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ANALYSIS OF THE MAJOR FACTORS OF DEGRADATION AND LOSS OF CORALS IN THE GREAT BARRIER REEF

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ABSTRACT

World coral reefs are degrading, and the need to reduce the major factors inducing the loss of corals is now widely recognized and became now globally important. Main anthropogenic risk factors include mortality and reef growth slowdown corals due to their high sensitivity to rising sea temperature, ocean acidification, water pollution from surface runoff and dredging, destructive fishing, over-fishing and coastal development. This study explores and investigates the major factors of degradation and loss of corals in Great Barrier Reef (GBR).

KEYWORDS: Corals, Coral degradation, Coral Bleaching, Acidification.

1. INTRODUCTION

Anthropogenic practices induce negative impacts on the environment, and destroy an ambient balance that respectively, harms many plant and animal species on our planet. Natural processes and anthropogenic practices cause impacts on the coral reef ecosystems around the world.

Coral reef ecosystems are important because they are one of the most bio diverse ecosystems on earth, occupying less than 0.1% of the surface of the World Oceans. They hold approximately a quarter (over 4000) of the worlds known fish species (Adam et al., 2014), including some of the world's most known fish that are demanded for our dietary needs (Speers at al., 2016). Coral reefs provide useful ecosystem for tourism, fisheries and protection from the shores, from the destructive effects of sea waves that cause erosion (Mulhall, 2009).

Coral degradation is a worldwide problem that occurs in any location, including the African coasts, the Caribbean, Australia and South East Asia (Cho, 2011). Coral Reefs are one of the most sensitive ecosystems, and its degradation due the various factors remains as a high pressing economic, social and scientific problem.

This paper focuses on the brief analysis (based on review of the scientific researches) of the major factors of degradation and loss of coral reefs on a global scale and specifically, closely investigating coral reef degradation on the Great Barrier Reef (GBR) location, caused by acidification, bleaching, and coral predation by Crown-of-Thorns Starfish (COTS).

2. Major factors of degradation and loss of coral reefs on a global scale Coral reefs are geo-biological structures formed by colonial coral polyps and some species of algae that can extract some elements from seawater. Corals that are formed in the tropical seas and are usually in shallow clear water, of normal salinity, and rich in dissolved gases and plankton, where ambient temperatures are not lower than +20 ° C with a depth of up to 50 m (Mulhall, 2009). In the early 1980s, the total area of coral reefs was about 600,000 km²; by 2000 it had been reduced to about 250,000 km² (Mulhall, 2009). That is about 0.07 % of the total World Ocean area (or quarter of the territory of Ontario, Canada). Their existence is threatened by impact of natural environmental factors, (climate change, ocean acidification, bleaching, cyclones) and human activities, or anthropogenic factors (dynamite fishing, cyanide aquarium fishing, excessive use of biological resources, flushing agricultural land, provoking algae growth and pollution). Table 1 shows general information about total area covered by major Corral reefs in global scale nowadays and projections for 2100.

Statistical information to complete Table 1 was obtained from (Speers et al., 2017). Statistical analysis was performed in R Data Programming. Table 1 shows that, in all locations, degradation of Coral Reefs projected a dramatic decrease of covered area of up to 81 – 96% loss: “Relative to today's coral habitat area, we estimate …the loss of 92% of coral cover globally by 2100.” (A.E. Speers et al).

Same data (A.E. Speers et al) used for a statistical analysis in R programing, and OriginPro8 program was used for graphic exploration with calculated results (Fig. 1).

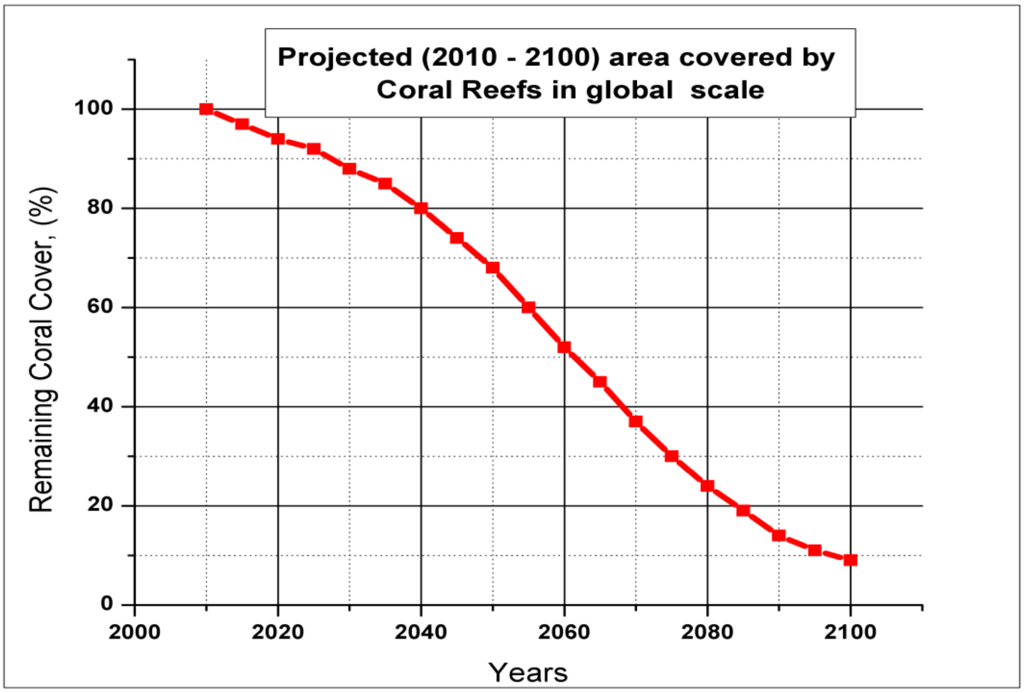

Figure 1: Projected (2010 – 2100) area covered by Coral Reefs (% of current cover remaining), showing predicted 92% degradation and loss of corals cover globally.

Plot in Figure 1 shows temporal trend of the degradations on the area covered by Corral Reefs on a global scale. The major impact factors (Anthony K. R.N et al.,; De'ath G. et al., 2012; Descombes, P. et al., 2015) harmed Coral Reefs on a ***global scale*** grouped in Table 2, and it briefly describes the impacts caused by each type of factor. Information about Projections for 2100 in Table 1, and plot on Figure 1, predicted dramatic degradation and loss of Coral Reefs on a global scale: about 90 % loss of covered area by 2100.

To support or disclaim temporal degradation of coral, it was analysed how it changed its covered area in the pass (1970 – 2010) in the Caribbean Sea (Figure. 2). The data for analysis was obtained from (Didier et al, 2017). Statistical analysis was completed in R programming: calculated mean of distributions in different three areas of Curacao location and depths (10, 20, 30 and 40 meters) with 95% Confidence bands. For graphical exploration of the calculated results, OriginPro 8 program was used.

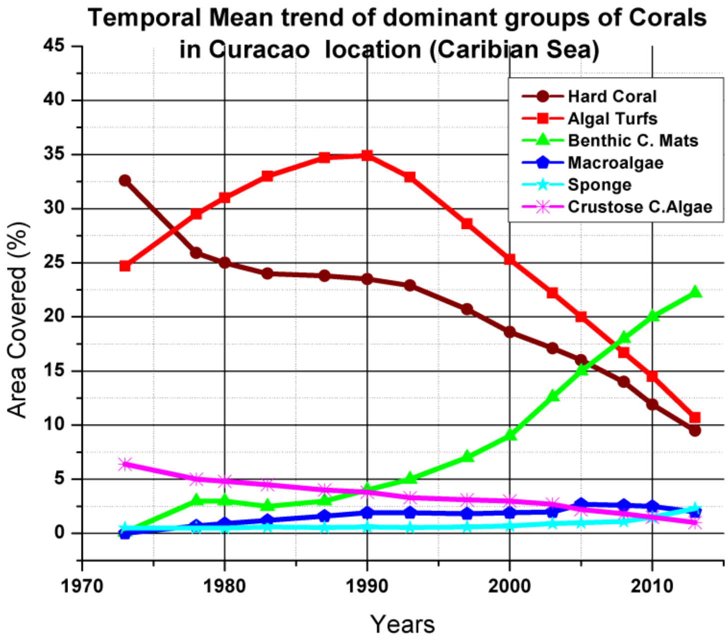

Figure 2: Mean (with 95% Confidence Intervals) percentage changes of dominant groups of corals (Hard Coral, Algal Turfs, Benthic Cyanobacterial Mats, Macroalgae, Sponges, Crustose Coralline Algae), covered surfaces at 10, 20, 30 and 40 meters depths in Curacao location of Caribbean Sea between 1973 and 2013.

Plots (Figure 2) shows mean percentage changes (with 95% Confidence Intervals) of dominant groups of corals in Caribbean Sea between 1973 and 2013. Even though some groups of corals (Benthic Cyanobacterial Mats) strongly increased covered area, the main groups of corrals for this location lost covered area: "Between 1973 and 2013 coral cover in Curacao declined by 71.8% over all sites and depths." (M. Didier et al, 2017).

Thus, according to Projections (Table 1 and Figure 1) the degradation and loss of Coral Reefs on a global scale, predicted about 90% decline by 2100, with "degradation speed" of about 1% per year. For the Caribbean Sea location "degradation speed" of some dominant groups of corals for the past 40 years was between 0.6 and 1.7% per year, with estimated average of 1.4% per year.

It is important to notice that listed above (Table 2) factors are major in global scale, and not all of them take place in some specific location. However, some factors that are not mentioned in the list above, have major impact for specific location. Thus, there is a complex of negative factors that influence degradation of coral reefs, making it very noticeable of it's loss. This paper does not analyze in detail, all the impacts that are named in Table 1, but it analyzes impact factors that harm Coral Reef cover on the Grate Barrier Reef (GBR).

3. Degradation and loss of corals on the Great Barrier Reef

The Great Barrier Reef (GBR) is the world's largest Coral Reef, stretched along of Australia for 2500 km and covers an area of about 344,400 km^2, including more than 2900 individual coral reefs and 900 islands in the Coral Sea (Sarah Belfield, 2007).

3.1. The Decline of Coral cover on the GBR

Similar to the coral’s degradation on a global scale, Coral Reefs in the GBR also are being degraded (De’ath G. 2012). Graph in Figure 3 shows temporal trends in coral cover for the whole GRB over 214 reefs and the period of 1985 – 2012. Data was obtained from (De’ath G. 2012) and statistical analysis was completed in R programming. For graphical exploration, OriginPro8 programming was used.

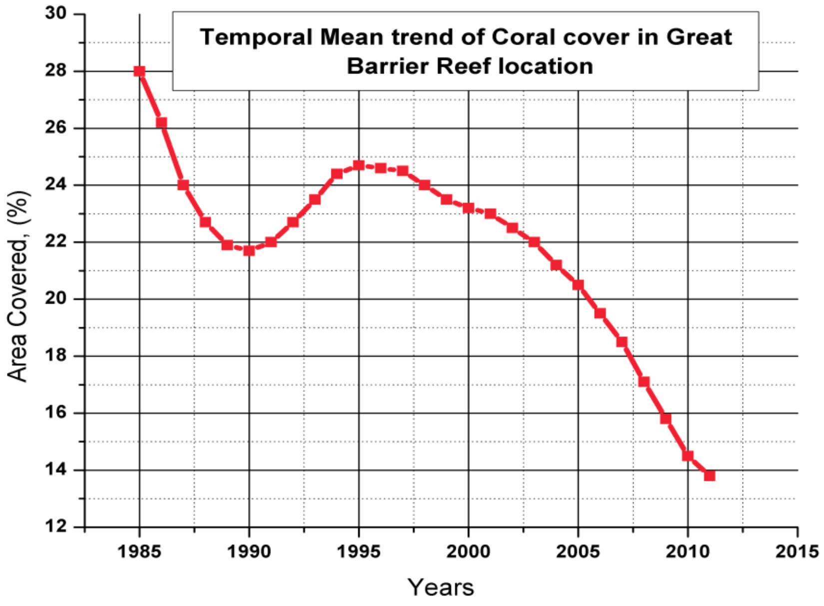

Figure 3: Temporal trends in coral cover for the whole GRB over 214 Reefs and the period of 1985 – 2012.

Even though the graph shows five years increasement of coral’s that covered an area (from 1990 to 1995), there is a general trend of plot disclaiming. “Based on the world’s most extensive time series data on reef condition (2,258 surveys of 214 reefs over 1985–2012), we show a major decline in coral cover from 28.0% to 13.8% (0.53% per year), a loss of 50.7%

of initial coral cover." (De'ath G. 2012). "This study suggests the GBR is on a trajectory similar to that of reefs in the Caribbean, where coral cover has declined by 1.4% per year (compare with 1.51% per year for the GBR current rate of decline) from 55% in 1977 to 10% today." (De'ath G. 2012).

However, the factors leading to degradation of coral in the Caribbean and GRB are different. "In contrast, the rapid decline in coral cover in the Caribbean has been attributed to a combination of coral diseases and storms, together with a phase shift from coral to algal dominance due to the loss of all major groups of herbivores from overexploitation, diseases, and possibly elevated nutrient runoff…" (De'ath G. 2012). Similar to Caribbean Sea corral's, diseases has never been observed in the GBR (Osborne K. et al, 2011).

3.2 Major degradation impacts on GBR

To identify the main impact factors of coral's degradations in the GBR location, the data was analyzed and presented on Figure 4 below (in R programming and OriginPro 8) (De'ath 2012, Osborne et al 2011, Ainsworth, et al 2016, Cinner, Et al 2016, Anthony, et al 2015, Descombes, P. 2015, Bozec, YM and Mumby, PJ 2015).

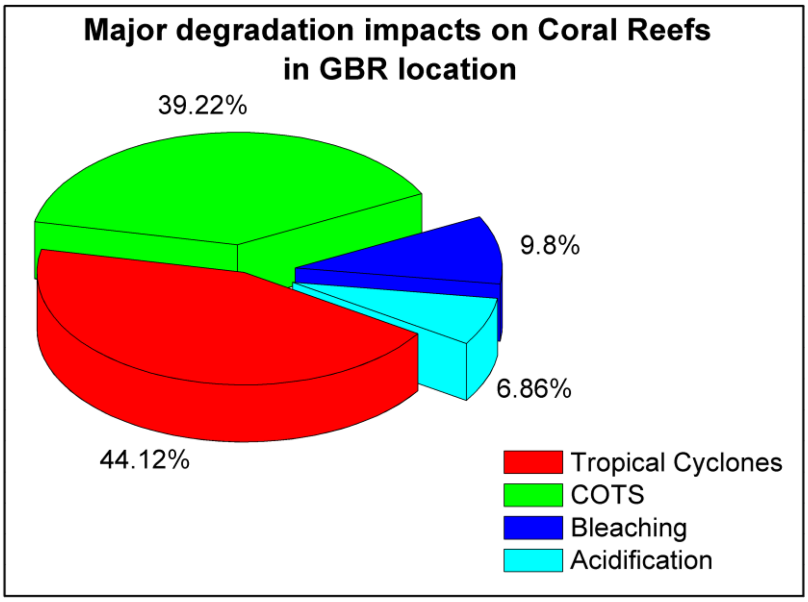

Figure 4: Major degradation impacts on coral reefs on the Great Barrier Reef location, based on the world's most extensive time series data on reef condition (2258 surveys of 214 reefs over 1985-2012).

The major degradation impact factors on GBR location are: ***Tropical Cyclones – 44.12 %; Coral predation by Crown-of-Thorns Starfish (COTS) – 39.22 %; Coral Bleaching – 9.8 % and Acidification – 6.86%.*** "Disturbances due to COTS, cyclones, acidification and bleaching occurred frequently from 1985 to 2012, with only 3 of the 214 reefs remaining impact-free." (De'ath G. 2012).

3.2.1 Coral predation by Crown-of-Thorns Starfish (COTS)

The population increasement of the coral-eating Crown-of-Thorns Starfish (COTS), or *Acanthaster planci,* is a large disturbances in GBR location. COTS is a multibeam starfish with body diameter - up to 50 cm, that feeds on the reef-forming corals. ***One star eats up to 13 m^2 of coral per year.*** The reasons for the rapid growth of the population of Thorns are not very clear: according to one version, it is responsible for the extermination of natural enemies of the COTS as a predatory reef fish, Shrimp-harlequin and, most importantly, mollusk Charonia tritonis. (Mah. C. 2015*).* Today COTS is one of the most distributing factors on GBR degradation corrals**.**

3.2.2 Coral Bleaching

Coral Bleaching is another threat to the existence of reefs induced by Global warming. This process is one of the most widespread and poorly studied problems of coral reefs (Pandolfi, 2015). When the water temperature rises at least one degree higher than usual, algae that live in polyps die. Damaged corals are evicted *symbiotic algae*, which give them a vivid color. As a result, there are "whitish" areas that form on the colonies. These areas, however, are not completely devoid of algae. In some cases, partial restoration or appearance of new species is possible. It is established, however, that discolored colonies do not grow and are more easily destroyed by wave activity (Ainsworth, et al 2016, Bozec, 2015). Large-scale discoloration occurred due to 1997-1998 El Niño, which caused a prolonged warming of the surface layers of the ocean to 1.5 ° C. "Coral bleaching occurs when the coral hosts expel their symbiotic dinoflagellates… Corals rely on the photosynthetic symbionts for their energy provision, and if bleached corals do not rapidly regain symbionts, they die. Mass bleaching events occur over broad spatial scales and affect a large component of the reef coral community. One such episode, in 1998, is often referred to as the largest mass bleaching event on record: in the Seychelles, more than 90% of live coral cover was lost." (Pandolfi, 2015*).* Extensive coral mortality results in large-scale changes to the reef environment, such as habitat loss and a collapse of the structural complexity of coral reef architecture (Cinner et al, 2015*).*

3.2.3 (Coral) Ocean Acidification

Acidification is a combined result of carbon dioxide emission to the atmosphere and increasing temperature of ocean water at the surface. "Coral reefs themselves also negatively affected by ocean acidification, because calcification rates decrease as acidity increases." (Widdecombe and Spicer, 2008). "*Anthropogenic carbon dioxide (CO_2) emissions to the atmosphere and subsequent uptake by the ocean are changing seawater chemistry, a process known as ocean acidification. Once dissolved in seawater, CO_2 is a weak acid that generates a number of changes in seawater chemistry. It increases the concentrations of bicarbonate ions and dissolved inorganic carbon, and lowers the pH, the concentration of carbonate ions.*" (Gaylord et al 2015). "Ocean acidification can cause condition abnormally elevated CO_2 and increase stress in marine organisms, thereby leading to decreasing biodiversity." (Widdecombe and Spicer, 2008).

Table 1: General information of total area covered by major Corral reefs in global scale nowadays and projections for 2100.

Region	REEF AREA, (hectares)	
	Past conditions (2010)	**Projections for 2100**
Middle East & African Countries		
East Africa	26,057	2,085 (92% loss)
Red Sea & Persian Gulf	11,771	471 (96% loss)
Most Asian Countries		
Coral Triangle	70,474	8,457 (88% loss)
East Indian Ocean	15,402	1,69 (89% loss)
Polynesia	29,183	4,377 (85% loss)
Latin American Countries		
Caribbean Sea & West Atlantic Ocean East	14,820	1,334 (81% loss)
Tropical Pacific Ocean	345	24 (93% loss)
Australia	29,626	3851 (87% loss)

Table 2: The major impact factors harmed Coral Reefs on a global scale [9,10 and 11]

Impact factors harmed global coral reef cover	**Impact Caused**
Tropical Cyclones and Storms	Structural damage, floods and sediment-action
Destructive fishing	Structural damage, mortality of flora and fauna
Crown-of- thorns starfish (COTS)	Coral mortality
Thermal anomalies (bleaching)	Coral bleaching, diseases and mortality
Sedimentation/ turbidity	Sediment stress and light limitation, enhancement of algal growth
Nutrient enrichment	Enhanced algal growth, increased turbidity
Pollution (herbicides, pesticides and heavy metals)	Toxicity, affects metamorphosis and larval survival.

Ocean acidification	Reduced coral growth and strength, enhanced algal growth
Decline in herbivores	Reduced algal mortality, algal overgrowth of corals

4. CONCLUSIONS

1. Coral Reefs in the GBR have temporal trends of corals on a global scale, are being degraded: analysis shows that a major decline in coral cover from 28.0% to 13.8% (0.53% per year), and a loss of 50.7% of initial coral cover. It will likely fall to 5 – 10% within next 10 years.

2. Major degradation impacts on coral reefs on the Great Barrier Reef location are:

- Tropical Cyclones – issued 42.12% of coral cover's degradation and loss;
- Coral predation by Crown-of-Thorns Starfish (COTS) - destroyed 39.22% of corals;
- Coral Bleaching – degraded 9.8% of covered area
- Ocean Acidification - issued 6.86% of coral's degradation.

Even though those factors are natural (environmental), they are in some way induced by human socio-economic activities.

3. Strong actions to control COTS population and to reduce bleaching and ocean acidification are essential for the future of GBR. "Without intervention, the GBR may lose the biodiversity and ecological integrity for which it was listed as a World Heritage Area.".[4]

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