Underwater Image Enhancement via Medium Transmission-Guided Multi-Color Space Embedding (Supplementary Material)

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***Abstract*—This supplementary material provides 1) the detailed network structure with hyper-parameters and 2) more visual results on various benchmarks to complement the main manuscript, including different types of synthetic underwater images sampled from Test-S1000 [1], real underwater images sampled from Test-R90 [2], challenging underwater images sampled from Test-C60 [2], Color Checker images taken by different cameras sampled from Color-Check7 [3], and challenging underwater images sampled from SQUID [4].**

We provide a comparison on a real underwater video in a separate file in the supplementary material. This video also can be found at YouTube https://www.youtube.com/watch?v=xzOzXd6Uz5k.

The code is publicly available at: https://li-chongyi.github.io/Proj_Ucolor.html.

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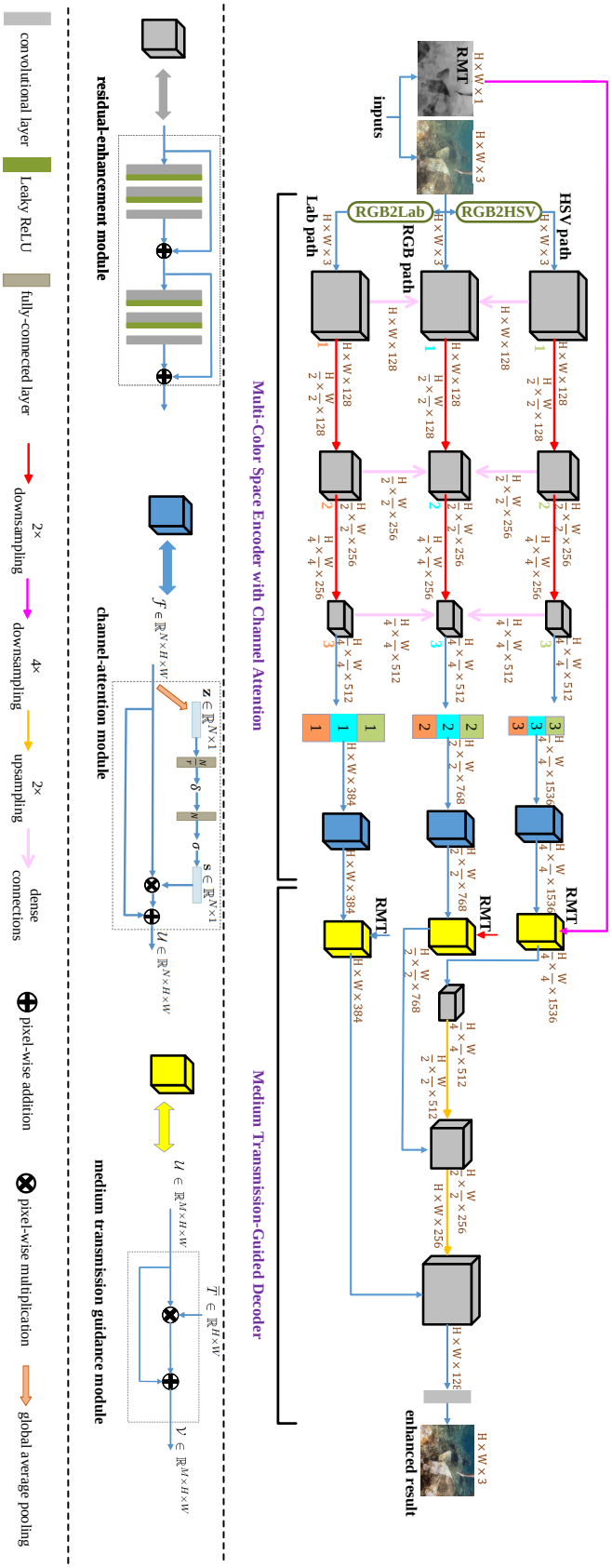
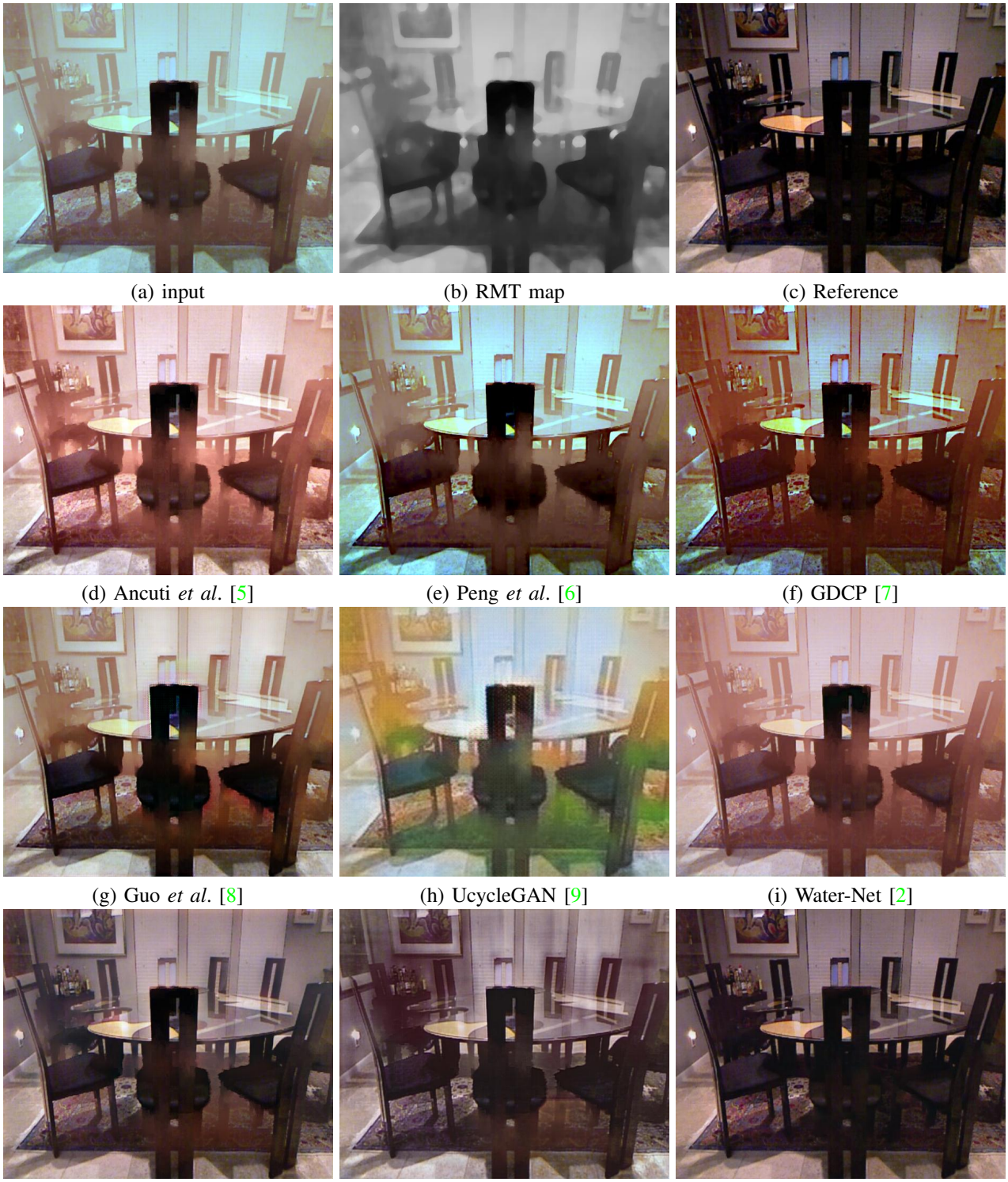


Fig. 1. The detailed network architecture of Ucolor. Given an underwater image of size $H \times W \times 3$, we present the sizes of input and output of each block in a format of height×width×channel. In each block, the convolutional layers have the same number of input and output channels. In the Ucolor, all convolutional layers adopt the kernel sizes of 3×3 and stride 1.



(a) input (b) RMT map (c) Reference

(d) Ancuti *et al*. [5] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 2. Visual comparisons on a synthetic type I underwater image sampled from Test-S1000 [1].

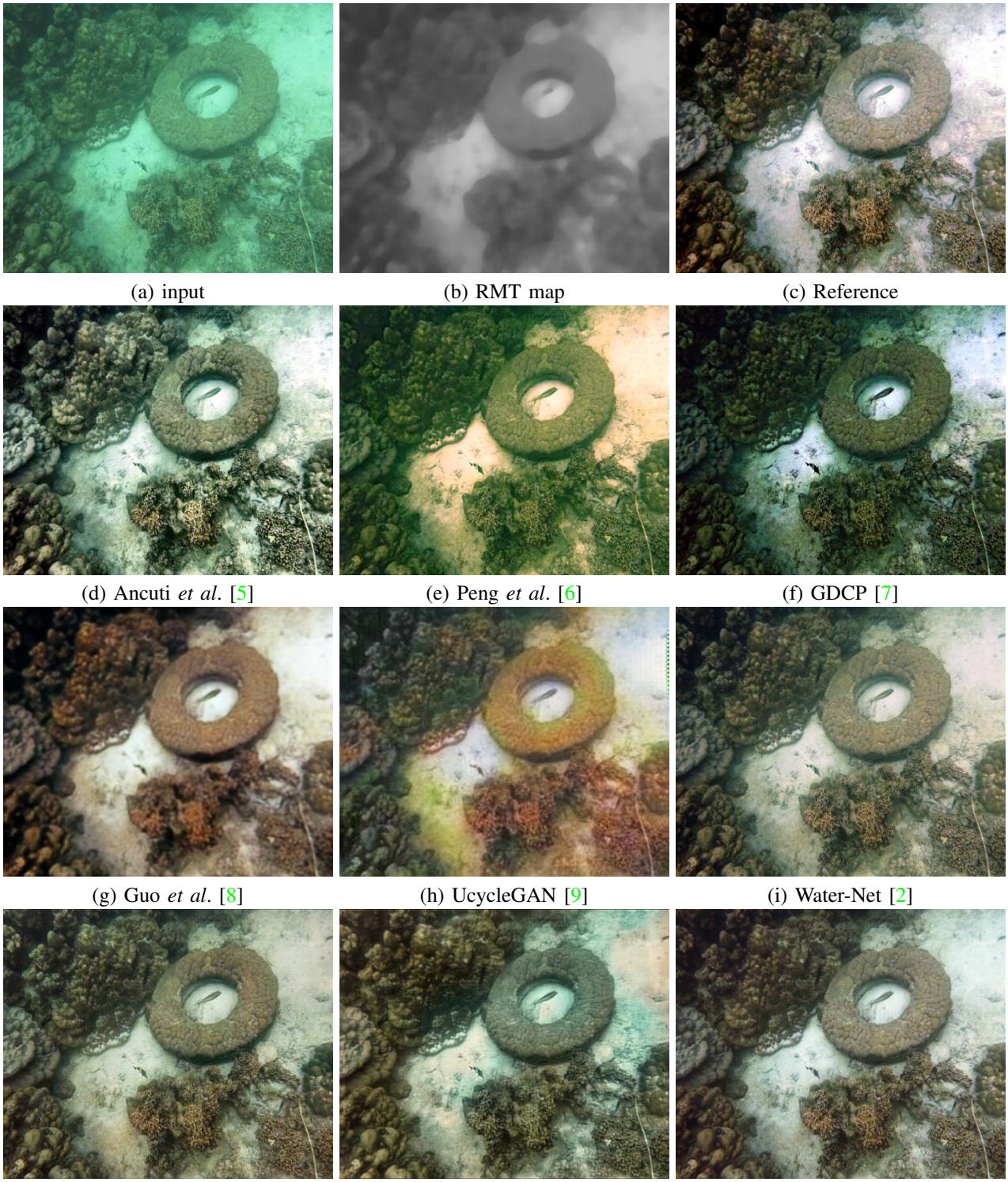
(a) input (b) RMT map (c) Reference

(d) Ancuti *et al*. [5] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 3. Visual comparisons on a synthetic type III underwater image sampled from Test-S1000 [1].



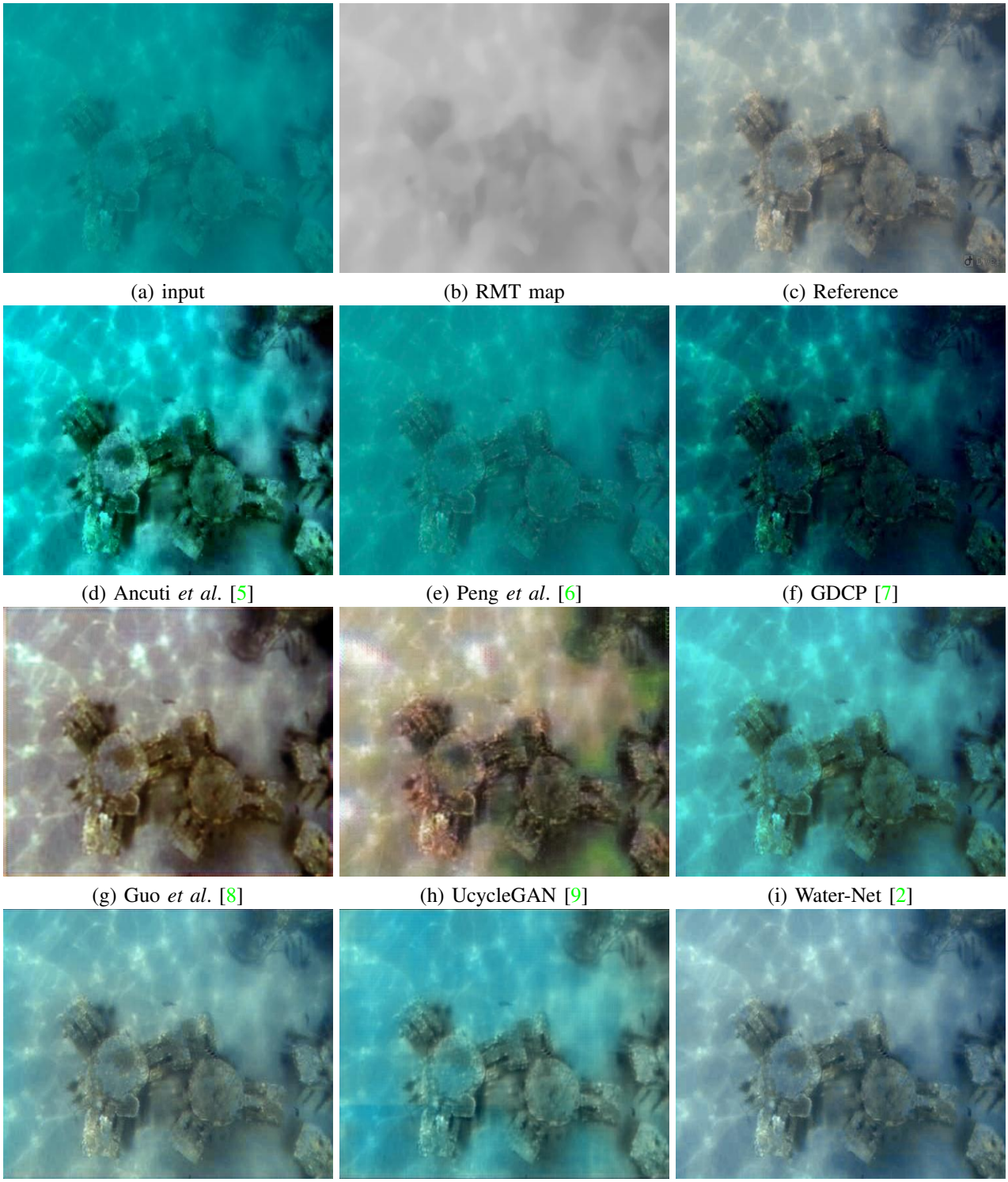
(a) input (b) RMT map (c) Reference

(d) Ancuti *et al*. [5] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 4. Visual comparisons on a real underwater image sampled from Test-R90 [2].



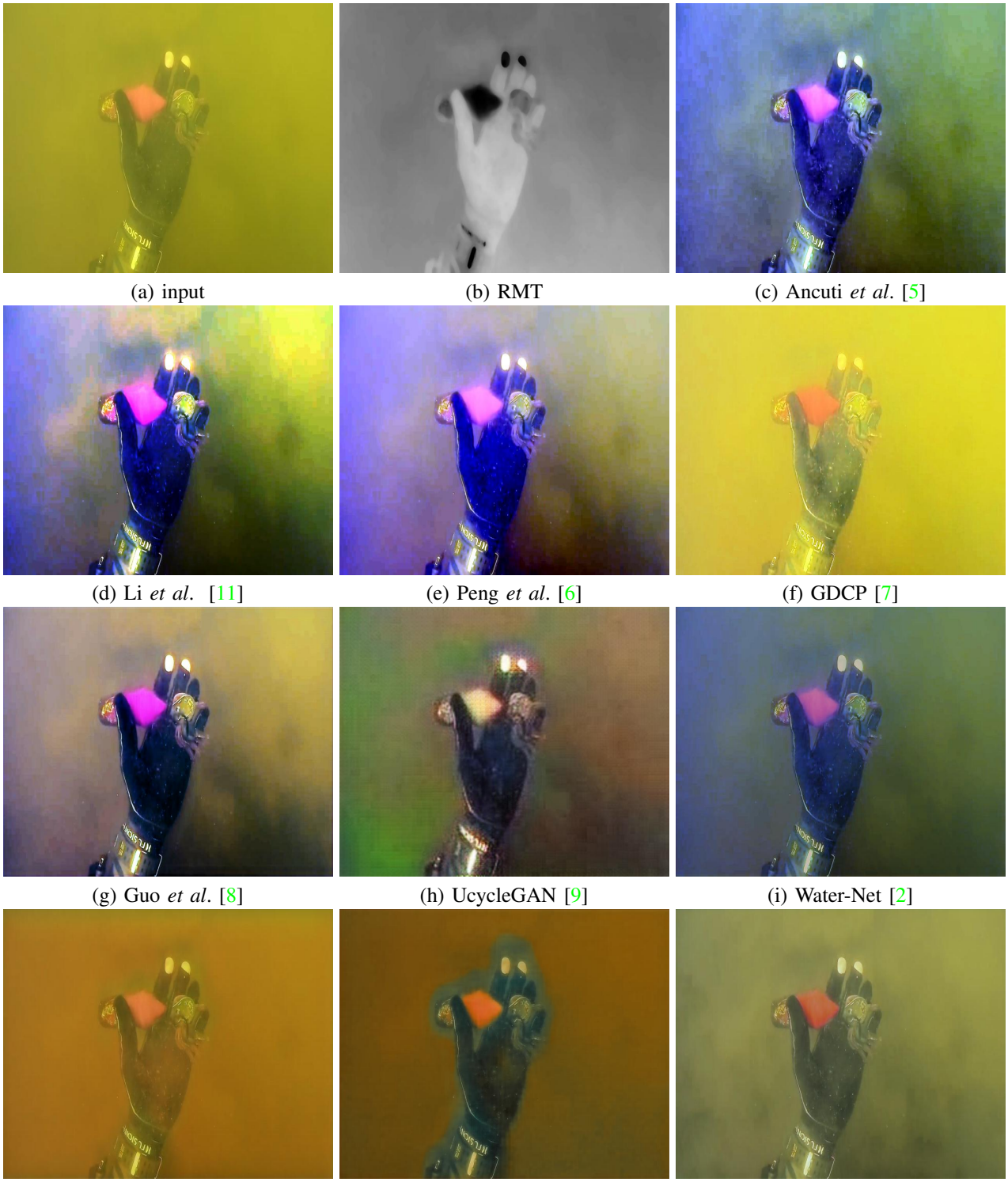
(a) input (b) RMT map (c) Reference

(d) Ancuti *et al*. [5] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 5. Visual comparisons on a real underwater image sampled from Test-R90 [2].



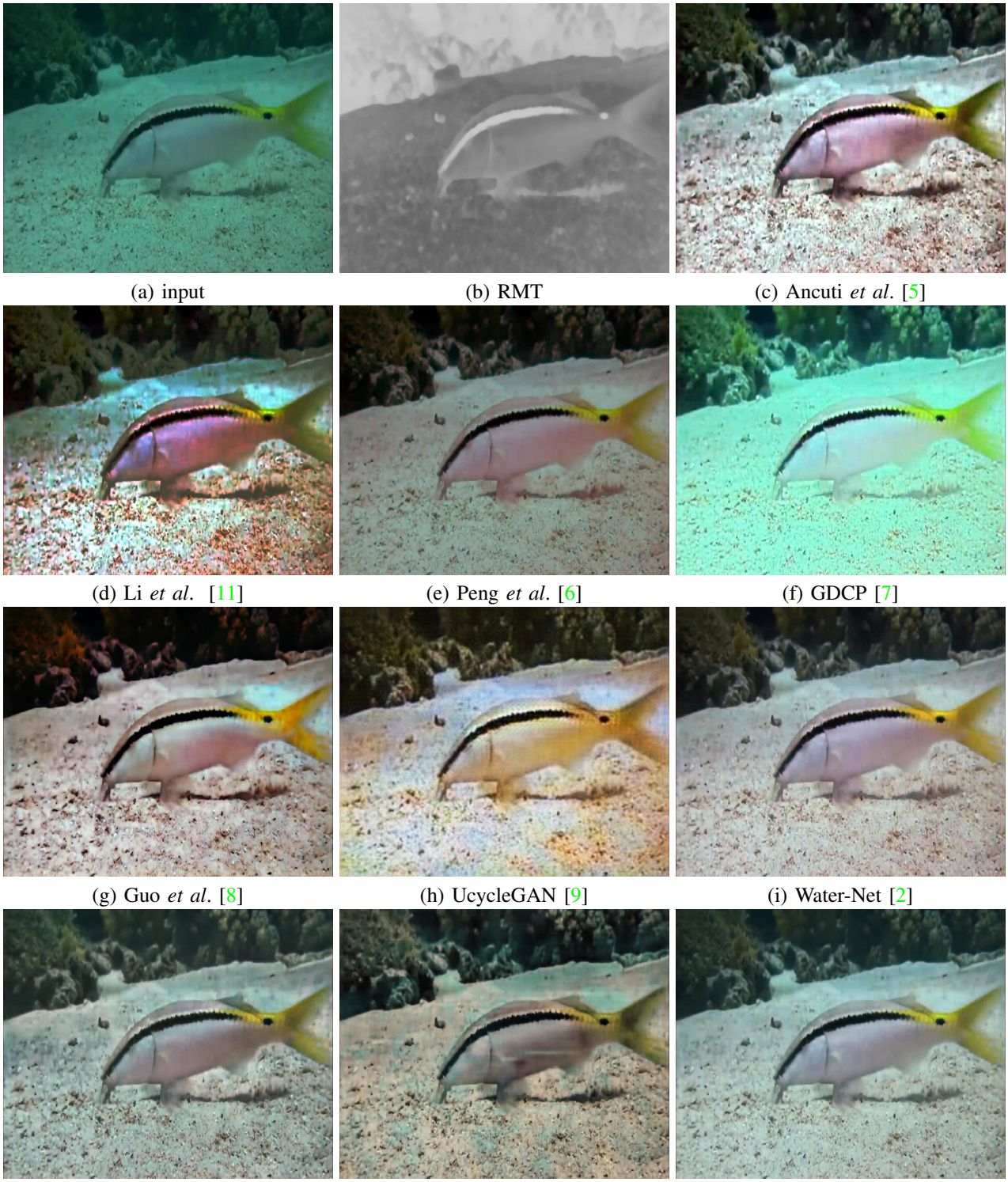
(a) input (b) RMT (c) Ancuti *et al*. [5]

(d) Li *et al*. [11] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 6. Visual comparisons on a challenging underwater image sampled from Test-C60 [2].



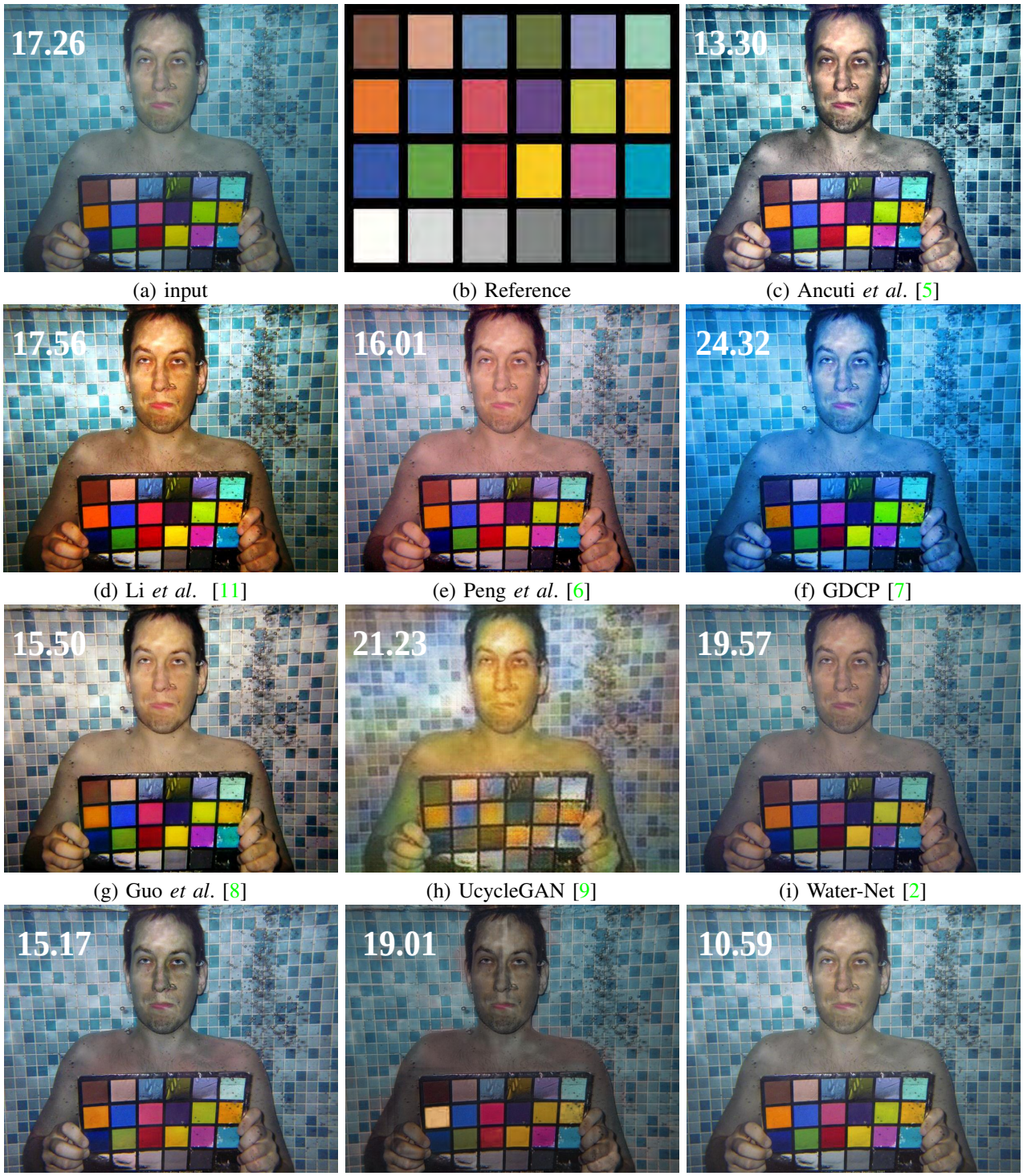
(a) input (b) RMT (c) Ancuti *et al*. [5]

(d) Li *et al*. [11] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 7. Visual comparisons on a challenging underwater image sampled from Test-C60 [2].



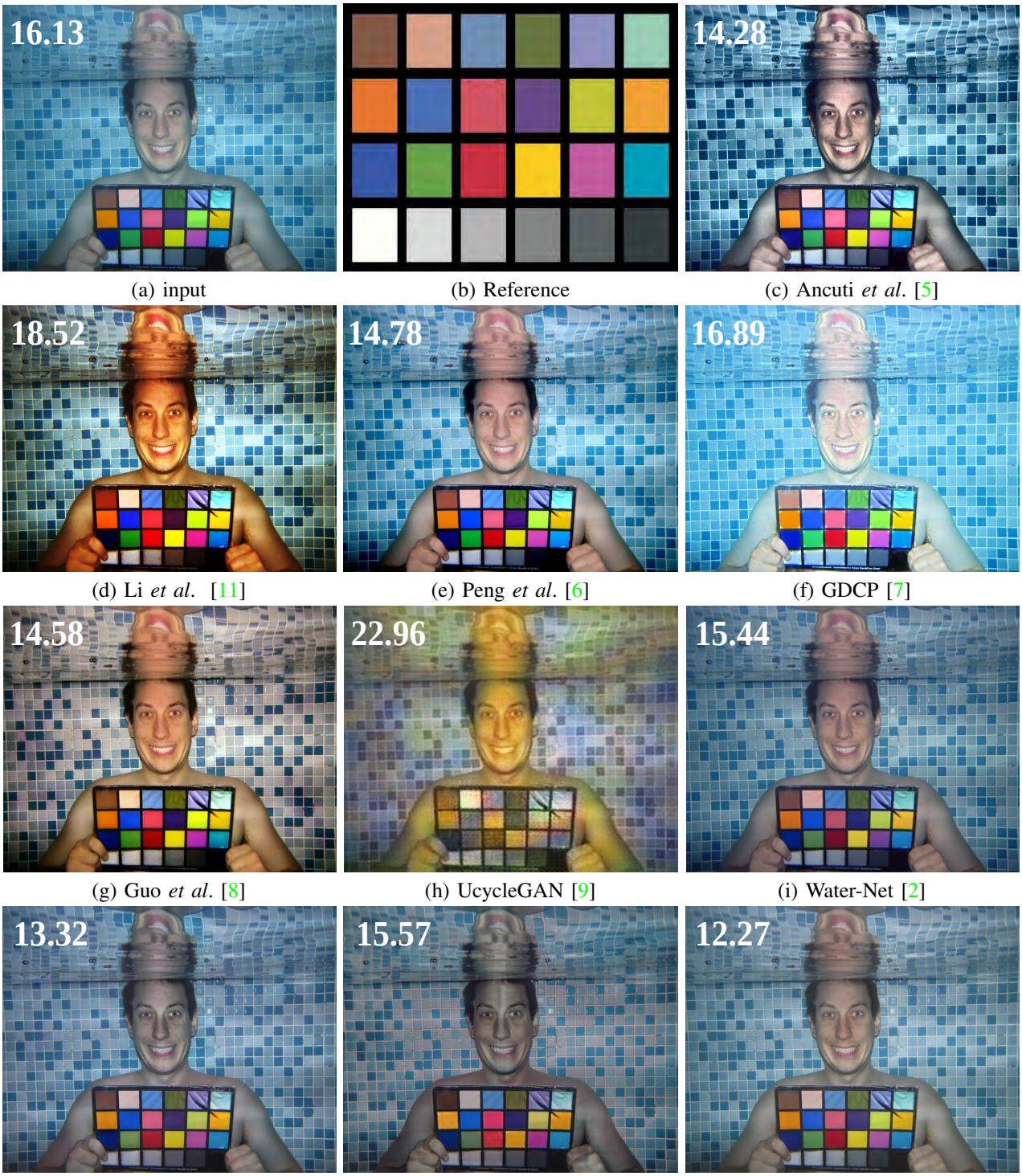
(a) input (b) Reference (c) Ancuti *et al*. [5]

(d) Li *et al*. [11] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 8. Visual comparisons on a Color Checker image taken by a Pentax W80 camera from Color-Check7 [3]. The values of CIEDE2000 metric for the regions of Color Checker image are reported on the results.



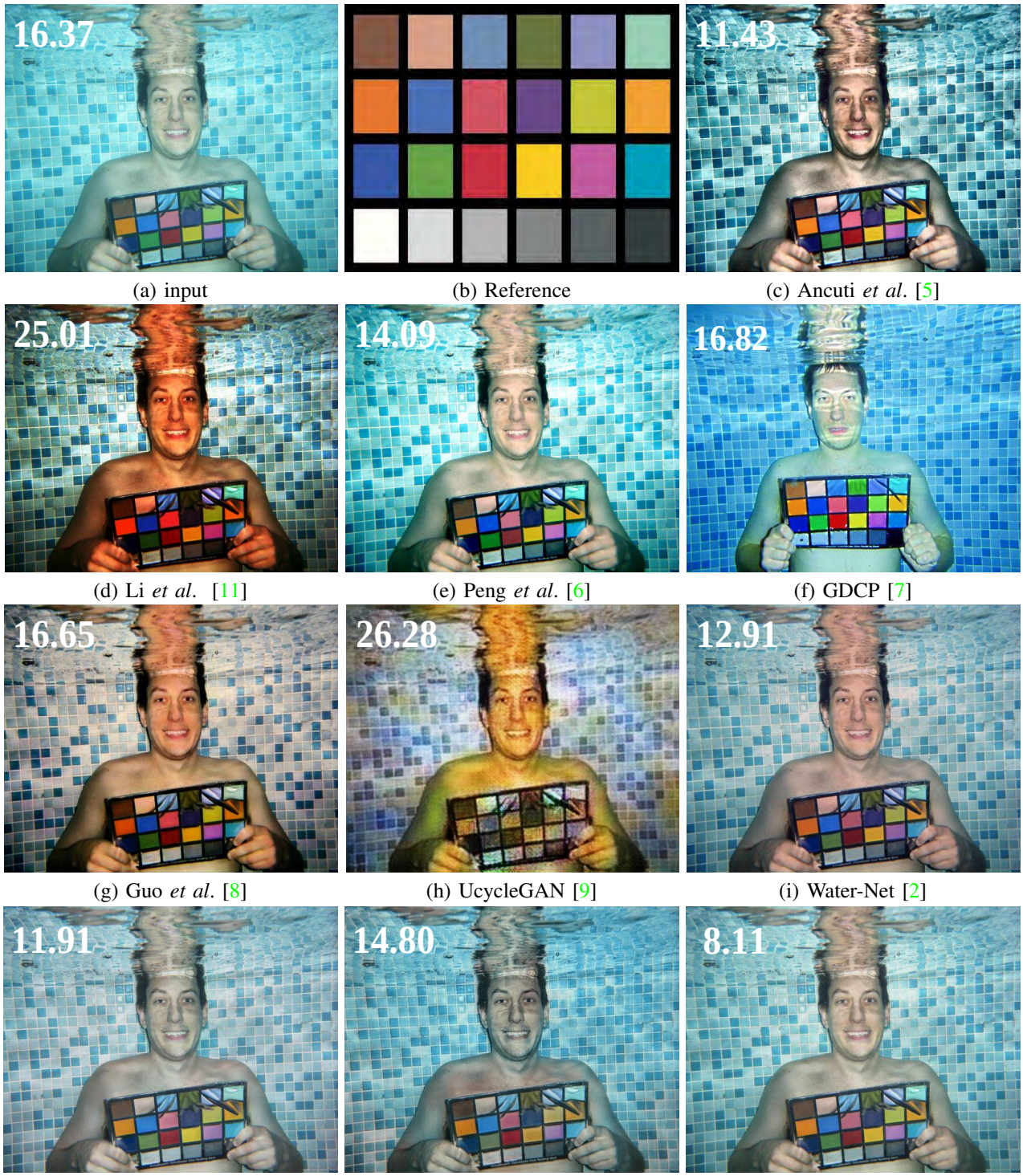
(a) input (b) Reference (c) Ancuti *et al*. [5]

(d) Li *et al*. [11] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 9. Visual comparisons on a Color Checker image taken by a Cannon D10 camera from Color-Check7 [3]. The values of CIEDE2000 metric for the regions of Color Checker image are reported on the results.



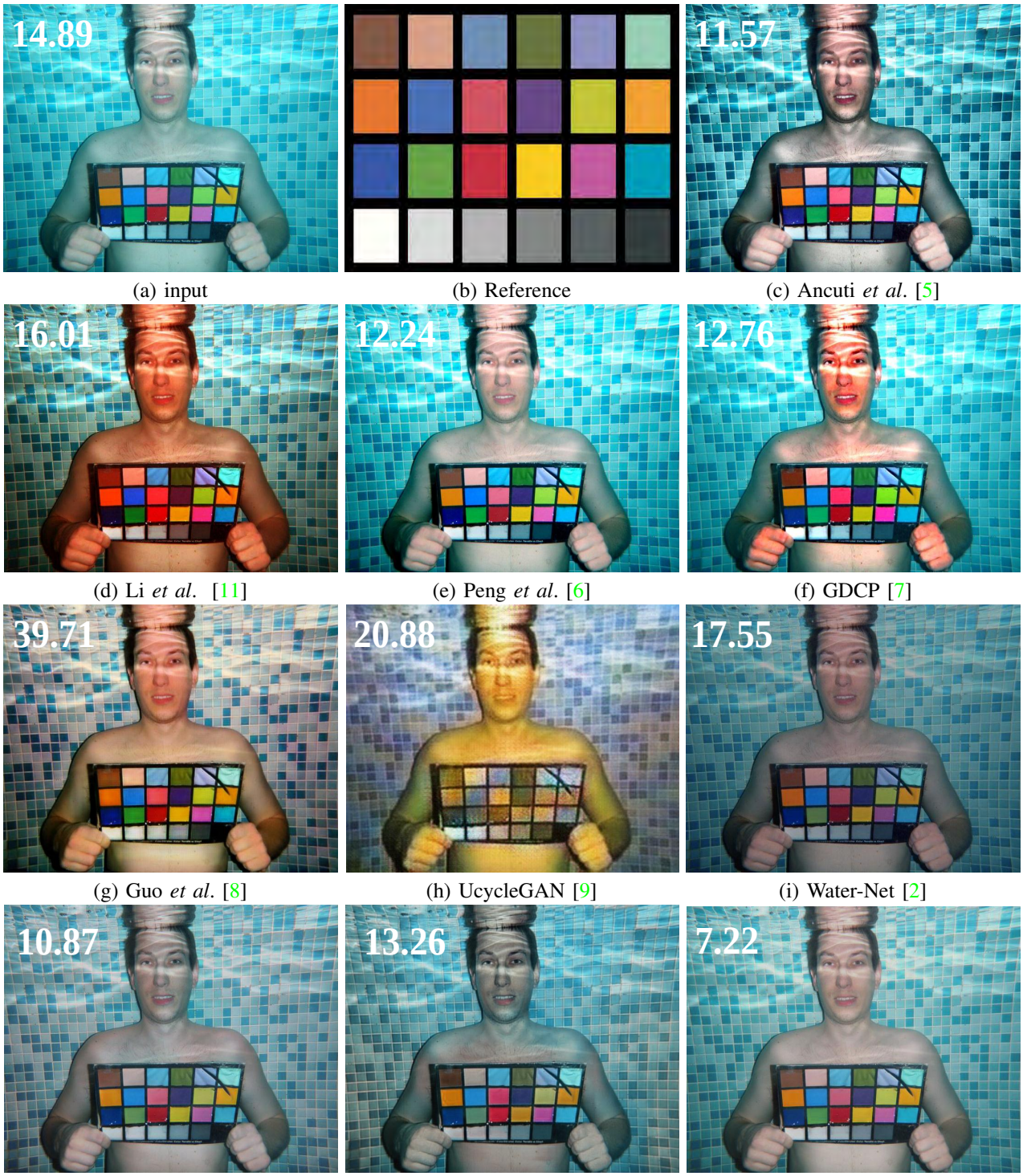
(a) input (b) Reference (c) Ancuti *et al*. [5]

(d) Li *et al*. [11] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 10. Visual comparisons on a Color Checker image taken by a Fuji Z33 camera from Color-Check7 [3]. The values of CIEDE2000 metric for the regions of Color Checker image are reported on the results.



(a) input (b) Reference (c) Ancuti *et al*. [5]

(d) Li *et al*. [11] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 11. Visual comparisons on a Color Checker image taken by an Olympus T6000 camera from Color-Check7 [3]. The values of CIEDE2000 metric for the regions of Color Checker image are reported on the results.

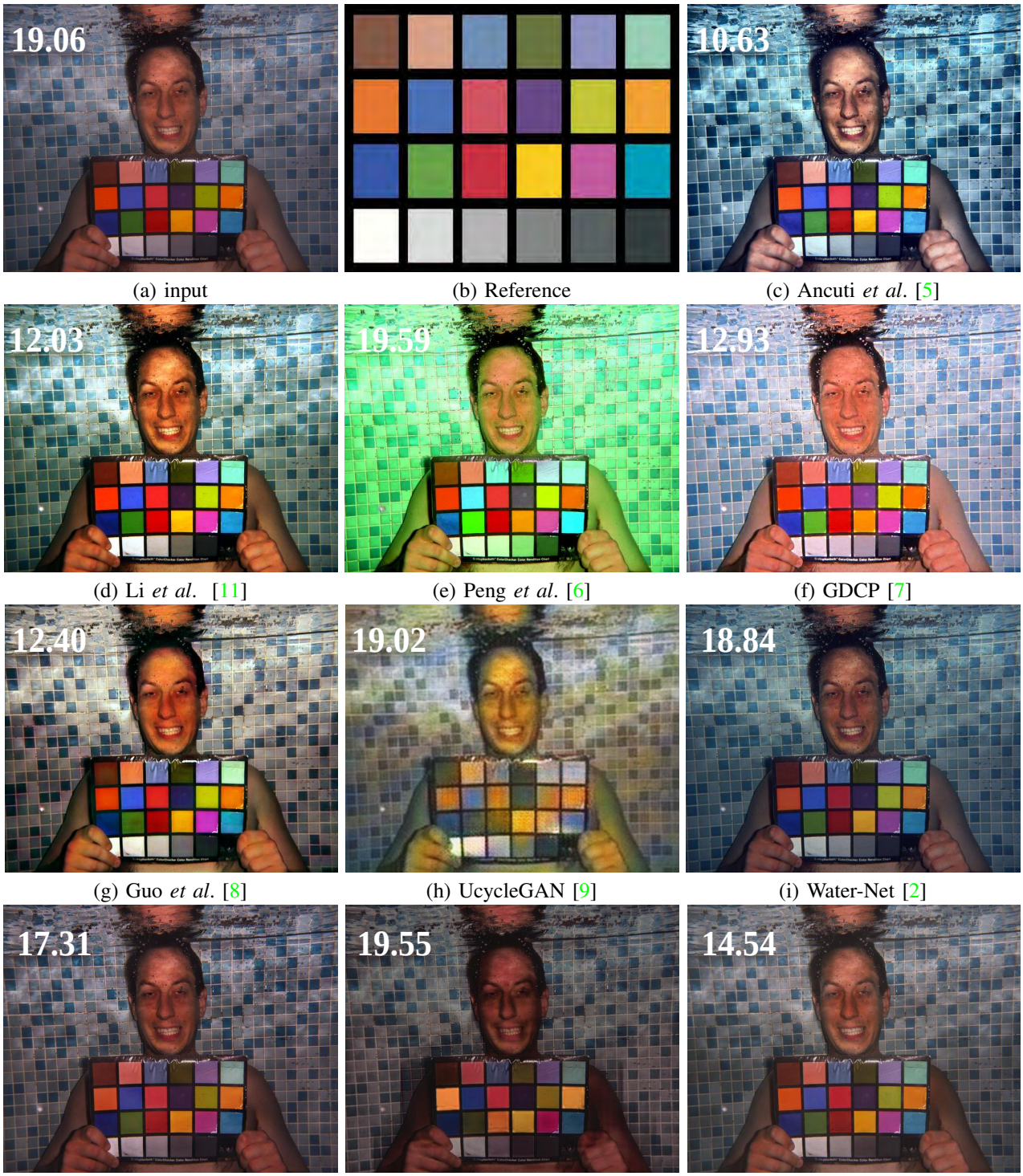
(a) input (b) Reference (c) Ancuti *et al*. [5]

(d) Li *et al*. [11] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 12. Visual comparisons on a Color Checker image taken by an Olympus T8000 camera from Color-Check7 [3]. The values of CIEDE2000 metric for the regions of Color Checker image are reported on the results.



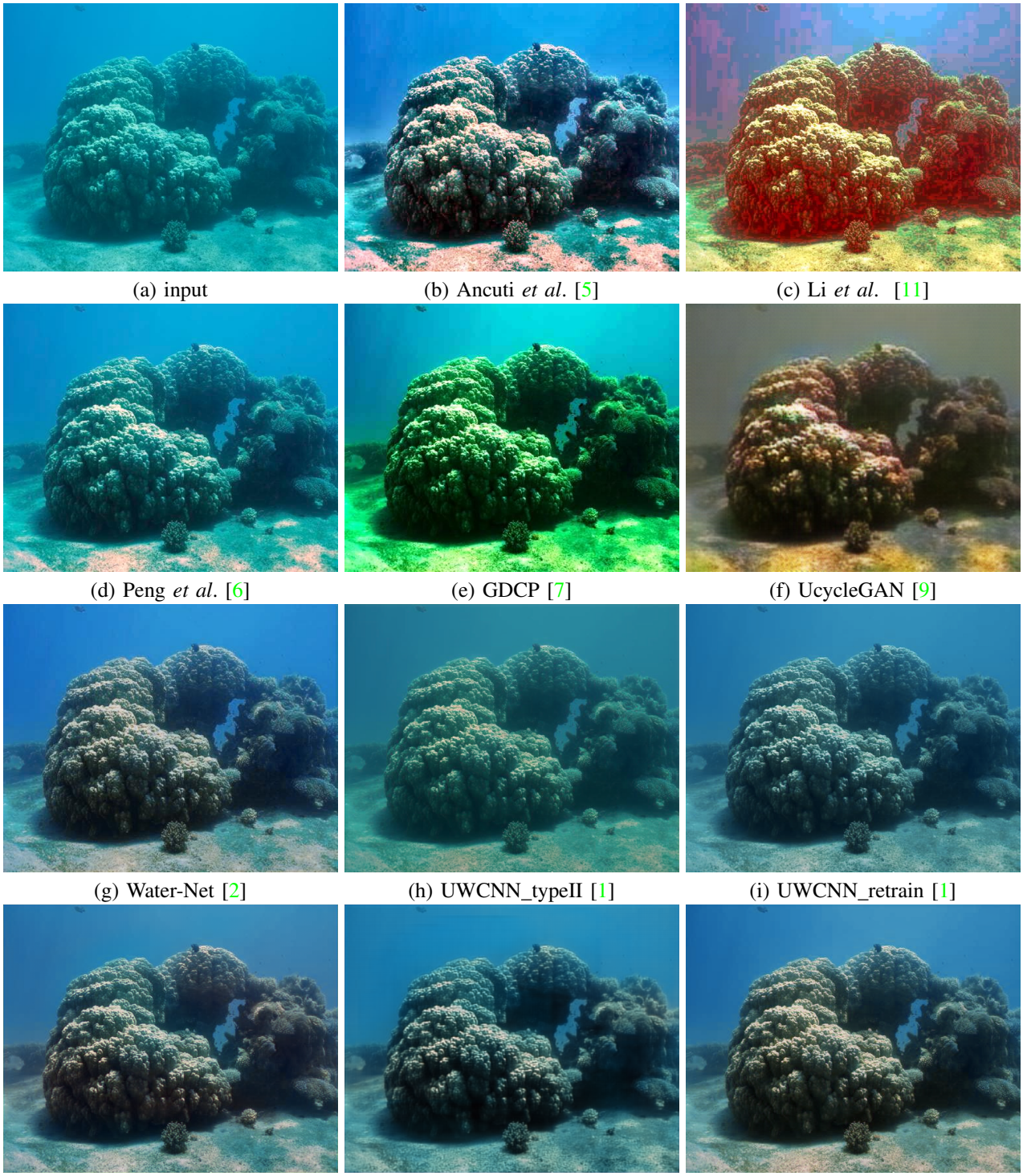
(a) input (b) Reference (c) Ancuti *et al*. [5]

(d) Li *et al*. [11] (e) Peng *et al*. [6] (f) GDCP [7]

(g) Guo *et al*. [8] (h) UcycleGAN [9] (i) Water-Net [2]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 13. Visual comparisons on a Color Checker image taken by a Panasonic TS1 camera from Color-Check7 [3]. The values of CIEDE2000 metric for the regions of Color Checker image are reported on the results.



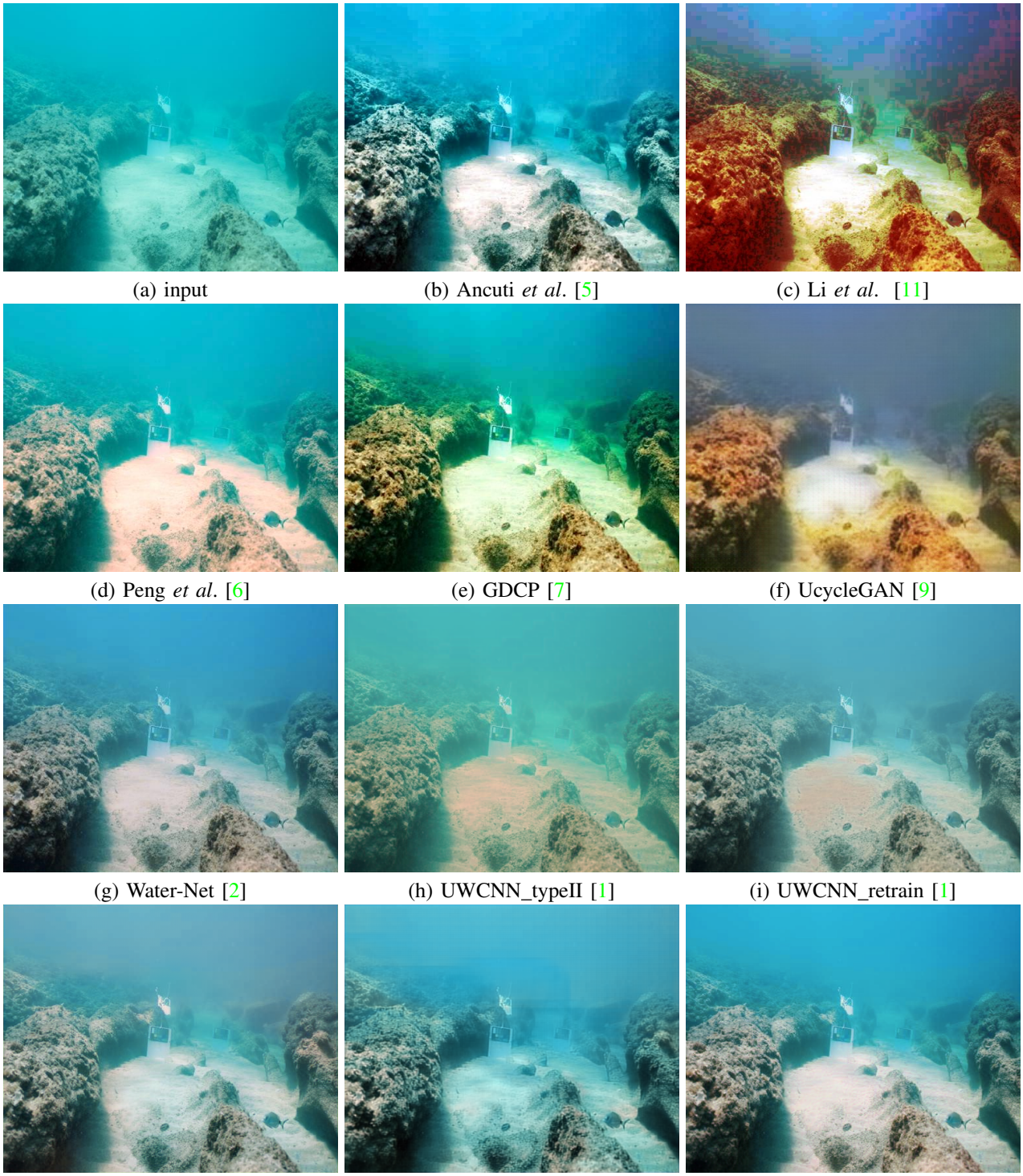
(a) input (b) Ancuti *et al*. [5] (c) Li *et al*. [11]

(d) Peng *et al*. [6] (e) GDCP [7] (f) UcycleGAN [9]

(g) Water-Net [2] (h) UWCNN_typeII [1] (i) UWCNN_retrain [1]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 14. Visual comparisons on a underwater image taken in Katzaa dive site from SQUID [4].



(a) input (b) Ancuti *et al*. [5] (c) Li *et al*. [11]

(d) Peng *et al*. [6] (e) GDCP [7] (f) UcycleGAN [9]

(g) Water-Net [2] (h) UWCNN_typeII [1] (i) UWCNN_retrain [1]

(j) Unet-U [10] (k) Unet-RMT [10] (l) Ours Ucolor

Fig. 15. Visual comparisons on a underwater image taken in Nachsholim dive site from SQUID [4].