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Anthropogenic Disturbances to Coral Reef Ecosystem: Strategies to Restore it through Coral Health Index

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Abstract—*The "Rainforests of the Sea": Coral Reefs are complex, dynamic, productive communities that flourish in the shallow depths of the tropical waters. They enclose within it convoluted ecological relationships between the organisms, which provide domicile to a magnificent array of organisms, formed by calcareous skeletons of certain coelenterates (of which coral polyps are the most important) and algae. However, they are dying-off due to human alterations in the biosphere, like introducing pollutants into the marine body ,from agricultural run-off or untreated human sewage or from oil spills, deforestation, sedimentation, destructive fishing practices, solid-waste dumping and global climatic variations. Thereupon, their conservation and restoration is of utmost importance for the sustenance of marine biodiversity. This could be pulled- off by careful zoning and effectual enforcement of the resources; used within marine managed area, potent regional supervision of coral reefs or hummocks and by adaptive management of coral reef communities(if reliable annual indicator of corals' community health is accessible to policy makers and resource managers) viz. Coral Health Index (CHI). It is a standard criterion for evaluating the coral community abundance which was developed by Conservation International's Science-to-Action Partnership. It quantifies the common elements associated with the coral reef vigor everywhere. It is composed of three metrics- benthos, microbes and fishes which are scaled to provide a score. These scores are then uniformly averaged and weighted to yield a definitive CHI score, ranging from zero (disintegrated coral colonies) to one (healthy coral colonies). This paper deals with the impacts and the intrusions caused by the anthropogenic activities on coral communities and its mitigation by one of the adaptive management process, such as Coral Health Index (CHI).*

Keywords: *anthropogenic disturbances, adaptive management, Coral Health Index, mitigation, three matrices.*

1. INTRODUCTION

Coral reefs are productive and diverse biological communities which dwell in the shallow depths of the tropical clear coastal and oligotrophic waters (devoid of high level of nutrients) by the augmentation of hermatypic corals, coralline algae and the other marine organisms. In this regard, they are often called as the *"Rainforests of the Sea."* which are characterized by their high species diversity and high gross productivity, which is among the highest of Earth's marine or terrestrial ecosystems (Connell 1978; Ray 1988). Variation of coral species is scattered across the ocean in the world, especially in tropical to subtropical strip (Birkeland, 1997).The Coral Reef ecosystem encloses within it convoluted ecological relationships between the organisms which provide domicile to a magnificent array of organisms, formed by calcareous skeletons (limestone, $CaCO_3$) of certain coelenterates (of which coral polyps are the most important) and algae. This biogenic creation of $CaCO_3$ gets accumulated, either inside or to the surroundings of the organisms, residing on the reef. Due to various environmental break down as well as the dichotomy existing between carbonate obliteration or dissolution coral reefs crafts or impart numerous distinctive types of three dimensional knotty or complex niches and habitats to various marine dwelling organisms like, mollusks, fishes, sharks, crustaceans etc. Thereupon, the diversity of niches and habitats partially explain the diversity and structure of living community that exist on many coral reefs worldwide (Veron 1986; Done 1992).

We all are aware about the fact that in temperate marine environment, unicellular algae are the primary producers by fixing the carbon on coral reefs whereas in the tropical environmental conditions algae, by symbiotic association, thrive in the 'endodermal' cells of the coral host. This mutualistic relationship between reef-building corals and unicellular dinoflagellates ("zooxanthellae") is the key factor for the existence of coral reef communities. Therefore, any alterations in the prevailing environmental conditions, which can influence the symbiotic association between the two, will affect their entire colonial formation. The key factors are:

1.1. Light is required to produce calcium carbonate by dinoflagellates by the process of photosynthesis (Nybakken, 1992). Compensation point of coral animals to light intensity is 200-700 fc, while the light intensity is generally at sea level 2500-5000 fc (Kanwisher and Wainwright, 1967).

1.2. Salinity affects the corals physiologically because of the osmotic pressure on living tissue (Zamani and Madduppa) . Optimum salinity for coral reef life ranges from 32%-35 ‰ (Nybakken, 1988).

1.3. Temperature influences the reproduction, metabolic rate and helps in restoring the outer shape of the reef. Therefore, it should balanced which ranges from 25°C to 30°C ;Nybakken, 1988).

1.4. Sediment- presence of sediments can reduce the intensity of light required for photosynthesis by the zooxanthellae in the coral tissue (Nybakken, 1992). Thereby, affecting their survival.

1.5. Wave is essential for carrying and transporting sediment material, oxygen, larvae and nutrients. That is why corals that live in the wavy conditions, flow more strongly than the protected areas (Tomascik, 1997). The waves also provide new plankton for food colonies (Nybakken,1992). However, a strong wave hit the seaward are sometimes able to destroy the structure of certain coral communities (Veron, 1986).

1.6. Substrate serve as a place of attachment of coral planul1ae which later grew into the coral animal and form a strong community (Zamani and Madduppa) . Bottom waters in the form of rocks or shells can be used as the initial substrate as occurs in the formation of coral islands (Sukarno *et al*., 1983).

Therefore, the above mentioned conditions acts as the *limiting factors* for the growth of the coral reef which if not balanced, will impinge on calcification, metabolism and coral nutrition; thereby disturbing the entire coral community. The metabolites, so formed, are transmitted between the host and the algae, and the nutrients are stored for deficit environment.

2. SIGNIFICANCE OF THE CORAL COMMUNITIES

Sometime, coral hummock can form atolls, islands, banks as well as the extensive sized masses like Great Barrier Reef of Australia. Not just being limited to this creation, active or alive reefs equip the sand, which acts as the buffer waves and line the tropical beaches, thereby prohibiting extensive coastal erosions. The equilibrium between reef accumulation and erosion, lies on alive layers of corals and coralline algae. The alteration from $CaCO_3$ agglomeration to reef attrition, gets enabled by the demolition of the key organisms or by the reallocation from autotrophic to heterotrophic mode of nutrition.

The coral reef act as the shield which safeguards the island from vast devastations set off during tropical storms, typhoons etc, by the formation of windward spur-and-groove, reef crests, reef flats which enable and promote scattering of the wave energy steadily and proficiently. They are frequently, associated with sea grass beds and mangrove forests on tropical shorelines, supply vast numbers of people with goods and services such as seafood, recreational possibilities, and providing significant aesthetic, cultural and economical benefits for many tropical countries (Done et al. 1996; Constanza et al. 1997; Berg et al. 1998). They are utilized for the constructional objective, by using their fragments for cement and lime manufacture, in Sudan, Saudi Arabia. Also, they are employed in crafting jewellery and can be exploited for ornamental trade as souvenirs, curios. It has been found that the cultural significance of coral reefs is extremely essential to islanders and tropical coastal populations. McAllister (1988) estimated fisheries losses due to reef degradation at over $80 million per year, impacting 127,000 jobs and 637,000 family members.

3. INTRUSION TO THE CORAL COMMUNITIES

Often coral reefs are referred as ‘stenotypic’; for the reason that they are able to bear or endure constricted range of environmental conditions. Reefs population is balanced by recruitment and reproduction process (can be quantitatively estimated) which assist in knowing and analyzing the sub-lethal consequences because of the environmental changes. Therefore, they are fragile in nature and any *disturbances* in the biosphere or in their surroundings thwart calcification and enhance erosion or weathering of the carbonate framework of the corals. These disturbances play an important role in shaping continuously coral reef communities and their architecture (Connell 1978; Grigg 1983; Brown and Howard 1985; Hughes 1989; Grigg and Dollar 1990; Done 1992; Connell et al. 1997; Hughes and Connell 1999). Disturbances can be natural (e.g., ingestion by parrotfish of large amounts of coral rock, Bruggeman 1994; Peyrot-Claussade et al. 1995; sponges and echinoids grazing, Hutchings 1986) or anthropogenic in origin. It has been estimated that 10% of all the coral reefs are already mortified beyond repair and 30% are critically endangered, which are at the verge of damage within 10-20 years. Some *Natural* incidents resulting in Coral reef disruptions are:

3.1. Storms- High velocity of wave can rupture corals resulting in their damage like, cyclones, tsunamis, hurricanes. Corals which are branched are more vulnerable to get affected adversely by storms. However, this natural event seldom destroys the entire corals.

3.2.Temperature Alterations- As discussed earlier, the optimum temperature for their sustenance in marine biodiversity is 25°C to 30°C, which if altered can result the coral polyps to banish dinoflagellates causing ‘coral bleaching’. The El Niño Southern Oscilation (ENSO) in 1997-1998 has destroyed 70-80% of corals, caused due to coral bleaching in the Indo- Pacific region.

3.3. Coral Diseases- It is instigated by *fungi, worms, bacteria and algae* which had major consequences on *Caribbean reefs* where, 80% of the corals have been demolished by the disease only. However, coral diseases are not much explored and as a

result only 30 diseases of corals are known and only 7 diseases have been investigated from Great Barrier Reef. The occurrence of coral diseases have been intensified in the last 10 years resulting in more destruction of the corals and indirectly affecting the marine ecosystem. This could be most probably due to, elevation of surface temperatures which provide and assist the growth of disease causing micro-organisms and due to human introduced pollutants into the water body which decreases water quality prohibiting the growth the proper of the reef. *For example*, oil spillage and its accumulation have caused Black Band Disease in the Red Sea.

However, the *human induced alterations* in the environment are most influential for the coral reef ecosystem. The two plenary presentations at the Seventh International Coral Reef Symposium (Guam, 1992) focused on world-wide destruction of coral reefs in the face of increasing pressure from man's burgeoning populations, indicating an awareness among coral reef scientists that anthropogenic (man-induced) disturbance is a critical problem (Buddemeier, 1993; Wilkinson, 1993). Some anthropogenic oriented activities that have led to the impairment of the Coral Reef Ecosystem are:

3.4. Destructive Fishing Practices: This is performed by employing home- *made explosives* which consists of fuse caps, fertilizers and fuel into the empty beer bottles (Nicolas J. Pilcher). Blast-fishers hunt for schooling fish such as sweetlips and fusiliers, which aggregate in groups in the open or hide under large coral heads. The bombs are usually dropped into the centre of an area judged to have many fish and after the bomb has exploded the fishermen use dip nets to collect the stunned and dying fish (Nicolas J. Pilcher). It disfigures the three dimensional framework of the reef, which cannot be repaired. Also, the damaged reefs are more easily dragged by the intensified wave speed preventing shelter for the coastline. The damaged area no longer remains home for the marine micro organisms of that region. For this reason, blast-fishing activity has now been prevented by charging for the resultant destruction. Sometimes, an aqueous solution of sodium cyanide or other chemicals are used to astonish the fishes and make them unconscious for the live-fish trade. This method is more destructive not only to the fishes but also to the coral reefs as well as the other marine organisms. It is believed that the most destructive fishing practices are purse fishing and normal trawl. In these fishing practices trawlers function around or over corals to catch higher level of fishes located near to these reefs, but usually they do not succeed in their target and are able to trawl corals only.

3.5. Solid Waste Dumping is another key factor for the ruin of the coral reefs. These solid wastes introduced by humans are non- biodegradable in nature and have longer shelf life for their persistence in the water, which affect the coral colonies adversely. Often, metals, rubbers, plastics, glasses etc. get cluttered around the coral reefs as the solid waste causing it to deteriorate with the span of time.

3.6. Sedimentation- As a result of terrestrial run-off which could be erosion of the soil due to deforestation, residues of the road construction stuff and other development can result in deposition of these filtrate damaging the nearby water body. One of the prime reasons for the deposition of the sediments in the water body is the elimination of the seagrass and mangrove plants which naturally act as the sieve to filter out the sediments in that region. This is the most well researched impact, affecting the corals in three distinct ways, *physically, chemically and photosynthetically*. Overload of the sedimentation prohibits the light rays to enter or penetrate into the river body, which is required by zooxanthellae for food production by *photosynthesis*. Most of the reef-building corals obtain the majority of their nutritional requirements via translocation of metabolites from their photosynthetic partners (Muscatine et al, 1981). Thereby, affecting the coral colonies to grow suitably, it will also affect the corals reproduction, nutrition and depth distribution. *Physically*, these sediments have negative impact on corals by adhering on the surfaces, which are used as the prey for supplying nutrients to the zooxanthellae. However, inherently corals have the ability to scrub themselves by the process of ciliary action and mucus secretion, but the elevated concentrations of the sediments are detrimental to their colonies. Brown and Holley (1982) and Howard and Brown (1984) analysed the *Chemical* impact of the sediments on coral communities like, presence of heavy metals (Zinc, Copper, etc.). Gog (1991) investigated and discovered that occurrence of Nickel (equivalent to 9 or more ppm) resulted in mortality of coral planulae and substantially reduced rates of larvae settlements if present at the concentration of 1ppm. Experiments with the organophosphate pesticide Dursban (chlorpyrifos) found seawater passed through a column of soil treated with a quantity of chemical equal to that applied to golf courses, was toxic to the coral Pocillopora damicornis (Te, 1992ft). Therefore, we find that sedimentation greatly influence the coral colonies in the most prospect manner.

3.7. Discharge of unregulated domestic and industrial effluents impact the coral reefs' biology, as they consist of the chemicals that are toxic to the coral communities'. Point-discharge of these toxins, into the water body, negatively impacts the environmental conditions of the coral colonies, which can result in affecting localized coral colonies. Oil pollution is such an extreme example of introducing toxins in their habitat, like petroleum hydrocarbons, which acts as the carcinogens. Research performed in the Gulf of Eilat has documented coral mortality, decreased fecundity and recruitment failure in response to chronic oil pollution (Fishelson, 1973; Loya, 1975, 1976; Loya and Rinkevich, 1979; 1980). Oil drilling occurring along the Saudi Arabian shoreline in the Arabian Gulf has disrupted the growth of the coral communities by asphyxiating them due to the contents present in the oil as well as by blocking the transportation of the oxygen to the corals. The emancipation of such un- desired products promotes the algal growth (diatoms), which is also

elevated by crude or partially release of the sewage or waste water into the water stream. This process is known as the eutrophication wherein the algal growth multiplies to an extent which not only affects the coral reefs adversely but also causes the death of the marine organisms by decreasing the dissolved oxygen (D.O.) of the water body. Thereupon, oil accumulation through smothering causes the colonies of the corals to detach among themselves resulting in their fragmentation. For example, oil spillage in the Gulf of Aqaba (1970) has affected coral Stylophora pistillata and deterred their colonies .

Apart from the oil discharge or spillage, excessive discharge of certain chemicals, through desalination process like chlorine, can result in coral bleaching of the coral communities. This activity is triggered by the enhanced production of the coral mucus which aftermath the evict dinoflagellates and assist in algal accumulation, thereby bleaching the coral colonies. Also, discharge or release of the chemical fertilizers (Nitrates, Phosphates) or dust from construction sites, instigate the growth of algae resulting in increased biochemical oxygen demand (B.O.D.) of the water body and impairs the coral hummock.

3.8. Overfishing practices by human species can also alter the growth and the destruction of existing coral colonies. It can shrink the genetic variation in a population by altering the environmental conditions for species to reproduce, and can also shift the trophic level of the marine ecosystem. Thereby, disturbing the entire marine bionetwork affecting prey-predator system. For instance, Sharks are generally referred as the "apex" or the top predators which police or maintain species loads and diversity throughout an ecosystem. Research have reflected that coral reef ecosystems diversity get elated and is preserved by the elevated numbers of the apex predators.

3.9. Global Temperature Shift- Due to increased climatic temperature or *global warming* caused by *pollution, ozone depletion, amplified Green House Gases emission (GHGs) in the atmosphere*, coral bleaching has encouraged, in the present scenario. Since, carbon dioxide (CO_2) is the prime GHG which is soluble in water, which if present in the biosphere in excessive quantity, lowers the pH, resulting in weakening of the coral skeletal framework. These fragile corals are then more inclined to destruction by high velocity of waves.

Sea level rise is another issue, due to change in climate parameters, which has caused the damage to the coral colonies. Sea water elevation will obstruct the light rays to enter in the marine environment, which is demanded by dinoflagellates for photosynthesis, thereby influencing and degrading coral growth.

4.0. Recreation- It has relatively minor but significant localized impact on the coral communities.[5] It has been investigated that the excessive sea diving tourism is one of the reason for the hindrances of the sexual reproduction in corals which inhibit them to re- colonize. For example, the popular diving spot, the Northern Red Sea, has suffered coral destruction due to human forced implications, which is directly being introduced into the water body.

Some *case studies* furnished by the explorers (from National Geo Wild), depicts variation in the health of the Coral Reef Ecosystem with respect to the human inhabitants in different following islands.

3.1.1. Flint Island and Reef: This Island is located in the South Pacific which is 4Km long and is at the top of an ancient volcano surrounded by deep oceans. Initially, in 1870s, indigenous plants were removed from this Island, instead 10,000 palm trees were planted to yield coconut oil. In 1900, Flint Island was deserted and now the present population of the corals there is 90% of the seafloor, which is over 3 times more than the other reefs in the Indo-Pacific region (which has still human inflations on coral reef communities). But, fishing of the shark in the Flint Island, has negative impact on the coral colonies since food web of the marine biodiversity has got interrupted.

3.1.2. Vostok Island and Reef: This Island was first discovered by Russian explorer, in 1820, and was named after his ship –Vostok. It is extended in less than 2.5km^2 area which has never been inhabited by human species. The abundance of the shark species and the health of the coral reef communities imply a nourished and intact system. It is one of the few destinations that resembles to the Pacific, 200 years ago.

3.1.3. Malden Island and Reef: It is located 200 km Northeast of the Starbuck Island. It is about 39km^2 in an area and was first mined for guano between 1850-1920s. This island once served the purpose for the test site for 3 low altitudes nuclear bombs in 1958. It has approximately 10 times more number of sharks (than other coral reefs of the world) as well as the microbes on the reefs, which has tarnished the coral colonies.

3.1.4. Millennium Atoll: It is a lagoon enclosed by string of islands. It is about 800 km far from the Malden Island. It was found that Blacktip reef sharks were in form of flocks or in greater abundance at this place. Millennium lagoon contains abundant single species of branching coral known as Acropora.

The above case research analyzed by the Nat Geo Explorers provides sufficient evidence that coral reefs' health is greatly influenced by the anthropogenic activities. This can be estimated by one of the adaptive management of coral reef communities, if reliable annual indicator of corals' community health is accessible to policy makers and resource managers, viz. Coral Health Index (CHI).

4. CRITERIA FOR CORAL COMMUNITIES HEALTH: A PROPOSAL- CORAL HEALTH INDEX (C.H.I.)

4.1. Brief Outline

Coral Health Index is a standard criterion for evaluating the coral community health, developed by Conservation International's Science-to-Action Partnership, quantifies the common elements associated with the coral reef vigor everywhere. It consists of three metrics- Benthos, Microbes and Fishes which are scaled to provide a score ranging from zero (disintegrated) to one (healthy). It is an adaptive management of quantifying coral reef communities, if reliable annual indicator of corals' community health is accessible to policy makers and resource managers.

4.2. The Concept of the 3 Matrices

4.2.1. Benthic screening provide most important data which involves the measurement of the *Crustose Coralline Algae* (CCA predicts the trend of the reef) and *Coral* (existing coral hummock condition). In a review site, using quadrats, transect line is drawn and image is taken from each quadrat by randomly selecting (minimum 5- CLA, hard coral, macro algae, un-described and turf algae) benthic type, which is evaluated by taking mean of the selected regions. As a result, the combination of two (coral+ CLA) identifies the present as well as the future coral reef. [1][It is scored from 0 (degraded) to 1 (healthy) based on proportional cover of coral and CCA]. It is obtained by means of the photograph taken inside the river body, which can be stored for future references.

4.2.3. Fishes assessment can be carried by numerous ways. One could be the evaluation of the *biomass* of non-cryptic fishes, which helps in determining the robustness of coral colonies of that area. A pair of divers swim along the adjacent belt of the transects and record the biomass of all the fish species occurring in that area. By evaluating length and weight, mass of the fishes are known, consequently summing the obtained value yield biomass (in fraction of 500 gm/ m^2) of the fishes. The summation of all the biomasses of the fishes, prevailing in that particular region give CHI score and reports the ability of the community to provide niche for various organisms.[1] [It is scored from 0 (degraded) to 1 (healthy) as a fraction of total fish biomass from the Kingman reference site (approximately 5 tons per hectare.]

4.2.4. Microbes thriving on the coral community reduce its growth and nutrition. Increased microbial growth represents enhanced anthropogenic activity in that community. Generally, *Vibrio* bacteria are exists in these regions, responsible for gastroenteritis and cholera. It is accomplished by collecting the samples from the water body and is cultured using biotechnological techniques. After a day, total number of colonies formed by the micro-organisms on each petri plates is evaluated and the mean value of respective culture plates represents micro-organisms concentration (in per microlitre). After this, two concluding mathematical steps are done: 1- average number of colonies are divided by 100 and to the resultant value 1 is added, and 2- the number so obtained, is reciprocated (since microbes have inversely proportional relationship with CHI score) and the final value is the CHI score of the microbes. [1][*It is scored from 0 (degraded) to 1 (healthy) based on an inverse relation of* Vibrio *concentration.]* –[1](www.science2action.org)

All the above mentioned decisive factors act as the analytical parameters which represent the health of the coral communities in that particular water body or island. The 3 matrices not only help us to know the existing coral colonies but also predict the forthcoming drifts in the coral communities. The scores so obtained, are further evaluated by using arithmetic mean to yield the concluding value, known as the CHI score. *For instance*, team of researchers explored the Line Islands Archipelago (bearing different oceanography and land area) and at each Island (total 9 in numbers) they evaluated number of fishes, benthos and microbes. Consequently, the matrices of the 3 parameters resulted in varied values of the CHI score, respectively. It was perceived that, 3 islands had value from 0.90 (denoting coral ridge to be very healthy), another 3 islands had the values ranging between 0.75- 0.90 (representing moderate coral reef growth), and the remaining CHI score of the 3 islands varied from 0.66- 0.38 (signified the destination to be influenced by anthropogenic activities). Thus, CHI score of each investigated Island assisted in knowing the health of the coral communities at respective Island and also aided in doing comparative study of the entire explored Islands.

4.3. Benefits of CHI

Dynamic coral communities provide home for diversity of marine organisms and also maintain and preserve the marine ecosystem. Therefore, their research, management and monitoring is extremely important to preserve marine ecology. CHI is one such significant tool to quantify their health and preserve them from demolition. *Benefits of CHI data* are thus, numerous, from reliability to the prediction of the trend of coral reef. It not only assists the researchers in quantitatively estimating the coral colonies nutrition, but it also give the clear impression of the corals' health to the society, in a more holistic way, so that they can initiate the approaches to protect the coral reef ecosystem. For example, degradation of coral colonies in Hawaii, which is a tourist destination for its aesthetic value, was estimated by CHI score. It was analyzed, from the data that the bleaching of the coral communities has occurred due to excessive fishing and pollution in the surroundings, requiring an immediate approach for its restoration and regaining its innate investment. Moreover, CHI provides standard and consistent data to pursue management of the coral colonies, both which are either re-constructed and

re-stored (the damaged corals) or preserved (existing in natural form). [1]It also, provides information regarding the number of live corals, from the value of CCA. If the value of CCA is higher, then amount of live corals will also be elevated, and vice-versa. Besides this, it also aid in analysis of quantifying healthy corals with respect to the microbes existing on the site of research. If the magnitude of the microbes is higher, then abundance and nourished coral colonies would be declined, and vice- versa. [2]Therefore, the amount of alive corals is 'status descriptor' and the CCA and the types of microbes are 'trend indicators.'[3] Sometimes, CHI depicts healthy coral communities but impoverished microbial value or score without much CCA in open areas then the reef may be rich at the present state, but will not be resilient on receiving anthropogenic forces or disturbances. Hence, microbial metric of CHI is extremely important to be aware of.

4.4. Case Study

One of the evidence revealing the recovery of the destroyed coral communities, are of Phoenix Islands. It was found that coral colonies of Phoenix Island were bleached in 2002 and died. However, the fishes and the pathogenic microbes were still present in the island. Using the fundamentals of CHI it was observed that the biomass of the existing herbivorous fishes in the Phoenix Island were higher making certain that the exposed substratum remained in a heavily grazed state, which is conducive for the re- colonization of crustose coralline algae (CCA), but not for the undesirable fleshy algae.[4] This ensured the reefs' trajectory from a fair state in 2005 back towards a familiar and "healthy" state in 2009.[5]

5. CONCLUSION

By knowing the momentous features of the Coral Reef Communities' dynamics, it is thereby, necessary for enforcing the imperative approaches for the safeguard and restoration of the thriving coral hummock colonies in the biosphere. CHI is one such tool, discussed in this paper, to assist the researchers or the explorers in estimating the quantity of the coral reefs' progress or evolution and nutrition. Anthropogenic perturbations have immensely affected the coral colonies causing it to deter unfavorably. Since, they are the only communities, of the marine habitat, that provide shelter to magnificent array of organisms and monitor the marine ecosystem; it is therefore, obligatory to protect and conserve such dynamic and unique communities of the biosphere.

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REFERENCES

[1] Chabanet, Pascale., Adjeroud, Mehdi., Andréfouët, Serge., Bozec, Yves-Marie., Ferraris, Jocelyne., Garcìa-Charton, Jose-Antonio., Schrimm, Muriel., *Human-induced physical disturbances and their indicators on coral reef habitats: A multi-scale approach*, 2005, pp. 216- 226.

[2] Pittman, Simon J.,Costa, Bryan M., Battista, Tim A., *Using Lidar Bathymetry and Boosted Regression Trees to Predict the Diversity andAbundance of Fish and Corals*, 2009, pp. 27-38.

[3] Mumby, Peter J., Hastings, Alan.,*The Impact of Ecosystem Connectivity on Coral Reef Resilience*., Vol. 45, No. 3.,June., 2008, pp. 854-862.

[4] http://www.britannica.com/EBchecked/topic/137083/coral-reef

[5] http://www.natgeotv.com/ca/shark-eden/facts

[6] http://www.eoearth.org/view/article/156613,*Threats to coral reefs*, 2008.

[7] Pilcher.,Nicolas J., *Corals and Human Disturbance.*

[8] http://coral.org/coral-works-to-protect-sharks/.,*Coral Works to Protect Shark.s.*

[9] Richmond.,Robert H.,*Coral Reefs: Present Problems and Future Concerns Resulting from Anthropogenic Disturbance.*, Vol. 33, No. 6.,1993, pp. 524-536.

[10] [1,2,3,4,5] Kaufman. Les., Obura., David., Rohwer., Forest., Sala., Enric., Sandin., Stuart., Tschirky., John.,*Coral Health Index (CHI) measuring coral community health*., 2011., pp. 1-16.

[11] Obura., D., Mangubhai., S .,(in review, 2011) *Coral mortality associated with thermal fluctuations in the Phoenix Islands*, 2002–2005. Coral Reefs.