The white circles indicate individual dust particles on the camera's sensor. Each spot will require Photoshop's healing brush tool to correct. It is far better to learn how to keep your sensor clean than to "fix in post."

I Love My Digital, But...

With new technology comes new problems. Here are solutions to two common frustrations of digital underwater photographers. **TEXT AND PHOTOGRAPHY BY STEPHEN FRINK**

I REGULARLY GET questions from photographers who are having trouble getting the underwater images they want from their digital cameras. Two questions in particular come up again and again. The first has a pretty easy solution, the second is a little trickier.

DUST BOWL BLUES

THE FIRST QUESTION: What can I do about the black spots that keep appearing in my digital photos?

More than likely, those black spots on your images are created by dust on the camera's sensor. If the spots appear in exactly the same position in a sequence of photos, dust is certainly the culprit. When you view an image at 100 percent magnification, the spots can be pretty obvious, and quite annoying.

Photoshop's healing brush usually does a fine job of removing the imperfections, but if you have 100 shots with dust on the sensor, the same series of Photoshop tasks have to be repeated 100 times. Some software, notably Nikon Capture, tries to address the tedium of this issue, but the reality is that it's better to avoid getting your sensor dirty in the first place.

This is an issue we didn't have to face before we had digital cameras with interchangeable lenses. There is an electrically charged sensor behind the mirror of every digital SLR camera, and dust can adhere to the sensor either by static electricity or simple gravity. Opening the camera in

Failure to match a dome's curvature with a lens's optical characteristics creates significant aberrations, as seen in the corners of this image.

dusty conditions can exacerbate the dust accumulation, but there can actually be dirt on the sensor when the camera ships from the factory. The best way to minimize dust accumulation is:

- Turn the camera off when changing lenses. At least then the sensor is not charged and it won't physically attract particles.
- Try to avoid changing lenses in dirty or windy conditions, and for sure don't switch lenses if there is a possibility of sea spray.

No matter how careful you are, your sensor will get dirty if you are shooting a digital SLR. Your choices then are to send the camera back to the factory every time for cleaning, which is expensive and time-consuming, or learn how to do it yourself. The web is full of tips on how to clean dirty sensors, and they include special sensor swabs and cleaning solutions. But I find the wet options suitable for only the most stubborn and insidious particles. A much easier and safer remedy is from VisibleDust (www.visibledust.com), which offers a variety of brushes that use compressed air to "charge" the bristles so that they pick up detritus on the sensor. A scuba tank works quite nicely, but VisibleDust also offers a product called Arctic Butterfly that uses battery power to spin the brush head to energize it.

Sensor cleaning is a skill every digital shooter needs to integrate into his location workflow, and until the camera manufacturers create sensors that repel dust, rather than attract it, the products from VisibleDust are essentials.

MUSHY CORNERS

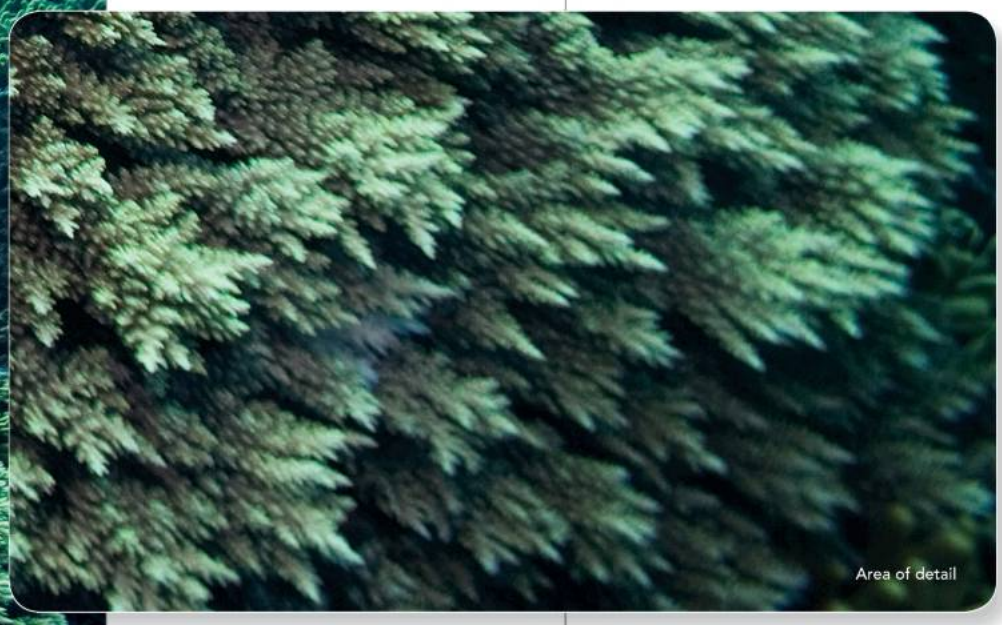
THE SECOND QUESTION I hear repeatedly: Why are the corners so "mushy" in my underwater wide-angle pictures?

This is the biggest conundrum facing underwater digital shooters today. Most of the early obstacles preventing digital acceptance have been overcome. Battery life is good enough for a day of diving, 4GB and 8GB cards make it unnecessary to come up until air or bottom time is exhausted, and resolution of the digital image far exceeds film. Ikelite and a few others are even making tremendous progress in adapting TTL to the digital paradigm. What keeps it from perfection? All too often, it is marginal underwater performance of wide-angle lenses on our digital SLRs.

I'll leave it to the optical engineers to explain why this is so, although I don't believe everything posted on the web as explanation. Ken Rockwell (www.kenrockwell.com) suggests, "Some lenses have visible lateral chromatic aberration, and some digital cameras have enough resolution to make this clearer than it can be on film if you look for it. This effect has always been with us and I see it when I look for it on film."

Truthfully, I think this is a big part of the problem. Our wide-angle lenses have never been perfect in the corners, but when our analysis was done on a slide viewed with a Schneider 4x loupe, all manner of sin was hidden. Now, we view our digital captures on high-resolution 23-inch monitors, pixel-peeping at every nook and cranny of the file at 100 percent enlargement. Cameras like the Canon EOS-1Ds Mark II and 5D, and Nikon D2X and D200 are incredible instruments, and if there are optical flaws, they will jump out at us.

OK, but that still doesn't explain why the underwater pictures are worse in terms of optical performance in the corners than when the same lens is used above water. The photo above is an example from a Canon 14mm lens, a very useful optic topside, used on a full-frame sensor (114 degrees) behind a nine-inch dome port. In the corners are areas of unacceptable resolution. Clearly, the lens performs far better on land than



this, so the issue is that the curvature of the dome doesn't match the optics of the lens.

Actually, I've tried this lens with the three different dome ports of the Seacam system, each with a variety of port extension rings; and while I could probably tweak it to be a bit better than this illustration, nothing really works well with this particular lens. If any other housing manufacturer has a port that works well with this lens, I'd love to know about it and pass it on to our readers.

I do not consider this a fault of the lens, by the way. The ports have to match the lens, as underwater photography is far too small a niche to expect camera manufacturers to consider potential underwater optical performance when they design a lens.

Some wide-angle lenses do perform quite well for underwater use. The Canon 15mm (full-frame fisheye), for example, is extremely useful in a housing, and the Nikkor 10.5mm fisheye (also 180-degree coverage on the Nikon 1.5 chip) is absolutely stellar in a wide variety of dome ports from various manufacturers. I know Ikelite, Aquatica, Nexus, Seacam and Subal users have all had spectacular results with their 10.5mm lenses. It is one of the sharpest wide-angle lenses I have seen for digital, although having said that, any full-frame fisheye is too wide to use for all underwater wide-angle applications. We have to figure a way to make our other lenses work as well.

My greatest frustration happens with our workhorse lenses, the wide-angle zooms. For Nikon shooters, this probably means the 12-24mm, and Canon enthusiasts use the 17-40 or 16-35mm zooms. As example, on page 95 is a shot taken with the 12-24mm Nikkor on a D1X.

While the corner performance looks pretty decent in the full view, a 100 percent crop of the corners reveals significant aberration.

In subsequent testing, I've found that the addition of a diopter can enhance the corner performance of the 12-24mm, but it can likewise compromise the distance view. It becomes a very fine line, with personal taste and objectives deciding where the "sweet spot" of the lens/port combination should rest.

Lately I've been spending way too much time with pool tests trying to dial in the optimal corner resolution on my 17-40mm lens. I find there is a massive difference in optical performance based on the curvature of the specific dome port, and the port extension is critical as well because that moves the optical center of the dome relative to the lens's nodal point. All of which is further complicated because once under water, the dome creates a virtual image, yet another focus variable.

Hollywood underwater cameraman Pete Romano makes a fairly concise explanation of dome port theory: "The dome port is a concentric lens that acts as an additional optical element to the camera lens ... When a dome port is used, all the rays of light pass through unrefracted, which allows the 'in-air' lens to retain its angle of view. Optically, a 'virtual image' is created inches in front of the lens. To photograph a subject under water with a dome port, you must focus the lens on the 'virtual image,' not the subject itself. The dome port makes the footage marks on the lens totally inaccurate for

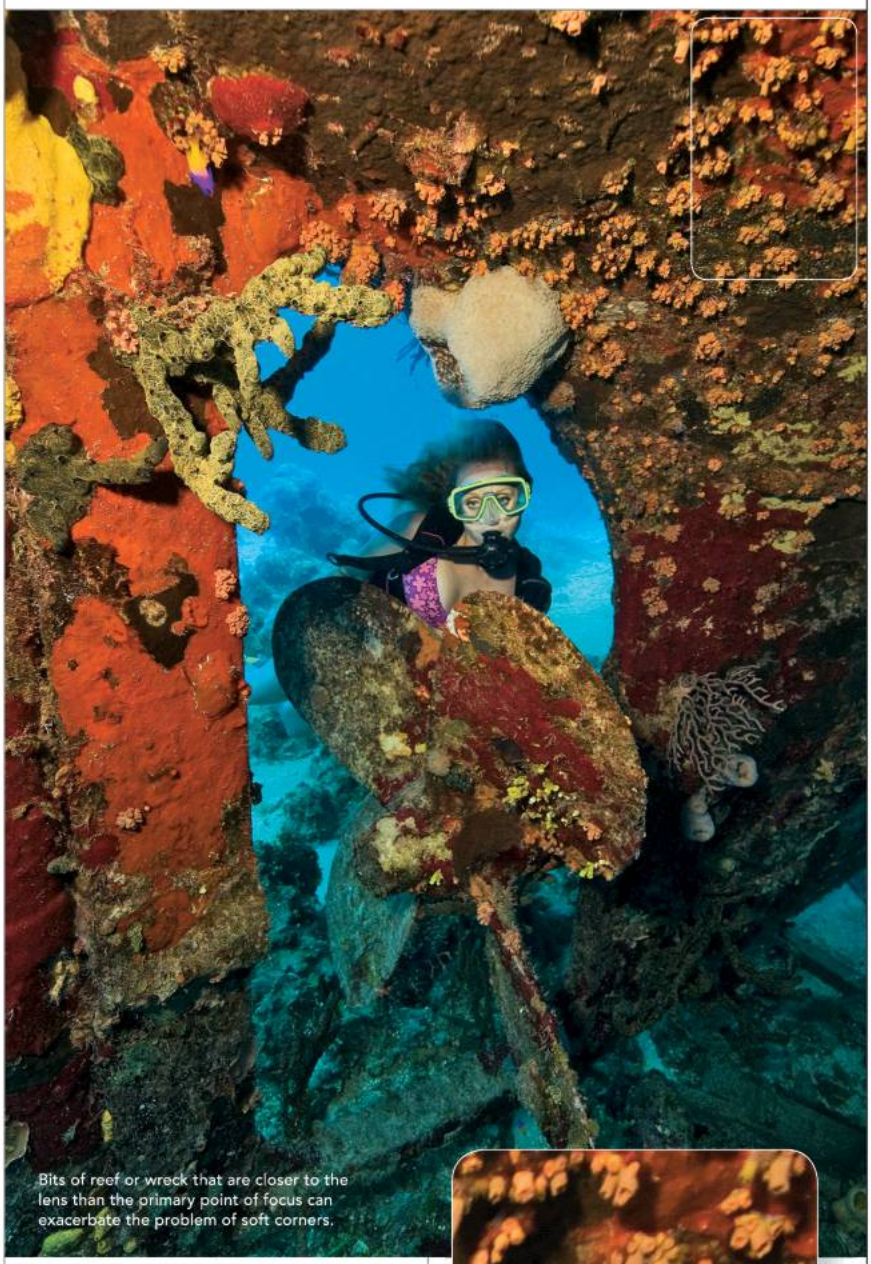
underwater focus."

While the exact calculation of the position of the virtual image is complex, ballpark estimation puts it at about twice the dome's diameter. With a six-inch dome, the lens has to be able to focus on a virtual image 12 inches away from the sensor or it can't focus at all. A nine-inch dome then allows a virtual image 18 inches away, and is therefore more likely to focus with a wider variety of lenses. But just because it is sharp in the center does not mean it will perform well in the corners, and this is where the curvature of the dome and optical center of the dome relative to the nodal point comes in.

I'd like to say there is a magic formula that will reveal the exact dome and port extension that is perfect for your particular lens. But the reality is that each lens will require a bit of in-water testing to determine if it is best used with or without a diopter; if a diopter, what power should it be (they typically come in strengths of +1 through +4); what curvature dome; and what length port extension.

Have you begun to wonder why you should have to be the beta tester on this? Why should you spend your valuable time in the pool doing tests? The reality is that some of the manufacturers actually do a very good job communicating their ideal port combination for your lens. Ikelite offers terrific guidance at www.ikelite.com/web_pages/port_chart.html, while some other manufacturers leave it more to their dealers (and consumers) to sleuth out. Nevertheless, new cameras and lenses are being introduced at such a furious pace that some level of personal responsibility for testing has to be accepted.

I'd hate to leave on a two-week expedition to Indonesia's Raja Ampat Islands only to discover my wide-angle shots would be better if I had a 35mm rather than 25mm port extension or a +2 diopter instead of a +4. A critical eye and a bit



Bits of reef or wreck that are closer to the lens than the primary point of focus can exacerbate the problem of soft corners.

of pool time is a small enough investment to add to that $5,000 or $10,000 you just spent on your digital camera and housing.

"Lens performance varies all over the field of the lens," Ken Rockwell writes. "Some lenses may do better in the corners while others do better elsewhere. Don't freak out and be a victim of analysis paralysis. Any of these lenses has the ability to let you create stunning images if you'll just get out there and stop reading test reports." SD

Area of detail