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Contents

Preface

The origin of this study can be traced back to an octocoral workshop held in India (2005), supervised by Dr Leen van Ofwegen and Dr. Phil Alderslade, who told me about the absence of information on the octocoral fauna of the Persian Gulf region, claiming bluntly that "everybody knows there is nothing there!" This planted the first seeds in my mind to prove them otherwise, thinking naively that "surely there must be octocorals in these waters!" A few years later, I discovered that their speculation was just a ruse to get me hooked on the subject, one for which I am now grateful.

A review of the literature of the region made it obvious that indeed very few records of soft corals and gorgonians existed for the Gulf region and the majority of the publications about its coral fauna focused on hard corals, mainly shallow-water scleractinians. Naturally, I thought of starting with the Iranian coastline as access to that was possible. My first challenge was that very little was known about even the hard coral communities of Iran, and to my regret this is still the case. Therefore I had to start from scratch and search wherever I could along the coastline. I also started searching the literature and contacting colleagues who published on this topic in order to obtain more information, which introduced me to several prominent scientists who had been researching corals in the Gulf region for decades. Their publications have been the key source of inspiration for Iranian coral scientists of my generation.

The following chapters are more or less ordered chronologically and therefore reflect the sequence of challenges, and the development of my knowledge during my research which was fed by discussions with friends and colleagues, involvement in consultancy work, and developments in my personal life. Although my early work was conducted within the boundaries of the Persian Gulf, but later work was conducted in adjacent areas where a lack of information has also persisted.

Introduction and overview

Climate change is firmly established as a scientific reality, with a variety of challenges for human society in the coming decades (Baker et al. 2008). Reports on global climate change suggest a significant global warming trend over the past 30 years, which is associated with continuously increasing greenhouse gas concentrations (Goldberg and Wilkinson 2004). A rise in average sea surface temperature (IPCC 2007), combined with the acidification of the oceans caused by increasing concentration of carbon dioxide through the atmosphere (Kleypas and Langdon 2006) are very likely in the coming decades.

Among marine ecosystems, coral reefs are particularly sensitive to climate-induced changes in the physical and chemical environment. Since the 1980s, coral reef bleaching and catastrophic mass mortalities of reef corals caused by elevated seawater temperatures has been reported worldwide from virtually every region that supports coral reefs (Glynn 1993, Hoegh-Guldberg 1999, Hoegh-Guldberg et al. 2007, Baker et al. 2008, Wilkinson and Souter 2008). Despite the scale of paleo-climatic changes that have occurred over geological time, coral reefs or coral-dominated sedimentary systems have persisted through time (Riegl and Piller 2003), indicating the potential of adaptation or acclimatization of such systems to survive changing conditions and increasing temperatures over long time scales (Edmunds and Gates 2008, Baker et al. 2008). These processes and responses are particularly well developed in areas with regular stressful and extreme conditions, such as in the Persian Gulf, where corals persist and may even thrive despite experiencing the highest annual temperature range encountered by any hard corals in the world (Sheppard et al. 1992, 2010, and described further in Section 1 of this thesis). The corals of the Persian Gulf live under levels of stress that would be fatal for corals living anywhere else in the world. By studying the corals of the Persian Gulf, their species biodiversity and dynamics, we may gain important insights into mechanisms of reef survival and the interaction between genes and environment, which eventually lead to a greater understanding about important questions such as whether corals can respond to warmer conditions quickly enough to keep up with temperature rise; or whether climate change will lead to extinction, range reduction/expansion, loss of coral cover or loss of biodiversity, changes to coral ecosystem services and the consequential impacts for the ecosystem (Riegl 2003; Baker et al. 2008).

One of the first steps in developing a conceptual functional model for any system is to understand and define the components of that system. To understand and study the way corals will respond to climate change, one of the key elements is to define their species diversity and their distribution boundaries (as presented in Sections 2 and 3). Spatial and temporal analyses of this biodiversity data combined with environmental data will reveal how these species have responded to environmental changes in the past and which may help to predict their possible responses in future. Coral biodiversity and biogeography in the Persian Gulf region is likely to be influenced by the Gulf's age which is much younger compared with similar enclosed seas in other parts of the world and is therefore a potentially confounding factor. Specific coral studies mainly started in parallel with national and international developmental projects in Gulf countries Gulf in 60's and 70's. The majority of these studies were undertaken in the southern Gulf where the pace of development was far greater than development of the northern Gulf. Scleractinians were favoured in the majority of these studies mainly due to their low abundance and diversity in the southern Gulf, while coral studies in the northern Gulf were few and very limited (given in Section 3). Furthermore, effects of climate change

are better studied on scleractinians compared to soft corals, but scattered reports suggest that while soft corals are generally more tolerant of extreme seawater temperatures, some species are at least as sensitive as scleractinian corals and may therefore be more effective as bioindicators. Later studies in the northern Gulf revealed that the diversity of octocorals in the region is much higher than previously expected and showed earlier work to be inaccurate (Section 2 of this thesis). These studies coincided with our better understanding of climate change in the past few decades and eventually led scientists to realize the importance of the Gulf as a laboratory for the study of global temperature rise on marine ecosystems and in specific on corals (described in Sections 1 and 4).

This thesis reviews the available coral studies in the Persian Gulf at a large scale, discusses the environmental challenges for corals in the context of climate change, and expands our knowledge of coral biodiversity and biogeography of the region, highlights the remaining gaps in our knowledge and goes on to provide recommendations for further research. This is of special importance given recent international interest in the region as a harbinger of coral adaptation to climate change as the impacts to the global environment, human society and the economy unfold.