Modern Techniques to Conserve Coral Reefs

Coral reefs are living dynamic ecosystems. They are the rainforest of our oceans that have been on our planet for more than 200 million years. Although all of the reefs in the world only occupy an area the size of Bolivia, they are small eco-dynamons. They provide invaluable services to us, such as acting as nursery grounds for marine fish and invertebrates, providing natural storm barriers for coastlines, purifying CO$_2$ from the atmosphere, and could provide potential sources for undiscovered pharmaceuticals. Annually, they produce 30 billion dollars for our world economy in tourism and food production, among others.

Unfortunately, coral reefs are experiencing unprecedented levels of degradation due to the impact of humans. Increased levels of greenhouse gasses are warming our oceans, making them more acidic and causing the coral to stress, bleach, and be more susceptible to newly emergent diseases. The increased acidity in the oceans is decreasing the coral’s reef-building calcification. Unless we take action now, coral reefs and many of their associated animals, may cease to exist within the next 25 to 50 years, causing the first global extinction of a worldwide ecosystem within our history.

Saving reef habitat alone will not stop this decline, because our threats are not just local, but global. However, novel ex situ conservation techniques, such as genetic banks using frozen samples, hold strong promise to help offset these threats. The Hawaii Institute of Marine Biology hosts a unique collaborative effort with the Smithsonian Institution, led by marine biologist Dr. Mary Hagedorn. Her Coral Conservation Program has a specific conservation aim to use human fertility techniques to create a live frozen repository of coral sperm, embryonic cells and small fragments. Frozen sperm from the endangered Elkhorn coral (Acropora palmata) and the Mushroom coral *Fungia scutaria* has been successfully preserved, thawed and used to fertilize fresh coral eggs. Embryonic coral cells from the Mushroom coral (*Fungia scutaria*) and the endangered Staghorn coral (Acoprora cervicornis) have been cryopreserved and achieved a 50% post-thaw viability. These frozen cells will be crucial for searching for coral stem cells and developing new culture techniques to aid in coral disease studies (Hagedorn et al, in prep.). Moreover, using advances in human stem cell biology, we anticipate that these frozen coral stem cells may one day be coaxed to produce new adult coral. In addition, small frozen fragments of the lace coral (*Pocillopora damicornis*, image left) have been successfully cryopreserved and have survived for up to 8 hours post-thaw. Dr. Hagedorn created the world’s first frozen repository for coral, and it now teaching Australian professionals to create a bank for The Great Barrier Reef. This program is important because a frozen repository can keep the cells and fragments alive for hundreds of years, thus providing a hedge against extinction, and these frozen resources might one day help to reseed our reefs.

Although coral are a focus group, the concept of maintaining key elements for the entire coral reef system is critical. Towards this end, Dr. Hagedorn’s laboratory has successfully cryopreserved larval stages of sea urchins, key grazers and maintainers of ecosystem health for reefs, also important for controlling alien algae species choking many reefs. She is also working on techniques to cryopreserve unicellular marine algae or zooxanthellae that live within coral and are similar to the algal lines now important for US bio-energy production. Finally, fish are essential to all areas of our oceans. Dr. Hagedorn is using the same stem cell technology and cryopreservation applications that she is developing for coral on the stem cells of fish. Recent reports have demonstrated that testicular stem cells transplanted to sterile host fish produced donor eggs and sperm, opening up the possibility of rederiving extinct species from cryopreserved fish stem cells. In the future, this type of stem cell preservation will be the platinum standard of marine collections for museums around the world.

The benefits of this conservation program to the maintenance and wellbeing of coral species throughout the oceans are profound. This unique form of biodiversity is at risk worldwide, and this program seeks to develop means to preserve critical forms of coral to avoid extinction and to restore species eventually back into nature. The exchange of knowledge and resources involved in this program will enhance the intellectual and technical infrastructure at home and abroad, and will strengthen the bonds of national and international collaborations. The program is exemplary in the multi-disciplinary, collaborative design that is the hallmark of successful scientific and conservation enterprises. In short, the Coral Conservation Program is timely, urgently necessary, and imminently feasible. It maintains the high standard of the Smithsonian to address global conservation challenges through sound science, multidisciplinary partnerships and visionary planning.