CREATING SUSTAINABLE LOCAL ENVIRONMENTAL PROJECTS: A CASE STUDY FOR NEW FUNDING METHODS OF CORAL REEF RESTORATION AND RESEARCH PROJECTS

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ABSTRACT

Numerous studies have shown through climate modeling and trajectory patterns based on historical and current data that the world's coral reefs may be close to extinction within the next few decades; indicating that protective measures may not be enough, and restoration programs are required to maintain biodiversity (Pandolfi *et al.* 2003; Goreau 2005; Hoegh-Goldberg 1999; Wilkinson 1999). Island economies worldwide are experiencing rapid growth through tourism and human population increases, with this growth comes development and industries that are negatively affecting coral reefs worldwide. In order to slow this destruction and increase the number of restoration projects new funding methods need to be introduced that allow localized and community based environmental and social projects to take place. By localizing efforts it is possible to increase the number of diverse projects undertaken in communities and increase the awareness of government and public on anthropogenic impacts to coastal ecosystems. This paper proposes a model for alternative project funding that was designed to bring education and awareness to locals and tourists, decrease human impacts on coastal ecosystems, and revive suspended restoration efforts based in the Gulf of Thailand. This funding model can be applied in a variety of industries to boost local economies while at the same time improving the health of the ecosystems they rely upon.

CHAPTER 1: FRAMING THE PROBLEM

Introduction

A majority of the historical coral reef ecosystems worldwide are now listed as depleted, rare, or extinct (Goreau 2005; Pandolfi *et al*. 2003; Wilkinson 1999). Large research and restoration projects have been undertaken over the last few decades and are generally funded through government bodies, private organizations, and the generosity of wealthy citizens or communities. Some of the most prominent and largest funding systems involving coral reefs have been developed by the Integrated Coastal Management Plan (ICM,) that was set forth from the 1982 International Law of the Sea, governed by the United Nations. This system is largely funded by the World Bank and the United States Agency for International Development (USAID). Both the World Bank and USAID provide funding towards projects and policies that support economic growth of coastal communities with the integration of environmental protection, but often fail to improve the protection or restoration of the coastal environments in which they operate (Nichols 1999). The ICM favors techniques which "apply uniform marine territory rights across states" and "standardize spatial regulation and economic development agendas" and does not focus on smaller more specialized projects (Nichols 1999). Although this system works well for large national or international projects, much of the time more broad or media friendly projects are preferred over more local and specialized ones.

The use of top down controls, policies, and solutions implemented by government bodies are often not as effective as integrating with traditional livelihoods to support locally based management of ecosystems. Often the motives for donating money by private organizations are to gain some return through economic growth, political prowess, or public relations. A large number of cases support the claim that the ICM polarizes communities' interests in favor of "more intensive state and international investments" (Nichols 1999). Often smaller and more localized efforts are excluded from this type of funding system and are unable to begin projects that are necessary. Environmental projects initiated outside of western funding are rare; China and a small number of South American countries are some of the only places to have developed successful programs independent of western aid (Nicholas 1999).

A more efficient and sustainable means of providing funding for environmental projects in small communities can be achieved through the utilization of local free markets. Lack of funding and knowledge are usually the largest restraints to local environmental projects, and often prevent community level projects from beginning. Consumer habits can bring money into projects in many creative ways. In order for environmental projects to occur efficiently and thoroughly, they need to be locally managed and attractive from a market standpoint. An effective way to utilize markets is to provide a good or service that is in demand by consumers, and at the same time brings in revenue that is used to provide services to local communities and ecosystems. By providing a good or service that is attractive to consumers, environmental projects are able to self-generate funds, thus ensuring their long term sustainability. Using the problem of tourism as the means to a solution is an efficient and effective method for solving many of the funding issues facing community level environmental efforts.

By taking coral reef projects entirely to the local level, individuals and communities can decide what is necessary for the reefs in their area. The level of funding received will be a direct reflection of the services provided through the free market using standards and ideas of 'eco-tourism.' This paper presents a case study of this concept that was designed to bring awareness to communities and tourists, decrease human impacts on coastal ecosystems, and revive restoration efforts in the Gulf of Thailand. This project utilizes consumer interest in environmental activism to provide educational diving courses that also raise money for broader environmental and social projects. This project can potentially provide a framework for the protection and restoration of coastal areas in developing communities where alternative forms of funding are difficult to acquire or less effective than localized efforts. Through more dispersed and localized efforts at the community level it is possible to create an efficient system to monitor, protect, and restore coral reefs around the world and raising awareness amongst government officials, the public, and tourists. This same funding model can be applied to a wide range of environmental projects to create more localization and community involvement in research and restoration. The utilization of eco-tourism and other funding techniques can help to shift extractive economies and activities towards more sustainable methods of development and growth.

A History of Koh Tao, Thailand

Koh Tao (literally translated "Turtle Island") is a 21 km^2 island located in the Gulf of Thailand. As little as fifteen years ago this island was almost completely void of any buildings, infrastructure, roads, or vehicles; ten years ago, the only forms of transportation on Koh Tao were buffalo carts and longtail boats. The island was visited occasionally by fisherman, coconut farmers, and the occasional backpacker, but remained largely undeveloped. In the early 1990's divers began visiting Koh Tao's 15 bays, each thriving with pristine coral reefs and marine wildlife. Seven years later two small dive shops were established on the island. It did not take long for word to spread amongst the backpacker community about this travel utopia, and shortly after to the general tourist population. This tiny island with only three small towns now sees more than 300,000 visitors each year (Tourist Authority of Thailand 2007). Koh Tao has become the main training center for dive students in South East Asia, and is the cheapest place in the world to obtain PADI Diving certifications, with more than 30 dive shops to choose from (Koh Tao Info 2007). The development of pristine tropical areas such as Koh Tao can be very beneficial to a region's economy through an increase in tourism and the markets directly related to tourism. However, this economic boom, if uncontrolled and unmanaged, comes at a cost to the environment, and if completely unchecked could lead to a collapse of the tourism market and the island economy. Koh Tao is repeating an environmentally destructive process that has already been seen elsewhere in the region.

Koh Tao is the northern most island in a three island chain. Koh Samui is the largest and southernmost island in this chain, and is closest to the main land. Koh Samui was discovered as a destination by foreign travelers in the early 1970's as an undeveloped area and quickly grew into a major nature-tourism destination. First to start frequenting Koh Samui were groups of backpackers who enjoyed the wilderness and pristine aspects of the island. To expand the industry and facilitate more tourists, small lodges, bungalows, and restaurants were built. Shortly after, came more recreational tourists and young people who were drawn to the diving and night-life activities on the island. To accommodate them, more shops were established, roads were paved, taxi trucks brought in, and convenience stores built. Development opened the island to families and mass tourism, forcing the backpackers to go elsewhere. Currenlty, Koh Samui has very little pristine wilderness, a 7-11 on almost every corner, and even a McDonalds. Many people now refer to this island as 'Little Bangkok,' due to its lack of island atmosphere and attitude. This rapid development was done without regulation, zoning, or many solid government controls. Anyone who owned or leased land could build whatever they wished, without a permit or any type of inspections. Waste treatment was not well planned, and most waste flowed directly to the sea. This led to a large loss of the reef ecosystems on Koh Samui, and changed the face of the diving industry there.

In the late 1980's the groups of backpackers started to go to Koh Phangan, the next island north of Koh Samui, for more nature based tourism. Many referred to Koh Phangan as "Koh Samui 15 years ago." Dive boats from Koh Samui began making daily trips to Koh Phangan to visit what was at the time diverse coral reefs. The cycle experienced on Samui repeated on Koh Phangan and within a short time tourists were heading north to Koh Tao, which they called the "New Koh Phangan." Now, dive shops from both Koh Samui and Koh Phangan make daily trips to Koh Tao, as their own reefs are too depleted to sustain diving tourism.

Even with the obvious results of these past processes, the people of Koh Tao have not taken preventative measures to avoid the same life cycles experienced on Phangan and Samui. Other islands in Thailand, such as Koh Phi Phi, do not allow motorized vehicles. In other areas of South East Asia, such as the Maldives, governments have placed limits to the number of beds (and thus people) allowed on islands, and also placed the coral reefs under national protection (Briguglio 1996). The local government on Koh Tao has failed to take similar initiatives in order to save its natural resources and prolong the current tourism boom. Over the last few years, resorts on Koh Tao have been expanding at locally unprecedented rates; swimming pools are being built to accommodate families with kids, night clubs are springing up in all three island villages, towns are expanding their limits, and roads to remote areas are being paved. Koh Tao is at a critical point in the boom-bust cycle experienced on Koh Samui and Phangan. The flourishing environment and economy of this small island has the potential to self destruct unless proactive initiatives are taken to prevent historical mistakes made in the area.

CHAPTER 2: CORAL REEFS AND HUMANS

The Value of Coral Reefs

Coral reefs are aquatic ecosystems that are concentrated near coastal areas in shallow waters up to depths of approximately 50 meters (Castro 2007). It is difficult to define all that constitutes a coral reef is or what its boundaries are, but a complete definition of a coral reef is offered by Wilkinson (1999):

> "A coral reef is a complex marine ecosystem of animals, plants and minerals in which most of the basal and vertical structures have been and are being constructed with calcium carbonate secreted by hermatypic corals and coralline algae, along with a variety of other carbonate- and silicate-secreting organisms."

Coral reefs play a vital role in global ecosystem health and in many human economies, they are some of the most diverse ecosystems on earth, comparable with rain forests. Coral reefs provide habitat and act as nurseries for fish and aquatic invertebrates, provide barriers from storms and waves to protect sea coasts, breakdown excess or xenic nutrients and compounds, and help to regulate atmospheric gases. The main structure of coral reefs is formed by hard corals, which are members of the Cnidarian phylum along with hydroids, jellyfish, and sea anemones (Castro 2007). Coral reefs account for less than 0.2% of the ocean floor, but are home to about 25% of all sea life, including sponges, worms, mollusks, crustaceans, reptiles, and fish (Castro 2007; Wilkinson 1999).

Reefs directly benefit humans by providing food (world average of about $220 U.S. dollars per hectare per year), raw materials ($27 US/ha/yr), recreation ($3,008 US/ha/yr), and biological materials used in medicines and scientific research. It was estimated that in 1994 the earth's coral reefs provided about $10.6 trillion U.S. dollars to world economies (Costanza 1997). Reefs provide many services that cannot be calculated or are yet to be realized by science. Reef building organisms secret calcium carbonate ($CaCO_3$) skeletons and serve as natural carbon sinks that play a role in atmospheric carbon sequestration and climate change stabilization (Goreau 2005; Nichols 1999). Without these climate buffers, predicted changes in the earth's temperatures could come about in a shorter time span than expected, and possibly involve irreversible positive feedback loops.

Requirements for a Healthy Reef

The most important factors controlling coral reef growth are temperature and light availability. Coral reefs are very sensitive to temperature and are healthiest in a temperature range of 22 to 28 degrees Celsius, and usually do not survive in waters that are not within an 18° to 36°C range (Hoegh-Guldburg 1999; Wilkinson 1999). Corals require light to facilitate photosynthesis within internal symbiotic algae that produce essential nutrients for respiration and growth (Castro 2007). Therefore, most hard corals only grow to a maximum depth of about 60 to 100 meters in tropical areas; increased latitude, sedimentation rates, or plankton growth will decrease this depth dramatically (Hoegh-Guldburg 1999; Wilkinson 1999). In low light conditions, algae within the corals are unable to produce enough nutrients, and both the algae and the coral animal are unable to survive. High intensity light also stresses corals, which use metabolic energy to secrete a film that protects them against ultraviolet radiation. The amount of light required (photosynthetically available radiation or PAR) restricts coral growth to between

25° North and South Latitudes, but in certain conditions some coral species may live outside this range (Castro 2007; Hoegh-Guldburg 1999; Wilkinson 1999).

Water quality is an important factor in coral health, and corals generally are able to grow in only clear water with low sediment and pollution concentrations. Corals require a salinity concentration in water between about 32 and 40 parts per million. Corals are sensitive to lower salinities and often do not survive near river deltas, and are affected by high run-off rates during storms (Hoegh-Guldburg 1999). Sediment not only affects PAR for symbiotic algae, but also creates stress to corals that use metabolic energy to produce mucus that sloughs off sediment which settles onto them. Pollution of waters can create a wide range of problems for corals, some of which are not yet understood. Coral larvae are extremely sensitive to even low amount of pollution, and since coral gametes float at the surface, they are prone to being coated by petroleum products leaked from boats and terrestrial areas (Castro 2007). Pollution can increase the amount of marine diseases in many of the same ways it affects terrestrial life; currently there are over 12 previously unknown diseases attacking corals worldwide (Goreau 2005). Corals generally do not grow in nutrient rich waters where quickly growing algae are at a competitive advantage. If water becomes nutrient rich or low in algal grazers, micro- and macroscopic algae can shade or smoother the slow growing corals (Castro 2007, Smith 2007).

Coral reefs exist based on a central theme of mutualistic, commensal, or parasitic symbioses based on co-evolution of organisms; most reef organisms are reliant upon another specific species of organism to survive. Corals also rely upon fish and invertebrate grazer species to consume competitive algae. The elimination of one of any species in a reef has far reaching effects throughout the coastal ecosystem. Symbiotic zooxanthellae that corals rely upon will eject themselves from corals when conditions are not sustainable for survival, most likely due to changes in light, salinity, or temperature. Without the photosynthetic zooxanthellae, the corals turn pale white and begin to die, this is known as ‘coral bleaching’ (Hoegh-Guldburg 1999). Temperature is the most dynamic of all controls on coral survival, El-Niño–Southern Oscillation phenomenons periodically raise ocean temperatures and have historically led to localized areas of coral bleaching (Castro 2007; Goreau 2005; Hoegh-Guldburg 1999; Wilkinson 1999).

Anthropogenic Impacts on Coral Reefs

Coral reefs are both a delicate and resilient ecosystem. Individual corals or animal species are very susceptible to disturbances and damage, but coral reefs are some of the oldest continuous ecosystems on earth (Smith 2002). The biggest threats to reefs are natural ones, such as tsunamis and cyclical ocean warming. One large natural event can almost completely decimate an entire reef, but these events are generally localized and infrequent, allowing the reef ample time to regrow between events. The time scale for re-growth is on the order of 10-30 years providing that there are ample sources of diversity in surrounding areas and that no new disturbances occur during this time (Goreau 2005). Anthropogenic effects tend to be less dramatic than natural ones, but are more frequent, widespread, and sustained, leaving no time for reef regeneration. Human impacts to coral reefs that are considered the most destructive include introduction of organic and inorganic pollutants, increased sedimentation, and exploitation of reef resources. Specifically, these impacts stem from industrial, agricultural, and resort effluent or waste water, petroleum leakage from boats and cars, deforestation, and fertilizers. Also impacting corals are structural damages caused by boats and anchors, fishing nets, exotic fish hunters, divers, and sand or coral miners (Goreau 2005; Nichols 1999; Wilkinson 1999.) The most threatening anthropological influence to coral reefs is alteration of the earth’s atmospheric concentration of green house gases, causing increases in sea water temperatures and changes in upwelling or ocean mixing; all leading to coral bleaching and increased concentrations of dissolved CO_2 in sea water. Increased CO_2 concentrations in the atmosphere alters sea water chemistry and can reduce the calcification processes of corals and coralline algae by lowering water pH (Goreau 2005; Hoegh-Guldberg 1999; Wilkinson 1999). In the late 1980's and early 1990's it was observed that the negative anthropogenic effects to coral reefs was localized around centers of human activity, and that remote reefs remained in pristine condition. In fact, at the time about 42% of the world's reefs were considered 'pristine." By 1998 even these pristine sites were experiencing mass die offs and widespread destruction (Goreau 2005; Wilkinson 1999). The 1997-98 El Niño-Southern Oscillation created the most widespread disturbance of coral reefs through increased sea temperatures in probably the past thousand years, followed by the second highest in 2001-2002 (Hoegh-Guldberg 1999; Wilkinson 1999). This indicates that human influence on reefs is becoming more apparent and widespread, which over time could lead to lowered global reef diversity and limit the ability for ecosystem succession by historical species. Many scientists have shown through modeling and trajectory patterns based off historical data that the world's reefs may be close to extinction within the next few decades; indicating that protective measures may not be enough, and restoration efforts must be attempted (Pandolfi *et al.* 2003; Goreau 2005; Hoegh-Goldberg 1999; Wilkinson 1999). Climate change in itself will probably not completely destroy coral reefs if some biodiversity can be maintained. But, coupled with overexploitation and increased development, coral reef ecosystems could be degraded to the point where they are no longer productive or valuable to the ecosystems and economies that depend on them.

On Koh Tao, many human activities have a direct and observable negative effect on reef health. Few waste water treatment systems exist, all grey water flows directly into the environment, and sewage is held in septic tanks that are poorly built and rarely emptied. Showers, sinks, washing machines, and other grey water sources flow directly out of many resorts, homes, and restaurants into small surface ditches that lead to the sea. This causes an increase in nutrient and pollutant concentrations in the island bays where it creates a competitive advantage for algae over corals; making rebound from bleaching events almost impossible in some areas. Development and deforestation releases tons of sediment into the coastal waters during rain events. This leads to reduced light availability for photosynthesis, causes further stress to corals for removal, and in some cases can bury reefs completely (Castro 2007; Wilkinson1999). Unfortunately, the people who are in the closest contact with the reefs and rely most heavily on its resources are sometimes the most detrimental to coral reef survival.

Specific impacts on the Reefs of Koh Tao and Suggestions for Change

Of the human impacts to coral reefs observed on Koh Tao, the most addressable are fishing and diving. On most nights, 15-25 pelagic fishing boats are visible from the beaches of Koh Tao, pulling in large numbers of fish and squid for markets in Bangkok. Fishing for pelagic fish does not directly relate to on-island fishing problems, but off-shore fishing practices often introduce abandoned nets and other trash into coastal areas which abrade and smother corals and entrain fish. Pelagic fish may grow as much as 5-15 kilograms (kg) per year, but most coral reef fishes only grow at a rate of approximately 1 kg per year (Birkeland 1997). Over-extractive coastal fishing activities can quickly decrease reef diversity, and the removal of alga-grazing fish allows marcoalgae to dominate in coral reef areas. Fishing around Koh Tao is unregulated and techniques include spears, traps, dynamite, cyanide, and large nets; all of which are very effective, but unselective and extremely damaging. Cyanide fishing is used to stun larger fish for live transportation to aquariums or restaurants, and results in widespread death of corals, invertebrates, and small fish. Dynamite fishing destroys entire coral heads and all of the life in the vicinity of detonation (Wilkinson 1999). It is often due to lack of education and awareness that both fishers and divers do not realize the negative effects of their activities and the magnitude of those effects on the health of the reef ecosystems they are reliant upon.

A study conducted in South Africa by Walters (2001), compared the behaviors of 222 divers that were observed without their knowledge. In less than 15 hours of combined observation time, the 222 divers were observed to contact the reef 129 times by accident, 38 times deliberately, and 55 times to anchor themselves. Over 75% of the contacts were from diver's fins, and 10% of the contacts were from dive equipment. Approximately 1.6% of these contacts caused immediate visual damage to the reef. Reef contact was higher during night dives than in day dives, and there was an inverse relationship between diver experience level and the number of contacts. It was also observed that photographers contact the reef more frequently than any other diver type, about 4.5 times per ten minutes accidently and 9.3 times per ten minutes deliberately. A study by Barker (2004) conducted in the Caribbean observed 353 divers in the same fashion and obtained very similar results. He noted that fins were responsible for the greatest proportion of major damage (95.2%), and found that divers starting from boats tend to cause less damage than those starting from shore. Divers with cameras were once again the most destructive divers, with about 1.6 breaks per ten minutes of branching corals; compared to 0.3

breaks per minute from divers without cameras. But unlike Walters, Barker found that about 79.8% of the diver contacts made minor damage to the reef (Walters found that only 1.6% of contacts showed immediate and visible damage). Although many of the contacts caused little visible damage even small scuffs and non-visible damage can severely impair reefs by providing sites for the entry of disease. Also, both studies noted that the resuspension of sediment from diver's fins settles on the corals and causes stress to them (Walters 2007, Barker 2004). Though these effects tend to be localized to individuals, in combination with other stress factors, reef resilience is greatly reduced. These two studies showed impacts on the scale of a few hundred people using a reef for recreational diving, but Koh Tao sees over 300,000 visitors per year, with more than half those visitors trying diving, and many taking at least one diving course (which involves 5 or more dives.)

Many of the negative impacts to coral reefs observed on Koh Tao stem from the fact that it is the cheapest place in the world to get PADI certifications. On Koh Tao the demand for diving courses often exceeds the supply of instructors. This fact, coupled with lack of regulations, has led to dive schools that resemble factories much more than institutions of safety and education. At some of the larger schools, class size often exceeds 12 students per teacher per course. In such large class sizes as on Koh Tao it is almost impossible for the instructor to properly monitor and control diver contacts with the reef and aquatic life. The study by Barker (2004) found that instructor intervention was the most effective way to reduce the diver contact rates with reefs (decrease from 0.3 contacts per minute to 0.1 contacts per minute.) With the larger dive schools comes a greater focus on marketing and revenue maximization, at the expense of safety and proper instruction. Many schools now use cameras to film each day's activities and dives in order to sell tapes to the customers after the completion of their course.

Many experienced divers strongly disagree with these tactics because it leads to more time focused on making funny and memorable movies then on learning how to dive properly. Some also attribute the unusually high incidences of trigger fish attacks on Koh Tao to camera operators. Many of the camera operators have been known to provoke these fish in order to capture a fight with a trigger fish on film; which almost guarantees the sale of the movie and provides a larger tip for the instructor.

The dive shops on Koh Tao are neither closely regulated nor owned by the Thai government. Most are owned by foreigners and thus all have separate standards, practices, and ideas about how humans should use and interact with marine life. For instance, there are some dive shops on Koh Tao that issue gloves and metal ‘lobster sticks’ to students, which are used to poke into holes and crannies where marine organisms make their home. In addition, ideas and standards of diving that are sometimes taught do not coincide with current conservation or scientific knowledge. Many instructors will cut up or otherwise kill crown of thorns starfishes in front of students and guests. This is done with good intentions, as many people notice that the starfish eats the corals, but what they fail to realize is that the crown of thorns is a natural and integral part of the reef ecosystem and its disturbance regimes.

Boats required to move people and equipment to and from the dive sites are another large problem associated with diving. Two separate boats are used to transport the divers to and from the site. The first is a small ‘longtail’ boat, which resembles a long canoe with a large diesel truck engine framed to the back, and the second is dive boats that are generally modified fishing boats. Both boats release fuels into the marine environment through leaks and water cooling systems. When sitting on these boats, it is very easy to see the leaks as a multi-colored film of oil spreads out radially from the vessel, contributing to pollution in the bays. The operators of these boats are sometimes not fully educated on reef life or health, and thus don't fully realize the consequences of some of their actions.

A readily observable problem among dive boat operators involves night dives. Powerful flashlights called 'torches' are used during night dives and generally require 4 D-size batteries per torch; for safety reasons batteries are generally only used for one or two dives. After the night dive, some of the boat hands or captains to toss the batteries overboard. In 2007 during the 2-Day Reef Conservation Course instructors and students have collected approximately 1-3 kg of batteries from the ocean floor. In these same areas are hundreds (I estimated the number at 165 in early August of 2007) of large, conical Trochidae shells that are relatively rare on Koh Tao, but the snail is collected as a delicacy food by boat hands while the customers are diving elsewhere. The problems associated with the diving and fishing community are the most accessible problems to alleviate through the use of education and community involvement.

To manage ecosystems and control destructive techniques and over-exploitation, local communities need to take management into their own hands and work together to protect shared resources. Destructive diving activities need to be addressed by the diving community through an alteration of some current practices and needs to include more education and proactive efforts by dive shops and instructors. The case studies provided later in this paper aim to create an economically attractive method for funding the education of divers and community members, research problems impacting coral reefs, and restore damaged ecosystems. At the same time, this project aims to allow communities to utilize new markets to actively protect areas through the use of tourism dollars. By increasing community involvement in projects through market based systems it may be possible to bring awareness and activism to communities to facilitate widespread monitoring and protection to decrease human impacts on reef ecosystems. Fishing practices are difficult to alter without policy changes at many government levels. Even with legislation to protect corals, it is extremely difficult for government organizations to enforce rules and manage entire ecosystems. It may however be possible for the community to designate some bays around the island as ‘no take’ zones to maintain some areas of high diversity (Goreau 2005). Tourism can lead to much higher GDP’s in developing countries than can fishing. In 1992, the world tourism market traded $1.9 Trillion USD, while the fishing industry traded about $27 Billion USD (Birkeland 1997). If tourism can be managed and controlled through sustainable practices, it can occur at a benefit to subsistence economies. Local extraction based communities can be shifted away from destructive practices through the creation of jobs in more sustainable eco-tourism and other non-extractive practices. These preventative solutions may help to slow coral reef degradation, but proactive restoration efforts are vital to sustaining reef biodiversity.

Restoration efforts be undertaken to sustain biodiversity and to prevent the collapse of economies dependant on coral reefs. Charles Darwin is credited as being the first coral reef restorationist when he realized that detached corals would not survive if allowed to roll around in the sand, but would if attached to the sea floor with wooden stakes (Goreau 2005). Current restoration efforts are similar, but more advanced, and include techniques such as cements and glues to attached broken corals or sponges, clay pots that facilitate coral attachment, transplantation of coral fragments, and placement of large boulders or other artificial reef bases in un stable rubble areas (Goreau 2005; Edwards 2007). These passive efforts work only if water quality, light availability, and temperature are all within the range for healthy coral growth. More active restoration efforts include the use of a Biorock^{tm} structure to increase the ability of corals to survive in a wider range of environmental conditions by reducing the amount of metabolic energy needed to secrete skeletal structures. Biorock (also known as Mineral Accretion or Seacrete Method) is an electronic artificial reef structure that uses low-voltage (DC current of about 10 volts) electrolysis to precipitate calcium carbonate and magnesium hydroxide from sea water which in turn raises pH at the surface of growing coral skeletons (Goreau 2007; Smith 2002). The higher pH allows corals and oysters to grow at an average rate that is 3-5 times faster than control areas. Not only does the Biorock method help to restore reefs and maintain biodiversity, it can be used as an educational tool or an alternative dive sites to relieve pressures on natural reefs (Edwards 2007; Goreau 2005; Smith 2002). The electronic reefs are extremely valuable as a tourist sites for diving and snorkeling in regions where natural reefs have been destroyed.

CHAPTER 3: ECOTOURISM

Definition and Background

As stated earlier, tourism can act to support economies and increase economic growth much more than extractive practices. Indeed, Koh Tao's economy is currently thriving with over 300,000 visitors per year. However, tourism is the second highest threat to protected areas, as listed by The World Conservation Union (IUCN). A problem with tourism is that there is high potential for monopolies and much of the wealth that is brought in to communities disperses amongst a small percentage of the population. The rest of the population can be affected negatively by this through higher prices of goods and services (Gössling 1999). Thus, the majority of the local population must continue or even increase extractive practices to provide for their livelihoods.

The impact of tourism on natural systems such as coral reefs may be decreased through a growing industry know as 'eco-tourism.' Eco-tourism is a relatively new term that has been used to describe products, destinations, and experiences associated with environmentally based tourism (Wight 1993). Although the definitions of eco-tourism differ depending on the motives and perceptions of different industries, two views prevail. The first is that popular interest in the environment can be used to market products or destinations by utilizing tourist interests. The second, is that this new consumer interest can be used to conserve the resources that support the product or destination (Wight 1993). The first of these two ideas represents what Wight calls "Eco-Sell" techniques, in which 'green' language is used to market unsustainable or even environmentally destructive products or services. The second view on ecotourism, which is the basis for the project presented in this paper, represents tourist industries that work to increase the protection of and reduce human impacts on important ecosystems.

‘Eco-Sell’ Versus ‘Eco-tourism’

Eco-tourism, if properly managed and controlled could act to minimize the negative effects of traditional tourism and slow the development of pristine areas. But, this type of tourism should not be confused with ‘eco-sell’ or nature-tourism techniques. The use of “green” and “eco-friendly” marketing techniques that are utilized to tap into the growing market of environmentally conscious society creates apathy for true environmentally friendly products and creates ambiguity for terms such as “eco” and “natural” (Wight 1993). Nature-tourism is a term used for the travel to relatively pristine areas, and is often more destructive than mass tourism because it encourages development in these areas (Gössling 1999).

Although there is no commonly held definition for eco-tourism, some standards have been set up to evaluate if tourism practices are truly environmentally effective and conservation based. The first of these standards is that eco-tourism should contribute as a means of income and education to the direct conservation of ecosystems (Gössling 1999). Secondly, ecotourism should not degrade natural resources and needs to be developed in a sustainable manner. The ecotourism industry must provide participatory, first hand experience with the ecosystems trying to be protected, but in a manner that does not negatively impact or encourage unmanaged development in the ecosystems. Additionally, it should include the education of all parties involved such as governments, communities, industries, and tourists. Lastly, it should promote the understanding and involvement of all these parties and promote responsibility of shared resources (Gössling 1999; Wight 1993).

It is important that the tourist industry takes it upon themselves to self monitor the uses of terms such as 'eco-tourism.' Due to the polarity of the meanings behind the term, this project strives to ensure that actions of the dive shop and the program will truly be in the best interest of the community and truly decrease human impacts on coastal ecosystems. Effective management and control policies need to be implemented that take into consideration the growth of economies and the protection of natural resources. Community involvement needs to be maximized in order to effectively conserve natural resources. Educating and involving the local communities in non-extractive practices that provide revenues can decrease over-exploitation for short-term, maximized profits. Local populations should be provided with jobs that directly relate to the protection of the natural resources and ecosystems such as diving instructors and guides. The Koh Tao project utilizes eco-tourism techniques while attempting to hold true to decreasing impacts on the environment and encouraging sustainable practices. This project attempts to involve the community in order to boost ideas of eco-tourism and sustainability as an effective way to earn profits without over-extracting resources.

CHAPTER 4: THE CPAD FOUNDATION

Background

The Coastal Preservation and Development Foundation (CPAD) is a non-profit organization that works with developing coastal communities to reduce their impacts on coral and terrestrial ecosystems. According to CPAD's mission statement, the group "seeks to identify sustainable development strategies for coastal communities; balancing commerce and natural resource conservation through scientific research, education, and relationships with local businesses" (CPAD Foundation 2007). CPAD was a joint organization between both the U.S. and Thailand, with most projects based on Koh Tao and the mainland of Thailand. CPAD established a list of objectives that included assessing the health trends of local ecosystems through long-term monitoring; educating locals and visitors about natural resources and the human impacts to them; and assisting communities in providing solutions to minimize environmental impacts while enriching sustainable business practices.

To achieve these objectives and implement projects that could benefit the communities economically, CPAD began working with local dive shops, the Thai Navy, Mohidol International University College, and students from the University of Colorado at Boulder. The first phase was to begin researching the reef around Koh Tao in order to get a baseline data set to which all future data could be compared. CPAD established survey sites in 8 of the bays around Koh Tao to be the location of an Ecological Monitoring Program (EMP), with pristine sites planned around Mo Koh Ang Tong National Marine Park. Ang Tong is an 83 island cluster located to the south west of the Koh Tao to Koh Samui island chain.

Between May and August of 2006 many of the projects that had been in development by CPAD were enacted with volunteers brought to the island from the U.S. and Bangkok. These projects included: a Coastal Research Certification Course (for volunteers), the EMP, construction and monitoring of a Biorock^{tm} structure, GPS mapping of water ways and development, construction of a Geographic Information System (GIS) database, waste vegetable oil recycling/biodiesel production, and a program to teach local kids to swim, snorkel, and then SCUBA dive. These social and environmental projects were well received in the community and brought people together in an effort to begin protecting Koh Tao. Many dive shops contributed time and resources to the programs with the hopes of sustaining the programs into the coming years.

In 2007 the CPAD Foundation lost its primary investor. This caused an immediate cessation of the projects, and the few paid CPAD employees lost their jobs. The swimming program, which had accumulated SCUBA equipment through donations, was terminated because long-term (and Thai speaking) volunteer instructors could not be found. The waste vegetable oil containers at restaurants were never collected, the biodiesel reactor that was built on donated money sits in the jungle uncompleted, and all of the valuable GIS data on island waterways and development have been lost due to the departure of personnel. This shook the confidence on environmental projects within the community, and made the projects that were being undertaken look unsustainable and ineffective. This perception may be difficult to overcome in the future, and could lead to an increase in apathy for new environmental and social projects.

CHAPTER 5: THE 2-DAY REEF CONSERVATION COURSE

Background and History

The suspension of CPAD projects on Koh Tao occured suddenly and left many of the community members without anything tangible to show for their invested time and money. One dive shop in particular, New Heaven Dive Shop, had invested much time and resources into the CPAD projects. For the entire length of the EMP program CPAD members had consistently used New Heaven's equipment and boats. In addition, New Heaven had been allowing CPAD members to use their land for projects, and the dive shop as a meeting site and base of operations. The owner of New Heaven, Devrim "Dev" Zahir, had provided the resources, as well his time and money, to CPAD because he shared and believed in the Foundation's goals and understands the importance of restoration and monitoring efforts

During the summer of 2007, Dev was attempting to sustain the abandoned CPAD projects, but with little time and resources this was nearly impossible. Dev asked me to volunteer running the EMP program, with the money for SCUBA tanks and equipment derived from a fee taken out of every PADI Open Water Course taught at the school (equivalent of $3.25 U.S. for a $316.00 course.) He could not raise the price of the course due to competition in the market (and fixed prices on Koh Tao), but instead took a small loss from each course for the collection of funds used for environmental projects. We preformed three rounds of EMP's in May and June 2007, bringing Dive Masters from New Heaven with us in hopes they would continue to volunteer for future EMP's. Dev and I knew that this was not the best way to run the program, because the dive shop's experiences a loss of revenue creating a disincentive for other dive shops to adopt similar programs. In order to ensure the sustainability and proliferation of the program the projects need to be both self-funding and economically attractive.

Course Goals

The broad goals of this 2-day conservation course are to increase knowledge and awareness of coastal environments, provide quantitative data on reef health and biodiversity, and continue restoration efforts. It is not feasible to run all of the original projects with a limited budget and underfunded staff, so it was decided that the two most important things to do were to continue the data stream from the EMP and the restoration work through the Biorock structure. The data from the EMP is critical for understanding trends in the coral reef health around Koh Tao and, upon discovering negative trends, persuading the community and government officials to change policies or contribute to work projects. The Biorock structure is still in the trial phase for Koh Tao, and to evaluate its effectiveness we felt it was important to upkeep this project as best we could. Coincidentally, these two projects turned out to be very marketable as there is a strong desire amongst the diving community to directly work with coral reefs.

In July of 2007 Dev and I designed a course to accomplish our goals and provide a salary for course instructors. We finally decided on a 2-day course that would include a lecture, an EMP dive, a coral collection dive, and a transplant/underwater clean-up dive (See appendix A for Course Description.) It was quickly realized that the 'Introduction to Reef Ecology' lecture was one of the more important components of the course. As shown by Barker, divers do much less damage to reefs after a 45-min briefing on "reef biology, contacts caused by divers, and the concept of a protected area, followed by an in-water demonstration lasting a few minutes"

(2004). We also found that divers became more aware of their surroundings while diving and made an increased effort to avoid unnecessary reef contact. For the EMP, the existing techniques established by the CPAD Foundation were used, but structured differently to fit our course and a lecture was added to accompany the first EMP dive. To make the course marketable, and to set it apart from other volunteer projects, we decided that education and diving skill enrichment would be the main focal points when advertising the program.

Program Description

The majority of the education involved in this course is presented in the lecture on the morning of the first day of the course. This lecture covers basics of Coral and Marine Biology/Ecology, human impacts on marine life and environments, EMP methods, equipment use, compass and navigation review, and underwater safety (see Appendix B for copy of lecture notes from 2007.) The goal is to educate people on coral reefs so that they understand the basis of how reefs function, how humans benefit from them, and how humans can be proactive in their protection. Additionally, participants learn to identify fish species and many types of marine life, making them more informed and aware divers.

An increase in diving skills is not the focus of the course, but is an inherent factor in the EMP and Biorock dives. Divers first learn equipment management and use while underwater, which is usually difficult for beginning divers. Most divers have never used the equipment or taken data while underwater while still focusing on skills and techniques involving air consumption and buoyancy. For many experienced divers, this is an attractive opportunity engage in something new while adding importance and variety to the normal routine of observational diving. Carrying equipment, especially on a conservation dive, requires that participants remain always aware of their buoyancy and air consumption while performing other tasks to ensure safety for both the divers and corals. Stray equipment can injure the corals, while poor buoyancy can be dangerous to divers working in shallow waters around boats and marine organisms such as sea urchins and poisonous stone fish.

The second day of the course focuses on restoration work with the Biorock structure. Here, participants learn to identify and safely collect dying corals. In this case, dying corals are classified as those which have been dislodged or broken, separated from corals of the same species, and mostly bleached. Corals to be collected for the purposes of the course must be in open or sandy areas, be at least 90% bleached, and contain no fish or invertebrate inhabitants. Participants learn to identify these types of corals, and how to safely handle them and transport them back to the boat. The corals are then transported to the Biorock structure in a large water tank that is kept cool through constant water replacement. At the site, the corals are carried underwater from the boat to the Biorock structure and affixed to the metal grid. Students learn the proper techniques for doing so and how to maximize the contact of living coral with the structure to maximize the coral's chances of survival. After affixing the corals, participants swim through the areas commonly used by diving and fishing boats to moor overnight and collect litter such as batteries, plastics, and electronics.

The feedback we received from the participants was that working underwater renewed an enthusiasm for diving which had decreased due to a long time of diving in similar areas. Many found that even writing on slates was exciting, when preformed in new and alien environments. Most were also pleased to get a chance to refresh and practice compass and navigation skills, which are required skills for the PADI Advanced Diving Certification but are rarely needed when on observation dives led by dive masters. The second day of the course is usually quite gratifying for participants; they are always visibly overjoyed and full of enthusiasm for the work they have done. Participants comment on how happy they are to have done something beneficial for Koh Tao, and also say that the course is some of the most fun they have experienced diving. After the course, participants have been so excited they tell their friends and family what they have done and learned, thus helping to improve awareness about the issues and provide word-of-mouth advertising for the program.

Methods

The EMP reef monitoring course offered at New Heaven Dive Shop is based on a combination of the standards and methods set forth by the CPAD Foundation, ReefCheck.org, and Green Fins International. All of the current instructors and volunteers were trained through the CPAD Foundation while it was still active. The EMP consists of data collection from 4 main areas of interest; substrate composition, fish abundance and diversity, invertebrate abundance and diversity, and water quality. The fish, invertebrate, and substrate data are collected along belt transects, which is a term used to describe a method in which a line is laid down from known starting and ending points and data are collected along that line. For the EMP on Koh Tao there are permanent starting and ending points for two lines; one shallow (~2-6 meters) and one deep (~6-12 meters), in eight of the bays as established by CPAD in 2005-2006. The sites were placed in areas deemed both representative of the surrounding coral reef, and in areas of both high and low human activities. This provides data that are representative of the entire bays in both high and low development areas, allowing the comparison of different areas in order to gain information on development policies/practices and focus local restoration efforts.

The data are taken on a 100 meter transect line, consisting of two 50 meter tape measures. For the EMP dive, the starting points must first be located within the bays using navigation and triangulation skills. Next, two divers are sent to layout the transect line, one navigating a known compass bearing, and the other carefully laying down the measuring tape. Upon laying down the line, the divers swim along the line and collect data on species abundance or substrate types. For the fish survey, data are taken in four, 20 meter segments of the 100 meter line, with a 5 meter gap between each segment. Data are taken 2.5 meters on either side of the line, and 5 meters above the ocean floor. This provides 4 research areas of 500 meters^3 on each line (shallow and deep). To conduct the survey, the diver swims slowly along the line and counts the number of fish observed from the list of designated indicator species, and marks this on his or her PVC slate. After completing an observation on one line, the divers swim to the other line, and perform a survey different from the one preformed on the first line (i.e. if the diver first looked at fish, he or she next looks at invertebrates and vise versa). After all three surveys are complete the divers carefully reel in the lines and collect the equipment. The fish species observed are species that have been selected by ReefWatch.org and the CPAD Foundation due to there value as indicators of reef diversity and health. There are 10 diversity indicator fish species observed in this study: 3 types of rays (Blue-spotted Stingray, Blue-spotted Ribbon Ray, and Manta Rays,) 5 species of butterfly fishes (Lined, Eight Banded, Weibel's, Copper Banded, and Longfin Bannerfish,) 4 species of snappers (Spanish Flag, Checkered, Black Spot, and One-Lined,) as well as moray eels, groupers, parrot fishes, rabbit fishes, surgeon fishes, sweetlips, and trigger fishes (See Appendix E for copy of data observation sheets.)

The invertebrate survey is conducted in much of the same way. In this survey, the same area is used as in the fish survey (four, 500 m^3 segments per line), but as most of the invertebrates are found on or under rocks and coral this is a much slower and more intensive survey. More skill is needed to maintain buoyancy while looking under the rocks and coral without contacting or harming any of the marine life. Once again, the species observed were chosen for their value as indicators of reef diversity and health. The invertebrates chosen as diversity indicator species for this study are: 3 species of sea cucumbers (Marbled, Black, and Red Spiked,) boring and giant clams, triton trumpets, octopuses, Crown of Thorns starfish, and Long Black Spine sea urchins.

The substrate survey is preformed differently than the fish or invertebrate surveys. For this survey, the transect line is used as a guide to collect a single datum point of the bottom composition every 50 centimeters within the all of the four 20 meter survey sections. The observer stops every 50 cm along the line and records what is directly underneath that point in the line. These data are used to determine the composition and dominant substrate types (in percent of floor bottom) of each survey area. The substrate is identified as either hard or soft coral, algae (Brown, Green, Non-calcified Red, or Calcified Red), rock, rubble, sand, silt, trash, dead coral, or other. Furthermore, the hard corals are identified by growth form (massive, sub-massive, encrusting, digitate, tabulate, croymbose, solitary, etc) and, when necessary, coded by health (partially bleached, fully bleached, recently killed, predation, etc). Diseased and dying corals are noted by the type of disease present (Black Banded, Red Banded, Yellow Banded, etc.) This is a very intensive survey and requires a long period of practice to be efficient and thorough. For this reason, most of the students of the 2-day course perform only the fish and invertebrate surveys, with the instructor collecting the data from the substrate survey.

Following the dive, data are taken on the abiotic factors for that specific day, including information about the water quality, number of visitors, and weather. While underwater, a Secci

Disk is used to determine the horizontal visibility. A Secci Disk is a metal disk that is painted with black and white segments and used to estimate visibility and light penetration levels. This is done using one diver to hold the disk, and a second diver to swim out from the disk along the transect line until the black and white sections can no longer be visually differentiated. The diver records his or her distance in meters from the disk, and then swims back until they can see the disk once again. These two values are averaged to give the horizontal visibility. Upon returning to the boat, the diver will check the vertical visibility in much the same way, to estimate light penetration depths for that particular day and time.

Next the water is sampled using a Van Dorn bottle lowered to 5 meters beneath the surface. The bottle is rinsed twice, and then the sample collected on the third time. Two samples are collected in this way, one is tested on the boat and the other is put on ice to be brought back to the dive shop for later testing. The sample tested on the boat is tested using a multi-meter for salinity, conductance (total dissolved solids), temperature, and pH. The other sample is put on ice and analyzed later using a colorimeter to test for turbidity, nitrogen, and phosphorous content. Also noted are the physical weather conditions (sunny, overcast, rainy, windy, etc.,) and other observations such as number of dive boats present, time of day, and disturbances found (nets, anchors, traps, etc).

Economic Analysis

The 2-day program is both affordable to the consumer and profitable for the dive shop. The course consists of a lecture and 3 dives. The normal cost of three fun dives on Koh Tao is 2,250 Thai Baht (conversion rate is about 32 Thai Baht (THB) to $1.00 U.S.) Because of the shallow nature of our diving, instructors and some students are able to do all three dives on two tanks of air, lowering overhead costs for the courses. To make the course more attractive during its initial stages, the current price is 2,000 THB/person for the two day course. Of that 2,000 THB/person, 200 goes to the instructor, and the other 1,800 baht goes toward the air tanks, and shop overhead. In return, the shop receives free the work which used to cost money to complete, and ensures a fairly constant supply of volunteers.

ReefCheck.org offers dive shops the ability to teach certification courses, and there are a limited number of dive shops in Thailand that do so. On Koh Tao, there is one dive shop that carries this course, which is a 4-day course involving 2 dives. The cost for the course is 11,900 THB, about 4 times the cost of our 2-day and 3 dive course. The price of our 2-day course can also be compared with a 1.5 day 'Discover ReefCheck' course (only 3-4 hours on day 1,) taught on Koh Lanta for 3,200 THB (Aqualogy Marine Education 2007). The 2-day course on Koh Tao currently costs 1,200 THB less, and has twice the number of dives. There are also courses offered through PADI, called 'Aware Coral Reef Conservation' courses. The cost of this 1 day/2dive course on Koh Tao is 3,900 THB, which includes a small manual, but does not including performing transect surveys and does not cover fish or invertebrate identification (both a Fish ID and a Reef Check course can be purchased through PADI for an additional 3,000 THB per each 1 dive course) (Crystal Dive Resort 2007). The PADI courses seem to not only be the most expensive per dive, but also the least intensive. The descriptions for the Project Aware courses indicate that they are more educational than practical and the course can also be taken by people who do not wish to dive.

Discussion of Results and Areas of Further Development

The course was initially tested in mid-July of 2007 with two very experienced local divers and business owners. Both commented that they learned much from the lecture, and had fun performing the surveys. Both gave good feedback on how to run the course in the future, and said that they would give the course a positive recommendation to others. At the end of July, the course was conducted with the first paying customers, two park rangers from Holland. The couple from Holland enjoyed the course, and were thrilled to learn more about the reefs and gain new diving skills. Although, after reviewing their data it was decided to extend the lecture portion of the course to cover more fish and invertebrate identification. It was also decided that lecture notes should be given to participants to increase understanding when working with language barriers. The next course was run on the 11^{th} of August, for four divers; two experienced French women, and two Thai Dive Masters. This time the data was much more congruent, indicating better understanding from the lecture. We taught the course to 3 Thai college students later in August; which they used as an independent study research project to receive course credit at Mohidol University International College in Bangkok.

As of now, there is only about 1 years worth of data collected from the bays around Koh Tao, with the data from the 2-day course and the CPAD work combined. Fluxes in fish and invertebrate numbers are apparent, but it is too early to say if these are annual cycles or actual declines in overall reef health and diversity. We plan to use the first few years of data as the baseline for comparing future trends. The bays selected for observation in this project range from well developed to undeveloped, which should provide quantitative data as to the immediate effects of terrestrial development. From surveys and colorimeter tests, we have determined already that the more developed bays such as the main town of Sai Ree (see map in Appendix D) have Phosphorus and Nitrogen concentrations about ten times higher than the least developed bays. Specific point sources for these nutrients have not been identified as of yet. Unlike development, diving is well established in all of the bays around Koh Tao. Because of this, we can not analyze the direct effects of diving without including the other variables. In order to accurately gain information about the effects of diving on the reefs we also need to begin collecting data in pristine areas, or affiliating with groups who are already doing so.

Due to these restraints in our current data, we cannot at this time say definitively whether our program has been beneficial to the protection of the reefs, it will take many years to do so. We can however get quantitative data on the immediate effects of the lecture portion of our program and the effects that an increase in awareness will be have on diver behavior. To do this we will begin surveying and observing randomly selected divers before and after completion of the course; using techniques much like in the Walters (2001) and Barker (2004) studies. Surveys will be used to compare the level of skills between larger and smaller dive schools to get quantitative data that could support the growing argument for class size and diver activity regulations. Additionally, we will start to collect data on the number of divers visiting Koh Tao each year, and conducting regular diver counts for each bay around the island. This project will begin in January of 2008 and will also utilize a new stream of volunteers coming from an organization known as i-to-i.

CHAPTER 6: THE I-TO-I VOLUNTEER PROGRAM

Program Background and Goals

After the first four 2-day course offerings, we began talking with the director of a group called The Secret Garden, which is a non-profit group also doing work on the island. The Secret Garden is an organization that works with the Koh Tao elementary school to teach English, swimming, and other important skills to young Thai kids. The group had taken over the kid's swimming program after CPAD funding stopped and were involved with an international volunteer organization named i-to-i (see www.i-to-i.com.) The director had heard of the New Heaven program through some of the participants and wanted to see if we would offer it as a 2 to 4 week course with volunteers arriving internationally from i-to-i. It was decided to expand the 2-day course into a longer program, and through this develop means to get work done on other projects that are lacking the funds to start. The 2-day course will still be taught in the future, and can be integrated into the longer course without much effort by the instructors. This will provide more volunteers for environmental projects and provide money to cover shop and instructors costs. It is hoped that this will act to bring in more widespread community and governmental involvement on larger environmental and social projects. With success, we hope that other dive shops will recognize the sustainability and profit potential of this or similar programs and enact programs to protect and restore the reefs around Koh Tao and other islands. A shift of island industry towards more sustainable eco-tourism could benefit the economy of Koh Tao and at the same time ensure its sustainability through more dispersed efforts. In an attempt to reach this goal, we have written a program that should encompass many traits of eco-tourism while at the same time providing needed funding towards protection and restoration projects.

With the success of the 2-day program, and the opportunity to expand the scope of the course, we decided in Mid-August of 2007 to write four separate programs that could be presented to i-to-i. The programs would need to be mutually beneficial to us and the volunteers to ensure viability and sustainability. The participants should finish the course and feel they have greatly increased their skill sets and knowledge of coastal ecosystems as well as feel that they have made a difference in protecting the island and increasing the welfare of its inhabitants. With rising environmental and social awareness in society, many people will pay for this type of volunteer activity, which i-to-i describes as 'responsible travel.' The 4 year old organization now sends "5,000 people per year to 500 projects on 5 continents" (i-to-i Foundation,) all of whom fund their own trips and pay their expenses while performing the work. For the dive shop and its program, we are now able to ensure a steady stream of volunteers from around the globe and at the same time bring in revenues to fund the environmental and social projects that we feel are necessary and beneficial to the island and the community. By keeping prices low, we are able to bring in participants from a wide range of countries and demographic backgrounds to spread awareness of problems and solutions for coral reef ecosystems. The proposal was accepted in November of 2007, and the first volunteers should arrive in early 2008.

Program Description

In order to increase the range of our market for volunteers it was decided to write four courses that could be preformed in either 2 or 4 weeks by both experienced or non-divers. Volunteers in all of the courses are involved in a wide range of social and environmental projects based on their interests and prior experiences. Volunteers become certified by the Professional Association of Diving Instructors (PADI) for both Open Water and Advanced Open Water

Diving (Emergency First Response and Rescue Diver Course is also offered, and is optional.) In addition, participants learn coastal research diving and advanced buoyancy skills that are not offered in PADI courses. A short description of each course follows, and a daily schedule of events can be found in Appendix F.

Program Description: 2-Week Non-Diver

The 2 week non-diver course (11 day course plus 3 days travel to and from Koh Tao) is scheduled to run two times per month, beginning on the 1st and 3rd Sunday of each month. Upon arrival in the early afternoon, participants will be transported to their pre-arranged accommodations, briefed on island safety and etiquette, and then given a 45 minute lecture entitled "Introduction to Marine Conservation," which provides background on the course, the island, and the projects being conducted at that time.

On the following day, participants in this course begin the PADI Open Water Certification, which runs for three days and consists of 5 dives. Following the completion of the Open Water Course, participants will spend one day assisting on an environmental or social project of their choice and one day performing a Roving Diver Survey. The Roving Diver Survey is designed to give students an introduction to species identification and underwater equipment management. This course is taught using standards established by Green Fins International and the data collected during these dives are sent back to Green Fins for analysis and presentation.

Saturdays are free days for the volunteers, and Sunday evenings will include weekly briefings, question and answer sessions, and a one and a half hour lecture covering "EMP Research Techniques: Fish and Invertebrate Surveys." This lecture describes the techniques and skills used to perform the EMP for both fish and invertebrates as well as techniques for testing water quality. Other topics covered in this lecture include underwater compass and navigation techniques, safety, and species identification. The following morning starts off with a lecture entitled "Introduction to Marine Ecology," designed to provide a basic understanding of physical ocean properties, coral reef anatomy/biology, reef ecology, and how humans interact and fit into these topics. Following the lecture, students perform a full fish and invertebrate transect survey, including water testing and data entry.

The final day of the program focuses on the Biorock project, with a coral collection/ transplant dive followed by an underwater clean-up. In addition, there is a 15 minute beach clean-up every morning, and a debriefing each evening. Students will leave on Thursday morning of the second week to travel back to Bangkok. By the end of this program, participants will have completed the PADI Open Water course, made a total of 15 dives, learned to perform roving and transect surveys, and given something back to the island through 11 beach clean-ups, one underwater clean-up, and one day spent working on an environmental or social project. They will have collected two rounds of EMP data to go into the EMP database, and hopefully gained more understanding and awareness of coastal ecosystems and the human role in their preservation.

Program Description: 2-Week Diver

The 2-Week Diver program is for any volunteers who already are certified in both Open Water and Advanced Open Water Diving. In addition to the 2-week non-diver course, volunteers in this category will be assisting on environmentally related projects that are led by the 4-week volunteers, and spending more time than the non-divers learning and performing the EMP Dives. Pre-certified divers will also have the option of learning substrate survey techniques, going on a night dive, and taking the PADI Emergency First Response and Rescue Diver courses (PADI courses not included in program price).

Program Description: 4-Week Diver & Non-Diver

The 4-week divers and non-divers receive a much more intensive course and workload due to their higher value to the program than the 2-week volunteers. All of the components of the 2-week courses are included, but the 4-week volunteers will be leading a chosen project that has been predetermined as beneficial to the people or environment of Koh Tao. For this 25 day course, there will be 4 lectures, about 34 dives, and over 5 days spent working on projects. Non-diving participants are once again required to take the Open Water and Advanced courses, the Rescue Diver course is not included in the program, but can be purchased separately. By offering the Rescue and other courses, it is possible for the dive shop to increase their profits by having more students for these courses. Even during low tourist seasons, it is possible to ensure a steady stream of students for Master Divers and Diving Instructors at the shop. This should work as a positive economic incentive for the proliferation of this dive course amongst other dive shops, leading to greater public knowledge and proactive reef restoration efforts.

Environmental Projects

The primary goal of this program is to increase the amount of volunteers and funding for all projects that can be beneficial to the environment and community of Koh Tao. In the same spirit as the Reef Conservation Course, the i-to-i program will allow New Heaven Dive shop to continue many projects started but unfinished by the CPAD foundation. In addition, it will allow it to expand the number of social and environmental projects we are able to undertake. As stated earlier, participants of the 4-week course will have to opportunity to select an environmental or social project they are interested in, and dedicate much of their time towards advancing that project in a leadership position. Participants of the 2-week course will assist on projects that are being completed at the time of their stay on Koh Tao. This will allow New Heaven to have a constant supply of volunteers and new ideas, and allows more flexibility in project selection than could be achieved through traditional funding systems.

The time span of these projects ranges greatly, and most will be ongoing and self sustaining after the initial investment. The first self-sustaining and income generating project will be the production of safe and non-toxic biodiesel to supplement petroleum diesel fuel usage in boats. Biodiesel is renewable fuel made from fat sources and is 74% cleaner burning than petroleum diesel fuel, can be used in any diesel engine without any modifications, and completely biodegrades in marine environments in less than 28 days (Pahl 2004). Biodiesel can be produced on the island in small reactors using waste vegetable from restaurants and native plant sources. Both decreasing waste leaked into the environment and the need to import expensive foreign diesel to the island. Work that I previously completed with the CPAD foundation in 2006 showed a large interest in the production and use of biodiesel and the potential of waste vegetable oil as the primary feedstock source. After the initial investment for the processor (generally about $1,000 US) this project will generate revenue through the distribution of the fuel in a community co-op model, providing jobs and supporting the local economy.

Other projects included in this plan are not necessarily self-sustaining, but we hope to develop creative ways to make these marketable and sustainable by integrating community involvement. Some of the projects currently planned under this program are the same projects that were abandoned by the CPAD Foundation, including the EMP, Biorock, and the kid's swimming programs. Additional projects planned include:

- A sea turtle hatchling program to provide safe habitats for juveniles and educate the public on anthropologic threats to sea turtles. Through an 'adopt-a-turtle' release program this project should be able to generate funds for operating costs and research.
- A protected nursery area for the growth of coral fragments to help sustain reef biodiversity and transplant corals to damaged areas.
- Recycling programs for plastics, metals, and batteries that are otherwise openly burned with unsorted trash collected on the island.
- Mooring buoy construction using fixed anchors to reduce coral damage from boat anchors and overturning of coral heads during storms.
- Waste treatment systems such as biological composting septic tanks and environmentally safe incinerators.
- And waste to energy systems involving bioreactors to produce methanol/ethanol from waste biomass.

In order to provide the most efficient and accessible technologies for the projects, we hope to maintain close ties with universities in both the U.S. and Thailand. Our biodiesel project will be completed by working closely with a student group called CU Biodiesel, at the University of Colorado, Boulder. Students from this organization will be using grant money to fund travel costs to Koh Tao to act as consultants in the development and implementation of this project. By providing resources for learning, internship, and independent study opportunities we hope to use Koh Tao as a launching point for student ideas. This will keep the program up to date and allow students access to real world experience in the field of biofuels technology.

Economic Analysis

Economically, the course is attractive both for the participants and the dive shop. The price of the course is reasonable in terms of U.S. dollars or the Euro, and already there has been a great deal of interest in the program. The price of the course covers all of the dive shops overhead costs for the participants, and allows a profit to be made by the instructors and the dive shop owner. Additionally, the course fee includes money to be used for materials involved in the environmental and social projects. Through this system, the program can self-generate the funding need for the research and environmental projects. The 2-week non-diver course is priced at 20,000 Thai Baht (THB) (about $634.00 US,) not including airfare, accommodations, or food. Because of fewer PADI diving courses involved in the 2-week diver course, it is disconnected at 14,500 THB. The 4-week non-diver and diver courses are 40,000 THB and 26,500 THB, respectively. The courses are competitively priced with other, similar courses offered in the region, but the scope of this course far exceeds any course in the area.

In addition to the course discussed previously, ReefCheck.org offers a longer Eco-diver course in Pattaya, Thailand. This course involves 6 dives over 7 days and focuses only on fish, invertebrate, and substrate surveys (Mermaids Dive Center 2007). The price of this course is 22,000 THB. Our course that most resembles this course, is the 2-week diver course at 20,000 THB and consists of 11 days, 15 dives, and experience with the Biorock and environmental projects. The only course regionally that is comparable in cost to our course is located in Kuala Lumpur, Malaysia. It is a ReefCheck.org course, and costs the equivalent of 6,400 THB for a 4 day/6 dive course, but also includes accommodation and food.

The main reason that we are able to keep our costs so low and still allot money towards the environmental projects is because we do not need to pay a percentage of profits to larger organizations. The dues paid to large organizations such as PADI are usually most of the market price of a dive course. By operating independently of these organizations, we are able to provide a more involved and extensive course to the public and offer it at a lower price. Being independent allows us to specialize the course to the region, and allows more flexibility in project selection and implementation. Our course, however, does not currently give an internationally recognized certification in eco-diving or coastal research. With the PADI and ReefCheck.org courses, part of the course fee goes towards a certification card that can be presented and recognized at other dive shops around the globe. To sell the course independent of certifications, it is marketed on lower prices, more underwater time, and the inclusion of the environmental projects. In looking at the success of the 2-day course, we believe there is a market for people who want to learn based on the content of the course and not the goal of having a certification. We found that, amongst the tourist population, there is a high willingness-to-pay for the protection of natural systems, especially when the person contributing funds is also able to actively participate in the protection of those systems. The New Heaven program will focus on this market while also working to get third party, independent certification from globally recognized organizations.

CONCLUSION

Because a majority of the historical coral reef ecosystems on earth are now listed as depleted, rare, or extinct, it is vital that humans play an active role in the protection and restoration of these ecosystems. The problems associated with the current decline in reef health will only increase with the ever growing human population of the earth. Over-fishing and development will continue well into the future due to the lag times of governmental policy implementation and the difficulty of enforcement. The price of rare fish and marine organisms in Asian markets will continue to drive reef depletion unless the problem can be combated through the consumers end with more education. In regards to water quality and climate change, it may already be too late for many of the earth's reefs. Measures to control the input of pollutants may help, but the lifetime of many pollutants and the speed of development have already decreased water quality enough to make preventative measures completely ineffective at restoring reef diversity. It is only through the use of proactive restoration efforts and broad education that society can hope to sustain coral reefs and the economies that rely upon them.

The New Heaven 2-day Reef Conservation Course and 2-4 Week Programs illustrate a model for providing environmental benefits through free market economics. By using creative market approaches such as ecotourism, small localized groups can fund needed environmental projects that are specifically tailored to their regions. The use of such programs creates a more educated and aware tourist population, brings communities closer together to create positive change, and allows for restoration efforts that would otherwise not be possible. By applying this same method to other marine, terrestrial, energy, and social projects a more dispersed restoration and protection effort can be created that may be far more effective than broad, top-down controls. The efforts of groups such as USAID and the World Bank are still important to controlling the future of coral reefs, but only through widespread changes within economies and communities can society expect to see any positive changes in coral reefs in the future. Empowering communities with knowledge and providing lucrative, non-extractive jobs to local citizens can help to shift communities to more sustainable economies that do not follow boom to bust lifelines. The hope of this project is that environmental projects can become profitable to allow for an unlimited number of proactive solutions to be implemented, which may be the only hope for coral reef ecosystems to survive climate change and environmental degradation.

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APPENDICES

Appendix A- 2 Day Course Overview

Environmental Reef Conservation Program

Course Schedule

Day 1

- Morning-Lecture followed by a brief break to practice fish ID's
- Afternoon- 1st Dive, Reef Check dive with two transect lines
- Debriefing

Day 2

- Morning- 2nd Dive, Collect coral to bring to the biorock
- Afternoon- 3rd Dive, Attach coral to the Bio-Rock(c) followed by an underwater clean up

Course Overview

This course is designed to give experienced divers an opportunity to learn about coral reefs, perform a reef check, transplant dying corals, and clean-up the beach or reefs. This is a two day course consisting of 3 dives and a lecture. By increasing awareness and involvement, New Heaven Dive Shop hopes to decrease our impacts on coral reefs and provide solutions to protecting and restoring the reefs around Koh Tao. Most of the successful projects involving restoring reefs around the world have been preformed by small groups and communities, not governments or policy makers. We hope to continue this tradition and do what we can to protect the environment where we live.

After completing the course, participants will know how to perform the reef check at New Heaven Dive shop and can return to help with data collection. From The reef check, they will gain knowledge about coral reefs and their inhabitants. Students will learn to identify indicator fish and invertebrate species as well as substrate types. Students will gain experience working with equipment underwater and will also gain practice in buoyancy and navigation.

Participants will also transplant corals onto an electric reef structure called a Bio-Rock(c) . Students will learn to identify dying corals and how to increase their chance of survival. There will also be a short clean-up project, allowing the students to give something back to Koh Tao and help keep it a beautiful place for those who come in the future.

Appendix B- Lecture

The following is the original outline written in July of 2007, by Chad Scott in order to teach the 2-day Environmental Reef Conservation Program lecture.

Reef Conservation Program
Lecture-Day 1

I. Introduction-

a. Project List and explanation of course

i. Research-EMP Dive
   1. Collect data to identify trends and persuade policy makers and citizens of Koh Tao to take action
   2. Identify problems and correlate them with human activities on lands and in the sea
   3. 8 Sites around the island with 1 EMP per site per month

ii. Restoration-BioRock Project
   1. A 90 m long electronic reef in Ao Tien Og
   2. Allows corals to grow more easily by using electrolysis to produce both Hydrogen and Oxygen gas from sea water as well as providing a calcium base for corals to grow on
   3. Transplant corals onto the structure and chart the progress of their growth

iii. Reef Clean Up
   1. To beautify and improve the health of the reefs and marine life
   2. Give something back to Koh Tao for the next people who come

b. General Goals of the projects

i. Increase awareness and educate the public about coral reefs and the human relationship to them

ii. Allow divers to learn new skill sets involving working with equipment underwater, taking data, navigating, and transplanting corals.

iii. Protect Koh Tao's reefs for future generations

iv. Obtain volunteers to help collect data and keep the projects active

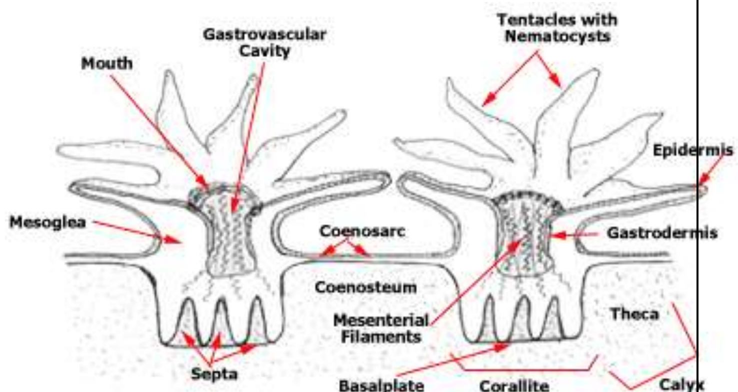
II. Coral & Marine Life

a. General Facts about coral reefs

i. Coral reefs cover only 0.2% of the ocean floor, but support 25% of marine life
ii. Coral reefs protect the beaches and coasts from large waves and storms
iii. Provide nurseries for juvenile fish and habitat for adult fish
iv. Coral reefs yield a direct economic gain of $375 Billion per year (US Dollars), in the form of medicines, foods, and other goods. This does not include the amount of money brought into surrounding areas through tourism.

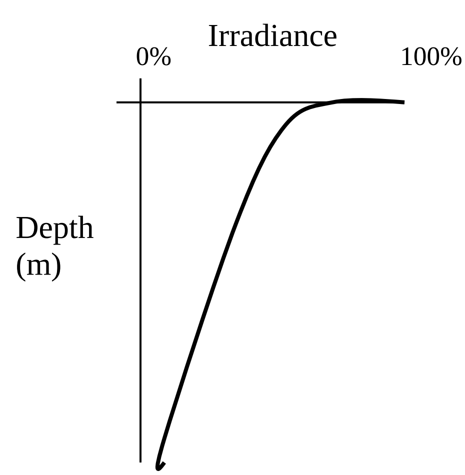
b. **Basic coral anatomy**

i. Coral is part of the Cnidarians family, along with sea anenomoes, jelly fish, and hydroids.
ii. Hard vs. Soft Coral- hard coral produce skeletons and build the reef using CO_2 to produce Calcium Carbonate ($CaCO_3$)
iii. A coral is made up by a colony of individual animals called polyps
iv. Each polyp is an individual, but all of the polyps are connected and share nutrients through the Coenosarc. Polyps range in size from the head of a pin to over 1 foot in diameter.
v. The polyps of most corals is both an animal and a plant (only such organism on earth). The plant component, zooxanthellae, and the animal live in symbiosis and mutual benefit from the relationship that they have.



Taken from www.peteducation.com

1. The zooxanthellae uses light to produce energy and nutrients through photosynthesis, which it shares with the animal
2. the animal consumes plankton and produces nutrients which the zooxanthellae need, and also provides the plant component with a safe habitat
3. This is why there are very few corals below the 1% light level in the sea. Some soft corals do not have the plant component, and this is why you see them much deeper.



vi. Coral Polyps use mucus secreting cells to protect themselves from infection and disease, and to shed sediment to allow light to reach the zooxanthellae

vii. Corals require light, nutrients, warm temperatures, and low competition to survive

c. **Problems and stresses to coral reefs**-Natural disturbances can kill corals much quicker than human disturbances, but natural ones are short lived and infrequent, allowing the corals to grow back in between events. Human disturbances tend to be long lived and have a longer duration which does not allow the coral time to rebound.

i. Quick facts
  1. 95% of Jamaica's reefs are dying or dead
  2. 1998 was the hottest year on record for oceans, more coral died this year than any other time in recorded history, 2002 was the second worse year.
  3. GreenPeace estimates that with current trends all of the worlds reefs could be gone by 2100
  4. Governments are very ineffective and slow at controlling problems with coral reefs. Where success has been achieved it has been by the hands of small groups of people and communities.

ii. Fresh Water run-off
  1. Increases turbidity of water (decreasing light)
  2. Causes stress to the coral through energy needed to produce mucus
  3. can bring in large amounts of nutrients such as nitrogen and phosphorus from human activity (Mississippi River case)

iii. Pollutants
  1. Stress corals
  2. increase algae growth (increase competition) and causes eutrophication
  3. Affects corral reproduction (gametes are killed at the surface)

iv. Physical Disturbances
  1. Boat anchors & mooring buoys
  2. SCUBA divers
  3. fishing and aquarium trade (dynamite, etc)

v. Overfishing
  1. Fish consume algae, without the fish, algae will out-compete the corals
  2. Fishing for certain species disturbances balances and can cause very large outbreaks of some other species (Crown of Thorns Example)

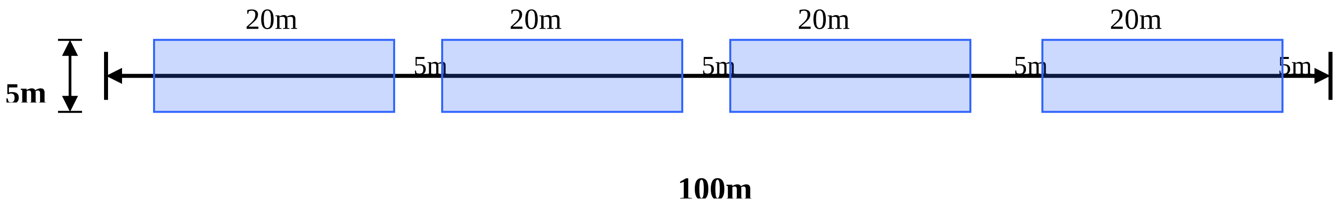
vi. Global/Ocean Warming
  1. Increased temperatures cause bleaching
  2. increased sea levels will change optimal reef locations

III. EMP Methods

a. **Roving Diver-**Green Fins

i. Pros & Cons

b. Transects-



i. What is the transect line and how do we put it down
   1. 100 meter line broken into four (4) 20 meter long sections.
   2. deep and shallow line each start and end at concrete markers that need to be located at the beginning of the dive
   3. All data taken will be centered from this transect line

ii. *Invertebrate transect-*
   1. 100 meter transect line, each 20 meter section can be thought of as a tunnel that is 20 meters long X 5 meters wide X 5 meters tall. And, everything within the tunnel area needs to be counted.
   2. (Go over species types)
   3. Make sure to swim around rocks and look under coral heads

iii. *Fish Survey*
   1. 100 meter transect line, each 20 meter section can be thought of as a tunnel that is 20 meters long X 5 meters wide X 5 meters tall. And, everything within the tunnel area needs to be counted.
   2. (Go over species types) spend a lot of time on this and quiz if necessary
   3. Move slowly down the line, continue moving and try not to be too loud. Don't count the same fish twice, some fish come in pairs, look for the mate when you only see one.
   4. If you are unsure draw a picture and look-up later

iv. *Substrate survey*
   1. Can be thought of as taking the type of ground cover at a point every 50cm. look directly underneath the tape and record the substrate type.
   2. Code the substrate types according to the PVC paper, if the substrate is the same for more than a few points draw an arrow to save time.
   3. Remember to confirm your location on the line frequently.

IV. Equipment overview and use

a. Secci Disk-Used vertically from the boat to find the 1% light level, and used horizontally under the water to estimate the visibility. To use vertically, lower the disk on one of the tape measures until you can no longer see the black and white triangles. Multiply the depth by 2.5 and this will give you the 1% light level at the site.

b. Multi-Meter-Used to obtain data on the salinity, temperature, total dissolved solids, and conductivity of the water. Two samples of water are taken using the blue water sampler from a depth of 5 meters. One bottle is put on ice to be analyzed later for nutrient content with the colorimeter. The other sample is analyzed from the boat using the directions on the multi-meter.

c. Transect line

i. Two 50 meter tape measures are connected to form the 100 meter transect line.
ii. The tape measures have black sections that are 5 meter long, do not record data in these sections.
iii. Use a weight to connect the two tapes at the center, if you are navigating than be sure to look back and wait for your partner.
iv. Be careful not to pull hard on the transect line, lay the line straight, and take care when reeling it in.

d. Weather Station

i. The weather station is used to take data about the surface conditions. Record on your slate the temperature, wind speed, and barometric pressure when you finish the dive.
ii. Also record the sky conditions such as; clear, partly cloudy, and overcast.

e. Slates-

i. First thing is to fill in your name, location, transect line, and date**.**
ii. Next record the bearings you will need to move from A-B and A-A
iii. Be neat and use hash marks to record the fish and invertebrates, at the end of you dive add up your hash marks at the end of each row.

V. Compass and Navigation

VI. Precautions and Safety

Appendix C- 2-Day Course Marketing Materials

REEF CONSERVATION PROGRAM

Learn new skills and help to protect Koh Tao's coral reefs! This is a great opportunity for experienced divers to learn new ways of working and interacting with the underwater world.

Participants of this course will:

- **Learn about coral reefs and the human interaction with them**
- **Perform a reef check according to CPAD guidelines**
- **Transplant dying corals onto a Bio-Rock(c) electronic reef structure**
- **And participate in a short underwater clean-up**

This 2 day course costs 2,000 Baht and includes a lecture, 3 dives, and all equipment.

Contact New Heaven Dive Shop in Chalok Ban Kao for more information.
077 457 045

Appendix D- Map of Koh Tao

Appendix E- Data Observation Sheets

Fish Survey

Surveyor Name:____________________ **Survey Location:**____________________

Survey Date (MM/DD/YY):____________________ **Survey Time (24hr):**____________________

FISH SURVEY REPORT SHEET - SHALLOW Disc - 10M Vis.

		0-20m		25-45m		50-70m		75-95m	
Rays	Blue-Spotted Stingray								
	Blue-Spotted Ribbon Ray								
	Manta Ray								
	General								
Butterfly fishes	Lined Butterflyfish								
	Eight Banded Butterflyfish			|				|	
	Weibel's Butterflyfish	||							
	Copper Banded Butterflyfish								
	Longfin Bannerfish								
	General								
Maray Eels	Muraenidae : General								
Groupers	Epinephelinae (> 30cm)								
	Epinephelinae (< 30cm)	||				|		||||	
Parrot fishes	Scaridae (> 20cm)			||		|||		|||	
	Scaridae (< 20cm)	|||||		||||||||||		||||||||		||||||||||||||||	
Rabbit fishes	Rabbitfishes : General			|				|||||	
Snappers	Spanish Flag Snapper								
	Checkered Snapper								
	Black-Spot Snapper								
	One-Lined Snapper								
	General								
Surgeonfishes	Acanthuridae : General								
Sweetlips	Haemulidae : General								
Triggerfishes	Balistidae : General								
Others	Note species								

FISH SURVEY REPORT SHEET - DEEP

		0-20m		25-45m		50-70m		75-95m	
Rays	Blue-Spotted Stingray								
	Blue-Spotted Ribbon Ray								
	Manta Ray								
	General								
Butterfly fishes	Lineo Butterflyfish								
	Eight Banded Butterflyfish								
	Weibel's Butterflyfish								
	Copper Banded Butterflyfish								
	Longfin Bannerfish								
	General								
Maray Eels	Muraenidae : General								
Groupers	Epinephelinae (> 30cm)								
	Epinephelinae (< 30cm)								
Parrot fishes	Scaridae (> 20cm)								
	Scaridae (< 20cm)								
Rabbit fishes	Rabbitfishes : General								
Snappers	Spanish Flag Snapper								
	Checkered Snapper								
	Black-Spot Snapper								
	One-Lined Snapper								
	General								
Surgeonfishes	Acanthuridae : General								
Sweetlips	Haemulidae : General								
Triggerfishes	Balistidae : General								
Others	Note species								

Survey Note: DEEP A (buched) 11 Meters Deep B
Deep B (No Found) 12 meters

Invertebrate Survey

Surveyor Name: CHAD SCOTT **Survey Location:** [illegible] Chalot

Survey Date (MM/DD/YY): 07/26/2007 **Survey Time (24hr):** 17 pm

INVERTEBRATE SURVEY REPORT SHEET - SHALLOW

		0-20m	25-45m	50-70m	75-95m
Triton Trumpet	Triton Trumpet				
Giant Clams	Boring	1			
	Tridacna maxima		1	2	
	General				
Octopus	General				
Starfish	Crown of Thorns				
Sea Urchin	Long Spine Black	3	5		1
Sea Cucumber	Marbled		1		
	Black	1			
	Orange Spiked				
	General				
Others	Note species				

INVERTEBRATE SURVEY REPORT SHEET - DEEP

		0-20m	25-45m	50-70m	75-95m
Triton Trumpet	Triton Trumpet				
Giant Clams	Boring	1			
	Tridacna maxima				
	General				
Octopus	General				
Starfish	Crown of Thorns	1			
Sea Urchin	Long Spine Black	56	50,30	60,75	50,150
Sea Cucumber	Marbled	1	5	1	1
	Black			1	
	Orange Spiked				
	General				
Others	Note species				

Survey Note: SA - SB = 150°
SA - DA = 260°

SUBSTRATE SURVEY REPORT SHEET - SHALLOW

Surveyor Name: CHAD **Survey Location:** Airlink **Survey Date (MM/DD/YY):** 09/30/07 **Survey Time (24hr):** 11:30 am

Survey Notes: Did not Find Deep TS

Substrate Types:

HC	Hard Coral	RKC	Recently Killed Coral	SC	Soft Coral	SP	Sponge
BA	Brown Algae	GA	Green Algae	RAN	Red Algae Non-Calcified	RAC	Red Algae - Calcified
NIA	Nutrient Indicator Algae	RB	Rubble	SI	Silt/Clay	RC	Rock
SD	Sand	TR	Trash/Garbage	DC	Dead Coral	OTH	Other

Segment 1		Segment 2		Segment 3		Segment 4	
Transect:	Shallow	Transect:	Shallow	Transect:	Shallow	Transect:	Shallow
0.5		25.5	HC	50.5	↑	75.5	SD
1.0	SD	26.0	HC	51.0	|	76.0	|
1.5	RB	26.5	HC	51.5	|	76.5	|
2.0	↓	27.0	RB	52.0	RB	77.0	|
2.5	RB	27.5	RC	52.5	|	77.5	|
3.0	HCS	28.0	RB	53.0	↓	78.0	|
3.5	RC	28.5	AH Clam	53.5	RB	78.5	|
4.0	RC	29.0	HCM	54.0	SD	79.0	|
4.5	HCE	29.5	RC	54.5	RB	79.5	|
5.0	HCS	30.0	SD	55.0	SD	80.0	|
5.5	RB	30.5	"	55.5	↓	80.5	|
6.0	|	31.0	HCS	56.0	RC	81.0	|
6.5	|	31.5	RB	56.5	HCS	81.5	|
7.0	↓	32.0	|	57.0	|	82.0	|
7.5	RB	32.5	|	57.5	↓	82.5	|
8.0	HC	33.0	↓	58.0	RB	83.0	|
8.5	"	33.5		58.5	"	83.5	|
9.0	HCS	34.0	RB	59.0	SD	84.0	|
9.5	HC	34.5	RC	59.5	SD	84.5	|
10.0	SD	35.0	RB	60.0	HCE	85.0	|
10.5	RC	35.5	""""	60.5	HCM	85.5	|
11.0	HCS	36.0	RC	61.0	RB	86.0	|
11.5	HC	36.5	|	61.5	RB	86.5	↓
12.0	RB	37.0	↓	62.0	HCS	87.0	HCM
12.5	↓	37.5	HC	62.5	SD	87.5	SD
13.0	SD	38.0	RB	63.0	|	88.0	|
13.5	SD	38.5	HC	63.5	↓	88.5	↓
14.0	RB	39.0	RB	64.0	RB	89.0	RB
14.5	RB	39.5	RB	64.5	SD	89.5	SD
15.0	RB	40.0	" "	65.0	|	90.0	RC
15.5	HCM	40.5	HCS	65.5	↓	90.5	SD
16.0	HC	41.0	"	66.0	RB	91.0	|
16.5	RC	41.5	RB	66.5	SD	91.5	|
17.0	RC	42.0	|	67.0	SD	92.0	|
17.5	HC C	42.5	|	67.5	RC	92.5	|
18.0	"	43.0	↓	68.0	RC	93.0	|
18.5	HC	43.5	RB	68.5	RC	93.5	|
19.0	HCS	44.0	|	69.0	SD	94.0	|
19.5	|	44.5	|	69.5	|	94.5	|
20.0	↓	45.0	↓	70.0	↓	95.0	↓

Appendix F-2 and 4-Week Program Overview/Schedule

New Heaven Reef Conservation Program

2 Week Non-Diver- Schedule of Events

Week 1		
Day	**Activity**	**Description**
Day 1-Sunday	Greeting and Orientation	Volunteers will be shown to their accommodations and briefed on specifics about the island and the program. Lecture, "Introduction to Marine Conservation,"
Day 2-Monday	PADI Open Water Course (OW)	Open Water Course Day 1
Day 3-Tuesday	PADI Open Water Course	Open Water Course Day 2
Day 4-Wednesday	PADI Open Water Course	Open Water Course Day 3 Final OW exam
Day 5-Thursday	Selected Projects	Volunteers will work on a selected eco-project
Day 6- Friday	RC Course	RC Dives: Roving Diver Survey
Day 7-Saturday	Off	Free day for volunteers
Day 8-Sunday	Weekly debriefing/Q&A	Volunteers have the day time free Weekly debriefing/Q&A. Lecture: "EMP Research Techniques: Fish and Invertebrate Surveys."
Week 2		
Day 9-Monday	RC Course	Lecture "Marine Ecology," RC dive, EMP Fish Transect Survey Data entry instruction
Day 10-Tuesday	RC Course	RC dives, EMP Invertebrate Transect Survey Water testing/data entry
Day 11-Wednesday	RC Course	Introduction to BioRock, Transplant Dives Underwater clean-up
End of 2 Week Program		

*Note: there will be a beach clean-up every morning, and there will also be a required short debriefing every evening.

Total Cost is 20,000 Thai Baht

New Heaven Reef Conservation Program

2 Week Diver- Schedule of Events

Week 1		
Day	**Activity**	**Description**
Day 1- Sunday	Greeting and Orientation	Volunteers will be shown to their accommodations and briefed on specifics about the island and the program. Lecture, "Introduction to Marine Conservation,"
Day 2- Monday	Reef Conservation (RC) Course	Lecture "EMP Research Techniques: Fish and Invertebrate Surveys." RC Dive, EMP Fish Transect Survey Data entry
Day 3- Tuesday	RC Course	EMP Invertebrate Transect Survey Water testing Selected environmental project work
Day 4- Wednesday	RC Course	Introduction to BioRock, transplant dives Underwater clean-up
Day 5- Thursday	Selected Projects	Work on selected eco-projects
Day 6- Friday	RC Course	RC Dives: Roving Diver Survey
Day 7- Saturday	Off	Free day for volunteers
Day 8- Sunday	Weekly debriefing/Q&A	Volunteers have the day time free, but will meet in the evening for the weekly debriefing/Q&A.
Week 2		
Day 9- Monday	EMP	Lecture "Marine Ecology," Fish and Invertebrates survey
Day 10- Tuesday	EMP	Fish and Invertebrates survey
Day 11- Wednesday	Bio-rock/Selected project	2 Dives to assist with the Bio-rock, Work on selected eco project
End of 2 Week Program		

*Note: there will be a beach clean-up every morning, and there will also be a required short debriefing every evening.

Total Cost is 14,500 Thai Baht

New Heaven Reef Conservation Program

4 Week Non-Diver-Schedule of Events

Week 1		
Day	**Activity**	**Description**
Day 1- Sunday	Greeting and Orientation	Volunteers will be shown to their accommodations and briefed on specifics about the island and the program. Lecture, "Introduction to Marine Conservation,"
Day 2- Monday	PADI Open Water Course (OW)	Open Water Course Day 1
Day 3- Tuesday	PADI Open Water Course	Open Water Course Day 2
Day 4- Wednesday	PADI Open Water Course	Open Water Course Day 3 Final OW exam
Day 5- Thursday	Selected Projects	Volunteers will work on a selected eco-project
Day 6- Friday	RC Course	RC Dives: Roving Diver Survey
Day 7- Saturday	Off	Free day for volunteers
Day 8- Sunday	Weekly debriefing/Q&A	Volunteers have the day time free Weekly debriefing/Q&A. Lecture: "EMP Research Techniques: Fish and Invertebrate Surveys."
Week 2		
Day 9- Monday	RC Course	Lecture "Marine Ecology," RC dive, EMP Fish Transect Survey Data entry instruction
Day 10- Tuesday	RC Course	RC dives, EMP Invertebrate Transect Survey Water testing/data entry
Day 11- Wednesday	RC Course	Introduction to BioRock, Transplant Dives Underwater clean-up
Day 12- Thursday	PADI Advanced Open Water Course	Advanced dives 1 & 2
Day 13- Friday	PADI Advanced Open Water Course	Advanced dives 3 & 4 (including night dive)
Day 14- Saturday	Off	Free day for volunteers Optional time to work on individual project
Day 15- Sunday	Off/Weekly General Meeting	Volunteers have the day time free Weekly debriefing/Q&A. Lecture: "EMP Research Techniques: Substrate Survey"

Week 3		
Day 16- Monday	RC Course	RC Dives, EMP Substrate Transect Survey
Day 17- Tuesday	EMP	Full EMP Work on selected eco projects
Day 18- Wednesday	Biorock	2 Dives to assist with the Bio-rock Work on selected eco-project
Day 19- Thursday	Selected Projects	Volunteers will work on an eco-project
Day 20- Friday	RC Course	RC Dives: Roving Diver Survey
Day 21- Saturday	Off	Free day for volunteers Optional time to work on individual project
Day 22- Sunday	Off/General Meeting	Free day Weekly debriefing/Q&A meeting
Week 4		
Day 23- Monday	EMP	Full EMP
Day 24- Tuesday	Project Wrap-up	Finish work on selected eco-project Prepare briefing for the monthly newsletter
Day 25- Wednesday	Chaalok Beautification day	Spend the day helping the community around the dive center, Farewell dinner/certification
End of 4 week program		

*Note: there will be a beach clean-up every morning, and there will also be a required short debriefing every evening.

Total Cost is 14,500 Thai Baht

New Heaven Reef Conservation Program

4 Week- Diver Schedule of Events

Week 1		
Day	**Activity**	**Description**
Day 1- Sunday	Greeting and Orientation	Volunteers will be shown to their accommodations and briefed on specifics about the island and the program. Lecture, “Introduction to Marine Conservation,”
Day 2- Monday	Reef Conservation (RC) Course	Lecture “EMP Research Techniques: Fish and Invertebrate Surveys.” RC Dive, EMP Fish Transect Survey Data entry
Day 3- Tuesday	RC Course	EMP Invertebrate Transect Survey Water testing Selected environmental project work
Day 4- Wednesday	RC Course	Introduction to BioRock, transplant dives Underwater clean-up
Day 5- Thursday	Selected Projects	Work on selected eco-projects
Day 6- Friday	RC Course	RC Dives: Roving Diver Survey
Day 7- Saturday	Off	Free day for volunteers
Day 8- Sunday	Weekly debriefing/Q&A	Volunteers have the day time free, but will meet in the evening for the weekly debriefing/Q&A.
Week 2		
Day 9- Monday	EMP	Lecture “Marine Ecology,” Fish and Invertebrates survey
Day 10- Tuesday	EMP	Fish and Invertebrates survey
Day 11- Wednesday	Bio-rock/Selected project	2 Dives to assist with the Bio-rock, Work on selected eco project
Day 12- Thursday	Selected Projects	Volunteers will work on selected eco-project
Day 13- Friday	RC Course	RC Dives: Roving Diver Survey
Day 14- Saturday	Off	Free day for volunteers, or optional time to work on individual project
Day 15- Sunday	Off/Weekly General Meeting	Free time during the day followed by weekly debriefing/Q&A. Lecture: “EMP Research Techniques: Substrate Survey”
Week 3		

Day 16-Monday	RC Course	RC Dives, EMP Substrate Transect Survey
Day 17-Tuesday	EMP	Full EMP Selected eco projects
Day 18-Wednesday	Biorock	2 Dives to assist with the Bio-rock Selected environmental project
Day 19-Thursday	Selected Projects	Selected environmental project
Day 20-Friday	RC Course	RC Dives: Roving Diver Survey
Day 21-Saturday	Off	Free day for volunteers Optional time to work on selected eco project
Day 22-Sunday	Off/General Meeting	Free day Weekly debriefing/Q&A meeting
Week 4		
Day 23-Monday	EMP	Full EMP Dive Work on selected eco projects
Day 24-Tuesday	Project Wrap-up	Finish individual projects Prepare briefing for the monthly newsletter
Day 25-Wednesday	Chaalok Beautification day	Spend the day helping the community around the dive center Farewell dinner/certification presentation
End of 4 week program		

*Note: there will be a beach clean-up every morning, and there will also be a required short debriefing every evening.

Total Cost is 14,500 Thai Baht