CHAPTER 5

INTER RELATIONSHIPS OF THREATS

The GoK reefs are exposed to a range of environmental extremities, including high temperatures, sedimentation, nutrients, algal coverage, industrial pressure, and destructive fishing practices (Patel and Bhaskaran, 1978; Patel, 1985; Arthur, 2000; Deshmukh et al., 2005; Bhattji et al., 2011). All these factors are inter-connected with each other, and in combination, place high pressures on the GoK reef habitat and its inhabitants. A reef is a multidimensional ecosystem, which functions via a complex inter-relationship with associated ecosystems and organisms (Hughes, 1994; McCook, 1999; McClanahan et al., 2001; Diaz-Pulido and McCook, 2002; Wilkinson, 2002; Birrell et al., 2005; Hutchings et al., 2005; Hutchings and Haynes, 2005; Humphrey et al., 2008). Damage to associated ecosystems also plays an important role in the sustainment of the reef corals (Hemminga et al., 1994). All the threats discussed in the previous chapters are associated with each other and it is important to understand their inter-relations and effects.

This chapter outlines several parameters known to exist in the study area for a long period of time, and their effect on the coral reefs. All the discussed factors are co-related with the previously listed threats, and the cumulative effects generated from their inter-relations are discussed below.

5.1 Abiotic factors

5.1.1 Sedimentation

Turbidity in moderate amounts is necessary for the protection of reefs from bleaching when exposure to sunlight. However, there is a fine balance between appropriate sedimentation and adequate sunlight. Heavy siltation can cause severe adverse effects on coral colonies. As discussed in Chapter 3, elevated sediment load in the GoK waters is the major cause of coral destruction (Nayak et al., 1989; Bahuguna et al., 1992; Sharma et al., 2008; Bhattji et al., 2011). One of the major contributors to this heavy sedimentation is reduced mangrove cover, as the roots of mangroves hold the sediment particles and do not allow them to escape into the neighboring reef ecosystem (Rashid, 1985). The GoK reefs are primarily affected by sedimentation, and along with the associated secondary threats, this causes severe harm to these already stressed colonies. Sedimentation obstructs the mouth of polyps, damages coral body cells, and also causes bleaching (Hubbard, 1986; Rogers, 1990; McCulloch et al., 2003; Goldberg and Wilkinson, 2004; Jordan et al., 2010). Such threatened colonies are then very vulnerable and hence, easily destroyed by excessive algae or predatory anthozoans (Bhattji et al., 2010).

5.1.2 Temperature

The current era of ecological and environmental changes can be linked to the effects of global warming, and coral reefs are no exception to this trend. Globally increased SST has both a direct and indirect effect on coral reefs (Hoegh-Guldberg, 1999; Buddemeier et al., 2004). The severity of the effect depends on site specific changes and other associated parameters. For example, Lakshadweep reefs are severely affected by direct photo-bleaching secondary to increased SST (Bhandari and Sharma, 2010). The clear water of the reefs allow high solar radiation to reach coral colonies, and the bleaching of coral polyps increases secondary to the loss of zooxanthallae (Lesser, 1997; Jones et al., 1998; Hoegh-Guldberg, 1999).

The condition of the GoK is different from that of other coral reef regions, as it is exposed to many integrated parameters working simultaneously to create higher stress towards coral colonies. This includes sedimentation, high nutrient waters, and overgrowth of algae. The fleshy algae found in the same area are temperature-sensitive, and have a higher growth rate with higher SST (Goldman and Carpenter, 1974). They grow quickly over coral colonies and almost completely block the exposure of the polyps to sunlight. Thus, overgrowing algae caused by increased temperatures significantly contribute to coral loss.

5.1.3 Hydrodynamics

The GoK reef region itself acts as a 'bioherm', and has properties of self construction and self sustainment (Cumings, 1932). However, its typical funnel shape causes high tidal amplitudes. The wave actions during the ebbing and flooding tides are heavy, and thus cause sustained damage to the reef front and algal ridge regions (Hashimi et al., 1978). High tidal dynamics results in exposure of corals outside the water for long periods of time. This leads to increased salinity and temperature of the water in tide pools, and thus causes stress to coral colonies as well as other reef biota present in that tide pool (Deshmukh et al., 2005). The flow and circulation of water in the Gulf also brings in a heavy sediment load deposited by the Indus River near the upper North West margin of the Gulf (Hashimi et al., 1978; Nair et al., 1982; Chauhan et al., 2006; Ramaswamy et al., 2007), further increasing the stress on the reef.

5.1.4 Industrialization

The coastal environment is always under high utilization by human activities along the coast. There are a number of ports and diverse industries, both large and small, flourishing in the coastal areas of the GoK (Singh, 2006; Singh et al., 2006; Ramaswamy et al., 2007; Biswas, 2009). The industrial runoff contributes to an elevated nutrient influx entering the reef ecosystem. Previous dredging activity near reef areas has deposited an

excessive amount of sediment into Gulf waters (Singh et al., 2006; Biswas, 2009). Furthermore, there are frequent reports of oil spills from the pipeline transferring oil from the coastal refinery to shipping vessels (Jagtap and Untawale, 1980; Boesch and Rabalais, 1987; Zingde and Anand, 1994; Vethamony et al., 2007). All these effects of industrial activity, together with the factors above, threaten the survival of coral reefs in the area.

5.1.5 Fishing practices

The coastal areas of the GoK are home to a large population of fishermen, and there is a strong fishing culture within the surrounding community. The catch from the GoK and Arabian Sea Fisheries contribute significantly to the Indian fishing industry and the Indian economy. Traditional fishing practices including bottom trawling, inter tidal fishing nets, and anchoring on the reefs, and all these methods cause considerable disturbance to reef biota (Biswas, 2009; Dave, 2011).

5.2 Biotic factors

5.2.1 Algal over growth

As discussed previously, reefs are also under threat from algal overgrowth, but this is a secondary threat, originating as a side effect from primary stressors like sedimentation, increased temperature and high nutrient

content. Algae is a common inhabitant of the reef, growing seasonally every year. However, recent climate change has created favorable conditions for its higher growth rate (Littler and Littler, 1984; Lapointe, 1989; Done, 1992; Hughes, 1994; Miller, 1998; McCook et al., 2001), and thus, the risk of coral algal phase shift has increased.

5.2.2 Intruder Anthozoan – *Palythoa*

Anthozoa belong to the same phylum as corals and shares many similarities with coral colonies. Like algae, anthozoans are also an important part of a balanced reef ecosystem. However, changing environmental conditions have increased their survival capacity in comparison to corals. The toxin produced by *Palythoa* is one of the most potent non proteinaceous toxins in the world (Suchanek and Green, 1981). This silent intruder uses this toxin to overcome the competition of neighboring coral colonies (Bastidas and Bone, 1996; Mendonça-Neto and Gama, 2009). Recently, reports of *Palythoa* outgrowing other reef inhabitants have been noted secondary to this survival advantage (Bastidas and Bone, 1996; Mendonça-Neto and Gama, 2009). As *Palythoa* also have greater adaptability to higher temperatures and can store sediments into their coenenchyme, they have an increased likelihood of survival and can hence outgrow the native coral colonies. It has been observed at certain locations that competition has

already begun, and this aggressive predator is quickly covering large areas, causing loss in coral habitat (Bhattji et al., 2010).

5.2.3 Loss of Associated Habitats

Loss of mangrove and sea grass beds can contribute heavily to the loss of coral cover (Rashid, 1985; Hemminga et al., 1994). As discussed earlier, mangroves are biological controllers of the abiotic threat of sedimentation. This natural protection has been removed from the system by the local human coastal population for fuel purposes. This great loss of natural protection went unnoticed for many years, and thus created a vast imbalance, leaving long-term effects on the surrounding ecosystems (Singh, 2006; Biswas, 2009). Mangroves, sea grass and coral reef ecosystems go hand in hand, as mangroves and sea grass beds absorb the high nutrient contains in the waters, which can be otherwise harmful to corals (Wafar and Whitaker, 1992; Moberg and Folke, 1999). Mangroves and sea grass ecosystems also act as a nursery ground for the young of many reef going fishes and arthropods (Mumby et al., 2004; Dorenbosch et al., 2005; Mumby, 2006), as well as helping to contain sediment and protecting the shore from erosion (Rashid, 1985).

5.3 Conclusion

When many parameters work in combination with each other, the resulting cumulative effect can be extremely significant, as is the case in the environment of the GoK reefs. The combination of various stressors is causing cumulative effect on the reefs of the GoK. Although the GoK reefs are protected through legislation by being declared as the Marine National Park and Sanctuary, natural and anthropogenic stressors still exist in the surrounding areas of National Park boundaries. This diversity of factors results in a cumulative loss of coral reef habitat in the GoK.

The following chapter explains the technique of remote sensing, and its role in protecting the coral reef habitat.