Building Climate-Resilient Corals: A Coral Restoration Strategy Integrating Molecular Repairs With Satellite-Monitored Artificial Reefs

Akkarajeerawat, Sunyapat (School: Bangkok Christian College)
Chanthammaphitak, Proadpran (School: Bangkok Christian College)
Sriratana, Naphudon (School: Bangkok Christian College)

Coral reefs are rapidly declining due to climate change and pollution, with more than 80% of reefs worldwide at risk of bleaching. However, current restoration efforts cannot ensure long-term survival as environmental stressors may damage coral DNA. Additionally, many substrates for transplantation fail to support planulae settlement and lack hydrodynamic stability for attachment. This study proposes a novel bottom-up restoration strategy that repairs, strengthens, protects, and monitors ecological recovery across all levels. At the molecular level, stressed corals (Palythoa grandis) were treated with ROS scavengers and exposed to blue light, resulting in 43% and 33% DNA recovery, respectively, confirmed through GSH-Px enzyme activity and DNA integrity analysis. Next, coral thermotolerance was enhanced through epigenetic preconditioning, which reduced bleaching rates by 5-fold, as validated by transcriptomic gene expression analysis. To further protect juvenile corals during in situ transplantation, a bio-adaptive artificial reef structure was developed. The surface mimicked brain coral textures, increasing planulae and juvenile attachment 2-fold. A bio-formulation was also incorporated to promote growth. Moreover, a branching-inspired structural design was selected as it dissipated up to 88% of hydrodynamic stress in computational fluid dynamics simulations. Finally, to promote global-scale reef restoration, an LSTM predictive model was developed using data from remote-sensing satellites and on-reef sensors to monitor bleaching-prone sites and guide future management. The proposed strategy was tested on Samae San Island, Thailand, where Acropora coral survival improved significantly after one month, demonstrating a sustainable approach for scalable coral cultivation.

Awards Won:
Second Award of $2,400
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: Full Scholarship from King Fahd University of Petroleum and Minerals(KFUPM) (and a $400 cash prize)
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: NOT TO BE READ -- $400 cash prize for each Full Scholarship from King Fahd University award recipient