm f/2.0 lens.

The Pentax K5 IIs, which has an APS-C sensor without a low pass filter, claims much better resolution than its otherwise identical twin sister, the K5 II. The long-awaited EOS M, Canon's first offering in the mirrorless system camera segment, introduces the new 'M' series bayonet and two dedicated lenses. The Four Thirds segment is represented by the Olympus E-PL5 which, with its extremely fast autofocus system and powerful 16-megapixel sensor, shows how far the 'PEN' series has come in just a few years. The Nikon 1 V2 also handles better than its predecessor and rounds out our test field with its 1-inch sensor.

Full-frame Quality for US$2,000 …

Until now, you had to spend around US$3,500 to enter the full-frame game with Canon. For this price, the EOS 5D Mark III offers a mature, robust, weatherproof DLSR with a 22-megapixel full-frame sensor, twin CF and SD card slots, 6fps burst shooting and the same high-density 61-point AF system as the one in the pro-grade EOS-1D X. To avoid devaluing its established models, Canon has made some compromises with the specifications of the EOS 6D. For example, its focusing system has only 11, relatively closely grouped AF areas with just one cross sensor in the center. Its burst shooting rate is lower too, at 4 fps, although in JPEG mode, it can be used to shoot 'endless' sequences that go on until the memory card is full. The slightly lower resolution is not necessarily a disadvantage and the 6D produces surprisingly little noise compared to its higher-priced siblings. The basic body design is borrowed from the

APS-C EOS 60D, with a single SD card slot, the same button layout and no dustproofing or built-in flash. Handling is great, with a clear, concise menu structure that doesn't confuse the user with over-complex configuration options.

Until recently, Nikon's least expensive entry ticket into the full-frame world was the D800 (for about US$3,000), with its weatherproof magnesium body and monster 36-megapixel sensor. Used with the very best lenses, this revolutionary camera produces stunningly sharp images, although the sensor's extremely high pixel density can cause noise problems at high ISO values. The enormous amounts of data captured by the sensor also slow burst shooting down to 4 fps, but a USB 3.0 interface accelerates data transfer. The D800 has 51 AF points with 15 cross sensors. Compared with this massed technology, the follow-up D600 has had to give up relatively little functionality, and is equipped with a 24-megapixel sensor and a burst shooting rate of 5.3 fps (for up to 15 frames). Its 39-point AF system has nine cross

DSLR AND SYSTEM CAMERAS – TEST RESULTS, PART 1

	Sensor Resolution [lp/h] better▶	Relative center resolution (ISO 100, wide-angle) better▶	Center Resolution (ISO 100) [lp/h] better▶	Center Resolution (ISO 400) [lp/h] better▶	Center Resolution (ISO 1600) [lp/h] better▶	Center Resolution (ISO 3200) [lp/h] better▶	Center Resolution (ISO 6400) [lp/h] better▶	Center Resolution (ISO 12 800) [lp/h] better▶
Full-frame								
Canon EOS 6D with Canon EF 50mm f/2.5	1824	93%	1703	1656	1622	1581	1480	1373
Nikon D600 with Nikkor AF-S 105mm f/2.8	2008	89%	1787	1733	1635	1573	1515	1481
Sony Cyber-shot DSC-RX1	2000	87%	1743	1729	1718	1673	1658	1449
APS-C and Micro Four Thirds								
Canon EOS M with Canon EF-M 22mm f/2 STM	1728	94%	1627	1603	1582	1441	1430	1257
Olympus E-PL5 with M.Zuiko 17mm f/2.8	1728	99%[2]	1716	1660[2]	1512	1537	1469	1277
Pentax K5 II with smc-D FA 100mm f/2.8	1632	83%	1353	1325	1301	1272	1216	1059
Pentax K5 IIs with smc-D FA 100mm f/2.8	1632	89%	1456	1445	1433	1399	1349	1204
1-inch Sensor								
Nikon 1 V2 with Nikon Nikkor 1 18.5mm f/1.8	1536	86%[1]	1323[1]	1266	1136	1106	1075	–

[1] Measured at the minimum ISO 160   [2] Measured at the minimum ISO 200

DSLR AND SYSTEM CAMERAS – TEST RESULTS, PART 2

	Signal-to-noise ratio [S/Nx] ISO 100 better▶	Signal-to-noise ratio [S/Nx] ISO 400 better▶	Signal-to-noise ratio [S/Nx] ISO 1600 better▶	Signal-to-noise ratio [S/Nx] ISO 3200 better▶	Signal-to-noise ratio [S/Nx] ISO 6400 better▶	Signal-to-noise ratio [S/Nx] ISO 12 800 better▶	Signal-to-noise ratio [S/Nx] ISO 25 600 better▶	Visual noise OECF20 ISO 100 ◀better
Full-frame								
Canon EOS 6D with Canon EF 50mm f/2.5	109	57	56	45	38	32	22	0.8
Nikon D600 with Nikkor AF-S 105mm f/2.8	86	68	44	38	33	27	23	0.7
Sony Cyber-shot DSC-RX1	101	61	61	50	50	39	35	0.9
APS-C and Micro Four Thirds								
Canon EOS M with Canon EF-M 22mm f/2 STM[4]	70	51	33	25	20	22	16	1
Olympus E-PL5 with M.Zuiko 17mm f/2.8[7]	94[2]	61	50	40	29	22	17	0.9[2]
Pentax K5 II with smc-D FA 100mm f/2.8[8]	46	36	35	28	20	17	16	1.2
Pentax K5 IIs with smc-D FA 100mm f/2.8[8]	50	36	34	28	20	17	14	1.1
1-inch Sensor								
Nikon 1 V2 with Nikon Nikkor 1 18.5mm f/1.8[5]	38[1]	31	22	22	16	–	–	2[1]

[1] Measured at the minimum ISO 160   [2] Measured at the minimum ISO 200   [3] AF measured with a Canon EF 24-70mm f/2.8   [4] AF measured with a Canon EF-M 18-55mm f/3.5-5.6 IS STM

sensors and is the same as the one built into the APS-C D7000. The D600 also shares its typically complex menu system with the D7000. There are now two SD card slots instead of the twin CF/SD slot in the D800 and a USB 2.0 port for PC connections. Not all of the body is made of magnesium alloy, but it is weatherproofed like its more expensive counterpart.

Nikon has made fewer compromises with its specifications than Canon as direct comparison of the two new cameras makes very clear. On the plus side, the Canon's built-in Wi-Fi module and rudimentary Android/iPhone app-based camera control are blazing a trail for trends that other manufacturers are sure to follow. The EOS 6D even has a built-in GPS module with tracking functionality. The results of our lab tests and hands-on camera handling and performance tests are detailed in the tables below and the individual camera profiles that follow. We have also included sample full-resolution RAW and JPEG test images for each camera on this issue's free DVD.

… and for US$2,800

Sony's Cyber-shot DSC-RX1 shows that photographic technology is sufficiently well developed to produce high-end, full-frame compacts that can command even higher prices than some similarly equipped DSLRs. The DSC-RX1's sensor offers 24 megapixels of resolution, while the fixed Zeiss Sonnar lens has a focal length of 35 mm and a maximum aperture of f2.0. The camera's precise aperture and focus rings give the impression of being physically connected to the aperture blades and focusing elements although they are, in fact, operated electromechanically.

At low ISO values, the RX1 produces resolution performance similar to that of the Nikon D600, but wins hands down at values of ISO 400 and above, probably due to its better noise reduction technology. The EOS 6D produced better visual results, although the Sony's lab test results were slightly better. The RX1's hefty price tag (about US$2,800) includes neither a usably powerful flash nor an external charger.

A Classic APS-C Camera Reloaded

Pentax has rejuvenated the 2010 APS-C K5 model, adding a new, more powerful AF module. The new camera is available in two versions called K5 II and K5 IIs. Our test results confirm that the absence of a low pass filter in the 's' version improves resolution by about 8 percent compared with the conventional version, although the 1,456 line pairs of resolution it recorded are only average for a 16-megapixel sensor.

A low pass filters removes unwanted high-frequency signals from the data entering the lens and produces slight (deliberate) blur to counteract the moiré effects caused by the RGB filter pattern in the sensor and the interpolation required to calculate colors from the brightness values it records. With the exception of cameras built around the innovative three-layer 'Foveon' sensor, which captures 'real' RGB values for each pixel, color digital cameras use RGB filters to produce color in the grayscale images they capture.

Center Resolution (ISO 25 600) [lp/h] better▶	Contrast range /subject range ISO 100 [in f-stops] better▶	Contrast range /subject range ISO 400 [in f-stops] better▶	Contrast range /subject range ISO 1600 [in f-stops] better▶	Contrast range /subject range ISO 3200 [in f-stops] better▶	Contrast range /subject range ISO 6400 [in f-stops] better▶	Contrast range /subject range ISO 12 800 [in f-stops] better▶	Contrast range /subject range ISO 25 600 [in f-stops] better▶	Real subject range [# of tonal values] better▶	Color Checker SG (Δ E) ISO 100 ◀better
1340	9.7	9.7	10	9.7	9.3	9	8	255	10.4
1379	10.7	10.3	9	8.3	8	7	6.7	255	9.3
1411	9.7	9.3	9.7	9	9	8	7.3	254	9.4
1065	9.3	9.3	8.3	8	7	6.7	6	255	10.7
1069	11[1]	10.7	10	9.3	8.3	7.3	6.7	254	9[2]
1080	9.3	8.7	8.7	8	7.7	6.3	6	256	6.6
1215	9.3	8.7	8.7	8	7.3	6.3	6	255	6.6
–	7.7[1]	8	8	7.7	7	–	–	254	9.2[1]

Visual noise OECF20 ISO 400 ◀better	Visual noise OECF20 ISO 1600 ◀better	Visual noise OECF20 ISO 3200 ◀better	Visual noise OECF20 ISO 6400 ◀better	Visual noise OECF20 ISO 12 800 ◀better	Visual noise OECF20 ISO 25 600 ◀better	Startup time [s] ◀better	Shutter lag (wide-angle) at >1000 lx in LiveView [s] ◀better	Shutter lag (wide-angle) at >1000 lx [s][2] ◀better	Shutter lag (wide-angle) at 30 lx [s][2] ◀better
1.2	1.3	1.6	2	2.3	3.5	0.3	2.2	0.35	0.42
1	1.7	2	2.5	3.2	4.3	0.2	1	0.34	0.77
1.1	1.4	1.6	1.8	2.1	2.5	2.1	–	0.43	0.43
1.4	2.2	2.9	4.1	4.1	6	1.6	–	0.93	1.1
1.1	1.5	1.8	2.3	3.4	4.7	0.8	–	0.27	0.48
1.8	1.9	2.5	3.4	4.5	5.1	0.7	2.31	0.35	0.55
1.8	2	2.5	3.5	4.6	5.4	0.6	2.26	0.38	0.51
2.4	3.2	3.3	4.7	–	–	1.3	–	0.15	0.76

[5] AF measured with a VR Nikkor 10-30mm f/3.5-5.6   [6] AF measured with an AF-S Nikkor24-70mm f/2.8   [7] AF measured with an M.Zuiko 14-42mm f/3.5-5.6   [8] AF measured with a Pentax smc-D FA 18-55mm f/3.5-5.6

Because of their unique structure, Foveon sensors do not produce moiré effects, even though they don't have a low pass filter. Because of its lack of a low pass filter, the K5 IIs produced obvious color banding in the line chart and color errors in the sieve in our studio test shot. These types of errors can just as easily occur in everyday situations, especially if the subject contains repeated parallel lines.

There are no detectable improvements in the processor performance of the K5 II cameras, and they produce only average resolution and noise results. Both cameras record video in MJPEG format and support SD and SDHC cards. The Pentax contrast-based live view AF is still very slow.

The only real improvement in the K5 II is the new phase-detection AF module, which is much more light sensitive than its predecessor and very fast, especially when used with the current range of ultrasonic lenses.

The K5 bodies are made of rugged, weather-sealed magnesium and are a pleasure to handle, with a wide range of dedicated controls and a number of useful user-configurable settings. All in all, they are great cameras to use. If Pentax would only take the trouble equip these cameras with more powerful processors and more contemporary sensor technology, they could become market leaders.

A Canon First …

With the EOS M, Canon has at last entered the mirrorless system camera market. The body is reminiscent of Sony's NEX models, but without the additional battery chamber/handgrip. Used with the dedicated EF-M adapter, the EOS M is compatible with all EF and EF-S lenses, but its small dimensions and lack of a grip make it very difficult to use with longer lenses.

Canon isn't exactly straining at the leash, and has so far introduced just one 'M' body

Our studio test shot contains some serious technical challenges as well as some random objects that were selected for their high recognition value. The details mentioned in the test results are outlined in red.

and two dedicated lenses – the 22mm f/2.0 pancake and a standard 18-55mm zoom. The camera's quiet stepper motor technology, which is optimized for video shooting, was introduced several months ago with the EOS 650D/Rebel T4i, as were the AF phase detectors built into the image sensor and the touch screen monitor.

The camera body is not only compact but also very solidly built and easy to use. The touch control system works well and its only drawbacks are its software-controlled mode selection and the fact hat it is too easy to select various functions unintentionially while using the camera in everyday situations. There is neither a built-in viewfinder nor an accessory finder available.

The EOS M focuses acceptably quickly in good light and at short focal lengths, but soon succumbs to focus 'pump' in lower light and at longer focal lengths. In the lab, the 'M' delivered the slowest focus times of all the

cameras we tested. For an 18-megapixel APS-C sensor, its noise behavior is below average from mid-range ISO values onward. Noise is simply bad above ISO 800 and was only trumped by the Nikon 1 with its even smaller sensor.

All in all, the EOS M feels like a half-baked concept that Canon felt it had to build to keep up with the mirrorless competition. Its current street price reflects its poor level of acceptance in the market.

… and two Proven Concepts

The Olympus PEN E-PL5 (also known as the 'PEN Lite') proves that quality comes from maturity. In spite of its relatively small 16-megapixel Micro Four Thirds sensor, it not only produced the best maximum contrast in our test, but also better noise characteristics than the EOS M, even at high ISO values. In the resolution stakes, too, it produced the best

The EF-M lens adapter makes it possible to use EF and EF-S series lenses with the EOS M body, although handling challenges are guaranteed!

COMPARING SENSOR SIZES

	Full-frame	APS-C	Micro Four Thirds	1-inch
Surface area	864 mm^2	329-370 mm^2	225 mm^2	116 mm^2
Length × Width / Diagonal	36 mm × 24 mm / 43.3 mm	22.3 mm × 14.8 mm up to 23.6 × 15.7 mm / 28.3 mm	17.3 mm × 13 mm / 21.6 mm	13.2 mm × 8.8 mm / 15.9 mm
Aspect Ratio	3:2	3:2	4:3	3:2
Crop Factor	1	1.5	2	2.7

results of all our 14-20-megapixel cameras at ISO values of 400 and above.

The Olympus also has really fast autofocus in all lighting conditions and a burst shooting rate that is twice as fast as the Canon's. Handling is very good, although some of the buttons are rather too small and long menus make it a little clumsy at times. The monitor does not have enough dots and displays a tiny live view image in the center of the frame in 4:3 mode. However, it can be tilted in all directions and even inverted if you don't happen to have the accessory flash attached.

The Nikon 1 V2 doesn't have either of these problems, thanks to its built-in flash and fixed monitor. Nikon has given the original '1' such a comprehensive facelift that you could be

The Nikon D600 has twin SD card slots that can be used to increase capacity, create backups or simultaneously record JPEG and RAW versions of each image

forgiven for thinking that the V2 is a completely new camera. The previous smooth, almost toy-like body has been replaced by an angular design with a large protruding handgrip. The new central mode dial and thumbwheel controls are a great improvement on the previous model's tricky ergonomics. However, we would still like to see Nikon do some work on the clumsy main menu and the confusing 'Fn' button settings.

In good light, the '1' delivered the fastest AF in our test. It has also inherited its predecessor's super-fast electronic shutter, which enables ite to shoot at up to 60 fps. The V2 also keeps the Slow View and Motion Snapshot movie modes introduced with the V1.

In keeping with the apparent need to increase resolution with every new release, Nikon has given the V2 a 14-megapixel sensor that unfortunately suffers from the same problematic noise behavior above ISO 400 as its 10-megapixel predecessor. The images it produces quickly lose detail and smudge textures, and our lab test results underscore our visual findings. Sharpness, too, could be better across the entire zoom and aperture range.

Video Functionality

Both full-frame DSLRs record high-quality Full HD video, with great sharpness and color rendition. The EOS 6D produced a few minor color artifacts, while the D600 produced footage that was generally a little sharper with a slight tendency toward overexposure. Both test lenses are only suitable for video use in manual mode. In Autofocus mode, the focus motors and image stabilizers cause noise that is too easily picked up on the video

soundtrack. The built-in mono microphones produce good-quality sound, although the Canon's lacks presence in the deeper tones. Stereo accessory microphones are available for both should you want to record higher-quality sound. The Sony DSC-RX1 has built-in stereo sound of surprisingly high quality, coupled with sharp images, sometimes with slightly pale colors, and some interference artifacts. Sony's video AF is quiet but very slow.

Among our APS-C test candidates, the EOS M delivered the best overall video results, with very good color rendition and good sharpness. Its stereo sound was the best in our test and its AF system was virtually silent, although it was sometimes quite slow and had to 'search' for focus.

The Pentax cameras only record video in MJPEG format, with rather gaudy colors and a tendency to overexposure. Sharpness is average in the K5 II and only a little better in the 's' version, which produced very few additional moiré effects. The built-in mono microphones are adequate but not particularly dynamic, so stereo accessory microphones are probably the better solution.

The Olympus E-PL5 records video that is sometimes pale and overexposed, with visible interference and only average sharpness. Autofocus is fast, but sometimes has to search and is occasionally audible as part of the otherwise very good sound. The Nikon 1 V2 produces sharp video with realistic colors and only occasionally overexposes, although there is obvious noise in darker areas, especially in footage captured in low light. Its AF is silent and fast, while overall sound quality is rather tinny.

Conclusions

If you are looking for a compact but solid and stable system camera with fast, quiet autofocus, the Olympus PEN E-PL5 is a great choice. In spite of its smaller sensor, it beats the uninspiring EOS M hands down, with better noise handling at all ISO levels and faster burst shooting. Its only weak point is its monitor, which needs to have greater resolution to really compete.

The best-quality images with the least noise at high ISO settings come, of course, from the full-frame DSLRs. The Canon EOS 6D and the Nikon D600 represent a new generation of cheaper full-frame cameras that include a mixture of features from the lower and higher ends of the existing range. Canon has made some serious compromises with the 6D, and its AF module (taken from the APS-C EOS 60D) is not really on a par with the rest of the camera's technology. The average burst shooting speed will also prove to be a hindrance for full-frame action fans. If you are prepared to accept these limitations, the 6D will reward you with typically excellent Canon ergonomics, intuitive handling and the best noise characteristics in its class. On the plus side, the 6D is the first camera at this level to have built-in Wi-Fi and GPS modules and also scores with its rudimentary but functional app-based remote live view functionality.

If you are more of a Nikon person, the D600 delivers four megapixels more than the Canon, the slightly clumsy Nikon menu and control system, a weathertight body, 39-point AF, comprehensive configuration options and built-in flash. However, in spite of its 24-megapixel sensor, the Nikon's more obvious noise at higher ISO settings places it behind the Canon in terms of overall image quality. Some users have reported that the D600's low pas filter tends to collect dust. We have yet to hear of any specific causes or remedies for this issue, but Nikon has agreed to clean the filter for free at its service centers.

In contrast, owners of the Sony Cyber-shot DSC-RX1 should remain happily dust-free, as the camera's fixed, bright 35mm Zeiss lens makes it virtually impossible for any type of dirt to enter the camera body. In spite of its compact dimensions, this high-end, 24-megapixel device produces very little noise and offers a full range of features, including many auto shooting modes, Full HD video capture at high frame rates and the very latest sweep panorama functionality. The Sony's settings rings make it intuitive and reliable to use and give it a high-end, almost analog feel. If your budget can stretch that far, the high price is well worth it …   (pen)

Canon EOS 6D

Medium-sized upper mid-range DSLR with a 20-megapixel full-frame sensor.

Good: The solid body is pleasant to handle and well rubberized, but still relatively light. Most controls easy to use. Rubberized central multi-controller, 8-way controller with Quick Control dial. Bright, sharp three-inch monitor with coating that is not too sensitive to smudging. Large, bright, clear viewfinder image. Main menu and sub-menu tabs scroll-free, also due to relatively few configuration options. Extra 'Quick' monitor menu gives access to major settings. Two user-configurable custom shooting modes with their own dial positions. Fast, precise AF, very quiet with USM lenses, reliable in low light. AF also available in live view mode, mirror movement relatively quiet in 'Silent' mode. User-friendly HDR functionality. Spot and 'Evaluative' metering covering 3.5 percent and 8 percent of the frame. Powerful battery. GPS with tracking functionality. Wi-Fi module with basic remote viewing/control via iPhone/Android app.

Not so good: Very slow contrast-based live view AF. No AF-assist lamp without accessory flash. No built-in flash. No X-sync socket. No dedicated white balance or exposure compensation buttons. 97 percent viewfinder coverage. Control panel illumination too dark. Only 11 AF points with one cross sensor. Burst shooting not too fast but 'endless' in JPEG mode. Self-timer not configurable.

Test results: Balanced, high maximum contrast up to ISO 12800. Best signal-to-noise results in our test at ISO 100, still good up to ISO 3200. Good visual noise results up to ISO 12800. Good central resolution up to ISO 3200. Very fast power on and virtually no shutter lag, even in low light, but AF slow in live view mode.

Image quality: Bright, realistic colors in our test shot in daylight. Very good sharpness stopped down and very good detail rendition for a 20-megapixel sensor. Balanced but slightly inconsistent exposure. Best noise characteristics in our test, only slightly inferior to the pro-grade EOS-1D X. Extremely low noise up to ISO 400, Minimal increase at ISO 800 and only slight loss of detail and 'frayed' edges, slightly inconsistent grays and slight color noise at ISO 1600. Details and texture fall off from ISO 3200 (the limit for 100% viewing), but still better than the Nikon D600 and Sony RX1. Loss of sharpness, reduced texture detail and luminance noise above ISO 6400. ISO 12800 comparable, but with all artifacts amplified. ISO 12800 is the limit for full-screen viewing. Above ISO 12800, smudging, noise and obvious green color smears. Serious image degradation at ISO 51200 and above. Few other artifacts.

Superior outdoor images with bright, realistic colors and even, balanced exposure. Sharpness very good above f5.6. Noise levels acceptable and with no significant loss of detail right up to ISO 1600.
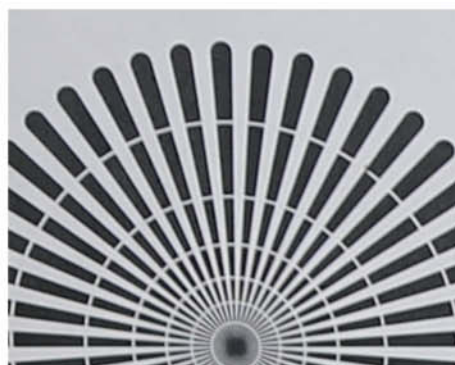

ISO 100　　ISO 400　　ISO 1600　　ISO 6400

Nikon D600

Upper mid-range DSLR with 24-megapixel full-frame sensor.

Good: Solid, medium-sized, well rubberized DSLR body with good weatherproofing. Plenty of dedicated controls. Large mode dial. Extremely configurable. Bright, sharp 3.2-inch monitor with wide angle of view and additional protective cover. Very bright 100% viewfinder image and illuminated control panel. 39-point AF module with nine cross sensors. Fast focusing. Quiet mirror, even less evident in 'Quiet' mode. Configurable self-timer and interval timer. Time-lapse functionality with video clip creation. Multiple white balance presets. Fairly powerful built-in pop-up flash with wireless control functionality for accessory flash. Twin SD card slots. Powerful Li-Ion battery with good reserve power, even after first 'low battery' warning. Microphone and headphone sockets. Remote control available using accessory Wi-Fi adapter.

Not so good: Multi selector too small and not sufficiently precise. Too many 'press-and-hold' function and settings. Inconsistent button assignments and no phase-detection AF in live view mode. AF slower than Canon and Pentax in low light. 'Info' screen only gives access to low-priority functions. Main Menu too long and scroll lists not concise enough. 'Drive' ring lock on the mode dial clumsy. Burst sequences too short, but fast. No X-sync socket.

Test results: High maximum contrast up to ISO 1600, fall-off only at ISO 6400 and above. High signal-to-noise ratio at ISO 800 and visual noise acceptable up to ISO 6400. High central resolution up to ISO 400, dropping off only above ISO 1600. Very fast startup time. Phase-detection AF fast in 1000-lux, slower in 30-lux environment. Contrast-based AF acceptable when compared with the rest of the test field.

Image quality: Good colors, although somewhat over-warm and matte in daylight (indoor) test shot. Good central sharpness stopped down and good detail for a 24-megapixel sensor. Inconsistent exposure tends toward underexposure. Grayscale wedges indeterminate as of level 16. Noise handling good up to ISO 400. Luminance noise begins in gray tones at ISO 800 and increases at ISO 1600 (the 1:1 viewing limit), although with good detail retention. ISO 3200 with some loss of detail and sharpness, and obviously distorted reds and midtones. Limit for full-screen viewing is ISO 6400, with obvious luminance noise and heavy loss of texture (but still better than the Sony RX1). Additional intense color noise at ISO 12 800. Few other artifacts.

Outdoor images with good colors and very good detail and sharpness stopped down. Inconsistent exposure and some visible moirés. Noise handling as in our studio test shot with some loss of texture above ISO 800. Color noise in evidence above ISO 3200 and serious loss of sharpness above ISO 6400.
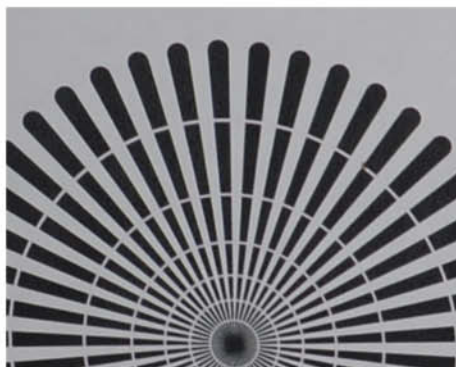
ISO 100

ISO 400

ISO 1600

ISO 6400

Sony Cyber-shot DSC-RX1

High-end compact with a 24-megapixel full-frame sensor and a bright, fixed 35mm lens.

Good: Extremely well-built metal body. Very compact for a camera with a full-frame sensor. Classic rangefinder design with rubberized handgrip and thumb pad. Zeiss f/2.0 Sonnar lens with electromechanical aperture and focus rings. Great ergonomics with large, precise mode dial and four-way rocker switch/control wheel. Scroll-free main menu and sub-tab system with direct settings via monitor icons and thumb wheel ('control dial'). High-resolution three-inch LCD monitor with wide angle of view. Fast, precise AF works well in low light. Manual focus override. Cable release thread. Very quiet shutter. Sweep panorama and three custom shooting modes. SD and Memory Stick Duo support.

Not so good: No optical image stabilizer. Exposure compensation dial too easy to move unintentionally. Focus mode lever difficult to operate. No viewfinder. Monitor smudges easily. AF noise transmits to camera body. Focus preselect (20-35 cm or 30 cm to infinty) not very reliable. Non-configurable self-timer. Fastest shutter speed only available at f5.6 or higher. Small pop-up flash not powerful enough and with long recycle times. Proprietary flash/accessory shoe design. Weak battery with in-camera charging. Tripod mount too close to battery chamber. High camera price and astronomical accessory prices (for example, metal sunshade for US$150 or electronic viewfinder for US$450).

Test results: High, balanced maximum contrast all the way up to ISO 6400. Very good signal-to-noise ratios up to ISO 1600 and still good up to ISO 6400. Visual noise excellent at ISO 800 and still very good up to ISO 6400 (acceptable thereafter). Good, generally consistent central resolution up to ISO 1600 (about 86 % of the potential maximum), only falling off above ISO 12 800. Short burst sequences and the slowest startup time in our test.

Image quality: Highly saturated, very slightly yellowish colors in our daylight test setup. Best sharpness and detail stopped down. Consistent exposure with a slight tendency toward underexposure. No moirés apart from a little shimmer in our line chart. Very clean images up to ISO 400 with a slight loss of texture above ISO 800, increasing for low-contrast details at ISO 1600. Color noise artifacts and mottled reds begin to show at ISO 1600, which is the limit for 1:1 viewing. Some tones grainy and washed out with loss of texture and detail at ISO 3200. Limit for full-screen viewing below ISO 6400 due to underexposure, heavy loss of sharpness and obvious dark noise artifacts thereafter. Most textures with herringbone degradation beyond ISO 12 800. Few other artifacts.

Outdoor images consistently well exposed with accurate, bright colors. Sharpness good to very good stopped down. Outdoor noise as in the lab, with loss of detail setting in at ISO 800 and obvious loss of texture above ISO 1600. Occasional edge moirés at wide apertures.

ISO 100   ISO 400   ISO 1600   ISO 6400
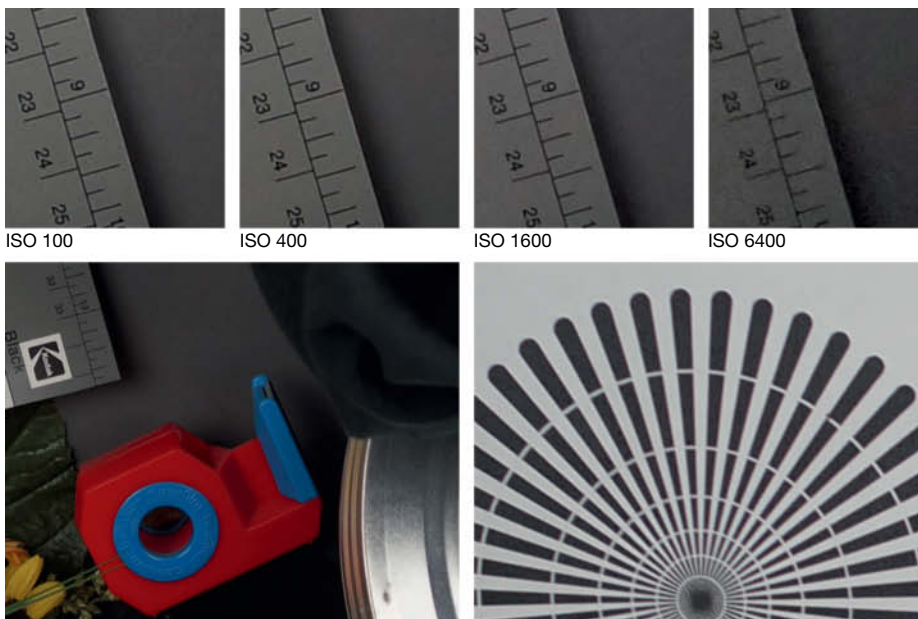
Canon EOS M

Mirrorless system camera with an 18-megapixel APS-C sensor and a very compact body.

Good: Robust metal body (four colors available), easy to handle. Metal-bodied kit lens with stepper motor. Adapter for EF and EF-S lenses available. Reliable touch screen control, although most functions also available via the main dial. High-resolution capacitive three-inch touch screen monitor with wide angle of view. Clear, scroll-free main menu with additional function menu and direct settings screen. Two-finger screen gesture playback control. Precise, very quiet hybrid AF system with integrated phase-detection sensors for short and medium focal lengths – works very well in adequate light. Combined auto/manual focusing. Quiet shutter. Compact, wireless-capable Speedlite 90EX flash supplied. Microphone socket. Tripod mount on the optical axis.

Not so good: No built-in viewfinder and no accessory finder available. Touch screen monitor prone to accidental operation. Mode selection via soft button. Manual focus and manual white balance complicated to use. Currently only kit zoom and 22mm pancake lens available with 'M' mount. EF-S lenses mounted using the EF-M adapter suffer from very slow focusing. Native AF with EF-M lenses slow and imprecise at longer focal lengths and in low light. Slow burst shooting, even slower and only three images possible with auto chromatic aberration correction.

Test results: High maximum contrast up to ISO 800, falling off only above ISO 6400. Signal-to-noise ratio very good at ISO 100 and still good at ISO 800, falling off quickly thereafter. Very little visual noise at ISO 100, increasing quickly above ISO 800 due to color noise. Very good central resolution with the 'pancake' test lens up to ISO 1600, reduced thereafter due to noise. Short startup time but obvious shutter lag, even at 1000 lux.

Image quality: Bright, accurate colors in our daylight test scene. Good central sharpness and detail, falling off rapidly toward the bottom of the frame. Clean images at ISO 200, less so at ISO 400 with first signs of color noise showing. Loss of texture and increased color noise at ISO 800 (the 1:1 viewing limit). As of ISO 1600, further loss of texture and obvious green/magenta color noise artifacts, making this the absolute limit for full-screen viewing. Artifacts increasingly evident at ISO 3200 (worse than the Pentax K5 results). Serious image degradation at higher values with fringing on the sieve and line chart and slight color shimmers. Otherwise few moirés or other artifacts. Dust speck at top center of sample images.

Outdoor images reliably exposed with authentic colors and good sharpness and detail stopped down. Noise handling as in the studio – unproblematic up to ISO 400, with loss of texture at ISO 800 and with obvious fringing and color noise after that.

ISO 100

ISO 400

ISO 1600

ISO 6400
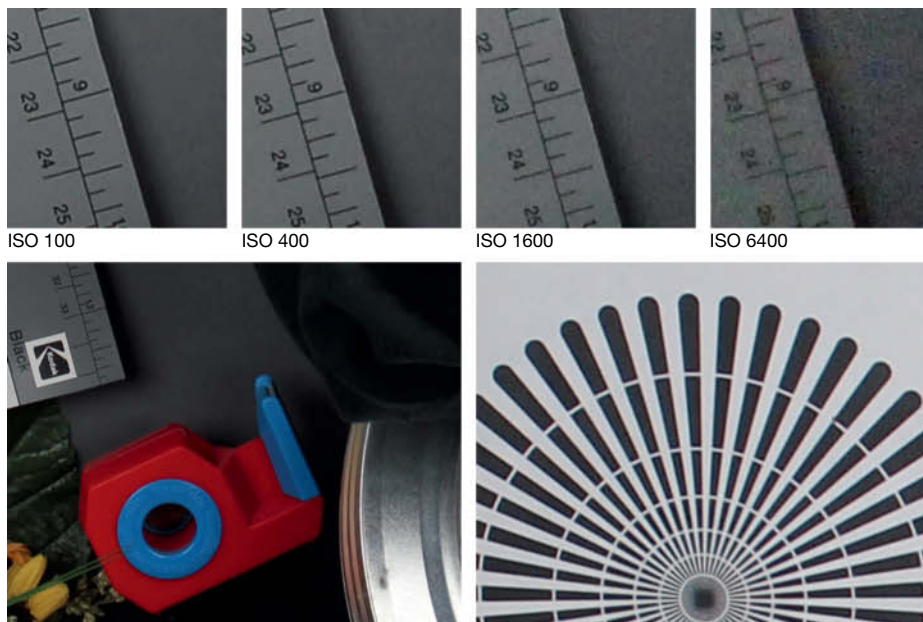
Olympus PEN 'lite' E-PL5

A Compact Micro Four Thirds camera with a 16-megapixel sensor and very fast autofocus.

Good: Very robust rangefinder-style body with rubberized thumb pad and removable handgrip. Sensor-shift image stabilizer. Precise handling. Large, clear central mode dial. Arrow pad with control dial and shortcuts. 'Fn' button for making direct settings via the icon bar at the edge of the monitor. Main menu with five scroll-free main screens and an additional, comprehensive configuration menu. Bright capacitive three-inch display with wide angle of view and touch screen focus, shutter release and playback functions. Monitor highly tiltable, can be inverted if accessory flash not attached. Fast, high-quality, silent AF that works well in low light. Combined auto/manual focus. Quiet shutter, fast burst shooting and user-configurable self-timer with interval timer and pre-release. Accessory flash fairly powerful and with wireless remote control functionality for slave flash.

User-configurable flash sync speed. Fairly powerful Li-Ion battery.

Not so good: Camera back 'bumpy' due to the monitor sticking out to the rear. Sunshade mount cover too loose. Control dial/arrow pad and other controls too small. Insufficient shutter button travel, shutter button movement imprecise. Monitor with too little resolution and sharpness. No viewfinder. Tripod mount off center and too close to battery/memory card chamber. No continuous charge level display.

Test results: Very high maximum contrast up to ISO 1600 and still good up to ISO 6400, only dropping off after that. Good signal-to-noise ratio up to ISO 1600 and little visual noise up to ISO 3200. Highest relative central resolution (99%) at ISO 200 and still excellent right up to ISO 6400, massive fall-off thereafter. Relatively slow startup but fast autofocus, even in low light.

Image quality: Very good color rendition with only a hint of over-warm tones in our daylight test scene. Good sharpness stopped down and satisfactory detail rendition for a 16-megapixel sensor. Consistent, balanced exposure tending slightly toward underexposure. Clean images at ISO 200, slightly rougher at ISO 400. 'Frayed', blocky edges at ISO 800, no obvious fall-off beyond that. ISO 1600 limit for 1:1 viewing, with loss of detail and texture and color smears at higher values. Significant loss of texture and edge/color definition at ISO 3200 (the limit for full-screen viewing). Images washed-out and unsharp at ISO 6400, but noise compensation still better than the Canon EOS M. Images smudgy as of ISO 12800, with fringing on the sieve. Few other artifacts.
Outdoor images with neutral colors, exposed reliably and consistently. Sharpness and center detail good. Noise performance still good at ISO 400, as of ISO 800 with loss of texture and noisy shadows. Continued loss of detail beyond ISO 1600 and a generally blurred look at ISO 3200 and above. Few other artifacts.
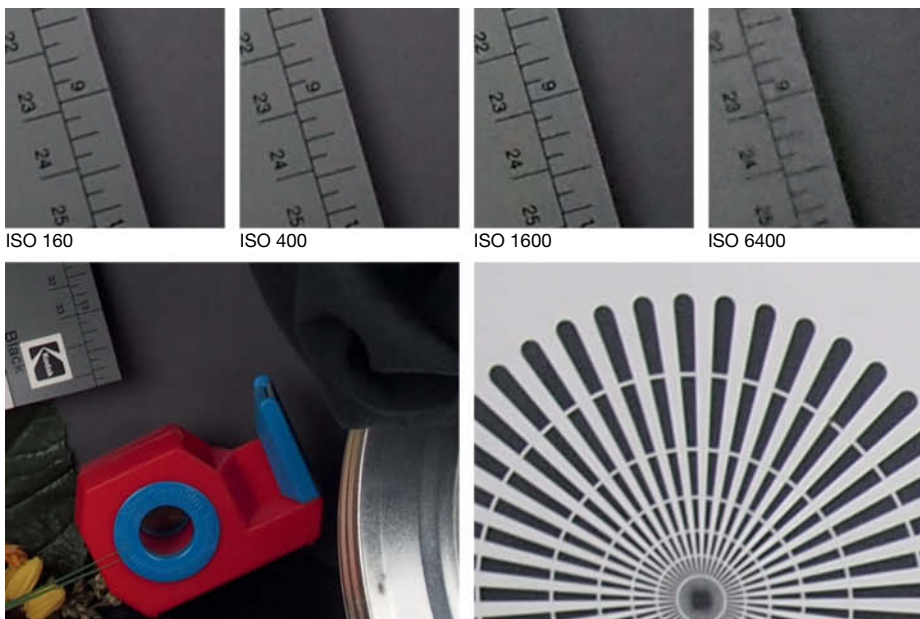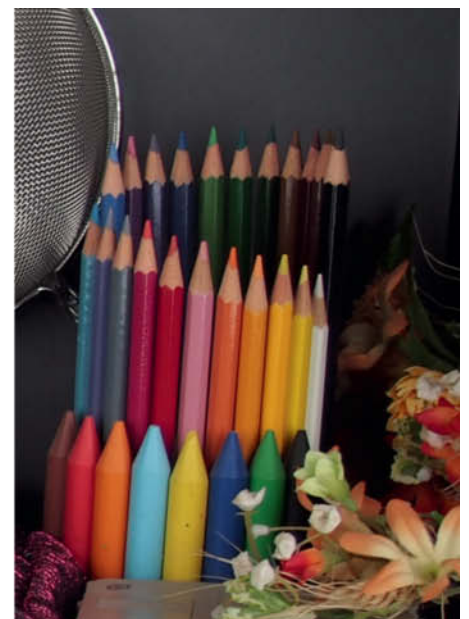
ISO 160   ISO 400   ISO 1600   ISO 6400

Pentax K5 II/K5 IIs

The follow-up model to the K5 with a new, more sensitive AF module. The K5 IIs variant does not have a low pass filter, providing greater resolution but increased risk of moiré artifacts.

Good: Sensor-shift shake reduction and horizon correction. Well-engineered, weatherproof magnesium body. Good range of dedicated controls, great handling in everyday situations. Useful selection of preset shooting modes including 'Hyper-program' which offers fast direct access to aperture and shutter priority modes. High-resolution three-inch monitor with wide angle of view, now 'gapless' for better visibility and fewer reflections. Two-level control panel illumination. Bright, 100% viewfinder image. Comprehensive, easily navigable menus with auto rotate. Quiet ultrasonic AF with unique 'Catch-in' mode. Very quiet mirror and quiet burst shooting. Multiple exposure, interval and HDR modes. Noise reduction adjustable for individual ISO settings. White balance adjustable post capture. Short flash recycle times, wireless flash control, X-sync socket.

Not so good: Not really a new model compared with its predecessor. Focus mode switch difficult to operate. Card slot tricky to access. No SDXC support. Over-bright, green AF-assist lamp. Contrast-based live view AF slow.

Test results: High maximum contrast with slight fall-off toward ISO 3200. Signal-to-noise ratio only good at ISO 100, average up to 1600 and much worse subsequently. Visual noise good up to ISO 1600, but increasing rapidly above ISO 3200. K5 II has only average central resolution, falling off rapidly above ISO 3200. K5 IIs much better, producing 86-89% of the potential maximum. Fast AF, slower in low light. Average startup time. Very slow live view AF.

Image quality: Bright, well-saturated colors. Woodgrain with yellow cast. 'Natural' style preset more neutral, but with dark reds. K5 II produces only adequate sharpness stopped down and poor detail rendition for a 16-megapixel sensor – K5 IIs much better in this respect. Both cameras expose well, but with obvious fluctuations. Clean images up to ISO 400. K5 II medium grays rougher. ISO 800 similar, with slight loss of detail. Colors and edges less clean at ISO 1600, but both better than EOS M. Limit for 1:1 viewing at ISO 3200, with loss of texture and blotchy colors, K5 II produces more luminance noise and heavy loss of detail beyond ISO 6400 (K5 IIs shows the same symptoms at ISO 12 800). Full-screen viewing limit at ISO 3200 for both. 'Natural' style preset produces only satisfactory moiré/interference performance in the K5 IIs.

Outdoor images with well-saturated colors but obvious yellow cast. Exposure variable with a slight tendency toward overexposure. K5 II with average sharpness, K5 IIs with good sharpness and detail stopped down. Care required with subjects that produce interference! Noise handling good up to ISO 400 (up to ISO 800 for the K5 IIs), falling off toward ISO 800/1600.
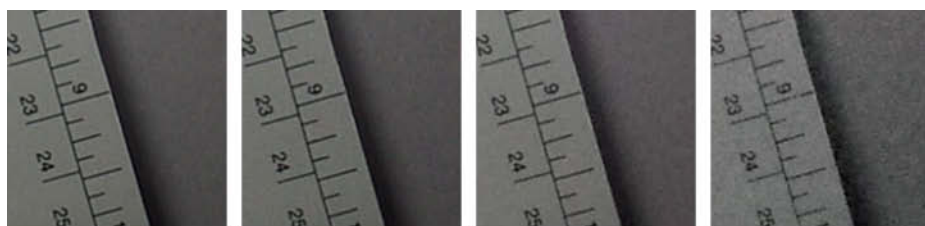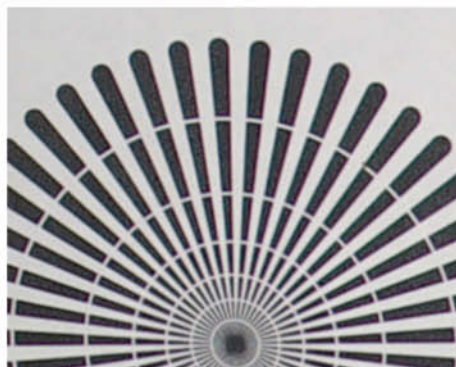
ISO 100 (K5 II)

ISO 400 (K5 II)

ISO 1600 (K5 II)

ISO 6400 (K5 II)

Nikon 1 V2

Mirrorless compact system camera with a 14-megapixel 1-inch sensor and innovative high-speed shooting features.

Good: Much better ergonomics than the V1, with a large, rubberized battery chamber/handgrip. and several improved details. Can be used with full-frame lenses via an adapter. Compact, stabilized and well engineered kit lens. Ultrasonic sensor cleaning. Small but precise multi selector with rotating outer ring. Precise mode dial, now with P/A/S/M settings. Useful thumb-operated command dia. Sharp three-inch monitor and very good, flicker-free electronic viewfinder. Hybrid autofocus with 74 phase-detection and 35 contrast-based AF points. Very fast (60fps), 14-megapixel burst sequences. Quiet shutter, silent in 'electronic' mode. Various high-speed/slow motion shooting modes, including Motion Snapshot, which combines brief movie vignettes with still images. Powerful battery with continuous status display.
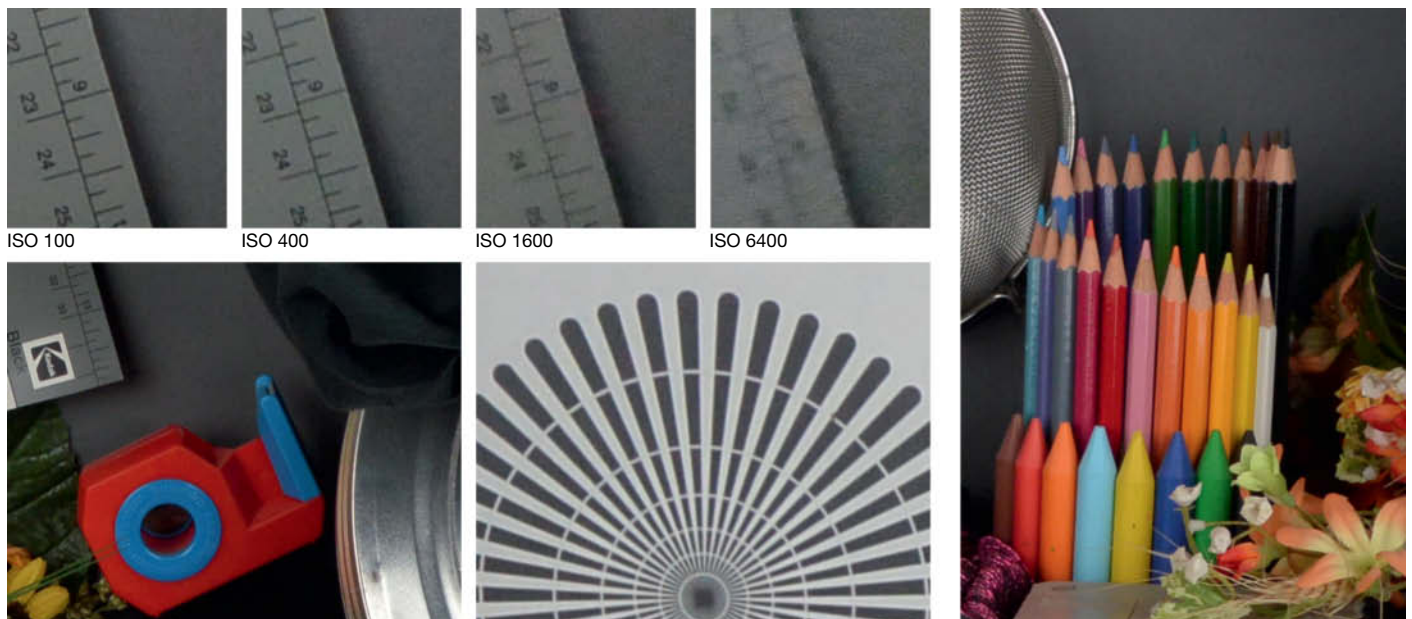
Not so good: CX Sensor only half the size of Micro Four Thirds equivalent and now with even higher pixel density. Body not much smaller than MFT models in spite of smaller sensor. Over-sensitive IR proximity sensor on shaky electronic viewfinder. Clunky main menu layout. Few configuration options. Reduced range of functions with access via screen icons. Self-timer constantly switches itself off. AF much slower in low light. Built-in flash too close to lens. Accessory flash via proprietary shoe only.

Test results: Consistent but average maximum contrast up to ISO 6400. Signal-to-noise ratio and visual noise satisfactory up to ISO 400, falling off rapidly above ISO 800. Good central resolution only at ISO 100, much poorer as of ISO 800. Average startup time. Virtually no shutter lag in good light, much slower at dusk.

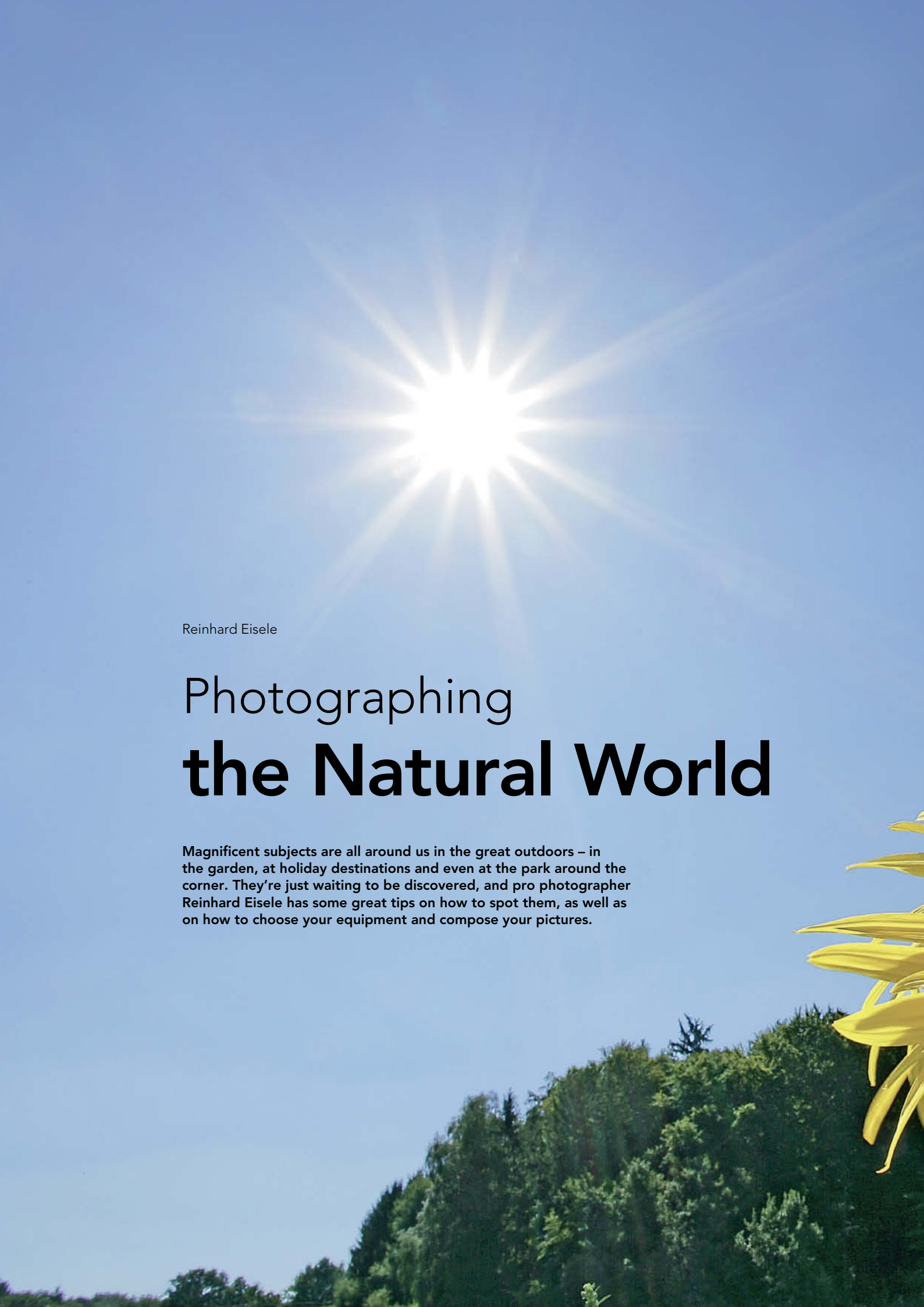**Image quality:** Authentic colors, not too bright and with a very slight yellow cast in our daylight test scene. Sharpness only satisfactory stopped down and poor detail for a 14-megapixel sensor. Good, balanced exposure. Reds and medium grays already mottled at ISO 160, Texture loss and duller colors at ISO 400 (the 1:1 viewing limit). Further loss of detail as of ISO 800, with little texture and a flat but not degraded look. Images washed out and with color noise smears at ISO 1600, which is the limit for full-screen viewing. Images completely washed out as of ISO 3200. Chromatic aberrations well compensated, few other artifacts.

Outdoor images with authentic colors. Variable exposure tends toward overexposure. Medium sharpness and detail rendition. Noise not a problem at ISO 160 and ISO 200. Loss of texture begins at ISO 400 and gets worse thereafter, especially in shadows. Obvious loss of detail as of ISO 1600 and an almost watercolor-style appearance beyond ISO 3200. Occasional fringing at wide apertures.

ISO 100

ISO 400

ISO 1600

ISO 6400

DSLR AND SYSTEM CAMERA OVERVIEW

	Full-frame		
Manufacturer/Model	**Canon EOS 6D**	**Nikon D600**	**Sony Cyber-shot DSC-RX1**
URL	www.canon.com	www.nikon.com	www.sony.com
Digitization			
Native resolutions (in pixels)	5472 × 3648, 3648 × 2432, 2736 × 1824, 1920 × 1280, 720 × 480	6016 × 4016, 4512 × 3008, 3008 × 2008 (36 × 24), 3936 × 2624, 2944 × 1968, 1968 × 1312 (24 × 16)	6000 × 4000 (3:2), 6000 × 3376 (16:9), 3936 × 2624 (3:2), 3936 × 2216 (16:9), 2640 × 1760 (3:2), 2640 × 1488 (16:9)
Sensor type, effective megapixels / Size / Self-cleaning	CMOS, 20 / Full-frame (36 mm × 24 mm) / ✓	CMOS, 24 / Full-frame (36 mm × 24 mm) / ✓	CMOS, 24 / Full-frame (36 mm × 24 mm) / n/a
Image format(s) / Compression rates / Video format	RAW, JPEG, RAW+JPEG / 2 / MPEG-4 H.264	RAW, JPEG, RAW+JPEG / 3 / MPEG-4 H.264	RAW, JPEG, RAW+JPEG / 3 / MPEG-4 H.264 or AVCHD
Video: max. resolution [pixels], length, fps	Full HD 1080p, 29 min. 59 s, 30	Full HD 1080p, 29 min. 59 s, 30	Full HD 1080p, 29 min. 59 s, 50
Memory card type / Average file size[3]	SD(HC/XC) / 8.5 MB	2 × SD(HC/XC) / 15.7 MB	SD(HC/XC) + MS Duo / 19.1 MB
Features			
Crop factor (35mm equiv.) / Bayonet	n/a / Canon EF	n/a / Nikon F (AF)	Fixed lens (35mm, f/2.0)
ISO settings	Auto (limits configurable), (50) 100-25 600 (51 200, 102 400) in 1/3 or 1/1 increments	Auto (200-upper limit + long exposure up to 1 s), (50) 100-6400 (25 600) in 1/3 or 1/2 increments	Auto (limits configurable as of ISO 100), (50) 100-25 600 (multiple exposure up to 102 400) in 1/1 increments
Shutter speeds [s] / Default flash sync [s]	Bulb, 30-1/4000 / 1/180	Bulb, 30-1/4000 / 1/200	Bulb, 30-1/2000 (1/4000) / 1/2000 (1/4000)
Focusing / Image stabilizing	AF (one-shot, cont., tracking, face detection), MF / ✓ (IS lenses)	AF (one-shot, cont., tracking), MF / ✓ (VR lenses)	AF (one-shot, cont., tracking), MF, DMF / − (electronic only in video mode)
AF points / Focus assist lamp	11 (1 cross sensor) or 1 (11 positions) / −	39 (9 cross sensors), 11 or 1 (39 positions) / ✓ (white)	9 or 1 (187 positions) / ✓ (orange)
Metering: Matrix / Center-weighted / Spot	✓ (63 sectors) / ✓ / ✓ (+ evaluative)	✓ (2016 pixels) / ✓ (4 metering area sizes) / ✓	✓ / ✓ / ✓
Programmed auto / Scene modes / Custom presets	✓ (with shift) / 7 or Intelligent Auto / ✓ (2 presets)	✓ (with shift) / 19 / ✓ (2 presets)	✓ (with shift) / 7 + Intelligent Auto / ✓ (3 presets)
Exposure: Aperture priority / Shutter priority / Manual	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓
Exposure compensation [EV] / Depth-of-field preview	±5 EV in 1/3 or 1/1 increments / ✓	±5 EV in 1/3 or 1/2 increments / ✓	±3 EV in 1/3 increments / −
Bracketing: Exposure / WB / Focus / Interval timer / Sound	✓ / ✓ / − / − / ✓ (16-bit, mono[7], 48 kHz)	✓ (highly configurable) / ✓ (+ D-Lighting bracketing) / − / ✓ (+ time-lapse) / ✓ (16-bit, mono[7], 48 kHz)	✓ / ✓ / − / − / ✓ (16-bit, stereo, 48 kHz)
Self-timer / Continuous shooting speed (JPEG/RAW)[6]	10 or 2 s / 4.4 fps, until card full; 4.4 fps, 18 shots	20, 10, 5 or 2 s (1-9 shots, interval 0.5-3 s) / 5.3 fps, 15 shots; 5.3 fps, 12 shots	10 or 2 s / 5.3 fps, 14 shots; 5.3 fps, 12 shots
White balance: Auto + Man. / Presets / Fine-tuning	✓ / 6 / ✓ (and Kelvin)	2 auto + 4 man. / 12 / ✓ (and Kelvin)	✓ (3 presets) / 9 / ✓ (and Kelvin)
Sharpness, Contrast, Saturation adjustable / Color spaces	✓ / sRGB, Adobe RGB	✓ (fine-tuning) / sRGB, Adobe RGB	✓ / sRGB, Adobe RGB
Viewfinder: Type / Magnification / Coverage / Eyepiece distance	Pentaprism / 0.71× / 97% / 21 mm	Pentaprism / 0.71× / 100% / 21 mm	− (optional optical or electronic) / − / − / −
Monitor: Diagonal / Resolution [dots] / No. of brightness settings	3.0" / 1 040 000 / 7	3.2" / 921 000 / 11 or automatic	3.0" / 1 228 800 / 5 or automatic
Live View / With AF using sensor / Dedicated sensors	✓ / ✓ / ✓	✓ (5-30 min. or unlimited) / ✓ / −	✓ / ✓ (with face detection) / n/a
Body material / Control panel / Auto monitor rotation	Magnesium + Plastic / ✓ (orange backlight) / −	Magnesium + Plastic, weather / ✓ (green backlight) / −	Metal / − / −
4-way selector / Multi selector / Command dials	✓ (8-way + center button) / 1 / 2	✓ (8-way + center button) / 2 / 2	✓ (+ center button) / 1 / 3 (4-way switch is also rotatable dial)
Flash guide number (ISO 100) / Charge time / Connector	− / − / ✓ (TTL shoe)	12 / 3.5 s / ✓ (TTL shoe)	n/a / 5.9 s / ✓ (proprietary flash/accessory shoe)
Playback			
Grid [# of images] / Zoom / Histogram	9 or 4 / ✓ (up to 10×) / ✓ (with RGB)	72, 9 or 4 / ✓ / ✓ (with RGB)	9 or 4 / ✓ / ✓ (with RGB)
Connectors / Dimensions			
Power source	Mains adapter (dummy battery), Li-Ion battery, battery grip	Mains adapter (dummy battery), Li-Ion battery, battery grip	Proprietary mains adapter, Li-Ion battery
Interfaces / A/V out / HDMI / Remote control	USB 2.0, WLAN, GPS / ✓ (proprietary) / ✓ (type C) / ✓ (IR, cable or Wi-Fi via PC/smartphone app)	USB 2.0, GPS input / − (plus stereo mic IN, headphones) / ✓ (type C) / ✓ (IR and cable)	USB 2.0 / − (plus stereo mic IN) / ✓ (type D) / ✓ (mechanical cable release)
Dimensions (W/H/D) / Approx. weight[6] Body only / With test lens	145 mm × 111 mm × 71 mm / 760 g, 1430 g	141 mm × 113 mm × 82 mm / 860 g, 1775 g	113 mm × 65 mm × 70 mm / 470 g (fixed lens)
What's in the Box			
Manual / User guide	Basic Guide, Manual, Wi-Fi Guide	Quick Start Guide, Manual	Manual
Accessories	Li-Ion battery LP-E6 (7.2 V, 1800 mAh, 13 Wh), charger, body cap, eye cup, shoulder strap, USB cable	Li-Ion battery EN-EL15 (7.0 V, 1900 mAh, 14 Wh), charger, body cap, monitor protector, flash shoe and eyepiece covers, shoulder strap, USB cable	Li-Ion battery NP-BX1 (3.6 V, 1240 mAh, 4.5 Wh), USB charger (battery charges in camera), lens cap, shoulder strap, USB cable, cloth bag, cleaning cloth
Optional accessories	Memory cards, mains adapter, IR or cable remote release, HDMI cable, camera bag, focusing screen EF-D/EF-S, wide range of other EOS accessories	Memory cards, mains adapter + battery dummy, IR and cable remote release, GPS receiver, Wi-Fi adapter, HDMI cable, microphone, wide range of other Nikon system accessories	Memory cards, charger, mains adapter, optical or electronic viewfinder, protective, gray and polarizer filters, sunshade, microphone, mechanical remote release, HDMI cable, camera bag
Software			
Standalone software (platform)	ImageBrowser EX 1.0, EOS Utility 2.12, Digital Photo Professional 3.12, PhotoStitch 3.1/3.2, Picture Style Editor 1.12 (Win/Mac)	Nikon ViewNX 2 (Win/Mac)	PlayMemories Home (Lite)
Ratings			
Test images[1] (c't test image shot in daylight)	Measured using 24-105mm f/4L IS EF USM	Measured using AF-S Nikkor 24-70mm f/2.8G ED	
Color rendition / Exposure	⊕⊕ / ⊕	⊕ / ○	⊕ / ⊕
Sharpness / Detail rendition	⊕⊕ / ⊕⊕	⊕ / ⊕	⊕⊕ / ⊕⊕
Image noise / Other artifacts[2]	⊕⊕ / ⊕⊕	⊕ / ⊕⊕	⊕ / ⊕⊕
Ease of use [4] / Printed manual	⊕⊕ / ⊕⊕	⊕ / ⊕⊕	⊕ / n/a
Feature set [4, 5] / Included accessories [4]	⊕ / ○	⊕⊕ / ○	⊕ / ⊝⊝
RRP: Body only / With test lens (US$)	2000 / 2600	2000 /3900	2800 (fixed lens) / −

[1] Judged by eye on a calibrated monitor (applies only to these cameras and therefore not comparable with earlier tests)　　　[2] Artifacts, noise, moirés, axial and longitudinal chromatic aberrations
[8] With accessory flash (included), Canon with own power source (2 × AAA)　　　[9] Only 3 shots with active auto chromatic aberration correction, slow write times　　　[10] Pentax K5 IIs without low pass filter

⊕⊕ excellent　　⊕ good　　○ satisfactory　　⊖ poor　　⊝⊝ inadequate　　✓ included　　− not included　　n/a not applicable

APS-C and Micro Four Thirds			1-inch
Canon EOS M	**Olympus PEN lite E-PL5**	**Pentax K5 II/K5 IIs[10]**	**Nikon 1 V2**
www.canon.com	www.olympus.com	www.pentax.com	www.nikon.com
5184 × 3456, 3456 × 2304, 2592 × 1728, 1920 × 1280, 720 × 480 (in 3:2, 4:3, 16:9 or 1:1)	4608 × 3456, 2560 × 1920, 1280 × 960, 1024 × 768, 640 × 480 (in 4:3, 16:9, 3:2, 1:1 or 3:4)	4928 × 3264, 3936 × 2624, 3072 × 2048, 1728 × 1152	4608 × 3072, 4608 × 2592 (16:9), 3456 × 2304, 2304 × 1536, 1280 × 856 (all 3:2)
CMOS, 18 / APS-C (23.3 mm × 14.9 mm) / ✓	Live MOS, 16 / Micro Four Thirds (17.3 mm × 13.0 mm) / ✓	CMOS, 16 (K5 IIs without low pass filter) / APS-C (23.6 mm × 15.7 mm) / ✓	CMOS, 14 / Nikon CX (13.2 mm × 8.8 mm) / ✓
RAW, JPEG, RAW+JPEG / 2 / MPEG-4 H.264	RAW, JPEG, RAW+JPEG / 4 / MJPEG	RAW, JPEG, RAW+JPEG / 4 / MJPEG	RAW, JPEG, RAW+JPEG / 3 / MPEG-4 H.264
Full HD 1080p, 29 min. 59 s, 25	Full HD 1080p, 29 min., 30	Full HD 1080p, 4 GB or 25 min., 25	Full HD 1080p, 20 min., 30
SD(HC/XC) / 8.2 MB	SD(HC/XC) / 10.3 MB	SD(HC) / 10.7 MB	SD(HC/XC) / 8.3 MB
Approx. 1.6× / Canon M (Canon EF, EF-S with adapter)	Approx. 2× / Micro Four Thirds	Approx. 1.5× / Pentax KAF3, KAF2, KAF, KA	Approx. 2.7× / Nikon 1 (Nikon bayonet with adapter)
Auto (100-6400, limits configurable), 100-12 800 (25 600) in 1/1 increments	Auto (200-configurable limit), 200-25 600 in 1/3 or 1/1 increments	Auto (limits freely configurable), 80-51 200 in 1/3, 1/2 or 1/1 increments	Auto (160-800/3200/6400), 160 6400 in 1/1 increments
Bulb, 30-1/4000 / 1/200	Bulb, 60-1/4000 / 1/250 (user-configurable)	Bulb, 30-1/8000 / 1/180	Bulb, 30-1/4000 (electronic 1/16000) / 1/250 (electronic 1/60)
Hybrid AF (one-shot, cont.), AF+MF, MF / ✓ (IS lenses)	AF (one-shot, cont., tracking), MF / ✓ (sensor-shift)	AF (one-shot, cont.), MF / ✓ (sensor-shift)	Hybrid AF (one-shot, cont., tracking), MF / ✓ (VR lenses)
31 or 1 (touch adjustment) / ✓ (red)	35, groups of 9 or 1 (35 positions) or touch AF / ✓ (orange)	11 (9 cross sensors), 5 or 1 (11 positions) / ✓ (green)	35 or 1 (135 positions) / ✓ (green)
✓ / ✓ / ✓	✓ (324 areas) / ✓ / ✓	✓ (77 areas) / ✓ / ✓	✓ / ✓ / ✓
✓ (with shift) / 8 / –	✓ (with shift) / 25 / ✓ (4 presets)	✓ (with shift and Hyper-program) / – / ✓ (5 presets)	✓ (with shift) / Scene Auto / –
✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓	✓ / ✓ / ✓
±2 EV in 1/3 or 1/2 increments / ✓ (4-way shortcut)	±3 EV in 1/3, 1/2 or 1/1 increments / –	±5 EV in 1/3 or 1/2 increments / ✓ (lever)	±3 EV in 1/3 increments / –
✓ / ✓ / – / – / ✓ (16-bit, stereo, 48 kHz)	✓ / ✓ / – / ✓ / ✓ (16-bit, stereo, 48 kHz)	✓ / ✓ / – / ✓ / ✓ (16-bit, mono[7], 32 kHz)	– / – / – / – / ✓ (16-bit, stereo, 48 kHz)
10 s (1–10 shots) or 2 s / 4.2 fps, until card full[9]; 4.1 fps, 6 shots	12 or 2 s or 1-30 s, 1–10 shots, interval 0.5-3 s / 8.2 fps, 17 shots; 8.2 fps, 14 shots	10 or 2 s / 6.4 fps, 32 shots; 6.4 fps, 24 shots	10 or 2 s / 60 fps, 40 shots; 56 fps, 40 shots
✓ / 6 / ✓	✓ / 7 / ✓ (and Kelvin)	✓ (3 presets) / 10 / ✓ (also Kelvin/Mired, 3 presets)	✓ / 6 / ✓
✓ / sRGB, Adobe RGB	✓ / sRGB, Adobe RGB	✓ / sRGB, Adobe RGB	✓ / sRGB, Adobe RGB
– / – / – / – / –	– (optional optical or electronic) / – / – / –	Pentaprism / 0.92× / 100% / n/a	Electronic (1.4m pixels), IR proximity sensor / k. A. / 100% / 18 mm
3.0" (capacitive touch) / 1 040 000 / 7	3.0" / 460 000 / 15	3.0" / 921 600 / 15	3.0" / 921 000 / 7
✓ / ✓ (with face detection) / ✓ (built into image sensor)	✓ / ✓ (with face detection) / n/a	✓ / ✓ (with face detection) / ✓	✓ / ✓ / ✓ (73 phase-detection)
Metal and Plastic / – / –	Metal / – / –	Magnesium, weatherproof / ✓ (green backlight) / ✓	Metal + Plastic / – / –
✓ (+ center button) / 1 / 1 (4-way switch is also main dial)	✓ (+ OK button) / 1 / 1 (ring surrounding 4-way switch)	✓ (5 buttons) / 1 (+ 3 levers) / 2	✓ (+ OK button) / 1 / 2 (1 ring surrounding 4-way switch)
9[8] / ±2 EV in 1/3 increments / 3.9 s / ✓ (TTL shoe)	10[8] / 4.1 s / ✓ (TTL shoe + accessory socket)	13 / 2.4 s / ✓ (TTL shoe, X-Sync socket)	6 / < 1s / ✓ (proprietary accessory shoe)
9 or 4 / ✓ (up to 10×) / ✓ (with RGB)	100, 25, 9 or 4 or calender / ✓ (up to 14×) / ✓ (with RGB)	81, 36, 16, 9 or 4 or calender / ✓ (up to 32×) / ✓ (with RGB)	72, 9 or 4 or calender / ✓ / ✓
Proprietary mains adapter, Li-Ion battery	Li-Ion battery	Proprietary mains adapter, Li-Ion battery, battery grip	Proprietary mains adapter, Li-Ion battery
USB 2.0 / ✓ / ✓ (type C) / ✓ (IR)	USB 2.0 / ✓ / ✓ (type D) / ✓ (cable)	USB 2.0 / ✓ / ✓ (Typ C) / ✓ (IR or cable)	USB 2.0 / – (plus stereo mic IN) / ✓ (type C) / ✓ (IR)
110 mm × 67 mm × 32 mm / 295 g, 500 g, 570 g[8]	111 mm × 64 mm × 38 mm / 330 g, 445 g, 470 g[8]	131 mm × 97 mm × 73 mm / 760 g, 1240 g	108 mm × 82 mm × 46 mm / 340 g, 450 g
Quick Start Guide, PDF Manual	Manual	Manual	Compact Manual, PDF Manual
Li-Ion battery LP-E12 (7.2 V, 875 mAh, 6.3 Wh), charger, USB cable, body cap, shoulder strap, Speedlite 90EX flash, kit lens without sunshade	Li-Ion battery BLS-5 (7.2 V, 1150 mAh, 8.3 Wh), charger, body cap, removable grip, carrying strap, USB and AV cables, accessory flash FL-LM1, kit lens(es) if applicable	Li-Ion battery D-LI90 (7.2 V, 1860 mAh, 13.4 Wh), charger, body cap, viewfinder and flash shoe covers, carrying strap, USB and AV cables, kit lens(es) if applicable	Li-Ion battery EN-EL21 (7.2 V, 1485 mAh, 11 Wh), charger, body cap, shoulder strap, USB cable, kit lens(es)
Pancake lens EF-M 22mm f/2.0 STM, memory cards, mains adapter, lens adapter for EF/EF-S lenses, HDMI cable, camera bag, IR remote control, GPS module, some EOS system accessories	Memory cards, camera bag, interchangeable lenses, microphone adapter, underwater housing and accessories, other PEN system accessories	Memory cards, mains adapter, battery grip, IR and cable remote release, camera bag, Pentax system accessories	Memory cards, mains adapter, flash unit, Nikkor bayonet adapter, remote release, GPS receiver, WiFi module, microphone, HDMI cable, camera bag, other system accessories
ImageBrowser EX 1.0, EOS Utility 2.12, Digital Photo Professional 3.12, PhotoStitch 3.1/3.2, Picture Style Editor 1.12 (Win/Mac)	Olympus Viewer 2 (Win/Mac)	Camera Utility 4 (Win/Mac)	Nikon ViewNX 2, Short Movie Creator (Win/Mac)
Measured using EF-M 18-55mm f/3.5-5.6 IS STM	Measured using M.Zuiko digital 14-42mm f/3.5-5.6 II R	Measured using smc DA 17-70mm f/4 AL (IF) SDM	Measured using 1 Nikkor VR 10-30mm f/3.5-5.6
⊕⊕ / ⊕	⊕⊕ / ⊕	⊕ / ○	⊕ / ⊕
○ / ⊕	⊕ / ○	K5 II: ⊕ / ○ / K5 IIs: ⊕⊕ / ⊕⊕	○ / ⊖
○ / ⊕	○ / ⊕	K5 II: ○ / ⊕ / K5 IIs: ⊕ / ○	⊖ / ⊕
⊕ / ⊕	⊕ / ⊕⊕	⊕⊕ / ⊕⊕	⊕ / ⊕
⊕ / ○	⊕⊕ / ○	⊕⊕ / ⊕	⊕ / ○
– / 600	– / 600	1000/1200 / 1500/1700	– / 900

[3] Average value, measured using largest native image size and best JPEG quality [4] Relative to similar class/price of camera [5] Photo features only [6] Measured values [7] Stereo using accessory microphone

c't

Reinhard Eisele

Photographing
the Natural World

Magnificent subjects are all around us in the great outdoors – in
the garden, at holiday destinations and even at the park around the
corner. They're just waiting to be discovered, and pro photographer
Reinhard Eisele has some great tips on how to spot them, as well as
on how to choose your equipment and compose your pictures.

Photographing nature doesn't always require a lot of travel. Once you develop an eye for them, the subjects in your immediate environment can be just as engaging as more exotic ones.

The range of equipment available for nature photography is vast, and the more you learn about it, the more you will want to expand your setup. What you actually acquire will be determined by your goals and, of course, your budget. Alongside the obvious cameras and lenses, a basic kit comprises filters, a flash and, most importantly, a tripod.

For an interesting and well-thought-out combination for hikers and climbers, take a look at the Novoflex BasicBall – a clever combo in which the tripod's legs are replaced by four telescopic rods. Screw the rods into the semi-spherical BasicBall base and voilà – not only do you have a tripod stable enough to take a heavy camera with a telephoto zoom, but you have also lightened your load by 200 grams or more.

Cameras and Lenses

Unfortunately there is no such thing as an 'all-rounder' camera. You just have to think carefully about how to compromise between what you need and what you want to achieve – a checklist can be helpful. If you intend to buy new equipment, up-to-date test reports like the ones regularly included in this magazine can help you make up your mind.

The multitude of available settings and the huge range of lenses available make single lens reflex (SLR) systems the favorite of outdoor and nature photographers. The three key criteria for camera selection are the quality of the image produced, the range of shutter speeds and the selection of lenses available. Stability is also crucial, and camera bodies that have a magnesium alloy body are ideal.

Because you'll be 'roughing it' with your lenses, they need to be robust. A good combination of lenses for nature and animal photography, providing good quality images without too much weight, comprises:
– a 17-40mm wide-angle zoom
– a 40-70mm standard zoom
– a 70-200mm (or 70-300mm) telephoto zoom
– a 300mm (or 400mm) telephoto
– a macro lens (60 or 100mm, for example)
– a 1.4x teleconverter for the 300mm
– a 2x converter for the 300mm and the 70-200mm zoom

Filters

There are really only three types of filter needed for nature photography: a UV or protective filter, a polarizing filter and a graduated neutral density filter. A protective UV-blocking filter has no affect at all on the quality of the image produced by the lens. It is simply there to protect the lens from scratches, dirt and splashes, all of which are quite likely when you are working outdoors.

A polarizing filter is absolutely essential. It sits in a rotating mount and the effect it produces depends on the angle it is set to. You can see exactly what it is doing by looking through the viewfinder, as our sample photos on the next page show. The main reason for using a graduated neutral density filter is to even out the excessive difference in brightness that often occurs between the land and the sky, especially when the sky is cloudy or colorless rather than deep blue.

For an in-depth workshop on using photographic filters, see *c't Digital Photography* Issue 3 (2011), page 74.

No nature photographer should ever be without a polarizing filter. Used correctly, it gives a photo rich, saturated colors. The top photo, taken without a polarizing filter, looks dull and washed-out. The middle photo, with its almost black sky, shows what happens if you rotate the filter too far. The bottom photo best reproduces the situation as it looked in reality.

ISO 100 | Tripod | Fill flash | 58 mm | f22 | 1/25 s

ISO 100 | Tripod | Fill flash | 58 mm | f2.8 | 1/1250 s

Depth of field alters the effect of an image. The photo on the left, taken with the aperture stopped down, looks more businesslike and realistic, while the one on the right, shot with the aperture wide open, is more atmospheric and has a romantic feel.

Aperture and Exposure – Getting it Right

Aperture and exposure settings are mutually dependent and are two of the most important factors to consider when composing an image. By providing preset combinations of time and aperture, fully automatic exposure systems ensure correct exposure, but in doing so they deprive the photographer of the opportunity to influence the look of the image using movement or focus and blur effects. The only way a photographer can influence the look of an image is to make exposure settings manually or use aperture- of shutter-priority auto mode.

The aperture setting determines the depth of focus in the image. Put simply, when the aperture is wide open, the light entering the lens is more broadly diffused, resulting in a short field of focus. Each time the aperture is narrowed, less light falls on the sensor, but this light is more tightly bundled, which extends the depth of focus. In other words, the smaller the aperture,the greater the depth of field in the resulting image. Deliberate use of depth-of-field effects is one of the most important photographic techniques.

Another thing you need to know is that the distribution of depth of field in front of and behind the subject varies according to the focus setting you have selected. Close up, the ratio is approximately 1:1, but as the distance increases, the proportion behind the subject increases, especially if infinity lies within the range of focus.

Aperture and Exposure How-tos

Aperture and exposure time are interdependent. The wider the aperture, the shorter the exposure time; the narrower the

aperture, the longer the exposure time. The length of the exposure thus plays an important role in determining how a photo will look, as it defines whether a subject is depicted in or out of focus and whether movement appears frozen or fluid.

For many subjects, especially those photographed handheld, photographers aim for an exposure time between 1/125 and 1/250 s. In adequate light, this usually produces an aperture between f5.6 and f11, which is fine for most situations in which the subject is moving slowly or not at all. Achieving certain kinds of effect in your image, however, involves finding the best possible combination of aperture and exposure time. For example, wildlife photographers prefer to use wider apertures, partly because a wide aperture separates the the subject from the background, allowing the animal's face to become more dramatic while the background fades into the distance.

A wide aperture also means a short exposure time. Movements are 'frozen' and the image is sharp. But what if you also want to focus on another animal in the background too? This is where your internal struggle begins, and you have to reconcile the need for sufficient depth of field with an exposure time short enough to avoid camera shake.

The size of the aperture you use has a much greater effect on images captured using telephoto lenses than it does on those shot using a normal or wide-angle lens. For example, if you want to capture the movement of water in a stream, the only way to capture the feeling of the water's flow is to choose a longer exposure time. Exposure times for this type of shot start at 1/15 s and definitely require a tripod.

A small aperture makes sense if you want both the foreground and the background to be in focus in a landscape shot, as the photo of a field of crocuses below shows. If the

crocuses only were in focus, and the snow-capped mountains in the background blurred, it would not be a successful photo at all, because the mountains are such a strong feature. The same would be true of the reverse arrangement. Only a completely stopped down aperture – in this case f32 – can provide the huge depth of field of almost 10 kilometers necessary to cover the distance from the foreground to the mountains. The focus setting is critical. While you do need to understand the theory of distribution of depth of field, the only way to really get a handle on things is to look through the viewfinder. Hold down the depth of field preview button and adjust focus to the point at which the foreground (the near point) and the background (the far point) are both just still sharp. At very small apertures, the stopped-down viewfinder image gets really dark, so you need to concentrate hard and focus carefully to get the right result.

A field of crocuses in a valley in the Karwendel Alps. A small aperture is required in order to keep both the flowers and the mountains in focus. Tricky compositions and long exposure times like this can only be mastered using a tripod.

ISO 100 | Tripod | 40 mm | f22 | 1/15 s

Sunrise at Lake Walchen in Bavaria. The weather conditions have to be right if you want to capture a beautiful image like this. In this photo, the light cloud cover is a key factor influencing the range of colors on show.

The Effect of the Time of Day

When photographing the natural world – and especially landscapes – you can achieve completely different effects simply by shooting at different times of day. Let's look at how to use nature's lighting to its best advantage around the clock.

Dawn and Sunrise

Early morning light is considered particularly soft, romantic and atmospheric. This is very true, at least if the sun actually comes up rather than being obscured by clouds. What makes it tricky is that this feeling of enchantment is elusive. Depending on the time of year, the morning sun quickly gets quite bright, dissipating the magical daybreak mood.

To capture this atmosphere with your camera, you'll need to carefully calculate exactly how the light will fall on your chosen subject. At the same time, be ready for luck to play a role and try to remain open to the randomness of nature. Many images simply cannot be conveived in advance and often just 'happen' once you're on the scene.

Morning and Afternoon

In the late morning and early afternoon, when the sun is higher in the sky, the shadows are shorter and there is less contrast between dark and light. The only difference between morning light and afternoon light is the angle of incidence of the sun's rays. The color temperature of the light and its effect are exactly the same. Some subjects lend themselves to being photographed in the morning, while others look better in the afternoon. The deciding factor is a subject's orientation. For example, a range of mountains that points from east to west can be photographed effectively at either time of day.

However, most landscape subjects do not coincide exactly with the points of the compass, so they have their own unique times in light and shade, and photograph well or poorly depending on the time of day. It's a good idea to carry a compass with you so you can estimate the path of the sun and its effect on your subject. This will help you be in the right place at the right time.

Noon

There's an old adage that says 'leave your camera at home in the middle of the day', especially if you want to take long-distance landscape photos. In some situations, however, noonday sun provides exactly the right lighting. Light shining down almost vertically from above is an advantage in dense forest, for example, especially if cloudy sky provides diffuse rather than direct sunlight. In such situations, what could have been a gloomy forest is suffused with soft light that brings out subjects that would have shown too much contrast in morning or afternoon light.

Midday lighting can also be just right on fine days at the seaside or lakeshore. In the morning or later in the afternoon, the water can appear light gray or pale blue, but at midday

The turquoise of the ocean in the Maldives is at its best at midday when the sun is shining directly on the water's surface

Clouds can make a photo of a sunset look even more dramatic. This photo was also taken in the Maldives using Fuji Velvia 50, a slide film that produces highly saturated colors.

it is a powerful turquoise or blue. At this time, too, the conditions are particularly good for macro photography. Similarly, if you want to photograph a flower indoors, light shining down from above can often replace the flash that would otherwise be necessary.

Early Evening

Depending on the time of year and the latitude, light changes in the late afternoon, taking on a warmer, reddish tone. The light that occurs and hour or two prior to sunset is ideal for many nature and landscape photographs, as long as the sky is clear and cloudless. The contrasts between light and dark and highlights and shadow are greater, and the shapes in the landscape stand out better because of the acute angle of the sun. Nature now bathes trees, rock formations,

dunes, individual plants and other details in near-perfect light. If the air is clear and the weather permits, the sky possesses an intense, glistening azure blue that you can intensify even further using a polarizing filter.

Late Evening and Sunset

The main characteristics of early evening and sunset light are warm colors, strong contrasts and, frequently, a romantic mood. For photographic purposes, if the weather is constant, evening and morning light have a similar effect due to their similar color temperature. Of course, this special light becomes brighter in the course of the morning and darker as the evening wears on.

Sunsets are an all-time favorite subject for photographers, but conditions must be right for a successful sunset photo. The sky at the point where the sun is going to set should be as cloud-free as possible and, if the sky on the horizon is hazy, the haze should not be so heavy as to obscure the sun. As long as they do not cover the point at which the sun dips below the horizon, clouds can make a sunset more dramatic.

Photographers often forget one important aspect of sunsets – the special time just after the sun has disappeared. Depending on the shapes in the landscape and the weather conditions, the colors that prevail about 10 to 20 minutes after the actual sunset can be quite glorious. The spectrum broadens, contrast is reduced and the mood can be even more spectacular than that of the sunset itself.

Come Rain, Come Shine

In nature photography, the weather determines the general feel of a photo, and is just as important as the time of day. It doesn't matter if you are photographing glowing colors or in subtle black and white, sunny clarity or a misty mood. The weather directly dictates the type of photos you can take and whether it is even worth unpacking your camera. But don't let that fool you into thinking that good weather is a prerequisite for good photos.

Is Fine Weather Good Photography Weather?

What exactly is 'fine weather'? For holidaymakers, swimmers and hikers, the answer is quite different than for nature photographers. Most people with a day off are happy if the sun shines, a few clouds come along now and then to stop it getting too hot, and the rain stays away. While it probably never crosses their minds how intense the blue of the sky is, whether the air is hazy, or how far into the distance they can see, these things are always on a photographer's mind. Frequently, the 'nice weather' that most people enjoy doesn't suit nature and landscape photographers at all.

This can be because the air is slightly hazy and colors are not at their best or, rather than appearing bright blue, the sky is a dull blue-gray color or even white. In photos, this type of sky appears overexposed and lacks texture. The sun is intense, but is blocked by high cloud that is not apparent at first glance, reducing contrast and shadows, while high, hazy cloud robs the landscape of its contours.

Cloudy Sky

A cloudy sky makes colors less bright and landscape photos less intense. The lack of contrast makes a photo softer and more balanced, but you need to find the right kind of subject. This is the perfect time to take photos in forests. On sunny days, the light shining through leaves or branches often creates a dappled effect that can be distracting, but when it's cloudy, the light is more even and the shadows work better.

Bad Weather can be Good

At first glance, a bad weather forecast seems to infer less than ideal conditions for outdoor photography, at least in terms of workplace comfort. Rain, snow or storms can make life

Gloriously fine days with perfect conditions for taking photos are few and far between. In fact, there are only about 10 to 12 a year. This photo, with the Zugspitz massif in the background, was taken on one such day in autumn.

ISO 100 | Tripod | 45 mm | f22 | 1/6 s

Impending bad weather can provide the perfect setting for the right subject – in this case, the 'tufa towers' at Mono Lake Reserve in California

Working 'under cover', this photo was shot at f5.6 with an exposure time of 20 s at ISO 50

difficult for photographers. Reluctant to expose themselves and their gear to the forces of nature, not many people venture out with a camera on bad days. It's no surprise that most nature photos are taken on fine days and very few are captured in bad weather.

But here's the thing: unfavorable weather conditions – rain clouds, storms, perhaps the first rumbles of a thunderstorm – can make for wonderfully dramatic photos. You'll need some form of rain protection for your camera though and, if you kit yourself out in good wet-weather gear too, you might just find that 'bad-weather photography' can be an unusual and very positive experience.

Sure, colors do not sparkle and shine in bad weather like they do at other times, but they are more intense and richer. Rain brings out the green of leaves beautifully, like a layer of varnish that heightens the contrast in the colors. After a long period of heavy rain in mixed or deciduous forest, the wet tree trunks

take on a dark color, producing great photo opportunities with stark contrast between the dark trunks and the gleaming leaves – ideal conditions for striking nature photographs.

Photographing Lightning

Thunder is not really relevant for photographers, except as a herald of lightning, which is a deservedly popular subject. In a wide-open space, lightning can be anything from very uncomfortable to downright dangerous or even life-threatening. To take good photos of lightning, you need a safe place to work from and, unless you live in Arizona where lightning is 'guaranteed' in some areas, it will be hit and miss as to whether you actually get to see and photograph any lightning at all from the safety of your hideout.

The ideal time to photograph lightning is in the early evening, when it is relatively

dark. This is because it is impossible to make an exposure at exactly the moment the lightning appears in the sky. Once a bolt of lightning is visible, it would be pure luck to capture its split-second flash using an exposure time of 1/60 s or less.

However, in darkness you can select a long exposure time in the hope that lightning will appear while the shutter is open. Careful observation will give you an idea of the general position in the sky where most of the bolts appear, allowing you to set up and align your camera accordingly. Thanks to the darkness, you can safely expose an image for 20 to 30 seconds using your camera's B (Bulb) setting, and simply wait for lightning to strike. Sometimes, lightning occurs at regular intervals, which gives you a better chance of predicting the next flash. Just make sure that no extraneous light enters through the viewfinder while the shutter is open, as this will reduce the quality of the images you capture.

A vertical world: the highly spatial feel of this shot of the Siebentisch Park in Augsburg comes from the symmetrical composition, the single-point perspective, the bright foreground and the fact that the trees are parallel to the edges of the frame

Composition – Anything is Possible (almost!)

Successful photography involves more than selecting a subject, finding the right light and knowing how to use your camera. You also have to put a lot of thought into composing the image. The human eye perceives things in landscape format, and for photos of scenery, which by definition probably involve a large area, landscape format is usually the right choice. It is also used more often than portrait format for detail shots. One or the other format will be more suitable for most shots, but it is always worth taking the time to experiment with both.

Using Space

The allocation of space is key to anything visual, and the way we are used to seeing things plays a fundamental role here too. Our eyes and brain try to organize the things we see and, when the eye detects information, the brain puts that information in the center of our attention and focuses on it. As a result, photos tend to have a central point of focus. However, we sometimes have to break the rules that are necessary to our survival in other contexts. Photos in which the main subject is positioned centrally are often simply boring.

The Rule of Thirds

Even allowing for artistic freedom, there is one inescapable rule of composition, known as ther 'rule of thirds', which is based on the theory of proportions enshrined in the Golden Ratio. The Golden Ratio has been used throughout modern history and has been regarded as the embodiment of aesthetics and visual harmony since the times of the Ancient Greeks. Interpreted simply for practical everyday use, it has been refined into the rule of thirds. This rule divides an image into nine equal parts using two vertical and two horizontal lines, and places the main subject at one of the four intersections or along one of the lines.

Achieving a Feeling of Depth

The third dimension is missing in two-dimensional photography, so it is up to us to get the viewer's mind to imagine it.

Every shape, whether dark or light, can be perceived as being very close or infinitely far away. It is possible to simulate depth by composing an image and positioning objects within the frame. The way our eyes and brain see things is of assistance here: we tend to perceive dark points on a light surface as being close, and light points on a dark surface as further away. Lines or repeated shapes also create the impression of space, as do objects like fences, hedges and lines of trees or clouds that stretch from the foreground into the background.

Perspective

Like the Golden Ratio, the use of perspective to convey depth goes a long way back in history. Used correctly, perspective gives two-dimensional images a three-dimensional feel. In central (single-point) perspective, the focal point of all the lines that do not run parallel to the edges of the image is positioned at a single point on the surface of the image. This point may be in the middle or offset, depending on the subject and the effect you want to achieve.
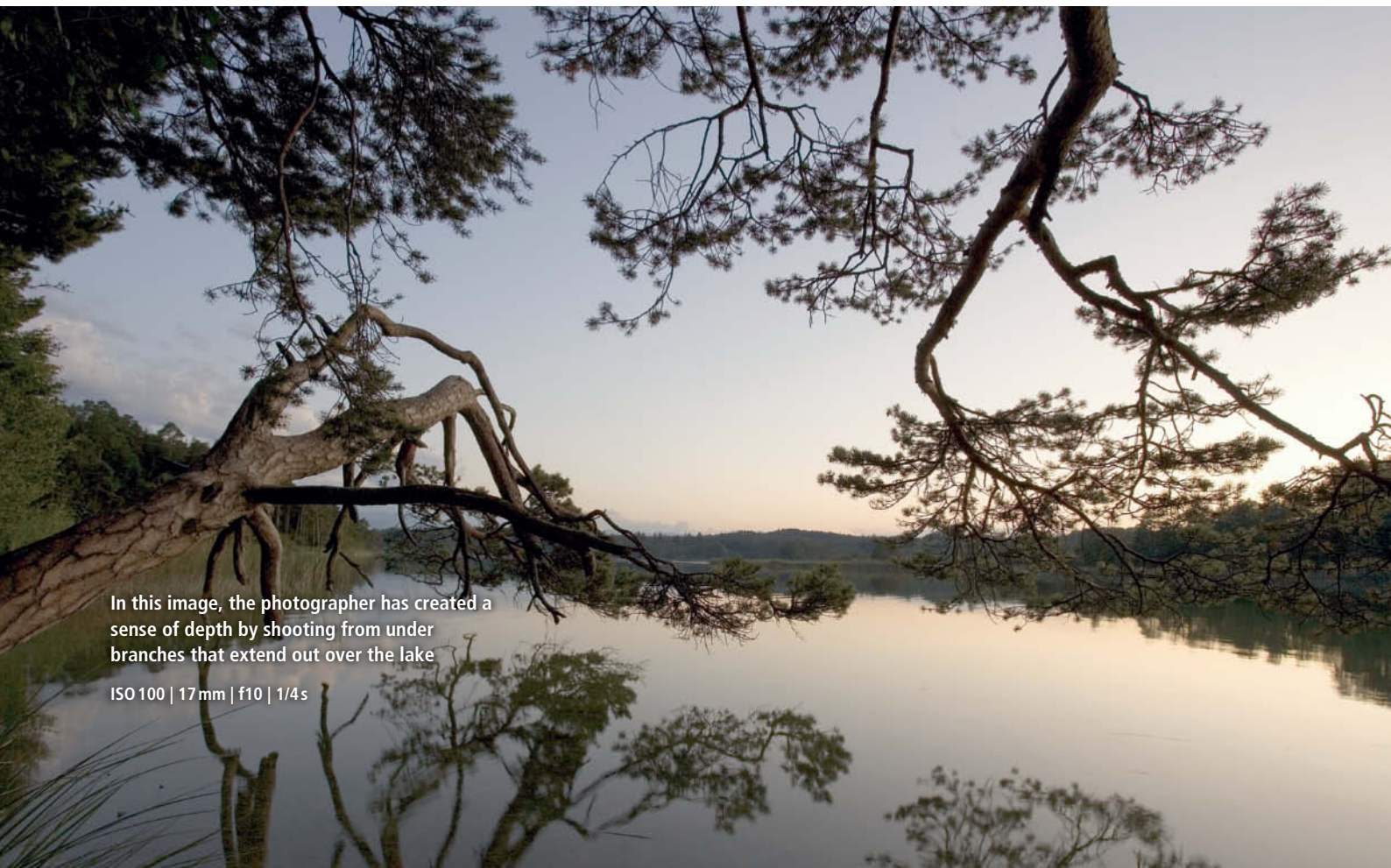
In this image, the photographer has created a sense of depth by shooting from under branches that extend out over the lake

ISO 100 | 17 mm | f10 | 1/4 s

For maximum effect, a wide-angle lens can be used to emphasize perspective by making nearby objects look larger than they actually are and background objects smaller – for example, to make the branches of a tree appear to stretch way out into the sky. A 'bird's-eye' view (i.e., the view from above) can appear quite normal or really unusual if, for example, objects are shown from above when we don't usually see them that way. Trees seen from above or other aerial photos are two good examples. Bridges and viewing platforms offer good opportunities for interesting shots. A 'worm's-eye view' (i.e., from below the subject) can produce spectacular results – looking up from beneath a flower or tree, for example.

The Effects of Color

Colors and the effects they have play a central role in nature photography, particularly when it comes to photographing flowers and plants. The mechanisms involved are the same as those that occur in colors used for interior decoration or clothing. The right combination of colors can express harmony or particular feelings, and can emphasize the design of an object. However, these techniques only work if you know how colors interact.

Contrast between light and dark is relevant not just for black, white and gray tones, but also for the differences in brightness between individual colors. On a color wheel, light colors are usually portrayed at the top and dark colors at the bottom. One of the major factors that determine how an image looks is the proportion of bright and dark colors it contains. Surrounded by dark colors, light colors look much brighter, and contrast between light and dark makes light stand out from shade and the lines in an image show up more clearly.

Complementary contrast occurs between colors that are positioned directly opposite each other on the color wheel. Two complementary colors make each other look brighter and work together to create a feeling of balance and harmony. The contrast between warm and cool colors is one of the most powerful there is and defines the way people perceive different colors. Yellow, red and orange tones are generally perceived as warm, while blue, turquoise and some greens are perceived as cool or even icy. The extremes of cool/warm contrast are found in the juxtaposition of blue or green and red or orange.

Simultaneous contrast refers to the way a color can seem to change in the presence of another color. For example, a neutral light blue surrounded by a red surface looks cold, but, if you position the same color next to a turquoise surface, it looks much warmer. A large area of color influences a smaller patch of a different color. Quantitative contrast refers to how much of one color is used in relation to another. The effect depends on the brightness of a color and how it covers an area, so that a small area of a light color can contrast with a larger area of a dark color and still seem balanced and harmonious.

Qualitative contrast refers to the difference in intensity between bright, saturated colors and lackluster, dull or refracted colors. It defines differences in color quality rather than the proportions in which they are used. Qualitative contrast becomes relevant on rainy days, for example, when the surroundings look dull but the color saturation of some plants really makes them glow.

As its name suggests, intensity contrast refers to the purity of individual colors. It usually has a powerful, intensely colorful effect that we are familiar with from the paintings of Piet Mondrian, Franz Marc and Henri Matisse. This effect is most evident when primary red, yellow and blue tones are combined – colors that often occur in beds of tulips or other flowers that have been carefully planted alongside contrasting greenery.

Different kinds of color contrast: the Rainbow Agama on the left epitomizes complementary contrast, the photo of the flowers demonstrates contrast based on the intensity of color and the photo of the chestnut blooms makes use of light/dark contrast

Become a Subject-spotter

To develop your ability to find suitable subjects, you need look no further than your immediate surroundings or your own garden. Especially if you are new to nature photography, it's important to find subjects that will be permanently available. Botanical gardens are ideal for photographing plants as they offer a huge range – everything from familiar flowers to exotic orchids and palms, and they are usually not too crowded if you avoid going at the weekend. For a first training exercise, try looking around without looking through the viewfinder, imagining how things would look using different lenses. You need to train your eye because when you're out hiking, you won't be able to look through the viewfinder all the time. Actually reaching for the camera is the second step in taking a photo.

ISO 100 | Mini tripod |
55mm macro lens | f11 | 1/1000 s

ISO 100 | 90 mm | f2.8 | 1/160 s
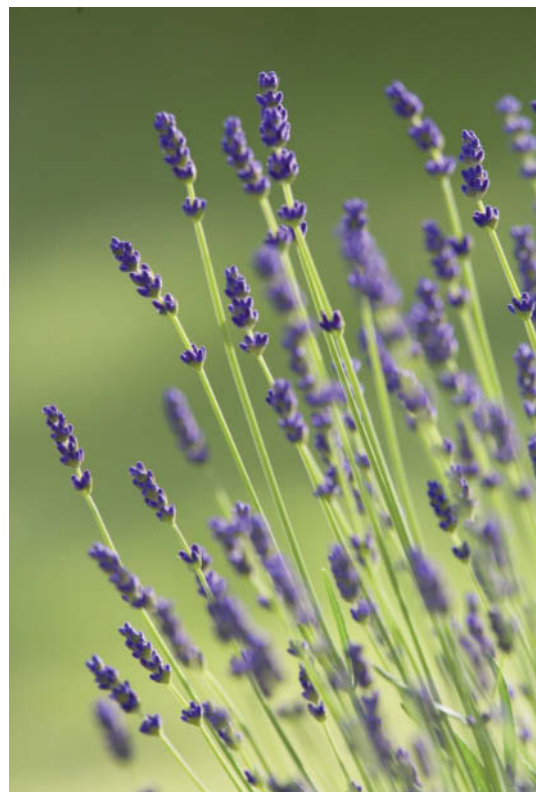
ISO 400 | 300mm lens and 2x teleconverter |
f9 | 1/400 s | -½ EV

Your own backyard provides plenty of potential subjects and makes an ideal training ground - if you make mistakes that you don't discover until you see your photos on a monitor, it's no problem to go back and try again

Location, Location, Location

'Hotspots' are places or regions that are popular with nature photographers and may even be marketed specifically as such. Of course, that means you won't be alone, but the upside is that you can share your enthusiasm with other photographers. Some well-known hotspots are the Bavarian Forest National Park in Germany, Lake Hornborga in Sweden (the perfect place to photograph cranes), many of the national parks in Kenya and several in Switzerland, in addition to numerous wildlife reserves that have been set up specifically with photography in mind.

At a hotspot, subjects are virtually delivered to your doorstep. Or if not, at least hunting for them in the company of other photography enthusiasts will be easier and more social than your solo field trips. In any case, hotspots make it easier for beginners to find subjects and help you to produce results faster than if you were working in unfamiliar territory in which you have to find your way from scratch.

http://www.photographyhotspots.com.au and www.fotolicht.com/fotoreviere.html are just two of the many websites that list major photographic hotspots around the world.

Finding and Remembering Potential Subjects

The angle of the sun's rays is crucial, because this is what really shows off a subject to its best advantage. We recommend taking a notebook and pencil along so you can jot down occasional reminders about locations that seem to offer promising opportunities and return at a more opportune time. Other ways to take useful notes are using a mobile phone camera, voice recordings or GPS.

The same is true of the seasons. Some subjects that simply look nice in summer will be transformed into excellent photographic subjects in spring, fall or winter. In the case of trees, particularly, fall is the time for stunning photos, while the summer months produce unremarkable results. Precise notes about time and position will make it easier for you to locate your discoveries again months later when they might just be looking their best.

A classic late-summer image. The dark background and the angle of incidence of the light make a commonplace spider web look unusual and spectacular.

Locating Great Landscapes

Next to plants, landscapes are one of the most frequently photographed natural subjects. Many people can find a vista to photograph by simply stepping outside, or at least won't have far to go, but if you are not lucky enough to live in a picturesque area, you'll have to put a bit of extra effort into getting a good shot. Planning your travels along photographic lines is easy, because countless photographers have already tracked down the subjects in spectacular destinations like the Grand Canyon, Bryce Canyon, Namibia, the Sahara, the Antarctic or the European Alps, and have published their photos in thousands of different magazines and other media. In locations like these, the real art is to develop your own unique view, because the vast majority of subjects have already been photographed and published.

On the other hand, it can be quite difficult to find interesting subjects locally or at less spectacular holiday spots. But don't give up – you are sure to find topographies worth photographing if you look carefully.

The right conditions transform even unspectacular landscapes into wonderful subjects. Here, a row of trees contrasts wonderfully with springtime rapeseed flowers.

A stunning example of a lone tree, photographed in Sri Lanka (on Fuji Velvia 50) so that the rays of the setting sun glow between the branches and twigs

Photographing Trees

Old, free-standing trees are one of the most evocative subjects in nature. Their age and beauty transform them into impressive natural memorials that span the centuries and radiate ancient, awe-inspiring vitality. No wonder photographers flock to them.

You might think that it's relatively easy to photograph trees. They are usually easily accessible and have obvious, clearly defined shapes. But the depiction of a tree in a photo often diverges hugely from the essence of the tree as you experienced it. Sometimes, photos of trees look like drab biological documentation or simply fail to convey the scale of the subject.

The first thing to do is find your tree. Germany has some well-known listed trees like the Tassilo lime tree in Wessobrunn and the Bavaria beech tree in Pondorf, which have heritage protection and have become attractions in their own right. In many regions, though, there are countless such trees still waiting to be discovered. Having set your sights on a particular subject, you will have to analyze it in the same way you would any other subject. Does the main subject stand out against its background? Are the surroundings distracting, and if they are, is there a way to reduce the effect or incorporate them into the image? What effect does the sun have on your subject? Is this the right time of day, or should you come back later, or tomorrow?

Photographing the Ocean

Many people think of the sea in connection with vacations, special occasions, swimming and water sports, with photography taking a back seat. However, the ocean and the coast can be a real treasure trove for photographers.

The sea 'as is' is already a fully-formed subject in its own right and doesn't need to be adorned with palm trees, boats or dramatic weather to make a statement. However, it is actually quite difficult to find authentic, uncluttered ocean photography opportunities. Water is often murky, with an indeterminate wave pattern and an indefinable blue/gray/green color. The sky too, is often uninspiring and contains just a few uninteresting clouds. If you are looking for natural ocean-based subjects that don't include include human activity, you'll need to look where the sea meets the land, along the coastline and on beaches. You will rarely find interesting photo opportunities if you shoot from a standard point of view.

Depending on the color of the sky, you may find that there are as many as six f-stops of contrast between it and the sea. If the color of the water is right, the sky will often end up overexposed and if the sky is right, the water will appear too dark. The best weather for ocean photography is on a cloudy day or when the sky is a deep blue, although the most reliable way to even out contrast is to use a graduated neutral density filter.

You won't be able to escape problems with contrast even when photographing breaking waves. They increase in height when they approach the shore and suddenly explode into a shower of intense white when they break. Auto exposure control simply cannot tell which part of the scene it needs to meter. The best way to get exposure right in this type of situation is to use manual (M) mode to take a spot reading of the crest of a breaking wave and apply the settings it provides to the whole frame.

Photographing Animals

The peace and tranquility usually associated with photographing landscapes and flora evaporates in an instant once you start photographing fauna. And even though animal photography doesn't have to involve wild chases or spectacular action scenes, it is primarily the energy and 'aliveness' of animals that makes this branch of nature photography so fascinating. Photographing animals is often compared with going on a hunt, as both require a high degree of commitment if they are to be a success and only really differ in the nature of the what happens when you finally 'pull the trigger'.

Animals can be just like people. If you want to photograph animals, you have to get to know them. Not as a biologist would, or with the meticulous approach of a behavioral scientist, but at least by observing them closely to see how they move, how they behave, whether they are shy or not and how they react to people. The more time you spend researching animals, the more you'll find that their behavior is often similar to that of human beings. Cows are a good example – if you approach them cautiously, they will often show great interest. Understanding behavior is one of the keys to successful animal photography, and is relevant not just for big game but for all living creatures because it gives you the edge you need to guess what they will do next.

The range of lenses you can use for animal photography is as diverse as the subjects and photos themselves. A 300 or 400mm telephoto is a good 'standard' lens, but bear in mind that you need a 600mm lens to capture a blackbird from 10 meters away if you want it to fill the frame. Seen from this perspective, a 300mm lens should probably be seen as a minimum working focal length.

A Final Tip ...

The 'road' to good photos of the natural world is not a straight one; it's rarely comfortable and involves many detours. What makes this particular genre special is the sheer enjoyment and pleasure of capturing photos and viewing the results. There is never any lack of potential subjects – you just have to get out there and find them.   (ssi)

The strength of this photo lies in the obvious mutual curiosity shown by the photographer and the subject

ISO 100 | 24 mm | f7 | 1/200 s

Reinhard Eisele

Photographer Reinhard Eisele has a degree in design and has authored more than 30 illustrated books on topics as diverse as travel, landscape and architectural photography. A wide range of photographic commissions have taken him all around the world, as an expedition photographer in Sumatra, working for GEO magazine in Borneo, shooting fashion in Hawaii and doing sports shoots in the Caribbean. His photos have been published in *Stern, Spiegel, Merian, Saison, GEO, National Geographic, Fotomagazin, Photographie* and *Bunte*, and are on stock at a number of international agencies.
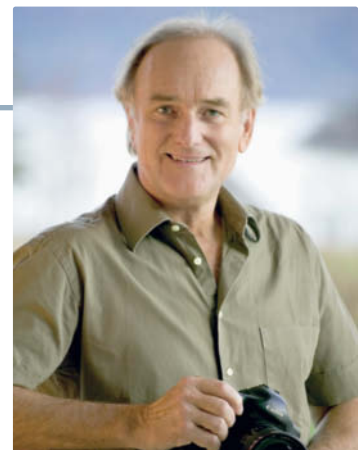
Dmitri Popov

Fast Photo Editing with

CameraBag

A lightweight, simple-to-use alternative to specialized applications such as Lightroom and Aperture, CameraBag is a low-price grab bag of effects for use on the road or on a home computer.

Many enthusiasts and professional photographers rely on heavyweight applications like Adobe *Lightroom*, Apple *Aperture*, *digiKam* and *Photivo* for all their RAW processing and photo editing needs. Although these applications offer a wide range of powerful tools that can produce impressive results in skilled hands, there are many situations that require the use of applications that help you to achieve the desired results quickly and with a minimum of effort. For example; while traveling, you might want to process one or two RAW files, tweak some basic settings, apply an effect or two and share the final result without spending too much time in the process. If this is the case, a lightweight application might be a better tool for the job than the mighty *Lightroom*. In fact, if vintage and creative photo effects are your thing, then an application that provides an easy way to create and apply effects can be a useful addition to your photographic toolbox. There are plenty of reasons to try out small-footprint alternatives to the established photo processing applications.

Lightweight photo editing applications are a dime a dozen, and there are also plenty of other programs out there that can be used to apply photo effects. However, there are not very many applications that effectively integrate essential photo editing and filter functionality into one, easy-to-use package. *CameraBag 2* (nevercenter.com/camerabag/desktop/) is a fine specimen of this rare breed, and this article takes a closer look at the application and what it has to offer in terms of features and functionality.

CameraBag 2 features a wide collection of ready-to-use styles which you can preview by hovering the mouse over their titles

CameraBag 2 for Desktop

CameraBag 2 (US$20) offers a combination of basic editing tools and creative filters. The desktop version is available for Mac OS X and Windows and requires a modest Intel Core 2 Duo processor with 1GB of RAM and a mere 70MB of free hard disk space. If you have the right codecs installed, the application can handle JPG, PNG, TIFF and RAW files, and the Mac version can open PSD files too.

CameraBag 2 has a clean, two-part interface comprising the main work area and a tool panel. The tools are split into three groups called Styles (these are the photographic effects), Adjust and Borders, and each group has a dedicated tab in the tool panel. When you hover the mouse over a

The Quicklooks feature displays all styles and adjustment presets as a thumbnail gallery. You can use it to quickly locate the effect you want and apply it to the current photo.
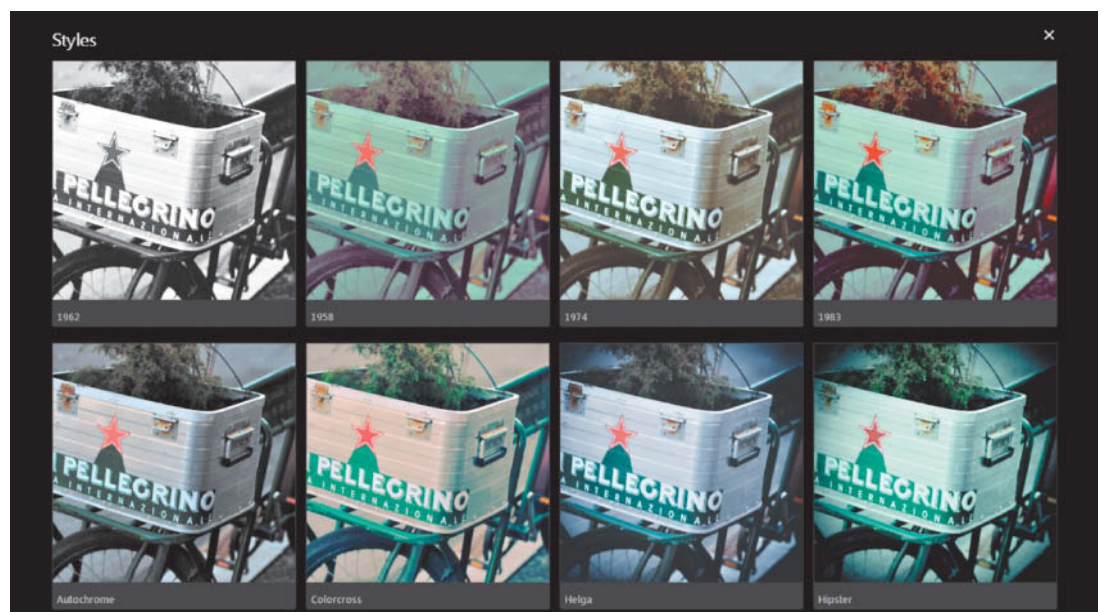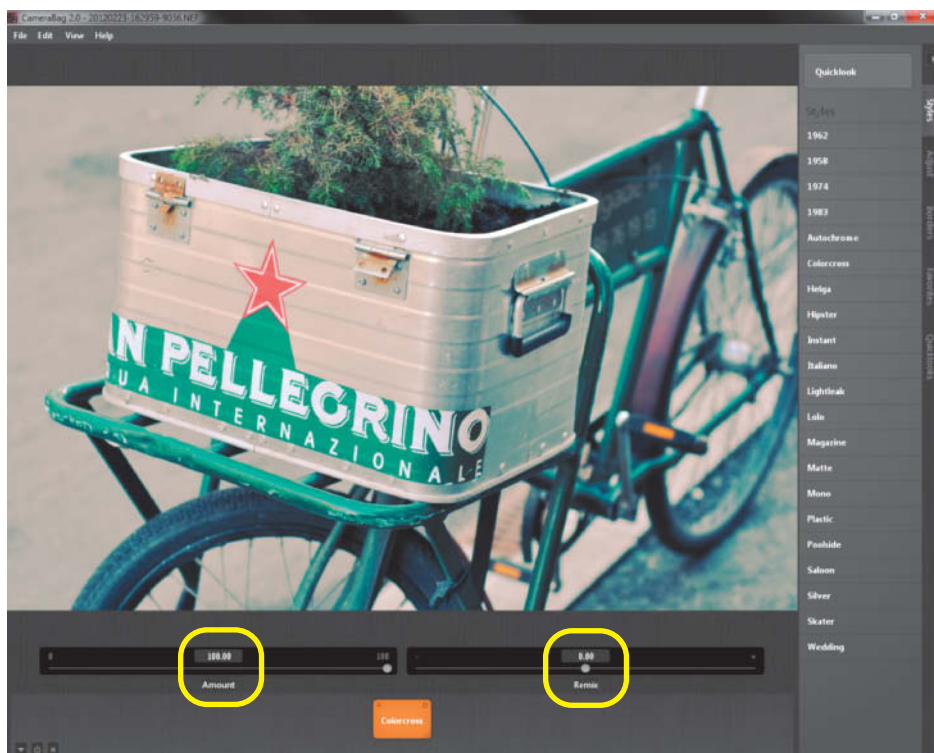
Each style has adjustable Amount and Remix parameters. Remix can generate a virtually unlimited number of variations on the current style by randomizing its settings.

CameraBag 2 **enables you to apply multiple styles to a single photo. Each style is represented by a tile in the tray, and you can rearrange the order of the tiles or temporarily disable specific styles.**

specific style, adjustment preset or border, the application displays a pop-up window with a preview of its effect. Additionally, the application also includes the unique Quicklooks feature, which allows you to preview all available styles, adjustment presets and borders in the form of a thumbnail gallery. Better still, you can apply any style or preset to the current photo simply by clicking on its thumbnail.

The Styles tab offers a lengthy list of ready-made effects, and the application allows you to control two parameters for each called *Amount* (which is equivalent to an opacity or fade effect) and *Remix*, which controls a style's internal settings. The latter is capable of generating a virtually unlimited number of variations on a particular style and what's more, you can apply multiple styles to a single photo, giving you the opportunity to create truly unique effects. To produce different effects, you can rearrange the order in which styles are applied by dragging 'style tiles' around the tray at the foot of the program window.

The Adjust tab contains five groups of adjustment tools called Basics, Light, Color, Photographic and Utility. The tools in the Basics group are for performing general tasks such as cropping and straightening as well as adjusting basic parameters such as exposure, contrast and saturation. The Multi Tool lets you adjust these parameters simultaneously. The Light group offers a curves editor for adjusting RGB values and luminance along with tools for tweaking brightness, shadows and highlights. The Color group provides an assortment of color correction tools, including Color Corrector for tweaking the color of a specified luminance region, Selective Saturation for adjusting the saturation of a specific hue and Color Balance for adjusting the red, green, and blue color mix. You will also find tools for split toning, tinting, and colorizing. The tools in the Photographic group enable you to apply vignette, grain and discoloration effects, while the Constrain Size tool in the Utility group can be used to specify the size of the output image.

Unlike styles, each adjustment tool has an individual set of controls. For example, the RGB Curve and Luminance Curve tools have curve editors and Amount sliders, while the Color Corrector features a color picker and the additional Color Method selection.

Each style and adjustment is represented by a tile in the tray at the foot of the main working area. This not only gives you a quick overview of the styles and adjustments you have applied to the current photo, but also allows you to disable and enable individual styles and adjustments. There is also a dedicated button in the tray that temporarily

disables all applied styles and adjustments, and a second button reverts a modified image to its original state.

You can save the current mix of styles and adjustments as a favorite by switching to the Favorites tab and pressing the Add Current button. You can then give your new favorite a name and press OK to save it. Using this feature, you can build a library of custom presets (or 'filters' as *CameraBag 2* calls them). Using the Save Filter and Load Filter commands in the File menu, you can save filters as .cbf files and import existing ones, allowing you to share your own filters with other users. The application's website features a page (http://nevercenter.com/camerabag/desktop/ ?section=dls) where you can download other people's filters and upload your own for others to use.

The program also includes batch processing functionality. To use this feature, open a photo, apply your desired styles and adjustments, navigate to File > Batch Process Folder and then follow the instructions provided.

CameraBag 2 (for desktop) is a great lightweight image editor and processor, but it does have a couple of shortcomings. First of all, it lacks any sharing capabilities, so if you want to publish processed photos on Flickr, Facebook or other sharing services, you have to do so outside the application interface. Additionally, it doesn't support printing, so you will first have to export your images before outputting them from a separate application.

CameraBag 2 for iOS

In addition to the desktop versions, *CameraBag 2* is also available for iOS, giving you access to most of its functionality on your favorite portable device too. Better still, the *CameraBag 2 HD* app for iPad costs just US$2 and the iPhone version is free of charge. In spite of being built on the same basic program architecture as its desktop counterpart, the portable version doesn't support RAW image processing and offers simplified functionality built around an interface that is optimized for touchscreen use. In other words, *CameraBag 2 HD* is better thought of as an addition to your photographic arsenal rather than a replacement for the desktop application.

When you launch *CameraBag HD* on your iPad, the differences between it and the desktop version become immediately apparent. For example, the main screen has an overlay toolbar at the bottom that gives you quick access to all the app's key features. The 'Camera' button can be used either to load an existing photo or take a new one with the built-in camera.
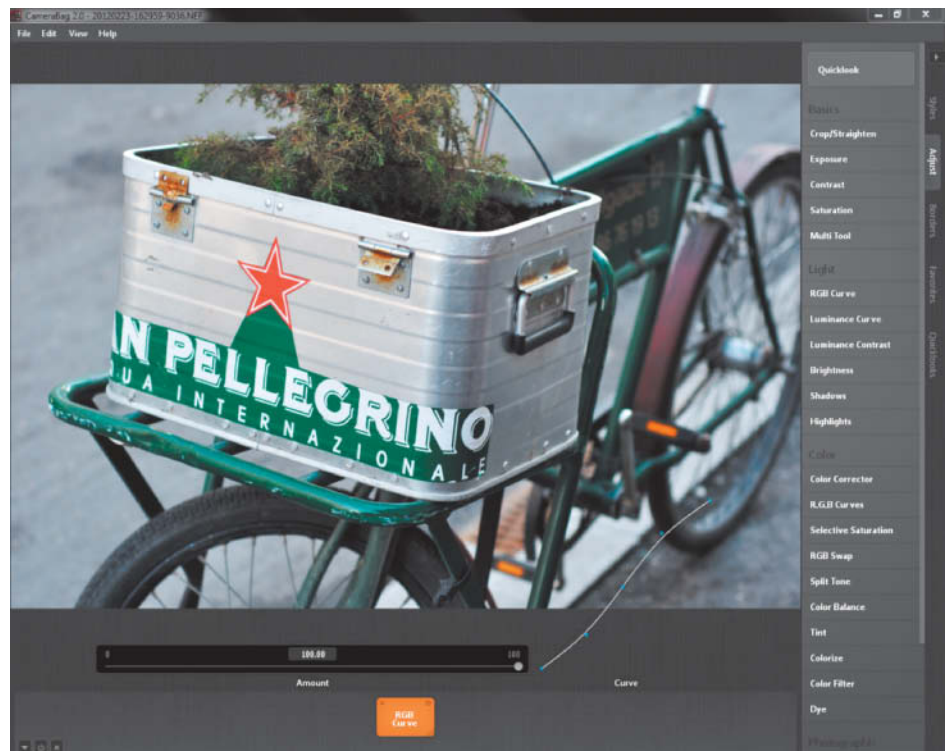
In addition to basic tools for tweaking brightness, saturation and contrast, *CameraBag 2* also includes more advanced adjustment features such as RGB and luminance curve editors

***CameraBag 2 HD* offers a comprehensive collection of ready-made filters. You can view and choose from the available filters in the sliding sidebar on the left, and you can preview filters by swiping the photo.**

CameraBag 2 HD includes functionality for sharing photos on Facebook, Twitter and Instagram
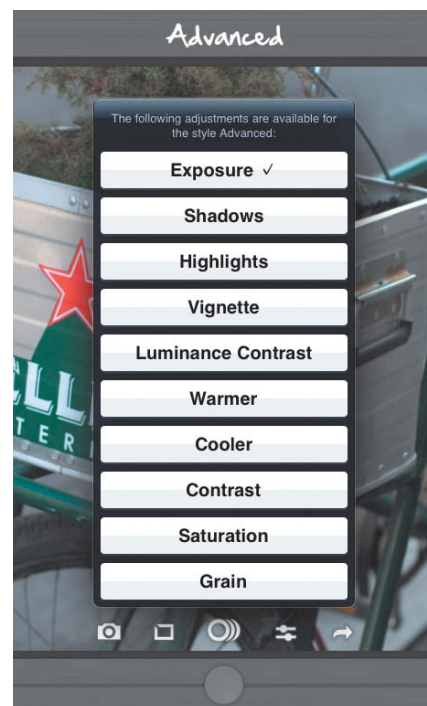
The app's Advanced filters can be used to adjust a whole range of image parameters

To access the photo filters, tap the 'Filters' button in the middle of the toolbar. This opens a sidebar on the left which contains a list of all available filters, and a simple tap on the filter of your choice applies it to the current photo. Like the desktop application, *CameraBag 2 HD* has a Remix feature that generates new variations of the currently applied filter. To use it, tap the tiny button in the lower right-hand corner of the photo. While you can apply any filter by selecting it in the sidebar, the app also allows you to flick between filters by swiping the photo. Swipe from right to left to jump to the next filter or swipe from left to right to return to the previous one.

By default, the app opens photos in the Basics view, where you can tweak key parameters such as Exposure, Vignette, Contrast and Saturation. To make an adjustment, tap the 'Adjustment' button (the second from the right), pick your desired parameter and use the slider at the bottom of the screen to make your setting. For further fine-tuning, the Advanced filter feature offers additional adjustable parameters, including Shadows, Highlights, Luminance Contrast, White Balance and Grain.

CameraBag 2 HD also offers a decent collection of borders. To use them, tap the 'Borders' button (the second from the left) and pick your desired border in the sliding sidebar. Just like the desktop version, the app lets you save adjustments and remixed styles as custom style presets. To do this, tap the 'Menu' button (the one on the right), tap the 'Save Current Style' button in the right sidebar, give the new style a name and press OK. The new style is then automatically added to the existing collection of filters. The right sidebar also features the 'Save' button for saving tweaked images, and the 'Share' button for uploading photos to Facebook, Twitter and Instagram. You can also use the 'Share' button to send photos via email, print them or perform other actions.

Conclusions

Some enthusiast photographers and professionals may dismiss *CameraBag 2* as a toy, although it is obviously not designed to compete directly with high-end software such as Adobe *Lightroom* and Apple *Aperture*. Nevertheless, it is a lot of fun to use and produces impressive results. Additionally, it can be quite liberating to take a break from using the usual tools of the trade and try something different. *CameraBag 2* offers a true cornucopia of styles that can be mixed in a variety of ways, and the ability to preview all styles and adjustments as a thumbnail gallery makes it significantly easier to find an effect you like. Other compelling features include the ability to save and share custom filters and batch process multiple images. Finally, iOS users will appreciate the free portable version that helps to keep your creative juices flowing when you are on the move.   (sea) **c't**

ALTERNATIVES TO CAMERABAG 2

Name	URL	Platforms	Description	Price[1]
Analog	http://www.realmacsoftware.com/analog/	Mac OS X	Has no photo editing tools, but supports round-tripping, allowing photos to be processed directly form the Aperture or iPhoto interface	US$9.99
Flare	http://flareapp.com/	Mac OS X	Offers basic photo editing tools and a handful of effects. Can be used as an external editor with iPhoto, Aperture and Lightroom.	US$19.99
FX Photo Studio	http://www.fxphotostudioapp.com/	Mac OS X, iOS	Provides basic editing tools and more than 170 effects. The desktop version can also handle RAW files.	US$9.99 (OS X), US$1.99 (iOS)
Pixlr	http://pixlr.com/	Web-based, iOS, Android	Web-based photo editor consisting of the Pixlr Editor for basic photo editing and Pixlr-o-matic for applying photo filters	Free

[1] in May 2013

Jobst-H. Kehrhahn

Smartphone Cameras

Can the camera modules built into the latest smartphones really compete with purpose-built compact cameras? We gave 11 popular smartphones the once-over, with some surprising results. This aricle gives you tips on how to take better photos with your phone, and our review on page 76 takes a look at the burgeoning smartphone art market.

It sounds like the digital camera market is in crisis. In February, news services reported that, worldwide, 14 percent fewer digital cameras (and 15 percent fewer compacts) were sold in November 2012 than in the previous month. Nikon promptly lowered its profit forecast and its share price slid by 19 percent – its worst drop in 28 years.

The main reason appears to be the constantly improving functionality built into smartphone cameras, which now offer fixed-lens compacts serious competition. GfK, a German market research company, predicts worldwide growth of 16 percent for smartphones with built-in cameras and reports a 20 percent drop in compact camera sales in Germany in 2012.

The consequences of this trend are obvious, and industry associations report that more than 20 percent of the images that end up getting printed in photo books are captured using smartphones. The proportion of users of social networking sites who uploaded smartphone photos increased in 2012 from 16 to 22 percent, and iPhones occupy first, second and fourth place in the top five community cameras at flickr.com (at the time of writing, third place was occupied by Canon's EOS 5D Mark II DSLR).

True to the motto "The best camera is the one you always have with you", the number of smartphones in use 'in the wild' is simply enormous. According to Handset Country Share Tracker (HCST) statistics, 27.4 million iPhone 5s were sold in the fourth quarter of 2012 alone, while Samsung's Galaxy S3 took third place on the list with 15.4 million units sold.

The Curse of the Tiny Lens

The smartphone market is a tough one to crack and even the tiniest details and features can make the difference between a massive hit and a flop. The greatest problem facing smartphone engineers is the trend toward ever thinner devices, which gives them no room for maneuver when designing lenses for built-in cameras. The tiny lenses that result can only capture a relatively small amount of light, which then has to be amplified electronically by the phone's firmware. Manufacturing tolerances are minimal too, making it difficult to build camera modules that produce consistent image quality.

The main limitations of smartphones compared to conventional compacts are:

Image artifacts: Amplifying signals from the sensor always increases noise, which then

has to be reduced electronically. The problem here is that too little noise reduction creates images with rough transitions and poor definition, while too much noise reduction runs the risk of 'smoothing' image detail to a point at which it is no longer recognizable. To see how effectively smartphones deal with this challenge, we included a household sieve in our test scene (see page 74). The problems the camera firmware had reproducing this detail are clearly visible in the enlargements we have included on the individual test pages.

In our test, the Nokia PureView 808 was the only one of our test phones to score a 'visual noise' value of less than 2, which equates to virtually no visible noise. This put it on a level with the much more expensive Canon PowerShot SX50 HS. High-end compacts such as the Fujifilm XF1 deliver even better results, hitting a truly excellent 1.3 at ISO 100 with the lens set to wide angle. As a comparison, the best value the iPhone 4S could produce was 3.3.

Another important test criterion is the signal-to-noise ratio (larger values indicate better results in our tables). The smartphones we tested delivered values between 20 and 40, which roughly equates to the levels produced by the current crop of compacts.

SMARTPHONE TEST RESULTS, PART 1

	Sensor-Resolution [Line pairs/Image height]	Relative center resolution (ISO 100, wide-angle) / Sensor resolution [%]	Center Resolution (ISO 100) [Lp/lh]	Center Resolution (ISO 200) [Lp/lh]	Center Resolution (ISO400) [Lp/lh]	Center Resolution (ISO 800) [Lp/lh]
Apple iPhone 4S[1]	1224	110	1349	–	–	–
Apple iPhone 5[2]	1224	103	1260	1027	–	–
HTC One X+	1224	80	976	980	973	692
Huawei Ascend D1 Quad XL	1224	120	1463	1320	1273	1069
Motorola RAZR i	1224	80	985	–	–	–
Nokia 808 PureView	1224	–[3]	–[3]	–[3]	1550	1455
Samsung Galaxy Note II	1224	75	917	910	760	754
Samsung Galaxy SIII	1224	72	887	887	752	742
Samsung Galaxy SIII mini	960	93	897	856	781	–
Sony Xperia T	1548	81	1255	984	923	570
Nokia Lumia 920	1224	80	977	994	986	959

[1] Auto ISO value = 64   [2] Auto ISO value = 84   [3] cannot be evaluated

SMARTPHONE TEST RESULTS, PART 2

	Real Tonal Range [8-bit values]	Color Checker SG ΔE ISO 100	Signal-to-Noise Ratio [S/Nx] 100 ISO	Signal-to-Noise Ratio [S/Nx] 200 ISO	Signal-to-Noise Ratio [S/Nx] 400 ISO	Signal-to-Noise Ratio [S/Nx] 800 ISO
Apple iPhone 4S[1]	242	9.9	19.37	–	–	–
Apple iPhone 5[2]	243	10.5	27.82	22.36	–	–
HTC One X+	233	7.8	33.43	34.06	33.86	33.58
Huawei Ascend D1 Quad XL	229	7.9	43	38	29	43
Motorola RAZR i	226	7.9	–	–	–	–
Nokia 808 PureView	237	9.7	35.07	24.88	20.92	14.78
Samsung Galaxy Note II	229	7.4	37.11	33.47	35.72	21.89
Samsung Galaxy SIII	218	8.9	35.33	33.55	34.43	21.4
Samsung Galaxy SIII mini	235	9.1	32.96	33.72	30.07	–
Sony Xperia T	224	9.1	24.69	19.51	17.26	12.3
Nokia Lumia 920	237	13.7	25.61	28.29	20.89	14.83

[1] Auto ISO value = 64   [2] Auto ISO value = 84

For example, the Nikon 1 V2, fitted with a 15mm f/1.8 lens (see page 22) produced a value of 38, sinking to 16 at ISO 6400. DSLRs, with their comparatively large sensors, offer much better quality across the board. The Canon EOS 6D fitted with the EF 50mm f/2.5 lens produced a value of 109 at ISO 100, and only began to produce values comparable with those of the smartphones we tested at ISO 6400.

Less dynamic range: If the dynamic range of a subject is too great for the camera's sensor to deal with, the captured data will no longer differentiate between all of the tonal values it contains, resulting in a loss of shadow and highlight detail. Dark gray and black transitions end up looking just black and bright details simply white out, so smartphone users have to keep these limitations in mind when capturing images.

The dynamic range of the cameras we tested lies somewhere between six and seven f-stops. As a comparison, the Canon PowerShot SX50 HS, the Fujifilm XF1 and the Olympus E-PL5 all cover about eight stops at ISO 100 at wide-angle settings.

Reduced ISO range: With the exception of the Nokia 808, none of the smartphones we tested can be set to ISO values greater than 800. As with conventional cameras , we found that sticking to ISO 100 produced the best results and the least noise.

Digital zoom: Zoom lenses require space, which is exactly what smartphones can't provide. None of the smartphones we tested has an optical zoom, and the digital equivalents on offer all produce poor results. Once again, the exception is the 41-megapixel Nokia PureView, which uses smart technology to enlarge details taken from full-frame images (see the individual test on page 68 for more details).

Depth of field: The smaller the sensor and aperture setting, the closer you have to get to a subject to defocus the background. In the real world, this means that most smartphone images are in sharp focus from the foreground right up to infinity. Influencing depth of field by manipulating the aperture the way you would using a high-end compact or a DSLR is impossible.

Edge performance: Image resolution and brightness always fall off toward the edges of the frame, whichever camera you use. The PowerShot SX50 HS, for example, showed virtually constant fall-off of 0.4 stops throughout the zoom range at higher ISO values, while the Fujifilm XF1 measured 0.7 stops. The results produced by our test smartphones were less consistent, although the iPhones and the Huawei Ascend D1 Quad XL produced value that were comparable with those produced by the compacts mentioned.

Still in Their Infancy

The potential future direction of smartphone photography is a much-discussed topic. Nokia's PureView technology, developed in tandem with lens specialist Zeiss, has been seen as a kind of starter's gun for the development of innovative approaches to smartphone photo technology. The 808's oversampling technology enables it to produce lossless 3× zoom photos and 4× zooms for 1080p Full HD video footage. 720p HD video can be zoomed up to 6× and VGA (64×360) video by up to 12×. Persistent rumors suggest that Nokia will introduce a Windows 8 phone with 'real' PureView technology sometime in 2013 – a move that would help Windows to get established in the smartphone market too.

Center Resolution (ISO 1600) [Lp/lh] better ▶	Overall Dynamic Range ISO 100 [f-stops] better ▶	Overall Dynamic Range ISO 200 [f-stops] better ▶	Overall Dynamic Range ISO 400 [f-stops] better ▶	Overall Dynamic Range ISO 800 [f-stops] better ▶	Overall Dynamic Range ISO 1600 [f-stops] better ▶
–	6.81	–	–	–	–
–	7.89	7.47	–	–	–
–	7.83	7.7	7.59	7.48	–
–	6.63	6.63	6.56	7	–
–	7.04	–	–	–	–
1382	7.84	7.45	6.88	6.19	5.31
–	7.44	6.9	6.97	6.77	–
–	6.9	6.84	6.79	6.61	–
–	7.54	7.71	7.44	–	–
–	7.42	7.33	6.87	6.42	–
–	6.34	6.47	6.02	5.25	–

Signal-to-Noise Ratio [S/Nx] 1600 ISO better ▶	Visual Noise OECF20 ISO 100 ◄ better	Visual Noise OECF20 ISO 200 ◄ better	Visual Noise OECF20 ISO 400 ◄ better	Visual Noise OECF20 ISO 800 ◄ better	Visual Noise OECF20 ISO 1600 ◄ better
–	3.3	–	–	–	–
–	2.7	3	–	–	–
–	2.6	2.9	2.4	2.5	–
–	2.5	2.5	2.5	2.5	–
–	3.4	–	–	–	–
9.93	1.7	2.2	2.6	3.4	5.7
–	1.8	2.1	2.1	3.4	–
–	1.9	2.1	2.2	3.7	–
–	2.2	2.3	2.7	–	–
–	3.4	4.1	4.9	6.6	–
–	2.8	2.8	3.3	4.2	–

Apple iPhone 4S

Great light, great photos. Apple's previous-generation smartphone captures appealing images if conditions allow.

Photos shot with the iPhone 4S in good light have plenty of detail and generally look attractive. In good conditions, we measured an excellent 1,300 line pairs of resolution – one of the better results in our test. Fine details don't appear oversharpened the way they

sometimes do in iPhone 5 photos or in those captured by some of the other phones we tested. The lens is so good that the software doesn't have to too much compensating to do. This is obvious in the detail of the test chart shown on the right. There are no visible sharpening lines, and the white and black of the central focus point (top left in the image) are evenly colored. The low light test shots showed more flaws (see the image on the left). The woodgrain is hardly visible, probably due to the camera's internal smoothing algorithm which is designed to reduce the obvious noise that the 4S otherwise produces. The result is that single-colored details often end up looking like a multi-colored rag rug – an effect that is very difficult to edit out later. Visual noise is only average, with a value of 3.3 at ISO 100.

⬆ Great resolution, natural-looking colors, neutral grays

⬇ Color noise, poor performance in low light

The sieve and the woodgrain are very blurred and show hardly any detail in this enlargement

The images show virtually no sharpening artifacts and good line definition. Darker areas show obvious color noise.

Apple iPhone 5

Apple has improved the quality of the camera in the iPhone 5, giving it much better low light performance than its predecessor.

On paper, the camera built into the iPhone 5 is no better than the previous model, with the same resolution and the same app doing the work. However, a closer look at our test shots reveals that low light detail is much better. In

spite of lower resolution, the sieve and the woodgrain (see left) look more realistic and show much more detail. The downside of the newer camera is its noise, which is even more obvious in low light. We also discovered a magenta flare-like artifact in some of our daylight test shots that we simply couldn't combat. Reports in the media tell us that Apple recommends holding the phone differently to avoid this issue.

⬆ Great resolution and good detail, even in low light

⬇ Still plagued by color noise, inexplicable flare effect

The low light enlargement shows more realistic-looking detail in the sieve than that produced by the 4S

The iPhone 5 sharpens more than the 4S, producing more obvious edging as a result. Detail definition in low light is much improved.

HTC One X+

Lots of options and heavy-duty sharpening are the main features of the HTC One X+.

This phone offers a broad range of camera options, with flash, scene modes and camera settings buttons arranged along one edge of the large screen and a zoom bar, effects, the shutter release button and a shortcut to the phone's photo gallery on the other. Our test shots produced an average of slightly more than 980 line pairs of resolution. The poorer the light, the more the camera smooths and sharpens, often producing over-the-top results that lack texture. There are obvious dark edge lines in low light. On the positive side, visual noise values are consistently good and the signal-to-noise ratio is satisfactory in good light with little noise in detail-free areas. The price you pay for all this 'smoothing' is a general lack of detail. Our auto-ISO low light test shot almost completely eradicated the detail in the sieve.

⬆ Lots of user-controlled camera options, bright lens

⬇ Low overall resolution, excessive automatic image optimization

Parts of the sieve texture were simply 'smoothed out'

The center point marker and the lines in the resolution chart show obvious edging. The 1.4 test field at bottom right still shows plenty of definition.

Huawei Ascend D1 Quad XL

In good light, the Quad XL produces high-quality images and excellent test results.

The Huawei has a comprehensive, hideable camera menu with settings for scene modes, shooting modes, white balance, ISO settings, image optimization and much more besides. However, in spite of great handling, the real highlight of this device are the images themselves. In good light, we measured more than 1,400 line pairs of resolution, which is better than anything the Apple phones produce and second only to the Nokia 808 PureView, which produces consistently higher values, even at higher ISO settings. The Huawei also produced the best chromatic aberration test result, and a look at the images themselves underscores the camera's technical values. Even our test grass landscape – a difficult subject for smartphones to reproduce – turned out with a fair amount of realistic-looking detail. The downside of this particular model is that image quality decreases rapidly in dwindling light.

⬆ Lots of options, great test results in good light

⬇ Rapid quality fall-off in low light

The Quad XL smooths too much detail in low light. Parts of the sieve and the woodgrain show no detail at all.

Although the center point marker has an obvious edge due to sharpening, the other detail enlargements show relatively good definition

Motorola RAZR i

The RAZR i is fully featured but nevertheless delivers relatively poor noise results.

Motorola has given the camera in the RAZR i plenty of features, including a dedicated shutter release button that can be used to activate the camera quickly in snapshot situations. The menu itself can be shown and hidden using a swipe gesture. There is no option for altering the ISO setting, but plenty of effects and other settings options. There is also a burst shooting mode that shoots 10 shots in quick succession, from which you can then choose your favorite.

In spite of al these features, the results are not particularly spectacular. A visual noise value of 3.4 and a signal-to-noise ratio of nearly 25 are relatively poor. The lab values are confirmed by the visual results, and our test shots show washed-out colors and poor detail in low light, with little improvement under better conditions. We measured resolution of almost 1,000 line pairs, which equates to about 80 percent of the theoretical maximum.

⬆ Fast camera launch using dedicated (physical) button

⬇ Image quality

Our test scene looks dull and shows obvious color noise

The focus marker has obvious edging due to sharpening. The resolution chart detail has better definition but looks pale and lifeless.

Nokia 808 PureView

Nokia's 41-megapixel miracle delivers high-quality photos and offers plenty of camera options.

The combination of a huge 1/1.2" sensor and oversampling technology (i.e., merging data from several pixels into one) results in images that are comparable with those produced by many purpose-built compact cameras. The visual and technical results of our test are conclusive, with a visual noise value of 1.8 eclipsing all the others in the test. The grayscale chart detail and the enlargement of the sieve shot in 8-megapixel 'PureView' mode show great detail definition. Even at ISO 400, we measured 1,500 line pairs of resolution. Nokia's oversampling technology also offers an extended ISO range (from 50 to 1600) and a usable digital zoom that combines data from multiple pixels to interpolate new 'zoomed' pixels. This technique works perfectly right up to the 1:1 limit of 3072×1728 pixels.

⬆ Innovative technology, great visual results

⬇ Bulky camera module makes the phone less sleek than the competition.

Our enlargement shows plenty of realistic-looking detail in the sieve and the woodgrain of the artist's palette

The Nokia shows sharp line definition and lots of detail. The only drawbacks are the slight red cast in the shadows and a little visible color noise.

Samsung Galaxy Note II

The huge 5.6" screen makes shooting photos with Samsung's Galaxy Note II a lot of fun.

'Big!' is the impression most people have when they handle Samsung's Galaxy Note II for the first time. The huge size of the screen makes the experience of taking photos more like looking through a window than peering at a smartphone display – a fun feeling. The Note's test results put a smile on our faces too,
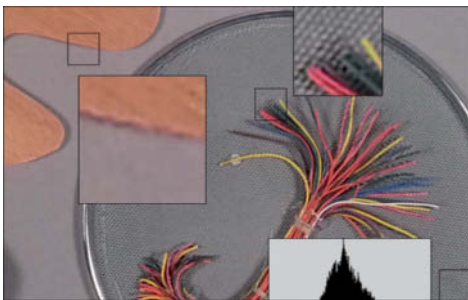
The Galaxy Note II tends to over-smooth its photos, as evidenced here in the lack of detail in the woodgrain

showing hardly any distortion, little chromatic aberration and noise values that are on par with the Nokia's. Nevertheless, the real-world visual results reveal some heavy-handed sharpening that gives the focus point and the lines in our test scene clear white edges. Here too, the woodgrain pattern has virtually disappeared. Resolution comes in at 900 line pairs, sinking to 750 at ISO 800.

🔼 Huge screen, wide range of camera options (see Galaxy SIII)

🔴 Images often oversharpened, especially in poor light, no dedicated (physical) shutter release button
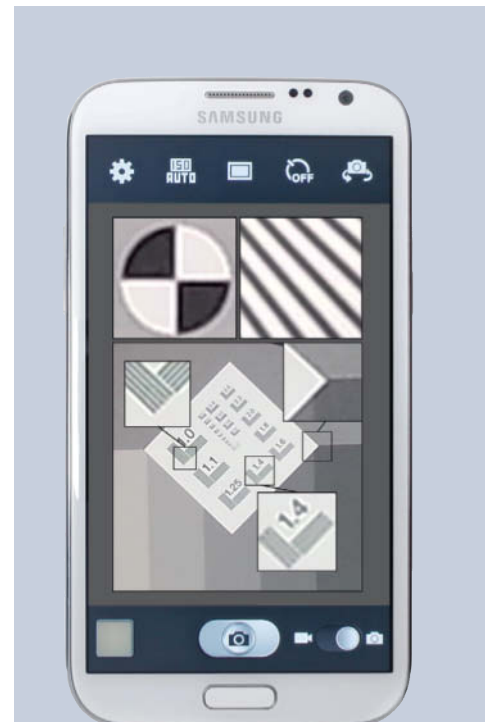
The focus marker and resolution test chart show obvious edging. Otherwise, the Galaxy Note II produces relatively little noise.

Samsung Galaxy SIII

The Galaxy SIII offers the user a very wide range of settings.

All Galaxy smartphones have a similar range of camera options, including user-configurable shortcuts, lots of shooting modes and plenty of scene modes, including 'Dawn', 'Autumn Color', 'Candlelight' and 'Party'. There are built-in HDR and panorama shooting modes and – unusually for smartphones – multiple metering modes, including 'Matrix',
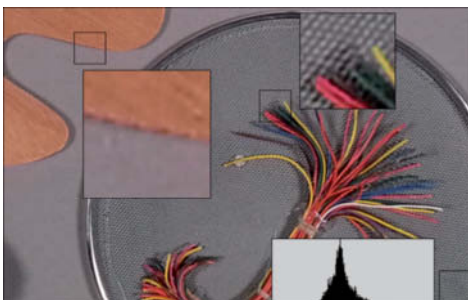
Like the Note II, the Galaxy SIII overcooks automatic optimization, producing washed-out details

'Center-weighted' and 'Spot'. Burst mode can capture sequences of up to 20 shots. Image quality and test results are very similar to those of the Galaxy Note II. Noise characteristics are just like those of its sister model up to ISO 400 and resolution measured a moderate 900 line pairs. The test images show the same edging artifacts too.

🔼 Plenty of options, great test results

🔴 Images tend to look oversharpened, no dedicated (physical) shutter button

Like its sister model, the Note II, the Galaxy SIII produces visible sharpening artifacts in the focus marker and the resolution test chart.

Samsung Galaxy SIII mini

Galaxy: take 3!
Cnsidering the size of the 'baby' Galaxy is, image quality is surprisingly good.

Small, light and cheap are the watchwords of the marketing concept behind the SIII Mini. This low-budget phone is not designed to hold its own against its high-spec siblings, so it came as something of a surprise that its 5-megapixel camera produced better-than-average results in our lab test.
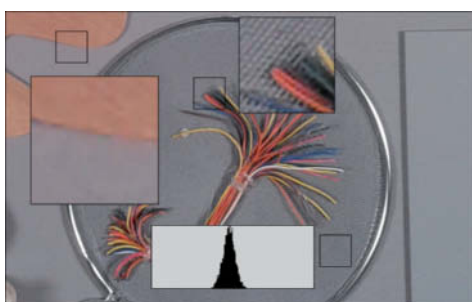
While the sieve still shows some texture, the woodgrain pattern in the artist's palette has all but disappeared

Visual noise values ranged from around 2 to just below 3 at ISO 400, and its signal-to-noise values are also firmly in the middle of our test field. A look at the ISO 100 test chart shows acceptably consistent grayscale values and very few color errors. At almost 900 line pairs, resolution measured over 90 percent of its theoretical maximum and sinks only a little to 800 at ISO 400. Last, but not least, the Mini's dynamic range of more than seven stops looks good compared to the eight stops captured by the Canon SX50 HS. Image quality in good light is OK, but slow focusing spoils the camera's otherwise decent snapshot qualities. Five megapixels (2560×1920) are quite sufficient for producing 8×6-inch (20×15-cm) prints at 300 dpi.

⬆ Surprisingly good image quality

⬇ Slow autofocus

Surprise - the enlargements taken from the Mini's test shots look better than those of its much larger siblings! Resolution is, of course, not as good.

Sony Xperia T

Sony's Xperia T offers a bewildering array of options, but sub-par noise characteristics.

The Xperia T is a good-looking Android device with various photo-friendly features, including quick start and a dedicated shutter release button that can be ready to shoot in less than a second. Four soft buttons at the edge of the screen give you access to the various shooting and scene modes, flash options and an
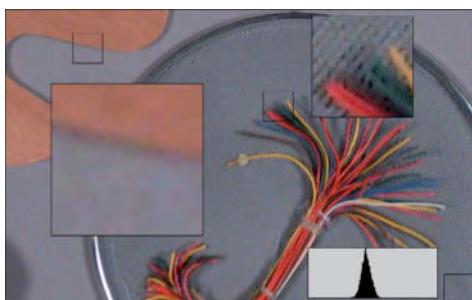
The enlarged view of the artist's palette and sieve reveals very poor detail definition

additional menu of standard (and non-standard) capture settings.

There are four focus modes, three metering modes (center, average and spot) and a built-in image stabilizer. Unfortunately, the Xperia's better-than-average features and handling are not matched by its image quality. Although we measured more than 1,200 line pairs of resolution (approx. 80 percent performance), noise characteristics are already poor at ISO 100 and get worse at higher values.

⬆ Lots of photo-friendly options and quick camera access

⬇ Average visual results

The focus marker has an obvious edge and the diagonal lines are very poorly defined

Nokia Lumia 920

The Lumia 920 is marketed under the same 'PureView' label as the 808, although the two devices only have an image stabilizer in common.

The 'PureView' moniker that Nokia has given the Lumia 920 stems from the revolutionary
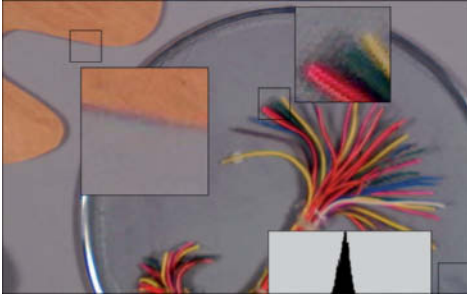
The Lumia 920's image stabilizer is designed to extend its range of usable exposure times

technology built into the 41-megapixel 808. However, the only photo feature the two devices have in common is an image stabilizer, making the 920 an immediate disappointment. White balance is problematic and all our test shots show symptoms of oversharpening. The Lumia 920 offers comparatively few settings options, sticking to standard fare such as shooting and white balance mode, ISO settings, exposure compensation and various aspect ratios. There are also separate controls for the focus-assist lamp and flash settings.

⬆ Camera quick start via the shutter release button

⬇ Average image quality, oversharpened images (sometimes with color casts)

The Lumia 920 doesn't live up to the expectations suggested by the 'PureView' label

In a recent interview with our sister website techstage.de, Google's Senior Vice President of Engineering promised "insanely great cameras" for upcoming Nexus devices. HTC isn't far behind, having recently introduced the One phone with its 'Ultrapixel' camera sensor that utilizes fewer (larger) pixels in a large (1/3") sensor to increase image quality. Although images captured by the One measure 'only' 2688×1520 pixels (i.e., four megapixels), they can be printed at 300dpi quality in 16:9 sizes of up to 5.1×9 inches (23×13 cm).

The advantage of this approach is that each individual pixel can capture more light, producing better-quality images with less noise. HTC claims that the Ultrapixel sensor can capture up to 300 percent more light than comparable 13-megapixel smartphone cameras.

Conclusions

Our tests show that technically adequate photos can be captured using smartphone technology, but only if the shooting conditions fulfil a number of important criteria. Smartphones are not yet good enough to completely replace compacts in the enthusiast sector, but are more than adequate for most everyday snapshot situations. At the moment, smartphone cameras still lack too many of the features that we take for granted in high-quality compact cameras.

On the other hand, if we take a step back and look at the speed with which smartphone photography is making inroads into conventional photographic fields (see our *Smartphone Art* article on page 76), we see that while many photographers still believe smartphones have a lot of catching up to do, others have already embraced the medium and have relegated their compact digital cameras to the status of has-beens. The target markets for both types of device are being redefined, but you can be sure that the number of 'smartphone photographers' out there will continue to increase. If you stick to the following basic guidelines, you too will be able to capture great smartphone images.

COMPARING SMARTPHONE PHOTO OPTIONS[1]

Manufacturer/Model	Apple iPhone 4s	Apple iPhone 5	Huawei Ascend D1 Quad XL	HTC One X+	Motorola Razr i
URL	www.apple.com/iphone/	www.apple.com/iphone/	www.huawei.com	www.htc.com	www.motorola.com
Resolution	8 megapixels (3264×2448)	8 megapixels (3264×2448)	8 megapixels (3264×2448), 6 megapixels (3264×1840), 5 megapixels (2592×1952), 3.8 megapixels (2592×1456), 0.3 megapixels (640×480)	3264×2448, 2592×1952, 2048×1536, 3264×1840, 2592×1456, 2048×1152	8 megapixels (3264×2448), 6 megapixels (3264×1840)
Exposure compensastion	–	–	Exposure (±2), Saturation (±2), Contrast (±2), Brightness (±2)	Exposure (±2), Saturation (±2), Contrast (±2), Sharpness (±2)	Exposure (±2)
Shooting modes	Single	Single	Single, Group, HDR, Burst, Smile recognition, Optimize, Panorama, Low light	Single, Group portrait, HDR, Self-timer, Burst, Smile release, Panorama	Single, Burst, Self-timer, HDR
Dedicated shutter button	–	–	–	–	✓
Display grid	✓	✓	✓	✓	–
Flash/Video light	On, Off, Auto	On, Off, Auto	On, Off, Auto	On, Off, Auto	On, Off, Auto
Effects	–	–	Vintage, Lomo cold, Lomo warm, Negative, Mono, Emboss, Gray sketch, Sepia, Distort, Big face, Big nose, Gobbler, Insect, Professor, Big grin	Distort, Vignette, Depth-of-field, Spotse, Mono, Country,Classic, Classic warm, Classic cool, Grayscale, Sepia, Negative, Solarize, Posterize, Aqua	Normal, Black & White, Negative, Sepia
Focus mode(s)	–	–	Autofocus: on/off	–	–
Front camera	✓	✓	✓	✓	✓
Geotagging/GPS tags	✓	✓	✓	✓	✓
Face recognition	✓	✓	✓	✓	–
HDR	✓	✓	✓	✓	✓
ISO settings	–	–	Auto, 100, 200, 400, 800	Auto, 100, 200, 400, 800	–
Compression settings	–	–	Superfine, Fine, Normal	–	–
Burst mode	–	–	✓	On, Off, 20 shot limit: On, Off, Auto display: On, Off	✓
Metering modes	–	–	–	–	–
Panorama mode	✓	✓	✓	✓	–
Configurable shortcuts	–	–	–	–	–
Selftiumer(s)	–	–	2, 5, 10	2, 5, 10	3, 5, 10
Choice of save location	–	–	✓	–	✓
Scene modes	–	–	Auto, Action, Portrait, Landscape, Night, Night portrait, Theater, Beach, Snow, Firework, Candlelight	Normal, Landscape, Portrait, Artifical light, Night, Text, Macro	Auto, Portrait, Landscape, Night portrait
White balance	–	–	Auto, Incandescent, Daylight, Fluorescent, Cloudy	Auto, Incandescent, Fluorescent, Daylight, Cloudy	–
Other	–	–	Red eye reduction, Review: On/Off, 3s, 5s, Return to defaults, HDR: Can be toggled to save normally exposed photo	Automatic smile shutter, Shutter sound on/off, Auto upload, Group portrait, Review: 3s, 5s,10s, unlimited, Touch shutter on/off	Quick camera on: on/off, Camera shake warning, Volume buttons configurable to zoom or shutter release, Low light auto HDR, On-Screen zoom

[1] Photo options only (excluding any additional app or tool functionality), no video options, options lists not necessarily exhaustive, multiple feature mentions possible, descriptions and/or function names can differ from manufacturers' own data

5 Tips For Taking Better Photos With Your Smartphone

Great light, great photos: The basic maxim of all great photography is particularly relevant in the realm of smartphone image capture. The usually tiny image sensors can only capture enough light to produce technically usable images if the scene itself is bright enough.

Low subject contrast: our tests show that no smartphone camera can effectively capture more than six or seven stops of contrast. If you attempt to capture more, be prepared either to accept a loss of detail or to use it deliberately as an element of your composition – an approach that can have distinct aesthetic advantages, especially in black-and-white images. Remember that most high-quality slide films were designed to capture a maximum dynamic range of about six stops – a range that was obviously sufficient for most subjects in the good old analog days.

Use low ISO values: If your smartphone has adjustable ISO values, always stick to the low end of the scale. We found that it is possible to produce adequate images in relatively low light, but the less work the camera firmware has to do to compensate, the less the resulting images will be prone to noise. The problem here is that most smartphones select the exposure time automatically, and deliberately extending exposure times by reducing the ISO value increases the risk of camera shake and blurred images. The best solution in low light situations is to support your phone using one of the many tripod-based smartphone clamps on the market.

Avoid zooming: Most smartphones only have digital zoom functionality, which extrapolates an enlarged detail from a standard-sized image without actually capturing additional image data. In contrast to 'real' optical zooms, this approach always produces inferior image quality: the greater the zoom factor, the more blurred the result will be.

Keep your lens clean: Most photographers clean their conventional lenses regularly, but often neglect to do the same for their smartphones. Even the slightest fingerprint on the glass covering your device's lens can have disastrous consequences for the quality of the images it captures. (keh)

| Nokia Lumia 920	Nokia 808 PureView	Samsung Galaxy Note II	Samsung Galaxy SIII	Samsung Galaxy SIII mini	Sony Xperia T
www.nokia.com	www.nokia.com	www.samsung.com	www.samsung.com	www.samsung.com	www.sony.com
8.7 megapixels (3552 × 2448)	Full resolution = 38 megapixels (7152 × 5368), 33 megapixels (7728 × 4354), PureView modes: 8 megapixels (3264 × 2448), 5 megapixels (3072 × 1728), 2 megapixels (2048 × 1152)	8 megapixels (3264 × 2448), 6 megapixels (3264 × 1836), 3.2 megapixels (2048 × 1536), 2.4 megapixels (2048 × 1152), 0.9 megapixels (1280 × 720), 0.4 megapixels (640 × 480)	8megapixels (3264 × 2448), 6 megapixels (3264 × 1836), 3.2 megapixels (2048 × 1536), 2.4 megapixels (2048 × 1152), 0.9 megapixels (1280 × 720), 0.4 megapixels (640 × 480)	5megapixels (2560 × 1920), 4 megapixels (2560 × 1536), 3.2 megapixels (2048 × 1536), 2.4 megapixels (2048 × 1232), 0.3 megapixels (640 × 480)	13 megapixels 4:3 (4128 × 3096), 10 megapixels 16:9 (4128 × 2322), 2 megapixels 4:3 (1632 × 1224), 2 megapixels 16:9 (1920 × 1080)
Exposure (±2)	Exposure (±4), Saturation (±5), Contrast (±5), Sharpness (±5),	Exposure (±2)	Exposure (±2)	Exposure (±2)	Exposure (±2)
Single For others, see scene modes)	Normal, Exposure bracketing, Interval, Self-timer	Single,Best shot, Best face, Face detection, Panorama, Share shot, HDR, Buddy photo share, Beauty, Smile, Low Light	Single, Burst, HDR, Face detection, Smile, Beauty, Panorama, Cartoon	Single, Best shot (on/off), Panorama, Smile, Cartoon	Normal, Auto scene detection, Front camera, Sweep panorama
✓	✓	–	–	–	✓
–	✓	✓	✓	✓	–
On, Off, Auto	On, Off, Auto, Anti-red-eye	On, Off, Auto	On, Off, Auto	On, Off, Auto	On, Off, Auto, Fill flash, Anti-red-eye
–	Normal, Vibrant, Sepia, Black and White	Negative, Black and White, Sepia, Washed-out,Cartoonify, Cold vintage, Warm vintage, Posterize, Solarize, Blue point, Green point, Red-yellow point	Negative, Black and White, Sepia, Washed-out,Cartoonify, Cold vintage, Warm vintage, Posterize, Solarize, Blue point, Green point, Red-yellow point	Black and White, Sepia, Negative	–
–	–	Autofocus, Macro	Autofocus, Macro	Autofocus, Macro	Single autofocus, Multi-autofocus, Face recognition, Sensor focus
✓	–	✓	✓	✓	✓
–	–	✓	✓	✓	✓
–	✓	✓	✓	✓	✓
–	–	✓	✓	✓	✓
Auto, 100, 200, 400, 800	Auto, 50, 100, 200, 400, 800, 1600	Auto, 100, 200, 400, 800	Auto, 100, 200, 400, 800	Auto, 100, 200, 400	Auto, 100, 200, 400, 800
–	Normal, Superfine	Superfine, Fine, Normal	Superfine, Fine, Normal	Superfine, Fine, Normal	✓
–	Exposure bracketing: 3, 5 images with ±0.3 EV, ±0.7 EV, ±1 EV, ±2 EV Interval mode: 2-1,500 5s to 30 min. interval per image	✓	✓	✓	✓
–	Infinity, Hyperfocal, Macro, Auto	Center-weighted, Spot, Matrix	Center-weighted, Spot, Matrix	Center-weighted, Spot, Matrix	Center, Average, Spot
	–	✓	✓	✓	✓
–	✓	✓	✓	✓	–
–	2, 10, 30	2, 5, 10	2, 5, 10	2, 5, 10	2, 10
–	–	✓	✓	✓	–
Auto, Close-up, Night, Night portrait, Sport, Backlight	Landscape, Auto, Close-up, Portrait, Sport, Night, Night portrait, Floodlight, Snow	Portrait, Landscape, Sport, Party/Indoor, Beach/Snow, Sunset, Dawn, Autumn color, Text, Candle-light, Firework, Backlight, Night	Portrait, Landscape, Sport, Party/Indoor, Beach/Snow, Sunset, Dawn, Autumn color, Text, Candlelight, Firework, Backlight, Night	Portrait, Landscape, Sport, Party/Indoor, Beach/Snow, Sunset, Dawn, Autumn color, Text, Candlelight, Firework, Backlight, Night	Portrait, Landscape, Night, Night portrait, Beach/Snow Sport, Party, Document
Auto, Cloudy, Daylight, Fluores-cent, Incandescent	Daylight, Auto, Cloudy, Warm, Fluorescent	Auto, Daylight, Cloudy, Incandescent, Fluorescent	Auto, Daylight, Cloudy, Incandescent, Fluorescent	Auto, Daylight, Cloudy, Incandescent, Fluorescent	Auto, Incandescent, Fluorescent, Daylight, Cloudy
Aspect ratio: 16:9, 4:3, Focus-assis lamp: on/off, Photo app search and suggest built into camer menu, Touch focus and Touch shutter release	Sound: on/off, Focus-assist lampt: on/off, Camera operation with phone locked Gray filter: on/off/Auto, Histogram view (during exposure compensation setting), Three custom settings presets	Buddy photo share, Share shot, Outdoor visibility, Auto contrast, Contextual filename, Voice-activated capture, Save flipped, Self-portrait (with front camera), Image stabilizer on/off	Outdoor visibility, Image stabilizer on/off Auto contrast, Save flipped, Self-portrait (with front camera), Buddy photo share, Share shot	Self-portrait (with front camera), Buddy photo share,	Quick start: Start only /Start and shoot, Smile shutter release for big, medium or small smile Image stabilizer: on/off, Shutter modes: On-screen butto, Touch shutter, Shutter button only Shutter sound: on/off Configurable quick start

✓ included   – not included

Our Test Setup

We took 11 popular smartphones to the *c't* lab and gave them a thorough test. Our test subjects were:

– iPhone 4S and 5
– The Galaxy Note II, SIII and SIII Mini models from Apple's arch-rival Samsung
– The unique 41-megapixel Nokia 808 PureView and the much-hyped, Window 8-based Lumia 920
– The HTC One X+
– The Motorola RAZR i
– The Huawei Ascend D1 quad XL
– The Sony Xperia T

We shot three separate sequences of test shots with each phone. The first was a 'well lit' TE42 test chart (see below) illuminated by a 1400-lux light source. We captured at least three images for each available ISO value, which we then analyzed using our custom evaluation software. The results are presented in tabular form on pages 64 and 65 and the images themselves are included on this issue's free DVD.

We used the test scene shown above to evaluate the visual qualities of the test devices at two lighting levels. The first used the same light source as the test chart sequence and a second 'low light' sequence was captured using a 250-lux light source, which is equivalent to 'normal' office lighting.
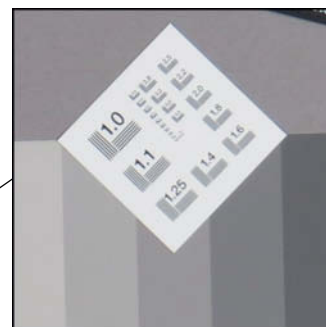
These comparison shots, captured using the Canon PowerShot SX50 HS show that a purpose-built compact is still superior to most smartphone cameras
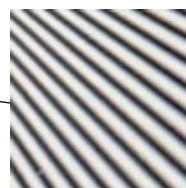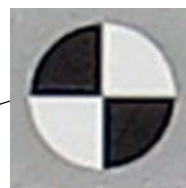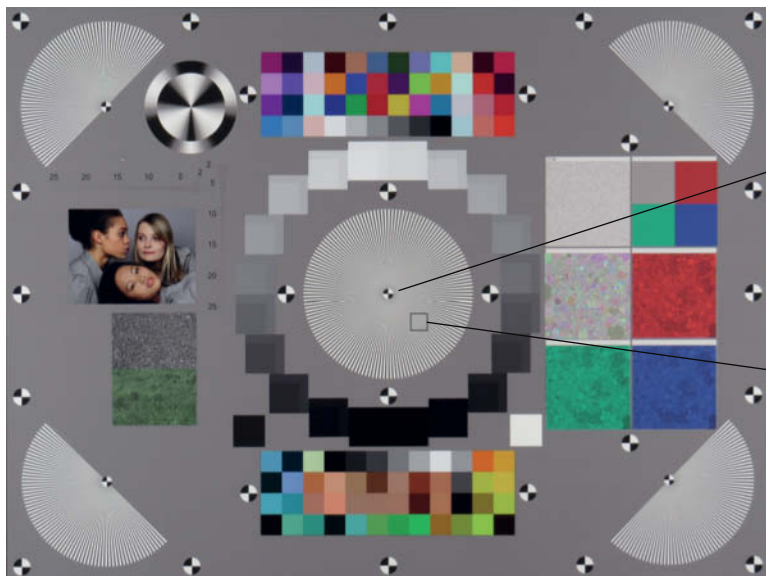
The enlarged test shot (TE42 test chart) captured using the Canon SX50 HS displays slight sharpening artifacts

Thomas Hoffmann, Sophia Sieber

It's not a restriction, it's a challenge!

Smartphone Art

What makes a photo great is imagination, not the inner workings of a complex, high-performance camera. Smartphones free their users from the technical dictates of conventional photography. A touch of a fingertip and your image is ready in a matter of seconds in any 'look' you want. But that doesn't mean smartphone photos are inferior to others – in fact, some pros have already ditched their SLRs in favor of these pocket marvels and are selling the results on the commercial art market.

Smartphone photos have long since left that murky, amateurish look behind. The cameras in these mobile, multi-talented devices are getting better and better, as our test on page 62 shows. While their miniature lenses are not yet in a position to compete with those built into compact cameras, where smartphones come out on top is that they're always handy and they don't attract attention.

A Grunt's Life, Damon Winter's 2011 sequence of photos of US soldiers in Afghanistan, made the most of these advantages to get closer to the troops, capturing intimate photos of daily life in wartime. Shot entirely with an iPhone, the series won the prestigious *Pictures of the Year International* award.

Smartphone art has obviously achieved professional status and even changes hands for significant amounts of money. Helen Breznik's photo *Carmella* was one of several to sell for more than US$1,000 last year. The image also won a runner-up prize at the MPA (Mobile Photography Award) *Photographer of the Year* competition, which has recently become an important international yardstick for artists who want to find out how their work measures up. The top prize is worth US$3,000 and the best MPA photographs are included in a touring exhibition. The benefits are not to be sneezed at, as Breznik's story shows.

Some artists, like Dutch photographer Carlein Van Der Beek, have already put

For Marc Basso, the camera that's always to hand is a Samsung Galaxy S2, so that's what he used to snap this Super Constellation when the aircraft was undergoing engine repairs at Lahr Airport in the Black Forest

their SLRs in mothballs. Van Der Beek told Carsten Peter in the National Geographic's German-language book *iPhone-Fotografie* that she hasn't touched her Nikon since she got an iPhone and that she finds the low resolution of the iPhone an exciting challenge rather than a limitation.

Van Der Beek regularly rummages around in the App Store and tests apps, always wanting to use them "in ways they weren't meant to be used", as she says in Peter's book. Her images are graphic, pictorial and abstract – ranging from high-contrast, grainy black-and-white architectural photos to traditional nature studies. Her efforts have already earned her a Mobile Art Grant from iPhoneArt.com.

Even though smartphone art is becoming professionalized and some big names are starting to be seen regularly, it is still a mass

Dutch artist Carlein Van Der Beek now works exclusively with her iPhone. With a background in abstract painting, she also has experience in analog photography. This image, called 'Walking on Sunshine' is one of a series created using various apps, including *Superimpose*, *PhotoToaster* and *Photo fx*.

Image: National Geografic/Carlein

Hagen Zeller photographed *My Basement at Home* in Hamburg's Schanzenviertel district and converted it to black and white using *Adobe Lightroom*

Norbert Luhe came across the subject for his image *Reifer Strom* ('*Ripe Electricity*') on a weekend walk. His main camera was at home, so he took the photo using his iPhone and converted it to black and white using *Lightroom*

Bewegung ('*Movement*') by sluxxxx

movement, as the explosion of apps like Hipstamatic and Instagram shows. The latter, which reproduces a range of analog styles, has become a social network that attracts 90 million users every month. On any given day, 40 million images are shared via the app. No wonder exhibitions are increasingly looking to 'Instagrammers' for content.

The photo community Flickr, where iPhones occupy first and second place for 'favorite device', is another place where you can observe the rapid decline of traditional cameras in favor of smartphones. Users of iPhones and the like are now also exhibiting in the *heise* online Photo Gallery. We counted around 260 smartphone images there, and have put together a selection for you on these pages. (ssi) **c't**

Axel Kaste photographed *div 01.01.2012 LR-0638* using an iPhone 4s. An installation using lights in the Bremen Art Gallery provided the surreal subject, *Lightroom* the finishing touches.

Badende am See (*'Bathers at the Lake'*) by seppthale

Dmitri Popov

Remote Control Apps
for DSLRs

Connecting cameras to mobile devices opens up a whole new range of creative opportunities for photographers. Cheap and free apps for Android and iOS are revolutionizing remote DSLR control. We grabbed some of the latest solutions to hit the market and took them for a spin.

Using a smartphone or a tablet as an extension of a DSLR camera opens up a whole new world of photographic possibilities. For starters, you can replace a dedicated remote control unit with an inexpensive app for your smartphone, which can then be used to trigger the shutter remotely as well as working with long exposure and time-lapse techniques. Some apps can also turn your Android device into a powerful tethered shooting tool that can come in really handy for macro, studio, and wildlife photography.

DSLR Remote control apps can be divided into two categories: those that allow you to use a mobile device as a remote shutter trigger and tethered shooting apps that give you full control over the camera. A typical remote shutter trigger app requires a special cable to connect the camera to the audio jack of the mobile device and transform the pulse sent by the app into a shutter release signal for a specific camera model. Usually, you can buy the required cable from the app's developer. Some apps also support IR transmitters so, if your DSLR has an IR receiver, you can trigger it wirelessly too.

Tethered shooting apps let you operate a DSLR camera via a USB port, and they can be used to control practically every camera setting, including aperture, exposure time, ISO values, shooting mode, white balance and many more besides. In principle, such apps provide a complete remote camera interface. To make use of tethered shooting apps, you need a device with a Micro-USB port running a system that supports USB OTG (On-The-Go) functionality. Android devices feature either a Micro-USB port or a proprietary port that requires an adapter, and the current Android release supports USB OTG out of the box. As a result, there are now several tethered shooting apps available for the Android platform. iOS is a different story and, because no iOS device can be directly connected to a DSLR via USB, tethered shooting apps for iOS are thin on the ground. There are, of course, apps like DSLR Camera Remote (from

**Most remote control apps require the use of a custom cable like the *Triggertrap* model shown here.
In spite of its brand-based labeling, this particular cable can also be used with other apps.**

To use tethered shooting apps, you need to connect your Android device to your camera using a USB OTG adapter (on the left) and the USB cable provided with your device. Some cameras, such as the Nikon D90 and Canon EOS 1100D/Rebel T3, can be connected using a standard mini USB cable.

ononesoftware.com), but these generally work with cameras connected to a regular computer, putting them beyond the scope of this article.

Test Hardware

We used the popular Nikon D90 and Canon EOS 1100D D/Rebel T3 DLRS to conduct our tests. Most of the apps covered in this article support best-selling DSLR cameras from Nikon and Canon, but please check that any app you have your eye on supports your particular camera before making a purchase. On the Android side, we performed the bulk of our tests using a Google Nexus 7 tablet, which runs a pure Android system unencumbered by third-party modifications.

More importantly, the Nexus label ensures that the device runs the most recent version of the Android system (in our case, 4.2). The 7-inch form factor also makes the Nexus 7 a perfect portable DSLR camera companion, and its large screen makes it easier to control the camera, especially in live view mode. Beside our Nexus 7, we also used a Samsung Galaxy S II and an HTC One X (running Android 4.0.4), a Samsung Galaxy S III and an ASUS Transformer Pad TF300T (running Android 4.1.1), an Apple iPhone 4S (running iOS 6.0.1) and an Apple iPad 2 (running iOS 5.1.1).

Technical Challenges

The sheer number of Android hardware and software permutations poses a serious challenge for developers and end-users. Because of the open nature of Android, each manufacturer is free to choose which features to implement and how to implement them. For example, while the current version of the system natively supports USB OTG, HTC chose not to enable this feature in their One series devices. This effectively precludes HTC One X, HTC One S and possibly other models from being used with remote tethering apps.

Another serious issue has more to do with politics than technology. To comply with EU regulations, all audio devices sold in Europe, including Android and iOS smartphones and tablets, have an artificial limit on the audio volume level. Designed to prevent hearing damage, this particular piece of regulation had unintended consequences for app developers. Many remote shutter trigger apps require a certain audio signal level in order to operate correctly, and insufficient signal levels can cause erratic behavior or render an app unusable, which has resulted in negative user reviews in some cases (triggertrap.com/triggertrap-eu-devices details an example of such misfortune). The good news is that most developers have addressed the issue by updating their software and modifying their hardware, while the bad news is that the issue can still cause problems for users. For example, while passive IR emitters are cheaper and easier to make, they may not work with devices that have a volume level limit. This issue is not limited to Android devices. For exampe, DSLR.bot for iOS (dslrbot.com) is one example of an app designed for use with a passive IR emitter, but the developer doesn't guarantee that the app will work properly (or work at all) on European iOS devices. There are two possible solutions
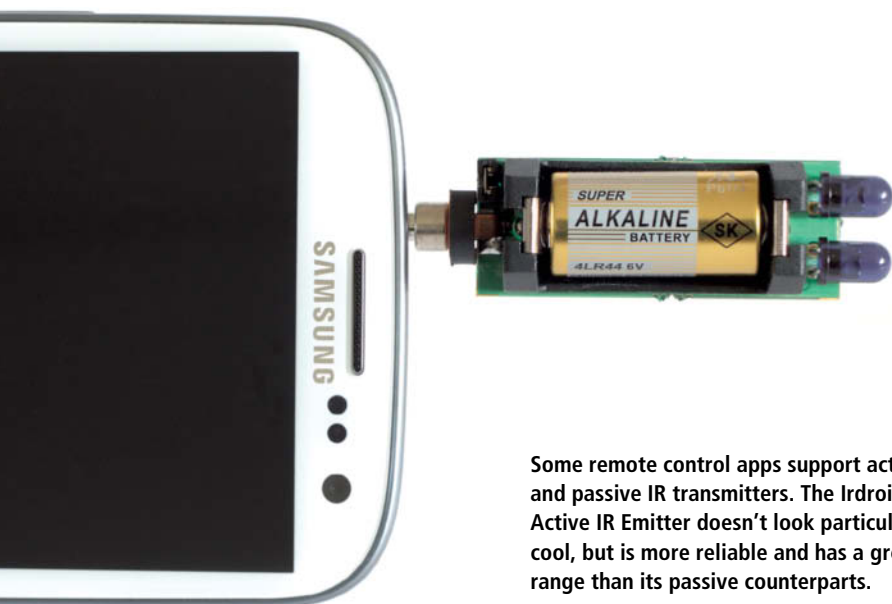
Some remote control apps support active and passive IR transmitters. The Irdroid Active IR Emitter doesn't look particularly cool, but is more reliable and has a greater range than its passive counterparts.

to this problem on both Android and iOS platforms. You can either choose the software and hardware combinations that are known to work on devices with a volume limit (using active IR emitters or special cables), or you can root or jailbreak your device. However, since this approach requires some technical skill and voids the warranty, you should only consider it as a last resort if all else fails.

Mounting Solutions

In many situations, especially when shooting over a prolonged period of time (for example, during a time-lapse or star trail session), holding an Android or iOS device connected to your camera in your hands is not a very practical approach. Among the various solutions to this problem, the Flash Dock for iPhones (www.pocketdemo.fr/flash-dock/) allows you to mount the device on the camera's hot shoe. The drawbacks of this particular product are that it only works with the iPhone and doesn't allow you to control the camera from a distance, which defeats the point of remote control in the first place. The Joby GripTight GorillaPod (joby.com/smartphones/griptight-gorillapod-stand) is a more flexible solution in every sense of the word. It works with virtually any smartphone, and it can be mounted in a variety of ways. The simplest solution is a plastic stand like the ones used to display rocks and gemstones (see http://bit.ly/wApTmw for an example). These are very cheap and are available in a variety of sizes. Some are large and sturdy enough to support a tablet device, but can normally only be used on flat surfaces.

Conclusions

Obviously, not all photographers need the ability to remotely control their cameras, but there are nevertheless many situations in which an Android or iOS device with a remote control app can come in handy. *DSLR Remote, Triggertrap, DslrDashboard, DSLR Controller* and *CamRanger* are described in detail in the following sections. All five proved useful and have very different strengths and weaknesses. The ability to precisely control focus and perform focus stacking makes apps like *DslrDashboard* and *DSLR Controller* perfect tools for those interested in macro photography. If you are looking for a better way to take long exposure photos, you might appreciate the features offered by the *DSLR Remote* and *Triggertrap* apps, while *Triggertrap* will also appeal to photographers interested in creative ways to trigger the shutter. All the apps we tested proved to be good at what they do, but we recommend that you try free apps first to make sure that you like what you see before going ahead and purchasing a commercial solution. The table at the end of this article also includes details of some other apps that didn't find their way into our test this time around.

A tethered shooting app transforms an Android device like this Google Nexus 7 into a full-featured tool for controlling your DSLR remotely

DSLR Remote (Android)

DSLR Remote (bitshift.bi.funpic.de/en/dslr-remote.php) is probably the simplest remote shutter trigger app available for Android. In this case, simplicity is not necessarily a bad thing. While the app is not overloaded with features, it includes a number of essential tools that are easily accessible via a user-friendly interface. This makes *DSLR Remote* a perfect app for mastering the basics of controlling your DSLR remotely. Better still, it is compatible with a wide range of Android
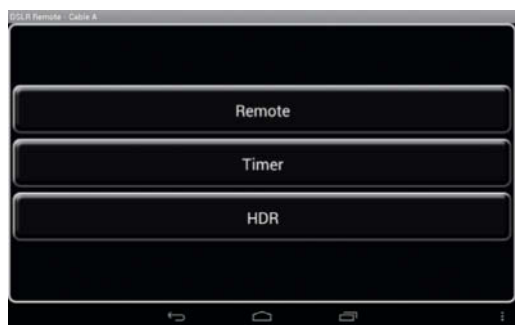
DSLR Remote has a clearly laid out interface and a offers variety of ways to release the camera's shutter remotely

devices and supports active and passive IR emitters as well as cable connection. Alongside Nikon and Canon, *DSLR Remote* also supports DSLR cameras from various other manufacturers, including Sony, Pentax, Olympus, Fuji, and Minolta.

DSLR Remote supports two types of cables: Cable A and Cable S. The former was designed for earlier versions of the app, so we
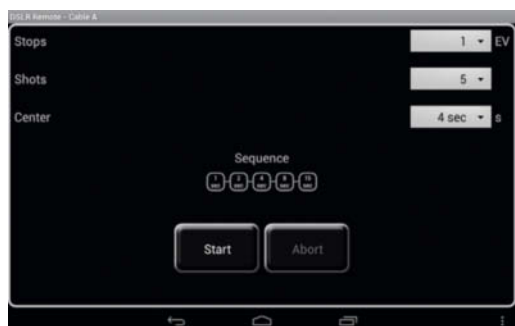
The app also offers a simple way to capture sequences of images using different exposure parameters, which is especially useful for creating HDR images. The highly visual interface helps you to keep tabs on your session.

recommend sticking to to the 'S' version for use with the latest releases. The project's website provides detailed instructions on how to make your own cable (see the 'hardware' section at the URL listed above) but if you prefer, you can also use the ready-built *Triggertrap* dongle and an appropriate cable (see the *Triggertrap* review below).

As an alternative to tethering an Android device to your camera using a cable, if your device has an IR receiver you can use an IR emitter instead. The project's website offers instructions on how to make passive and active IR emitters (once again, see the online 'hardware' section). Building a passive IR emitter is a simple matter of wiring two IR LEDs together using a regular audio cable, making it a great DIY project for a rainy weekend. The major drawback of using a passive IR emitter is that its effective range depends on the volume level of the Android device, so if the output signal is not strong enough, the IR emitter may not work at all. The solution to this problem is to use an active IR emitter. Using instructions on the project's website, you can make your own, although this does require a working knowledge of DIY electronics. Alternatively, you can use a commercial IR emitter such as the Irdroid (www.irdroid.com), which works fine with *DSLR Remote*.

Deploying *DSLR Remote* on your Android device requires only a few simple steps. Install the latest release of *DSLR Remote* from the Google Play Store, connect your device to your camera using your chosen cable and launch the app. To make *DSLR Remote* play nicely with your camera, you need to configure its settings appropriately. Navigate to Menu > Settings and choose the Cable S item from the Remote Type list. In the Cable Settings section, select the desired trigger behavior from the Trigger list. The three options here are *Shutter*, *Shutter and Focus* and *Focus then Shutter*. The trigger behavior is

equivalent to pressing the camera's shutter release halfway, so the effect of the option you select will depend on your specific camera model. If the documentation supplied with your camera provides no clues, you can simply try different options to see which works best. If you choose the *Focus then Shutter* option, you can also configure the *Lead Time* option which determines the time interval between obtaining focus and triggering the shutter. If you are using *DSLR Remote* with an IR emitter instead of a cable, you have to configure the app accordingly. Select *Infrared* from the Remote Type list, and pick the appropriate camera maker from the Camera list. you can then configure your display options and return to the main screen.

DSLR Remote's interface is simplicity itself, and features just three buttons: 'Remote', 'Timer', and 'HDR'. The 'Remote' button opens the shutter trigger interface containing the 'S' (Shutter) and 'F' (Focus) buttons (which are not displayed if you are using an IR emitter). The latter is used to obtain focus, but if the *Focus then Shutter* option is enabled, you can simply tap the 'S' button to obtain focus and trigger the shutter. The Timer interface is designed for capturing time-lapse and long exposure images. Here, you can specify the number of shots and the desired interval between them. You can select an interval from a few seconds to several hours and an appropriate exposure time using the *Shutter* option. Remember to set your camera to Bulb (B) mode before using this feature. Finally, the HDR feature enables you to capture multiple long-exposure shots which can then be combined into a single HDR image (also requires Bulb mode). The HDR interface provides three adjustable options: *Stop* (the exposure step value), *Shots* (the number of shots you wish to capture), and *Center* (the exposure time value for 'correct' exposure). Tap Menu > HDR Settings to adjust the interval between shots, specify the shutter time limit

The timer function enables you to individually select the number of shots, the delay and the interval

and enable mirror lockup. Once you have configured the *Stop, Shots,* and *Center* options, the app displays a graphical sequence diagram which makes it easier to track the progress of your sequence during shooting. Each square in the diagram represents one shot, and the number in the square indicates the exposure time. Tap the Start button to initiate a session.

DSLR Remote is also able to trigger the camera's shutter using the ambient light sensor and microphone built into some Android devices. This functionality can be useful for all kinds of creative photography and configuring it is quite straightforward. Simply tap the 'Menu' button and choose the desired trigger, configure the required settings and tap the 'Start' button to activate the trigger. The sound and light triggers worked reliably in our tests, so give them a try if you are looking for alternative ways to trip your shutter.

Finally, if you have a stereo Bluetooth receiver, you can re-purpose it for use with *DSLR Remote*. The /hardware/bluetooth/ section of the project website includes detailed instructions. Unlike using an IR emitter, this solution provides greater range and doesn't require a clear line of sight to control the camera. Better yet, you don't need expensive Bluetooth gear. We tested this feature using a cheap Bluetooth A2DP adapter (available on eBay for US$20-30) and

it worked perfectly. Bear in mind that if a Bluetooth adapter is connected to the camera via an S cable, there is no need to enable the *Bluetooth* option in the Settings section. Simply pair your Android device with the Bluetooth adapter to use *DSLR Remote* in the usual manner.

Conclusions

All in all, *DSLR Remote* is a handy app with a simple interface that gives you quick access to all the essential tools and big buttons that make it easy to operate with one hand. There is practically no learning curve, so you can master the app's basics in a matter of minutes. We particularly like the fact that it is not overloaded with fancy or useless features. Instead, *DSLR Remote* focuses on doing a few things well. The app scores highly for supporting multiple connection types, including passive and active IR emitters, special cables and even Bluetooth. It also offers the advantage of being compatible with hardware from third-party manufacturers such as the *Triggertrap* cable or the Irdroid IR emitter. Best of all, the app is free, so you have nothing to lose by giving it a try.

In short, if you are in the market for a cheap, flexible remote trigger and you already own an Android device, *DSLR Remote* is probably just what you are looking for.
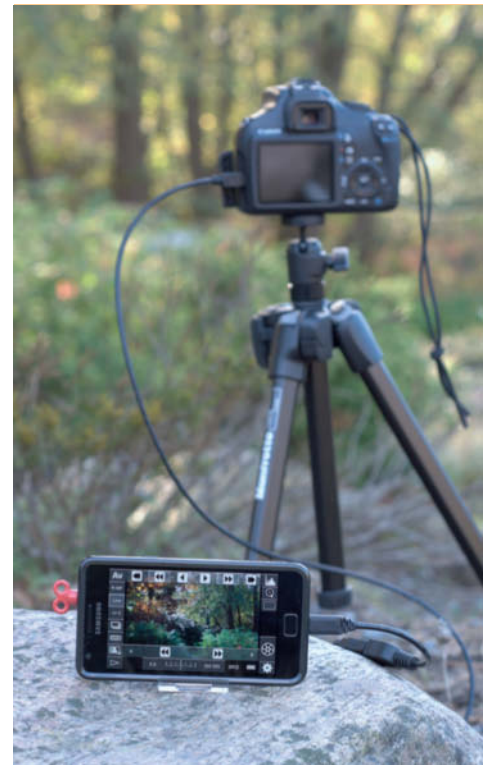
A simple plastic prop stand is sufficient to temporarily transform an Android or iOS device into a remote monitor. Make sure that the stand you use is stable enough to last a whole session.

CamRanger (iOS)

CamRanger is designed to control Canon and Nikon DSLRs remotely form the interface of an iPad, iPhone or iPod Touch. As well as the free app, you need to acquire the *CamRanger* Wi-Fi Dongle, which costs about US$300 at amazon.com. The dongle connects to the camera via USB and sets up a Wi-Fi network, so

CamRanger in live view mode. Parameters such as aperture, focus and ISO value are easy to control.

you don't need any further computers or a separate internet connection. Once you have registered your *CamRanger* online, you iOS device has access to the *CamRanger* network. The manufacturer claims Wi-Fi range of up to 50 meters and the device's Li-Ion battery can be swapped out (replacement batteries cost about US$30), so long shoots shouldn't be a problem. The clean interface looks good, is intuitive and gives you access to all the important camera settings. These include focus, aperture, exposure time and ISO value. The app's live view mode enables you to view your subject in detail, while tapping the screen adjusts focus and a double tap zooms in to the live view image, making *CamRanger* an obvious choice for use in macro situations. The app also includes a built-in focus stacking featurethat lets you merge a series of image taken at different focus settings into a single image with extended depth of field (see our article in Issue 6 of *c't Digital Photography* for more on this fascinating subject). HDR and Time-lapse functionality are also part of the package.

Conclusion

CamRanger is a well-thought-out package that offers true Apple-based wireless remote control for Canon and Nikon users. The downside of the app is the high price of the obligatory dongle, which is sure to deter some people from trying it out.

Triggertrap (Android and iOS)

Triggertrap is available for Android and iOS. It has a more polished interface than *DSLR Remote* and includes a number of unique features. *Triggertrap* only works with the specially designed dongle and cable combinations available for purchase from the project's website (triggertrap.com/products/dongle/). The dongle and cable bundles are quite expensive, but the good news is that you can use one dongle with different cables. Better still, the dongle and cables from *Triggertrap* work with other remote shutter trigger apps such as *DSLR Remote*. European users will also appreciate the fact that the latest version of the dongle supports devices with a volume level limit.

Before you start using *Triggertrap*, you have to configure the app for your specific camera model. To do this, launch the app and tap the settings icon in the upper right corner of the interface. Instead of manually tweaking the options in the Shutter and Focus sections, you can simply choose the appropriate item from the list in the Presets section. *Triggertrap* can be rather finicky when working with AF lenses, but the Universal Fast Autofocus or Universal Slow Autofocus presets usually fix that.

Although *Triggertrap* offers advanced functionality, basic operation is quite straightforward, with separate interfaces for each triggering mode. Cable Release is the simplest mode, and allows you to trigger the shutter by tapping the 'Shutter Release' button. The mode dial icon lets you choose between different triggering modes and the app conveniently displays a brief description of the currently selected mode, so you shouldn't have any problems figuring out when and how to use each one. If you are still in doubt, tap the Info icon in the upper right corner to access comprehensive context help. The Info icon is available in other triggering modes too, so help is always just a tap away.

In addition to Timelapse, Long Exposure HDR and Long Exposure HDR Timelapse modes, *Triggertrap* features several unique modes, including TimeWarp, DistanceLapse, Star Trail, and Bramping. TimeWarp mode enables you to capture accelerated or decelerated time-lapse sequences of steadily moving objects such as the Sun or clouds. DistanceLapse is similar to regular time-lapse mode, but uses your device's built-in GPS receiver to trigger the shutter at specified distance intervals. This mode can be particularly useful for capturing time-lapse sequences from a moving vehicle. As the name suggests, Star Trail mode is designed specifically for star trail photography and, unlike conventional star trail techniques that capture a single long exposure, it combines multiple exposures taken over a longer period of time into a single image. You can set the predefined interval and the overall time period and stack the resulting sequence using an image editing application. Finally, Bramping (bulb ramping) mode lets you produce time-lapse sequences that take changing lighting conditions into account. Instead of relying on the camera's light meter, you can use Bramping to specify exposure parameters for start and end photos and the app then gradually adjusts exposure for each shot in between.

If you happen to have two mobile devices, you can link them using *Triggertrap* to trigger the shutter remotely via a Wi-Fi connection. However, please note that Android devices can only act as Wi-Fi slaves, so you need an iOS device to perform Wi-Fi master duties. *Triggertrap* can handle
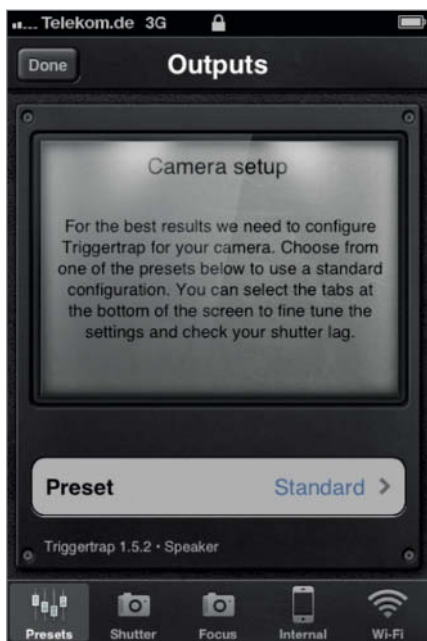
Triggertrap has a wide range of preferences that help to fine-tune the app for use with a range of camera models. The default settings are designed for use with autofocus.

Alongside standard features such as time-lapse and long exposures, *Triggertrap* also offers special effects such as TimeWarp, which speeds up or slows down conventional time-lapse sequences

Star Trail mode enables you to capture mulitple long exposures of a night sky which you can then merge into a single mega-image

multiple slaves, so you can use a Wi-Fi master device to trigger several cameras at once. The ability to act as a Wi-Fi master is not the only feature that is only available in *Triggertrap* for iOS. The Android version of the app also lacks Bang, Seismic, Tesla, Peekaboo and Motion modes, as well as support for Bluetooth triggering and the ability to control the built-in camera. *Triggertrap*'s developers plan to add some of the missing features to the Android version in the future, but for now, if you want to get the most out of *Triggertrap*'s capabilities, you will have to use it with an iOS device.

Conclusions

Triggertrap is a powerful app that offers an extremely wide range of modes. The polished interface makes it easy to use, and the comprehensive built-in help is excellent. The availability of ready-made dongles and cables is also a huge plus. The cables may not be cheap, but the developers guarantee that they will work with virtually every combination of Android device and camera. Our tests showed that *Triggertrap* cables work well with other apps too. The app's developers have chosen to cram in as many features as possible, which will appeal to many experimental and creative users but adds ballast once the novelty wears off. After all, how often do you really find yourself wanting take accelerating or decelerating time-lapses? Our main issue with *Triggertrap* is the lack of feature parity between its Android and iOS versions. The Android version lacks several important modes, doesn't support Bluetooth connections and cannot act as a Wi-Fi master, making iOS the operating system of choice if you want to use this particular app to the full.

DslrDashboard for Nikon (Android)

If you want to use your Android device for tethered shooting with Nikon DSLRs, *DslrDashboard* is the right tool for the job. This app lets you control practically every camera setting remotely, from aperture and ISO, to exposure bracketing and Active D-Lighting. Initially, *DslrDashboard* was designed to work with the Nikon D5000 only, but the current version of the app supports others too, including the D90, D7000 and D800 models. There is no official list of supported cameras but, since the app is free, you can easily install it and test it with your camera. As mentioned elsewhere, to make use of *DslrDashboard* (or any tethered shooting app for that matter), you need to connect your Android device to the camera using a combination of a USB OTG Micro-USB cable and the regular USB cable supplied with the camera. Once you have done that, turn the camera on and choose *DslrDashboard* when the Android device prompts you to select the appropriate app for handling the detected hardware.

While *DslrDashboard*'s interface is relatively crude, it is functional and relatively easy to master. The shutter trigger and AF buttons on the left do exactly what they say and the scrollable buttons in the toolbar to the right let you adjust camera settings such as image quality, ISO, white balance, metering mode, exposure compensation and Active D-Lighting. Using the 'Camera Mode' button at the top, you can switch the camera to Host mode, in which *DslrDashboard* assumes full control of the camera, enabling you to remotely switch the current shooting mode

(Aperture Priority, Shutter Priority, Manual, etc.). Tap the 'Lv' button to switch to live view mode. The live view interface supports several gestures, enabling you to change the focus area by tapping on the screen and trigger the shutter by swiping from left to right. The additional toolbar includes buttons for zooming in and out, which can be useful for more precise focusing.

Speaking of focusing, *DslrDashboard* also allows you to adjust focus manually in discrete steps. To do this, enable the manual focus toolbar by tapping on the small triangle in the lower-right corner of the interface. The toolbar contains four buttons that can be used to move focus to the closest focusing distance or infinity, while two other buttons shift focus closer or further away by increments determined using the slider on the toolbar. This feature can be used for focus stacking applications, although *DslrDashboard* has a dedicated focus bracketing tool too, which is activated using the 'FOCUS BKT' button. The feature enables you to configure the number of images you want to capture, the focus step value (i.e., the amount of focus shift between shots) and the direction. Tap 'Start Focus Stacking' to capture the specified number of photos from the current focus point, moving focus back or forward depending on the direction you have selected.

The app provides support for exposure bracketing, too, which you can activate using the 'BKT' button located next to the 'Lv' button. Tap the button to specify EV increments, direction and number of shots in the Custom Bracketing settings dialog. Close the dialog, long-tap the button to enable bracketing and then tap the shutter release button to initiate a bracketing session.

The *DslrDashboard* interface is functional and includes buttons for various basic camera settings, including image quality
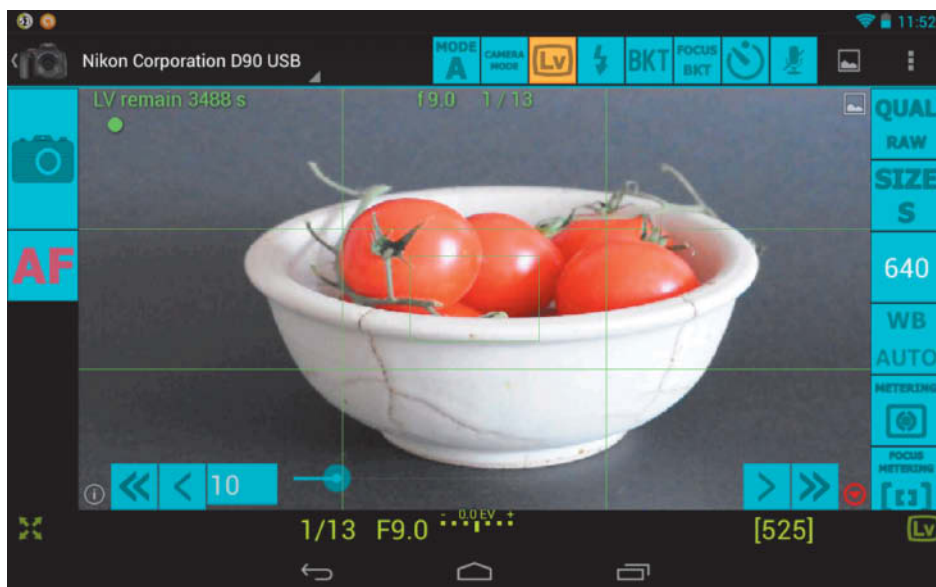
Captured images are saved on the camera's memory card by default but, if you tap and hold the app's shutter release button until it turns red, the app will save them to your Android device. *DslrDashboard* lets you preview photos using its built-in image browser, which includes histogram and Exif metadata displays.

DslrDashboard also includes the Flash Commander tool that can be used to configure and control multiple flashes and flash groups from the Android interface. If your Android device has a built-in GPS receiver, the Settings section of the app includes options for geotagging your photos.

Conclusions

DslrDashboard is probably the most powerful and flexible of the current crop of tethered shooting app for Nikon cameras. Its major drawback is its rather clunky interface: the scrollable toolbar on the right scores no points for user-friendliness and the apparently random arrangement of the buttons means that you have to scroll to reach functions that are used regularly, such as exposure compensation. Some features are not particularly intuitive. For example, it took us a while to work out how to use the exposure bracketing feature. However, if you are willing to spend time learning how to use it, *DslrDashboard* offers plenty of useful functionality. In short, if you are a Nikon user and you already own an Android device, *DslrDashboard* is a must-have app – you just have to learn to work around its quirks.

DSLR Controller for Canon (Android)

While *DslrDashboard* makes a perfect app for Nikon shooters, Android-toting Canon photographers are sure to appreciate *DSLR Controller*. Similarly to its Nikon counterpart, *DSLR Controller* allows you to control the camera and its settings from an Android device via a USB cable connection. *DSLR Controller* is not free, but is nevertheless reasonably priced. The project's website maintains a comprehensive list of Android devices and Canon DSLR cameras known to work with the app, so you check compatibility before you commit to making a purchase.

The app features a polished interface that puts all essential controls at your fingertips. Using the available buttons, you can change settings like aperture, shutter speed, ISO and white balance, and you can also enable a live histogram, zoom in and out and activate the grid overlay. Tapping on the EV bar at the bottom of the main interface enables you to use swipe gestures to adjust exposure compensation, bracketing and flash compensation – a really cool solution.

DSLR Controller has a dedicated manual focus interface which is activated by tapping the focus mode button. You can then use the buttons at the top of the interface to adjust focus in discrete steps with user-selected lengths, while the buttons at the bottom of the frame adjust focus continuously. Simply

DSLR Controller **has a built-in browser for checking recently captured photos. The browser view also provides histogram and detailed Exif data.**

tap and hold the appropriate button until the desired area of your subject is in focus. The app also supports 'focus pull' using preset focus settings that are evoked as required using the 'A' and 'B' buttons. To save the current focus setting as a preset, simply long-tap the button you wish to assign it to.

Similar to *DslrDashboard, DSLR Controller* comes with separate interfaces for exposure, time-lapse and focus bracketing, all of which are accessible via the settings button. The main interfaces are straightforward and intuitive to use, so you shouldn't have any problems figuring out how they work. The app also has a simple built-in image browser, which is useful for previewing captured material.

In certain situations, using a cable connection to control your camera can be limiting, but *DSLR Controller* provides a clever solution to the problem, transforming the Android device connected to the camera into a Wi-Fi bridge to other devices running *DSLR Controller*. To enable this feature, tap the settings button in the lower right-hand corner and select 'Wi-Fi passthrough mode'.

Launching *DSLR Controller* on a nearby Android device then automatically establishes a connection. Note that both devices have to be connected to the same wireless network for this feature to work.

Conclusions

DSLR Controller is not the cheapest app by Android standards, but is probably worth every cent to Canon users. The app features a well-thought-out and user-friendly interface and a wide range of tools that are easily accessible and simple to use. The app is not very well documented, but it is so simple to use that you won't need a manual to get the hang of it. Wi-Fi passthrough mode is our favorite feature, and its only drawback is that you need at least two Android devices to use it! (sea)
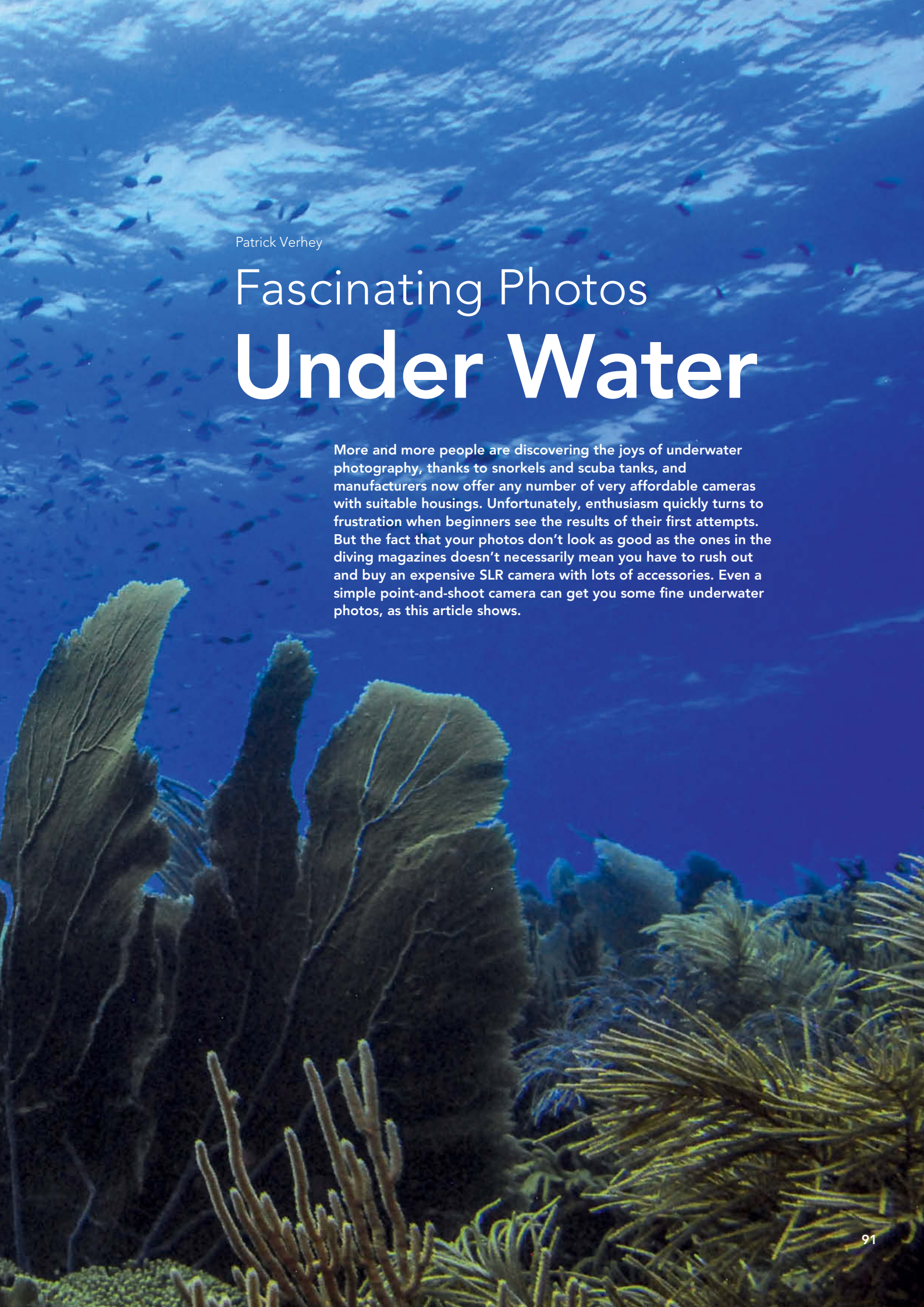
DSLR REMOTE CONTROL APPS

OS/Name	Version	Price[1]	Supported Cameras[2]	Details
Android				
CamCap	0.9.1	9.20	Nikon, Canon	No-frills tethered shooting app for selected Canon and Nikon cameras
DSLR Controller	0.96.0 (see test)	8.99	Canon	Excellent tethered shooting app for Canon cameras
DslrDashboard	0.3.15 (see test)	free	Nikon	Powerful and flexible tethered shooting app for Nikon cameras
DSLR Remote	1.5 (see test)	free	Canon, Nikon, Sony, Pentax, Olympus, Fuji, Minolta	Easy-to-use remote release app with a clean interface
Helicon Remote	2.6.3	free	Canon, Nikon	Tethered shooting app with additional focus stacking functionality. Works with a range of Canon and Nikon cameras. The free version has no RAW support.
PhotoIRmote	2.0	5.90	Canon, Nikon, Pentax, Sony, Olympus, Samsung	Remote trigger app that works via cable or passive and active IR emitters. Current version not compatible with Samsung Galaxy S III and Google Nexus 7.
Remote Your Cam	0.3.0	6.49	Canon, Nikon	Relatively simple tethered shooting app, still in beta. Some functions only available for Canon and Nikon cameras.
Triggertrap	1.1.1 (see test)	free	Canon, Nikon, Olympus, Panasonic, Leica, Sony and others (see the Triggertrap website)	Powerful remote trigger app with user-friendly interface and excellent help functionality. Requires custom dongle (approx. US$35) and camera-specific cable (approx. US$8).
iOS				
CameraMator	1.2	free	Canon,Nikon	Tethered shooting app for use with CameraMator app (US$299). Mounts on the camera hot-shoe and enables wireless control. Android version of CameraMator due soon.
CamRanger	1.5.3 (see test)	free	Canon, Nikon	Good-quality tethered shooting app that also supports wireless remote control for Canon and Nikon DSLRs. Requires CamRanger Wi-Fi dongle (approx. US$300)
DSLR.bot	5	4.99	Canon, Nikon, Sony, Pentax	Remote trigger app. Requires a passive IR emitter (US$22 from the project website). Possible limited functionality with some European iOS devices due to volume restrictions.
DSLR Cam Control	1.0	free	Canon, Nikon, Sony, Pentax	Remote trigger app. Requires iRED IR transmitter.
ioShutter SLR	1.0	free/9.99 (Pro version)	Canon, Nikon, Pentax, Samsung, Hasselblad, Contax (dependent on digital back model)	Remote trigger app for a wide range of cameras. Requires custom cable (approx. US$90).
Triggertrap	1.5.2 (see test)	free	Canon, Nikon, Olympus, Panasonic, Leica, Sony and others (see the Triggertrap website)	Powerful remote trigger app with user-friendly interface and excellent help functionality. Requires custom dongle (approx. US$35) and camera-specific cable (approx. US$8).

[1] In US$ (April 2013)   [2] The latest list of supported models is usually available at the project website
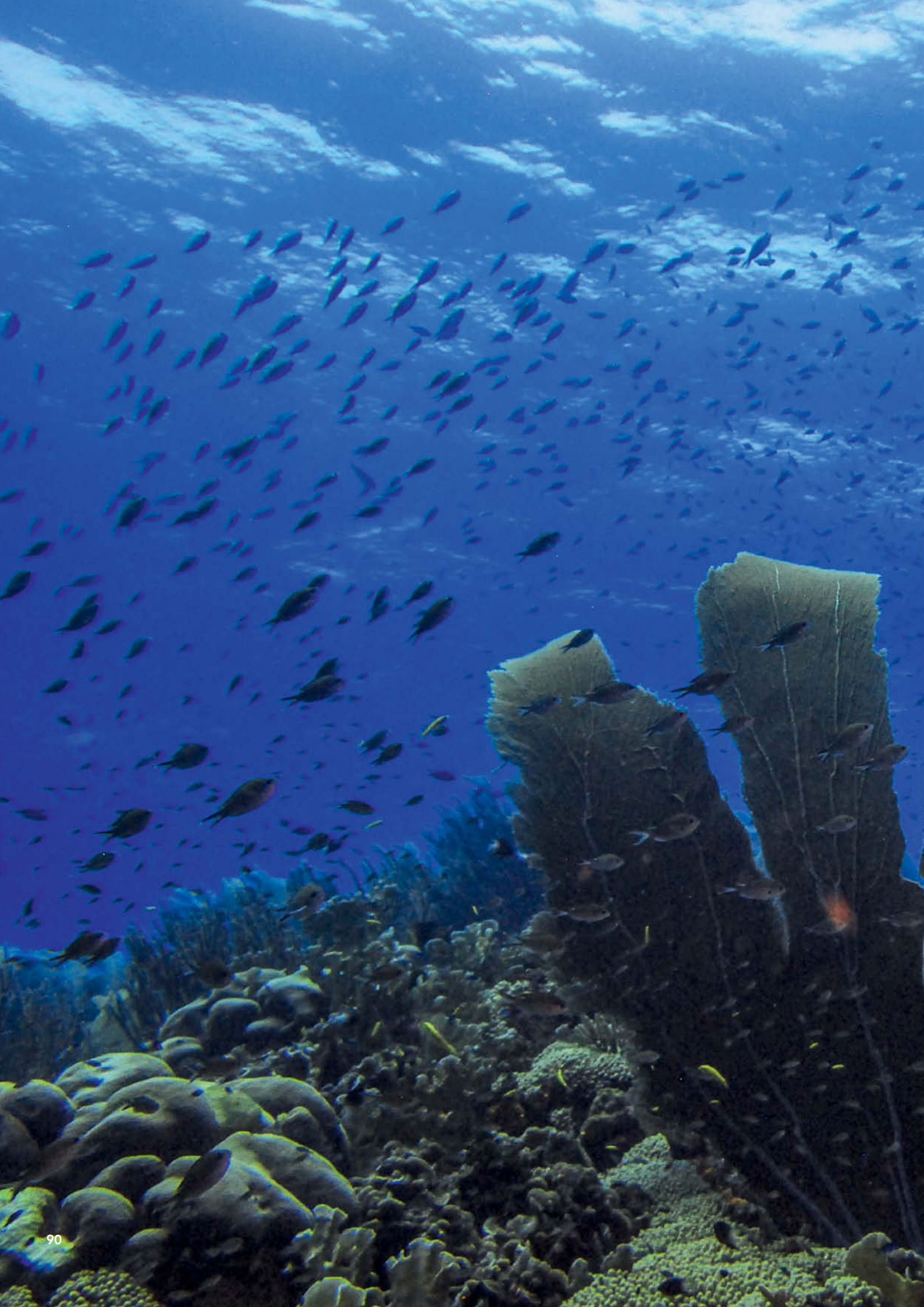
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Patrick Verhey

Fascinating Photos
Under Water

More and more people are discovering the joys of underwater photography, thanks to snorkels and scuba tanks, and manufacturers now offer any number of very affordable cameras with suitable housings. Unfortunately, enthusiasm quickly turns to frustration when beginners see the results of their first attempts. But the fact that your photos don't look as good as the ones in the diving magazines doesn't necessarily mean you have to rush out and buy an expensive SLR camera with lots of accessories. Even a simple point-and-shoot camera can get you some fine underwater photos, as this article shows.

First things first: to be able to take photos under water, you have to have the right equipment. You'll need a camera or housing and accessories such as flash brackets, flashes and lamps. It's possible – but not necessary – to spend a huge amount of money. Setting up can cost anything from a hundred to tens of thousands of dollars.

But will photos taken with equipment costing only a few hundred dollars be as good as ones taken with a US$13,000 kit? Fear not, the answer is 'yes', because it is the photographer, not the camera, who takes the photo. DSLRs, with their superior image quality, would be first choice for many people, and for good reason. Their large (and expensive) aluminum housings with easy-to-use controls make it easier to shoot under water. However, the same result can be achieved with much less expensive gear.

If you want some nice souvenirs from your diving vacation, basic, affordable equipment will do the trick. What is often missing, though, is the necessary know-how, and that's what we want to share with you here. For most of the photos in this article I used two cameras: an expensive professional DSLR that cost almost US$13,000 and a cheap point-and-shoot with an accessory flash for about US$800) However, this article is not so much about direct comparison as about teaching you how to take good photos using either of these systems.

The Right Gear

The main challenge in underwater photography is the water itself. The electronic components and precision mechanics in the camera don't like it at all! Underwater photographers therefore have to take special care of their cameras, and there are quite a number of options for doing so.

Amphibian cameras are waterproof from the start. The best known of these is the Nikonos V, which was the standard for all photographers for many years. Unfortunately, Nikon stopped making this range years ago. Now, the Sea&Sea Motor Marine and its imitators are the only true amphibian cameras available for divers. However, since these are all analog rangefinder cameras, it is only a matter of time before they will be discontinued too.

Digital compact cameras that are waterproof from 3 to 15 meters began to appear on the market not long ago, priced from US$200 to $450. The three to 10 meters maximum diving depth is quite sufficient for snorkelers, although short dives can very quickly reach depths greater than three meters, spelling 'death by drowning' for some models.

There is another option for photography in the shallows: German manufacturer ewa-marine makes amazingly reliable, very reasonably priced waterproof bags of heavy-duty plastic, most of which suit more than one type of camera. Bags for small compact cameras cost less than US$120 and prices rise to about US$400 once you get into the DSLR range. They are easy to use, since all the buttons on the camera can be accessed through the bag – unless, of course, your camera is a touchscreen model.

Because of the way they are designed, the maximum depth at which these housings can be used is about 10 meters. The system would probably still be waterproof at greater depths, but the increasing pressure would cause the plastic to press against the buttons on the camera. The system was designed with snorkelers and water sports enthusiasts in mind but is also useful for keeping sand out of cameras at the beach and protecting them from rain.

Scuba divers, however, need equipment robust enough to function at depths of 30 or 40 meters, and some camera manufacturers offer custom underwater housings that fit the bill. Olympus is still the market leader, selling complete solutions comprising flash, flash controls and a camera. Canon, too, has built up an extensive selection of housings for different cameras. Nikon came on the scene late last year with its own housing for the Nikon 1 J1 and J2. The Canon camera and housing sets cost at least US$580, while the Olympus set, comprising camera, housing and external flash, costs almost US$13,000.

Like the Canon and Olympus products, Sea&Sea and Intova products are

This photo was taken with a fairly old Sea&Sea camera without a flash. I illuminated the fish with a diving lamp and used the camera in auto mode. The outline of the light beam is clearly visible, which makes the photo particularly attractive.

Point-and-shoot | ISO 200 | 5.4 mm | f2.8 | 1/64 s

I've been using a DSLR housing with a Nikon D7000, two flashes and an angle finder rigged up like this for about two years. The Sea&Sea point-and-shoot costs about US$800 and is ready to use off the shelf.

point-and-shoot cameras with appropriate housings but, because Sea&Sea and Intova deal exclusively in underwater photography, their equipment is designed specifically for subaquatic conditions. They also offer wide-angle converters and a good number of other accessories that can be used under water when required.

Some manufacturers have specialized in making housings for DSLR heavyweights like the Nikon D800 and the Canon 5D Mark II. Because the construction process is extremely complex, these housings are not usually available until at least six months after a camera comes on the market. The construction of the housing and the small production runs explain the high price of US$3,600 for the Aquatica housing (minus accessories) which we used with our Nikon D7000 for this article. Although most manufacturers see DSLR cameras as their main market, some also offer housings for rangefinder cameras and, more recently, for mirrorless system cameras as well.

Housings are usually made of polycarbonate or aluminum. Ikelite and Fantasea are the leaders in the polycarbonate housing segment, while Aquatica, Nauticam,
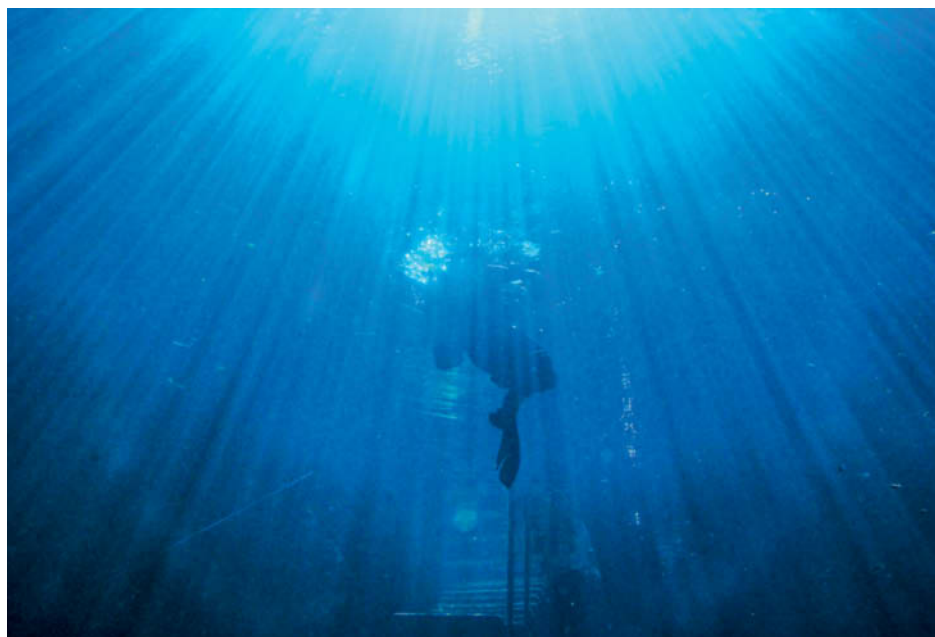
Here, I didn't need any artificial light at all. I was in a spring in Florida, photographing into the sunlight from inside a cave. In this shot, the rays of the sun showed up beautifully in the milky water, and the diver's silhouette complemented the mood. This photo was shot less than three meters below the surface.

DSLR | ISO 1600 | 22 mm | f13 | 1/1250 s | Ambient light only

Sealux and Subal have gone the aluminum route, with Sealux and Subal pursuing the professional market. Uwe Kiehl's UK-Germany is an established German manufacturer that makes housings for both system cameras and DSLRs. A full list of all the manufacturers and their products is beyond the scope of this article, the selection we have listed should give you an idea of what is available.

Underwater housings are complex and expensive and you'll need a new one if you change your camera. Italian firm Easydive has come up with a fresh take on the concept with its universal Leo II housing for Nikon and Canon DSLRs. This model has five buttons that allow you to control the camera via USB. Though it's unlikely you will need to use all the camera's settings underwater, I find that I

Comparison of a DSLR and a point-and-shoot camera, using the same settings and flash position. The point-and-shoot image (right) is slightly out of focus because it was at the absolute close focus limit, but that's also what makes its color saturation more attractive. Thanks to its larger sensor, the DSLR (left) didn't require such a high ISO setting.

DSLR | ISO 200 | 417 mm | f7.1 | 1/60 s | Flash at 1/3 power   **Point-and-shoot | ISO 800 | 4.7 mm | f7.9 | 1/15 s | Flash at power level 1**

A rare sight, since the full glory of this anemone can only be seen at night. The photo was taken during a night dive to the wreck of the SS Thistlegorm in the Red Sea.

DSLR | ISO 200 | 13 mm |
f16 | 1/125 s | Flash at 1/2 power

Reflection

Red
−5 m

Orange
−10 m

Yellow
−20 m

Green
−30 m

Blue
−60 m

The light is influenced by
– depth
– subject distance
– weather
– surface conditions

The quality of natural light under water depends on many different factors, including the presence of algae, particles in suspension, dirt and other impurities

quickly need more than five. Leo II prices start at US$2,200.

Many experts see the future of underwater photography in the Micro Four Thirds system, since it combines many features that are important for taking photos in an underwater environment. The technology and image quality are only minimally inferior to those of current consumer and prosumer DSLRs, and many photographers get really excited about the minimal shutter lag, extensive exposure control options, TTL flash and the wide range of available lenses. Their compact design and affordable prices ensure MFT cameras an enthusiastic welcome from the underwater community. The Nikon WP-N1 housing for around US$1,040 teamed with the Nikon 1 J2 camera with a 10-30mm lens for around US$600 are a good of example of a mirrorless underwater combo. This is by no means the cheapest solution once you have added a flash, but you wouldn't even get a housing for a mid-range DSLR for that price.

Operating a Camera Under Water

Your choice of housing will be determined by the options you need. Of course we'd all like to have all the camera's functions available, but the truth is that they aren't really necessary. Some manufacturers of housings for the professional market are now incorporating as few functions as possible, because every additional button makes the housing more complex and more expensive.

The shutter release, aperture and exposure time controls need to be accessible all the time. It also makes sense to have the zoom function available, although under water it is more practical to zoom by changing your position. Access to the ISO setting is helpful, but not strictly necessary. In order to be able to analyze your images immediately, you'll need to be able to access image playback, and if the camera has a video function that you
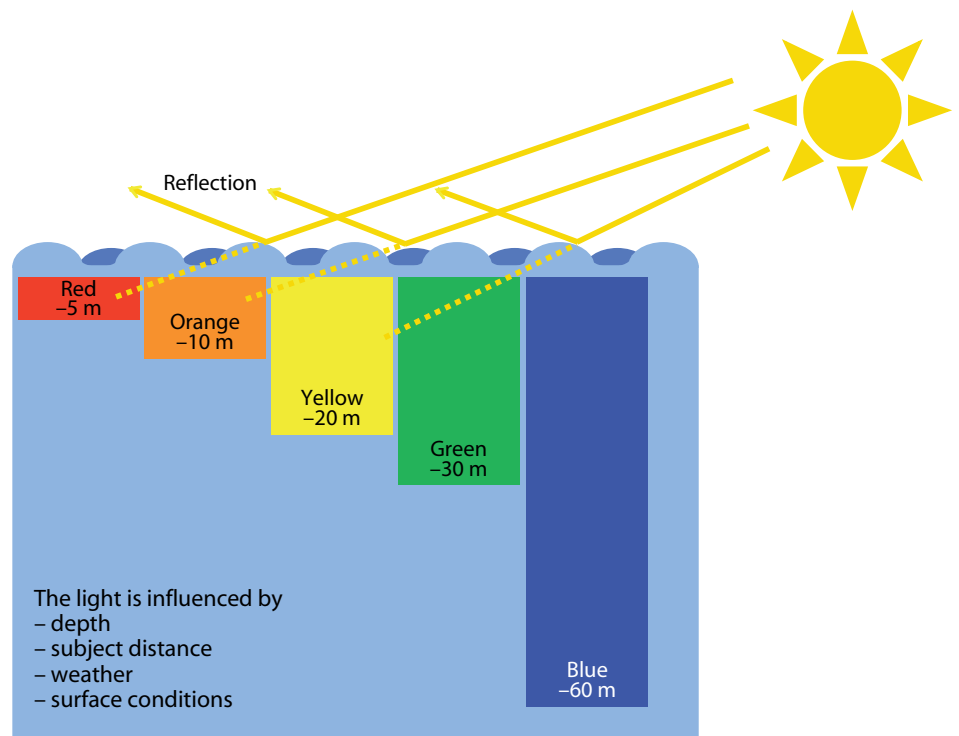
want to be able to use, you'll need a button for that too.

Most housings for point-and-shoot cameras offer all the standard functions. Take care when you are deciding which to buy, because the more compact the camera, the closer the buttons are to each other. This is fine so long as you are not wearing gloves but if, like me, you dive in cold water, test whether you can still operate your camera wearing thick gloves.

Once you have settled on a camera and a suitable housing, it's time to compare prices. Unfortunately, there are no true specialist retailers of underwater photography equipment. Some photography retailers have a few random underwater housings amongst the equipment on their shelves, but generally speaking, underwater photographers are the odd ones out amongst their clientele. Diving schools are likely to be your best source of help, and there's always the Internet. Some

Ten Basic Underwater Shooting Rules

1. Get closer, then closer still.

2. Always use accessory rather than built-in flash.

3. Use manual exposure and flash control. Flash and aperture ensure a correctly exposed foreground, while exposure time and ambient light take care of the background.

4. Shoot upward from below.

5. Focus on animals' eyes and always on the main subject.

6. You need perfect buoyancy control and faultless diving skills (unless you're snorkeling).

7. Patience, time and the ability to think ahead are the keys to success.

8. Shoot, assess, adjust, shoot. When in doubt, delete.

9. Always respect and take care of the environment.

10. Don't forget to take care of your equipment.
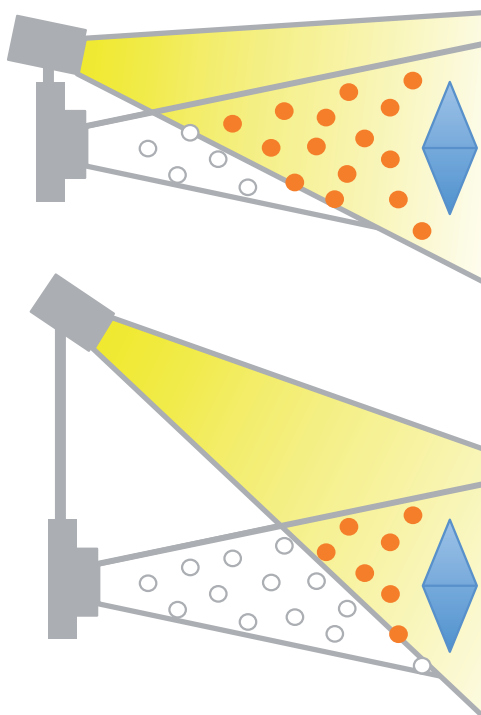
On-camera flash is not a good idea, as particles suspended in the water reflect some of the light directly back toward the camera. A flash bracket that increases the distance between the flash and the lens axis is the best solution.

online shops specialize in underwater photography and provide advice as well. Check out www.uw-fotopartner.com and www.digital-dive.de for starters.

Investigating the market for used equipment may be a faster way to your goal. Rapidly changing technology and the fact that many technology-lovers like to have the latest and best of everything mean that there is a steady supply of used housings and cameras coming onto the market. Have a look at the major online auction sites and in divers' and photographers' forums such as uwpix.com.

Underwater Optics

Water has completely different physical characteristics from air, some of which are highly relevant for underwater photography. First of all, we need to consider refraction. Camera lenses are designed to refract light at exactly the point at which the air and the glass of the lens meet. Under normal cicumstances, this would make all images taken under water out of focus, so underwater housings are designed with a layer of air between the lens and the housing.

For lenses with normal focal lengths, that is the end of the story, but things get a bit more complicated if you are using a wide-angle. To prevent the port (the part of the housing that contains the lens) intruding into images, you have to use dome ports made of curved glass. Because light refracts, the curve of the glass must be calculated precisely, and has to be positioned exactly the right distance from the lens. This is why ports are usually only available for one particular lens model. Such stringent requirements make dome ports expensive – for example, the mid-range Aquatica 4" Mini Dome used for this workshop cost US$1,130.

To make the fish stand out, the foreground was illuminated by two flashes and the background deliberately left out of focus and dim

DSLR | ISO 200 | 17 mm | f9 | 1/80 s | Flash at 1/2 power

A really good dome port also prevents chromatic aberrations. Since incident light hits the dome port at a different angle under water, the effective focal length of the lens changes by about 25 percent, transforming a 50mm lens into a 62mm-equivalent lens. This deviation has to be taken into account when you are choosing a lens. It makes good sense to use wide-angles underwater, but the focal length you choose will depend very much on the specifications of your housing's port.

In water, a dome port produces a virtual image which, seen from the point of view of the camera, seems to be about 25 per cent closer to the lens than the subject actually is. The camera focuses on this virtual image but, because it has no further effect, it is still possible to achieve a focused image using autofocus. However, the virtual image shortens the minimum focus distance of the
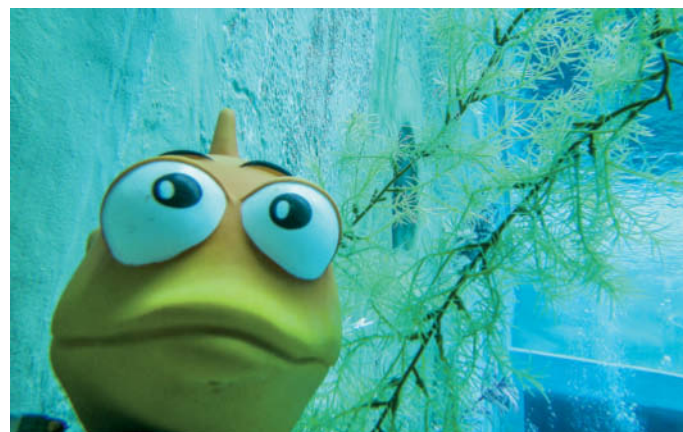
It's not much fun under water without artificial light. Here we compare an image exposed manually using flash (left) with one taken without flash in auto mode (right). A point-and-shoot camera was used in both cases.

ISO 800 | 4.7 mm | f7.9 | 1/15 s | Flash power level 1

ISO 100 | 4.7 mm | f2.8 | 1/30 s

lens, so fixed-focus cameras cannot produce a focused image if they have a dome port fitted.

Even more important is the way water absorbs light. This becomes all the more significant the farther the light has to travel, and the deeper you dive, the more artificial light you will need. It is the total length of the optical path that counts. For example, if I photograph a fish 10 meters away at a depth of 10 meters, the light has travelled 20 meters by the time it reaches the camera. Unfortunately, light is not absorbed equally across the spectrum. The red component disappears at the five-meter point along the optical path and all the other colors are gradually absorbed as the wavelengths decrease. Eventually, after about 30 meters, the only color left is blue, which is why so many underwater pictures have a green or blue cast. Also, the lack of contrast under water creates a foggy impression.

It is sometimes possible to take photos under water without extra light, but you will definitely get better results using flash. Unfortunately, flash is not the do-it-all solution we need because the light it produces is subject to absorption. To capture as much of the chromatic spectrum as possible, you have

Flash is usually better than a diving lamp. This image looks rather two-dimensional, with an area in the middle that is too bright. Using a flash would also have prevented the slight blur due to the snail's movement.

Point-and-shoot | ISO 50 | 5.4 mm | f2.8 | 1/493 s

Flash illuminates the image evenly and reveals some of the color surrounding the subject. It also prevents motion blur.

DSLR | ISO 200 | 17 mm | f13 | 1/80 s | Flash at 2/3 power

to stick within the 2.5-meter maximum flash-to-subject distance.

Fresh water has different absorptive properties from sea water and usually appears more green than blue, so photographers often refer to 'green' and 'blue' water. Depending on the type of water you are working in, you'll have to deal with different ranges of vision. Dams have the amazing ability to confront you with absolute darkness at depths of 10 meters or more. This does not mean that visibility is particularly poor there, but rather that the bottom of artificial lakes are often very dark and reflect almost no light at all.

Another potential problem, especially in still, warm water, is algae. In these circumstances it can be quite possible to have 10 meters of visibility but no residual light from the surface. Here we encounter the physical limits of photography. Not that it's impossible to take good photos under such conditions, but it is more difficult than it would be at a bright, colorful coral reef with a clear 50-meter visual range.

As a rule of thumb, most cameras can capture usable images at distances of up to a third of the actual range of sight.

The beam of light from the diver's lamp makes this image more visually appealing and the divers serve as a reference for the size of this enormous sea fan. The camera was positioned about 50 cm from the coral.

DSLR | ISO 320 | 10 mm | f8 | 1/125 s | Flash at 1/2 power

This coral was lit using flash. The slight angle to the surface of the water provides more ambient light and adds a feeling of depth to the image. The camera's port was almost touching the coral at the bottom.

DSLR | ISO 400 | 10 mm | f9 | 1/80 s | Flash at 1/2 power
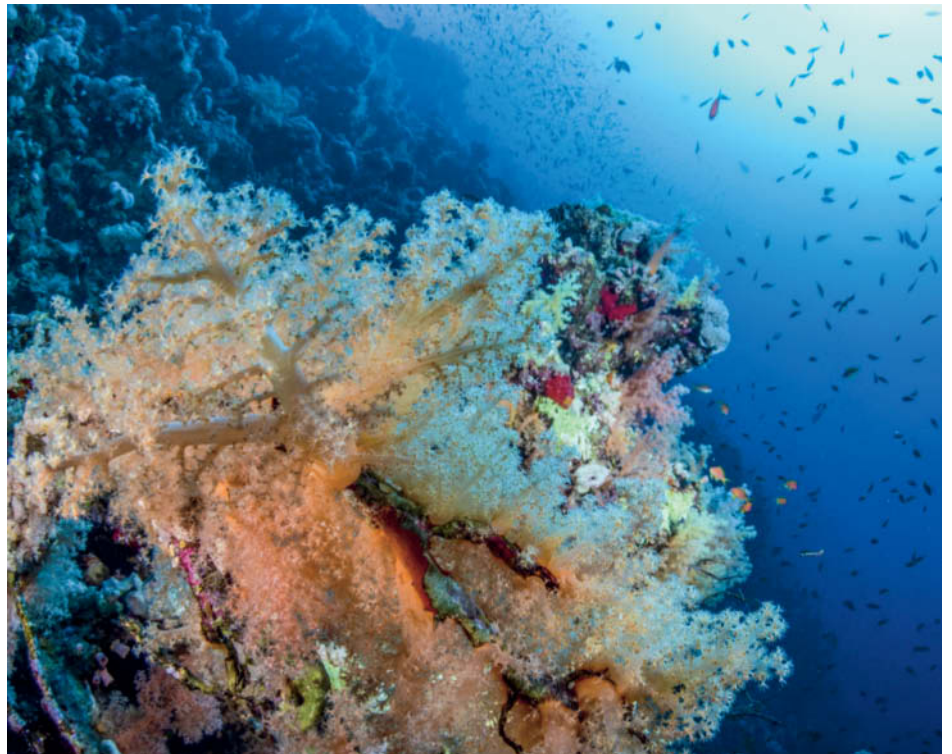
The Right Light

It is almost impossible to reproduce the incredible colors of the underwater world in a natural way unless you add some light. Most cameras have a flash built in, but because of its position close to the lens and the algae, plankton and sand suspended in the water, the results are often only average. Sometimes, divers make things worse by stirring up sand and other particles with their fins. These particles reflect the light from the flash, producing multiple, bright, out-of-focus spots in the resulting images and making it harder to see the subject. To get around this problem, mount the flash on a flash bracket. The more light the flash has to deliver, the more reflection and backscatter there will be. To ensure even illumination, it's best to combine ambient light and flash in roughly equal proportions. As soon as you see reflections in the image, change the position of the flash and adjust the power setting. The softer the light from the flash, the softer and less distracting the reflections will be. Accessory diffusers are available for most flash units. For wide-angle photos, two flashes mounted to the left and right of the camera have proved to be the best setup for producing even illumination across the frame.

Many cameras have TTL flash functionality. This works well on land, where the light delivered by the flash is measured through the lens and the exposure adjusted accordingly. Unfortunately, most TTL systems do not deal well with conditions under water, so the best way to get good results is to work with manual flash.

Some point-and-shoot cameras do not have an accessory flash connector, but many underwater housings allow a camera's built-in flash to function as a trigger for an external

This type of sea fan is a popular subject at the Red Sea. The flash provides color in the foreground, while the water and fish are illuminated by ambient light. Since the coral is part of a vertical rock formation, it was quite easy to maintain a good shooting position.

DSLR | ISO 400 | 11.5 mm | f16 | 1/125 s | Flash at 1/2 power

Early in this dive, we came upon a group of cuttlefish that were very approachable. I became set on taking a fabulous photo showing one of them with its legs splayed as far apart as possible. However, since underwater creatures never do what the photographer would like them to, it took 45 minutes and almost 50 shots to get what I wanted. And after all that, previous dives and the large number of shots I took killed my flash batteries, so I had to adjust my exposure settings quickly to carry on shooting using ambient light.

Point-and-shoot | ISO 50 | 5.4 mm | f2.8 | 1/159 s | Ambient light

This photo, shot with the same 10-17mm lens as others in this workshop, shows how strong the distortion of the fisheye lens behind the dome port really is. This distortion is virtually invisible in the other photos. Things that are distractions on land often make good creative tools under water.

DSLR | ISO 400 | 10 mm | f16 | 1/60 s | Flash at 1/2 power

Photographic Courses as Part of Diving Training

Nearly all diving associations offer special courses in underwater photography. Most of these courses have been available for ages, but it is only since digital photography really took off that efforts have been made to market and publicize them better.

First check out who is behind the course. Generally it is will be a diving instructor who has taken an extra course licensing them to offer courses using the training materials provided by a particular association. You may strike it lucky and get someone who understands the craft of photography really well, but you can't expect the trainers on these courses to have years of professional photographic experience.

However, the point of diving photography courses is primarily to improve the participants' diving skills, not their photography. While courses touch on composition and correct lighting, the main focus is on correctly operating a camera under water. Considerable attention is paid to buoyancy control and diving skills and diving instructors are in a much better position to teach these aspects than professional photographers.

It's often possible to borrow a camera during a course, which is a good way to get a feel for underwater photography without having to spend a lot of money first.

In my view, anyone who ventures into the water with a camera in hand should attend a dive photography course led by a diving instructor. Perfect buoyancy control and safe diving practice are the best route to great photos and, most importantly, to protecting the underwater environment. If you still have to think a lot about diving while you are diving, then it's best to leave your camera at home.

If, on the other hand, you already have some experience and want to take your photography skills to a higher level, I recommend attending a workshop with an experienced photographer. Such courses usually last about a week and start by explaining how to compose an image. The participants then get an opportunity to take a photo of the same subject, after which they can comment on each other's work. Unfortunately, these types of workshops can be quite expensive and are usually aimed at experienced photographers who have their own gear,

although there are also semi-professionals who offer reasonably priced workshops specifically for beginners.

Solo diving is a new trend that suits photographers very well. Although it is still widely regarded as unsafe or simply bad practice, most major dive schools are now offering solo diving courses. It is gaining popularity and many diving centers tolerate it alongside more conventional diving if you have the right gear and experience. Since photographers prefer diving alone and do not make good diving partners, you might want to consider this approach. However, to safely dive alone, you need to complete appropriate training and use all the right equipment. Even if you have done the right training, solo diving is not permitted everywhere, so you will have to make detailed inquiries before setting out.

WARNING: Anyone who dives solo does so explicitly at their own risk.

Transporting diving lights and underwater flash by air requries special permission from the airline, so make sure you contact your carrier in good time before starting out on a trip.

slave flash. Such housings have a connector for a fiberoptic cable that captures the light from the built-in flash and converts it into a trigger signal.

There are a great many lighting accessories available with varying degrees of usefulness. Many photographers use orange or magenta filters for underwater photography to compensate for the color shifts shooting in water produces. While helpful, such filters are no substitute for a flash and correct exposure. In greenish (fresh) water, a magenta filter produces more natural colors than an orange filter.

Another option is to use white balance adjustments instead of a filter. To use this approach, you need a white reference board and you have to readjust white balance each time you move to a different depth. Filters are definitely the easier option, but have to be easy to attach and remove, especially if you are photographing close up or in very still water, as they can easily distort colors.

So far we have only mentioned flash as a light source and you are probably wondering whether it is also possible to use a lamp. Indeed, this is possible, and it does have some advantages. Lamps are easier to set up, since you can see exactly what the light illuminates, and are very useful on night dives. Unfortunately, the disadvantages
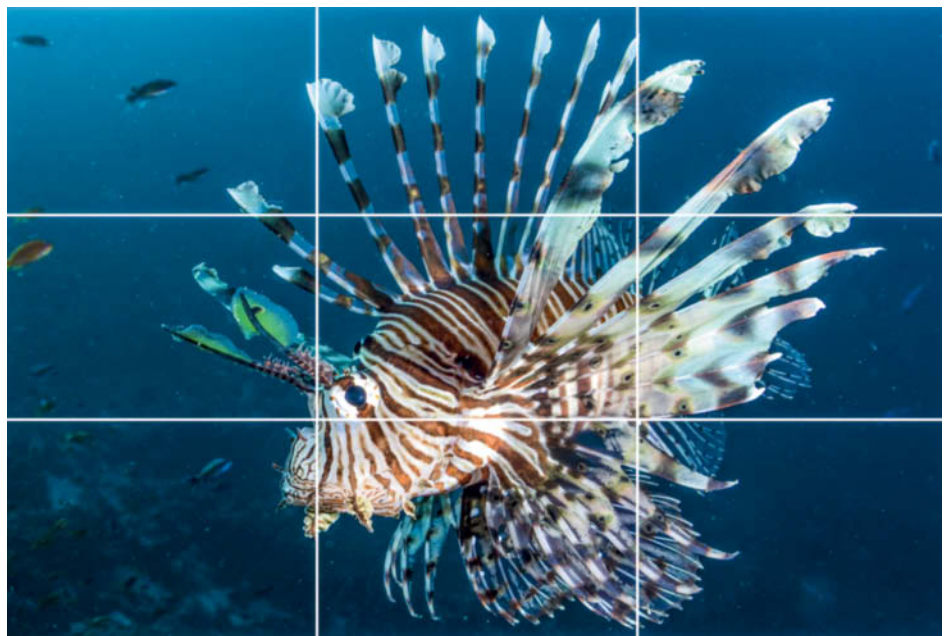
The grid lines emphasize the clean composition of this image. The main subject, the eye of the fish, is almost exactly at the point where two lines intersect. The underside of the body follows the lower horizontal line, forming the main element of the image. The beautiful fins are spread wide, filling the frame. The deep blue water in the background doesn't distract the viewer from the main subject and allows the fish to float freely and dominate the composition. The space to the left makes the image more dynamic by making the fish appear to swim through the frame.

DSLR | ISO 400 | 17 mm | f11 | 1/250 s | Flash at 1/2 power

In this case, the eye is not ideally positioned, but having the fish on a slight diagonal provides the requisite vitality. Here too, some space has been left in front of the fish, and its body is located in the lower third of the frame.

DSLR | ISO 400 | 17 mm | f11 | 1/80 s | Flash at 1/2 power
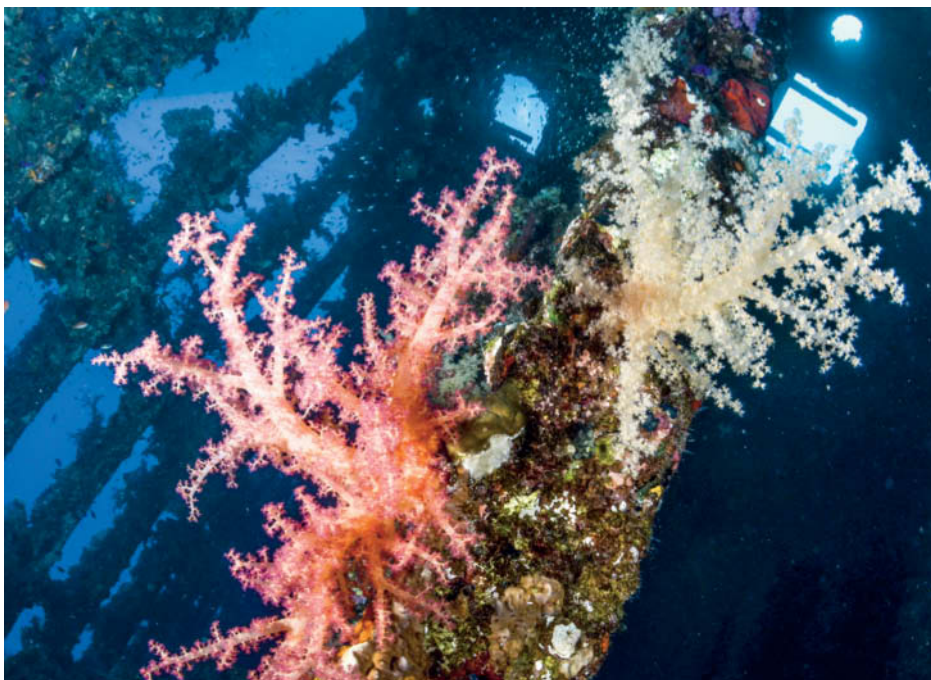
The coral makes a beautiful foreground and the sunlight coming through the holes in the wreck adds depth to this image. Once under water, beginners are inclined to shoot parallel to the surface, which usually makes sense. However, the wreck in these photos is lying on its side on the ocean floor, so I held the camera at almost a 45-degree angle to the surface. As long as the surface of the water is not too obvious, the viewer will not notice this kind of 'trick'. Situations like this allow you to get creative and enjoy photographing subjects from unusual angles.

DSLR | ISO 800 | 10 mm | f13 | 1/200 s | Flash at 1/2 power

Gorgonians, or sea fans, make a simple yet impressive subject. The branches form abstract shapes with spectacular colors. Gorgonians are usually free-standing, so it is easy to get close to them and compose an image with the blue of the water in the background. For example, this coral is about 30 cm from the camera.

DSLR | ISO 1600 | 40 mm | f7.1 | 1/400 s | Twin lamps

outweigh these advantages. Flash provides much more lighting power and uses a lot less energy. In most flash units, four standard AA batteries provide sufficient power for 100 shots without any problem, whereas a lamp with comparable output would last 30 minutes at most. Even LED technology is of little help under water, as color temperature issues make it unsuitable.

The deciding factor and main argument for using a flash is still its ability to 'freeze' movement. The same reasons apply under water as on land and using flash is the only way to capture ultra-sharp photos of fish in motion.

Getting the Exposure Right

Having decided to use flash and got your setup fully assembled, you now have to select your exposure settings. Compact cameras offer a huge number of auto exposure modes and some even have special underwater modes – in some cases with a choice between snorkeling and diving settings. These usually use a medium exposure time to reduce blur to a minimum and the largest possible aperture for optimum focal range. The program sets the white balance to match depths of three to six meters for snorkeling and deeper for diving.

Since white balance and programmed auto exposure don't adjust to different depths and types of water, you should get used to working completely manually. That may sound like a lot of extra work, and even more poorly exposed images, but it's really not that hard once you have had some practice.

Start with a medium flash power setting to give yourself a little extra light in reserve. It is advisable to start at f8 and 1/60 s, then, assuming the flash is set to 1/2 power and ISO

to a mid-range setting of around 400, you have enough scope to change your settings in either direction. At the beginning of the dive you can take a few test shots to see whether these settings work under the prevailing conditions.

From now on, all you have to do is adjust the aperture to achieve the right flash exposure for the foreground and the exposure time to regulate the amount of ambient light. Don't be afraid to select quite a long exposure time to capture more of the light from the surroundings. If you do, the flash in the foreground helps to prevent motion blur. Avoid using long focal lengths or zoom lenses if you want to be sure of capturing sharp images.

The aim in underwater photography is always to use the best possible mix of flash and ambient light. Underwater images look best when the viewer cannot even tell that a flash was used

A brief comment on post-processing at home: I have no desire to spend hours at the computer trying to make good photos out of average ones, so I always try to take good photos in the first place. Doing some extra work on the exposure afterwards can be helpful, though, as can adjusting the color

The manatee cutting diagonally across this image is nicely reflected in the surface of the water. We can see the rays of sunlight on its back and there is enough space for it to 'swim into the picture'. Unfortunately the eye is indistinct, but since it is very small compared to the body anyway, this is not particularly noticeable.

DSLR | ISO 1600 | 10 mm | f9 | 1/60 s | Ambient light only

values. Since it is easier to work on a slightly underexposed image, it is best to shoot one or two f-stops too dark. This also produces better color saturation, which is worth a lot under water. When it comes to digital post-processing, the advantage of system cameras is that they can capture RAW-format images too.

Diving with Photography in Mind

Good snapshots can happen when you are just swimming along, but good photographs take time. Are you are diving in order to take photos, or simply taking a few snaps while you're out diving? If you belong to the second group, there is little about your diving practices that will have to change. You will spend more time making sure you don't lose contact with the rest of your group, so you will use more air, but other than that, things will be much the same as usual.

If, however, you are diving specifically to take photographs, it's easy to lose track of time and other essential things such as air consumption and depth. I've often found myself in situations where I've been diving for several minutes at a depth of 30 meters, when suddenly I spot a shark lying in a

perfect position on a reef, or some other great subject. At times like this I dive down, get myself in position and take a series of photos. Having got my image in the bag, I grab a look at my diving computer and realize with a shock that not only am I now 40 meters down, but also that it's time for a decompression stop. Since it took almost five minutes to take the photos and the whole experience was quite exciting, my air supply is suddenly right down. Situations like this can quickly become quite dangerous, so it is essential to pay even more attention to safety when you're taking photos than you do when you're on a normal dive.

This is where a good diving partner – a patient person who knows about photography and takes note of the depth, time and direction – is worth their weight in gold. Sadly, they are few and far between. A diving partner can also help you with your lighting, and you can achieve fantastic effects using a spot lamp set up so to point toward the camera just below the lens axis.

Composition Under Water

A good photo owes its quality to good composition under water just as much as it

It took an entire 60-minute dive to get this photo of a feather star. I chose a place on the reef and turned off all my lamps. Working in the dark, I then had to position my camera to get the framing right. Since I cannot set focus on my DSLR manually, I used the focus-assist lamp in my flash to set the right distance then switched to manual. Then it was simply a matter of waiting until the feather star unfurled itself.

DSLR | ISO 200 | 17 mm |
f11 | 1/60 s | Flash at 2/3 power

does on land, and some composition techniques are even easier to apply under water than they are on land.

Probably the most frequently used rule of composition is the rule of thirds, which divides an image (mentally) into nine equal parts using horizontal and vertical lines. On land, these are often aligned to the horizon or a building, but there are few straight lines under water, which makes the idea of using a 180-degree fisheye lens very inviting. The ultra-wide-angle distortion that is so often distracting on land does not matter so much here. In fact, under water, distortion can be effectively incorporated into a composition.

In photographs of animals, the eye should always be visible. This makes the image more lively and enables the viewer to relate to it better. Of course positioning a fish perfectly and illuminating it clearly according to these rules is no easy matter, so practice first on slower-moving subjects.

Aligning things on the diagonal is another very effective compositional technique. Under water, many things – including shipwrecks, corals and fish or, in fresh water, individual tree trunks – can be placed diagonally in the frame. Diagonal composition creates energy and depth.

There are many circular subjects in the water, including corals, portholes of wrecks and rock formations. If you are using a wide-angle lens, circles work very well as foreground elements. Abstract forms can also create interesting images, like the one of a sea fan on page 103.

When you are snorkeling, you will shoot most of your photos looking downward from

Another example of freshwater photography close to the surface: some of the trees are out of the water, some are just at the surface and a few are under water. Because there is good visibility and plenty of sunlight, everything above and below the surface blends into one. The main subject, the tree on the diagonal, creates a very attractive sense of movement.

DSLR | ISO 1600 | 18 mm | f10 | 1/500 s | Ambient light only

near the surface. If you aim the camera along the surface of the water instead of downward, you will capture more ambient light and your image will be more dynamic, because including the surface gives it a sense of depth.

The Third Dimension – Finding the Right Position

In Issue 10 of *c't Digital Photography*, Alexander Jansen's article on stance and breath control provided valuable tips on correct positioning and how to hold a camera when taking photographs on land. Unfortunately, these don't apply in the underwater world. The design of the camera housing makes it obvious how you should hold it and the flash bracket automatically makes an ideal grip for your other hand. Your fingers should be able to reach all the main controls without changing your grip.

The great thing about underwater photography is that you are almost weightless. No matter how heavy your camera is on land, it will be buoyant once you are under water and the weight won't be such a hassle when you are positioning the camera. The point-and-shoot camera we used for this article was actually slightly positively buoyant,
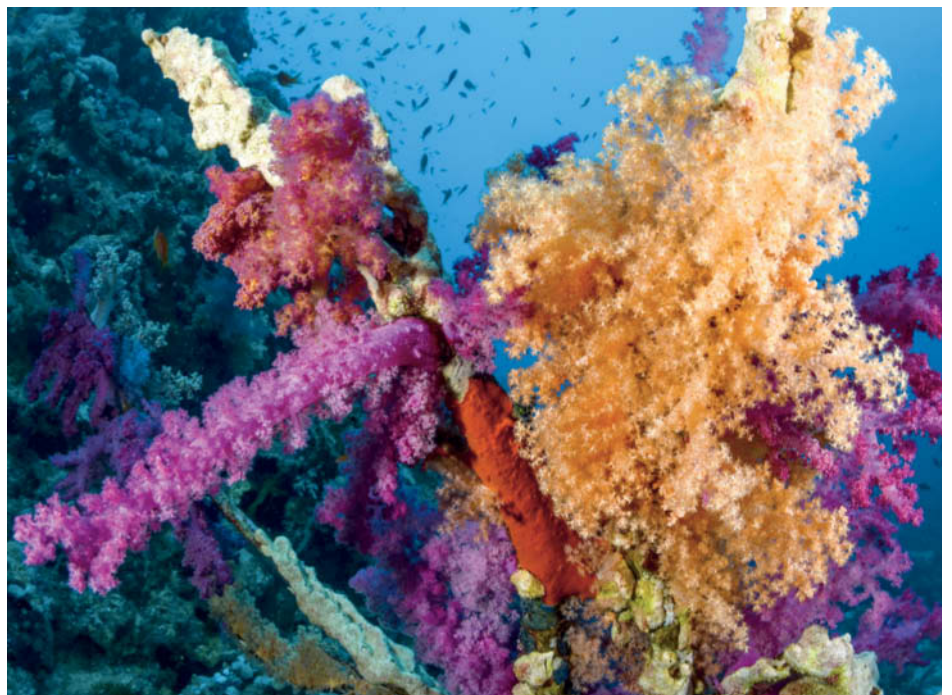
A coral garden on a steep wall in the Straits of Tiran. The currents are strong and there is not a lot of time to concentrate on shooting but, with a little luck, it is still possible to capture beautiful images.

DSLR | ISO 200 | 10 mm | f10 | 1/60 s | Flash at 1/2 power
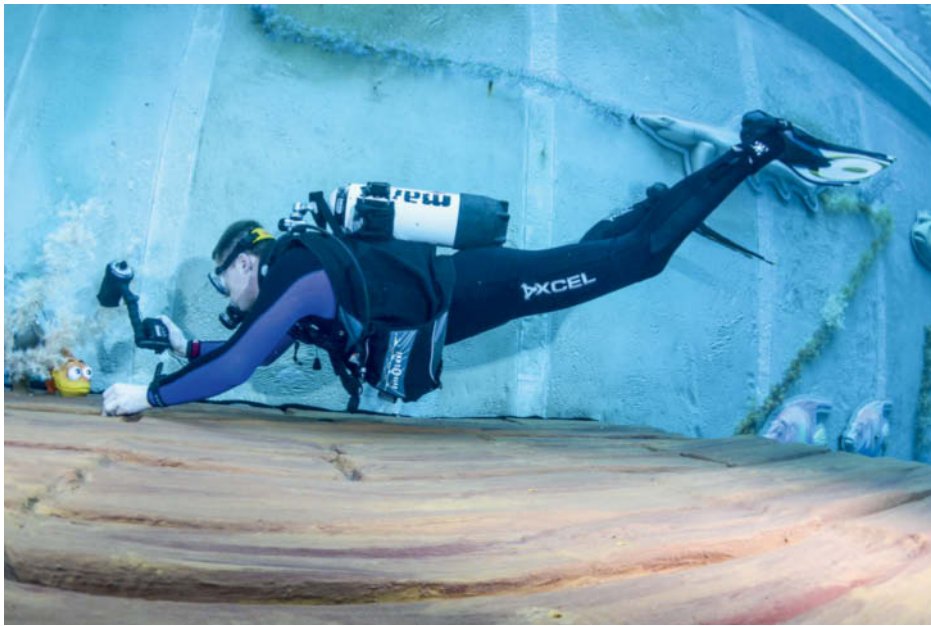
I find this is the best position for taking photos: the photographer's body is slanting downward and the weights have been selected so that only two fingers are needed to get a firm hold.
DSLR | ISO 800 | 10 mm | f8 | 1/80 s | Flash at 1/2 power

which means that we only had to guide it and barely had to hold on to it at all. On the other hand, we deliberately established negative buoyancy in the DSLR so that it would sink slowly if left to its own devices. The degree of buoyancy you use is entirely a matter of personal preference.

In the water, the weight of the housing can be easily adjusted using simple aids. Cameras are usually too heavy, so you almost always need additional lift. Which option you choose will depend on your budget. The best (but also the most expensive) solution is to use carbon flash brackets, which generate lift. I use these with my DSLR housing. You can also use a neoprene cover for your flash or simple foam surrounds that protect your flash bracket and provide extra lift. If you want to spend the bare minimum, you can use aluminum flasks or plastic pipes filled with foam. With a little imagination, there's no limit to the DIY buoyancy aids you can create from simple components found at any hardware store.

For locating subjects under water, a monitor works better than a viewfinder, so point-and-shoot or mirrorless system cameras are the obvious choice. Most DSLRs have live view too, but that just makes autofocus slow and increases shutter lag, so you end up using the viewfinder anyway. To do so, however,

you have to get your eye as close as possible to the eyepiece, which is quite tricky when you are wearing a diving mask. The design of the housing can make it even more difficult.

A mask with large eyepieces and a small interior volume brings your eyes closer to the camera, and the accessory market also offers magnifiying viewfinders that protrude a little from the housing, allowing space for the regulator between your mouth and the housing. The best option is a 45-degree angle finder, because it allows you to position the camera very close to the floor, allowing you to stretch your body out horizontally without damaging any underlying vegetation or reefs. Since this is the most desirable position for underwater photography anyway, this type of viewfinder is well worth having.

Point-and-shoot cameras are far better than DSLR housings in this respect, as you really can hold the camera at arm's length yet still assess your composition on the monitor.

Under water, the third dimension comes into play, since the water gives us the ability to 'fly'. The number one rule in nature photography is to respect nature and not damage it. When I taught diving in Thailand, I finished all my dive briefings with the words: "Leave only bubbles and take only memories". The 'Notes on the Underwater Environment' box opposite goes into more

detail on a topic that is very close to my heart.

Perhaps you are wondering how, floating freely in the water, armed with what is probably quite a large camera, you are supposed to photograph a small object near the ocean floor from as close as possible, preferably looking up to the surface from below? Yes, and without bumping into anything, and ideally somewhere where there is a gentle current flowing!

Congratulations, you just identified the greatest challenge in underwater photography, and with a little practice and good diving skills, you too will able to master such situations. Set up the camera, flash and exposure the way you think you need them for the image and make a test shot of some nearby coral to check the exposure and flash settings. Now look for something to hold on to. This could be a stone, sandy ground or a piece of dead coral – you can almost always find something that works. Now you can approach your subject slowly and carefully, taking care not to disturb anything with your fins.

The best way to swim is at an angle of about 45 degrees, facing downward, so that your fins point away from the floor. When taking photos, I prefer to dive with a little extra lead, so I wear light, large fins. You will usually only need to use two or three fingers to get a grip. By breathing out gently, you can increase the upward pressure on your handhold and carefully move closer to the subject. Having got into position, you can relax and start shooting.

Start with stationary subjects like crabs, snails and plants. Since fish are inclined to swim away, you have to work very quickly and precisely around them. It is not easy to strike the balance between speed and restraint that is required to avoid startling fish. It is much easier to allow a fish to swim into the frame than to chase it with the camera. To be honest, there is always a measure of luck involved in a good underwater photo.

Time of Year and Time of Day

So what are the ideal conditions for underwater photography and when is the best time to plan a trip? Basically, the same rules apply underwater as anywhere else. In the morning and evening the sun is not so high in the sky, so you get more attractive angles in underwater light rays. I like diving at sunrise and I love the magic moment when the dark water near the boat suddenly becomes a blue, transparent ocean – as if someone had switched a light on.

The seasons also play an important role under water. Cold fresh water is often clearer than warm fresh water, but even in the sea, it's worth paying attention to the seasons. While there is less seasonal variation in the tropics, there are still better times for finding certain fish, for example. You are more likely to encounter a shark in the off season than when there are a lot of other divers in the water. Tropical seas are also prone to algal blooms, which have a detrimental effect on visibility. The Red Sea, for example, is warmer in the summer months than in winter, but also murkier. Every meter of visibility counts in underwater photography, so book your travel accordingly.

Shooting Underwater Video

Since almost all digital cameras now also shoot video of acceptable quality, I would like to address this topic briefly. Unfortunately, different rules apply for videos than for photos. The vagaries of light sensitivity, mixed light, frame rates and film formats require different skills and, more importantly, different settings. Flash and focus-assist lamps are no use for videos either. Basically, shooting underwater video requires a lighting system that is prohibitively expensive for most people.

Another problem with underwater video is that the red component of the image is absent. Because there are not many settings options for video, and usually no extra lighting, you either have to use special software and spend a lot of time adding color at the post-processing stage or go for the simpler solution of using an orange or magenta filter while you are shooting. Such filters are available for most camera models starting at around US$80, and provide nice color saturation and usually better contrast as well. Filters can, of course, be used for stills photography too.

My personal opinion on video under water is that while the video function in a camera is nice for the odd occasion when you want to film something, it's best to concentrate on one thing at a time. That's the only way to get results worth talking about. I really like videos, but what keeps me from making them is the amount of time it takes to edit the material and add sound and captions. Just viewing and sorting photos is enough for me!

The Perfect Photo is Just Around the Corner

If you utilize the tips in this workshop and practice a bit, you will soon taste success in the form of great photos. Take photos whenever you can, because you have to be a master of your craft in order to capture the perfect image at just the right moment. Of course, you also have to be lucky enough to be in the right place at the right time.

I put this workshop together with the help of a cheap point-and-shoot camera and a full set of professional camera equipment. I've been photographing under water using SLRs for the last 10 years or so and haven't had a point-and-shoot in my hands for ages. I often used both cameras at the same time for this workshop, and was surprised how easy the point-and-shoot was to use.

I became extremely frustrated at the beginning because working with the point-and-shoot wasn't at all like working with the DSLR. However, I got used to the cheaper camera after a bit of practice and ended up taking some great shots with it. Don't get downhearted if your photos aren't perfect right from the start. At the end of the day, the biggest drawback of all small-sensor cameras is their inability to capture usable images at high ISO values. While a DSLR still delivers acceptable images at ISO 3600, high noise levels mean ISO 600 is the highest you can go with a point-and-shoot. Since lighting conditions are only average (at least they are in German waters), cameras that are capable of capturing noise-free photos at high ISO levels obviously have the advantage.

Lastly, and most importantly – have fun making your own underwater images!   (jr)

Notes on the Underwater Environment

Environmental protection is a very touchy, much-discussed topic in the underwater photography community. On the one hand, beautiful photographs of incredibly colorful reefs with multicolored fish can make non-divers more aware of the issues involved. The better understanding people have of the beauty and fragility of the underwater world, the greater their desire and motivation to protect it. Underwater photos obviously have a contribution to make here. However, there are inevitably divers who charge recklessly through a coral reef with only the next photo in mind. Worst-case scenarios involve seahorses being grabbed by the tail to turn them toward the camera and gorgonians (sea fans) being broken off because the photographer did not want them in the frame. I am not exaggerating here – I have witnessed both these events while diving.

No matter how wonderful the subject may be, it is never okay to damage the underwater world. Always pay attention to your buoyancy and proper positioning of your fins, and take care not to destroy anything. Hard coral grows at a rate of about 10 centimeters a year, so if your careless fin movements knock a piece off, it won't grow back in a hurry. Remember, too, that you are not the only diver who may inadvertently break off a piece of coral.

Whenever you're about to go diving, just picture yourself sitting at home in the evening, eating your dinner, when suddenly the door flies open and an enormous manta ray bursts in, puffing and panting noisily and dripping water everywhere. You 'visitor' then stands between you and your food and fires off five or six flashes that are so bright you see stars. Finally, as it leaves, the manta's fin smashes the antique vase that is standing on your coffee table. Your dinner is soaked and your living room looks like a disaster area. 'Unrealistic', I hear you say? When I look at how some divers carry on in manta dive locations, I find this scenario unfortunately all too easy to imagine.

So this is my personal plea to you – please respect and protect our environment!

Thanks.

About the Author

Patrick Verhey was born in 1977 and has been diving since 1991. He took his first underwater photos in 1995 and has been a diving teacher since 2005.

For more information on the author and his diving workshops, visit www.aquapixs.com

Ralph Altmann

Image Processing
in 32-bit mode

32 bits don't just mean another increase in color depth like the one
we experienced when 16-bit colors took over from 8-bit.
Thirty-two-bit processing heralds the beginning of a new era in image
quality and spells the end of limitations to tonal range, pixel
brightness and contrast, giving us the opportunity to capture the
world around us the way it really looks. It's possible that all image
processing will take place in a 32-bit color space in the future.
Photoshop already supports 32-bit processes, and this article
introduces some 32-bit tools and explains what's good about them as
well as explaining which aspects of the concept still need improving.

Because extreme tonal range can only be captured and processed in 32-bit mode, most digital photographers have come across the concept of 32-bit as part of the HDR image creation process. But conventional RAW images can benefit from 32-bit processing too. Many of today's quality cameras can capture a greater tonal range than most monitors or printers are able to reproduce. *Photoshop* introduced 32-bit saving and processing functionality in 2005 with the CS2 version of the program. CS3 built on these beginnings and offered 32-bit layer and mask functionality for the first time. Specialized HDR programs have been using 32-bit processes internally for years, but have yet to provide effective ways to edit such images in their native color depth. The only other program we have come across that is even remotely capable of 32-bit editing is *Photoline* (see the box on page 116 for more details).

What Does '32-bit' Actually Mean?

The tonal values contained in a 32-bit color space are handled by the computer's processor in the form of floating point numbers with a length of 32 bits – hence the term '32-bit'. Unfortunately, this term suggests that 32-bit image formats simply double the color depth of the image data concerned, the same way the jump from 8-bit to 16-bit did. However, the most important aspect of 32-bit processing is the inherent increase in the range of luminance it covers, enabling it to duplicate the range of tones that exists in nature, from an unlit nighttime scene to the brightly shining sun. Technical light sources such as lasers are often even brighter than that. From one extreme to the other, we are talking about a difference in brightness that is roughly equivalent to $1:10^{12}$ or more (i.e., 1 to 1 trillion, or 43 f-stops).

An 8- or 16-bit image can only represent a fraction of this range, where 'white' (generally signified by '100%') is represented by the highest available tonal value. The actual brightness of this tone can vary enormously depending on the ISO value, exposure time and aperture used to capture an image. You can find out what these were by checking a photo's Exif data, but not by looking at the image data itself. In contrast, a 32-bit color space enables us to allocate a digital value to every available level of brightness. These are the attributes that make it possible to correctly merge a sequence of photos into a

finished HDR image. The scale of 32-bit tonal values can, in fact, be calibrated using Lux values, although this is not particularly helpful in a photographic context.

Thirty-two-bit images have virtually unlimited tonal range, with values ranging from 0 to 10^{38} and more, depending on the image format you use. While an 8-bit sRGB image has a theoretical maximum dynamic range of approximately 12 EV (i.e., 12 f-stops) and a 16-bit image 20 EV (20 stops), a 32-bit image can capture a range of more than 260 stops, which is more than ever actually occurs in nature. The floating point TIFF format used by *Photoshop* and other image processing applications is capable of saving this extended range, while other popular HDR formats have to make some compromises. OpenEXR, for example, uses less disk space but can only save a maximum range of 35 EV – although even that is sufficient for most photographic purposes. Instead of simply clipping tones that are out of range, the 32-bit space can also record the 'negative' brightness values that sometimes occur in very dark scenes, although these are usually saved only temporarily. Not all contemporary HDR formats can save these values, which are discarded during transformation to LDR anyway.

The range of brightness in an LDR image (i.e., between 0% for 'below the normally detectable range' and 100% for 'maximum brightness we can capture') takes up only a very small portion of the 32-bit color space. *Photoshop* saves these values by default in the 32-bit range between 0.0 and 1.0 – a range that is easily large enough to save the values for a high-contrast 16-bit image too. This brings us neatly back to the subject of color depth – i.e., the number of levels of brightness available for each of the RGB colors. In an 8-bit space, we can reproduce 2^8 (= 256) brightness values per channel, and 2^{16} (= 65,536) values for a 16-bit image. No digital camera has yet been able to fully utilize even this range, and the best-quality images that today's high-end devices can capture have been limited to 14-bit, or 16,384 brightness values per channel. *Photoshop*'s pseudo-16-bit mode can reproduce 32,769 (i.e., $2^{15} + 1$) values, which is more than sufficient for capturing any 'real' scene. The range between 0 and 1 on the 32-bit scale encompasses more than 16 million different levels of brightness. For more on the subject, see 'Bit Depth Explained' in issue 5 of *c't Digital Photography*.

Thirty-two-bit techniques make it easy to achieve high color contrast and fine transitions between a broad range of tones

Advantages of the 32-bit Color Space

Currently, even pro photographers see using 16-bit techniques as more of a luxury than a

LDR

JPG (gamma-coded)
0   117   186   255

Camera (10-bit RAW)
0   184   512   1023

18 %
(medium gray)
Scale of natural brightness values (linear)
10 lx   5000 lx   10000 lx

HDR

8-bit Histogram

32-bit Histogram

−16   −10   (EV)   −5   0

Negative values   0.001   0.18   32-bit (linear)   0.5   1.0
0

−9.96   EV Scale (logarithmic)   −2.47   −1   0 EV
−15   −10   −5   −1   +1   +5 EV

Comparing different ranges of brightness: LDR images capture only part of the range available in nature, and the lower and upper limits are stated using zero and the highest value available for the color depth being used. In contrast, 32-bit formats can define digital values for every level of brightness. Although the 32-bit scale is itself linear, editing processes and histogram displays use the logarithmic EV scale (shown at the bottom of the illustration above). This gives 32-bit histograms an unusual appearance, with the tonal values in a 'normal' photo occupying only the right-hand portion of the scale.

necessity, so 32-bit images would at first appear to be a simple waste of effort and processing power. Many popular image processing applications are still not capable of processing 32-bit image data to the full, so we only begin to see what 32-bit color depth really offers when we start applying radical processing steps to our photos. The extreme alterations to contrast, brightness or color that are often necessary for high-contrast source images can cause banding and other visible artifacts in images saved in a low color depth format. The greater the color depth you use, the lower the risk of producing such artifacts. The 32-bit color space is extremely robust in this respect, and it is rare for any image data to get lost during 32-bit processing. Additionally, 32-bit shadows seldom get 'swamped' and highlights are virtually immune to clipping, regardless of the number or scope of the processing steps you apply to an image.

Another welcome side effect of working with 32 bits is that you simply can't 'overexpose' an image. However much you increase brightness – to lighten shadows, for example – the bright tones and the differences between them will be retained. And, even if they appear to fade increasingly to white on the monitor, reducing image brightness will make them visible again. A monitor can only ever display part of the range of brightness that the 32-bit color space can reproduce, the same way that a photo can only capture a small portion of the range of

brightness in nature. You can use your application's settings to determine which part of the scale you see.

Photoshop's 32-bit Exposure tool works in the same way as a camera's exposure settings, although camera settings remain fixed once selected, whereas the basic settings in a 32-bit image can be altered after capture. It is not yet possible to alter other parameters, such as aperture or focus post-capture in 32-bit images.

A 32-bit image can therefore be seen as a small piece of virtual reality that only turns into a photo when processed using a computer. This is why the computer-generated images (CGI) that have been in use for years in the movie and advertising industries are generally captured using 32-bit formats. Combining CGI images with 'real' image material enables us to produce extremely natural-looking lighting.

Photoshop's Exposure tool also allows us to alter the gradation using the Gamma Correction slider. This adjustment has a similar effect to using a different grade of paper or film in an analog context, although 32-bit images have no definitive gamma distortion levels attributed to them. In contrast to LDR images, which usually have a 'gamma' of 2.2, 32-bit images are coded in a linear fashion. This difference is not usually apparent on a monitor, as color management automatically accounts for different coding methods. Linear coding has definite advantages in various image editing situations.

To date, 32-bit images can only be read by specialized applications and cannot be properly reproduced in an image browser or using a printer, so the last step in the 32-bit editing process always involves 'tone mapping' – i.e., assigning the tonal values contained in one range to those contained in another. Altering gamma or exposure values within the 32-bit space is also a form of tone mapping, although in this case, the tonal values of a 32-bit image are assigned to those in the LDR color space. The greater the range of tones in the 32-bit image, the more difficult it becomes to execute this step, and the resulting image will consist of a highly compressed range of tones and an irrecoverable loss of image data.

Because there are almost as many different approaches to tone mapping as there are photographers, and because there are no optimum settings, it is best to leave tone mapping until as late as possible in the editing process. The better you prepare an image for 32-bit processing, the better the result of the tone mapping step will be.

Working in 32-bit Mode

Photoshop's HDR Toning tone mapping tool is introduced in the article on page 122. The following sections deal with the idiosyncrasies of the 32-bit color space and working in 32-bit mode, and also include hands-on examples of how to approach 32-bit image processing.

What's Possible and What's Not

Adobe has always developed its 32-bit processing functionality on an equal footing with its 8-bit and 16-bit tools, so 32-bit images can be edited in *Photoshop* using many of the same tools that can be applied to LDR images. Nevertheless, some tools work differently in 32-bit mode, while others have limited functionality or don't work at all. Since the initial integration of 32-bit layer and mask tools in CS3, development has slowed down somewhat, and some important functions are still not available for 32-bit images, even in the current CS6 release. These still appear in the toolbox (even in 32-bit mode), but their menu entries are grayed out (see the illustration below).

Tools such as Curves, which is designed to function with LDR tonal values between 0 and 1, have no place in the broader-based 32-bit environment. We can imagine a new, adaptive Curves tool that automatically alters its range according to the type of image being processed, but such intuitive 32-bit innovations have yet to be invented! The histogram panel is also 'dead' in 32-bit mode, and many other HDR applications have a head start on Adobe in this respect. *Photoshop* only displays a histogram in the HDR Toning and Levels dialogs.

As of CS3, you can work with 32-bit layers and masks almost as smoothly as in other modes. You can align, merge and transform images as usual, and the Puppet Warp tool introduced with CS5 is available in 32-bit mode too. You can also create layer and vector masks, although the range of available blending modes is quite limited. Annoyingly, 32-bit-compatible adjustment layers are only available in the more expensive *Extended* version of the program, although only about half the usual range of these and their corresponding tools in the Image > Adjustments menu are available. We

would particularly like to see 32-bit Curves, Brightness/Contrast, Vibrance, Color Balance and Black & White tools. Simple inversion of a layer or selection is not yet possible, which is understandable in a 32-bit color space in which individual tones are not clearly defined, but nonetheless annoying in layer masks whose tonal values lie between 0 and 1 anyway. The Invert and Threshold functions are available in CS6 for use on layer masks, and we will demonstrate a workaround for regular layers later on. HDR Toning makes a usable alternative to the missing Shadows/Highlights tool, which has been available in the regular Image menu since the release of CS5.

The Smart Object stacking functionality included in *Photoshop Extended* also works in 32-bit mode but, apart from the useful noise reduction and vibrance settings you can make when merging layers using Median and Mean modes, there is no real reason to convert a 32-bit image into a Smart Object.

The regular Selection, Brush, Stamp, Gradient, Eraser, Vector (Paths) and Text tools work fine, although the Magic Wand is disabled, so you will have to use the Quick Selection tool instead. The Dodge, Burn and Sponge tools are grayed out, as is – surprisingly – the Paint Bucket tool, which only has to fill a selection with a single color. The Healing Brush and Move tools are not grayed out in 32-bit mode, but if you attempt to use them, *Photoshop* now displays an error message to remind you that you can't. This is marginally better than earlier versions, which simply issued an 'application error' message.

We would also like to see the Noise Reduction and Lens Corrections filters included in the 32-bit toolbox. Until this occurs, you have to remember to reduce noise in your HDR source images before merging them, ideally during RAW conversion. Excess noise always becomes obvious at the tone mapping stage, if not earlier. The same is true of chromatic aberrations, whereas lens distortion can be effectively removed after tone mapping has taken place. Apart from Smart Sharpen (in basic mode), Unsharp Mask is the only sharpening filter that works with 32-bit images, although its Threshold slider is inexplicably grayed out.

In spite of these limitations, there are effective ways to reproduce most standard effects in 32-bit mode. The following sections show you how.

Since the introduction of *Photoshop CS3*, many standard tools can also be applied to 32-bit image data. The ones highlighted here in red are not (yet) 32-bit compatible.
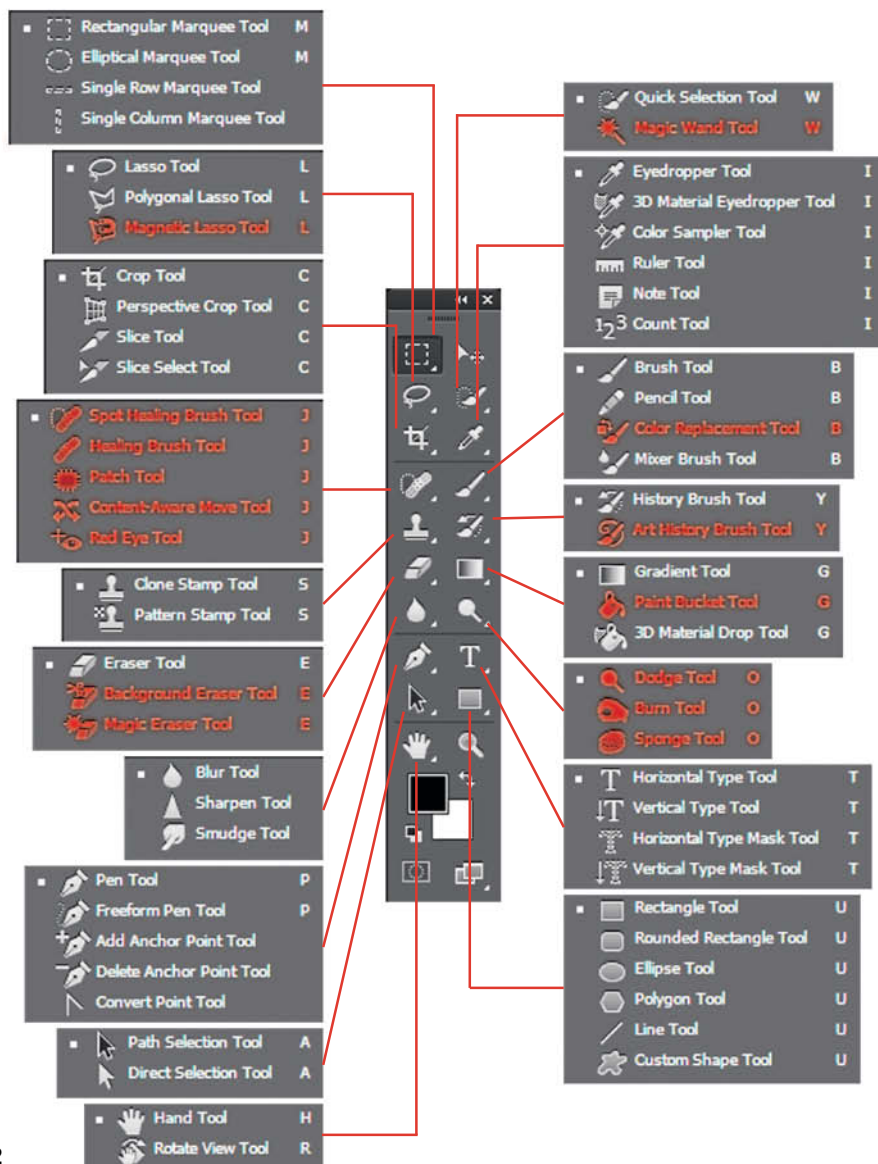
32 Bits, Please!

Before we go into detail about processing 32bit images, let's take quick look at how they are created. Different types of 32-bit image often have quite different attributes.

Conversion from 8-bit and 16-bit Files

All you have to do to switch an image to 32-bit mode is use the Image > Mode > 32 Bits/Channel command. The resulting image retains its original color space but the image data itself is linearized and converted to floating point numbers between 0.0 and 1.0 on a channel-for-channel basis. 'Linearized' means that the gamma distortion is removed. The lowest tonal value in the original image (i.e., zero) is given the 32-bit value 0.0 and the highest value (255 in 8-bit mode, 32,678 in *Photoshop* 16-bit mode) is given the value 1.0. This change does not involve any alterations to dynamic range and the monitor preview remains the same.

Merging Bracketing Sequences Using HDR Pro

The HDR Pro module is located under File > Automate and enables us to merge two (or more) photos from an exposure bracketing sequence to create a single image with greater dynamic range than the originals. When you merge two source images, the range of tonal values in the merged image always lies between 0.0 and 1.0, regardless of how large the difference in exposure of the originals or the scale of the increase in dynamic range. Even if it may sound like it, this is not a self-contradiction, as any increase in dynamic range doesn't have to be represented by 32-bit values above 1.0 and can just as easily be part of the range of darker tones.

If you merge three or more images, HDR Pro assigns an exposure value of zero to the middle one, while the others in the sequence are assigned values that equate to their brightness or darkness relative to the median image. This process takes place automatically and you cannot influence the choices the program makes. The EV of the darkest image determines the white point of the resulting 32-bit image. If this image has an exposure value of -2, the brightest pixels will have a 32-bit value of 4.0, while -4 EV equates to 16.0 – in other words 2^n, where n
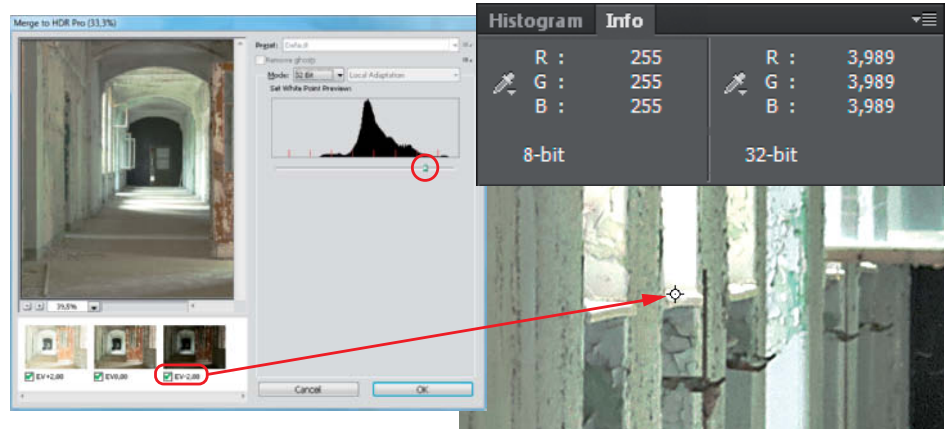
The EV value of the darkest photo in a series determines the white point in a finished HDR image. The White Point Preview slider located beneath the histogram in the HDR Pro dialog window can be used to determine the brightness level at which the white point is displayed on the monitor.

represents the smallest (negative) EV value. This value is relevant when it comes to displaying the image on a monitor, as we will see. The highest pixel value that a monitor can display is 1.0 (or 255 in 8-bit nomenclature), so the farther the white point lies above this value, the more highlight detail will fade to white on the monitor. Remember though, that the tonal values themselves are still present and can be recovered at any time.

Merging Bracketing Sequences Using Photoshop Tools

You can also use *Photoshop* layers to create HDR images. Simply load a bracketing sequence as a layer stack with the brightest image on the bottom and set the layers to Lighter Color blending mode. The exposure of the individual layers then has to be precisely adjusted using an Exposure adjustment layer as a clipping mask. For example, if you brighten all the darker source images, pixel data will be assigned to values above 255, which can then only be visualized in 32-bit mode. The white point value once again increases by a number of EV increments equivalent to the increase in exposure that you apply. For example, if you brighten your image by 6 EV, the white point will shift from 1.0 to 64.0 ($64 = 2^6$).

Alternatively, instead of brightening darker images, you can darken the brighter images in a sequence. If you do this in 32-bit

mode (or, if necessary, in 16-bit mode), dynamic range will increase while the white point remains at 1.0. This approach produces results that are closer to our normal visual habits and are easier to handle in the preview image display.

Merging Multiple Images

Superimposing multiple images with the same exposure value also increases dynamic range. Adding luminance values multiplies the white point value and is therefore only possible in 32-bit mode (i.e., can be performed using all versions of *Photoshop* from CS3 on). The *Extended* version of the program includes functionality that enables us to calculate overall mean and median pixel brightness, but only after converting the layer stack into a Smart Object. Here too, the white point has a maximum value of 1.0.

Importing 32-bit Images

HDR images that have been saved in HDR or EXR format using another program can be processed in *Photoshop*. The white point value in such images depends on the program used to create them. We have come across white point values of more than 10,000 – more than 13 EV higher than the standard '8-bit white point'. Values this high can represent real-life, bright lighting conditions, but nevertheless cause some programs severe problems during processing.

Navigating Your Way Around Differences in Brightness

The actual values of the white point and other tonal values within the virtually endless 32-bit space are largely irrelevant when it comes to determining range of contrast or image quality, but critical when it comes to displaying a preview image. The image below is displayed by *Bridge* and *Lightroom* as an almost pure white frame, and in *Photoshop*, we had to adjust the 32-bit Preview Options (located in the View menu) in order to be able to recognize its content. The *Exposure* option has the same effect as the White Point Preview slider in the HDR Pro dialog, and *Photoshop* automatically uses this value as its preview exposure value. Preview gamma values of less than 1 represent a considerable compression of dynamic range. Combining settings for these two sliders makes it possible to reveal detail for all brightness levels in most images, but can reduce overall contrast.

Neither the 32-bit Preview Options nor the 32-bit Exposure slider at bottom left of the preview window make any changes to the actual image data, although the options settings are saved with the image and are automatically reinstated when the image is reopened. These settings work for 32-bit TIFF and PSD images, but not for those saved in EXR or HDR formats. Unfortunately, neither *Bridge* nor *Ligthroom* can read the settings data stored with TIFF files, so these are always displayed too brightly. At the end of the day, it is usually simpler to apply a specific exposure correction to an image before saving it (see page 117).

Brightness and contrast are two terms that most people are familiar with, but that lose their intuitive feel when we switch to working in the 32-bit color space. The differences become apparent as soon as you try to change both. The familiar Brightness/Contrast tool is not available in 32-bit mode, making changes to these parameters much less trivial than usual.

Light and Exposure

In a photographic context, brightness is expressed in relation to the white point. The best example of this is probably the famous 50% gray, which is generally defined as 18 percent of the maximum available brightness. In the 32-bit color space, brightness has an absolute value which is, ideally, proportional to the brightness of the subject. A 32-bit image basically represents a small piece of virtual reality. In the real world, we turn up the dimmer to make a room brighter. This is exactly what a camera set to automatic exposure mode does – it recognizes dim light and adjusts the exposure parameters accordingly, producing a photo that, at first glance, looks no different from the same scene exposed for different lighting.

In the virtual space occupied by a 32-bit image, we can increase the amount of light by adjusting the Exposure slider (Image > Adjustments > Exposure). This has the same visual effect as the Exposure slider in the

32-bit Preview Options dialog, but alters the pixels in the image directly according to a factor calculated using the exposure value – for example, factor 2 at +1 EV. If only *Photoshop* would provide us with a usable 32-bit histogram, we could see that this type of adjustment 'stretches' the histogram curve. The previous white point and all tonal values below it are assigned twice as much brightness. Our medium gray reference point is now twice as bright too, but still represents 18 percent of the brightness of the white point. As in our automatically metered photo, visually nothing has changed. What this all means is that the Brightness slider is not suitable for altering brightness in this context.

Let's take a graphical look at how the three sliders in the Exposure dialog actually work (see the '32-bit Test Tool' box opposite). The response curves we used are included on this issue's free DVD. As previously explained, the Exposure slider alters the steepness of the curve – pixels with the tonal value zero are not altered and the rest become either brighter or darker. In color images, this adjustment is made separately for each color channel but, to keep things simple, the explanations below will cover only a single channel. Our diagram shows a fictional white point with the 32-bit value 1.5. The illustrated 0.5EV increase in exposure brightens this white point (i.e., the brightest pixels) to a value of more than 2.1,which means that the Exposure slider's main job is actually to adjust the white point.

An imported image with an extremely high white point value (on the left) can be adjusted for viewing using the *Exposure and Gamma* 32-bit Preview Options (in the center). The alternative *Highlight Compression* option rarely produces usable results and is immediately deactivated by the 32-bit Exposure setting anyway (on the left).
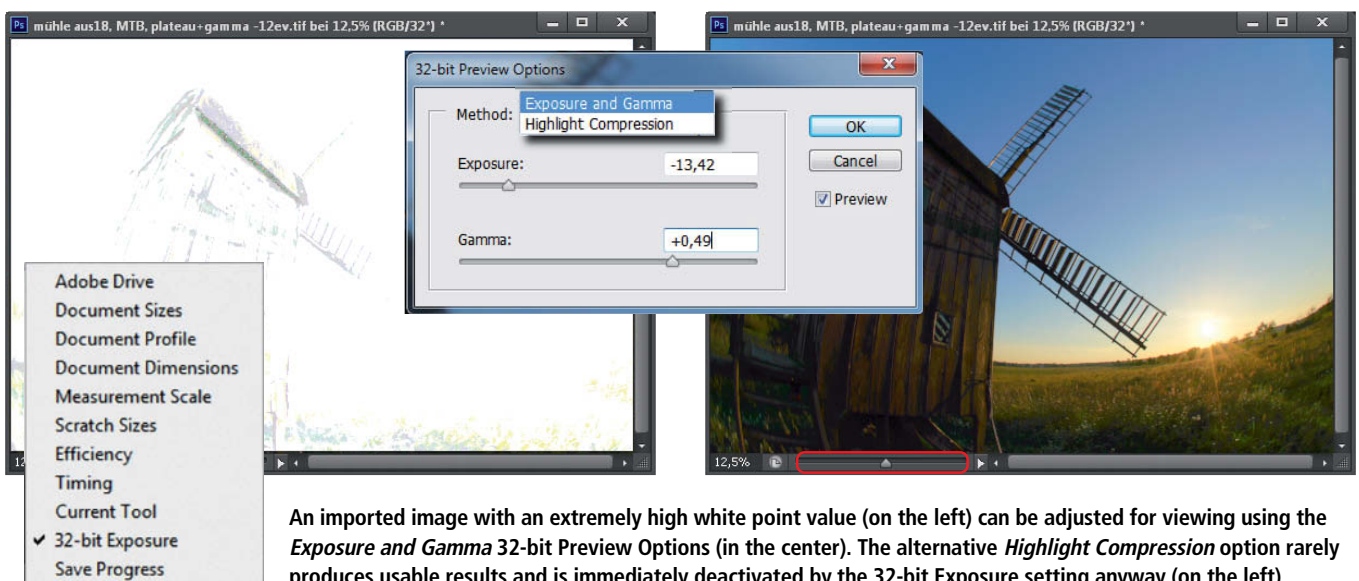
Adjusting exposure adjusts all the tonal values (including the white point) proportionally. The highlighted square, which contains only values between 0 and 1, indicates the limits of the LDR color space. In contrast, in the 32-bit color space, the white point can be assigned any value and can be shifted to any point within the space without causing unwanted tonal clipping.

The 32-bit Test Tool

Many of the illustrations printed in this article were produced using a custom multi-layer test image that makes the changes in tonal values produced by the application of various adjustment tools visible in the form of a two-dimensional curve. These curves are similar to those found in the curves tools included in *Photoshop* and other image processing applications. The horizontal axis represents the original tonal values (Input Values) and the vertical axis the processed (Output) values. The diagonal line from bottom left to top right represents the tonal values in an unprocessed image (i.e., the input and output values are the same). Adjusting or shifting the curve then assigns new values to some (or all) of the pixels. The Curves dialog acts simultaneously as a tool and a display of results, whereas the curves produced by the test image only show results, although they do this for any tool that applies global changes to the tonal values in an image. Because they show how RGB tonal values respond to processing, I have called them 'response curves'. They give us a useful view behind the scenes of our image processing software and help us to understand how many of the tools we use actually work.

You can conduct your own tests or reproduce ours using the custom curve-creating image included on this issue's free DVD. The image is based on a background layer created from a gray gradient that runs from -0.5 to +2.5. To perform a test, activate the background layer in the Layers panel and select a tool. The changes the tool makes, including those that only affect selected colors, are then shown in real time in the curve. Please note that this method only reliably indicates global changes to tonal values. It cannot be used to analyze sharpening and other local adjustments that depend on the nature of the surrounding pixels.

To help you better understand how to use response curves, we have posted an 8-bit version of the response curve at www.simpelfilter.de/analyse/gradation.htm. Try it out with the Curves tool (unfortunately not available in 32-bit mode) and see what you think.

Adjusting the midtone (or gamma) slider in the Levels dialog significantly alters the curve. In this case, the adjustment was only applied to the red channel. The highlighted square toward the bottom left corner of the graph contains the tonal values found in a conventional LDR image, ranging from 0 (=0%) to 1 (=100%).
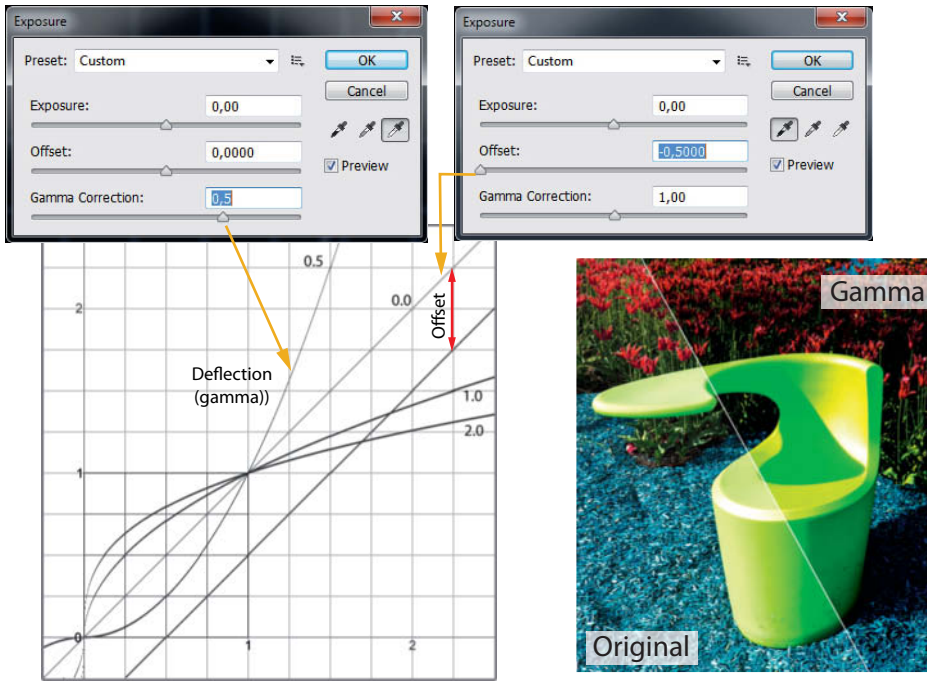
A Gamma adjustment changes the shape of the curve, while changing the Offset value shifts the entire curve, which can result in negative tonal values

to. The available values range from -0.5 to +0.5 and sampling a pixel using the eyedropper sets the lowest of its three RGB values to zero. The 0.5 boundary value doesn't limit the settings you can make, and you can even select an offset value that exceeds the slider's range.

The tricky part of using the Black Point Eyedropper and the Offset slider is that is it is very easy to produce negative tonal values – in other words, pixels that are (theoretically) 'blacker than black'. The problems that this can cause when displaying and processing images are explained on the following pages. You should only use these tools if you really know what you are doing.

The Gamma Correction slider adjusts tonal values up or down according to a non-linear exponential function and cannot produce negative values. But here too, working with 32 bits can produce some surprises. Normally, when working with LDR values between 0 and 1, a gamma value of more than 1 always indicates an increase in tonal value, while values below 1 signify a reduction. In the HDR color space, this relationship is inverted, so that pixels that have values greater than 1 (or negative values) become darker when a gamma value of more than 1 is applied, and vice versa. Changes in contrast are affected the same way, with gamma values of less than 1 increasing contrast and values above 1 reducing it (because shadows are brightened more than highlights).

Two of the sampler eyedroppers included in the Exposure dialog also affect the Exposure slider's setting: the white point eyedropper (on the right) assigns the value 1.0 to the pixel you click on. The center gray point sampler uses an Exposure adjustment to set the brightness (or 'luminance') of the selected pixel to 0.18, or 18%, which represents the medium gray tone

used in the center of a gray card. It is impossible to adjust the gray and white points simultaneously, as the two samplers overwrite each other's settings.

The left-hand eyedropper governs the black point and works in concert with the Offset slider, which shifts all the RGB values by exactly the same (absolute) amount that the slider is set

PhotoLine

PhotoLine (www.pl32.com) is a cheap, reliable image processing application that deserves more recognition than it gets. From version 17 on, it can process 32-bit images and gives *Photoshop* a good run for its money. All the conventional editing tools are available in 32-bit mode and even the histogram continues to function when you load 32-bit data.

The application's limitations only become apparent once you start processing. Almost all the available tools either clip tonal values above 1.0 and (if present) below zero or produce fairly dramatic color errors. Therefore, the best way to get the most out of the program is to shift the tonal values of your 32-bit image to within the prescribed range before going ahead with editing. Unfortunately, there are almost no serviceable 32-bit tools included. The White Point and Automatic correction tools aren't up to the job, and

there is no equivalent Exposure tool. However, you can work around these limitations by reducing dynamic range by sight in the Histogram Correction dialog

(see below). Sampling an appropriate value using the sampler pipette (eyedropper) helps to set the right white point. The only way to display the windmill image shown on page 114 was to set 1% for the upper limit and apply maximum compression to the curve multiple times. *PhotoLine* doesn't currently include dedicated tone mapping tools.
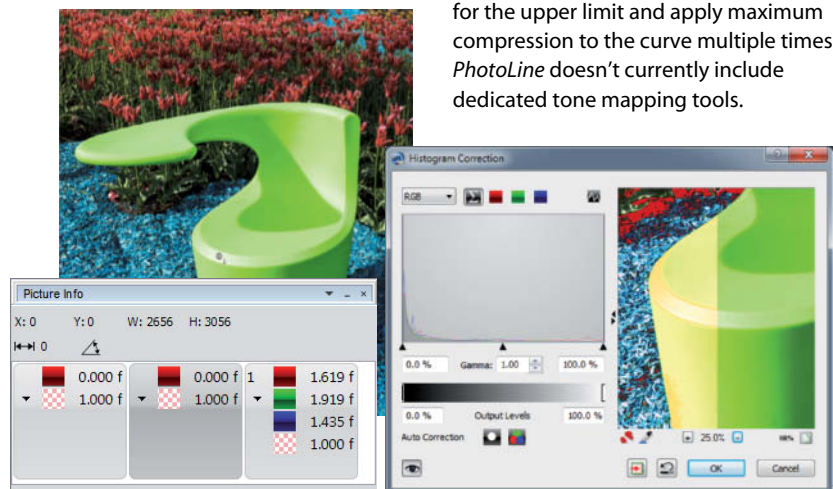
Adjusting Brightness and Contrast

Although the tones in a 32-bit image can have just about any value, processing and displaying image is easier if you stick to values between 0 and 1. This section explains how to set your black and white points to these values and how to adjust contrast so that the maximum possible contrast is visible on your monitor. The sample image shown here (included on this issue's free DVD) has very high contrast and an exaggeratedly high white point,which we have to correct before we proceed.

Step 1

Find your white point: Set the 32-bit Preview Options (in the View menu) and the 32-bit Exposure slider (in the status bar) to their default values. The slider can be set by double-clicking anywhere on the scale. Now navigate to Image > Adjustments > Exposure and move the Exposure slider to the left until the brightest pixels are easily identifiable. This is easiest to do if you switch to a 100% view first, either by zooming in (Ctrl++) or directly (Ctrl+1).
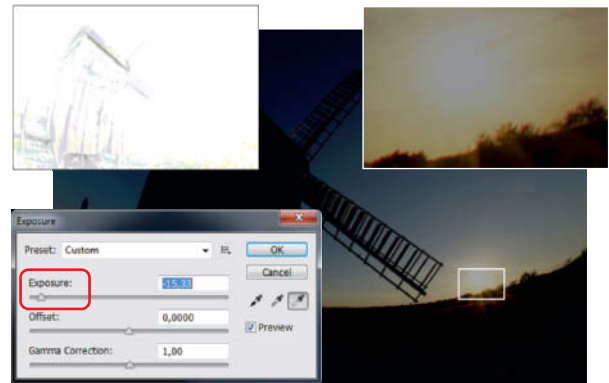
Step 2

Set the white point to 1.0: Switch the Info panel on (see the illustration) to help you find the true white point. Activate the right-hand eyedropper and click your selected white point in the preview image. Exposure will now be automatically adjusted so that the brightest of the pixel's three RGB values is set to 1.0. If the selected white point has a color cast, this will remain in place. The Exposure slider automatically sets itself to the new value and must not be moved from now on.
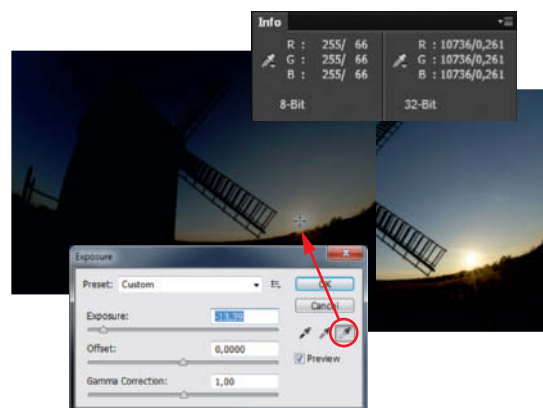
Step 3

Find and set the black point: The left-hand eyedropper sets the black point and alters the offset value rather than exposure. The easiest way to find the true black point is to move the Gamma Correction slider to the left until the dark tones become transparent and then click on the darkest point using the eyedropper. The Offset slider then shifts automatically to a negative value at the left-hand end of the scale. This in turn shifts the RGB values of the chosen black point so that the lowest of these is set to zero. All other tonal values are shifted by the same amount. Although the slider is limited to a maximum value of 0.5, the eyedropper can be used to set any offset value you like.

Finally, move the Gamma Correction slider back to the 1 position to reinstate the original level of contrast in the image. So far, we have subjected the image data to either proportional scaling or linear shifts – in other words, all these steps are non-destructive and can be undone without reducing image quality, even after we have clicked the *OK* button. The next section explains the challenges involved in setting the black point.

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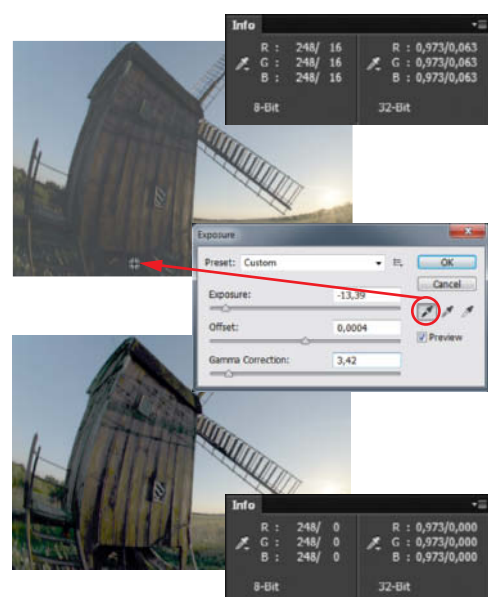
Adjusting Brightness and Contrast Part 2

Step 4

Adjust contrast: As well as helping us find the black point, the Gamma Correction slider also helps us to adjust contrast too. If you find a setting at which your image looks OK, you can stop here. Alternatively, if you continue with the following steps, using the Gamma Correction slider saves *Photoshop*'s HDR Toning tone mapping tool a lot of work when it converts your results to LDR.

Gamma values above 1 reduce contrast, while those below 1 increase it. If you like the look of intense HDR effects, it is better to increase contrast before tone mapping. Although Gamma adjustments don't alter a photo's curve in a linear fashion, the robustness of 32-bit image data means that they can usually be undone without losing any
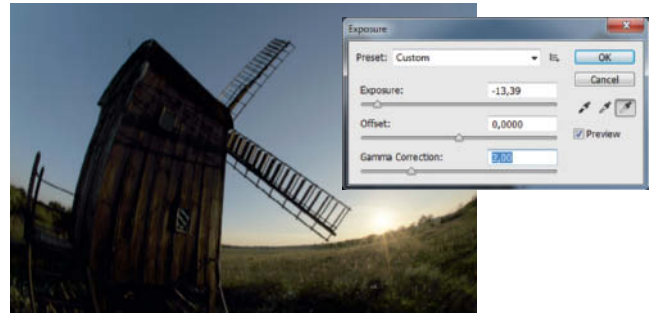
data. In this case, the order in which you perform exposure and gamma adjustments doesn't make any difference to the results.

Step 5

Remove color casts: Now that all the tonal values are between 0 and 1, you can safely use the automated adjustment tools in the *Photoshop* Image menu. The Auto Tone tool is great for removing color casts in the shadows and highlights. By default, the target colors for the black and white points are black and white, with a clipping value of 0.10%. These values can be altered in the Options dialog in the Levels tool. Set the Clip values to 0% and select other target colors if you wish. If you select the *Enhance Per Color Channel* algorithm option, the results will be the same as the ones produced using the Auto Tone tool. If you check the *Save as defaults* box, the settings you make will be used as standard for all the Auto correction tools.
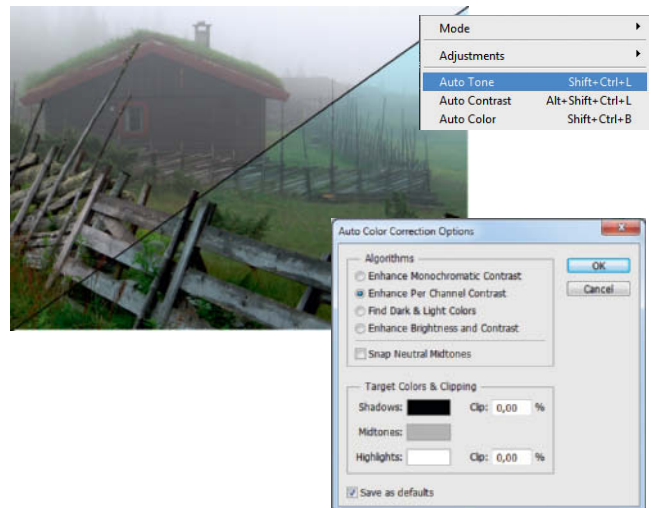
Is Altering the Black Point a Good Idea?

If you can't find the darkest pixels in your image when setting the black point, the darkest areas in the frame will end up with negative RGB values. This is not generally problematic when you are working in 32-bit mode, but some *Photoshop* tools can't handle values less than zero. Even the Black Point Eyedropper itself cannot reduce values to below zero.

So, if you have selected a black point that is too bright and you want to correct it, you can't just resample the black point somewhere darker using the eyedropper. To work around this problem, use the Offset slider to raise the values in the darker areas above zero and make them transparent. Because *Photoshop* always displays negative values as black (regardless of which preview options you set), this is the only way to differentiate between dark areas. You can now close and reopen the Exposure dialog and select a new black point.

The Black Point Eyedropper shifts all the RGB tonal values by the same absolute amount, which alters the relationships between them, especially the lower ones. In turn, this causes changes in color and saturation. Zero or negative values in one or more channels cause problems for the HDR Toning tool. This is why I don't usually bother altering the black point in 32-bit images. Remember that you can alter the black point later in 16-bit mode without encountering any of these obstacles.

If you are working on a bright image that really requires a different black point, always set the white point first. Otherwise, you will end up with an indefinable shift and a spoiled image. By the same token, you shouldn't alter exposure once you have set the black point. If you do, the workaround we have just explained is often the only way to produce satisfactory results.

Levels Without Limits

The Levels tool isn't one I use very often, largely because the Curves tool is capable of making all the same adjustments and much more besides. However, if only due to a lack of alternatives, the Levels tool plays a significant role when we are processing 32-bit images. The conventional adjustments covered by Levels can be handled using the Exposure tool, but the Levels tool is nevertheless very useful when it comes to filling some of the gaps in *Photoshop*'s 32-bit processing arsenal. Before we go into detail on these, let's take a look at the way the tool works in the HDR color space. Remember that when we are working with 32-bit data, dynamic range is no longer limited by the values 0 and 255, even if itappears so in the tool window.

In the LDR color space, because 0 and 1 (the black and white points) represent the absolute limits of brightness, moving the two outer sliders further out increases the overall dynamic range of the image. However, in the HDR space, these are just numbers that tonal values can lie beyond. In this dialog, 0 is still considered to be the black point (and the corresponding eyedropper is still called the Black Point Eyedropper), although tonal values below zero are present and can be processed at any stage. Adjusting these sliders has no effect on the 32-bit histogram, but instead alters exposure. Shifting the right-hand slider to a value of 128 is equivalent to increasing exposure by 1 EV.

The two main sliders work in opposite directions and also have no effect on the histogram, only on exposure. The shift of 64 points shown here (from 255 to 191) represents a change in exposure of -0.5 EV. Shifting the two left-hand sliders is equivalent to moving the Offset slider in the Exposure tool. But for the eyedroppers and a hidden function that we will explain shortly, the Levels tool could be completely replaced by the Exposure tool. In this case, the eyedroppers work slightly differently from their counterparts in the Exposure tool, which sets only the lowest and highest of the three RGB values to the corresponding black or white point value (0 or 1), while shifting the others by a corresponding amount. This approach is prone to producing color casts and shifts. In the Levels tool, the default settings set all three channels in the selected pixel to 0 or 1, although you can use the Options dialog to set other target colors with higher or lower values.

Always set the white point first when using the Levels tool and the black point when using Exposure. The center eyedropper reduces midtones without adjusting their brightness, and is best used in areas of medium brightness. Using it also nullifies any white point you have previously set. Settings you make using the eyedroppers are not reflected in the sliders, and you cannot make changes to the gamma setting until you have used the eyedroppers.

The black and white point (input) sliders adjust the points at which the response curve has the values 0 and 1, which lightens or darkens the corresponding pixels (in this case, producing negtive values). The shift in the curve is marked in red and the change in tonal values in orange. The center slider alters the gamma value and thus the degree of deflection in the curve.

Tricks with Levels

The lower (output) sliders can be used to invert the tonal scale. To do this, simply shift them past each other in opposite directions. You can do this in the LDR color space too, although it is simpler to use the Invert command (not available in 32-bit mode). Use the settings shown at the bottom of the next page to work around this limitation. If you shift the sliders to their extreme positions (0 and 1), the tonal curve will be correctly
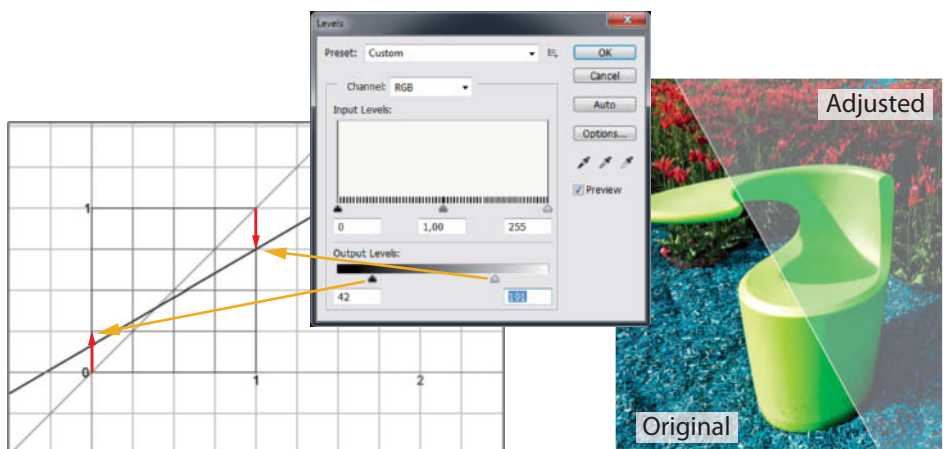
The two outer sliders brighten dark pixels and darken bright ones – the corresponding shifts are marked by the red arrows. The resulting response curve is less severe, indicating a reduction in overall exposure.
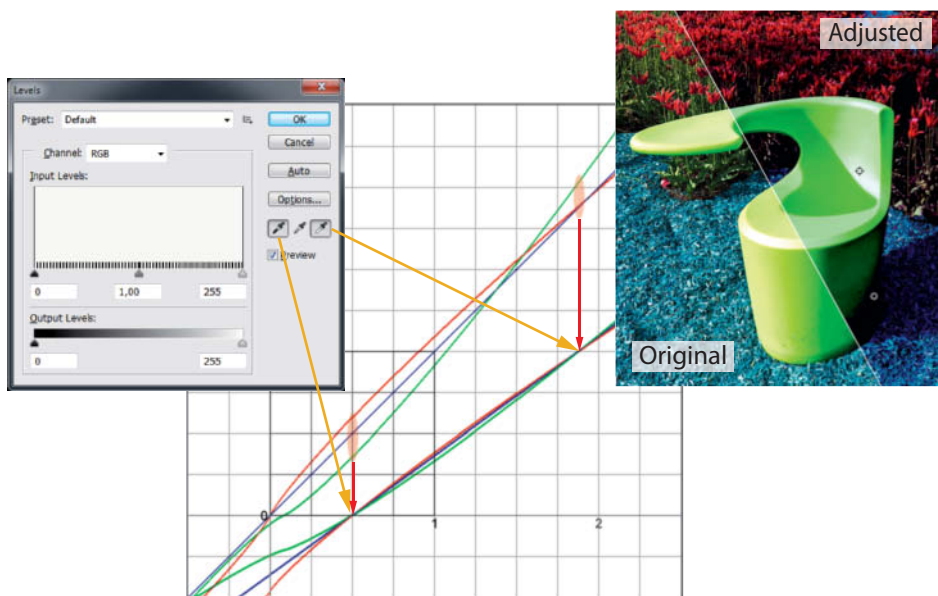
Using the black and white point eyedroppers to converge the individual color channels and remove color casts. The left-hand convergence point represents the original state and the right-hand one the result of applying eyedropper adjustments to a hypothetical image.

inverted, but high values from the original will become negative in the adjusted image. If you want to invert your image data, make sure that you set the white point to 1 first. You can also use the left-hand output slider to zero in on the white point: simply move it to the right until the brightest pixels in the original image become dark but not yet negative.

It is also possible to achieve an effect called 'partial solarization' by partially inverting the tone curve. To do this, invert your image, navigate to Edit > Fade Levels and select the *Difference* option in the Mode drop-down. You can then apply the same Levels adjustment as before by opening the Levels dialog while pressing the Alt key. Alternatively, you can use
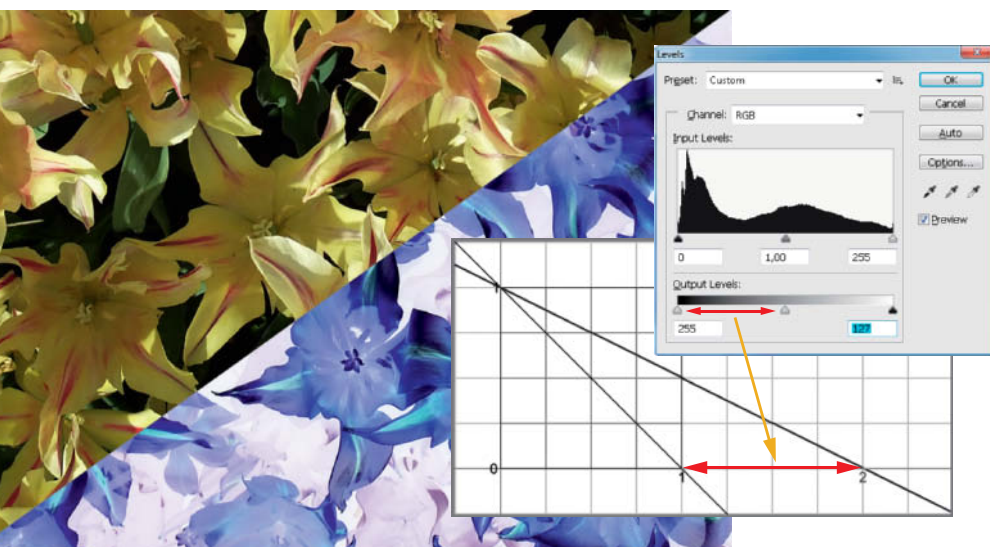
Switching the output slider positions in the Levels dialog inverts the tonal curve. Further shifts with the left-hand slider enable you to adjust the inversion to fit images with a high white point.

two separate Levels adjustment layers with identical invert settings and set to Difference blending mode (for the lower layer) and Normal (for the upper one). There is a hands-on example of how to perform the 'Levels Trick' on page 119.

Conclusions

If you don't happen to need your 32-bit images for photometric or CGI applications, the final step in the editing process will usually be conversion to LDR, which in turn requires the best possible quality source material if the tone mapping process is to be successful. the criteria to apply to a 'finished' 32-bit image are similar to those you would apply to 8- or 16-bit image data, namely: predefined black and white points and balanced contrast across the entire tonal range. We have shown you the *Photoshop* tools and tricks you can use to achieve these aims on the previous pages.

For tone mapping to be effective, it helps if most of the tonal values in your image lie between 0 and 1 before you start, although they will all be compressed to within this range during the process anyway, even if you don't switch to another mode first. This is an interesting feature of *Photoshop*'s native tone mapping tool (Image > Adjustments > HDR Toning), which can be applied to any RGB or grayscale image, independent of its color depth.

If you are tone mapping within the 32-bit space, the image willl retain its color depth, but its tonal range will be limited to between 0 and 1. In contrast, if you tone map an 8- or 16-bit image, it will be temporarily converted to 32-bit for as long as the HDR Toning dialog is in use. This way, all image types can benefit from the often superior contrast adjustments offered by the tone mapping process. In fact, the dividing line between the LDR and HDR color spaces is blurred if you don't consider the file format to be your defining criterion. An 8- or 16-bit image can easily contain a greater range of contrast than one that just happens to be saved in a 32-bit format.

The HDR Toning dialog represents the interface between the LDR and HDR worlds, opening automatically when a 32-bit image needs to be converted to a different color depth. Although the tool is fairly complex and not particularly easy to get to grips with, we have written a separate article on the subject (starting on page 122) in which we go into detail on how tone mapping can benefit not only HDR images, but 'normal' 8-bit and 16-bit photos too.   (anm)

How About an S-Curve?

The Curves tool would appear to be the only way to apply the popular 'S-Curve' used for adjusting contrast to a 32-bit image, although applying the Levels tool twice works too, as previously explained. A more flexible method involves using adjustment layers, but to do this you will need the *Extended* version of *Photoshop*. This example shows how to reduce contrast by brightening shadows and darkening highlights, which is equivalent to applying an inverted S-curve. It is, of course, possible to increase contrast by applying the opposite settings. Before you start, set the white point to 1. We have included a custom *Photoshop* Action that covers most of the following steps on this issue's free DVD.

Step 1

Brighten the Shadows: Create an adjustment layer that inverts the original image, producing a layer in which the original shadows are almost white. Now move the Gamma Correction slider to the left (i.e., to give it a higher value) until detail begins to show in the white areas.
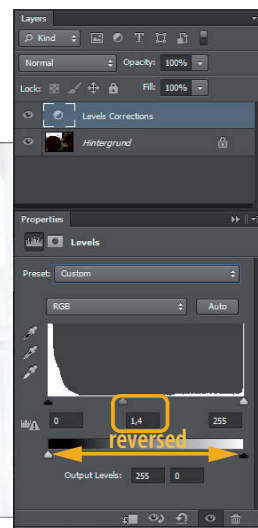
Step 2

Apply the change to the highlights: Duplicate the adjustment layer (Ctrl+J). The new layer will be positive, but, due to the altered gamma value, will have brightened shadows and darkened highlights.
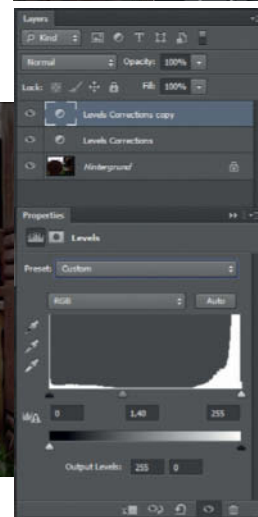
Step 3

Fine-tuning: Adjust the shadows and highlights individually using the Gamma Correction sliders for each layer. The lower layer is the shadows layer and the upper one contains the highlights. A shift to the right brightens the layer, while a shift to the left darkens it. Contrast is increased by shifting both sliders to values less than 1. In the response curves shown opposite, contrast is increased in the left-hand curve and decreased in the right-hand one.
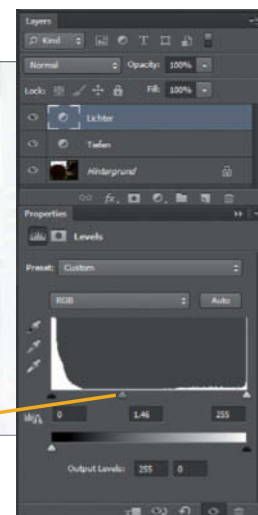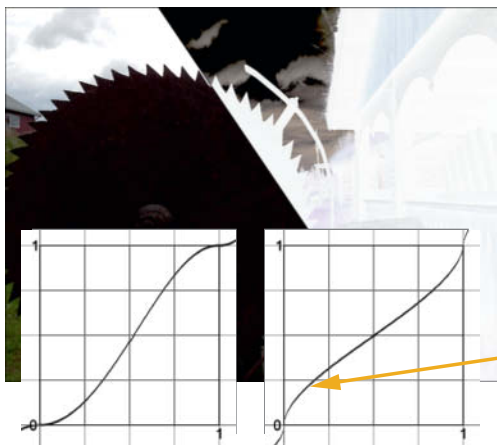
Ralph Altmann

Tuning Your Photos with
Tone Mapping

The dynamic range of many photos is too great for output on a monitor or in a print. One way of tweaking them is to the use the tone mapping techniques originally invented for converting 32-bit images to conventional file formats. 'Normal' 8- and 16-bit images can benefit from this treatment too, and this article shows you how to use Photoshop's dedicated HDR Toning tool to give your images that extra edge.

Tone mapping, the final step in the 32-bit image editing process and the interface between the HDR (High Dynamic Range) and LDR (Low Dynamic Range) worlds, is also useful when processing any kind of very high-contrast digital image. Today's high-end cameras can capture images with a dynamic range of 10 or 11 f-stops – a range that requires an HDR bracketing sequence of two or three separate source images if shot using a mid-range camera. Both approaches result in an image with too much contrast for

display on a conventional monitor or print output. The 'lost' details in such images can usually be found in the shadows. They are difficult to retrieve because every adjustment that brightens the shadows also brightens the rest of the tonal range too, resulting in pale midtones and burned-out highlights. The Shadows/Highlights tool introduced with the first *Photoshop CS* version in 2003 was the first tool to enable separate local adjustments to shadow and highlight contrast. In this case, 'local' means that the

differences in brightness between directly neighboring pixels are analyzed and adjusted, while more distant pixels remain unchanged. The *Unsharp Mask* filter works on the same principle, and using it with low Amount values and very high Radius settings (50 pixels or more) to improve detail definition was a technique that pioneering imaging experts managed to keep under their hats for quite a while.

Meanwhile, the developers of HDR software were working on 'operators' that map high-contrast tonal values to conventional color spaces without sacrificing detail. This conversion of HDR image data to LDR is called tone mapping. Although it is generally associated with HDR techniques, the term actually covers any adjustment to contrast that 'maps' existing levels of brightness to new tonal values, whether using gamma adjustments, Curves adjustments or the Shadows/Highlights tool. Ansel Adams' zone system is probably the most famous example of analog tone mapping. Tone mapping itself has nothing to do with the often exaggerated HDR effects it is used to produce. These are the usually result of applying excessive increases in local contrast and have unfortunately contributed to the dubious reputation that HDR techniques have acquired.

A Stepping Stone
between Two Worlds

HDR software is generally constructed to process sequences of source images that have

Tone mapping techniques really come into their own when applied to high-contrast images with dark details

been exposed differently, but inquisitive early adopters soon found out that it can also be used to process multiple copies of a single LDR image with different 'exposures'. This discovery was the birth of 'Pseudo HDR'. This particular technique can be handy if applied to multiple RAW images, which can contain more detail than a conventionally developed single image, but makes no sense if you are using JPEG source material. Using multiple copies of a source image seems to have become more of a nod to the functionality of HDR software than a necessity, as most contemporary applications can open and tone map individual LDR images and some also offer wide-ranging processing options for the post-tone mapping stage.

Tone mapping LDR images in *Photoshop* is quite simple. The HDR Toning tool has been available in the Image > Adjustments menu since the CS5 release and works with RGB and grayscale images saved at any bit depth. The tool's dialog is the same as the one that appears when you convert a 32-bit image to 8- or 16-bit, because *Photoshop* automatically converts LDR images to 32-bit when HDR Toning is activated and back again when you close the tool. If you are working with an earlier version of *Photoshop*, you have to manually convert your image to 32-bit and then immediately back to 8- or (preferably) 16-bit to open the HDR Toning tool. The only difference in the CS5 version of the tool is that a script automatically merges to the background layer and converts to 32-bit when you select the HDR Toning command.
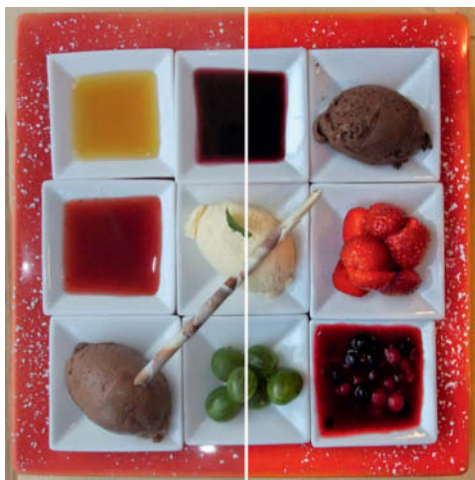
HDR Toning in Photoshop

Although the HDR Toning dialog offers various toning methods, we are only interested in the (default) *Local Adaptation* option. Adobe constantly changes the grouping and naming conventions for the tool's various sliders, although the CS6 version is still not ideal. The local contrast settings are grouped in a section with the misleading name 'Edge Glow' plus an additional 'Detail' slider. These sliders fulfill the same purpose as the 'local operators' used in dedicated HDR applications, producing the unmistakable look that is the trademark of so many heavily processed HDR images. In contrast, the *Photoshop* tool uses moderate default settings that preserve a more natural look.

All the other sliders make global changes to contrast and color and are, by default, set either to their (neutral) zero value or, in the case of the Saturation slider, to +20%. The default Toning Curve is perfectly straight, which would appear to indicate an unprocessed image. However, this is not the case, and simply opening the tool automatically lightens or darkens the source image by means of a non-linear function that analyzes the difference between the brightest and darkest pixels it contains. Except in the case of images with very low dynamic range, source images are usually brightened, sometimes quite a lot. The closer the tonal values are to zero and the closer they are to one another, the more the differences between them will be amplified. Colors are often quite literally torn apart, which can be beneficial to color contrast but often makes the colors themselves look unnaturally gaudy and produces color casts in shadow areas as well as increased color noise.

Unfortunately, these automatic alterations are not reflected in the default slider settings and there is no 'zero' setting in which the image retains its original colors. The Exposure and Gamma sliders can be used to undo any automatic changes by guesswork, but this only really makes sense if the program has brightened the image too much. Try to avoid using these sliders to increase brightness or contrast, as this can lead to unwanted clipping, and the HDR Toning tool has no clipping warning or clipping preview features.

Clipping is also a risk if you alter the global Shadow and Highlight sliders, which adjust brightness in their respective image areas, often overdoing things in the process. Adjusting the Highlights slider can easily cause brighter areas to burn out and the Shadow slider quickly produces swamped

shadows with no discernible detail. To be on the safe side, always use the Eyedropper tool to sample the brightest and darkest areas in an image. If the HDR Toning window is already open, you can activate the Eyedropper by clicking on the preview image while holding down the Shift key.

The safest and most flexible way to avoid clipping is to use the Toning Curve located at the bottom of the HDR Toning window. Although they look slightly different in this context, the curve and its associated histogram are just like the ones you are sure to have come across in the *Photoshop* Curves tool.

The HDR Histogram

The entire tone mapping process is based on the scale of tonal values that runs along the horizontal axis (see the illustration on page 111 for a schematic view). A conventional 8-bit (LDR) histogram covers tonal values from 0 to 255, which roughly represent the range of brightness that the human eye can perceive. Accordingly, the center of the normal scale (with a value of 128) represents what we perceive as 'medium brightness'. In contrast, the Toning Curve uses a logarithmic scale of EV (i.e., f-stop) values and assigns

Tone mapping can be used to give normal photos a quick makeover, accentuating selected colors and details
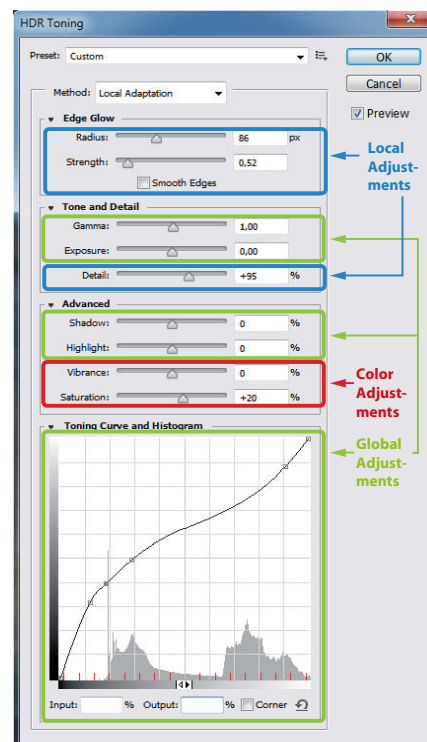
In its default Local Adaptation mode, the HDR Toning tool enables you to make local and global adjustments to color

Tone Mapping 32-bit Images

Photoshop's HDR Toning tool was originally developed for tone mapping 32-bit images, but works just as well with 8-bit and 16-bit images because it automatically converts them (temporarily) to 32-bit as part of the process. Nevertheless, due to the dynamic range they cover, some 32-bit images cause the tool more problems than images with less bit depth. When an LDR image is converted to 32-bit, the resulting image contains only tonal values between 0.0 and 1.0. The darkest tonal value in the original is mapped to the 32-bit value 0.0 and the brightest to 1.0. Gamma distortion is removed for all values that lie between 0.0 and 1.0 before they are mapped to

appropriate intermediate values. In contrast, an original 32-bit image captured as part of an HDR sequence will usually contain many tonal values greater than 1.0. Negative tonal values can also occur during processing, but any detail these may contain is eradicated because the tool cannot handle them at all and simply clips them.

The tool's *Equalize Histogram* and *Local Adaptation* methods automatically reduce tonal values greater than 1.0 (so that the total range doesn't exceed 0-1) while attempting to retain as much detail as possible. The *Highlight Compression*

method does not take the image being processed into account and simply darkens the highlights (usually excessively) even if all the tonal values in the original image have values less than 1. The *Exposure and Gamma* method has to be adjusted manually to suit the image at hand. Its default settings (Exposure = 0, Gamma = 1) clip all values less than 0 and greater than 1, while the values in between are processed linearly.

Local Adaptation is the favorite method of many photographers because, as the name suggests, it allows you to make local adjustments to contrast. Experience has shown that the more 'normal' the range of tones in the original image, the better the results turn out. The brighter the highlights in an image, the more the tool tends to produce edge artifacts and the trickier it becomes to find the right settings for the toning curve. The best approach is to adjust 32-bit images so that they contain only tonal values between 0 and 1 before proceeding with tone mapping. This way, an image remains in its original 32-bit format and is unlikely to suffer a visible reduction in dynamic range. Keep in mind that a range of tonal values between 0 and 1 covers more than 24 f-stops.

If you don't use the Eyedropper tool to set the white point (see the workshop section on page 117), you can still set it by eye in the HDR Toning dialog box. To do this, select the *Exposure and Gamma* method and reduce the Exposure value until the highlights are well defined. Then reduce the Gamma value until midtone detail reappears and the shadows are not completely black. Now click 'OK' and open the dialog again, this time in *Local Adaptation* mode. Although the tool has mapped the original brightness values to new tonal values, the histogram reveals that the image itself hasn't actually been altered at all. You can now go ahead and tone map your image and adjust local contrast.

When you have finished, convert your 32-bit image to 8- or 16-bit format using the Image > Mode command. The HDR Toning dialog will re-open, and you need to select the *Exposure and Gamma* method (with its default settings) to complete the conversion.
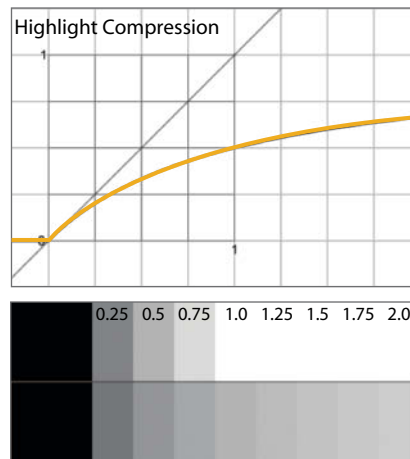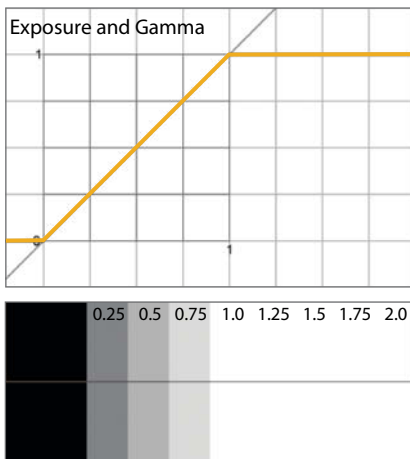
These illustrations show how the default settings for the four HDR Toning methods alter tonal values in a 32-bit image that originally contains both negative tonal values and values as high as 2.0. The grayscale bars beneath each graph show before/after views of the monitor or printer image for each.
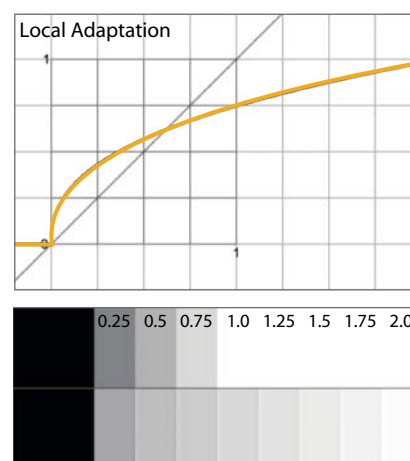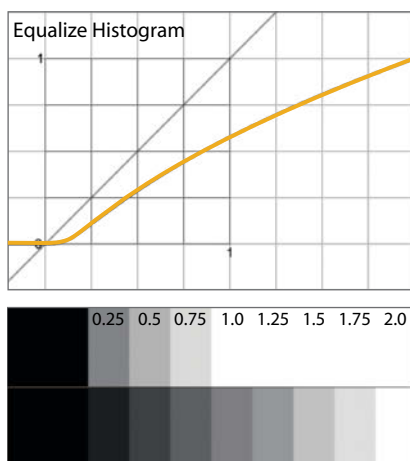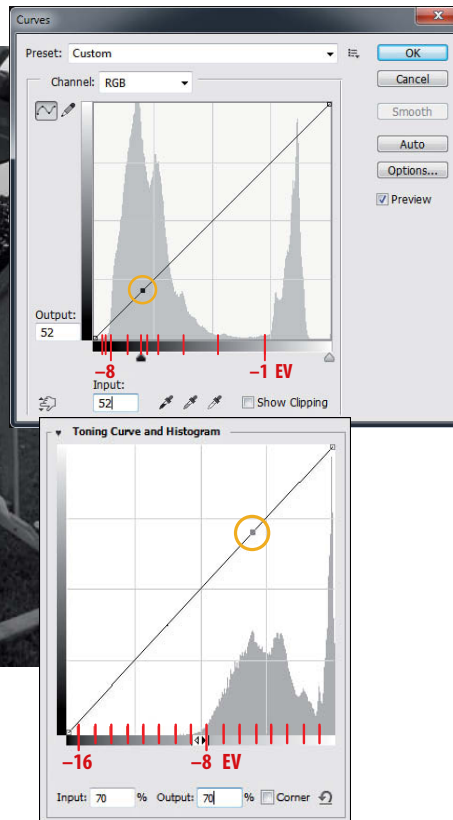
A dark gray pixel with a tonal value of 52 lies on the left of the LDR histogram (above left) but much further to the right in the HDR histogram (below left), where you would normally expect to find highlight values. The shadow values fill almost two thirds of the left-hand part of the scale. To make comparing the two curves easier, we have highlighted equivalent EV scales in red.

values according to the nature of the image being processed. *Photoshop* estimates the dynamic range of an image based on the number and brightness of darker pixels present and 'stretches' the scale to fit what it finds. If there are black pixels with a tonal value of zero, it program assumes that the image has a dynamic range of 16.5 EV, which is basically the range that can be saved in an 8-bit Adobe RGB JPEG image file. The individual EV increments are marked in red along the axis. If the image dos not include any pure black pixels, *Photoshop* uses a smaller overall dynamic range. If, for example, the darkest pixels have values of around 16 (out of 255), the EV scale will cover only 11 stops and the histogram will be 'stretched' accordingly.

The EV scale always begins at 0 at the right-hand end, which is equivalent to the 32-bit value 1.0 (i.e., 255 for an 8-bit image). Only 32-bit images can have positive EV values greater than this. The middle of the LDR scale (i.e., 128) lies at -2.4 EV – in other words, still quite a long way to the right. Just as a camera theoretically has the ability to carry on halving the exposure time ad infinitum, the EV scale has no limit at its left-hand end. The brightness value 0 (zero) lies at the far left of the EV scale at infinity. Slightly illogically, *Photoshop* indicates pure black pixels with an obvious peak at the far left of the scale as well as including them in its calculations for the vertical scale. This means

that the histogram can end up looking quite flat just because the image contains a number of black pixels.

The Toning Curve

You can set and shift control points on the toning curve the same way as in the Curves tool, although this too is not an insignificant task when applied to the 32-bit color space. The initial contrast and brightness adjustments performed in the background are not mirrored in the histogram or the toning curve, so applying an apparently identical adjustment to two images can have very different results if one of the images received differing adjustments to contrast and/or brightness before tone mapping begins. For example, if you move a control point along the horizontal center grid line, the Output box shows a value of 50%. In an image with tones ranging from 0 to 255, the same tone has an equivalent (Lab) lightness value of 36%, although it could just as well be 20% or 8%. Images that produce an HDR histogram with a lot of space at the left-hand end but have no pure black pixels (a typical combination for JPEG images captured using a compact camera) are not brightened as much and therefore have 'lower' 50% values. This makes it impossible to duplicate adjustments reliably using the toning curve, so you simply have to use trial and error for each image in turn. If you move the cursor

around the image with the mouse button pressed, a circular point on the curve indicates the luminosity value for the pixel at the current position, helping you to analyze the nature of your image before you start to make any adjustments. A Ctrl-click sets a control point, and you can set as many as you like for the most important image areas and shift them manually to achieve the effect you want.

The greatest advantage the toning curve over the Curves tool is robustness. While you have to take care not to flatten a conventional curve too much when adjusting contrast, the toning curve is much less prone to such anomalies. With just a few control points (with the *Corner* option activated if necessary), you can delve deep into the distribution of tonal values in your image without running the risk of producing dull or lifeless tones. However, the automatic adjustments performed at the beginning of the process often brighten an image sufficiently, so you may only need to make modest adjustments or even reduce brightness using the toning curve.

Adjusting Local Contrast

HDR Toning slightly increases local contrast by default. To see how things would look if this were not the case, set the Detail slider to 0 and Radius and Strength to their lowest-possible values. The result will be a weak-looking image, especially if you have already performed adjustments using the toning curve. A little extra local contrast is usually a good thing and counteracts any weakness that the tool's automatic pre-adjustments or your own adjustments to the toning curve may cause. The Radius setting determines the breadth of the area (in pixels) on either side of edge details that you wish your adjustment to affect, and the optimum value will depend on the nature of the textures in your image. The default value

The Toning Curve can be used to brighten an image zone by zone.
Please note: the tonal values given in the Output box at the bottom of the dialog box have no bearing on reality. We have added the real, measured Lightness (L*) values in the illustration above, although these too are only valid for images with good shadow detail. You may find that you have to shift the control points even further to produce adequate output brightness.

is three percent of the height of the image. If you find that your adjustments produce halo artifacts at object edges, increasing the Radius value often helps make this less obvious.

Alternatively, you can shift the Amount slider slightly to the left, which actually alters the threshold value that the slider was named after in earlier versions of *Photoshop*. Unlike the Threshold slider in the Unsharp Mask filter

dialog, this slider defines the upper limit of an adjustment, preventing contrast from being increased for tonal values greater than the value you select. This is also the tool's main advantage over the Unsharp Mask filter, which increases contrast in low- and high-contrast areas (disproportionately so in the latter), whereas HDR Toning only adjusts contrast where necessary (i.e., where contrast is low).

Nevertheless, we would like to see an additional Threshold slider here too, with which we could then exclude very low contrast areas from adjustment, thereby preventing unnecessary additional noise.

The *Detail* slider was added in *Photoshop CS5* and determines the type and strength of changes to contrast. Values between 100% and the default value of 30% produce impressive increases in contrast that cannot be achieved using other tools but don't have the over-the-top look of typical HDR processes. The *Smooth Edges* option added in CS6 helps to prevent the 'double edge' artifacts that often occur at the transitions between dark and bright areas when you use high Detail values.

Negative Detail values invert the effect and reduce local contrast, producing a kind of soft-focus effect – achieved by excluding high-contrast edges from softening – that leaves the image looking generally sharp. This approach is great for enhancing the look of skin and other surfaces that require a smooth finish.

Program Flaws and How to Work Around Them

For a tool that is already in its fifth iteration, HDR Toning is still surprisingly flawed in some respects. The main reason for this is probably that the tool was originally designed for tone mapping HDR images created from 32-bit bracketing sequences shot specifically for the purpose. Such sequences don't usually contain any of the near-black pixels that cause the tool problems and have to be brightened by way of an additional processing step (see page 129). The idiosyncratic handling, misleading histogram and often-unpredictable results of adjustments to the toning curve are – hopefully – teething troubles that Adobe will soon rectify with a completely reworked version of the tool.

The lack of a memory functionality is particularly irritating. Opening the dialog with the Alt key pressed doesn't recall the previous settings as it does with other tools, and the Ctrl+F shortcut cannot be used to apply them to other images. For this reason, HDR Toning

The Detail setting determines whether local contrast ends up looking edgy and three-dimensional or smooth and romantic.

is also not really script compatible. You can use it as part of a script or an Action, but not with a particular set of settings, even if they are saved as a preset. Smart objects are simply rendered if you try to apply HDR Toning to them. Note too that the color space of images is switched automatically (and without warning) to the RGB working color space set in the Color Settings dialog.

Additionally, HDR Toning cannot be applied to a single layer in a stack, and if you try, it will merge all the available layers to the background first. This is logical for LDR images, which have to be converted to 32-bit before they can be processed (single layers cannot be converted). HDR Toning can, however, be applied to 32-bit images, making this limitation unnecessary, and we have written an Action (included on this issue's free DVD) that enables you to apply it to individual layers, whether they are in 8-bit, 16-bit or 32-bit mode.

It can also make sense to preserve your original image and superimpose a tone-mapped version onto it in order to blend out overbearing HDR effects or apply them partially, and this is exactly what our Action does.

The Fade command is also grayed out after tone mapping. However, you can use the History Brush to copy pixels from a version saved in the History panel into your active image – provided that both have the same color depth and that you are working on the same layer. You can only copy pixels into a background layer from another background layer.

A look at the dedicated HDR competition shows that *Photoshop* is not necessarily top of the heap when it comes to user friendliness. The main advantage of the HDR Toning tool is that it is always available within the *Photoshop* workflow – a feature that makes some of its other shortcomings easier to bear. (anm)

The HDR Histogram and Dynamic Range

Just how much detail can a photo really contain? Is it worth brightening the shadows, or will you just end up with excess noise and other unwanted artifacts? The HDR histogram answers some of these questions, but can also cause confusion regarding the actual dynamic range involved.

Generally, the histogram's EV scale covers a range of about 16 f-stops, which – in view of the fact that most cameras cannot capture more than 10 stops of contrast – is more than enough for most photos. Hence the most significant portion of most image histograms lies in the right-hand half of the graph. The illustrations on the right show the results of applying the default HDR Toning settings to high-contrast JPG images captured using three different cameras. Instinctively, we assume that the image from the full-frame Canon DSLR is most likely to contain not just noise but also usable detail at the left-hand end of the (12-stop) scale. The histogram produced by the Fujifilm camera, with its much smaller sensor, registers no tones to the left of the 10 EV point in the center of the scale and provides about 9 stops of usable data without too much noise or banding. The histogram from the Olympus bridge camera apparently has a much larger dynamic range of more than 12

stops, despite its sensor being even smaller than the Fuji's. However, this is an illusion caused by firmware trickery that clips the darker tones in-camera to reduce noise. More than 1.6 million of a total of 10 million pixels in our sample image are pure black, compared with just a handful in the other two images. In theory, this type of artificial clipping leads to a greater dynamic range, but in reality, it produces rougher transitions between tones (see the brighter version of the image on the right). The details are visible, but pale and uninteresting.

Additionally, due to the large number of black pixels (indicated by the obvious peak at the left-hand end of the curve), one of *Photoshop*'s inherent weaknesses flattens the rest of the histogram curve to a point at which the differences between tones are hardly recognizable. Other dedicated HDR programs present compressed histograms that don't allow dominant areas to distort the overall picture.

Canon EOS 5D Mark II

Fujifilm FinePix F200EXR

Olympus SP 570 UZ

The amount of usable data contained in the last few bits of a JPEG image depends on the camera used to capture it. Among these examples, the histogram from the Canon EOS 5D Mark II DSLR has the greatest range, while those from the two compacts show hardly any pixels at all in the left-hand portion of the curve.
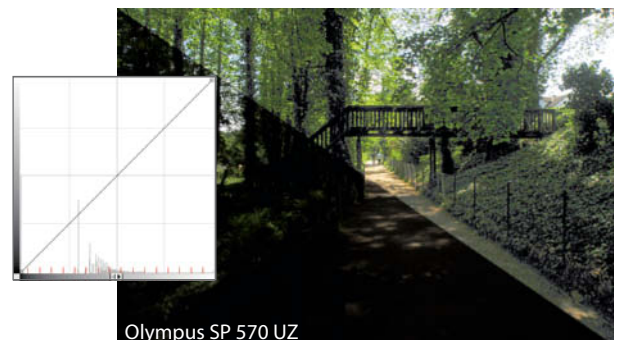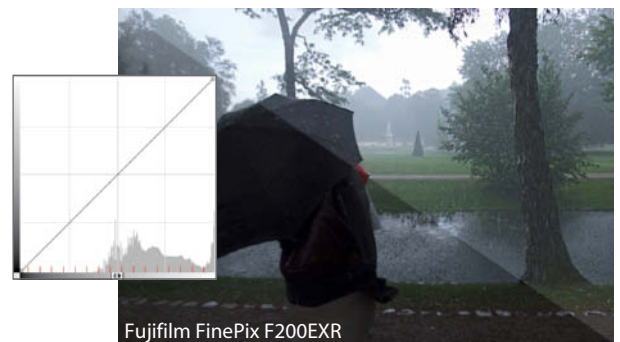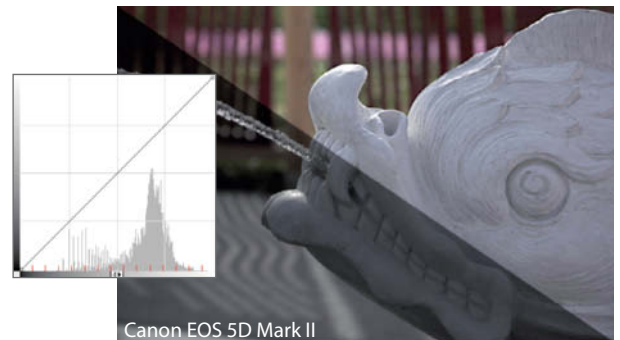
Optimizing Contrast with HDR Toning

This example uses the *Photoshop* HDR Toning tool to process a photo of the dark depths of a derelict industrial complex. You can't get blacker than this, but, noise permitting, we still want to try to coax a few hidden details out of the situation.

Step 1

Reduce noise: HDR Toning is merciless when it comes to increasing shadow noise. Always reduce noise (and especially color noise) in advance of processing. But take care: too much noise reduction can also swallow up detail and reduce shadow definition. Converting an image to 16-bit mode before applying the Reduce Noise filter with medium settings helps to lessen this effect. You should also remove any chromatic aberrations in advance, as these also tend to be exaggerated by the HDR Toning process.
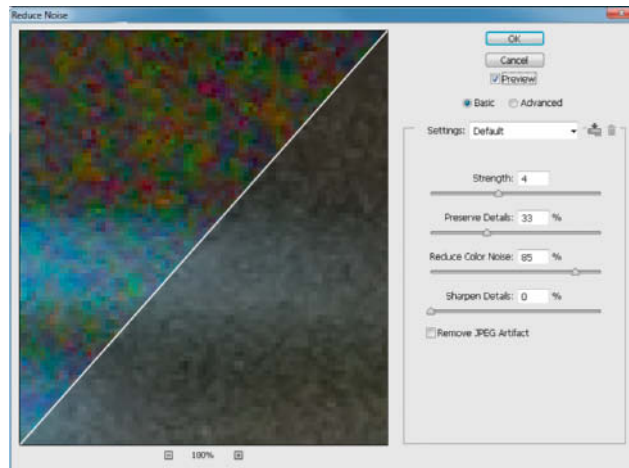
Step 2

Check for color casts in the shadows: Dark shadows that we are only going to brighten a little (if at all) should not contain color casts, as these can also be amplified during processing. Areas in which one or two channels contain tonal values of zero are paticularly tricky to handle and HDR Toning tends to turn them into extreme color casts that are virtually impossible to remove later on. If your preview image looks anything like the right-hand one in the illustration, halt the process and prepare your image as described in the next step.
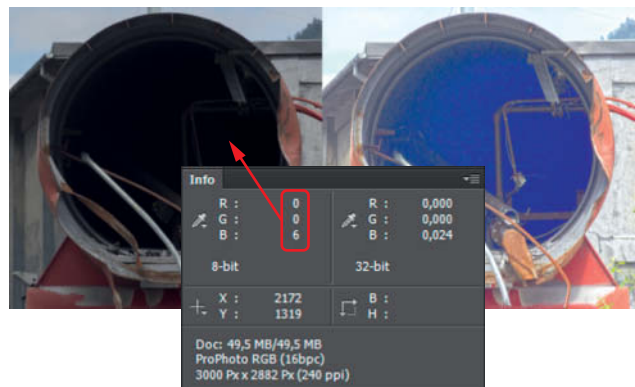
Step 3

Lighten the shadows: This step is only necessary if the shadows in the preview image show color casts as described in Step 2. Open the Levels dialog and enter a value between 5 and 10 in the *Adjust shadow output level* box at bottom left. Alternatively, you can use the Auto Color command in the Image menu or the Auto function in the Curves and Levels tools to do the same. If you use Curves, select the *Find Dark & Light Colors* algorithm for the best results. Set the *Target Colors* Clip value to 0.0. Unlike manual adjustments, using the Auto options influences the white point in your image too, which can cause slight changes to the overall mood.

›››
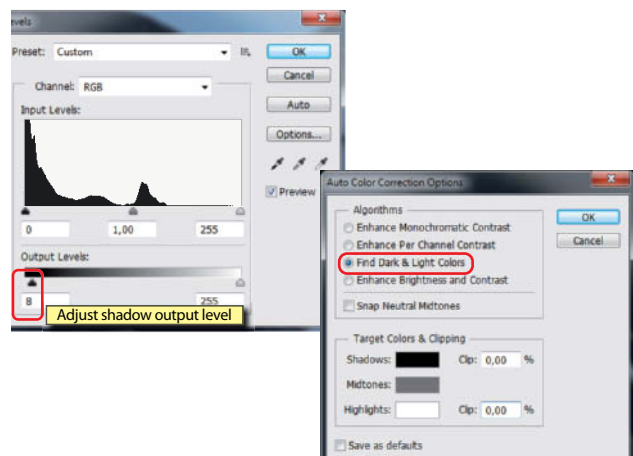
Optimizing Contrast with HDR Toning continued

Step 4

Open the HDR Toning dialog: You can now begin to apply HDR Toning to your prepared image. There is no dedicated command in *Photoshop* versions prior to CS5, but you can still open the dialog simply by converting your image to 32-bit mode and immediately back to 16-bit. If the program issues a *Merge layers before mode change?* warning, click 'Merge' (HDR Toning cannot be applied to layer-based images). Now select the *Local Adaptation* option in the Method drop-down.

Step 5

Select your zones: Move the cursor around the preview image with the mouse button pressed. This shows the current position of the cursor on the toning curve and in the histogram beneath it. Ctrl-Click on the preview image to insert control points on the toning curve for all significant tonal zones, making sure that you select at least the black point (i.e., a zone where black needs to remain black) and one or two details that you wish to brighten. This works best if you set the Eyedropper radius to 1 pixel and the preview to its 100% view (Ctrl+1). The results of setting manual control points are often imprecise, so you will have to experiment to find exactly the right locations. Unfortunately, the Navigator doesn't work while the HDR Toning dialog is activated, but you can shift the preview image using the Hand tool or the scroll bars and zoom in and out using the Ctrl-plus and Ctrl-minus keystrokes. Ctrl+0 fits the preview image to the available space in the window.

Step 6

Adjust brightness for your chosen zones: Now shift your control points up or down until you achieve the effect you are looking for. You can shift the black point control point right down to the zero line and, if this darkens the shadows too much, you can add one or two more points to bend the rest of the curve slightly upward. The *Corner* option removes the default limitation and equalization of changes from point to point, enabling you to produce angular changes in curvature. You can also use multiple points to limit the steepness of individual portions of the curve. Steep sections increase contrast and the visibility of details in that particular zone, while shallow sections have the opposite effect. Try to avoid producing horizontal sections. If you need to reverse the curve, try to do so in places where the image does not contain any tonal values (i.e., in 'valleys' in the histogram). Always check the preview image to see whether twists in the curve produce pale or unnatural-looking colors.
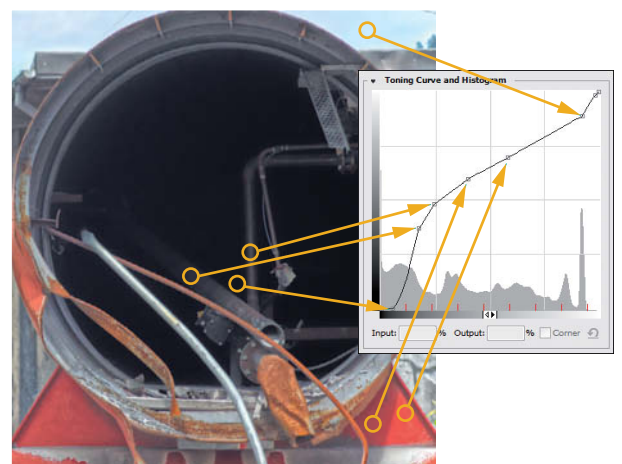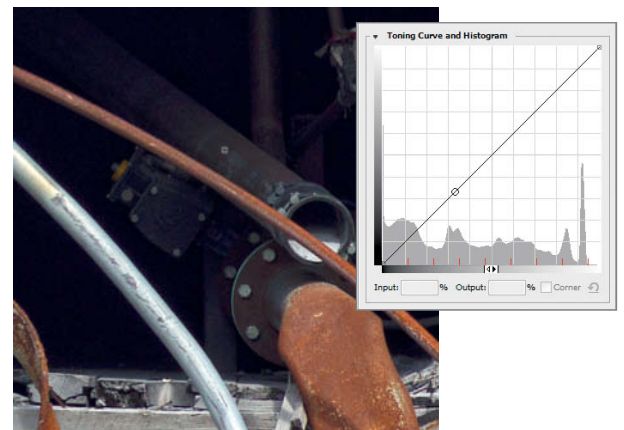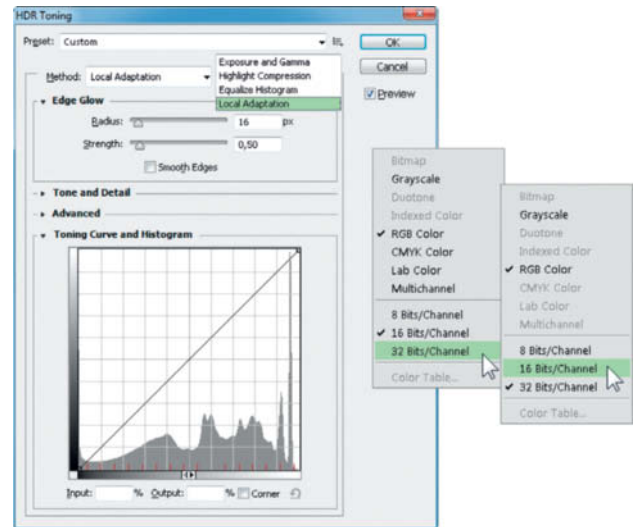
Step 7

Adjust local contrast: Check local contrast to see if it is already sufficient (or too strong). Use the 100% view to check for the double edges that can occur if you use extreme settings. Adjust the Radius and Amount settings so that there are no visible halos. Double edges can also be minimized by reducing the Amount setting. The *Smooth Edges* option added in CS6 is a useful additional smoothing tool.

The strength of the effect is actually set using the Detail slider. The default setting is 30% and the maximum value is 300%. A medium (0%) value produces results that are barely visible, even if you increase the other sliders' settings. Negative values (limited to -100%) tend to smooth details out too much.
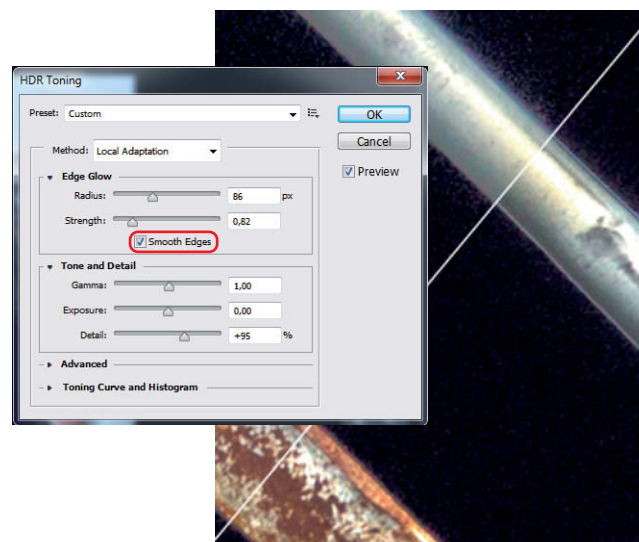
Step 8

Save your settings: *Photoshop* 'forgets' the HDR Toning settings you have made as soon as you close the dialog box, so you have to save them as a preset if you want to apply them to other images or create other variations on the image you are adjusting. In Windows, *Photoshop* saves presets in a small HDT file in a folder called *C:\Users\<User>\AppData\Roaming\Adobe\Adobe Photoshop CS6\Presets\HDR Toning*. You can, however, alter the path to save the preset file in the same folder as your image, which has the additional advantage of preserving your settings while not adding too many presets to the drop-down list in the tool's dialog. You can now click the 'OK' button to see the effect your settings produce. If you are not satisfied with the results, simply apply the preset you have just saved to the original image and re-tweak its settings.
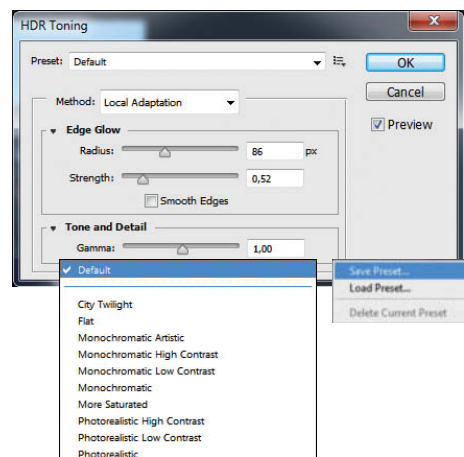
Step 9

Fine-tuning: If you brightened the shadows while preparing your image for processing, you can retrieve the missing deep black tones by shifting the black point slider in the Levels or Curves dialog to the left-hand end of the histogram. If you press the Alt key while making this adjustment, potential clipping is shown in real time in the preview window, enabling you to select the exact point at which clipping sets in. Alternatively, use the Black Point Eyedropper tool (the left-hand one of the three) to select the pixels that represent the black point in your image.
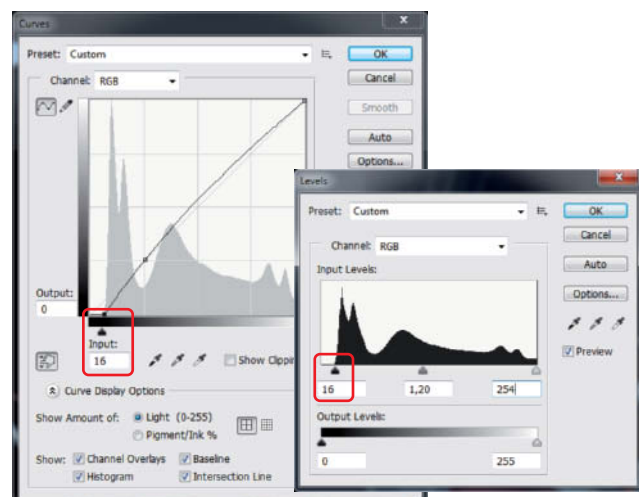
Tim Tadder

Wig Out!

How does he do it? Tim Tadder's 'water wig' portraits aren't composited and they are not created using multiple images. In fact, all he did was take a simple idea and give it a professional edge. We spoke to him about his work and got him to let us in on some of his secrets – and he's only too happy for you to try out his crazy idea for yourself.

Tim tells us: "The idea of creating and photographing water wigs came to me while I was watching the TV show 'Time Warp'. The show had people throwing water-filled balloons in other people's faces, and the whole thing was captured using a Phantom high-speed camera capable of capturing 1,000 frames per second. I had already seen similar photos of bursting balloons, but the combination of balloons and faces was new, and the result was the 'water wigs' project.

Bald heads make great water wig subjects, but we started by practicing on a showroom dummy. It took a whole day to get the technique and the lighting right, and we had to learn just how much to fill the balloon and how hard we had to throw it to get the effect we were looking for. The learning process involved a lot of mistakes, and we ended up producing a lot of really funny images.

The model for this shot was a professional wrestler. He was a real character, and this pose seemed to make the most sense, as if he was saying "Hey, you like my hair?" This shot was really about creating a moment of stillness within the surrounding chaos.

This is our UPS delivery man. He has such a cool look that we simply grabbed him for a shoot one day after he'd dropped off our packages. UPS eventually got hold of the image and put it in an article in the company newsletter.

This is my neighbor JR. We took about five shots of him straight off. He had no idea what he was getting into and he was a great sport, but I knew he wouldn't stick around for too long! We worked fast and got a few nice shots before letting him go. Back then, we had no idea that these images would become so popular. We were really just testing a concept that happened to work really well. I'm glad my friends and neighbors still talk to me now it's all over.

We used an inflatable kids' paddling pool to keep the water as localized as possible and to prevent it from ruining our studio gear. Our technique also required us to work in complete darkness – climbing a ladder in the dark and throwing a water-filled balloon onto a person's head from the top takes practice!

This technique requires millisecond accuracy to work effectively, so I ended up shooting with the shutter locked open and using a sound trigger to control the flash.

To create the images with the 'water snakes', we used long modeling balloons that we arranged around the model's head. My well-hidden assistant then burst the balloon with a pin. For these images, we used a laser light beam to release the shutter at the correct moment. The colors are all original and were created using filters attached to the flash heads. The only digital adjustment we made was a slight increase in saturation.

If you want to try shooting water wigs yourself, start small. Practice throwing balloons at inanimate objects, as even the most patient model won't put up with this treatment for long. A single light source is sufficient to get started, and if you don't have access to a sound or laser trigger, it's still worth taking the 'trial and error' approach to see what you can capture and whether the technique works for you."   (jr)

The Author

Tim Tadder is a professional advertising photographer from Los Angeles, California. Strong, dynamic images that make a bold statement are his trademark, and he combines unique lighting effects with a variety of locations to achieve his characteristic look.

You can find out more about Tim at timtadder.com or through Emissary Artists at www.emissaryartists.com.

This image was carefully planned, and we were on the lookout for just the right model when this guy appeared. His facial hair fit perfectly with the shape and concept we were going for. The water wig has an amazing angelic quality that contrasts really well with the model and his apparent inner stillness … **c't**

Book Reviews

Motor City

Detroit for John, Mary Lou and Mr. Duke

There is probably no other place whose recent destiny has depended so heavily on the rise and fall of a single industry than the US metropolis of Detroit. When the auto industry was at its peak, the city was home to more than two million people, but today its population is less than half of that. The many faces of the decline of the city – shockingly decimated residential neighborhoods and business districts, deserted streets and countless cases of personal economic disaster – have been extensively documented by journalists and photographers from all over the world.

In the midst of sobering circumstances, this book proves that it is possible to show Detroit in a conciliatory and optimistic light. The unusual title is not an artificial or abstract invention but rather a highly personal dedication to the photographer's uncle, his wife and their dog. Karin Jobst lives in Hamburg, Germany and experienced Detroit as a visitor.

The photos on display here show Jobst's great interest in hidden details as well as her eye for the big picture. She works in a documentary fashion but manages to introduce a degree of subjectivity that emphasizes the artistic nature of her images – at least at first glance. Most of these photos are dominated by pale, dream-like and sometimes surreal colors. Some images look like double exposures, while in others, foreground elements such as fences and railings create an unusual perspective. In spite of her unconventional approach, the way the photographer plays with our visual habits is neither forced nor intrusive.

She challenges but never harasses the viewer. In fact, the opposite is true, and the visual inconsistencies in the images collected here engender a compassion in the viewer that is simultaneously relaxed and enigmatic. Although people appear in very few of the photos, this apparently empty city looks neither deserted nor cold.

A raft of tiny details makes it clear that, despite the obvious challenges and constraints, Detroit's inhabitants continue to love and look after their city as best they can. Detroit has obviously been through hard times, but has not lost its dignity in the process.

Karin Jobst has taken a close look at a city that has seen seriously hard times, and the resulting images reveal many contradictions

Image: Karin Jobst, 2012 Kehrer Verlag

Hall of Mirrors

Identical

Martin Schoeller's previous book *Close Up* was a famous break with visual tradition, and his latest work *Identical* continues his exploration of unusual viewpoints. Schoeller gets much closer to his subjects than most portrait photographers and concentrates almost exclusively on their faces. If you were to approach someone as closely as this in an everyday situation, you would have to brace yourself for a harsh reaction.

The uncompromising composition of these images and the neutral expressions of the subjects, combined with the complete lack of surroundings and emotional overtones, enables the viewer to concentrate on the tiniest of details in each image. The large size of the pages and the high-end print quality make the stark presentation even more effective.

Visually, *Identical* follows exactly the same pattern as *Close Up*. However, instead of a collection of single portraits of celebrities, the new book is made up of sequences of images of monozygotic twins and multiple siblings, all dressed and made up the same and mostly with the same haircut. The book comprises a total of 50 sequences, portraying 45 pairs of twins, two sets of triplets and two sets of quadruplets.

The author's new choice of subject represents more than just a superficial change of tack. While the previous book left its viewers space to satisfy their curiosity regarding the feelings and inner life of its famous subjects, this volume gives its readers no option but to reflect on themselves.

The search for mutual features and differences in such similar faces automatically makes us consider our own appearance much more than we normally would. Anyone who is even slightly interested in outward appearances will find that this intriguing book leads to a deeper consideration of the processes of perception, prejudice and categorization.

The question of what makes an individual unique is just as far-reaching. How different from others does a person have to look to be recognized and considered as a separate being with his or her own innate destiny?

(Robert Seetzen/tho)

Identical

Martin Schoeller
Published by teNeues
132 pages, 110 color photos,
Text in English, German and French
12.6 × 9.8 inches
US$75
ISBN 978-3-8327-9664-8

The fascinating similarities between monozygotic siblings pose interesting but sometimes confusing questions

Image: Martin Schoeller, 2012 teNeues

Coming up in Issue 13

Hardware Acceleration for Faster Image Processing

▮ Adjusting colors, applying filters and converting image formats are all editing steps that require plenty of computing power, and using the right combination of CPU and graphics card can seriously speed up these types of processes. We test a selection of graphics cards and onboard graphics chipsets in all price segments and give you the low-down on which components work best with which systems and software. And we can tell you this much in advance – big is not always beautiful!

Compact Camera Mega-test

▮ To stem the flow of photographers abandoning their cameras in favor of smartphones, manufacturers are continually introducing new, high-spec compacts with bright lenses and high image quality to tempt users back to the fold. We test the latest conventional, high-end, outdoor and super-zoom models, and the results provide interesting insights on the current state of the game.

City Slicking

▮ Taking Photos in big cities is a real technical and aesthetic challenge, providing you with countless potential subjects and stimuli for all your senses. Before you take off on your next photo safari in the concrete jungle, get inspired by our in-depth workshop – pro photographer Torsten Andreas Hoffmann gives you all the tips you need to grab that unique city scene.