The Universe Below: Creating Underwater Allskies

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It has become fashionable to broaden the thematic spectrum of planetarium shows. Our visitors no longer gain insight into the wonders of just the night sky. They can also enjoy laser-enhanced music shows or programs on general natural science at the planetarium of their choice. As planetarium operators, we have to incorporate new media and imagery to address these topics.

So it was natural to us at allsky.de to include non-astronomical allskies as a vital part of our range of products. This year we decided to run a whole assignment for the first time entirely on one topic. We travelled to Egypt to produce material on antique astronomy. Starting at the Giza Pyramids, we photographed our path up the Nile to Luxor, the Valley of Kings, and Abu Simbel. During the preparations for the trip it occurred to us that we could really cover another fascinating world untapped by allsky photography: the reefs of the Red Sea. In our functions as show producers at the Kiel Planetarium we had long wanted to have some allskies of coral, wrecks, or just waves from beneath. Yet all the material we knew of was either computer-rendered, made up of several unrelated shots, or showed severe technical deficiencies.

Preliminary Thoughts

The challenge of shooting any photograph underwater is really trifold. An ordinary diver has to watch out for currents and fragile coral twigs while monitoring the limited capacities of his life-support system. An underwater photographer has to keep in mind the optical properties of seawater that alter his results in color, field of view, and detail, while he needs one eye and hand for his camera all the time. A planetarian shooting allskies has to look for the right distance, angular elevation, and overall light dynamics of his subject.

Luckily we are also sports divers, and one of us holds a scientific divers' certificate. We already had some general knowledge of underwater photography as well as the right diving skills.

> Long experience in the field of allsky still photography led the team of allsky.de to create a thematic program of underwater allskies. The experiences and techniques they developed are not just a curiosity among divers, but may serve as an encouragement to designers of progressive planetarium shows.

We began to dream: Hovering in the water, one can capture scenes that would normally ask for a Hollywood elevator or a high ladder at least. Yet in any case one needs a fixed point in the water column to control the orientation of the camera.

The question arose whether we should use a tripod as on land, or suspend a buoy at the position and depth we wanted to take a photo and hold the camera at a point in reference to it. In the end we decided to completely transfer terrestrial allsky techniques underwater because it appeared to be the approach that asked for the least preliminary tests and training.

Preparations

First came the choice of a camera. Due to difficult overall exposure times, allsky photography demands an inflationary amount of raw imagery. Since it is not possible to change a film roll underwater, we chose to use a digital camera. We also wanted to have immediate proof of the outcome while still in Egypt to be able to correct mistakes. With a limited budget and the need for a fisheye lens combined with high resolution, we chose the Nikon Coolpix 5000 with its 16mm fisheye converter, together with the appropriate Sea&Sea housing and dome port. The dome port is the spherical glass window in front of the lens which corrects the decrease in the field of view that a flat window would produce underwater. Next we wanted to address technical issues. On land we usually take six photographs using a QTVR-head that prevents parallax and provides an even angle of 60° between the images. We needed an underwater equivalent that was extremely sturdy, absolutely non-corrosive at contact with seawater and, above all, easy to handle. To enable parallax correction, we simplified the design to two perpendicular metal rods that could be attached to each other at any point using a single screw. Another screw fixed the camera to the vertical rod. The construction was then screwed onto a fixable swivel joint that exactly copied the design we already used. Having accomplished this, we lost our enthusiasm for welding and turning and decided to use a spare sturdy tripod by Manfrotto as a mounting.

In complete negligence of traditional underwater photography we decided to use no flashlight. It is part of the art of allsky photography to get along without any flashlights that would result in an unevenly illuminat-

The camera system we used in Switzerland. Image courtesy Tilman Göhlert.

ed scene, regardless of a stationary or rotational mount. Our itinerary would not have allowed us to carry several heavy flashlights up and down the Nile Valley anyway.

Practical experience

Before flying to Egypt, there was an opportunity to do some practical fieldwork at the Verzasca and Maggia valleys in southern Switzerland. The area features mountain rivers that have formed breathtaking caverns, holes, and gorges, cutting their way through richly patterned gneiss formations of the southern Alps. For this project we teamed up with passionate underwater photographer Tilman Göhlert. He achieved great results using the Nikon F801 and Ikelite housing. Yet the limited number of exposures of the analog camera greatly limited the quantity of the outcome, and we had to restrain ourselves to just one uniform exposure per location. Strong currents, very narrowly spaced settings, as well as sediment perturbation by the divers, made the dives technically demanding.

On assignment

After a highly productive week on the Egyptian mainland, the diving team separated from the others who would continue at the ancient sites for a couple more days. We had chosen dive spots around Sharm el Sheikh and Ras Mohammed National Park at the southern tip of the Sinai Peninsula. The locations in Switzerland were shallower than six meters, but we now descended to much greater depths. Over the period of the next week we produced the raw material for about fifteen allskies.

We usually divided the equipment among us. Once we had reached a spot that seemed promising, the diver carrying the camera started to measure the exposure for the major features, especially the darkest and brightest spots. Meanwhile the other one set up the tripod, unfolding it in the midst of the water column and landing it on a sandy spot. The whole procedure reminded us more of a moon landing than of preparations to take some photos. While it is very important to set up the tripod evenly on land, one lacks a clearly marked horizon under water. It therefore does not matter if the rotational axis of the camera is not exactly vertical. Once we had determined an exposure, the camera was screwed onto the tripod head, and a couple of low-resolution samples were made to control the outcome on site over the LCD display. Then we shot our round of six pictures at optimum resolution, holding our breath to prevent bubbles from entering the field of view. To overcome problems in the zenith region during stitching, we also shot a view straight up. In order to stay out of sight, the whole dive group including the photographer performed a ballet around the tripod.

On the first dive, we tilted the camera up about 30°. This trick makes a difference to allskies shot with a single 180° fisheye lens by avoiding stitching; this way one receives a dome original that covers roughly 210° of vertical field of view, which resembles a much more natural approach to the real viewing situation. Yet after our first trials in Switzerland we saw the need to abandon that tilt and aim straight at the horizon. In an underwater allsky, the objects should have a much higher angular elevation (i.e. they have to be much closer) than on land, as the visibility is decreased by the water. Doing so, we became dependent on a seventh shot to the zenith.

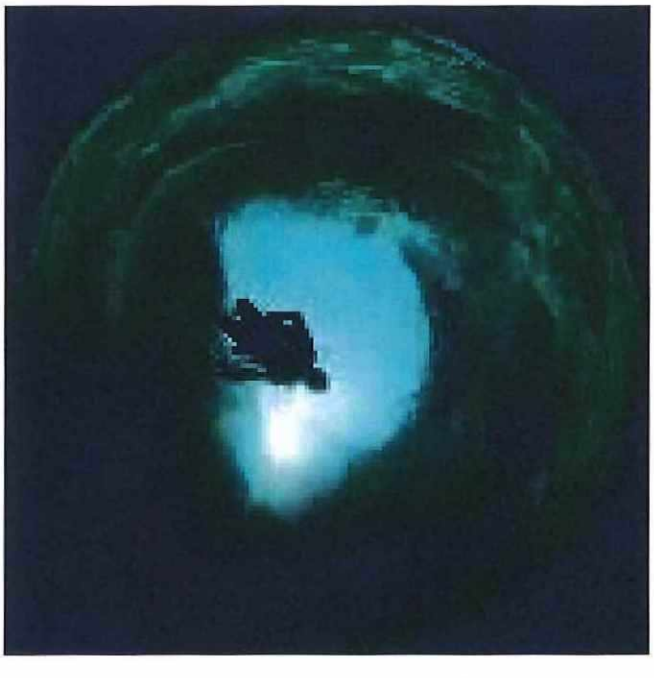
Unfortunately we did not gain usable material on the first dive, which was at one of the best locations. The following days we stayed in depths of 5 to 25 meters. The reefs we visited were more-or-less steeply sloped, sometimes followed by a drop-off. We preferred sandy spots surrounded by coral blocks in each direction so we could get a decent view without the danger of destroying coral. One highlight was an underwater cave we photographed at Ras Mohammed. Its most difficult light situation required two complete series of different exposures as well as some single shots at maximum shutter speed.

To complete our topical range of underwater scenes, we set out for a wreck in the Strait of Suez. The SS Thistlegorm is regarded by many as the "Holy Grail of Wreck Diving". Sunk during WWII, it is famous for its state of preservation but just as infamous for the currents and challenging water depth at the site. We had the chance to explore it on our own on two dives, during which we took allskies of the propeller and bow as well as of its spectacular cargo from motorcycles to railroad cars. The advanced depth as well as the weight of the heavy allsky equipment made us use up our air quickly - air consumption is a major issue doing underwater allsky photography. Nevertheless it was to be the crowning finale of our field work.

Post-production

Blending the raw material to dome originals really proved to be a lesson in oceanography.

During the final steps of stitching the images, we even found an equivalent to the



A Swiss riverbed. The sky has to be shaded for projection. Image courtesy allsky.de.

The digital camera used in the Red Sea. Image courtesy www.e-mocean.com.

sharp line of the terrestrial horizon. Due to the refraction index of seawater, all the light entering the sea from above comes through a circle of 48.3° around the zenith. In reality a diver sees a bright blue circle above him, while the rest of the underwater world appears considerably darker. As the surface of a liquid is never inclined, it means that this circle serves just as well as a horizon. This effect is only visible in shallow waters down to about 10 meters because of light scattering. The sun appears within this bright area. As all our images were taken in a dark environment, the sun was depicted as an ugly white burn spot in the images. This spot decreases in size with increasing water depth.

It turned out that, except for the most shallow allskies, all the views of the deep blue water had to be manipulated. Erasing the "sun burn" generally produced a very satisfactory image. Yet even the most perfect allsky still has to be projected onto a dome. Reality is bitter, and most conventional full-dome projection methods do not blend to 100% seam invisibility.

The hints of projector overlap in the uniform blue of deep waters could be distracted by inserting an artificial sea surface with or without a sun, and if the size were chosen carefully, the audience would never notice. For this case, we had planned from the beginning to produce a "macro allsky" of the zenith area in shallow waters, with a beautiful sun and wave crests. These images now serve as individual allskies or as parts of other images.

We switched off most of the features of a digital camera that are intended to improve the image quality. Color correction, alignment, or automatic exposure would have made it impossible to blend the photos to one coherent allsky. However, the raw images did not look very staggering using that method ...

With the Digistar3 projection system of the Kiel Planetarium at hand, we could directly evaluate our allskies and then recalibrate the color and brightness to their aesthetic optimum and physical accuracy.

Another problem was that the deep blue waters prevented our eyes from adapting to darker parts of the image. The effect was not appreciated to its full extent until we conducted our first tests in the dome. The solution was to correct the brightness of seabed and water ("landscape and sky") separately.

Evaluation

At optimum resolution, we resurfaced with about as many exposures after one dive as an analog system would have stored. Yet our techniques are subject to refinement, and working somewhat quicker, the 500 MB chip we used would not have been sufficient. All of our equipment served very well, and even the aluminum tripod suffered almost no damage from the seawater. In a next trial it would be interesting to experiment with a buoy rather than a tripod, yet this demands a different stitching process. This could be used at reef walls or places where no clear ground is available.

One will readily recognize the difference in color saturation between our allskies and professional but conventional underwater photography. Yet one has to keep in mind that most of the coral images we see actually were shot as close-ups, using a strong flashlight. Look at the background in professional underwater photographs: Distant objects rapidly loose contrast and their color becomes a uniform greenish-blue. Flashlights do not reach that far; on the contrary, they illuminate particles suspended in the water and turn the image into a snow blizzard at worst. After all, the allskies now resemble what you would see if you jumped into the water to look for yourself - which was our ultimate goal.

Conclusion

This report once more proves that a planetarium production may actually require fieldwork. There are many subjects that have not yet been captured in an allsky. Then, look at the many possibilities to animate allsky sequences using slide projection. New digital methods allow to use an allsky as a real virtual environment rather than just a background facade for a plot. Producers may dare a lot more to explore the immersive impact of exceptional places, and they shall be encouraged to use real life material! It will be interesting to see this medium transferred to real life all-dome video, overcoming the last boundary between the audiences' imagination and reality. C

The foredeck of SS Thistlegorm at 20 meters depth. Note the railroad car! Image courtesy allsky.de.

A coral reef five meters down. The sky is original; note the bright zenith! Image courtesy allsky.de.