Aqaba Marine Reserve

Management Plan

2022-2026

وزارة البيئة

AQABA

UNDP

Aqaba Special Economic Zone Authority

This document, views expressed and the presentation of the material, do not necessarily reflect those of UNDP.

Prepared by: Mr. Ehab Eid, Mr. Abdulla Abu Awali and Mr. Jonathan McCue

Revised by: Dr. Nedal Oran

Funded by: United Nations for Development Program (UNDP)

Available from:
Environmental Commission at the Aqaba Special Economic Zone Authority
Address: Aqaba Special Economic Zone Authority - Aqaba - Prince Al Hussein Bin Abdullah II Street and Queen Rania Al Abdullah Street
Tel: 0096232091000
Fax: 0096232091056
Po.Box Aqaba 2565, Jordan

Contents

List of Abbreviations

Abbreviation	Extension
ACT	Aqaba Container Terminal
ADC	Aqaba Development Company
AMP	Aqaba Marine Park
AMR	Aqaba Marine Reserve
ARA	Aqaba Regional Authority
ASEZ	Aqaba Special Economic Zone
ASEZA	Aqaba Special Economic Zone Authority
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Plants and Animals
CoP	Conference of Parties
CoT	Crown of Thorns
CSR	Corporate Social Responsibility
DO	Dissolved Oxygen
EIA	Environmental Impact Assessment
FENGO	Jordan's Federation for Environmental NGOs
GCF	Green Climate Fund
GEF	Global Environmental Facility
GoA	Gulf of Aqaba
GoJ	Government of Jordan
IBA	Important Birds Area
ICZM	Integrated Coastal Zone Management
IMO	International Maritime Organization
IUCN	International Union for the Conservation of Nature
IUCN ROWA	International Union for the Conservation of Nature/ West Asia Office
JNPAs	Jordan's Network of Protected Areas
JREDS	The Royal Marine Conservation Society of Jordan
MAB	UNESCO Man and Biosphere Reserve
MAC	Mean Absolute Cover
MAM	Multi-Annual Mean
MARPOL	International Convention for the Prevention of Pollution from Ships
MEA	Multilateral Environmental Agreements
MOA	Ministry of Agriculture
MOE	Ministry of Environment
MOTA	Ministry of Tourism and Antiquities

MOU	Memorandum of Understanding
MSL	Mean Sea Level
MSS	Marine Science Station
NAP	National Adaptation Plan
NDC	National Detrimental Contribution
NMP	National Monitoring Program
Pas	Protected Areas
PERSGA	The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
RHC	Royal Hashemite Court
RSCN	Royal Society for the Conservation of Nature
SDG	Sustainable Development Goals
SEB	Skeleton Eroding Band
SME	Small and Medium Enterprise
UN	United Nation
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WHC	World Heritage Convention

Summary

In June 3rd, 2020, His Majesty King Abdulla II gave his directive to declare the existing Aqaba Marine Park (AMP) as a new Aqaba Marine Reserve (AMR). Based on this, the Aqaba Special Economic Zone Authority (ASEZA) has initiated an active process to declare the site and the process was conducted under the supervision of the Royal Hashemite Court, the Ministry of Environment (MoE) and a steering committee, which was developed for this purpose. Based on that, an official decision was made by the Board of Commissioners No. 38 (2020) to declare the AMR. This was followed by the inclusion of the AMP within the Jordan National Protected Areas Network (JNPA), and the site was declared by the cabinet of Jordan as the first Marine reserve in Jordan in December 2020. As a result, a bespoke Management Plan (MP) is required to support policy implementation for the AMR. The MP is expected to drive the efforts at the AMR as part of the JNPA network, to positively contribute to the marine conservation potential of the wider region, contributing towards the protection of key marine and terrestrial faunal diversity in the area which are considered, at least of significant proportion of its habitat, among the best representative of coral reef species.

This Aqaba Marine Reserve Management Plan (AMRMP 2022-2026) is presented as an innovative management tool that solidifies the recognition of Aqaba as a socio-ecosystem, where successful conservation requires integrated management of the protected areas with the populated zones of Aqaba. This includes acknowledging the capacity of relevant ecosystems and their biodiversity to generate services, and contributing to the recovery of those components that have been altered primarily by anthropogenic causes (invasive species, habitat degradation and fragmentation, among others), in ways that guarantee a sustainable human presence and quality of life or good living.

From a regional perspective, the Gulf of Aqaba is part of a separate biogeographic zone within the wider Red Sea and is of global significance in having the northern-most latitude reefs in the Western Indo-Pacific. Aqaba reefs also lie within this Red Sea biogeographic zone which is designated as a Worldwide Fund for Nature (WWF) “Global 200 Eco-Region” on account of its unique marine biodiversity.

The AMR is distinctive and unique because of its high number of species, diverse number of habitats, high endemism, and remoteness. It is located in the North-Western Indo-Pacific biogeographic region that currently contains onward World Heritage Site. To this end, the AMR (circa 2.8km2) represents a unique and outstanding marine ecosystem that sustains intact ecological setup and interacting biological processes which in need of long-term conservation support for its unique diversity and endemism. It covers both shallow habitats and reef formations and deep-sea areas that ecologically interacting by natural exchange. The occurrence of seagrass beds and sand beaches has regulated nutrient and sediment input into these reef complexes. Such habitats contain a high percentage of endemic species and diverse habitats that host significant populations of globally important and endangered species, including sharks, dolphins, napoleon wrasse, groupers and marine turtles. The AMR is critically important for the wider region as it is believed to serve as an important larvae export area and host important spawning sites for key fishery species. The AMR boundary also encompasses a variety of fish and coral communities more usually separated by several hundred kilometers. Critically, this wide range of intact marine ecosystems has proven resilience of reefs to coral bleaching. It also has been internationally recognized as an Important Bird Area (IBA) for both resident and migratory birds.

The AMRMP (2022-2026) updates all previous plans produced for the AMP. It differs from previous Management Plans produced because it rejects the paradigm of constant conflict between conservation and development and accepts that development in Aqaba is not possible without conservation and that effective conservation depends upon the development model being adopted by ASEZA.

It is based on a shared vision: "Aqaba Marine Reserve is a model of effective planning and management that ensures that the unique ecological values and associated social and economic benefits are used sustainably for future generations through active stakeholder stewardship". The achievement of this shared vision is based on general principles, which guide, orient, and prioritize decision-making by natural resource managers as well as all other actors involved in the management of the Aqaba Marine Reserve. Development of the plan began with the formation of a core work group composed of regional and national authorities, who provided significant contributions to the creation of a shared vision for the plan.

It aims to optimize the management actions of ASEZA and to meet the current needs of the broader society, as well as respond to the environmental challenges of the AMR. It is needed to help protect the outstanding marine biodiversity on offer within the proposed boundary limits. In fact, the exceptional environmental conditions of the AMR provide for coral growth and reef development in the Gulf of Aqaba with numbers of coral species higher than many other locations nearby in the northern or the southern Red Sea.

It is prepared to help address a series of threats that the AMR is facing, namely Population Growth, and the Associated Recreational and Tourism Growth; Port Development; Sea Level Rise; Flood Risk; Extreme Low Tide Events; Oil Spills: Water Quality Issues; Ballast Water; Marine Debris; Living Marine Resource Extraction; Natural Predators and Coral Disease. To address these management challenges, it is necessary to develop strategies specifically geared toward the conservation of marine ecosystems and their biodiversity.

The main areas of intervention of the AMRMP (2022-2026) are determined by six objectives and a series of outputs, which correspond to the objectives of ASEZA. The objectives include:

1. Maintain and improve healthy, resilient, bio-diverse reefs and seagrass habitats within the AMR up to and beyond 2026
2. Create and implement the necessary mechanisms to promote the AMR as a model for ecologically sustainable tourism which complies with international principles and standards
3. Effective surveillance and patrolling is being implementing to cover the entire AMR area
4. Improve and strengthen institutional/legal framework and associated management capacities
5. Marine Conservation awareness and Education is improved at the International and National Level
6. Sustainable financial mechanisms are established and implemented to finance future AMR related management operations and activities

Four ecosystem assemblage targets have also selected to represent the core focus for this AMRMP (2022-2026). The category assessment "scores" presented (for each key conservation target) have been derived from a series of attributes and indicators that are set for the AMR.

- Coral Reefs
- Seagrasses
- Terrestrial Ecosystems
- Open Sea Ecosystems.

The relatively good biodiversity health of the AMR is one of the reasons for its high conservation importance. Based on this analysis, five Management Programs have been identified for effective management of the AMR including i) Natural Resource Management, ii) Science, iii) Education and Outreach, iv) Infrastructure Program and v) Administration programs. The actions related to each program were also developed.

Data Sheet

Name of Marine Reserve	Aqaba Marine Reserve	
Location of Marine Reserve	Southern Beach, Aqaba, Hashemite Kingdom of Jordan	
Date of Declaration of the AMR	8th of December 2020	
Area of the AMR in relation to Jordanian Territorial water	2.8Km^2 out of 96 Km^2 which represents 3% of the total Jordanian Territorial water area	
Coastal length in relation to Aqaba coastline	7Km out of 27Km which represents 26% of the total coastline length	
Land Tenure	ASEZA own the land	
Management Authority	Aqaba Special Economic Zone Authority (ASEZA)	
Partnerships	Ministry of Environment (MoE)	
Number of Staff	Permanent: 25	Temporary: n/a
Current Designation (IUCN Category)	Category VI	
Reasons for Designation	To achieve a marine reserve that supports the protection of health coral reefs and marine ecosystems whilst supporting socio-economic development of Aqaba.	
List primary Marine Reserve objectives		
1) Maintain and improve healthy, resilient, bio-diverse reefs and seagrass habitats within the AMR up to and beyond 2026; 2) Create and implement the necessary mechanisms to promote the AMR as a model for ecologically sustainable tourism which complies with international principles and standards; 3) Effective surveillance and patrolling is being implementing to cover the entire AMR area; 4) Improve and strengthen institutional/legal framework and associated management capacities; 5) Marine Conservation awareness and Education is improved at the International and National Level; 6) Sustainable financial mechanisms are established and implemented to finance future AMR related management operations and activities.		
Significant threats to the Marine Reserve		
Threat 1: Population Growth, and the Associated Recreational and Tourism Growth; Threat 2: Port Development; Threat 3: Sea Level Rise; Threat 4: Flood Risk; Threat 5: Extreme Low Tide Events; Threat 6: Oil Spills: Threat 7: Water Quality Issues; Threat 8: Ballast Water; Threat 9: Marine Debris; Threat 10: Living Marine Resource Extraction; Threat 11: Natural Predators and Coral Disease; 12: conflict of management interest between relevant stakeholders		
Critical Management Programs		
A. Natural Resource Management; B. Science; C. Education and Outreach; D. Infrastructure; E. Administration		

Part One: Introduction

1.1 Background and Context

The Jordanian shoreline falls within the Gulf of Aqaba (GoA) and extends to a maximum of 27km in length. This provides Jordan with the only access to the sea including activities such as ship transport, fishing (secondary importance), and industrial development. Across the GoA (into Egypt) is a small but thriving tourism industry that is served by a number of hotels, an airport and ferry services to adjacent localities, which include the towns/resorts of Taba and Dahab. Along this coastal stretch includes the presence of 13 km of a discontinuous series of fringing reefs, which contains unique marine and coastal ecosystems, habitats and rich biodiversity composition.

With such a limited shoreline, all coastal activities in Jordan are concentrated within this stretch. As a result, it is subjected to considerable and conflicting marine resource use pressures. Such competing activities include tourist (hotels, resorts, and tourism related activities), a variety of port developments, an industrial complex, a marine park and a Marine Science Station. This situation places all coastal habitats (including important coral reefs) under continuous direct and indirect pressures throughout the year. In particular, the development of new port facilities and the expansion of existing ports are expected to extensively damage coral reef integrity within the vicinity. In addition, industrial related accidents/spillages coupled with illegal activities can impact significantly upon this sensitive marine environment especially in light of the ongoing and planned tourism and economic development proposals.

In 1997, the Aqaba Special Economic Zone Authority (ASEZA) established the Aqaba Marine Park (AMP). Its boundaries fall within the southern parts of the Jordanian coastline. In 2000, the Aqaba Marine Park By-Law No. 22 (2001) was issued. The establishment of the AMP was important in order to conserve the marine biodiversity resources of Aqaba. The AMP includes representative portions of Jordan's known marine biogeographic zones and supporting physical environments including some of the world's most unique coral reefs that are critical as a genetic reservoir. The AMP area is 2.8Km2 and it supports the conservation of around 3% of the Jordanian Territorial water.

In June 3rd, 2020, His Majesty King Abdulla II gave his directive to declare the AMP as a national Marine Reserve (referred herewith as the Aqaba Marine Reserve (AMR)). Based on this, ASEZA has initiated the process to declare the site (following generous support from the United Nations Development Program (UNDP)), and the process was conducted under the supervision from the Royal Hashemite Court, the Ministry of Environment (MoE) and steering committee members and the process was started through an official decision (made by the Board of Commissioners No. 38 (2020)) to declare the AMR. This process was ended with an official declaration of the AMR in December 2020 by the cabinet of Jordan.

As ASEZA is the autonomous manager, regulator and developer of the Aqaba Special Economic Zone (ASEZ), it has both the rights and the responsibilities to oversee the conservation of Aqaba's coast and marine resources. Most importantly, the vision and mission of ASEZA has puts in place the institutional framework for marine conservation. ASEZA, through its already established Environment Commission (which contains a specialized Beaches Administration Directorate) are tasked with the remit to

manage, enforce and develop the proposed AMR, using the existing Aqaba Marine Park Bylaw No. 22 (issued in 2001 in accordance with the ASEZA Law No. 32 of 2000) to help with regulation.

1.2 Purpose and Scope of Plan

This Aqaba Marine Reserve Management Plan (AMRMP) updates all previous plans produced for the AMP. The first Management Plan was developed in 2000 which was subsequently updated in 2013 to cover the period of 2014-2018 (funded under a UNDP project). The latter was published taking all stakeholders' interests and challenges into consideration.

This plan is designed to support and guide the immediate development and management over the next 5 years (2022-2026). It aims to optimize the management actions of the existing AMP Management Plan (2014-2018) to better address the current needs facing the AMR and the wider society in general, as well as to respond to modern environmental challenges facing the coastal zone of Jordan (under the wider responsibility of ASEZA).

It is designed to present an innovative management tool that solidifies the recognition of Aqaba as a socio-ecosystem, where successful conservation requires integrated management to protect the core marine biodiversity assets with the populated zones (rural and urban) of Aqaba. This includes acknowledging the capacity of ecosystems and their biodiversity to generate services, and contributing to the recovery of those components that have been altered primarily by anthropogenic causes (invasive species, habitat degradation and fragmentation, among others), in ways that guarantee a sustainable human presence and quality of life or good living.

The AMRMP (2022-2026) is based on a shared vision, agreed upon by local stakeholders, as follows: "***Aqaba Marine Reserve is a model of effective planning and management that ensures that the unique ecological values and associated social and economic benefits are used sustainably for future generations through active stakeholder stewardship***".

The AMRMP (2022-2026) differs from previous Management Plans produced for the AMP. This is because it rejects the paradigm of constant conflict between conservation and development and accepts that development in Aqaba is not possible without conservation and that effective conservation depends upon the development model being adopted by ASEZA. This approach makes it unnecessary to choose between conservation and development and instead, recognizes that the two are closely related. To this end, management of the AMR cannot be separated from management of unprotected areas (urban and rural zones), as many of the direct and indirect drivers of change originate from the more populated zones in Aqaba.

To address the management challenges facing the AMR, it is necessary to develop strategies specifically geared toward the conservation of marine ecosystems and their biodiversity. But management actions must also have a socioeconomic component. It is important to implement a development model that recognizes the dependence of Aqaba on natural ecosystems, and the fact that the resilience capacity of marine ecosystems has limits that must not be exceeded. This AMRMP (2022-2026) recognizes the authority of various entities operating in the ASEZ administrative area, and seeks greater coordination and collaboration to make the actions being proposed more effective.

The main areas of intervention of the AMRMP (2022-2026) are determined by five basic objectives, which correspond to the objectives of ASEZA. To achieve the objectives, an action strategy is developed which encompasses all of the proposed individual management programs.

Part Two: Current Status

2.1 Location

The AMR is located within the GoA, which is a semi-enclosed basin (Figure 2) located in the sub-tropical arid zone (28–29°30N; 34°30–35°E), and extends over a length of 180 km with a width between 5 and 25 km. The hills on either side of the GoA also rise steeply from the coastline. The 500 m contour on the west side of the GoA is generally within 5 km of the coast, and the east side within 7 km. Hills and mountains rise to over 1,700 m and which are bound by the Gulf of Suez on both sides. The 500 m contour line represents an average distance of 30 km from the coastline on the western side of the GoA, and within 25 km along the eastern coast. At some locations, isolated hills rise more steeply where the 500 m contour is positioned within 4–5 km of the coast.

Figure 2: semi-enclosed Gulf of Aqaba of Jordan[1]

Within the GoA, some areas of relatively narrow beach exist, although along most of the shoreline, a rockier (non-beach) appearance prevails. It consists of a series of embayment's that have in each a comparatively similar and wide range of intertidal/benthic communities and physical features including rocky shore, reef flat, reef face, fore reef, sandy shore, sandy bottom, and sea grass ecosystems. The southern half of the Jordanian coastline consists of a series of arcuate bays created by

[1] Copyright: JREDS

valleys between mountain outcrops. There are also flat terraces extending out to fringing reefs, rock platforms, cobble beaches, or 1,000 m high vertical cliffs. The head of the GoA, however, is low lying; only rising 2 m above sea level.

Figure 3 outlines the boundaries and UTM coordinates of the proposed AMR. These reflect those originally defined for the AMP. This AMRMP (2022-2026) hereby relates to activities falling within these boundary limits. The AMR extends over 7km in length from the Passenger Terminal in the north to the Royal Diving Club in the southern boundary limit of the AMR. The park's terrestrial boundary currently lies 50 m east of the Mean High-Water Mark (MHWM) and the marine boundary lying 350m west of the MHWM.

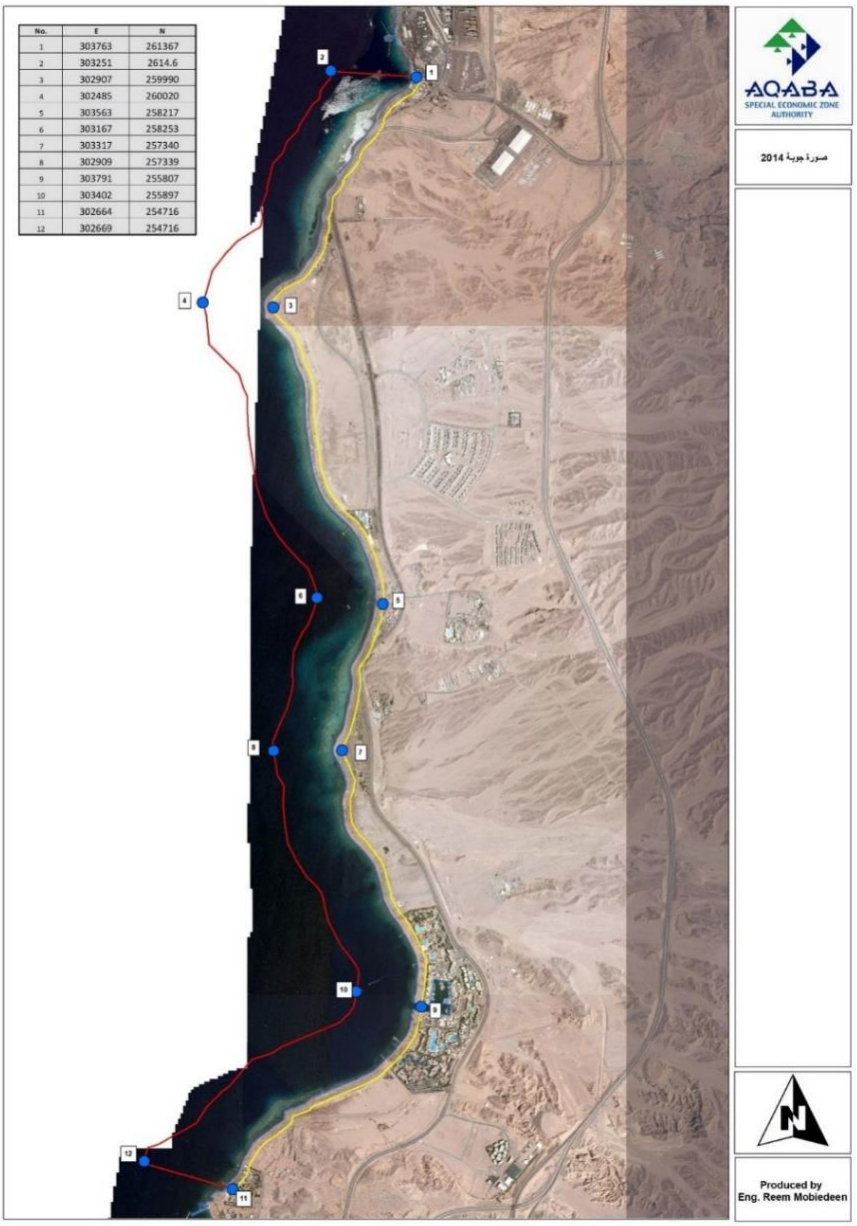


Figure 3: Aqaba Marine Reserve Boundaries with coordinates, Aqaba/ Jordan[2]

The size of the proposed AMR is appropriate to contain the different features which sustain (intact) the long-term conservation of its biodiversity. In addition, it represents part of an important national network of protected areas in Jordan, and therefore the establishment of this proposed AMR will positively and significantly contribute to protection of marine biodiversity within the wider Red Sea region and international marine protected areas in adjacent countries (Saudi Arabia, Egypt, Sudan etc) as well as being an important flyway for marine soaring birds.

2.2 Regional and International Context

The AMR represents an outstanding marine ecosystem that sustains intact ecological setup and interacting biological processes which in need of long-term conservation support for its unique diversity and endemism. It covers both shallow habitats and reef formations and deep-sea areas that are ecologically interacting by natural exchange. The semi-enclosed nature of the Gulf of Aqaba has tempered the drastic effects that may impact on the area, such as high waves, strong currents and known earthquakes (and hence possible tsunamis). Also, the relatively calm conditions in the area and the crystal clear waters have gracefully shown the colourful and beautiful life of the coral reefs. The occurrence of seagrass beds, and sand beaches has regulated nutrient and sediment input into these reef complexes.

Of importance regarding the significance and integrity of the marine ecosystems is the high resilience demonstrated by the coral reefs, which- to date - have been unaffected by bleaching and other effects of global warming. More specifically, this Jordanian coastline supports small yet important coral reef communities comprised of a discontinuous belt of fringing coral reefs with two different morphological reef units; the coral reef flat and the outer reef slope. This coral habitat is one of the most diverse high-latitude reef systems in the world. The coral reefs make a significant contribution to the economy of Jordan. The GoA and its coral reef could play a major role as a revenue earner for Jordan. The GoA holds valuable economic resources for pharmaceutical, recreational and tourist use, and for fisheries.

From a regional perspective, the GoA is part of a separate biogeographic zone within the wider Red Sea, and is of global significance in having the northern-most latitude reefs in the Western Indo-Pacific. Aqaba reefs also lie within this Red Sea biogeographic zone which is designated as a World Wide Fund for Nature (WWF) “Global 200 Eco-Region” on account of its unique marine biodiversity.

The AMR is distinctive and unique because of its high number of species, diverse number of habitats, high endemism, and remoteness. It is located in the North-Western Indo-Pacific biogeographic region that currently contains no World Heritage Site.

[2] ASEZA, 2020

2.3 National Context

2.3.1 Legal and Policy Framework

2.3.1.1 National Framework

The Government of Jordan (GoJ) has ratified the Convention on Biological Diversity (CBD) in 1993, which implies its commitments to the convention provisions. The CBD urged parties to establish a network of Protected Areas (PAs) in its specific conservation objectives highlighted in "**Article 8**" which require:

1. Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;
2. Develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken to conserve biological diversity;
3. Regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to ensuring their conservation and sustainable use;
4. Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas;
5. Cooperate in providing financial and other support for in-situ conservation, particularly to developing countries.

In addition, The Conference of Parties (CoP) of the CBD agreed in 2004 (Decision VII/5) that marine and coastal protected areas are an essential tool for the conservation and sustainable use of marine and coastal biodiversity. The CoP also agreed that a national framework of marine and coastal protected areas should include a range of levels of protection, encompassing both areas that allow sustainable uses and those that prohibit extractive uses (i.e., "no-take" areas). Therefore, declaring the proposed AMR is a requirement for the GoJ. Moreover, the establishment of AMR will also support the MoE to effectively implement the Nagoya Protocol, especially that a complete setup has been developed for this protocol in Jordan, including a bylaw, which is currently under ratification according to the legal mechanism in Jordan.

By declaring the AMR, the MoE will be capable to report to the CBD through the National Biodiversity Strategy and Action Plan (NBSAP), which aimed to define the status of biodiversity, the threats leading to its degradation and the strategies and priority actions to ensure its conservation and sustainable use within the framework of the socio-economic development of the country. In addition, it aims to mobilize the adequate financial resources for the management and conservation of biodiversity, developing the human resource base and strengthen institutional capacity for biodiversity conservation and management and improving public awareness and education.

Also, Aichi targets[3] will be achieved especially that the proposed AMR declaration will be mainstreamed into the five strategic goals. However, the AMR will directly be linked to[4]:

[3] https://www.cbd.int/sp/targets/
[4] Al Tawaha et al. 2019a

1. **Target 9**: By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.
2. **Target 10**: By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, to maintain their integrity and functioning.
3. **Target 11**: By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

In addition, through the establishment of the proposed AMR, the GoJ will be capable to comply with its requirements set in United Nations Framework Convention on Climate Change (UNFCCC), which Jordan is party with since 1994. The proposed AMR will also offer nature-based solution to support global efforts towards climate change adaptation and mitigation, and it will be a critical tool to maintain climate change resilience and rebuilding ecological and social resilience. In addition, the reserve will increase species survival by allowing them to move around and escape certain pressures. The sea is considered a major sink of carbon, which in consequence will help Jordan's government in carbon sequestration, carbon trade and to contribute to the production of the Jordanian National Adaptation Plan (NAP) as well as the National Determined Contributions (NDCs).

Jordan is committed to achieving the Sustainable Development Goals (SDGs) where the establishment of the proposed AMR will, in particular, support delivery of SDG14 ("Life under Water"). This SDGs aims to *"conserve and sustainably use the oceans, seas and marine resources for sustainable development"*. This is especially required in that the United Nations (UN) have stated that Jordan has, at present, achieved 0% of its SDG14[5]. In addition to improving on this SDG compliance percentage, the proposed AMR will also support Jordan's government to achieve SDG13 on Climate Change, which aims to *"take urgent action to combat climate change and its impacts"*. Moreover, the AMR will indirectly aid to achieve SDG3 (Good Health and Well-Being), SDG5 (Gender Equality) SDG8 (Decent Work and Economic Growth), SDG10 (Reduce Inequality), SDG15 (Life on Land) and SDG17 (Partnership for the Goals).

Additional conventions and Memorandum of Understandings (MOUs) will be achieved through the declaration of the proposed AMR including the effective implementation of the following:

1. Convention on International Trade in Endangered Species of Plants and Animals (CITES);
2. World Heritage Convention (WHC) - United Nations Educational, Scientific and Cultural Organization (UNESCO);
3. Jeddah Convention/ Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment;
4. Convention on Migratory Species;
5. International Convention for the Prevention of Pollution from Ships (MARPOL);
6. The London Convention;
7. The Reef Check Initiative in Jordan, where the MoE is the focal point.

[5] https://sustainabledevelopment.un.org/memberstates/jordan

2.3.1.2 ASEZA Specific Framework

The AMP establishment dates back to 1977, when the first proposal was made to conserve the area, which is located between the Marine Science Station (MSS) as its northern border and the coast guard to the south. The AMP contains three important and massive coral reef reserves, which were the key reasons behind proposing this site for conservation at this time. This proposal was further acknowledged by the recommendations of the International Union for the Conservation of Nature (IUCN) in 1992, and an earlier study, conducted by Mahasneh and Meinesz (1984), which highlights the necessity to follow the Aqaba Regional Authority (ARA) proposed boundaries after Ormond (1978). In 1997, an agreement was signed between the Global Environmental Facility (GEF) and the GoJ to establish the AMP, under the umbrella of the ARA. In the same year, decision number 5 was issued in July 1997 by the Board of Directors of ARA to announce the declaration of the AMP over a 7km shoreline length.

A request was sent to the MoE in June 10th 2020 to include the proposed AMR within Jordan's Network of Protected Areas (JNPAs). Accordingly, a letter was forwarded by the MoE in June 17th 2020 to the cabinet based on the Protected Areas and National Parks Bylaw No. 29, (2005) and the request was approved to add the proposed AMR within the JNPAs in August 18th 2020[6].

ASEZA is the autonomous manager, regulator and developer of the Aqaba Special Economic Zone (ASEZ). It has both the rights and the responsibilities to oversee the conservation of Aqaba's coast and marine resources. ASEZA was established in 2000 equipped with Law No. 32 of 2000 and was mandated to transform Aqaba into a world class Red Sea business hub and leisure destination. In addition, it aims at enhancing the quality of life and prosperity of the Aqaba community through sustainable development. ASEZA was mandated with a series of regulatory, administrative, fiscal and economic responsibilities.

The Environment Commission was established within ASEZA with a mandate "***to evaluate the state of the environment in the zone, develop the necessary regulations and procedures to protect the environment and to establish cooperation with the local community, national and international environmental organizations in order to protect and contribute to the sustainable development through finding the balance between investment requirements and the protection of the natural resources for the next generations***".

In order to achieve the mandates of the environmental commission, three main directorates were established which are the Environment Directorate, the Beaches Management Directorate and Ben Hayyan laboratory. The Environment Directorate is working towards achieving a vision "***to lead in the field of environmental protection and resource efficiency and seeking of environmental excellence in ASEZ***" and a mission to "***well protected environment supporting local sustainable community and economy***". This is addressed by policies such as:

1. Preventing pollution of the environment and sound managing of its resources;
2. Zero discharge to the sea;
3. Enhancing the local environment and improving its environmental performance.

[6] https://www.jordantimes.com/news/local/aqaba-marine-park-be-listed-first-marine-nature-reserve

In addition, the Directorate is supported by the Environmental Protection By-Law No. 21 for the Year 2001, issued under Articles (52) and (56) of the Aqaba Special Economic Zone Law No (32) for the Year 2000.This law addresses issues such as sea water usage, solid waste disposal, dangerous materials, radioactive materials, wastewater, and cooling water disposal. According to the law, no permits are granted to any establishment that produce and dispose solid wastes, except after the Responsible authority is able to check that the establishment has complied with environmental requirements prescribed for this purpose. It also has articles that deal with Environmental Impact Assessment (EIA), environmental auditing, protection of air, and protection of marine environment.

The second Directorate within ASEZA is the Beaches Administration Directorate. This was originally named the AMP Directorate, though as a result of institutional changes taking place within ASEZA, it was transformed into a "Section" (lower category) in 2015. A second change then occurred in 2017, where it was renamed the Beaches Administration Directorate. In spite of these changes, the Directorate remains governed by the Aqaba Marine Park bylaw No. 22 (2001) which is identified to govern the proposed AMR and from which shall define the perimeters of the AMP and its aims. It describes the formation and structure of the committee responsible for establishing the AMP's policies, requesting the preparation of annual administration plans, defining financial allocations necessary for the Park, issuing administrative, financial and technical instructions, and any other functions required. It also stipulates a number of prohibited actions and activities, which may result in the destruction, damage or deterioration of the natural environment of its wild life or affect the aesthetics of the area. Several instructions have been issued to aid the implementation of this bylaw including the followings:

1. **Instruction No. 82 for the year 2005**: Regulating of Conducting Scientific Research in AMP: This instruction organize the research and monitoring attempts which will be conducted within the AMP boundaries and set the steps and regulations for.
2. **Instruction No. 83 for the year 2005**: Regulating Entrance into AMP: This instruction organize cars entry to the park, tourists and sports activities within the park. This instruction prohibit all forms of fishing, including fishing coloured coral reef fishes. It also prohibits the transferring or taking any organisms, sediments, or corals for any purpose except by a special permit from the chief commissioner.
3. **Instruction No. 84 for the year 2005**: Regulating the Boats Function in AMP: This instruction organize boat entry to the park, what is prohibited, and what diving boats should do when they enter the park.
4. **Instruction No. 85 for the year 2005**: Regulating Diving in AMP: This instruction organize the diving within the AMP where all regulations related to licensing registrations, entrance point and illegal fishing activities which might be used during the diving is provided.
5. **Instruction No. 86 for the year 2005**: Regulating the Underwater Cleanup Dive in AMP: This instruction set the clean-up campaigns rules and procedures and how to perform these without threatening the marine life.
6. **Instruction No. 161 for the year 2014**: this instructions provide the needed framework to organize the marine sports at Aqaba including licensing, safety and precautions.

This bylaw, however, is in need or review and update to reflect the new objectives, vision and management programs being proposed within this AMRMP (2022-2026). This is addressed further in Section 5 of this AMRMP. In addition to the previously mentioned laws and bylaws, other legislative frameworks exists that contribute towards governing the marine park area, such as:

- **Instructions Numbers (g/1) for the year 2020**: Issued by the Minister of Agriculture under the Agriculture Law No (13) in 2015 for the Regulation of Fishing in Aqaba. These are the latest and detailed instructions and it was issued in order to organize fishing in Aqaba.

The third Directorate is the Ben Hayyan Laboratory, which is very specialized, working under a vision to ***"become a world-class centre of excellence, Promoting food safety and environment protection, contributing to better world by Improving the quality of life of people, and facilitating trade within ASEZ, Jordan and the wider region"***. In order to achieve this vision, the laboratory has set their mission through the creation of a state-of-the-art laboratory that will provide cost effective, reliable, and accredited analytical services to regulatory agencies and commercial enterprises; create training and research opportunities and establish working ties with peer institutions involved in food safety and environmental conservation.

In summary, the AMR will formally be governed by the Protected Areas and National Parks Bylaw No. 29 (2005), issued in reference to the environmental law No. 7 of 2016 that is implemented by the MoE. Details of a Memorandum of Understanding (MoU) between ASEZA and the MoE in order to facilitate cooperation, ensure data sharing, track the management plan implementation and monitor the protected area effectiveness are set out in Section 4.

2.3.2 Land Tenure

The AMR's land tenure follows the existing ASEZA master plan. Within that plan, it clearly states that all lands belong to the government represented by ASEZA. Private ownerships are limited to a number of parcels within the AMR area, however there are a number of illegal custody of land parcels by some people for agricultural purposes. The ASEZA plan sets a comprehensive vision that defines long-term development throughout the area with respect to land use, zoning, density, and design guidelines to simplify and streamline the planning approval process.

2.3.3 System of National Protected Areas

The cabinet has approved a network of protected areas to be established in Jordan, with an aim to conserve critical ecosystems and habitats and ensure the sustainability of their associated species. Marine Protected Areas however were not covered with this network, even though the AMP was declared by ASEZA. Following an internal review, the AMR is now proposed to be included within the Jordan National Protected Areas Network (JNPA).

This inclusion is critical as the importance of the AMR cannot be overemphasized. It is not only aesthetically spectacular, with its un-spoilt coastal landscapes and diverse seascapes, but it also supports high levels of biodiversity, including many endemic and endangered species. The AMR contains an array of habitat types, including extensive coral reef complexes, seagrass beds and intertidal and mudflat areas, which all enable the survival (breeding, feeding and resting) of significant populations of endangered sharks, manta rays and dolphins, not to mention numerous other fish and invertebrate species. In fact, the AMR encompasses a variety of fish and coral communities more usually separated by several hundred km. The Jordanian reefs are thus a vitally

important potential reservoir of reef species, and a natural laboratory for the study of climate change impacts on coral communities.

The AMR, as part of the JNPA network, will help to positively contribute to the marine conservation potential of the wider region, contributing towards the protection of key marine and terrestrial faunal diversity in the area which are considered, at least of significant proportion of its habitat, among the best representative of coral reef species (see Annex A). Undoubtedly, the AMR serves as a biodiversity 'hotspot' lying close to the centre of marine biodiversity in the Red Sea and boasting hard and soft coral fauna that is amongst the richest in the Region. Thriving on this rich reef ecosystem, over 200 fish species (including pelagic) inhabit the AMR and hosts significant populations of globally-important and endangered species, including: sharks, cetaceans, Napoleon Wrasse, grouper, and marine turtles. The AMR also acts as an important spawning ground for key fishery species as well as a larvae export area.

The key incentive for Jordan towards embracing and "selling" the importance of the AMR being part of the JNPA network is that the MoE may be able to convey to the Parties of the Convention on Biological Diversity that 100% of its coastal and marine areas are managed as conserved areas in support of Aichi Target 11 and Sustainable Development Goal 14. This would great enhance the value of the Aqaba brand internationally. In fact, a fully functioning and resources AMR, if managed properly, has several key elements, which can make it one of the most important contributors to Jordan's economy as follows:

- It is one of the nearest tropical seas to mainland Europe, which can attract many tourists due to the low travelling and accommodation costs.
- It embraces one of the most unique, fascinating and highly diverse coral reef communities. About 1000 species of fish, 150 species of reef building corals, 120 species of soft corals and 1000 species of molluscs, flourish in the GoA. Coral species in the Gulf represent about 40% of the maximum number of coral species found in any area of the Indo- Pacific (Jordan Country Study on Biological Diversity).
- The warm, clear and calm waters of Aqaba make it suitable for many aquatic sports, such as snorkeling, diving, water-skiing, wind surfing, boating etc.

2.3.4 Socio-Economic Context

2.3.4.1 Issues of Relevance

The resident population is growing rapidly in Jordan generally and at Aqaba city specifically, and is associated with an exponential increase in number of visitors to Aqaba where a total of 423,000 locals have visited Aqaba out of 931,000 tourist recorded in 2019. The population increase is associated to a number of factors including (but not limited) to the increasing demands over the limited resources available, increase solid waste creation, increase infrastructure along the limited coastline and the demands for more job creation. In addition, Aqaba is considered the only maritime in Jordan, and a major touristic destination, which resemble intense visitation rates which will overburden the limited resources. Aqaba therefore offers a unique tourist opportunity of which the coral reefs are an important component. Therefore whilst Aqaba is a primary tourist destination for local and foreign tourists, its potential has yet to be fulfilled.

Visitors to Aqaba enjoy water sports activities such as diving, which is considered a major industry at Aqaba with the presence of around 30 diving centers established so far. More than 80% of the diving sites are located within the boundaries of the proposed AMR. Snorkeling/swimming and diving are considered the cause the most damage to marine biodiversity within the proposed AMR.

In addition, the increasing user demands within the limited coastal area that Aqaba possesses will result in the demand for more beach front related tourist and housing related projects (to increase accommodation and leisure). The established (and future planned projects) are expected to increase pressure on available beach areas whilst also placing an increased emphasis on having to re-direct visitors (national and international) to those beaches that are currently managed by the AMP.

2.3.4.2 Primary Stakeholders

The following outlines the primary stakeholders to support delivery of this AMRMP (2022-2026).

ASEZA Commission of Environment

- Advisor for the Environment;
- Bin Hayan Laboratories.

ASEZA Beach Management Department:

- Aqaba Marine Park section;
- Southern beach.

ASEZA Environmental Department:

- EIA section;
- Green Economy section;
- Audit and Environmental research section;
- Enforcement and monitoring section;
- Outreach/Awareness section.

ASEZA Research and Planning Department:

- GIS section;
- Planning section;
- Land use section;
- Projects section.

ASEZA Supporting Departments:

- HR section/ training unit;
- Organization development department/ Knowledge management department;
- Department of Tourism;
- City Services Department.
- Northern beach section;

- Directorate of Works;
- Directorate of Tenders and Engineering Studies;
- Directorate of Financial Affairs;
- Directorate of Administrative Affairs.

Non ASEZA Stakeholders

- JREDS;
- RSCN;
- ADC;
- ACT;
- Rangers "Royal Department for Environmental Protection;
- Universities at Aqaba (University of Jordan, Al Balqa etc);
- Hotels and mega-projects;
- Diving centers/ Aqaba diving association;
- Fishermen's Associations;
- Glass boat operators;
- Jordan Navy;
- Jordan Maritime Authority;
- Aqaba Port Management and Operation Company / Prince Hamzah Pollution Control Center;
- Aqaba Port Marine Services Company.

More detail on the role and mandate of primary Aqaba stakeholders of relevance towards the implementation of this AMRMP (2022-2026) are shown in Table 3 below.

Table 3: Preliminary Stakeholder List and their Role towads delivering the AMRMP (2022-2026)

Stakeholders	Mandates of Primary Stakeholders (to help support the AMRMP (2022-2026)
The Aqaba Special Economic Zone Authority (ASEZA)	ASEZA, with representation from key ministries, has the power to plan and execute projects in the region. ASEZA is administered and supervised by a series of "Boards of Commissioners" which is composed of six full time minister level members, including the Chief Commissioner and the Vice Chief Commissioner. The 3 key Commissioners for ICZM related delivery are: • Environmental Regulation and Enforcement; • Land Infrastructure and Services; • Investment and Economic Development. ASEZA has absorbed into the Commission for Environmental Regulation and Enforcement a number of functions and mandates of relevance to the Marine Reserve Nomination File, notably:

	• Management and protection of the environment, water resources, natural resources and biological diversity within ASEZA. • The administration and regulation of the coastal areas in ASEZ including the Aqaba Marine Park. • The responsibility for ensuring ASEZAs sustainable development. With relation to seawater quality sampling, ASEZA sub contract all work currently to the Marine Science Station (MSS) and have done so since 1999. Monthly reports are produced that are presented yearly as an "Annual Environmental Appraisal of the Jordanian Coast". ASEZA promote a "Self-Monitoring" Program for new developments as recommended from specific Environmental Action Plans (from an EIA). For example, Tala Bay are monitoring currents and water quality every month which is over and above the needs of Blue Flag criteria for Marinas. The newly established ASEZA Tourism Division falls within the Investment and Economic Development Commission. Part of ASEZA is Ben Hayyan Aqaba International Laboratory which was established in 2007 under the EU funded Program "IS-ASEZA" to support ASEZA in guiding ASEZA towards becoming a dynamic and attractive engine of economic growth, enhancing public health and streamlining trade in the economic zone. There are currently approximately 40 staff employed which is likely to grow over time. Adhering to highest standards and best management practices, it shall provide technical services and studies as well as applied research in the fields of water quality assessment, wastewater and grey water management, water demand management and reclaimed water re-use. Its aim is to become internationally accredited (according to ISO 17025) by 2009 with accreditation sought from the Swedish Board for Accreditation and Conformity Assessment (SWEDAC).
Jordan Maritime Authority (JMA)	The role of the JMA is to regulate, control and develop the maritime sector in Jordan including all maritime transportation modes and labour force taking into account achieving the highest performance standards, the protection of the marine environment and enhancing the maritime safety and security. The JMA enjoys financial and administrative autonomy and is linked to the Minister of Transport and its main office in Aqaba. One of its core objectives is to contribute towards marine environment protection and boost maritime safety and security standards. Importantly, it does not however, see its role in providing beach safety, which should be the role of ASEZA (public) and hotels (private).
Aqaba Development Corporation	The Aqaba Development Corporation (ADC) was launched at the beginning of 2004 by ASEZA (The Aqaba Special Economic Zone Authority) and the Government of Jordan, as a new private sector corporation to be the central development body for ASEZ. Ownership of Jordan's ports, the city's international airport and strategic parcels of land as well as the development rights for these assets and key infrastructure and utilities has been transferred to ADC. ADC's objectives are to develop and manage these strategic assets of the zone to unlock and leverage value from this asset base. A key priority for ADC is to ensure that the 2001 – 2020 Master Plan for the zone is realized in a systematic way which maximizes the potential of Aqaba to reflect best commercial practice. ADC invest in all major sectors, including infrastructure, transport and logistics, trade and industry, property and real estate, tourism, and education in a manner that is consistent with

	ADC's mandate and the vision of the Aqaba Special Economic Zone (ASEZ). Of relevance to Blue Flag development in Aqaba, two recent real estate contracts have been signed for beach parks (Pranice Beach Development and Al Qabas Beach Park).
Hotels and Real Estate Developments	The main private sector stakeholders concerned with the coastal zone include the following: • Movenpick Hotel (Northern beach frontage); • InterContinental Hotel (Northern beach frontage); • Saraya Development (Northern beach - new lagoon development); • Ayla Oasis Lagoon Company (Northern beach - new lagoon development); • Tala Bay Development (Southern Beach - marina and tourist/residential development); • Pranice Beach Development; Currently, all private hotels or developments with a beach will sign a Management Contract with ASEZA to manage the beach. This clearly states that all beaches are, and always will be State owned (through ASEZA), and so the public should be able to access beaches.
The Royal Marine Conservation Society of Jordan (JREDS)	The Royal Marine Conservation Society of Jordan (formerly known as the Jordan Royal Ecological Diving Society (JREDS)) began in 1993 with a mission to protect Aqaba's marine life from further degradation. On August 8, 1995, JREDS registered with the Ministry of Interior as the first and only Jordanian non-profit, non-governmental organization dedicated to preserving and protecting the marine environment in the Kingdom. JREDS aims at the conservation, rehabilitation and enhancement of the marine eco-system in Jordan through grass roots participation, promoting sustainable management of natural marine recourses, lobbying, awareness generation and the development of technical capabilities. JREDS assist in develop certain actions within the Aqaba Marine Park, though there is no formal MoU established between them to assist in specific activities (and to help the Park Rangers to free their time so their enforcement commitments can be achieved).
The University of Jordan	The University of Jordan in Aqaba is located in a distinguished place on the road to King Hussein International Airport on the northern side of the city, and on the main road linking Aqaba to Dead Sea leading to Amman and the northern cities of Jordan which continue to lead the way to Syria, Lebanon, Turkey, and Iraq. Also, The University of Jordan in Aqaba is located on the road that links the city to Saudi Arabia, and runs along the southern region of the city of Aqaba. Part of the University of Jordan is the Marine Science Station (MSS) which was established in 1974 as the only research station in Jordan dealing with the Marine environment. Currently there are 8 PhD researchers working on a range of topics areas. MSS is seeking to introduce marine environmental studies into the Jordanian curriculum. Currently the marine life gallery and long history of scientific research has attracted many visitors and tourists.
Royal Jordanian Navy	The Royal Jordanian Navy is naval warfare branch of the Armed Forces of the Kingdom of Jordan. The naval element of the armed forces, although designated the Royal Jordanian Navy, remained an integral part of the army. Performing essentially a coast guard mission, in 1988 it had 300 officers and men based at Aqaba,

	the country's only port, with access to the Red Sea. The navy assisted in the maintenance of harbor security, operating in conjunction with customs and immigration personnel to ensure the enforcement of the country's laws and regulations.
Royal Department for the Environmental protection and Tourism	The Royal Department for Environment Protection and Tourism (RDEPT) was formed after merging two main department of the Public Security Department (PSD) in March 2020, which are the Royal Department for Environment Protection (RDEP) and the Tourism Police (TP). The RDEP was originally established in June 2006, after direct instructions by His Majesty King Abdullah II Ibn Al-Hussein. Since its establishment, the RDEPT has adopted a clear strategic approach to combat environmental violations, achieve environmental protection, and preserve the Jordanian environment in a sustainable manner. For that, the RDEPT keeps an up-to-date implementation of the best international practices, and a follow-up mechanism to the evolution of the various violations toward the environmental components. The department was mainly established to be the enforcement arm of the Ministry of Environment and aid the existing efforts that aims to protect ecosystems, soil, air and water elements.
Ministry of Environment	The vision of the Ministry of Environment has evolved with a focus on the institutional dimension by an emphasis towards establishing a distinguished ministry that has the means of institutional structure that is based on comprehensive excellence standards. The Ministry aspires to achieve the highest levels of effectiveness, creativeness and competences in implementing its activities and achieving its objectives. That can be achieved through the ministry's core role in protecting the environment and maintaining all of its components including air, water, soil and ecosystems and its sustainability. In a way that lines completely with Royal orientations in this field, and in line with the national directions and strategic priorities regarding the environment sector that is documented in the Jordan 2025 vision, in order to reach the ambition and dream of providing better life for everyone on the Jordanian lands.
Ministry of Agricultural	The Ministry of Agriculture is responsible for the agricultural sector, promoting self-sufficiency and rural development and linking the production to the requirements of the markets inside and outside Jordan. It also aims to promote plant production, control plant pests, preserve forests and pastures, and also regulate the establishment of breeding farms or livestock holdings, poultry farms, fish farms, amphibians, fishing, beekeeping, animal health and veterinary quarantine, as well as the role of the Ministry in the protection of wild birds and wild animals.
Aqaba Company for Port Operations and Management	Aqaba Port Authority was established in 1952 by a royal decree and took its present name (Aqaba Ports Corporation, APC) in 1978. APC is a governmental body with an independent character responsible for establishing, developing, maintaining and operating port activities (receiving of ships, handling and storing cargo). The Prince Hamzah Marine Oil Spill Combat Center was established in 1996 as a section within the Aqaba Company for Ports Operation & Management (Ports Corporation at that time) - as a response for the global and national trend to preserve the marine environment and protect the biodiversity - in order to deal with cases of oil spills at sea (upper gulf of Aqaba), therefore the center was equipped with the necessary equipment to perform this role in terms of boats dedicated to combating marine pollution, oil skimmers, oil booms, various absorbent materials as well as a set of support equipment (pumps, generators, searchlights,

	transportation, …), The center also coordinates and exchanges experiences with the relevant authorities and bodies at the local, regional and global levels.
Aqaba Diving Association	The Aqaba Diving Association is a Jordanian NGO whose main mission is to develop the scuba diving industry and support local diving businesses.
Fishermen Associations at Aqaba	Fishermen's are considered an important group at Aqaba since they are practicing fishing since long time ago and fishing is considered as a tradition. Two cooperatives exist at Aqaba and are considered a key stakeholder

2.3.5 Management and Organizational Background

As ASEZA is the autonomous manager, regulator and developer of the Aqaba Special Economic Zone (ASEZ), it has both the rights and the responsibilities to oversee the conservation of Aqaba's coast and marine resources. Most importantly, the vision and mission of ASEZA has puts in place the institutional framework for marine conservation. ASEZA has also established an Environment Commission, which contains a specialized Beaches Administration Directorate where part of their tasks is to manage, enforce and develop the proposed AMR (Figure 4).

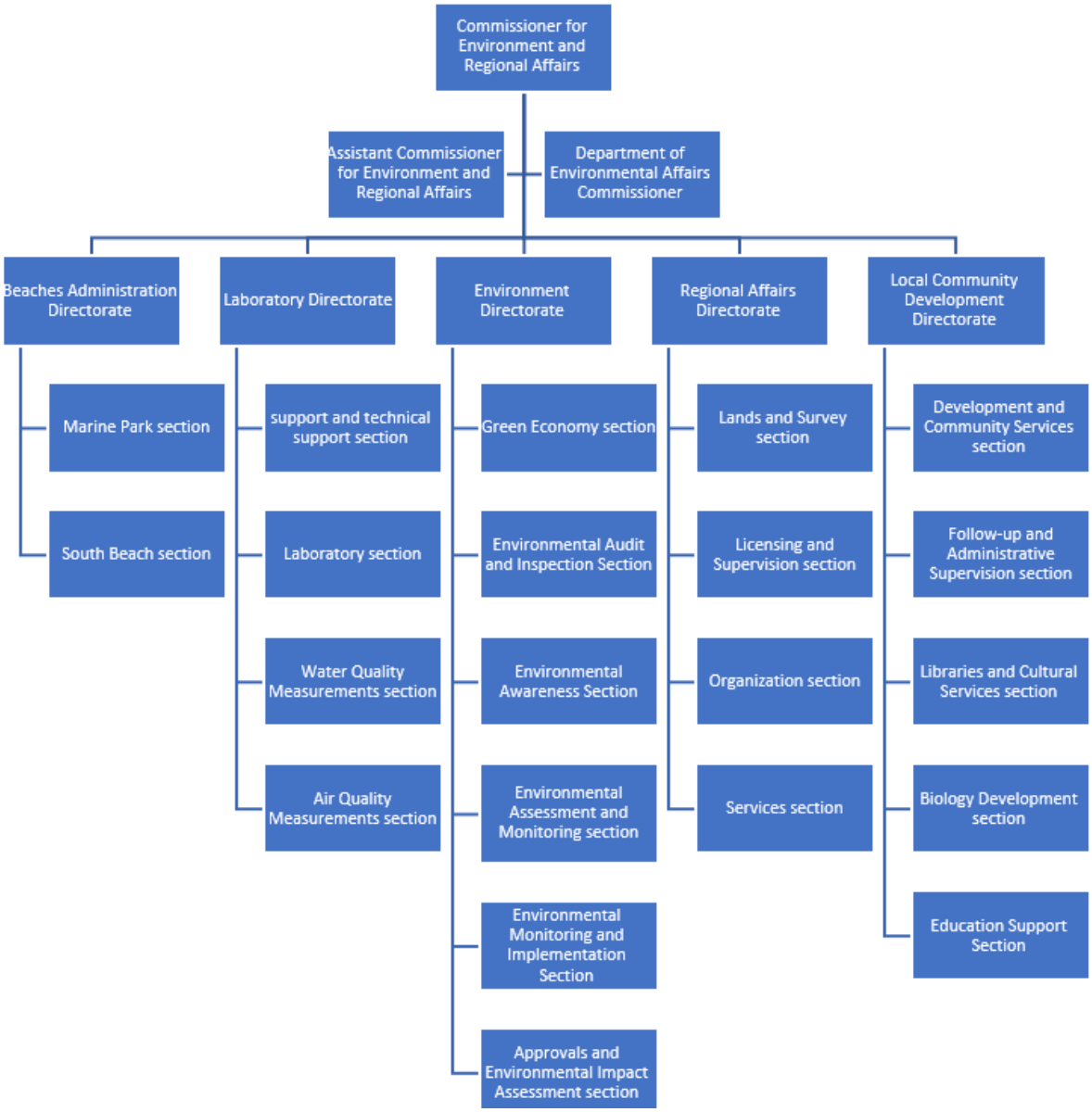


Figure 4: Organogram of the Commissioner for Environment and Regional Affairs[7].

Currently, a total of 26 staff members are recruited for the AMP, divided into the following management categories:

1. Management (1);
2. Administration (4);
3. Rangers (10);
4. Gardening and maintenance (8);
5. Technical staff (1);
6. Drivers (2).

[7] ASEZA, 2020

The staff of the AMP are currently responsible for a range of tasks including the following key functions:

1. Issuance of annual permits and monitoring of the activities of glass-boats and recreational boats;
2. Issuance annual permits and monitoring of the activities of dive centers;
3. Issuance annual permits and monitoring of the activities of fishing, (bait collection and commercial fishing licenses);
4. Routine clean up dives for the collection of trash underwater around the Park;
5. Acting as life guards in light of the considerable needs to ensure minimum safety measures within the public beach;
6. Surveillance of the public beach especially with regards to compliance of visitors to trash collection and management of the Park's facilities.
7. Rehabilitation and restoration of degraded ecosystems

When transitioned to being the AMR, it will formally be governed by the Protected Areas and National Parks Bylaw No. 29 (2005), issued in reference to the environmental law No. 7 of 2016 that is implemented by the MoE. Of note, the current AMP regulation calls upon a special committee known as the "Aqaba Marine Park Committee" to administer the Park, under the Chairmanship of the Commissioner and the membership of the Park's Manager, the Vice Chairman and three Members appointed by the Chief Commissioner upon the Commissioner's recommendation. This function is, however, not being implemented and prevents the Park from fulfilling its role and adopting the necessary decision making process for strategic management of the Park.

2.4 Physical Environment of the Marine Reserve

2.4.1 Geology of the Gulf and Reefs Formation

The GoA is part of the Wadi Araba – Dead Sea Rift Zone that in turn is a segment of the major geo-structure extending from East Africa to South Turkey with 6,000 km length. Accordingly, tectonics and evolution of this rift graben system have had an important bearing on the regional structure of the rocks exposed in the study area[8]. Faults are the main tectonic features in the area and are restricted to the basement complex. They vary in length from a few tens of meters to a few tens of km. Most of them strike N-S, NE-SW and E-W[9]which is the main cause for the presence of the majority of wadis that trend in an east to west direction, and bringing weathering products to the low-lying areas, where they then form alluvial fans[10]. The area of the proposed marine reserve is a Precambrian granitic rock that is partly covered by quaternary alluvial and shore deposits consisting of gravel sand and clay beds of up to 100 m thickness[11]. In addition, the alluvial fans (comprising of wadi sediments) exist as key geological formations within the proposed AMR area[12] (Figure 3).

[8] Bender, 1968
[9] Ikhlas et al. 2016
[10] SOCER 2015
[11] Bender 1968; Farajat 2002
[12] Ikhlas et al. 2016

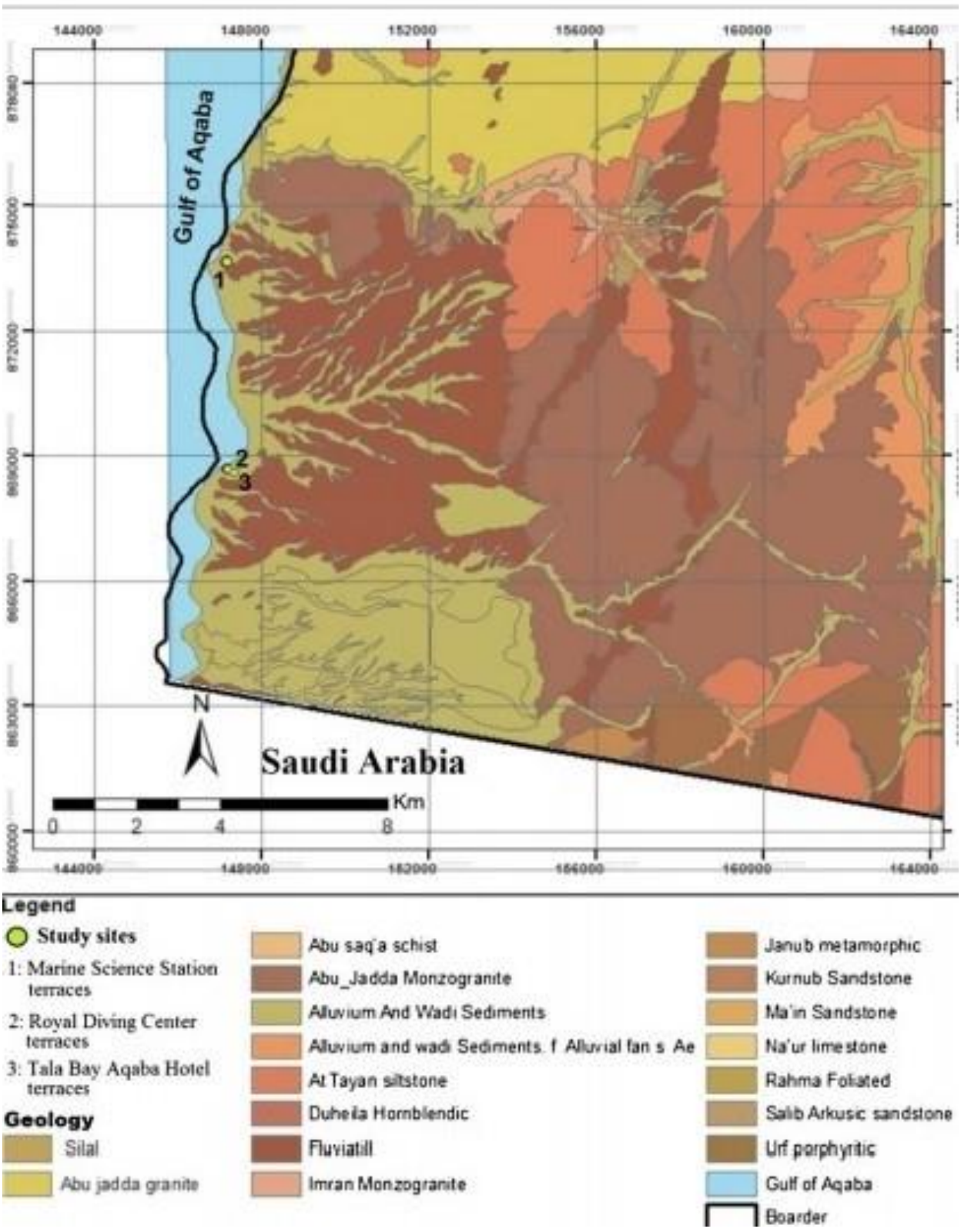


Figure 3: Geology of the proposed AMR site[13].

[13] Source: Ikhlas et al., 2016

Coral reefs were formed within the Jordan GoA during the middle of the Pleistocene epoch (circa 781,000 to 126,000 years ago). Since then, reef-building organisms have repeatedly recolonized and built reefs during each subsequent sea level rise episode, which is marked by a thin and narrow biogenic pavement of less than 5 mm, on the reef flat or more frequently on the outer slope of an older reef uplifted during episodes of tectonic activity. The stability of the coral reef morphological characteristics within the GoA of Jordan, (since the middle Pleistocene epoch) suggests that their evolution is controlled by both geological and ecological factors. Moreover, the topography and the absence of a continental shelf coupled with the very steep inclination of submarine slopes, has played a major role in limiting the seaward extension of coral built formations[14].

2.2.2 Bathymetry

A unique feature of the GoA is its great depth in proportion to its width, where the deepest point reaches 1825 m with an average depth of 800 m. The continental slopes are also among the steepest in the world whilst the walls of the GoA are very steep, with the normal gradient ranging from 60 to 70 percent. The bathymetry is influenced by three deep elongated basins, each separated from each other by relatively low sills[15]. Figure 4 illustrates the bathymetry of the GoA.

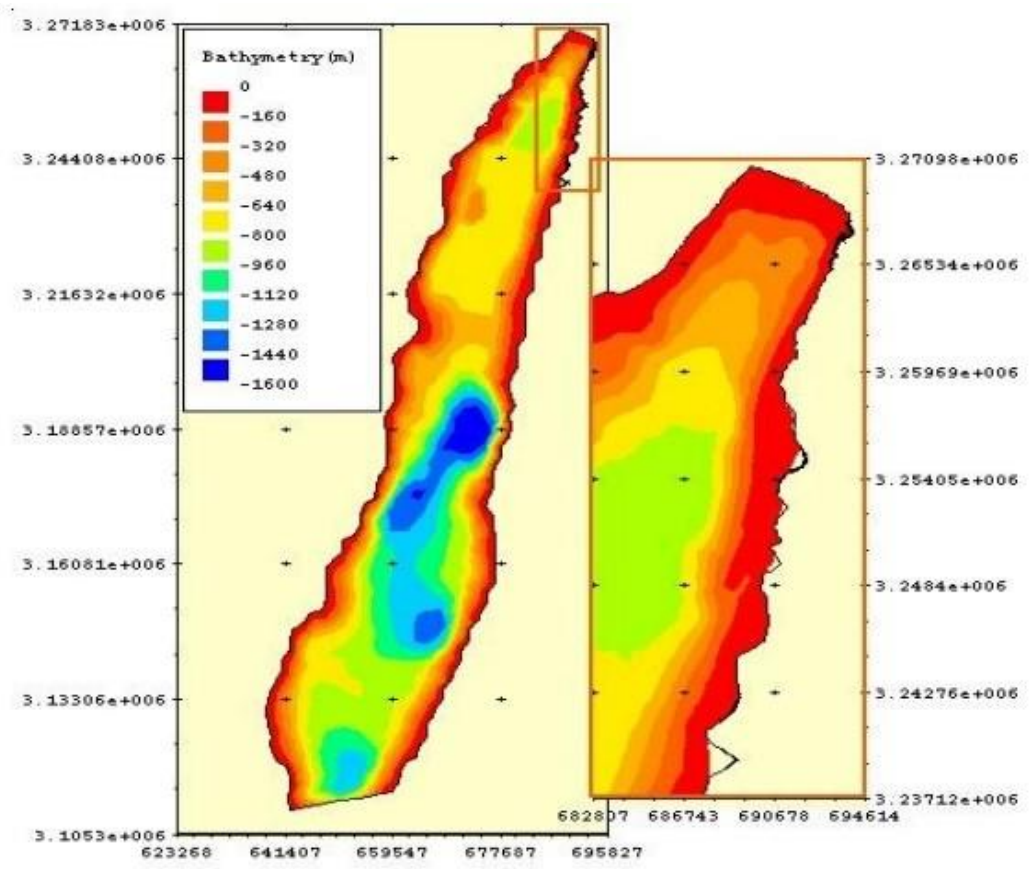


Figure 4: The bathymetry at the Gulf of Aqaba[16]

[14] Bouchon et al. 1981
[15] UNDP, 2015
[16] Source: UNDP, 2015

The bathymetric area at Aqaba is split into three sectors[17] and as follows:

1. The southern sector (Aqaba/Eilat) Deep, which is most relevant to this proposed AMR, and is characterized by steep slopes. These scarp-like features extend almost to the basin floor. Along these southern beaches (including within the AMP), there is a narrow fringing reef area of circa 50m which then shelves off steeply to -20m depth.
2. The western slope, which has a slope angle of 17.5º, is steeper than the eastern slope (which possesses a slope angle of 14.0º). The western slope changes its slope angle abruptly and is inclined much more gently (5.7– 6.4º)
3. The eastern sector with two obvious dominant features, namely a linear ridge-like structure trends sub parallel to the strike of the Gulf, and, further north, a "cone" is evident as demonstrated by the bathymetric data.

2.2.3 Soils and Sediments

2.2.3.1 Sediment Characteristics

Sediments within the proposed AMR area are mainly black reflecting the mineralogy of the surrounding geology, (i.e. high calcium carbonate content give whiter sediment colours). No distinctive smell can be detected, indicating well-oxygenated sediments. Surface sediments have similar textural composition whilst the main grain size diameter ranges between 1.4 to 1.7 ø mm and are classified as medium sand. They are often moderately sorted with low mud contents ranging between 0.16 - 0.5 %[18]. Low calcium carbonate (CaCO3) and organic carbon concentrations are found within sediments in Aqaba, ranging from 3-10% and between 0.01-0.17 % for CaCO3 and O.C, respectively[19].

2.2.3.2 Alluvial Fans

Alluvial fans are divided into two zones; active and inactive. The active zones are those where recent floods flow. They are less elevated than the inactive zones, which are about one meter higher in elevation. About 18 alluvial fans clearly exist, their extent ranges from 30 km^2 to less than 1 km^2. The length of the vertical axes range from 0.6 to 5 km, while the widths range from less than 1 km to 7 km. Coastal wadis deposit terrestrial sediments on land forming alluvial fans, the remainder flows to the sea to form small deltas. The minimal age of the alluvial fans that occur within the proposed AMR is more than 20,000 years ago[20].

Coarser rocks and gravel are deposited near the mouth of the canyon, often near the apex of these fans where coarser material can also be found in and along the main channel beds further down the fan from the apex. Intense fluvial erosion of the Aqaba granites (inland) has produced extensive alluvial fans, which fill the wadis and mantle the lower hill slopes. As the distance from the head of the fan increases, the size of the materials continues to decrease, from rocks and gravel, to small gravel and sand, and finally to fine sands and silts where the active wadi deposits are found in the lowest part of the wadi profiles. Their sediments are mainly derived from the granite weathering products, especially in the southern part where Pleistocene gravels prevail[21].

[17] Ehrhardta et al. 2005
[18] ECO Consult 2006
[19] SOCER 2015
[20] Ikhlas et al., 2016
[21] UNDP, 2015

2.2.3.3 Beach Composition and Classification

The major sources of sand for these beaches being the sediments carried from adjacent beaches by longshore currents, the sediments produced as a result of the scouring of waves at the base of the alluvial fans, and the sediments carried by flash floods during the rainy season. These southern areas are also made up of a series of capes and embayment. The wide bays are generally located at the mouth of a wadi outlet separated by narrow capes. A wide reef flat commonly protects the sandy beaches offshore, while beaches lined offshore by patch reefs are made up of pebble to cobble size lag sediments.

The sandy stretches along the southern coast are quite patchy with beachrock being exposed along most of the shoreline of Aqaba's southern stretch, forming 1–3m wide strips along the shoreline (Figure 5). These beachfront features are cemented by calcium carbonate, the clasts of which it is comprised are similar to the present-day loose beach sediments varying in size from millimeter scale to a few centimeters. Numerous uplifted fossil reefs are also unique to this southern part of the GoA and are exposed close to the southern shores of the Gulf. These Pleistocene reef features formed during sea level high stands and reached their present position as a result of sea level fluctuations and tectonic uplift[22].

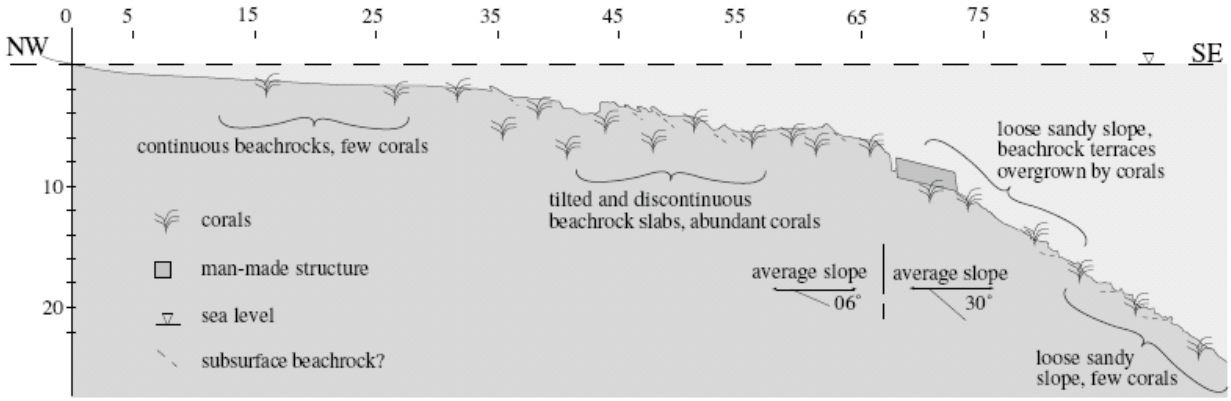


Figure 5: Indicative Aqaba cross section showing the transition from low angle slope of beach rock at shallow- depth to a high angle slope with outcropping beach rock slabs at greater depth[23].

With regard to beach, sediments found along the southern beaches in Aqaba are of two types:

1. Marine sediments ($CaCO_3$) derived from offshore;
2. Wadi or flood related siliciclastic (quartz) sediments derived from the hinterland.

Towards the northern boundary of the existing AMP (South Beach area), the beach composition changes with finer grained materials being washed offshore, and larger stones and reef blocks making up a higher percentage of the beach intertidal area.

[22] Al-Rifaiy and Cherif, 1988
[23] Shaked et al 2002

The exposed beach-rocks that are seen along the southern beaches are found only where the overlying sediments have been removed by coastal erosion. It is clear that along southern beaches, there is a negligible sediment supply onto beaches, meaning that beach building sands are in small quantity and never likely to be in enough volume to enable attractive beaches for recreational purposes. Coupled with this, the lack of beach sand to cover the foreshore beach rock presents a serious safety and visitor hazard for bathers and swimmers.

2.2.4 Physical Oceanography

2.2.4.1 Sea Level

Sea level in the northern part of the GoA fluctuates during the year by up to one meter. The level increases between Decembers through May though reduces during the period of July through October. The difference is reportedly due to the influence of monsoon winds in the Indian Ocean, which, in the winter results in a net flow of water from the Indian Ocean to the Red Sea and the GoA and vice versa in the summer months. Other factors that influence tidal levels include a decrease of water volume due to intensive evaporation from the sea surface, and the variation of a positive component of water exchange through Bab el Mandeb and Suez Canal.

The maximum sea level range reference to global Mean Sea Level (MSL) during the year 2013 was 154.3 cm, where the highest value reported at 101.7 cm observed in December 12th, and the lowest value was -52.6 cm recorded on April 23rd. The sea level anomalies mostly depict a clear yearly cycle (Table 1), where the lowest monthly mean anomaly (5.0 cm) occurs in June. The highest monthly mean anomaly was 47.4 cm that is experiences in November[24].

Table 1: Annual mean of the sea level (cm) at the northern GoA reference to Global Mean Sea Level (MSL) and to Multi-Annual Mean (MAM) for the years 2004-201325.

Annual mean of the sea Level (cm)			
year	Ref: Global MSL I	Ref: MAM2*	Differnece:1-2
2004	16.4	-10.4	26.8
2005	16.8	-10.1	26.9
2006	15.6	-14.4	29.0
2007	0.5	-27.9	28.4
2008	8.9	-19.8	28.7
2009	5.2	-23.3	28.5
2010	7.2	-21.5	28.7
2011	-11.7	-39.7	28.0
2012	4.1	-24.4	28.5

[24] National Monitoring Program 2013
[25] National Monitoring Program 2013

2013	16	-21.9	28.9

*: Multi - Annual mean (MAM) Was calculated for 10 years (2004 - 2013)

2.2.4.2 Exchange of Water

The GoA has a low rate of water exchange with that of the Red Sea due to the presence of narrow and shallow passage of Straits of Tiran[26]. Water residency time of water at the GoA can exceed two years in the upper depths of the Gulf and three years in the lower depths[27]. In terms of the southern shoreline section of Aqaba, longshore tidal currents are very small and occur in both easterly and westerly directions.

2.2.4.3 Waves

Within the GoA, wind direction is the main driver of wave heights and directions in Aqaba, where the main winds are directed from north, and thus the predominant wave direction is from the north. In addition, the distance from the land upwind drives the heights of sea waves, or the fetch, generally increasing in height the further the wind blows from the land. During the winter months, wind generated waves and swell in the northern Red Sea, as far south as 20°N, are normally less than 2 m in height from the North-North-West, but occasionally reach heights of over 2 m. During the south-west monsoon period in the summer months, the situation within the proposed AMR area remains similar to these observations, with wind and swell waves from the north-north- west, generally less than 2 m in height[28].

2.2.4.4 Tides

A very limited tidal range is experienced within the GoA. A range of one meter or less most commonly is experienced (locally known as "Azzyab") [2930], where semidiurnal tides occurs with two high and two low tides every 24 hours. Tides in the northern GoA showed a maximum sea level range of 1.42 m during 2004 with the highest value reported being 0.94 m above MSL (in November 2004) whereas the lowest was -0.48 m below MSL recorded in August 2004. Table 2 below illustrates the tidal characteristics at Aqaba ports.

Table 2: Tidal characteristics at the Aqaba Ports31

Datum	Elevation (LAT, Meters)
Highest Astronomical Tide (HAT)	1.5+
Mean high water springs	+1.10 (MHWS)
Mean low water springs	+.030 (MLWS)

[26] UNDP, 2015
[27] ISPAN, 1992
[28] UNDP 2015
[29] Al Tawaha et al. 2019
[30] UNDP, 2015
[31] ADC 2008/ National Imagery and Mapping Agency, 2002

Mean high water neaps (WHWN)	+0.90
Mean low water neaps (WHWN)	+0.50
Mean sea level (MSL)	+0.70
Lowest astronomical level tide (LAT)	+0.00

Of interest to this Nomination File, low summer tides are noteworthy with respect to the thermal stress in inter-tidal/ shallow water corals. Extremely low tides occur in the upper GoA during which the reef flat and part of the shallow lagoon may be uncovered for up to 20 minutes each low tide over a maximum period of two days on rare occasions. Despite these extreme low tides, most of the colonies are able to regenerate after exposure if parts of the living tissue remain intact onto the reef skeleton[32].

2.2.4.5 Currents

. Currents at the northern GoA do possess some consistent seasonal trends, although they are quite variable in direction. Southerly currents along the western coast are mostly observed throughout the year, with a short period (November-January) of northward flow and a reversal in early February, when the water column is vertically mixed and a clear onshore (westward) current is observed near the surface and a return (offshore) current over the bottom. This cross-shore pattern is consistent with a wind-driven Ekman circulation[33].

The currents within the proposed AMR area, are therefore classified as being relatively weak (< 5 cms-1) and the dominant direction is in a southeast direction, parallel to the predominant wind direction. Currents are, however, stronger at the surface (average of 10.3 ± 9.0 cms-1 at 2 m depth) than at depth (at 4-26 m depth, the average speeds are 2.1 ± 1.4 cms-1). The average direction of the current recorded at 2 m and between 4-26 m depth is 246 ± 83°N and 153 ± 82°N, respectively. This indicates that the surface current is five times stronger than subsurface current and the current direction is generally parallel to the wind direction[34]. Due to the current directions, it makes the GoA vulnerable to the effects of pollution low rates of exchange, combined with high rate of evaporation mean that introduced pollutants can affect the Gulf for long periods of time[35].

2.2.5 Chemical Oceanography

2.2.5.1 Temperature

Sea surface temperatures in the GoA range from winter lows of 20.5°C (February) to highs in late summer (September) of over 27°C. During the summer months, the GoA is thermally stratified and a strong thermocline exists, with seawater temperatures below a depth of approximately 200 m remaining a constant 21.5°C. As sea surface temperatures fall in the winter, the thermocline collapses and mixing between the upper and lower layers of seawater occurs[36].

[32] Fishelson 1973
[33] Berman 2000; Genin & Paldor 1998
[34] UNDP 2015
[35] UNDP 2015
[36] UNDP 2015

2.2.5.2 Salinity

Salinity within the GoA ranges from 40.3 to 41.6 psu (practical salinity units) compared to an ocean's average salinity of 35 g/l. Vertical salinity differences are very small between 50-150 m. In general, the eastern side of the Gulf is less saline, most likely due to the influx of lower salinity waters from the Red Sea[37]. The lack of regular freshwater input and the high evaporation rate contribute heavily to the particularly saline conditions within the GoA.

At depths greater than 200 m within the deep basins, the salinity is remarkably homogeneous at 40.6‰, with the exception of the hot brines[38], which emerge from the sea floor in areas with an active seafloor rift and are characterized by very high salinity and high temperatures. It occurs at depths of more than 2,000 m where water temperatures can reach up to 60°C and salinity exceeds 300‰[39].

2.2.5.3 Dissolved Oxygen

Dissolved Oxygen (DO) is typically high in the northern Red Sea including the GoA, and its concentrations in surface waters are lower in summer than winter due to higher temperatures and salinity[40]. Several factors affects the concentrations of dissolved oxygen (DO) in the Red Sea including the horizontal and vertical water circulation, water temperature, and salinity[41]. The DO levels are near saturation (i.e. 4.8–6.5 ml O2 L^{-1}) in surface waters in most of the Red Sea and Gulf of Aden[42]. In the GoA there is a gradual decline with depth but never below 50% of oxygen saturation[43].

2.2.5.4 pH

pH is considered one of the most important parameters to measure seawater acidity. Records of pH appear to fluctuate around 8.3 with very minor variations, which is typical for all coral reef waters[44]. This is because these waters are always saturated with calcium carbonate, which acts as a buffer and resists any change in the pH.

2.2.5.5 Primary Productivity

The waters of the GoA are typical oceanic oligotrophic waters and visually are thus exceptionally clear. This high transparency is related in part to the absence of major terrestrial river/stream inputs flowing into the sea[45] meaning that the euphotic zone is

[37] ECO Consult 2006; UNDP, 2015
[38] Morcos 1970; Degens & Ross 1969
[39] SOCER 2015
[40] Poisson et al. 1984
[41] UNDP, 2015
[42] Sheppard et al. 1992; Quadfasel and Baudner 1993
[43] SOCER 2015
[44] MSS Data, 2010; Sorkin, 1995
[45] Al Tawaha et al. 2019

deeper that most seas, extending to 77–105 m within the GoA[46]. The input of terrigenous nutrients is therefore limited to sporadic dust (not flood related) events[47].

During the winter season, nutrients concentrations in the whole water body of the GoA increase due to mixing and stratification related events or situations. At the beginning of summer light intensity increases, which enhances primary productivity and subsequently consumes the excess of nutrients which results from winter mixing condition. Therefore, during summer the concentrations of nutrients are generally very low. These recordings may be impacted upon by anthropogenic activities, which may increase nutrient concentration through either tourist or industrial interventions.

Primary productivity throughout the GoA is low, relative to other seas/oceans, due to the thermocline preventing the recycling of nutrients from deeper water to the euphotic zone. Table 3 shows the seasonal spatial variation that is experienced throughout the GoA.

Table 3: Annual average primary productivity (g carbon m-2 d-1) in the Red Sea48.

Location	Primary Productivity g carbon m-2 d-1
Gulf of Aqaba	0.2-0.9
Gulf of Suez	0.22
Northern Red Sea	0.21 - 0.50
Central Red Sea	0.39
Southern Red Sea	1.60
Gulf of Aqaba	1.60

Seasonal peaks of chlorophyll in the northern GoA occur in spring over the period of February to May, when surface water concentrations reach 0.4 mg chlorophyll a m^{-3}. Significant primary production occurs at 200 m within the GoA due to high water transparency[49].

2.3 Biotic Characteristics

2.3.1 Biological Oceanography

2.3.1.1 Zooplankton

The distribution of zooplankton biomass within the GoA is fairly homogeneous. Generally, there are several environmental factors might disturb zooplankton production in the proposed AMR area directly and/or through other regions[50] such as;

[46] Stambler 2005
[47] Sheppard et al. 1992
[48] Sheppard et al. 1992
[49] Sheppard et al. 1992
[50] Aoki et al., 1999

1. Air pressure, which may affect zooplankton biomass as lower air;
2. Pressure, which can lead to a higher zooplankton biomass[51]. The disturbance of sea surface layer by low air pressure causes vertical mixing and subsequent nutrient enrichment;
3. Currents, which have different respective effects on zooplankton abundance and distributions within the proposed AMR area[52]. It is possible that the water is subject to a positive effect when it shifts northeastward.

The zooplankton community (> 150µm) within the GoA includes the presence of 73 species (45 genera) within 10 taxa namely; Tintinnidea, Foraminifera, Trachymedusea, Thecosomata, Cladocera, Ostracoda, Copepoda, Malacostraca, Chaetognatha and Urochordata. The most abundant zooplankton form is the holoplanktonic which constitutes 91.5%, and they are mainly Copepoda and Chaetognatha, which together comprise more than 90% of the total zooplankton. Copepods alone contribute 87% of the total zooplankton abundance[53]. Most copepod species are epipelagic, with seven species found in the GoA; which include *Paracalanus indicus, Calocalanus clausi, Phaenna spinifera, Clausocalanus ferrani, Calanua robstior, Euchirella messinensis, Candacia tenuimana*, and *Corycaeus subullatus*[54].

2.3.1.2 Chlorophyll

The concentration of chlorophyll is higher in winter season within the GoA, due to a number of reasons including deep water vertical mixing during winter in which deep water concentrations of different parameters in the offshore water come up to the surface. Increased nutrient concentrations in the euphotic zone enhance primary productivity resulting in higher phytoplankton abundance and increased chlorophyll a concentrations. In addition, water column stratification and high irradiance during summer often results in a depletion of the inorganic nutrients within the upper waters through enhanced primary productivity at the subsurface level (50-75 m)[55].

The strong seasonal fluctuations in the waters of the GoA is associated with de-stratification caused by a seasonal succession in the phytoplankton community that is more akin to temperate waters than tropical waters[56]. Chlorophyll a concentrations have been measured in water samples from 13 stations over the period of 2009-2013. These show Chlorophyll a concentration in green circles (Figure 6) along with the difference in productivity between the various recording stations.

[51] Tomosada and Odate, 1995
[52] ECO Consult, 2006
[53] Al-Najjar (2002)
[54] Al-Najjar (2002)
[55] Manasrah et al. 2004; Niemann et al. 2004; Badran et al. 2005; Rasheed et al. 2012
[56] Lindell & Post 1995; Post et al. 2002

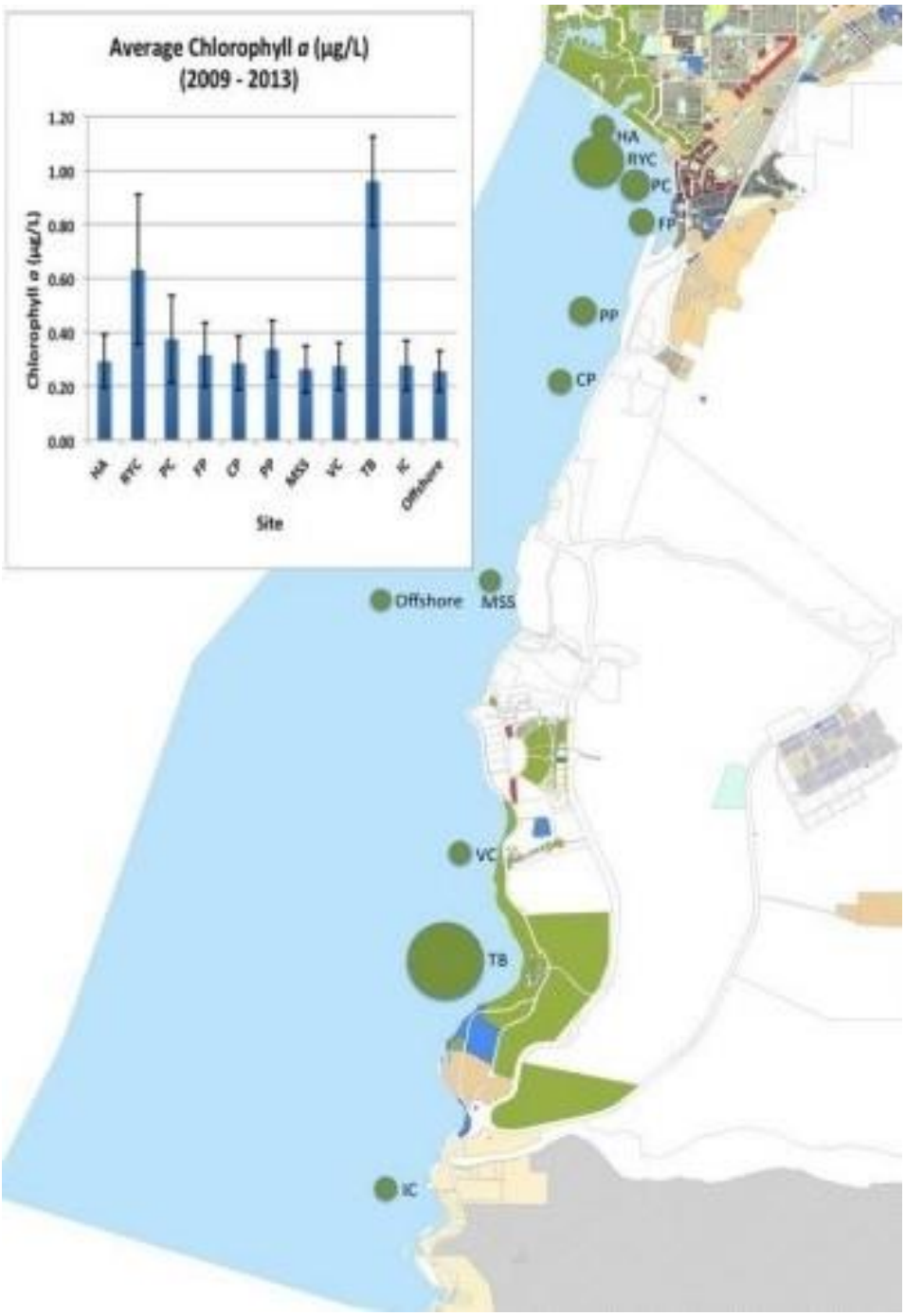


Figure 6: The average Chlorophyll a concentration (µg/L) over the years (2009-2013). It shows the range of Chlorophyll a between years. HA: Hotels area, RYC: Royal Yacht Centre, PC: Public Beach, FP: Fishers Port, CP: Clinker Port, PP: Passengers Port, MSS: Marine Science Station, VC: Visitor Centre, TB: Tala Bay, IC: Industrial Complex, Offshore: Offshore station (control station)[57].

2.3.1.3 Nutrients

[57] UNDP, 2015

Nutrients (notably nitrogen, phosphorous, and silica) are utilized by phytoplankton for growth and reproduction. In the GoA, nutrient levels are poor[58], due to the limited inflow of nutrient-rich waters. The concentrations of nitrogen in the GoA is low especially during summer with 1.0 µM[59]. The seasonal variations in silicate concentrations follow the variations in phosphate concentrations, where it is generally low during summer and high during the winter[60] (Figure 7). However, the concentrations of silicate at the MSS that represents the northern boundaries or the proposed AMR showed a high concentration during winter (~ 2.0 µM) and low values during summer (1.0 µM).

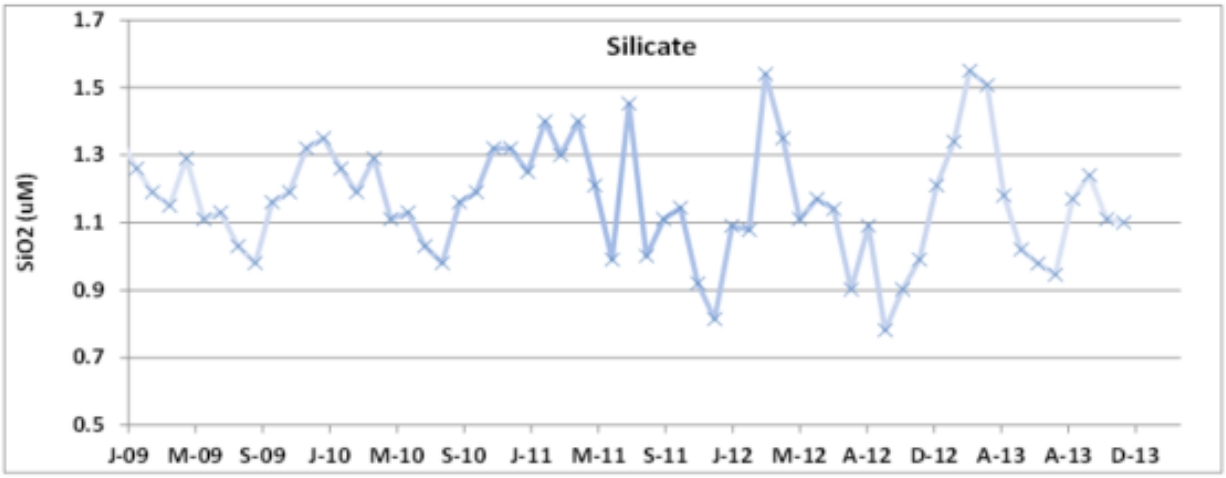


Figure 7: Time series of silicate concentrations (µM) from the coastal water in front of the Marine Science Station for the period January 2009- December 2013[61].

Loss of phosphate (from the plant to the tanker) and during shipments (transportation, storage, and loading) has been a major concern within the GoA since mid-1970s[62]. The lost phosphate particles tends to land around the storage areas, under the ship loader, near the berth, and to the sea, and is estimated between 0.05 and 0.1%[63]. The concentration of the dissolved inorganic phosphate range was between 0.02 to 0.2µM in the GoA[64]. Generally, the phosphate-phosphorous and other nutrients are generally higher in winter than in summer, since deep mixing dominates during winter[65]. The total phosphorous concentration in bottom sediments[66] is in the range between 87 to 460µg g^{-1}. The bottom sediments of the Jordanian coast waters contain 0.07% total phosphorous, 0.05% total nitrogen, and 0.35% organic matter as organic, and the phosphate concentration in the interstitial is about 50 times higher than those of the overlying waters[67].

[58] Sheppard et al. 1992
[59] Rasheed et al. 2002
[60] Rushdi 1996
[61] UNDP, 2015
[62] Rasheed et al. (2005)
[63] The Jordan Phosphate Mines Company
[64] Rasheed et al., 2002; Abu-Hilal et al., 2008
[65] Rasheed et al. (2003); Manasrah et al. (2006)
[66] MSS records, 1999
[67] Al-Rousan (1998)

The phosphate dust is leading to negative effects especially associated with the concern that increasing suspended solids within seawater will cause siltation on the coral reef, decreasing water clarity and light penetration, and thus depressing coral growth[68]. In addition, phosphate particles will decrease the space available for new larval settlement, and enhance mucus production by coral which is an energy consuming process[69]. It is noted that raw phosphate (flouroapatite) does dissolve in seawater and therefore it may contribute to the levels of inorganic phosphates being recorded within receiving waters[70]. This is critical especially as nearly three to four times higher phosphate levels are being recorded within the Phosphate Loading Berth areas as opposed to that of the waters in adjacent areas[71].

In order to solve the phosphate issue at the northern GoA, ASEZA has constructed, expanded, installed, tested, and operated a new phosphate terminal at the southern parts of the Jordan's GoA. The new Dry Bulk Jetty will be used for export and will be provided with Dust and Spillage Controls facilities[72].

2.3.2 Marine Ecosystems and Habitats

The following outlines the range of marine ecosystems and habitats that are associated with the proposed AMR area.

2.3.2.1 Sandy and Rocky Shores

The sand beaches along the southern coast of Aqaba are composed of coarse particles, originating from the disintegration and decomposition of terrestrial rocks, and varying amounts of calcareous, sand sized particles of biological origin[73]. The particles have been transported to the beach by rivers/streams during flash floods in the wadis, where different amounts of calcareous, sand sized particles of biological origin, such as fragments of shells and coral, are also usually present [74]. In addition, the beach of the proposed AMR is characterized by the presence of rocky shores region on ancient coral reefs occurring now above the tidal limit (i.e. 'fossil reefs'), where coral sand has formed beach rock, and where coastal geological formations (e.g. lava flows) protrude into the sea[75]. The fossil reefs are derived from uplifting or they were formed during the early part of the Holocene when sea levels were up to 1 m higher than present[76].

2.3.2.2 Fossilized Reefs

The lower part of Aqaba's coral reef is divided into three steps, each representing a separate geological epoch millions of years apart. Each fossilized reef include fossilized animals that inhabited the marine area during the period. The upper part displays stone corals found within the reef today. Different types of shallow and deep corals are also presented in this part. The somewhat

[68] Abu-Hilal, 1999
[69] Te, 1992
[70] Abu-Hilal et al., 2008
[71] Abu-Hilal, 1985
[72] ADC 2014
[73] SOCER 2015
[74] UNDP, 2015
[75] UNDP, 2015
[76] Sheppard et al. 1992

well preserved "fossil" (or relic) coral reef present along the proposed AMRs southern shores is of great scientific importance. Therefore, the protection of these features is of fundamental importance from a cultural perspective to protect Jordanian heritage because of its uniqueness to the area. Table 4 below lists the five distinct locations of fossilized reef in Aqaba.

Table 4: Locations of fossil Reef in Aqaba[77]

Locality A	**East of the Marine Science Station**
Locality B	600m from "Locality A", in the inner part of the wadi
Locality C	Opposite to the national campsite (1.5km from "locality A") characterized by morphological terraces due to the sea level fluctuations
Locality D	Opposite to the northern end of the big bay
Locality E	Opposite to the Royal Diving Center

2.3.2.3 Coral Reefs

The most significant feature of Jordan's marine environment is undoubtedly its coral reef ecosystem, and the associated corals species. The coral reef ecosystem covers a small area, estimated at four km^2 in total (including vertical and horizontal faces), though it occurs along approximately half of the country's short (27 km) coastline (i.e. over 13 km in length) and possesses a remarkably high marine biodiversity. Aqaba reefs also lie within this Red Sea biogeographic zone, which is designated as a World Wide Fund for Nature (WWF) "Global 200 Eco-Region" because of its unique marine biodiversity[78] (see Figure 8).

[77] ECO Consult 2006
[78] Olson and Dinerstein. 2002

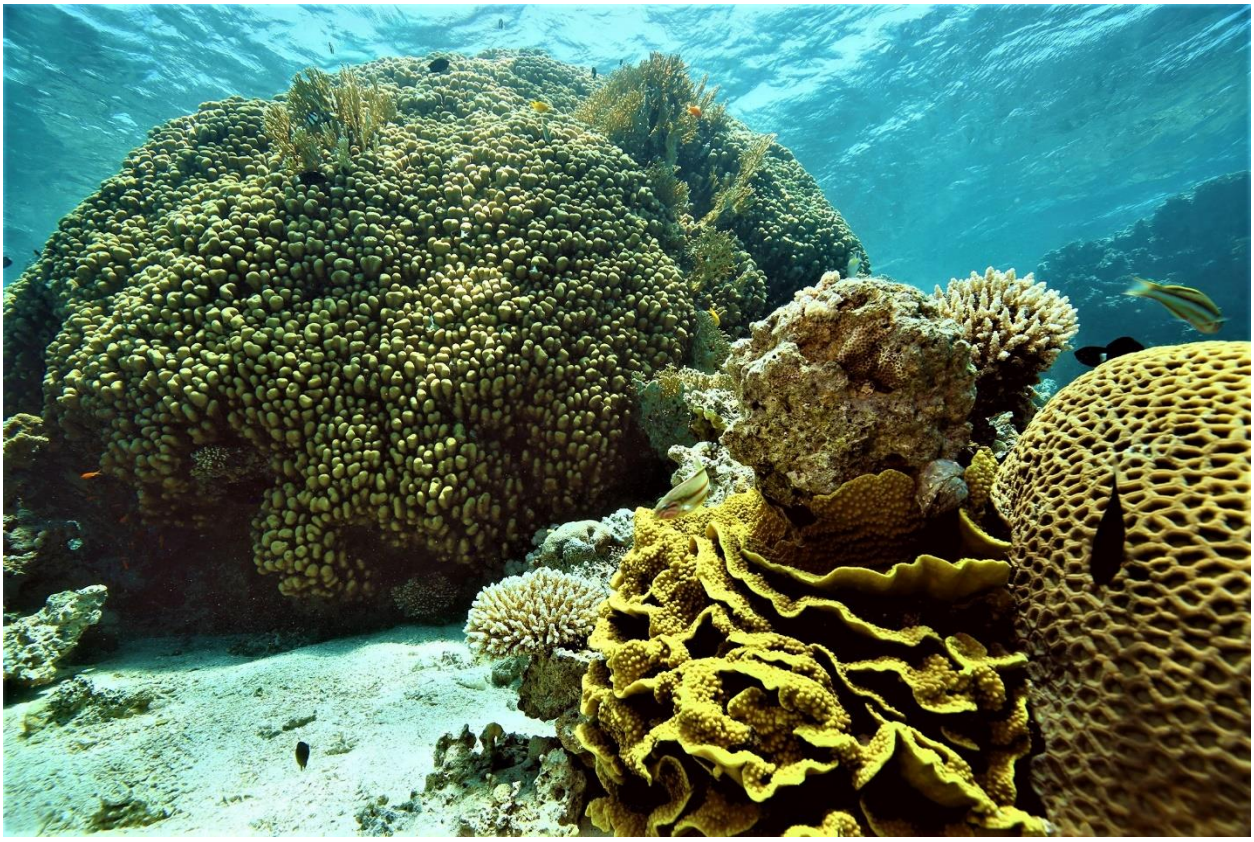


Figure 8: Example of the pristine coral reef ecosystem found within the AMP.

The Jordanian coastline is fringed by a discontinuous series of coral reefs in which two morphological units can be distinguished: i) the reef flats and ii) the outer slopes[79]. The succession from the exclusively sedimentary head of a bay to the next headland as follows: i) scattered coral heads, ii) fragmented reef flat elements, iii) a continuous reef flat representing a narrow fringing reef and iv) a well-structured reef where a back reef channel develops[80]. The most remarkable characteristics of outer reef flats along the Jordanian coast is the vertical drop-off and the absence of "spur and groove" structures which are typical of most reef formations (Shinn, 1963; Stoddart, 1969). In addition, a continental shelf is absent in the GoA where the gradient of the outer slopes varies between 20-40 degrees and depths of several hundreds of meters are reached very rapidly. Generally, the fringing reef flat in the Jordanian part shows identical morphological characteristics represented by narrow reef flat and vertical drop-off.

With regard to the general distribution of corals along the coast, there is a trend of increasing hard coral cover from north to south towards the Saudi Arabian border. Also, the deeper water (>15m b.s.l) have more percent cover of healthy corals compared with the shallower water. This is attributed to the better protection from possible damaging factors, which affect the shallower reef corals. The rest of the items, for example sponge, clams, sea anemone, ascidians, algae and others, are less significant in terms of their distribution along the Jordanian coast of the GoA[81].

[79] Bouchon et al. 1981; Al Tawaha et al., 2019
[80] Bouchon et al. 1981
[81] Al Tawaha et al. 2019

The GoA contains 157 identified hard coral species from which all have been confirmed within the boundaries of the proposed AMR. These species are composed of 153 scleractinian corals (Anthozoa, Scleractinia), one organ pipe coral (Anthozoa, Alcyonacea), and 3 fire corals (Hydrozoa, Milleporidae). Scleractinian coral species found in this study belong to 15 families and 59 genera. Of the scleractinian corals, 147 are zooxanthellate (hosting the photosynthetic dinoflagellates of the family Symbiodinaceae). Fifteen scleractinian corals found and photographed during recent field surveys (Figure 9) are currently known to occur exclusively in the Red Sea, and are hence considered Red Sea endemics[82].

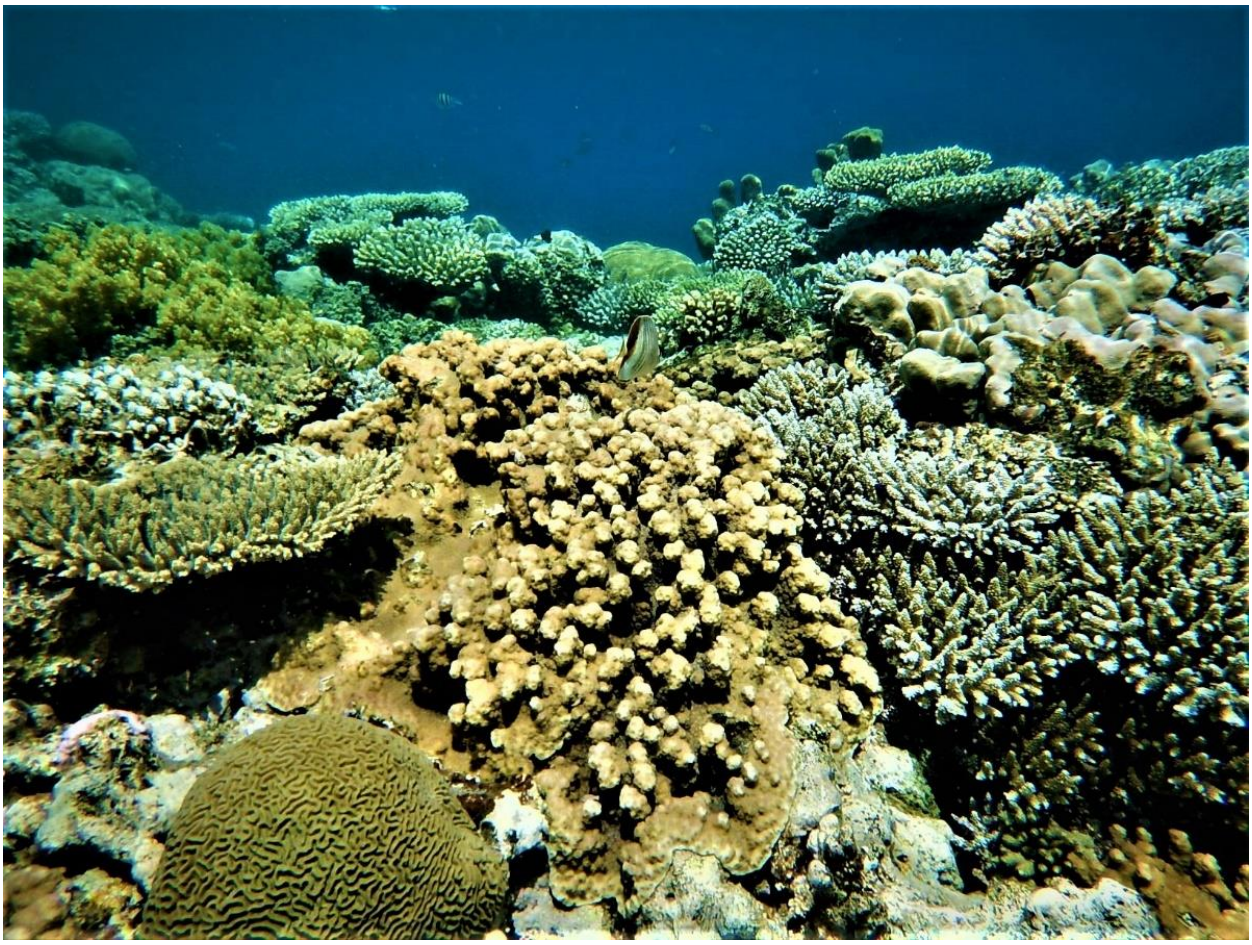


Figure 9: Hard coral coverage found (from recent diver surveys) within the AMP.

In particular, 65% (No=15 species) of the 23 known Red Sea endemic coral species were found in Jordan (Table 5). Based on the collected data, 9.8% of the scleractinian corals recorded between 0 and 30m in Jordan in the present study are Red Sea endemics. It is noteworthy that 5 of the Red Sea endemics, namely *Pachyseris inattesa* Benzoni & Terraneo 2014, *Cyphastrea kausti* Bouwmeester & Benzoni 2015, *Cyphastrea magna* Benzoni & Arrigoni 2017, *Echinophyllia bulbosa Arrigoni*, Benzoni & Berumen 2016, and *Sclerophyllia margariticola* Klunzinger 1879 have been only recently described or resurrected thanks to the integrated

[82] Al Tawaha et al. 2019a

systematics approach including morphological and genetic data coming from a reference collection assembled in Saudi Arabia[83] (Figure 10).

Table 5: Red Sea endemic hard corals species recorded at GoA. IUCN international status as follows: VU: Vulnerable, NT: Near Threatened, LC: Least Concern, DD: Data Deficient, and NE: Not Evaluated

No.	Species name	Family name	IUCN Status	Exists at AMR	
				Yes	No
1	*Pachyseris inattesa*	Agariciidae	NE	√	
2	*Acropora maryae*	Acroporidae	DD	√	
3	*Acropora squarrosa*	Acroporidae	LC	√	
4	*Montipora hemispherica*	Acroporidae	DD	√	
5	*Cantharellus doederleini*	Fungiidae	LC	√	
6	*Echinophyllia bulbosa*	Lobophylliidae	NE	√	
7	*Oxypora convolute*	Lobophylliidae	DD	√	
8	*Sclerophyllia margariticola*	Lobophylliidae	NE	√	
9	*Cyphastrea hexasepta*	Merulinidae	VU	√	
10	*Cyphastrea kausti*	Merulinidae	NE	√	
11	*Cyphastrea magna*	Merulinidae	NE	√	
12	*Echinopora tiranensis*	Merulinidae	DD	√	
13	*Erythrastrea flabellate*	Merulinidae	NT	√	
14	*Merulina scheeri*	Merulinidae	LC	√	
15	*Stylophora mamillata*	Pocilloporidae	LC	√	

In addition, the proposed AMR holds the presence of 14 vulnerable species (threatened) according to the IUCN Red Lists, 30 Near Threatened (NT), five Data deficient (DD) and 41 Not Evaluated (NE) species. The remaining species, which constitutes 67 are Least Concern (LC) species. Table 6 below illustrates these species.

Table 6: Vulnerable and Near Threaded species recorded in the proposed AMR

No.	Species name	Family name	IUCN Status	
			VU	NT
1	*Turbinaria mesenterina*	Dendrophylliidae	√	
2	*Turbinaria reniformis*	Dendrophylliidae	√	
3	*Leptoseris incrustans*	Agariciidae	√	
4	*Leptoseris yabei*	Agariciidae	√	
5	*Pavona cactus*	Agariciidae	√	

[83] Al Tawaha et al. 2019a

6	*Pavona danai*	Agariciidae	√	
7	*Pavona decussata*	Agariciidae	√	
8	*Pavona venosa*	Agariciidae	√	
9	*Acropora anthocercis*	Acroporidae	√	
10	*Acropora pharaonis*	Acroporidae	√	
11	*Alveopora allingi*	Acroporidae	√	
12	*Montipora meandrina*	Acroporidae	√	
13	*Montipora stilosa*	Acroporidae	√	
14	*Cyphastrea hexasepta*	Merulinidae	√	
15	*Goniopora columna*	Poritidae		√
16	*Goniopora lobate*			√
17	*Goniopora minor*			√
18	*Acropora arabensis*	Acroporidae		√
19	*Acropora austere*			√
20	*Acropora digitifera*			√
21	*Acropora hyacinthus*			√
22	*Acropora nasuta*			√
23	*Acropora secale*			√
24	*Alveopora viridis*			√
25	*Montipora cryptus*			√
26	*Montipora efflorescens*			√
27	*Galaxea fascicularis*	Euphylliidae		√
28	*Fungia fungites*	Fungiidae		√
29	*Leptastrea bottae*	incertae sedis		√
30	*Leptastrea inaequalis*			√
31	*Plerogyra sinuosa*			√
32	*Cynarina lacrymalis*	Lobophylliidae		√
33	*Echinopora forskaliana*	Merulinidae		√
34	*Echinopora fruticulosa*			√
35	*Erythrastrea flabellata*			√
36	*Favites halicora*			√
37	*Favites vasta*			√
38	*Hydnophora exesa*			√
39	*Hydnophora microconos*			√
40	*Platygyra crosslandi*			√
41	*Platygyra lamellina*			√
42	*Trachyphyllia geoffroyi*			√

43	*Stylophora pistillata*	Pocilloporidae		√
44	*Tubipora musica*	Tubiporidae		√

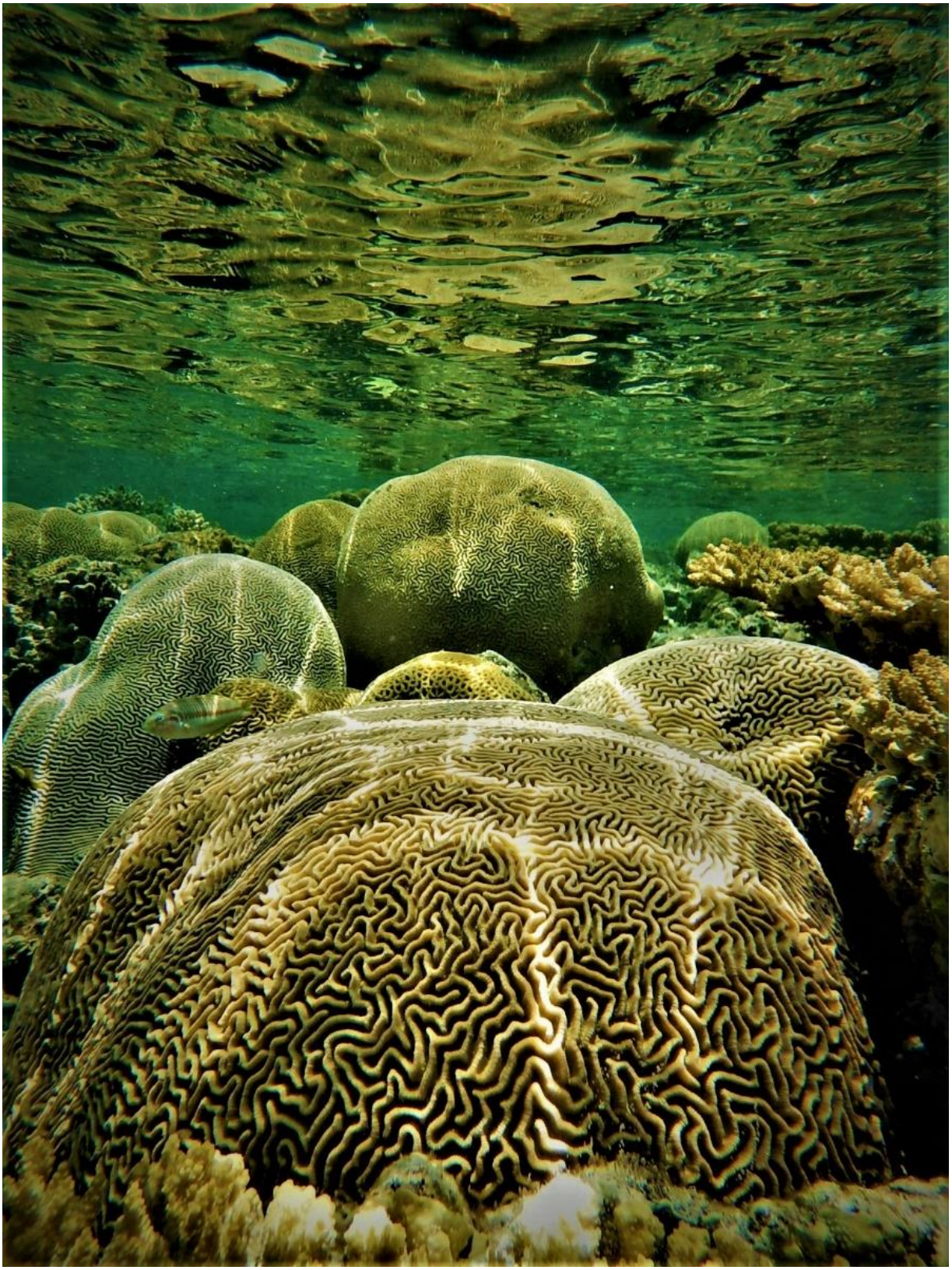


Figure 10: Massive coral species in clear oligotrophic waters of the proposed AMR

Based on species diversity, coral coverage and rarity Index, the North First Bay, North Power Station, MSS, and King Abdullah Reef were found to contain the highest diversity of coral species[84]. From another point of view, Ras Al-Yamaniah (Eel gardens) showed the lowest species diversity (Figure 11).

[84] Al Tawaha et al. 2019a

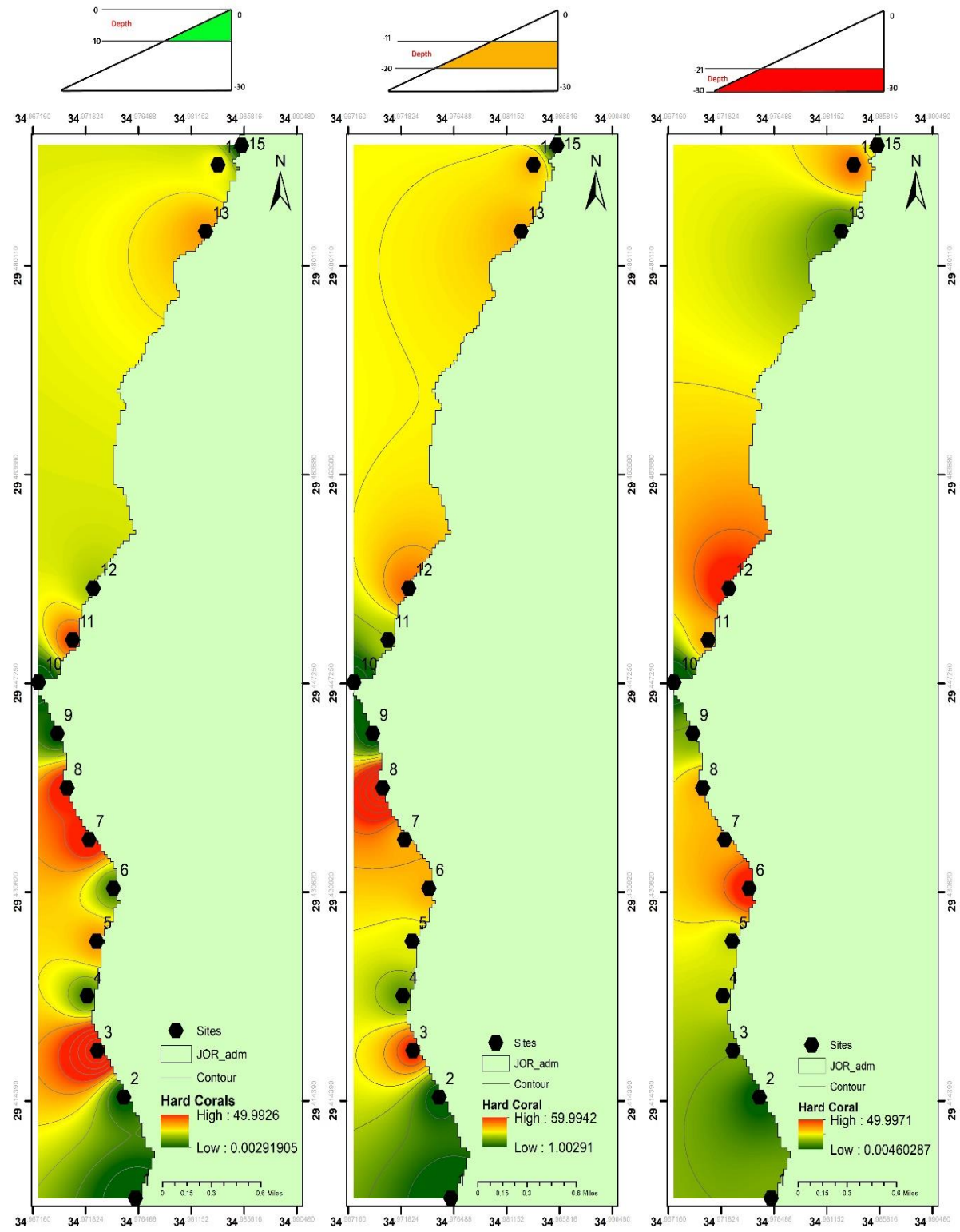


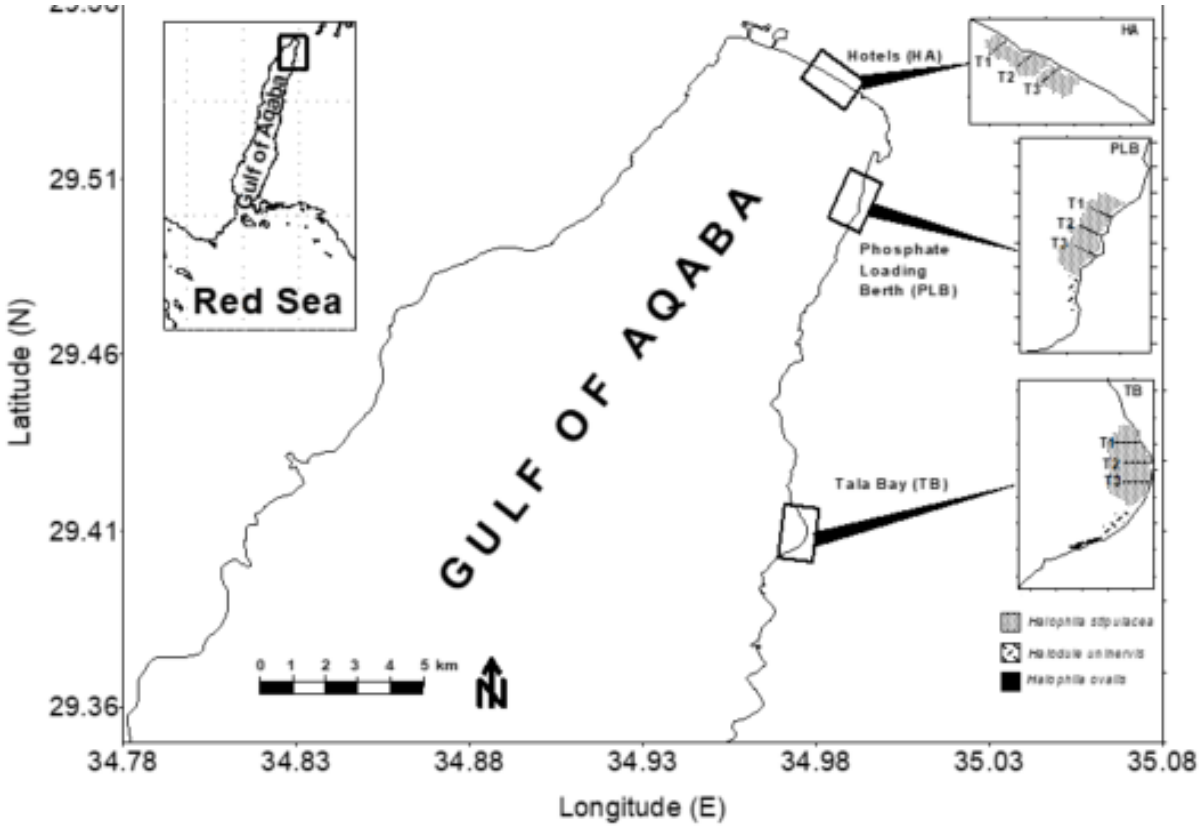
Figure 11: Hotspot areas for hard coral diversity (highest at sites 8: King Abdullah Reef, 11: North First Bay, 12: MSS, 15: North Power Station) and lowest at site No. 10: Ras Al-Yamaniah[85].

[85] Al Tawaha et al. 2019b

Despite the presence of a detailed survey on soft corals, but it is expected to have 120 species along the GoA of Jordan[86].

2.3.2.4 Seagrass Meadows

The seagrass stands along the proposed AMR are small in comparison with the magnitude of coral reef extent, and the greatest extent of seagrass beds are found at the Al-Mamlah Bay (Tala Bay) area (Map 2) which is located at the southern edges of the proposed AMR. The species richness and biodiversity nevertheless is very high with studies indicating the importance of conserving these meadows. The seagrass distributions increased with increasing depth up to 12 m, and thereafter decline.



Map 2: Location of occurrence of seagrass species and survey transects along the Jordanian coast[87]

Three species have been recorded in the proposed AMR, where the most common and distributed species is the *Halophila stipulacea*. The other two species *Halodule uninervis*, and *Halophila ovalis* are less abundant and only found at shallow depths within the vicinity of Tala Bay. Table 7 below illustrates the seagrass species recorded at the proposed AMR.

Table 7: seagrass species recorded at the proposed AMR[88]

[86] UNDP, 2015
[87] Al-Rousan et al., 2010
[88] Al-Rousan et al. 2005

Species name	Family name	IUCN Red List Status
Halophila stipulacea	Hydrocharitaceae	Least Concern
Halodule uninervis	Cymodoceaceae	
Halophila ovalis	Hydrocharitaceae	

Seagrass meadows provide appropriate habitats and shelter for many crustaceans and other invertebrates as well as providing a nursery and breeding ground for fish species. Fish assemblages and their relationship with sea grass meadows and coral reef habitats revealed a higher abundance of pisciverous fish in seagrass dominated areas over coral reefs[89].

The *Halophila stipulacea* is considered a prevalent species in the proposed AMR area, where its coverage varies and ranges from 35 to 55 percent coverage in more shallow waters between 0 and 10 m depth reducing to 20 to 40 percent in deeper waters from 11 to 30 m depth (Table 8).

Table 8: Seagrass species cover, distribution in two different depth within the proposed AMR[90]

Site	Seagrass cover %		Seagrass species
	Shallow (0-10 m)	Deep (11-30 m)	
1	45	35	*Halophila stipulacea*
2	50	40	*Halophila stipulacea*
3	45	35	*Halophila stipulacea*
6	35	20	*Halophila stipulacea*
9	50	35	*Halophila stipulacea*
10	55	40	*Halophila stipulacea*
11	55		*Halophila stipulacea, Halodule uninervis*

2.3.3 Marine Biodiversity

2.3.3.1 Macroalgae

The GoA includes eighteen genera of benthic macroalgae including seven chlorophytes, eleven Rhodophytes, and ten Phaeophytes[91]. The brown algae (Phaeophyceae) has the highest biomass and Mean Absolute Cover (MAC) within the proposed AMR area. Coastal waters adjacent to the industrial complex (further to the north of the proposed area) have the highest brown algae coverage and associate biomass, which is significantly different from those recordings observed close to the Phosphate loading port. The highest coverage appears to be evident during spring months. Occasionally, local Aqaba fishermen mix algae with fish pieces and flour to make a paste which is used as bait in fish traps. Table 9 shows the common macroalgae species recorded within the proposed AMR area.

Table 9: Common macroalgae species recorded in the AMR area.

Species name	Family name	IUCN Red List Status

[89] UNDP, 2015
[90] Al Tawaha et al 2019b
[91] UNDP, 2015

Coulerpa serrulata	Caulerpaceae	Least Concern
Padina pavonia	Dictyotaceae	
Laurancia papillosa	Rhodomelaceae	
Ulva lactuca	Ulvaceae	
Hydroclathrus clathrus	Scytosiphonaceae	
Centroceras clavulatum	Ceramiaceae	

2.3.3.2 Coral Turf Algae

The turf algae along the GoA coastline exhibits higher coverage within shallower depths (circa 8 m). Sites where turf algae and low living coral reef coverage occur within close proximity to heavy industrial developments, whereas the area adjacent to the public beach (inside the existing AMP, which prohibits fishing) is the site where least turf algae and live reef cover occurs[92]. Average turf algae coverage, in relation to the total reef area for all water depths is 28%, whilst bare dead coral to total reef proportion constitutes a greater percentage (40%)[93]. This may indicate that the potential phase-shift from coral reef to turf algae is not yet incurable; but with intervention and suitable management action, its prevalence could be slowed, halted, or even reversed specially at sites in close proximity to anthropogenic influences such as construction activities and nutrient (i.e. Phosphorus and Nitrogen) over-enrichment[94].

2.3.3.4 Marine Fauna

2.3.3.4.1 Fish communities

The endemism in the Red Sea is high, with an estimated 25 species of fish only occurring in the Red Sea. This observation is reflected in the diversity of fish found within the GoA, where a total of 507 (belonging to 109 families) have been recorded so far, which constitutes 40% of the known, 280 fish species of the Red Sea. Eight families represent more than 41% of the recorded fish species in the GoA including Wrasse labridae (51 species), Pomacentridae (29 species), Serranidae (25 species), Apogonidae and Blenniidae (24 species for each), Gobbiidae (21 species), Carangidae (17 species) and Syngnanthidae (16 species). Seven species are recognized as endemic, and several are considered to be commercially important varieties.

More than 50% of the species recorded in Jordan are coral reef dwelling species, which demonstrates the species richness found at the proposed AMR area, which in part is due to the presence of healthy coral reefs[95]. A first record for an extremely rare species was confirmed from 2 m depth at the seagrass meadow in Al-Mamlah Bay in the proposed AMR belongs to Sea Grass Wrasse *Novaculichthys macrolepidotus*, which was recorded for the first time in 2004[96]. Three introduced species to the GoA have been

[92] UNDP, 2015
[93] SOCER 2015
[94] SOCER 2015
[95] Khalaf, 2004
[96] Khalaf, 2004

also recorded including *Sparus auratus, Dicentrarchus labrax,* and *Tilapia* sp. from the fish farm project which was established before in Eilat[97]. Table 10 shows the endemic fish species recorded in the AMR area.

Table 10: Endemic fish species recorded in the AMR[98]

Species name	Family name	IUCN Red List Status
Rhinobatos punctifer	Rhinobatidae	Near Threatened
Heteronarce bentuviai	Narcinidae	Data Deficient
Torpedo panthera	Torpenidae	Data Deficient
Pseudanthias heemstrai	Muraenidae	Not Evaluated
Chlidichthys rubiceps	Pseudochromidae	Least Concern
Pseudochromis dixurus	Pseudochromidae	Least Concern
Pseudochromis flavivertex	Pseudochromidae	Least Concern
Pseudochromis fridmani	Pseudochromidae	Least Concern
Pseudochromis olivaceus	Pseudochromidae	Least Concern
Pseudochromis springeri	Pseudochromidae	Least Concern
Cheilodipterus lachneri	Apogonidae	Not Evaluated
Gorgasia silneri	Congridae	Not Evaluated
Ophichthus echeloides	Ophichthidae	Not Evaluated
Physiculus marisrubri	Moridae	Not Evaluated
Caesio suevica	Caesionidae	Least Concern
Diplodus noct	Sparidae	Least Concern
Atrobucca geniae	Sciaenidae	Data Deficient
Parupeneus forsskali	Mullidae	Least Concern
Chaetodon fasciatus	Chaetodontidae	Least Concern
Chaetodon paucifasciatus	Chaetodontidae	Least Concern
Chaetodon semilarvatus	Chaetodontidae	Least Concern
Heniochus intermedus	Chaetodontidae	Not Evaluated
Amblyglyphidodon flavilatus	Pomacentridae	Least Concern
Amphiprion bicinctus	Pomacentridae	Least Concern
Chromis pelloura	Pomacentridae	Not Evaluated
Chromis trialpha	Pomacentridae	Not Evaluated
Pomacentrus albicaudatus	Pomacentridae	Not Evaluated
Cheilinus trilobatus	Labridae	Least Concern
Cirrhilabrus blatteus	Labridae	Least Concern
Cirrhilabrus rubriventralis	Labridae	Least Concern

[97] Khalaf, 2004
[98] Khalaf, 2004

Gomphosus caeruleus	Labridae	Least Concern
Larabicus quadrilineatus	Labridae	Data Deficient
Paracheilinus octotaenia	Labridae	Least Concern
Thalassoma rueppellii	Labridae	Least Concern
Calotomus viridescens	Scaridae	Least Concern
Chlorurus genazonatus	Scaridae	Least Concern
Scarus collana	Scaridae	Least Concern
Trichonotus nikii	Trichonotidae	Not Evaluated
Uranoscopus marisrubri	Uranoscopidae	Not Evaluated
Belenniella flaviumbrinus	Blenniidae	Not Evaluated
Ecsenius aroni	Blenniidae	Least Concern
Ecsenius frontalis	Blenniidae	Least Concern
Ecsenius gravieri	Blenniidae	Least Concern
Meiacanthus nigrolineatus	Blenniidae	Least Concern
Enneapterygius destai	Tripterygiidae	Least Concern
Ctenogobiops maculosus	Gobiidae	Least Concern
Acanthurus nigricans	Acanthuridae	Least Concern
Acanthurus sohal	Acanthuridae	Least Concern
Thyrsitoides marleyi	Gempylidae	Not Evaluated
Sufflamen albicaudatum	Balistidae	Not Evaluated
Arothron diadematus	Tetraodontidae	Least Concern
Canthigaster margaritata	Tetraodontidae	Least Concern

Three flagship species have been identified for the GoA including the whale shark (*Rhincodon typus*), Reef stingray (*Taeniura lymma*), and the masked butterfly fish (*Chaetodon semilarvatus*)[99].

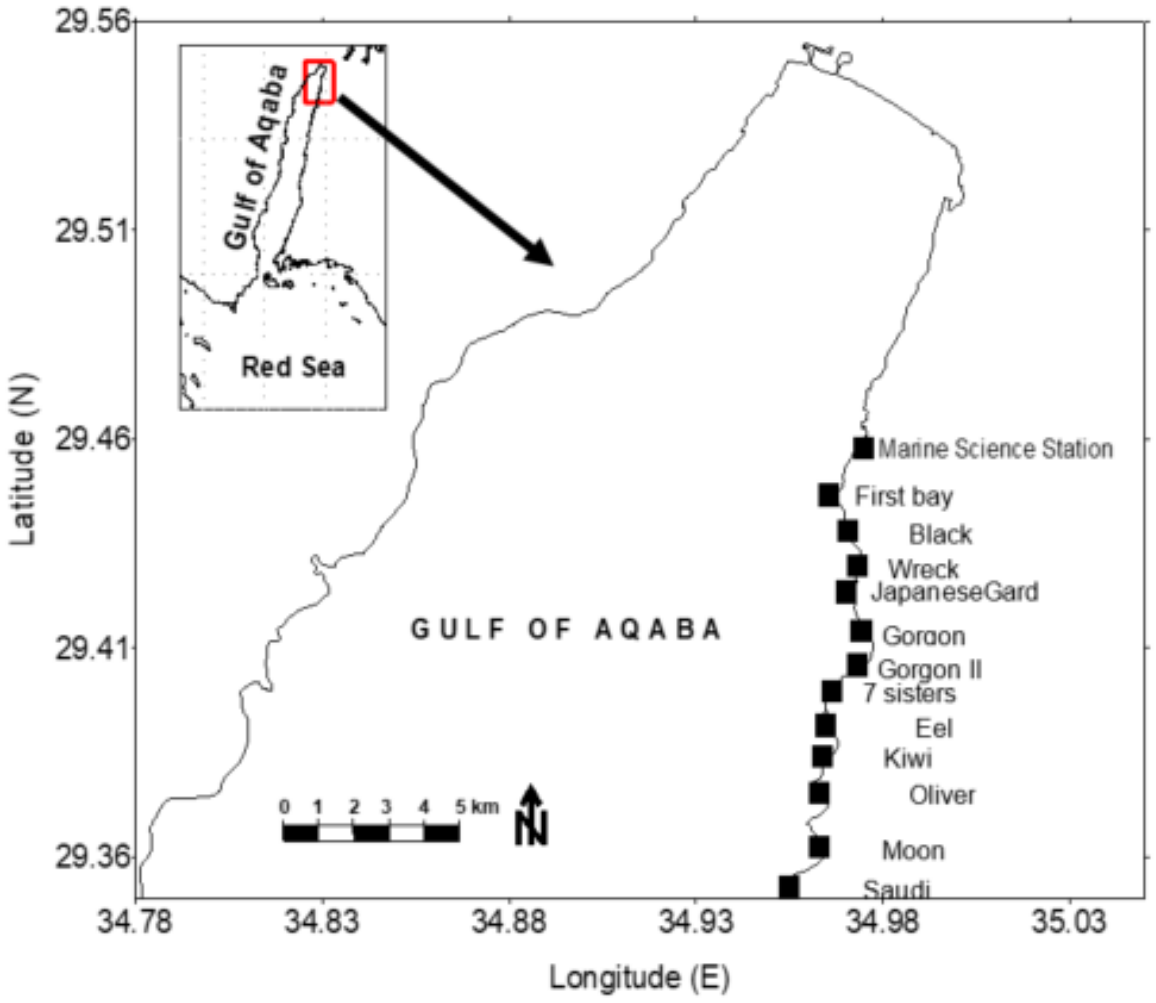
Around 70% of the Jordanian marine fish catch are species belong to the Scombridae family, which is considered of great importance commercially to Aqaba. Main species fished include migratory species such as *Katsuwonus pelamis* and *Euthynnus affinis*. Other important commercial fish species are *Decapterus macarellus, Decapterus macrosoma, Caesio lunaris, Caesio suevica* and *Caesio varilineata*[100].

Finally, the most abundant shallow water pelagic species are the silver side fish *Atherinomorous lacunosus*, and the clued fish, *Spratelloides gracias*. The most common inhabitant of deep sea fishes are *Ago amanuensis*, *Rhinobatos punctifer*, *Mureanesox cereus*, *Carangoides equal*, *Paracaesio sordid*, *Polysteganus coeruleopunctatus*, *Argyrops spicier*, *Upends davidaromi*, *Trichiurus lectures* and *Thyrsitoides marley*.

[99] Khalaf, 2004
[100] Khalaf, 2004

2.3.3.5 Sea Turtles

Three turtle species have been recorded at the GoA, and a fourth is expected to be encountered which is the Endangered green turtle *Chelonia mydas*[101]. The loggerhead turtle *Caretta caretta* is a vulnerable species according to the IUCN Red List, and which has been recorded at Aqaba, although this record is most likely to be a migrant specimen derived through the Suez Canal[102]. Although uncommon with few recorded, but the vulnerable leatherback turtle *Dermochelys coriacea* has been confirmed from the GoA water[103]. The most abundant and widely distributed species along the GoA and the proposed AMR is the hawksbill turtle *Eretmochelys coriacea*. The Black Rock location (towards Tala Bay) demonstrates the highest turtle population within the proposed AMR area[104] (see Map 3)



Map 3: Turtle study sites (most popular recorded) in Jordanian waters[105].

[101] Disi et al, 2001
[102] Disi et al, 2001
[103] Disi et al, 2001; Eid and Al Tawaha. Pers. Observation (2018)
[104] UNDP, 2015
[105] UNDP, 2015

Despite some reports which states that urban and industrial development are affected the nesting behavior patterns of the hawksbill turtle[106], other reports indicate that no nesting have been reported from the Jordanian parts.

2.3.3.6 Marine Invertebrates

The coastal waters of the Jordanian GoA and its coral reef ecosystem hosts a plethora of marine fauna including hundreds of species of marine invertebrate (Table 11). Major groups of invertebrates occupying this zone include gastropod molluscs, rock oysters, barnacles, and chitons. Twenty percent of molluscs and Echinodermata as well as several species of algae occurring in the Gulf may be endemic.

Table 11: Total number of species and genera of invertebrate phyla recorded from the Jordanian side of the GoA107.

Group	Number of species	Number of genera
1. Sarcodina	58	54
2. Porifera	72	44
3. Cnidaria	237	101
a. Hydrozoa	24	21
b. Scyphozoa	3	3
c. Total Anthozoa	219	77
C1. Hard corals	158	51
c2 . Others	52	26
4. Nomatoda	242	129
5.Mollusca	645	300
a. gastropoda	479	207
b. polyplacophora	17	8
c. Bivalvia	162	82
d. Cephalopoda	2	2
e. Scaphopoda	2	1
6. Annelida	37	34
7.Crustacea	1202	131
8. Echinodermata	125	82
a. Asteroidea	21	17
d.Ophiuoidea	29	16
c.Echinoidea	29	25
d. Holothuroidea	32	11
e. Crinoidea	14	13

[106] ECO Consult 2006
[107] UNDP, 2015

2.3.3.6.1 Giant Clams

Giant clams support a wide variety of reef dwelling vertebrates and invertebrates, and it is considered a significant species in the overall production of a healthy reef as it contributes in the foundation for reef growth and development. The preservation of both species of giant clam is therefore a necessity in sustaining marine biodiversity along the proposed AMR area.

A study on the distribution of the Giant clams *Tridacna maxima and T.squamosa* within Jordanian waters suggests that both species are considered keystone species within a coral reef ecosystem and fulfil a niche role within the community. Due to a lack of abundance in Giant clams numbers, they are considered endangered in Jordanian waters and hence require protection[108]. Both species are, however, considered of lower risk/conservation dependent species according to the IUCN Red List assessment.

2.3.3.6.2 Sponges

Sponges of the phylum Porifera, are the most primitive of the multicellular animals. All members of the phylum are sessile and exhibit little detectable movement. Many sponges, like corals, contain symbiotic algal cells and are at least partly autotrophic. The number of Porifera species and genera reported from the Jordanian coasts of the GoA. There are 72 species of sponges known from the Jordanian coast of the GoA[109].

Several sponge species e.g. *Sigmosceptrella* and *Prianos* produce compounds that show great promise as a drug to combat malaria, tuberculosis and other infectious diseases. Many compounds extracted from sponges have also anti-viral, anti-neoplastic and anti-cancer properties. There are no reports, from Jordan, on the use of any species of sponges in any type of industries, production of chemical compounds, or for medicinal applications.

2.3.3.6.3 Cnidarians

There are limited areas within the GoA where cnidarians occur and the taxonomic validity of some species must, as a result, be revised. The phylum includes three classes:

1. **Hydrozoa**: Hydrozoans display either the polypoid or the medusoid structure, and some species pass through both forms in their life cycle. Twenty-four hydrozoan species belonging to 21 genera were recorded from the Jordanian side of the GoA. The most famous hydroid species is the fire coral or stinging coral (*Millepora exesa*).
2. **Scyphozoa**: Most frequently referred to as Jellyfish. In this class the medusa is the dominant and conspicuous individual in the life cycle; the polypoid form is restricted to a small larval stage. Only three species belonging to three genera were recorded from the Jordanian side of the GoA.

[108] UNDP 2015
[109] Al-Sabi', 2000

3. **Anthozoa**: Anthozoans are either solitary or colonial polypoid cnidarians in which the medusoid stage is completely absent. This class includes the major constructors of tropical reefs, the scleractinian corals. Scleractinian corals live in symbiotic association with brown coloured dinoflagellates known as "zooxanthellae".

2.3.3.6.3 Gastropods

Out of 950 species of molluscs occurring in the whole Red Sea basin, 645 species are recorded from the GoA inhabiting fringing reefs (reef flats, Millepora fringing reefs, fringing reefs with massive corals) and fore-reef hard substrata (coral patches, coral carpets and small patch reefs). The phylum mollusca is represented by five classes in the Jordanian coastlines of the GoA, including[110]:

1. **Gastropoda** is represented by 462 species, which equals about 71 % of the phylum;
2. **Bivalvia** or **Lamellibranchia** is represented by 162 species, which equals about 25% of the phylum;
3. **Polyplachophora** is represented by 17 species, which equals about 2.6% of the phylum;
4. **Cephalopoda** is represented by 2 species only, which equals about 0.3% of the phylum;
5. **Scaphopoda** is represented by 2 species only, which equals about 0.3% of the phylum.

The most important molluscs in the assemblage include the parasitic gastropod *Coralliophila neritoidea*, the encrusting gastropod *Dendropoma maxima* and the coral-associated bivalve *Pedum spondyloideum*[111].

2.3.3.6.4 Chaetognatha

Four common species of Chaetognatha (arrow worms) representing two genera have been recorded in the Jordanian side of GoA including *Sagitta enflata, Sagitta hexaptera, Sagitta pacifica* and *Spadella* sp.

2.3.3.6.5 Urochordata

Approximately 20 species of adult urochordates, commonly known as tunicates, have been recorded from the Jordanian side of the GoA. These are divided into three classes namely: Ascidiacea (6 species), Larvacea (8 species), and Thaliacea (6 species)[112].

2.3.3.6.7 Macro, Micro and Meiofauna

The animals living in the intertidal sand are divided into three groups based on size; the largest includes the macro fauna, which displace the sand surrounding them by digging and burrowing; the meiofauna, or interstitial fauna, generally occupy the interstitial spaces between the grains; and the micro fauna, which are usually one-celled animals.

[110] SOCER 2015
[111] Zuschin and Stachowitsch 2007
[112] SOCER 2015

Table 12 shows the occurrence of the major species of molluscs and crustaceans in the supra-littoral fringe and mid-littoral zones of the rocky intertidal along the proposed AMR area. The table shows the type of substratum on which the species occur in greatest abundance. To be noted (within the table) is the range of three species, *Acanthopleura gemmata*, *Cellana radiata* and *Nerita sanguinolenta*, in middle and lower midlittoral. Among the fauna of the rocky intertidal zone are those that are sedentary or permanently attached to the substratum, and those that are free and mobile. In the former group are those that cement themselves substratum and include the giant barnacle *Tetraclita squamosa rufotincta*, the smaller barnacle *Tetrachthamalus oblitteratus* and the oyster *Ostrea forskali*. The mussel *Brachidontes variabilis* and the clam *Isognomon cf. recognittis* attach themselves to the substratum by byssus threads. The mussel occurs in cracks and depressions on slab, while the clam can be found in crevices and on the underside of pebbles.

Table 12: Vertical zonation and the most abundant substrate occurrence of the dominant rocky intertidal molluscs and crustaceans in the Jordan GoA. Abbreviations in parentheses refer to substrate: S = slab; B = boulders; P = pebbles[113].

Supralittoral Fringe		
Nodilittorina subnodosa (Philippi, 1847) (S) *Nodilittorina millegrana* (Philippi, 1848) (B) *Ligia exotica* Roux, 1828 (P)		
Supralittoral Fringe-Midlittoral (Upper)		
Littorina scabra scabra (Linnaeus, 1758) (B)		
Midlittoral		
Upper	Middle	Lower
Celiana radiata (Born, 1778) (B, S) *Clypeomorus moniliferum* (Kiener, 1841) (P) *Monodonta dama* (Philippi, 1848) (P, B, S) *Nerita polka orbignyana* (Recluz, 1842) (P) *Nerita quadricolor* (Gmelin, 1791) (B) *Planaxis sulcatus* (Bom, 1780) (P, S)	*Acanthopleura gemmata* (Blainville, 1825) (S) *Brachidontes variabilis* (Krauss, 1848) (S) *Cerithium caeruleum* (Sowerby, 1855) (S) *Clibanarius signatus* (Heller, 1861) (S) *Clypeomorus tuberculatum* (Linnaeus, 1758) (S) *Grapsus albolineatus* (Lamarck, 1818) (B) *Grapsus granulosus* (H. Milne Edwards, 1853) (S) *Grapsus tenuicrustatus* (Herbst, 1783) (B) *Isognomon cf. recognitus* (Mabille, 1895) (S, P)	*Acanthopleura gemmata* (S) *Cellana radiata* (S) *Nerita sanguinolenta* (S)

[113] After Hulings and Wahbeh 1988

	Nerita sanguinolenta (Menke, 1829) (P, S) *Ostrea forskali* (Chemnitz, 1795) (S, B) *Peasiella cf. isseli* (Semper, 1867) (S) *Plagusia tuberculata* (Lamarck, 1818) (B) *Siphonaria laciniosa* (Linnaeus, 1758) (S) *Tetrachthamalus oblitteratus* (Newman, 1967) (S, P) *Tetraclita squamosa rufotincta* (Pilsbry, 1916) (S, B) *Thais hippocastanum* (Linnaeus, 1758) (S)	

The mobile forms are represented by the chiton *Acanthopleura gemmata*, the patellid limpet *Cellana radiata* and the pulmonate limpet *Siphonaria laciniosa*. Other mobile gastropods include the nerites, *Nerita sanguinolenta*, and *N. polita orbignyana*; the littorinids *Nodilittorina* sub-*nodosa*; and *N. millegrana*; the ceriths *Cerithium caeruleum*, *Clypeornorus moniliferum* and *C. tuberculatum*; the trochid *Monodonta dama*; the smallest gastropod *Peasiella cf. isseli*; the black *Planaxis sulcatus*; and the rock shell *Thais hippocastanum* gastropods, *Nerita quadricolor* and *Littorina scabra scabra*, are very rare along the coast of Jordan and are, and unlikely to be observed. The mobile crustaceans occurring in the rocky intertidal include the isopode *Ligia exotica* and the amphibious grapsoid crabs *Grapsus granulosus*, *G. albolineatus*, *G. tenuicrustatus* and *Plagusia tuberculata*. *G. granulosus* is the most abundant, inhabiting in the upper and mid mid-littoral on slab where refuges are available. The other grapsoids are characteristic of the mid mid-littoral boulder habitats, with *G. albolineatus* being the most common.

The sympatric species of gastropods living in the rocky intertidal zone include the supra-littoral fringe *Nodilittorina subnodosa* and *N. millegrana*, the midlittoral *Nerita sanguinolenta*, *N. polita orbignyana* and *N. quadricolor*, and *Clypeamoms moniliferum* and *C. tuberculatum*. Among the rocky intertidal crustaceans, sympatric species include those of the crab Grapsus, *G. albolineatus*, *G. granulosus* and *G. tenuicrustatus*. There are varying degrees of spatial and reproductive isolation within the sympatric species that prevent interbreeding. The occurrence of so many sympatric species in the rocky and sand beach (*Hippa celaeno* and *H. picta*) intertidal zone of Jordan is unusual when compared with other geographic areas.

Other components of the rocky intertidal fauna that can be seen at low tide are groups of shells in various positions. Throughout the cooler part of the year, these are commonly seen on top of slab whereas, during the warmer period, they are under stones. Ten represent fishes found within the rocky intertidal zone, some of which are amphibious. An example of the latter is the comical, leaping blenny *Alticus kirkii magnusi*[114] which can be seen on boulders. Though it is well adapted for life out of water, it remains in close proximity to the water level or close to sea-spray from breaking waves, often following the flood and ebb tide levels.

[114] Klausewitz, 1964

Another common intertidal species is *Antennablennius hypenetes* (Klunzinger, 1871) which can be seen on submerged slab. Unlike the previous species, it does' not leave the aqueous medium. Both species feed on algae.

Components of the flora that can be seen in the rocky intertidal zone include large or macroalgae. Particularly notable are the green algae, including the leafy *Ulva lactuca* (Linnaeus) Le Jolis and the thread-like or filamentous *Enteroinorpha cornpressa* (Linnaeus) Grev. Brown algae, such the sac-like *Colpornenia sinuosa* (Mert.) *Derbes et solier*, and the fan-shaped *Padina pavonia* (Linnaeus) Gaillon, can also be seen. Common red algae include *Galaxura lapidescens* (Sol.) Lamour, and the filamentous *Erythrotrichia* sp.

The meiofauna includes representatives of most of the major animal groups, as well as some groups that are restricted entirely to the interstitial habitat. Hulings (1975) characterized the sand beach meiofaunal community in Jordan as dominated by harpacticoid copepods with turbellarians, nematodes, archiannelids, polychaetes and ostracods as being significant component. Other taxa reported included cnidarians, gastrotrichs, oligochaetes, mollusks, halacarids and tardigrades. The major groups of meiofauna include threadworms called nematodes and shrimp-like benthic copepods called harpacticoids.

The micro-fauna possess numerous hair-like cilia and, for one-celled organisms, have evolved into an extremely diverse group in terms of shape and structure. There is also a wide variety of feeding habits among the ciliates including those that are herbivorous, carnivorous, bactivorous and omnivorous.

2.3.4 Terrestrial Ecosystems, Habitats and Biodiversity

2.3.4.1 Biogeographical Affinity

Jordan contains four bio-geographical zones, namely the Mediterranean, Irano- Turanian, Sudanian and Saharo-Arabian zones. The current AMP is located within Jordan's Sudanian Penetration Zone, which is characterized by having warm winters and very hot summers, where the temperature ranges from 15-45°C. It is also unique in having the lowest point on earth where it reaches about -400 m at the Dead Sea level. The rainfall ranges from 50-100 mm/year and the soil is mostly alluvial, saline, sandy (or sand dunes), hammada, some granite fragments and Lisan marls (Al Eisawi, 1996).

2.3.4.2 Vegetation types

Acacia and Sudanian rocky vegetation type is located at the western parts of Jordan extending from Al Karamah in the north until Aqaba in the south and constitutes 2,621.44Km^2. The terrestrial side of the current AMP is situated within the proposed AMR, where it is characterized by hilly ground covered with hammada soil type; the leading plant species are *Acacia raddiana* and *Acacia tortilis*, which can be found at the eastern parts that are adjacent to the marine reserve (Al Eisawi, 1996).

2.3.4.3 Habitats

The proposed AMR contains several habitats, that formulate the terrestrial section and as follows:

2.3.4.3.1 Alluvial Fans

These mainly align in an east west direction, where several shallow wadi systems flow into the fans, and represent good examples of specific terrestrial ecosystems. These are important for acacia trees and other Afro-Subtropical flora and fauna. These fans can be subdivided into the following sub-habitats:

1. **Wadi systems**: Several wadis flow east west, but their water flow is seasonal. Flora and fauna species have adapted themselves to such conditions and are very specific to these habitats. True subtropical trees growing in such habitats are the *Acacia*, *Tamarix*, *Ziziphus* and *Haloxylon*. Typical fauna associated with wadis include desert rodents such as the gerboa, spiny mouse, jerds, as well as common reptiles such as agamas and lizards, the wild cat, and foxes. These wadis exist to the east of Aqaba town and are not found at the property site.
2. **Fringing Granite Mountains**: Whilst not directly within the proposed AMR, the geology of such mountains has created a special soil and edaphic condition, which could be classified as a unique habitat for Jordan. The pristine Granite Mountains of Aqaba still maintain important flora and fauna. These mountains are breeding sites for many resident and migratory globally, regionally and locally threatened birds, particularly for raptors.

2.3.4.4 Terrestrial Flora

The terrestrial part of the proposed AMR is sparsely covered with vegetation. The flora that can be observed is mostly confined to some shrubs and saline plants such as *Zygophyllum dumosum*, *Anabasis articulate*, *Juncus mariümus* and *Fagonia* spp. A more detailed study is required to confirm and produce a list of flora species that exist in the existing AMP and its adjacent areas. Table 13 represents the flora species that are common at the Acacia and Sudanian rocky vegetation that contains the adjacent areas of the proposed AMR.

Table 13: terrestrial flora species survive within the proposed AMR and its adjacent areas

Species name	Family name	IUCN Red List Status	Present at AMR	
			Within	Adjacent
Acacia raddiana	Fabaceae	Not Evaluated		√
Acacia tortilis	Fabaceae	Least Concern		√
Anabasis articulata	Amaranthaceae	Not Evaluated	√	√
Hammada scoparia	Amaranthaceae	Not Evaluated	√	√
Cassia italica	Fabaceae	Not Evaluated	√	√
Zygophyllum dumosum	Zygophyllaceae	Not Evaluated	√	√
Caralluma spp.	Apocynaceae	Not Evaluated	√	√
Fagonia spp.	Zygophyllaceae	Not Evaluated	√	√
Reaumuria hirtella	Tamaricaceae	Not Evaluated	√	√
Gymnocarpos decandrus	Caryophyllaceae	Not Evaluated	√	√

Helianthemum lippii	Cistaceae	Not Evaluated	√	√
Asteriscus graveolens	Asteraceae	Not Evaluated	√	√
Sclerocephalus arabicus	Caryophyllaceae	Not Evaluated	√	√
Anastatica hierochuntica	Brassicaceae	Not Evaluated	√	√
Capparis spinosa	Capparaceae	Least Concern	√	√

2.3.4.5 Terrestrial Fauna

2.3.4.5.1 Mammals

A single common species to Jordan has been recorded in the proposed AMR which is the red fox; *Vulpes vulpes*. In addition, the feral dogs *Canis familiaris* can be encountered frequently in the area. However, the areas adjacent to the AMR area hold the presence of eight mammalian species that belongs to three families and according to Table 14 below:

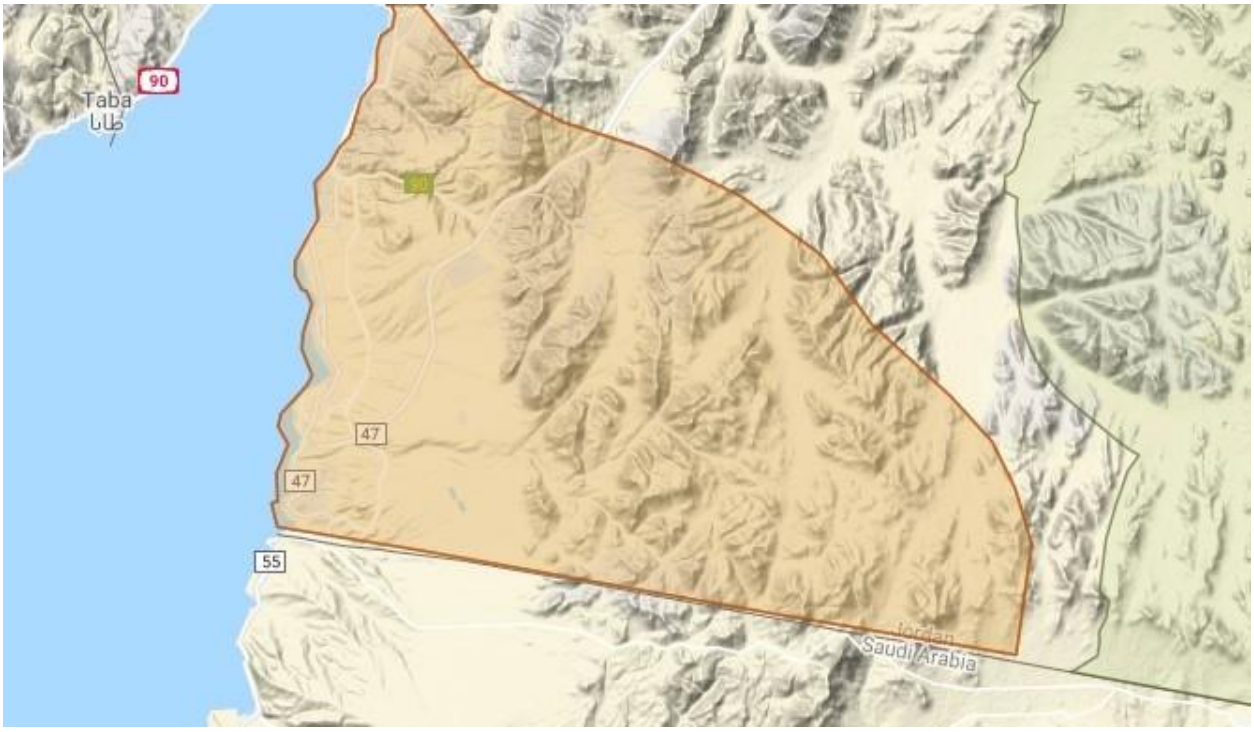
Table 14: Mammalian species survive within the proposed AMR and its adjacent areas

Species name	Family name	IUCN Red List Status[115]	Present at AMR	
			Within	Adjacent
Rousettus aegyptiacus	Pteropodidae	Near Threatened		√
Tadarida teniotis	Molossidae	Least Concern	√	√
Pipistrellus kuhli	Vespertilionidae	Least Concern	√	√
Acomys dimidiatus	Muridae	Least Concern	√	√
Dipodillus dasyurus	Gerbillinae	Least Concern	√	√
Gerbillus gerbillus	Gerbillinae	Least Concern		√
Meriones crassus	Gerbillinae	Least Concern		√
Vulpes vulpes	Canidae	Least Concern	√	√

2.3.4.5.2 Birds

The GoA is considered a major bird migration route that connects Europe and Asia with the African continent (Eid and Qaneer, 2013). This route hosts around 250 different species, and up to 1.5 million birds flying over it. Therefore, the Aqaba coast and surrounding mountains have been declared as an Important Bird Area (IBA), where the area of the proposed AMR is situated within (Map 4).

[115] Eid et al. 2020



Map 4: Aqaba coast and surrounding mountains IBAs

This IBA designation requires that the site contains a migratory bottleneck site also holding a breeding bird community representative of the Rift Valley. The enormous spring passage of raptors such as *Buteo buteo* and *Accipiter brevipes* has added a value to consider this IBA designation. Generally raptors cross the Rift Valley into Jordan further north up Wadi Araba, though spring passage at Aqaba undoubtedly exceeds 50,000 raptors per season. Other spring migrants occurring in good numbers include *Nycticorax nycticorax, Ardea cinerea, Sterna hirundo, Chlidonias leucopterus*, *Sylvia curruca, S. atricapilla, Passer hispaniolensis* and *Emberiza hortulana*. *Falco pelegrinoides* and *Corvus rhipidurus* are resident and the town has a small population of *Corvus splendens*[116].

Other important bird's species which can be observed within the proposed AMR is the Red Sea endemic White-eyed Gull *Ichthyaetus leucophthalmus* which is a resident in the region. Another species includes the Western Reef Heron *Egretta gularis* which was known to breed previously in the area though would benefit from a specific rehabilitation (breeding) Program. In addition, some tern species can be observed such as the Common Tern *Sterna hirundo* and Little Tern *Sternula albifrons*.

2.3.4.5.3 Reptiles

Very low diversity of reptiles exist in Jordan, with eight recorded species from which three have been observed in the proposed AMR area. Table 15 illustrates the reptilian species that survive within the proposed AMR area and its adjacent localities.

Table 15: Reptilian species survive within the proposed AMR and its adjacent areas

[116] Available at http://datazone.birdlife.org/site/factsheet/8202

Species name	Family name	IUCN Red List Status[117]	Present at the proposed AMR	
			Within	Adjacent
Cyrtopodion scabrum	Gekkonidae	Least Concern	√	√
Hemidactylus turcicus	Gekkonidae	Least Concern	√	√
Ptyodactylus guttatus	Gekkonidae	Least Concern		√
Ptyodactylus hasselquistii	Gekkonidae	Least Concern		√
Laudakia stellio	Agamidae	Least Concern		√
Uromastyx aegyptia	Agamidae	Vulnerable		√
Spalerosophis diadema	Colubridae	Least Concern	√	√
Echis coloratus	Viperidae	Least Concern		√

2.5.5 Past and Present Biodiversity Research

The Jordanian coast lies at the centre of marine biodiversity research in the Gulf of Aqaba as it boasts high levels of endemism in fish and invertebrate species. The wide range of habitats present within the AMR will help ensure long-term protection of viable populations of important plant and animal species essential to the sustained health of biodiversity, making the proposed AMR a critical area for global conservation and scientific research standpoints.

The combination of optimal temperature, visibility and salinity conditions creates an environment of exceptional regional and global coral growth and reef development within the AMR for marine research. The AMR is characterized by 13 a suite of different bio-physiographic reef zones, each providing typical coral reef assemblages (Hard Corals of Aqaba: a Field Guide 2019). Furthermore, it also serves as an important larvae export area, acting as a source of recruits for all species of plants and animals present in and around the reef, including invertebrates and fish species. The proposed AMR also hosts important spawning sites for the key fishery species.

Due to these conditions, the number of coral species observed in the AMR are greater than in the southern Red Sea plus other locations within the Gulf of Aqaba. It is logical that the proposed AMR will support a unique and higher, on average, subset of the endemics that are perhaps available elsewhere in the Gulf or in the wider Red Sea. For these reasons, the potential for future marine research being a core focus sector is very real and achievable.

2.6 Cultural and Socio-Economic Values of the Marine Reserve

2.6.1 Archaeological Sites

[117] Eid et al. 2020

Owing to Aqaba's location on a major trading route, Aqabawis are a unique mixture of Bedouin, Hijazi (of Arabian Peninsula), and Egyptian and Levantine origins. They hold dearly to the customs for which Arabs are known; pride and hospitality. The early days of the Islamic era saw the construction of the city of Ayla. The ruins of Ayla, unearthed in the mid-1980s by an American-Jordanian archaeological team, are a few minutes' walk north along the main waterfront road. By 1170, Salahuddin conquered Aqaba. The Mamluks took over in 1250, but by the beginning of the sixth century, it had been overtaken by the Ottoman Empire. The city then declined in status and for 400 years or so it remained a simple fishing village (Aqaba Ecotourism Development Plan 2014).

Until the 1960s, the GoA was relatively undeveloped, with sparsely populated coastline mostly by Jordanians in search for better job opportunities. More recently, in 1965, King Hussein traded 6000 Km^2 of Jordanian desert with Saudi Arabia for another 12 kilometers of prime coastline to the south of Aqaba. Archaeologists who have worked extensively in Aqaba believe that civilizations were built or established in safe and secure areas. Hence, there is little potential of having surface archaeological sites on flood plains and alluvial fan of Wadi Araba or the proposed development area. Such a location renders them at risk of being directly in the way of flash flood events. This fact is very evident in the existing discoveries of archaeological sites and their concentration around the classic and Islamic Ayla. These sites are located along the coast that has formed an attractive site for the settlement of the various civilizations that inhabited the region.

Aqaba contains sites reflecting human habitation back to 4000 BC during the Iron Ages, resulting from the city's strategic location at the junction of trading routes between Asia, Africa and Europe. Some Biblical sources suggest that Aqaba was referred to as (Ezion-Geber), where King Solomon built ships to export copper from Araba Valley area to the known world that time, as trading routes developed connecting Aqaba with southern Arabia and Yemen, while the town grew into a thriving city. The Nabateans populated the region extensively, drawn by the strategic trading location of Aqaba. In Roman times, the great Via Nova Triana came down from Damascus passing through Amman to Aqaba, where it connected with a west road leading to Palestine and Egypt. No formal archaeological excavations exist within the boundaries of the AMR.

2.6.2 Recreation and Tourism Use

2.6.2.1 Dive Sites and Artificial Reefs

A number of dive sites are recorded within the current AMP boundary area. Details of these are presented within the "Hard Corals of Jordan: A Field Guide– 2019". Figure 14 outlines those dive sites that are located within the proposed AMR and Table 19 describes the observations and locations of each dive site. Most that are selected maximize the diversity of habitats and substrate profiles and included natural and artificial substrates. The different reef zones explored include the flat, crest, upper and lower slope down to a maximum of 30m.

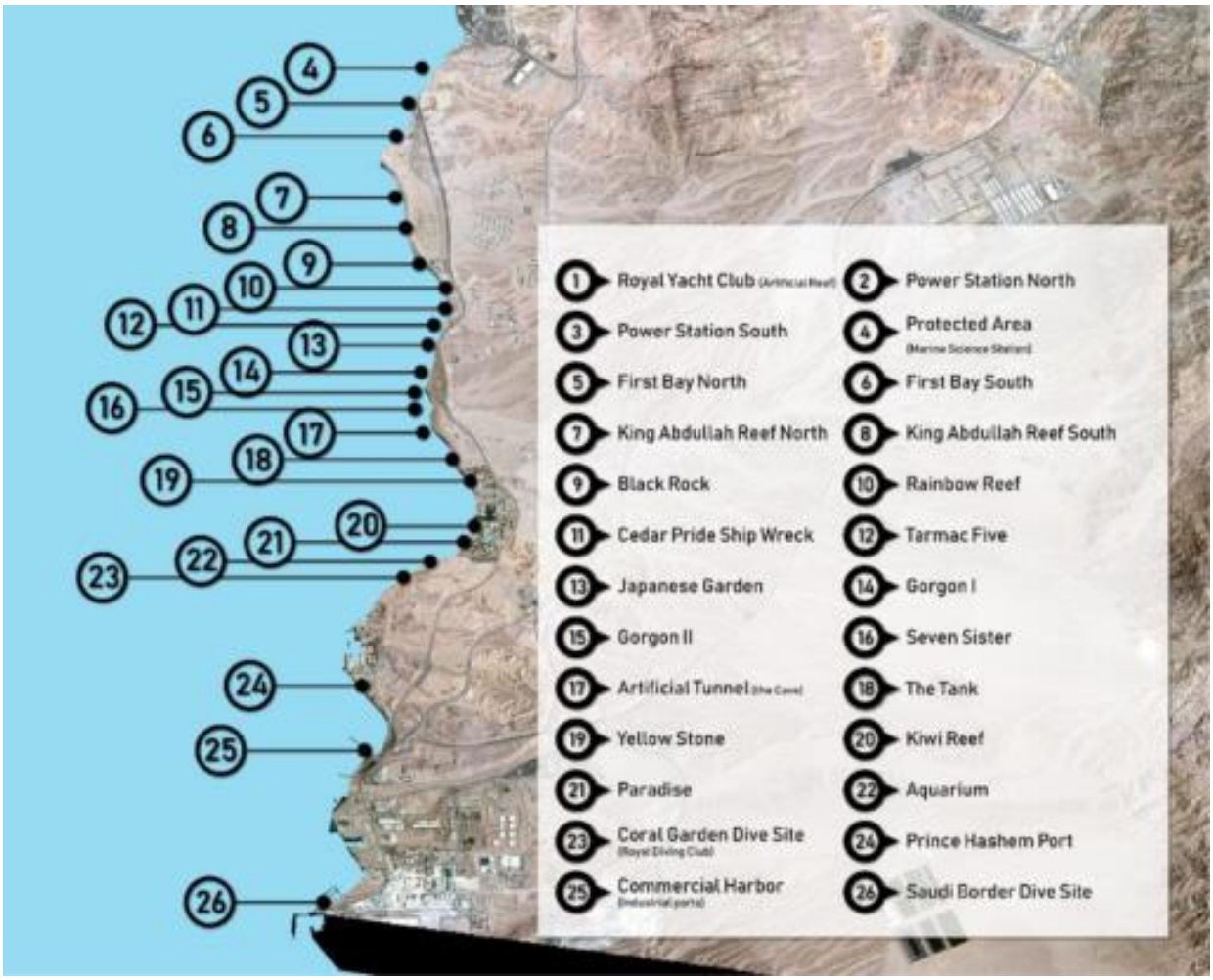


Figure 14: Dive sites within the Aqaba Marine Reserve (NB: sites 1-3 inclusive are further north)

Table 19: Dive Sites within the proposed Aqaba Marine Reserve

No.	Name	Coordinates	Description of Dive Site
1	Marine Science Station/ Al Mahmiyeh	Latitude 29°27'8.56" Longitude 34°58'10.23"	The site is accessible through beach and boat but only for scientific researches and after obtaining the necessary permission. The site is protected since mid-1970 when the MSS was founded, and where only research activities are allowed. However, corals and fish species are collected to be displayed at the MSS public aquarium
2	First Bay (North)	Latitude 29°27'1.30" Longitude 34°58'8.50"	The site is accessible by boat or shore, and represents the first diving site within the AMP, and is characterized by the presence of fringing reef located between 2 – 5 m depth and has a wide sandy plain at 9 m depth with intermittent coral clusters. There is a pinnacle with a banana shape to the west of the mooring at 15 m. This is a good reference point if diving deeper on this site as it is opposite the shore entrance through the fringing reef

3	First Bay (South)	Latitude 29°26'57.10" Longitude 34°58'8.70"	The site is accessible through boat and easily reachable from shore. It contains many black coral trees and usually has a large number of coronet fish hunting smaller glassfish. The site also has a large number of colourful parrotfish.
4	Military museum	Latitude 29°26'42.03" Longitude 34°58'1.77"	The Military Museum, scuttled in 2019, offers 21 fascinating relics of battle placed along the seabed to mimic a tactical battle formation, creating an exciting underwater experience intriguing divers and snorkelers alike. Military hardware here, donated by the Jordan Armed Forces-Arab Army, includes tanks of different sizes, an ambulance, a military crane, a troop carrier, and a combat helicopter. The site complies with best environmental practices and its location was specifically chosen for its lack of coral and other marine life.
5	King Abdulla Reef (North)	Latitude 29° 26.536′ N Longitude 34° 58.166′ E	The site is accessible through boat or shore, and is considered one of the most popular diving sites, where reefs contain beautiful fan colours and large shoals of pennant fish. Torpedo rays and Hawksbill turtles are also a common sight. The site has very high densities of coral coverage and is ideal for underwater photography
6	King Abdulla Reef (South)	Latitude 29°26'31.00" Longitude 34°58'7.40"	The site is accessible by boat or shore, and holds the presence of an extraordinary ecosystems and species diversity, and the AMP has installed mooring at the site.
7	Al Yamaniyah	Latitude 29°26'24.20" Longitude 34°58'8.30"	Refer to King Abdulla Reef south
8	Aquarium	Latitude 29°26'12.00" Longitude 34°58'11.40"	Refer to King Abdulla Reef south
9	Black Rock	Latitude 29°26'3.70" Longitude 34°58'19.00"	The site is accessible by boat or shore, and is ideal for snorkelers, as a coral garden starts just below the surface and extends outwards for approximately 30m when it drops away steeply. The reef has a prolific number of fish and turtles could be observed. A new highlight of this dive is the area beneath the new jetty at Club Berenice where shoals of small fish gather providing food for many predators such as lionfish and barracuda. The sea grass area to the south holds the presence of several species including grey morays and seahorse.

10	Baby bubbles	Latitude 29°25'58.10" Longitude 34°58'23.80"	This site provides an excellent training area for divers with standing depth down to 5m on a flat sandy bottom – here you can practice without any danger of damaging corals.
11	Rainbow Reef (Cable Area)	Latitude 29° 29°25'55.10" Longitude 34°58'24.50"	The site is accessible by boat and shore, and is named after the reef shape, which resembles the rainbow. The alternative name "cable area" is named after the telecommunication cable that connects Egypt and Jordan, which is visible at the site. It is considered ideal for night dives, where several species could be observed including large Spanish Dancers, lobsters, Feathered Starfish, moray eels and Lionfish. In addition, divers could easily reach the Cedar Pride Shipwreck if diving started from the shore.
12	Alhusany	Latitude 29°25'52.00" Longitude 34°58'23.03"	Refer to Rainbow site above.
13	Cedar Pride Shipwreck	Latitude 29°25'49.60" Longitude 34°58'22.80"	One of Aqaba's most iconic dive sites, the Cedar Pride is a former Lebanese freighter that sustained extensive damage during a fire. It was scuttled for divers in 1985 approximately 150m offshore on its port side at a maximum depth of 26m across two reefs. Since then, the wreck has been colonized by numerous hard and soft corals. The site is marked by a surface buoy and can be accessed from the shore or by boat. Experienced divers can explore the ship's interiors, and the site is highly recommended for underwater photographers and night divers.
14	Tayoung	Latitude 29°25'43.10" Longitude 34°58'17.50"	The wreck of the crane barge Tayoung is perfect for more experienced technical divers. Sunk on its starboard side not too far from the Japanese Garden, Tayoung is covered with multi-coloured corals from bow to stern and offers a great opportunity to swim through the ship's wheelhouse and explore its machinery.
15	Tarmac Five	Latitude 29°25'51.2"N Longitude 34°58'24.6"E	Divers enjoy a joint dive between Tarmac and the Cedar Pride especially when boat diving is performed. Also a great deep technical dive can be done here down a gulley starting at 40m dropping to 75m plus, this site is known as Kleta's Wall (named after a German dive master who explored it in 1996). There are many large gorgonian fan corals here and some fantastic gullies to explore. Large tuna fish and other pelagic species are often spotted at depth here. See above section on submerged wrecks.
16	Japanese Gardens	Latitude 29° 29°25'39.20"	The site is accessible by boat or shore, and is located to the south of the Shipwreck. One of the best dive sites worldwide with very good conditions for diving and snorkeling. The reef begins in shallow water and then gently

		Longitude 34° 34°58'18.70"	slopes to the magnificent colourful reef bed where very large schools of Anthias (Gold fish) play with the golden sunbeams while getting their snack of plankton around the pinnacles. Lyre Tail Groupers, Royal Angelfish, Moray Eels, big Clam Shells are also very common here. In 2013 many corals were placed here from the Saudi Border to save them from destruction due to development of a new port facility there.
17	Abu Hasbah	Latitude 29°25'234.60" Longitude 34°58'13.30"	Refer above to the Japanese Gardens.
18	Gorgone I	Latitude 29°25'28.00" Longitude 34°58'15.60"	The site is accessible by boat or shore, and it was named after a large Gorgonia fan coral located at 16m depth. Maximum depth of the site is 18m and is excellent for newly certified divers. It has an entry access from shore of 3m wide and 4m deep, after passing through this wonderful passage the diver is met with a vast cabbage coral. This dive provides examples of a fantastic array of the different varieties of the coral of the Red Sea. The site has three large pinnacles extending from the bottom to near the sea surface, inhabited by unique soft and hard corals forming a safe and wealthy home for many kinds of beautiful invertebrates and fish, boulders, sea fans and table corals.
19	Gorgone II	Latitude 29°25'16.90" Longitude 34°58'15.90"	The site is accessible by boat or shore, and resemble the Gorgone I in species diversity and richness, especially for corals. The site is named after Gorgonia fan-coral that used to sit at 22m depth and is sadly no longer there. Several species could be observed such as Moray Eels, Lionfish, Blue Tangs and other surgeonfish. Multiple coral clumps create a small maze giving the diver something to wander leisurely through on their safety stop.
20	Seven Sisters	Latitude 29°25′11.9″N Longitude 34°58′19.4″E	Easily accessed from shore over grass, the Seven Sisters reef begins at 3m and extends down to 16m. The site has two sets of pinnacles bustling with sea life and vibrant colours. From blennies and damsels to butterflies and barracuda, are plentiful as these pinnacles make a great nursery. Larger species are less common at this shallow level. The Seven Sisters is a great location for an underwater photo-shoot.
21	Tank	Latitude 29°25'9.20" Longitude 34°58'18.60"	A submerged M42 Duster, tank (found in 1999) is a great location for learners and beginner divers, or an interesting safety stop on a dive of the nearby canyons. This site is also highly recommended for snorkelling and free-diving as it sits on a sandy bottom under just 6m of water. Soft corals and sponges have taken hold in the hull.

22	Hercules C-130	Latitude 29°25'6.60" Longitude 34°58'17.80"	Scuttled in 2017 and already an Aqaba favourite, this C-130 military aircraft is easily accessible from shore or by boat. The Hercules is an impressive sight with a length of 30m and a wingspan of 40m, and it is almost always visible from the surface. This majestic wreck is in close proximity to the Cedar Pride and the Tank. The aircraft lies flat on its belly on a sand bed at an average maximum depth of 16m. This site is ideal for divers of all experience levels, and it is highly recommended to combine the C-130 with other wrecks in the vicinity for advanced tech divers.
23	Artificial Tunnel (the Cave)	Latitude 29°25'2.60" Longitude 34°58'23.50"	This site is accessible by boat or shore, within the AMP. It was established after port relocation to the south of Aqaba beach, and transplantation efforts of corals at AMP. The Cave is one of the newly created diving locations; the local experts planted coral reefs at the site four years ago and protected the site until the reefs regenerated. It is located south of tank dive site.
24	Eel Canyon	Latitude 29°24'59.40" Longitude 34°58'25.60"	The site was named after garden eel that protrude from the sand at the bottom of the canyon.
25	Shorouq	Latitude 29°24'55.50" Longitude 34°58'22.30"	A large, well-preserved wreck that lies on her starboard across two reefs to the west of Kirk's Forest Reef - named after Kirk Green, a pioneer of diving in Aqaba back in the '80s. Al Shorouq is a deep and technical wreck as her bow is at 38m and her stern at about 60m. At these depths, the coral growth is slower than above – remarkably free from encrustation and corrosion. The ship was scuttled in 2008 and although intended for shallower water, it drifted away and could have easily ended up under over 100m of water.
26	Yellowstone Reef	Latitude 29°24'52.30" Longitude 34°58'27.30"	This site is accessible by boat or shore, and was named for a large coral boulder, which looks yellowish when viewed from the surface. The site lies just north of the Tala Bay hotel development. With the deeper depths of this reef at over 30 m, deep divers may experience some of the larger sea life we have here such as stingrays and Napoleon Fish.
27	Blue Corals	Latitude 29°24'43.60" Longitude 34°58'33.60"	Known for its blue corals, this site is open-ended in terms of size and depth. The reef begins at 10m and contains 3 massive coral shelves and a number of pinnacles protruding from the sandy bottom and seagrass bed. In the shallows, turtles, morays, reef fish, and an invertebrates can be seen, especially nudibranchs.
28	Kiwi Reef	Latitude 29°24'24.00"	This site is accessible by boat or shore, and was named for a diver from New Zealand who discovered this dive site. The site consists primarily of dense sea-grass beds along a steep slope. At a depth of 12-20 m, a series of small

		Longitude 34°58'29.40"	coral pinnacles litter the bottom creating small clusters of self-contained ecosystems.
29	Moon Valley	Latitude 34°58'21.63" Longitude 29°24'18.66"	Named after a valley in Wadi Rum, this site drops of steeply but offers a nice dive in the medium depth range 10-25m. Large pelagic creatures can be spotted here, especially the occasional shark, lots of Unicorn Fish and some large Napoleon Wrasses.
30	Paradise	Latitude 29°24'16.20" Longitude 34°58'14.80"	Named after the red soft coral growing in the area which catches the current. This site is accessible by boat only, where a gentle slope with patch corals leads to a pinnacle and cave at the edge of a wall at greater than 40 m can be found. In addition, a soft coral garden at 10-15 m exists, where several species can be encountered such as Stingrays and Eagle Rays.

Along the southern shore and within the boundaries of the proposed AMR (from the MSS to the northern boundary of Tala Bay) there are six public beaches equipped with all the main services such as umbrellas, seats, toilets, parking lots, sales kiosks, barbecue stoves, ambulance and rescue units, camping areas, playgrounds, etc (Figure 15).

On the shores of the AMR, there are jetties and special sites used for the loading and unloading of passengers by glass-bottom boats. On these beaches there are areas designated for different categories of swimmers, marked with special signs. In addition to the AMP visitor centre, which includes administration offices, galleries, halls of various purposes, and a restaurant.


Beach 1
Beach 2
Beach 3
Beach 4
Beach 5
Beach 6
AQABA
SPECIAL ECONOMIC ZONE AUTHORITY
صورة جوية 2014
Produced by
Eng. Reem Mobiedeen

Figure 15: Public beaches available within the AMR boundary[118]

2.6.3 Other Socio-Economic Uses

2.6.3.1 Fisheries or "bait" Areas

As for the services provided to fishermen within the AMR, fishing is only permitted within the boundaries of the proposed AMR for the purposes of collecting live bait. This can only take place in the early morning hours until nine o'clock as a supporting mechanism from ASEZA to the fishermen in response to the limited areas they have to operate within. Fishing is however allowed within the pelagic waters outside the boundaries of the AMR and within 100m depths and 300m distance before the limit of Jordanian territorial waters. Fishing in the northern parts of Aqaba is also allowed under conditions of keeping a distance from ship anchors, swimming and marine sports areas as well as security sensitive sites. Fishing is not permitted near ports, docks, industrial and border areas (Figure 16). No specific fishing sites are located directly within the AMR.

[118] ASEZA, 2020

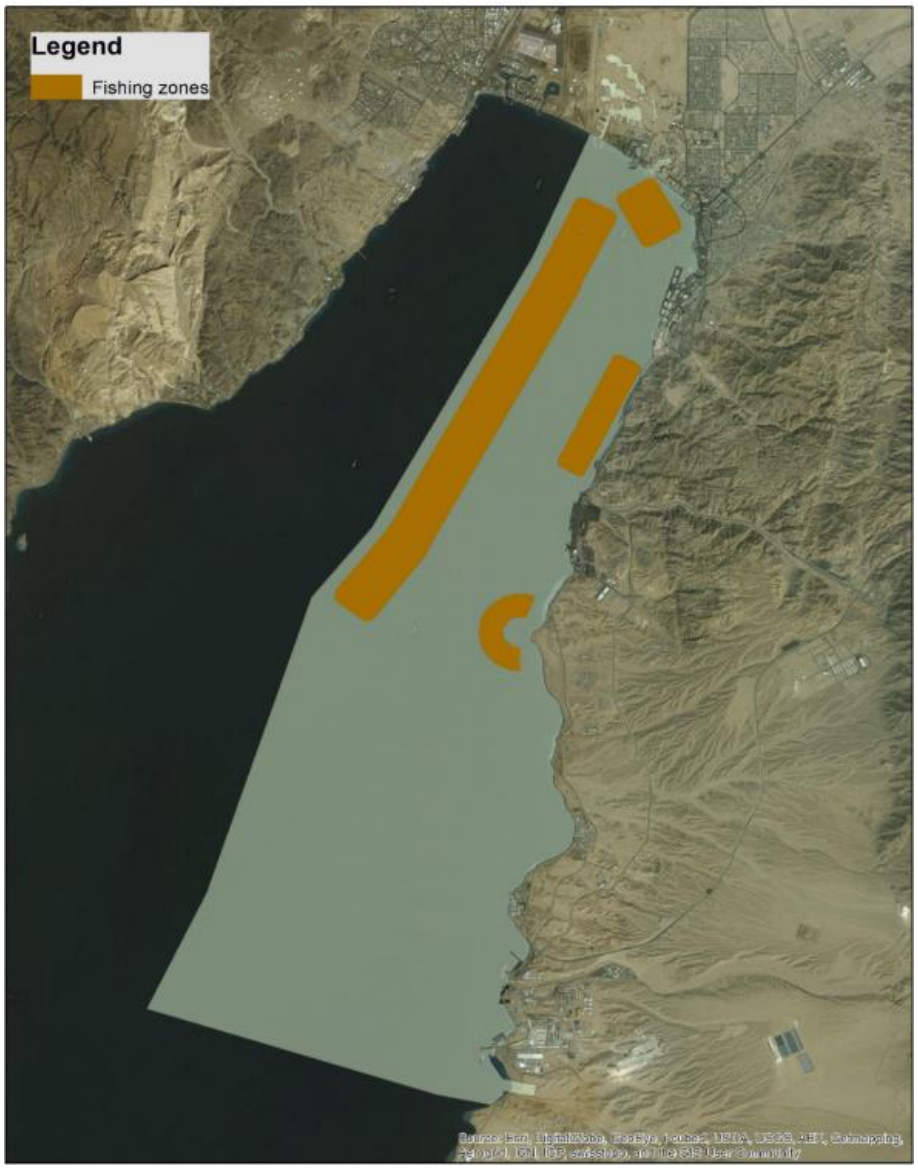


Figure 16: Fisheries sites closeto the AMR

2.6.4 Education Use/facilities

2.6.4.1 Aquarium

A single aquarium is located at the Marine Science Station at Aqaba southern beach. Despite its importance as a tourism attraction, substantial harvesting of live corals and fish specimens occurs directly from the sea for exhibition purposes.

Part Three: Analysis of Conservation Targets and Threats

3.1 Conservation Targets

3.1.1 Identification of Conservation Targets

Conservation targets are species, assemblages or ecosystems that are selected as representing the biodiversity of a marine reserve or protected area – such that strategic actions, taken to ensure their continued viability and reduce the pressures impacting them, will adequately address the conservation needs of the system as a whole.

A series of Conservation Targets, or elements, have been chosen to represent and encompass the biodiversity values of the AMR, and to provide a basis for setting goals, developing strategies and actions, and monitoring success. For the purposes of the AMRMP (2022-2026), the selected targets are required to meet the following criteria, where possible (adapted from Third National Communication (TNC) Report, 2007):

- **Targets should represent the marine ecosystems and biodiversity of the site**. The focal targets should represent or capture the array of ecological systems, communities, and species of importance at the project area and the multiple spatial scales at which they occur.
- **Targets reflect eco-region or other existing conservation goals**. Focal targets should reflect efforts at the regional and national level where they exist (i.e.: NPAS and the Jordan National Biodiversity Action Plan. Focal targets are focused upon protecting the AMR plus the identification of the AMR as one of the regions key marine areas of ecological, biological and social importance.
- **Targets are viable or at least feasibly restorable**. Viability (or integrity) indicates the ability of a conservation target to persist for many generations. If a target is on the threshold of collapse, or conserving a proposed target requires extraordinary human intervention, it may not represent the best use of limited conservation resources.
- **Targets are threatened**. All else being equal, focusing on threatened ecosystems and species will help ensure that critical threats are identified and addressed through conservation actions.
- **Targets are endemic**. Focus on endemism level and will help ensure that critical threats are identified and addressed through conservation actions.

Four ecosystem assemblage targets have also selected to represent the core focus for this AMRMP (2022-2026).

- Coral Reefs;
- Seagrasses;
- Terrestrial Ecosystems;
- Open Sea Ecosystems.

3.1.2 Assessment of Conservation Target Viability

The following Conservation Target Viability assessment, as conducted under this AMR Conservation Planning process, provides:

- A means for determining changes in the status of each focal target over time, to measure success of conservation strategies, compare the status of a specific conservation target with future conditions, and with other projects in the Gulf of Aqaba (or Red Sea region) that focus on that target;
- A basis for the identification of current and potential threats to a target and identification of past impacts that require mitigation actions;
- A basis for strategy design and the foundation for monitoring.

Each Conservation Target has been assessed using the following viability ratings:

- Very Good – The Indicator is considered to have an ecologically desirable status, requiring little or no intervention for maintenance;
- Good – The indicator lies within the acceptable range of variation, though some intervention is required for maintenance;
- Fair – The indicator lies outside the acceptable range of variation, and human intervention is required if the viability of the target is to be maintained;
- Poor – Restoration of the conservation target is increasingly difficult, and impacts may result in extinction from the AMR area

The overall viability rating for the AMR is GOOD, with one target rating as FAIR – Seagrass (Table 20). The relatively good biodiversity health of the AMR is one of the reasons for its high conservation importance.

Table 20: Biodiversity Viability Summary for Aqaba Marine Reserve

Conservation Targets (Current Rating)	Landscape Context	Condition	Size	Viability Rank
Coral Reefs	Very Good	Good	Good	Good
Seagrasses	Good	Fair	Fair	Fair
Terrestrial Ecosystems	Fair	Fair	Good	Good
Open Sea Ecosystems	Good	Good	Good	Good
AMR Biodiversity Health Rank				Good

The category assessment "scores" presented above (for each key conservation target) have been derived from a series of attributes and indicators that are set for the AMR as follows (Tables 21a to 21d):

Table 21a: Coral Reefs Target Viability (AMR relevance)

Coral Reefs – Target Viability								
Category	**Key Attribute**	**Indicator**	**Poor**	**Fair**	**Good**	**Very Good**	**Current Status**	**Desired Status**
Landscape Context	Water Quality	Turbidity	>100mg/l	10 - 100mg/l	<10mg/l	0mg/l	Very Good	Very Good
		Water temperature	<24 or >30˚C	24-25 or 29-30˚C	25-26 or 28-29˚C	26-28˚C	Good	Good
		Salinity	<35‰	35-40‰	40.6‰	40.6 to 41.6‰	Good	Good
	Connectivity	# man-made structures / impacts that block natural water flow					Very Good	Very Good
Condition	Coral Health	% live coral cover			Current status		Fair	Good
	Recruitment	# coral recruits / m2	0.00 to 10.0 recruits/m2	10.0 to 15 recruits/m2	15 to 20 recruits/m2	> 20 recruits/m2	Good	Very Good
	Trophic Structure	# species of sharks		Current status			Fair	Good
Size	Abundance of Reef Fish	Biomass of reef fish (g/100m2) north		Current status			Fair	Good
		Biomass of reef fish (g/100m2) south			Current status		Good	Very Good

Table 21b: Seagrasses Target Viability (AMR relevance)

Seagrasses – Target Viability								
Category	**Key Attribute**	**Indicator**	**Poor**	**Fair**	**Good**	**Very Good**	**Current Status**	**Desired Status**

Landscape Context	Water Quality	Turbidity		Current Status			Fair	Good
Condition	Density of Seagrass	% cover of seagrass		Current status			Fair	Good
Size	Size / extent of ecosystem	Extent of seagrass cover		Current status			Fair	Good

Table 21c: Terrestrial Ecosystems Target Viability (AMR relevance)

Terrestrial Ecosystems – Target Viability								
Category	**Key Attribute**	**Indicator**	**Poor**	**Fair**	**Good**	**Very Good**	**Current Status**	**Desired Status**
Condition	Health of beaches and intertidal vegetation	% successful fisheries nesting sites		Current status			Fair	Good
Size	Size / extent of ecosystem	Extent of beach sand and coastal vegetation cover			Current status		Good	Good

Table 21d: Open Ocean Ecosystems Target Viability (AMR relevance)

Open Ocean Ecosystems – Target Viability								
Category	**Key Attribute**	**Indicator**	**Poor**	**Fair**	**Good**	**Very Good**	**Current Status**	**Desired Status**
Condition	Health of the open ocean	% zooplankton health No. of oil spill/chemical spill incidents Salinity		Current status			Fair	Good
Size	Size / extent of ecosystem	Extent of ocean under protected status			Current status		Good	Good

3.2 Threats to Biodiversity

3.2.1 Rating Critical Threats

For this AMRMP (2022-2026) the term "stress" is defined as *"the impaired aspects of conservation targets that result directly or indirectly from human activities (e.g., low population size; increased sedimentation; lowered groundwater table level)"* (see Tables 22 and 23 for scores and criteria used in this AMRMP).

Table 22: "Stress" Scores and Definitions of relevance to this AMRMP (2022-2026)

Stress Scores for the AMRMP (2022-2026)		
Criteria	**Score**	**Definition**
Severity: The level of damage to the conservation target that can reasonably be expected within 10 years under current circumstances (i.e., given the continuation of the existing situation).	Very High	The threat is likely to destroy or eliminate the conservation target over some portion of the target's occurrence at the site
	High	The threat is likely to seriously degrade the conservation target over some portion of the target's occurrence at the site
	Medium	Medium: The threat is likely to moderately degrade the conservation target over some portion of the target's occurrence at the site.
	Low	The threat is likely to only slightly impair the conservation target over some portion of the target's occurrence at the site.
Criteria	Score	
Scope: The geographic scope of impact on the conservation target at the site that can reasonably be expected within 10 years under current circumstances (i.e., given the continuation of the existing situation).	Very High	The threat is likely to be widespread or pervasive in its scope and affect the conservation target throughout the target's occurrences at the site.
	High	The threat is likely to be widespread in its scope and affect the conservation target at many of its locations at the site.
	Medium	The threat is likely to be localized in its scope and affect the conservation target at some of the target's locations at the site.
	Low	The threat is likely to be very localized in its scope and affect the conservation target at a limited portion of the target's location at the site

For this AMRMP (2022-2026) the term "Source of Stress (Direct Threat)" is defined as *"the proximate activities or processes that directly have caused, are causing or may cause stresses and thus the destruction, degradation and/or impairment of focal conservation targets"* (e.g., population growth etc).

Table 23: "Source of Stress" Scores and Definitions of relevance to this AMRMP (2022-2026)

Sources of Stress Scores for the AMRMP (2022-2026)

Criteria	Score	Definition
Contribution: The expected contribution of the source, acting alone, to the full expression of a stress (as determined in the stress assessment) under current circumstances (i.e., given the continuation of the existing management/ conservation situation).	Very High	The source is a very large contributor of the particular stress.
	High	The source is a large contributor of the particular stress.
	Medium	The source is a moderate contributor of the particular stress.
	Low	The source is a low contributor of the particular stress.
Criteria	**Score**	
Irreversibility: The degree to which the effects of a source of stress can be restored	Very High	The source produces a stress that is not reversible (e.g., sabkha converted to a shopping center).
	High	The source produces a stress that is reversible, but not practically affordable (e.g., sabkha converted to agriculture).
	Medium	The source produces a stress that is reversible with a reasonable commitment of resources (e.g., ditching within a sabkha).
	Low	The source produces a stress that is easily reversible at relatively low cost (e.g., off-road vehicles trespassing onto coastal vegetation).

The following outlines commentary of the key threats that are facing the AMR and Management Strategies proposed to help redress the threat identified.

3.2.2 Strategies to Reduce Threats

The following tables develop further the threats identified in Section 3.2 and define the status, target scores and proposed management strategies to reduce the threats identified (see Section 5 for complete Action Plan listing).

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 1: Population Growth, and the Associated Recreational and Tourism Growth	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses; Terrestrial Ecosystems;			
	Commentary on the Threat: The resident population is growing rapidly in Jordan generally and at Aqaba city specifically, and is associated with an exponential increase in number of visitors to Aqaba where a total of 423,000 locals have visited Aqaba out of 931,000 tourist recorded in 2019. The population increase is associated to a number of factors including (but not limited) to the increasing demands over the limited resources available, increase solid waste creation, increase infrastructure along the limited coastline and the demands for more job creation. In addition, Aqaba is considered the only maritime in Jordan, and a major touristic destination, which resemble intense visitation rates which will overburden the limited resources. Visitors to Aqaba enjoy water sports activities such as diving, which is considered a major industry at Aqaba with the presence of around 30 diving centers established so far. More than 80% of the diving sites are located within the boundaries of the proposed AMR. Snorkeling/swimming and diving are considered the cause the most damage to marine biodiversity (see Annex A) within the proposed AMR. The North King Abdullah Reef is found to be the site that is most affected by these activities. Therefore, careful considerations to AMR carrying capacity is required. The increasing user demands within the limited coastal area that Aqaba possesses will result in the demand for more beach front related tourist and housing related projects (to increase accommodation and leisure). The established (and future planned projects) are expected to increase pressure on available beach areas whilst also placing an increased emphasis on having to re-direct visitors (national and international) to those beaches that are currently managed by the AMP. Two touristic destinations exist within the proposed AMR boundaries which include the Pranice beach and diving centre and Tala Bay. Environmental friendly practices are being implemented at Tala Bay especially as a result of the resort recently obtaining both Green key and Blue Flag international eco-certifications. However, pressures associated with waste management remains a potential pressure facing the proposed AMR area. A mega project (Marsa Zayed) is planned at the northern parts of the proposed AMR. This project is the largest real estate project in the history of Jordan, covering an area of 3.2 km2 and 2 km of waterfront, and a total cost estimated at 10 billion USD. Its potential scale runs the risk of it completely changing the social characteristics and character of Aqaba. The project requires the relocation of the existing main port and includes high-rise buildings, a marina, a cruise ship terminal, hotels and approximately 21,000 units of housing - apartments, villas and townhouses. This would almost double the existing housing stock of Aqaba and accommodate 50,000 people, mostly expatiates and residents of Amman. As a consequence, visitor pressure on the coastline, in particular, is expected to increase in targeted areas which is likely to require additional management, enforcement and resources for public areas, and proactive engagement through voluntary incentives with the private sector managing			

	privatized beaches. This will demand the need to strengthen the concepts of environmental eco-certifications for the touristic facilities, whilst also applying best practices in environmental-friendly development.	
	Stresses (Direct): Reduced extent of coastal habitats including beach vegetation; Reduced viability of terrestrial species; Reduced viability of nesting bird populations; Reduced viability of coral reefs; Removal of important marine nursery habitat; Reduction / pollution of freshwater lens. Presence of introduced predators – particularly dogs - reducing hatching success; Introduction of exotics – Casuarina, coconut palms.	
	Sources of Stress (indirect); Infrastructure development (tourism, research, enforcement, etc.) with removal of natural vegetation; Increased demand for land / tourism at adjacent or within the AMR; Increased erosion of sandy beaches; Inadequate, unplanned water and fuel management practices, with increased nutrients, sediment and pollutants in marine environment and freshwater lens; Lack of management presence in area and lack of direct management control.	
Severity	Very High	Where development occurs, there is generally complete removal of terrestrial vegetation, with associated impacts on biodiversity (dredging/port development is being addressed as a separate issue)
Scope	Medium	There is currently only localised development and tourist activity, though this is predicted to increase in the future.
Contribution	High	Where development impacts occur, they are the primary contribution to habitat loss and associated impacts
Irreversibility	High	It would be feasible to reverse the threat, but there are likely to be very high economic and political barriers.
Management Strategies	Strategy 1.1: Develop, adopt and promote AMR specific development guidelines, with input from ASEZA guidelines (including ICZM and future Marine Spatial Plan updates post 2020). Strategy 1.2: Ensure effective surveillance and enforcement against illegal development activities within the AMR – eg. non-permitted clearance of reef habitat, overwater / seawall construction, dredging etc; Strategy 1.3: Ensure effective surveillance and enforcement against illegal development activities within the AMR – eg. non-permitted clearance of beach areas, overwater / seawall construction, dredging etc .This should ensure effective management and monitoring of low impact tourism development. Strategy 1.4: Identify and map sensitive areas that would be severely damaged by vegetation clearance and inform ASEZA and MoE; Strategy 1.5: Strengthen and implement guidelines for sustainable development for any new developments, and ensure that new development activity is accomplished in a low-impact, eco-friendly manner (to be defined – ISO13009 beach certification etc.) and minimizes impacts to the natural environment (Ensure infrastructure is in place to minimize tourism impacts on the reef – signs, mooring buoys, designated dive sites). Strategy 1.6: Ensure development guidelines are followed in the construction and operation of the AMR Headquarters and rangers stations; Strategy 1.7: Encourage local residents / education / tourism developments to adopt and follow new AMR development guidelines;	

	Strategy 1.8: Ensure all EIAs produced (for ASEZA) that relate to future Aqaba developments are fully vetted and approved, and take into account zoning recommendations and regulations, and AMR guidelines. Strategy 1.9: Identify resilient coral sites and work with stakeholders to develop and implement zoning for coral protection. Strategy 1.10: Strengthen and implement guidelines for sustainable development for any new developments emphasizing low-impact high-end development

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 2: Port Development	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses; Terrestrial Ecosystems; Open Sea Ecosystems			
	Commentary on the Threat: The estimated area of hard corals affected by direct impact, based on ports relocation to the southern beach of Aqaba near the Saudi border, is 32,509 m2. In spite of this extensive damage, coral transplantation efforts have been conducted since 2012 where corals from the southern region of the coast have been transplanted onto damaged reefs in tandem with the introduction of a range of artificial structures) using a range of cement and metal structural units which have been constructed within the proposed AMR area. Regardless, it is expected that the damages anticipated from the port relocation on the AMR area will be minimal due to its proximal distance away from critically important sites as well as the contingency measures being applied by the port. In spite of the above, two ports are still located close to the proposed AMR boundaries, namely the passenger port which is located at the northern edges of the proposed AMR, and the Aqaba Container Terminal (ACT) is situated northern of it. These collectively may create negative environmental effects especially of the impacts of any wastes created and disposed within GoA receiving waters. Positive indicators do exist including a suite of environmental rewards that ACT have recently been awarded for their environmental and social safeguarding credentials. Also, the proposed AMR management team should be able to build upon the Social Corporate Responsibilities program to help support the AMRs budget to help provide mitigation strategies to negate any potential environmental impacts.			
	Stresses (Direct); Reduced extent of seagrass and viability of associated biodiversity; Reduced viability of seagrass in adjacent areas to the port; Reduced viability of coral reefs; Removal of important marine nursery habitats.			
	Sources of Stress (indirect); Sedimentation impacts on seagrass and coral from port maintenance and capital dredging Programs; Demand for landfill for port developments; Demand for deep water access.			
Severity	Very High	Where port maintenance dredging occurs, there is complete removal of the benthic flora and fauna (predominantly seagrass)		
Scope	High	There is currently moderate localised maintenance dredging activities, though this may be predicted to increase in the future.		

Contribution	Very High	Where port development impacts occur, they are the primary contribution to habitat loss and associated impacts.
Irreversibility	Medium	It would be feasible to reverse the threat with some effort
Management Strategies	Strategy 2.1: Develop, adopt and promote AMR development guidelines, with input from ASEZA/MoE and others; Strategy 2.2: Ensure effective surveillance and enforcement against illegal (non-port related) dredging activities within the AMR; Strategy 2.3: Identify and map sensitive areas that would be severely damaged by dredging and inform ASEZA; Strategy 2.4: Limit dredging within the AMR to small scale non-mechanical operations (artisanal permits only) and for access purposes only, with a more robust assessment process to include strengthened environmental clearance process for dredging applications; Strategy 2.5: Ensure all EIAs are fully vetted and approved, and take into account zoning recommendations and regulations, AMR guidelines etc		

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 3: Sea Level Rise	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses; Terrestrial Ecosystems;			
	Commentary on the Threat: The relationship between global mean sea level rise and local sea level rise depends on a combination of factors, including changes in ocean circulation, variations in oceanic levels due to thermal expansion and relative sea-level change associated with land movements. The GoA is an extension of the Levantine or Dead Sea Fault, and part of the Red Sea Rift that are tectonically active leaving the possibility of sea level increase. Therefore, it is expected to witness a sea level rise throughout the GoA, which will have several consequences including infrastructure loss and other serious economic and social losses. The consequences of sea level rise will have serious effects on the limited shorelines that naturally occur plus the impact that unplanned infrastructure development can have on shoreline extent. In 2019, strong tidal currents (and storm surges) led to major infrastructural impacts on the submerged artificial diving sites. For that, the existence of healthy coral reefs will certainly aid to protect diving industry, and the infrastructure within the AMR.			
	Stresses (Direct); Reduced live coral cover; Reduced coral growth rates; Reduced biodiversity; Erosion of beach; Reduction in extent of herbaceous beach vegetation; Ecological shifts in benthic communities			
	Sources of Stress (indirect); Increased water temperatures; Increased strength of storm events; Changes in currents; enhanced sedimentation and impacts of smothering sensitive submerged habitats;			
Severity	Very High	Sea level rise (and climate change) is a global phenomenon, and is considered a significant risk to a wide range of species and marine ecosystems throughout the AMR – particularly the nearshore and terrestrial ecosystems		

Scope	Very High	The impacts of sea level rise (and climate change) are currently being felt in Aqaba through increased bleaching events, and it is expected that the severity and frequency of these events will increase over the coming years.
Contribution	Very High	Sea level rise (and climate change) is becoming one of the single largest contributing factor to the decline in biodiversity viability of the marine ecosystems.
Irreversibility	Very High	Sea level rise (and climate change) impacts may not be reversible within our life time – strategies need to be geared towards mitigation.
Management Strategies	Strategy 3.1: Identify resilient areas within the AMR in the context of site level management and the national protected areas system (NPAS). Strategy 3.2: Identify and increase protection of resilient coral reefs, source populations and key larval dispersal routes; Strategy 3.3: Establish monitoring protocols that inform management for building reef resilience; Strategy 3.4: Engage stakeholders in climate change adaptation strategies – including shoreline protection through conservation / rehabilitation of beaches and reefs; Strategy 3.5: Investigate mechanisms for direct interventions – eg. coral nurseries, shading of key sites, promoting higher herbivore densities; Strategy 3.6: Strengthen protection of marine trophic structure - maintenance of top predators and herbivores.	

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 4: Flood Risk	**Status**	Historical	Active	Potential
	Conservation Target(s): Terrestrial Ecosystems;			
	Commentary on the Threat: Several wadis flow east west, though water flow remains seasonal, flowing in a seaward direction. Despite low annual average rainfalls, flash flooding is becoming a more frequent problem especially along the more vulnerable northern parts of Aqaba. These areas contain all the town residential expansion area, the Aqaba International Industrial Estate, the King Hussein International Airport, and all the northern light industries and logistics areas. Forty six (46) catchment areas have been identified which input into the Aqaba basin from the Jordanian side. There are seven main catchments draining to the coastline. Within the proposed AMR area, runoff from Wadi 9 (Al-Mamlah) passes through the tourist area of the "Coral Coast" and Tala Bay within the proposed AMR. A significant sediment load is also carried by runoff from this catchment where a key source of pollutants occurs. Runoff with extreme flooding is caused when rainfall occur in adjacent regions of Aqaba, which will have negative consequences on the marine life at the GoA, where it will change water salinity, turbidity, temperature and also disruption of microbiological activity and life cycles of flora and fauna. AS stated above, the northern parts of Aqaba are the most vulnerable regions for flash flood hazards since they are located downstream from areas of major wadis. In spite of this, latest climate predictions show a decrease of rainfall by 2050 reaching less than 50% of current rainfall in the North			

	of Aqaba. In order to mitigate the negative effects of flash flooding on Aqaba generally and the AMR specifically, ASEZA has established 40 dams at the eastern wadis flowing to Aqaba.	
	Stresses (Direct); Reduced terrestrial biodiversity; Erosion of beach; Reduction in extent of herbaceous beach vegetation; Ecological shifts in benthic communities.	
	Sources of Stress (indirect); Increased strength of storm events and flood conveyance from wadis; Changes in sediment input to beaches resulting in enhanced sedimentation and impacts of smothering sensitive submerged habitats;	
Severity	Very High	Wadi flood risk is considered a risk to a wide range of terrestrial and intertidal species and marine ecosystems throughout the AMR – particularly the nearshore and terrestrial ecosystems. Severity is lessened should engineering planning solutions (drainage) be properly managed as part of the AMR future design.
Scope	Medium	The impacts of wadi flash flooding may be felt more in other northern parts of Aqaba, and it is expected that the severity and frequency of these flash flood events will increase over the coming years, though impacts in the AMR are less than elsewhere.
Contribution	Very High	Changing precipitation levels (and climate change) is becoming one of the single largest contributing factor to the decline in biodiversity viability of terrestrial and marine ecosystems.
Irreversibility	High	Changing precipitation levels (and climate change) impacts may not be reversible within our life time – strategies need to be geared towards mitigation of flood risk.
Management Strategies	Strategy 4.1: Identify resilient areas within the AMR in the context of needing flood risk management measures to be introduced (using Nature based Solutions where possible as part of the national protected areas system (NPAS). Strategy 4.2: Identify and increase protection of wadi systems plus ensuring the land use planning is cognisant of flood risks associated with wadi and flood conveyance routes; Strategy 4.3: Establish flood risk monitoring protocols that inform management for managing floods plus the impact that increased sedimentation can have on nearshore habitats; Strategy 4.4: Engage stakeholders in flood risk management strategies – including flood conveyance interventions; Strategy 4.5: Investigate mechanisms for direct engineering interventions – eg. Flood storage areas, use of vegetation, drainage channels etc.	

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 5: Extreme Low Tide Events	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses.			

	Commentary on the Threat: A major characteristic of the proposed AMR are the healthy coral reefs, which will be affected by an increased frequency of extreme low tide events. Such events cause corals to be exposed during daylight hours, which subsequently lead to the overheating and drying out of coral tissues. In addition, some irresponsible activities might happen in the event of extreme low tides, where people may be more able to walk onto reefs to collect souvenirs and cause serious damage to individual corals (Al Tawara et al 2019).	
	Stresses (Direct): Trophic shifts in marine ecological communities.	
	Sources of Stress (indirect):	
Severity	Very High	Dependent upon the increased frequency of extreme low water events and knowledge of tidal conditions/tectonic land uplift issues.
Scope	Medium	Such events cause corals to be exposed during daylight hours, which subsequently lead to the overheating and drying out of coral tissues.
Contribution	High	Some irresponsible activities might happen in the event of extreme low tides, where people may be more able to walk onto reefs to collect souvenirs and cause serious damage to individual corals.
Irreversibility	High	A major characteristic of the proposed AMR are the healthy coral reefs, which will be affected by an increased frequency of extreme low tide events.
Management Strategies	Strategy 5.1: Initiate and formalise tidal monitoring to help predict onset of extreme low ide events and build reef resilience. Strategy 5.2: Initiate strategies /protocols of action to mitigate the impacts of such low tide events; Strategy 5.3: Engage stakeholders in the impact of extreme low tide events and associated strategies – including conservation / rehabilitation of reefs; Strategy 5.4: Investigate mechanisms for direct interventions – e.g.: coral nurseries, shading of key sites, promoting higher herbivore densities.	

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 6: Water Quality Issues	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses; Terrestrial Ecosystems; Open Sea Ecosystems			
	Commentary on the Threat: The GoA is highly vulnerable to pollution, where both water stratification and intense dust storms are the major contributing factors to the observed seawater chemistry. In order to identify water quality deterioration, several parameters should be investigated including pH, total dissolved solids (TDS), total alkalinity (TA), Cl^{-}, $NO3^{-}$, SO_4^{2-}, PO_4^{3-}, NH^{4+}, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Sr, Cd, Co, Cr, Cu, Fe, Mn, Pb, and Zn. Generally, the mean value of pH at Aqaba is 8.26, with no clear trend due to the calcium carbonate buffering capacity of water[119]. The average value of			

[119] Al-Taani et al. 2020

	TA recorded at 146 mg/L, while the TDS average value is 41.95 g/L. The high TDS values are linked to water stratification and poor water circulation during the sampling period, which in consequence created a unique environmental conditions of higher temperature, evaporation, and salinity rates compared to other oceans. In addition, the lack of input of freshwater into the coastal water contributes to high salinity water, and the negligible supply of sediments into the water results in clear water conditions with high transparency. Inorganic nutrients such as nitrate, ammonium, and phosphate are minor constituents of seawater, but are essential for marine ecosystem productivity and growth. Relatively low levels of inorganic nutrients such as $NO3^{-}$, PO_4^{3-}, and NH^{4+} have been observed in surface water layer. The coastal waters of Aqaba are extremely oligotrophic, with very limited nutrients supplied to Gulf's water through terrestrial runoff. Any high NH^{4+} levels could be associated with leaks from sewer systems and/or because of water discharged from fish farms which are enriched with enhanced nitrogen or possibly from fertilizer plume events[120]	
	Stresses (Direct); Contamination of waters from boats throughout the AMR, due to inappropriate sewage and grey water treatment, leading to eutrophication, with associated accelerated algal growth and coral loss; Inappropriate solid waste disposal from boats; Contamination of waters by runoff containing herbicides, insecticides/detergents;	
	Sources of Stress (indirect): Reduction and pollution of freshwater lens.	
Severity	High	Water pollution is strongly influence by stratification and intensity of dust storms are the major contributing factors to the observed seawater chemistry.
Scope	Very High	High TDS values are linked to water stratification and poor water circulation which can create unique environmental conditions of higher temperature, evaporation, and salinity rates compared to other oceans.
Contribution	High	The lack of input of freshwater into the coastal water contributes to high salinity water, and the negligible supply of sediments into the water results in clear water conditions with high transparency. Inorganic nutrients such as nitrate, ammonium, and phosphate are minor constituents of seawater, but are essential for marine ecosystem productivity and growth.
Irreversibility	Medium	Generally, the mean value of pH at Aqaba waters is 8.26, with no clear trend due to the calcium carbonate buffering capacity of water. The average value of alkalinity recorded at 146 mg/L, while the TDS average value is 41.95 g/L. Relatively low levels of inorganic nutrients such as NO3−, PO43−, and NH4+ have been observed in surface water layer.
Management Strategies	Strategy 6.1: Set up Monitoring strategies In order to identify water quality deterioration, several parameters should be investigated including pH, total dissolved solids (TDS), total alkalinity (TA), Cl−, NO3−, SO42−, PO43−, NH4+, Ca2+, Mg2+, Na+, K+, Sr, Cd, Co, Cr, Cu, Fe, Mn, Pb, and Zn. Strategy 6.2: Set up a MoU with industries to partner on Programs to reduce nutrient input to the open ocean ecosystems. As the coastal waters of Aqaba are extremely oligotrophic, with very limited nutrients supplied to Gulf's water through terrestrial runoff, any high NH4+ levels is likely to be associated	

[120] Al-Taani et al. 2020

	with leaks from sewer systems and/or because of water discharged from fish farms which are enriched with enhanced nitrogen or possibly from fertilizer plume events.

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 7: Oil Spills	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses; Terrestrial Ecosystems; Open Sea Ecosystems			
	Commentary on the Threat: Jordan imports oil and liquefied natural gas (LNG) from adjacent countries, which pose threats of oil or liquid spills, which as a consequence, will have detrimental effects on its coastal waters and its associated ecosystems, the impacts of which is exacerbated noting the small width and semi-enclosed nature of the GoA. Several steps have been established by ASEZA such as the zero-discharge policy, cooperation at regional level through the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA), and the improvements made by the International Maritime Organization (IMO). Although few incidents of oil spills have been recorded in Aqaba, careful monitoring, preparedness and regulation enforcement shall all be required and formalized[121].			
	Stresses (Direct): Jordan imports oil and liquefied natural gas (LNG) from adjacent countries, which pose threats of oil or liquid spills, which as a consequence, will have detrimental effects on its coastal waters and its associated ecosystems, the impacts of which is exacerbated noting the small width and semi-enclosed nature of the GoA. Contamination of waters and corals from oil/chemical spills throughout the AMR; Inappropriate oil waste disposal from boats; Contamination of waters by runoff containing oils/chemicals (including insecticides/detergents etc).			
	Sources of Stress (indirect): Inadequate, unplanned oil and fuel management practices, with increased pollutants into the marine environment and freshwater lens; Lack of management presence in area with regard to oil spill contingency planning and lack of direct management control relating to oil spills.			
Severity	Very High	Where tankers operate in the open sea ecosystems (plus adjacent to ports), the transport and shipment of oils/fuels occurs, there is a major risk of oil spills and hence impacts on reef ecosystems, seagrass beds and sandy beaches.		
Scope	High	There is currently moderate localised chemical loading activities (adjacent to the port), though this may be predicted to increase in the future.		
Contribution	Very High	Where port development impacts occur, they are the primary contribution to habitat loss and associated impacts associated with oil / chemical spill impacts.		

[121] Al Tawaha et al. 2019

Irreversibility	Medium	It would be feasible to mitigate major threats with some oil spill contingency effort (booms), though irreversibility is unlikely.
Management Strategies	Strategy 7.1: Support ASEZA by providing monitoring information to help support implementation of the zero-discharge policy and continue careful monitoring, preparedness and regulation enforcement support as required. Strategy 7.2: Continue to cooperate at regional level through the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA), and adhere to recommendations/proposals already defined by the International Maritime Organization (IMO).	

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 8: Ballast Water	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses; Open Sea Ecosystems			
	Commentary on the Threat: Invasive species (contained within ship/tanker ballast waters) are considered to be the third greatest threats to the world's oceans with at least 7,000 different species being transported in ships "ballast tanks" around the world (Globallast/IMO 2014; IMO 2012). Ballast water on container ships, bulk carriers, and tankers, visiting the ports in Jordan and the neighboring countries in the GoA, remains a potential source of pollution that can carry and seriously pollute the marine environment of the GoA with invasive species. Therefore, port`s managers and other official responsible authorities in the region need to embrace all possible measures to address and mitigate the threat that ballast waters can present. Jordan has participated over ten years in an international project with UNDP and IMO GloBallast, and as a result has established a vast array of experience and knowledge. In addition, a Ballast Water National Strategy has recently been developed in line with the Ballast Water Convention which is effective towards supporting and providing advisories on implementation and control[122].			
	Stresses (Direct); Contamination of waters from boats throughout the AMR leading to risk of invasives; Inappropriate waste disposal from boats; Contamination of waters by runoff containing herbicides, insecticides/detergents.			
	Sources of Stress (indirect); Reduction and pollution of freshwater lens; Reduction of native marine species as a result of the introduction of voracious predators of juvenile fish and crustaceans (i.e.: Lionfish).			
Severity	Very High	Invasive species (contained within ship/tanker ballast waters) are considered to be the third greatest threats to the world's oceans with at least 7,000 different species being transported in ships "ballast tanks" around the world (Globallast/IMO 2014; IMO 2012).		
Scope	High	There is currently moderate localised ballast water release within the AMR, though this may be predicted to increase in the future.		
Contribution	High	Ballast water on container ships, bulk carriers, and tankers, visiting the ports in Jordan and the neighbouring countries in the GoA, remains a potential source of pollution that can carry and seriously pollute the marine environment of the GoA with invasive		

[122] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Implementing-the-BWM-Convention.aspx

		species. Recently, ASEZA is working toward developing an assessment report of biofouling in Jordan which will be the base of publishing its action plan.
Irreversibility	Medium	Strategies to mitigate the risk of invasive species (e.g.: Lionfish etc) are timely and costly to implement, though are possible to initiate.
Management Strategies	Strategy 8.1: Support the implementation of the "Ballast Water National Strategy" which has recently been developed in line with the Ballast Water Convention (effective towards supporting and providing advisories on implementation and control).	

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 9: Marine Debris	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses; Terrestrial Ecosystems; Open Sea Ecosystems			
	Commentary on the Threat: Most of the litter reported in GoA coastal waters results from recreational and shipping activities. Many items come from the Aqaba passengers' port just north of the MSS beach whilst it is estimated that 19 million items enter the marine environment from ferryboat each year. Shipping and port activities contribute 30% of marine litter whilst the fishing industry represents only 3%. The most significant accumulated debris in Aqaba's seas is plastic whilst micro plastics are considered another supporting factor that is seriously threatening the status of scleractinian (reef-building) corals. The positioning of Aqaba as a major touristic destination, coupled with quantities of waste being generated (an estimated 120 tons per day of waste is collected and transported to the dumpsite located in Wadi Al- Yutum which is 8 km northeast of Aqaba town and the attitude of visitors) is creating a serious problem to marine life. Marine litter reported in the proposed AMR include plastic items/fragments including sheets, bags, containers); polystyrene (cups, packaging, buoys); rubber (gloves, boots, tyres etc); wood (construction timbers, pallets, fragments of both); metals (drink cans, oil drums, aerosol containers, scrap); paper and cardboard; cloth (clothing, furnishings, shoes); glass (bottles, light bulbs); fishing gear (nets, abandoned/lost fishing gear); and plastic pellets. In almost all reports, plastics were by far the most abundant. Large quantities of plastic materials and in part the result of dropping other items such as soft drinks cans, match boxes, plastic straws, sanitary napkins, disposable diapers and garment pieces such as shoes, boots, sandals shirts and small blankets which were found on the southern beaches and on the bottom of the sea in the passengers port area. Thousands of cigarette butts and filters, cigarette boxes and spent disposable lighters are commonly observed on most beaches within the proposed AMR. It is also observed that the AMR area receives litter from several wadis and small valleys. Debris from several wadis and small valleys is transported to sea by occasional but very strong floods caused by rainstorms common to the region. Debris of foreign origin as indicated by inscription or imprinting were also found. Many of these were from Eilat			

	on the west side of the GoA as indicated from the imprinting language (Hebrew). They include cardboards, canned food in tins, non-carbonated natural water plastic bottles, plastic oil containers and plastic cover and caps, and many other debris items were originated from Egypt and Saudi Arabia. The seasonal distribution of the litter clearly indicates a relationship between passengers' port activities during the late spring and the whole summer. These periods coincided with high peaks of passengers' movement from the Arabian Gulf States and Saudi Arabia to Egypt via Aqaba port in Jordan and Nuwaibi port in Egypt. Lost or abandoned gear contributes to the marine debris and litter. This causes a phenomenon known as 'ghost fishing', which significantly affects coral health and abundance.	
	Stresses (Direct): Marine plastic impacts on marine fauna (turtles etc); Micro- plastic ingestion issues in marine fauna and fish assemblages	
	Sources of Stress (indirect); Thousands of cigarette butts and filters, cigarette boxes and spent disposable lighters are commonly observed on most beaches within the proposed AMR. Lost or abandoned gear contributes to the marine debris and litter. This causes a phenomenon known as 'ghost fishing', which significantly affects coral health and abundance	
Severity	High	Marine litter reported in the proposed AMR include plastic items/fragments including sheets, bags, containers); polystyrene (cups, packaging, buoys); rubber (gloves, boots, tyres etc); wood (construction timbers, pallets, fragments of both); metals (drink cans, oil drums, aerosol containers, scrap); paper and cardboard; cloth (clothing, furnishings, shoes); glass (bottles, light bulbs); fishing gear (nets, abandoned/lost fishing gear); and plastic pellets.
Scope	High	Most of the litter reported in GoA coastal waters results from recreational and shipping activities. Many items come from the Aqaba passengers' port just north of the MSS beach whilst it is estimated that 19 million items enter the marine environment from ferryboat each year. The seasonal distribution of the litter clearly indicates a relationship between passengers' port activities during the late spring and the whole summer. These periods coincided with high peaks of passengers' movement from the Arabian Gulf States and Saudi Arabia to Egypt via Aqaba port in Jordan and Nuwaibi port in Egypt.
Contribution	High	Shipping and port activities contribute 30% of marine litter whilst the fishing industry represents only 3%. It is also observed that the AMR area receives litter from several wadis and small valleys. Debris from several wadis and small valleys is transported to sea by occasional but very strong floods caused by rainstorms common to the region.
Irreversibility	Medium	The most significant accumulated debris in Aqaba's seas is plastic whilst micro plastics are considered another supporting factor that is seriously threatening the status of scleractinian (reef-building) corals.
Management Strategies	Strategy 9.1: Produce a Marine Plastics Strategy for the AMR. Strategy 9.2: Initiate the new ISO13009 Beach Standard for all public beaches within the AMR.	

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 10: Living Marine Resource Extraction	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Open Sea Ecosystems			
	Commentary on the Threat: The marine fishing industry is insignificant in meeting Jordan's current fisheries requirements (protein), the vast majority of which is imported[123]. Because of the small size of the marine fishing industry in Jordan, fisheries management is not undertaken to a scale that delivers national needs. To this end, it is important to develop a sustainable fisheries management plan that is based on scientific research outputs and developed in in consultation with the local scientific community. Another major impact that is affecting sustainable fisheries management is associated with the gear being currently used which consists of non-biodegradable materials that can damage hard corals[124]. Living marine extraction is also happening as corals are collected and dried as part of the ornamental trade business for souvenirs and jewellery at Aqaba and even as far as the Jordan capital city, Amman. In addition, substantial harvesting of live corals and fish specimens occurs directly from the sea for exhibition purposes at the marine aquarium[125].			
	Stresses (Direct); Reduced commercial species populations; Trophic shifts in marine ecological communities.			
	Sources of Stress (indirect); Lack of management presence; Limited enforcement of fishing regulations; Low income of local Aqaba fishing communities; Traditional occupation; Market demand from fishing coops; Increased local and tourist demand for local fresh fish.			
Severity	Very High	Lobster, conch and finfish populations are considered to be significantly lower than ten years ago		
Scope	Medium	Localised fishing occurs throughout the AMR under license. The open sea is considered a separate target.		
Contribution	Very High	Fishing pressure and unsustainable fishing practices are considered to be the primary cause of stock decline, with increasing numbers of fish traps, and increasing numbers of fishermen.		
Irreversibility	High	It would be feasible to reduce the fishing pressure with adequate patrols and the strengthening of the prosecution system		
Management Strategies	Strategy 10.1: Establish an effective surveillance and enforcement presence in the AMR, with effective enforcement of Fisheries regulations and zones; Strategy 10.2: Engage fishermen in surveillance and enforcement activities; Strategy 10.3: Establish zones for fisheries management based on informed decisions and strong scientific data; Strategy 10.4: Develop and implement an effective sustainable fisheries management plan for AMR and in adjacent open sea, integrating mechanisms including:			

[123] De Young (2006)
[124] Dameron et al. 2007; Abu-Hilal and Al-Najjar, 2009; Gilardi et al. 2010; Niaounakis, 2017; Sheehan et al. 2017; Lamb et al. 2018
[125] Al Tawaha et al. 2019

	• Education of fishers on policies and regulations and long term benefits • Catch monitoring, • Strategy evaluation and adaptation • Catch shares, quotas and permits Strategy 10.5: Investigate feasibility for active rehabilitation and restoration of traditional and non-traditional commercial species Strategy 10.6: Investigate potential for diversification into other marine resource use /extraction activities Strategy 10.7: Develop and implement a supplemental / alternative livelihood Program targeting traditional users of the AMR, focused both within the AMR and in stakeholder communities outside, to reduce reliance on natural resource extraction within Aqaba. Strategy 10.8: Identify the primary stakeholder fishing communities and increase knowledge of coral reefs, sustainable fishing practices and the marine environment through implementation of a Turnoff focused education Program targeted at primary level Strategy 10.9: encourage fishing in deep sea areas, and avoid coastal lines to protect the unique habitats and ecosystems

Threats to the Marine Biodiversity of Aqaba Marine Reserve				
Threat 11: Natural Predators and Coral Disease	**Status**	Historical	Active	Potential
	Conservation Target(s): Coral Reefs; Seagrasses; Open Sea Ecosystems			
	Commentary on the Threat: There is a general agreement among scientists and researchers that predators such as corallivorous gastropods, including *Drupella cornus* and the crown-of-thorns (*Acanthaster planci*) as well as coral diseases represent common threats to coral populations in many countries around the world[126]. Coral predation and diseases are threatening the coral reefs in Jordan[127]. Natural predators, which could cause serious effects to reef building corals, is *Drupella cornus*, which is found in the Red Sea and along the Jordan coast of the GoA[128]. *D. cornus* prey almost exclusively on living coral tissues[129] and display outbreaks similar to the outbreaks of *Acanthaster planci*[130]. The field observations along the Jordanian coast reveals that this snail is mostly infects branching corals such as *Acropora* spp. and *Stylophora* spp., with an average of about 14 and 10 snails per colony for the *Acropora* and *Stylophora*, respectively, while only 4 snails per colony on the massive coral Porites[131]. Along the Jordanian coast of the GoA, the Crown			

[126] Birkeland 1989; Schumacher 1992
[127] Al-Moghrabi 1996 and 2001; Al-Horani et al. 2006
[128] Johnson and Cumming 1995
[129] Turner 1994
[130] Turner 1994a; Black and Johnson 1994; McClanahan 1997
[131] Al-Horani et al., 2011

	of Thorns (CoT) did not form serious problems in the past, although sometimes, individuals of CoT are encountered in some places, but no actual outbreaks have been recorded[132]. The Skeleton Eroding Band (SEB) coral disease was studied along the Jordanian coast in the GoA[133]. Although the infection rate was relatively low, this disease was frequently encountered with *Acropora* spp. and *Stylophora* sp., coral species while relative infection-rates were highest among *Seriatopora* sp. (75%), as well as *Stylophora* sp., *Hydnophora* sp., and *Galaxea* sp. (50% each). The SEB was found to a depth of 30 m but may occur even deeper.	
	Stresses (Direct): Enhanced coral predation and diseases threatening the coral reef health.	
	Sources of Stress (indirect); Reduction of native marine species as a result of the introduction of voracious predators of juvenile fish and crustaceans (i.e.: Lionfish).	
Severity	Very High	Natural predators, which could cause serious effects to reef building corals, include Drupella cornus, which is found in the Red Sea and along the Jordan coast of the GoA. D. cornus prey almost exclusively on living coral tissues and display outbreaks similar to the outbreaks of Acanthaster planci.
Scope	Very High	Reduction of native marine species – voracious predator of juvenile fish and crustaceans.
Contribution	Very High	Predators such as corallivorous gastropods, including *Drupella cornus* and the crown-of-thorns (*Acanthaster planci*) as well as other coral diseases are contributing to a reduction in marine biodiversity.
Irreversibility	High	Along the Jordanian coast of the GoA, the Crown of Thorns (CoT) did not form serious problems in the past, although sometimes, individuals of CoT are encountered in some places, but no actual outbreaks have been recorded more recently.
Management Strategies	Strategy 11.1: Initiate an Action Plan to mitigate the risk of *Drupella cornus* and the crown-of-thorns (*Acanthaster planci*) on AMR stands of branching corals such as Acropora spp. and Stylophora spp. Strategy 11.2: Set up a research and monitoring Program to record the onset of natural predators and coral diseases (including the Skeleton Eroding Band (SEB) coral disease). Strategy 11.3: Collaborate with partners to develop national markets (restaurants, Chinese) and locate international markets for lionfish fillet and other products. Strategy 11.4: Engage commercial fishermen and tour guides in lionfish extermination as a management intervention within the AMR Strategy 11.5: Collaborate with partners to develop and implement mechanisms for increasing national awareness of the impacts lionfish is having on the reef fish within the AMR.	

[132] Antonius and Riegl, 1997; Loya and Gur, 1996; AlMoghrabi, 1997
[133] Winkler et al. 2004

3.4 Monitoring Success of Conservation Target

The series of indicators allocated to each conservation target provides a framework for AMR site level monitoring, which can be incorporated into a specific AMR Science Program. A Measures of Success program has been developed to monitor the success of conservation strategies, as an integrated component of the Management Action Planning process (Table 24)[134].

Table 24: Monitoring Success for each Conservation Target

Target	Indicator	Methods	Frequency	Location	Who	Cost	Funding Source
Coral Reefs	Turbidity	Secchi disc at AMR monitoring sites,	Annual	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	No. incidence of significant increased turbidity from development impacts / year	AMR Patrol Reports	Annual	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	No. of incidents of poor development practices reported and confirmed / year	AMR Patrol Reports	Annual	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	No. of fishing infractions as a % of total number fishing boats / year	AMR Patrol Reports	Annual	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	% of illegal fishing cases presented that are	ASEZA Fisheries Compliance Unit reports	Annual	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD

[134] Costs and funding sources are to be updated following wider consultation on this AMRMP (2022-2026) with national stakeholders

	successfully prosecuted / year						
Seagrass Ecosystems	Seagrass biomass	AMR Patrol Reports	4 times/yr	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	Seagrass % cover	AMR Patrol Reports	4 times/yr	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	Seagrass height	AMR Patrol Reports	4 times/yr	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	Seagrass production	AMR Patrol Reports	4 times/yr	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	Light intensity	AMR Patrol Reports Secchi disc at AMR monitoring sites,	4 times/yr	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
	Water temperature	AMR Patrol Reports	All year	All relevant areas of the AMR	Natural Resource Management and Science Program.	TBD	TBD
Terrestrial Ecosystems	Extent of littoral vegetation	Satellite imagery, aerial flyover	Annual	AMR /ASEZA Offices	Natural Resource Management and Science Program.	TBD	TBD
	% of developments following ASEZA/AMR guidelines	Over flight; site survey	Annual	AMR /ASEZA Offices	Natural Resource Management and Science Program.	TBD	TBD

	No. of incidents of poor development practices reported and confirmed /year	AMR staff Patrol reports	Annual	AMR /ASEZA Offices	Natural Resource Management and Science Program.	TBD	TBD

Part Four: Management Planning

4.1 Factors Affecting Management (lessons learned)

Several factors are confronting the current AMRs ability to function effectively. These include:

1. Around half of the total coastal stretch of the AMR remains accessible to the public and will have to absorb the extensive pressure of visitors and activities, which will generate a significant source of pressure on staff during peak times such as week-ends and holidays;
2. A combination of poor strategic management approaches to respond to the threats within the AMR coupled with a lack of information to document the negative impacts of these threats on marine resources, has prevented the AMP from building a strong case for strengthening its role to manage marine biodiversity effectively in Aqaba.
3. The leisure activities practiced on the public beaches (including snorkeling, diving, glass boaters and beach visitors) all constitute an extensive pressure on the fragile ecosystem of the Park, which are not reflected in the absorption capacity of AMP's resource capabilities. For example, the increasing marine litter issue, which results from the increasing beach visitor numbers being experienced, is a significant threat facing the AMPs marine biodiversity. Likewise, fishing (commercial and recreational) constitutes another important threat to marine biodiversity and this needs to be more effectively monitored and controlled. Given the AMP's mandate and resources in enforcing fishing regulation, the AMP's role in the managing and regulating any activity that is jeopardizing marine biodiversity remains very important.

Therefore, it is clear from the above that prevailing "fire- fighting" day to day working conditions being faced by AMR staff have often driven the current management team to work in a reactive mode, having to respond to constantly rising pressures that the Park's resources are facing, as opposed to being able to set strategic and adaptive approaches that are would be better aligned towards targeting the threats that the AMR is facing. This has also incurred an extensive pressure on human resources of the Park and has resulted in heavy turn-over of the staff, due to hardship conditions and lack of needed incentives at the administrative level to respond to extensive workload.

Although some of the Park's responsibilities have been out-sourced (such as cleanup campaigns and some maintenance activities), this extensive workload on the Park's staff (from every day duties) is preventing it from responding to the conservation mandates entrusted to the Park, including key mandates within its regulation such as *"Implementing, updating and monitoring scientific research programs to rehabilitate coral reefs and other natural resources… and facilitating and participating to scientific research programs…"*. This gap in operational management has prevented it from gathering, analyzing and disseminating information to the public and to the decision makers who need scientific information for policy setting within ASEZA as a whole.

4.2 Management Vision

The vision for the Aqaba Marine Reserve is proposed as follows (for stakeholder acceptance):
"Aqaba Marine Reserve is a model of effective planning and management that ensures that the unique ecological values and associated social and economic benefits are used sustainably for future generations through active stakeholder stewardship"

4.3 Management Objectives and Outputs

4.3.1 Objectives and Outputs

Table 25: Proposed AMR Objectives and Outputs (2022-2026)

AMR Objectives and Outputs	
Objective 1	**Maintain and improve healthy, resilient, bio-diverse reefs and seagrass habitats within the AMR up to and beyond 2026**
AMR Plan Outputs	1.1. Conservation and restoration strategies/interventions (including an updated AMR Zoning Strategy) are updated and introduced to improve, protect or sustain existing and marine biodiversity levels. 1.2. Scientific research surveying/monitoring and citizen science Programs are implemented to support marine ecosystem management of threatened / endemic species. 1.3. Support provided to socio-economic sectors to ensure delivery is in line with the principles of Jordan's Network of Protected Areas (JNPAs) and regulations assigned to the Protected Areas and National Parks Bylaw No. 29 (2005). 1.4. Climate resilient strategies are mainstreamed to support ecosystem service delivery and EbA project implementation.
Objective 2	**Create and implement the necessary mechanisms to promote the AMR as a model for ecologically sustainable tourism which complies with international principles and standards.**
AMR Plan Outputs	2.1. Guidance, standards and criteria for dive centres, glass bottom boat operators and lodge developments are established to support implementation of the Aqaba Ecotourism Plan and are in line with Global Sustainable Tourism Council (GSTC) Criteria for Sustainable Destinations. 2.2 Devise a set of "Limits of Acceptable Change" to determine carrying capacities set for tourism activities within the AMR (particularly dive sites). 2.3 Construction of key interventions proposed as set out within the Aqaba Ecotourism Plan (including an aquarium following international standards). 2.4 Develop the current Blue Flag initiative in Aqaba to embrace the requirements set out within the latest international beach standard (ISO13009). 2.5. An innovative AMR Marketing Plan is developed and implemented to help promote community engagement and associated product development.
Objective 3	**Effective surveillance and patrolling is being implementing to cover the entire AMR area.**
AMR Plan Outputs	3.1 Necessary surveillance and enforcement capacity (equipment) is enhanced to support implementation of the AMRMP Vision. 3.2 Necessary operational patrol enforcement / surveillance teams (human capacity and multi-agency support) are enhanced to support implementation of the AMRMP Vision.
Objective 4	**Improve and strengthen institutional/legal framework and associated management capacities**

AMR Plan Outputs	4.1. Legislative and institutional organizational development needs are improved upon to support delivery of the AMR Vision. 4.2 Setup, implementation and management of a marine environmental information system to help support implementation of the AMRMP Vision. 4.3 Monitoring and evaluation systems are introduced to improve the measurement and reporting of results based outcomes.
Objective 5	**Marine Conservation awareness and Education is improved at the International and National Level**
AMR Plan Outputs	5.1 Stakeholder communication strategy is developed and implemented following best international and national Protected Area practice. 5.2 Educational and awareness raising strategy (national and international level) is developed to demonstrate the global importance of AMR). **5.3** Promote national and international cooperation for the marine ecosystem conservation and biodiversity needs within the wider Gulf of Aqaba to support any future designation as a World Heritage Site, Biosphere Reserve etc.
Objective 6	**Sustainable financial mechanisms are established and implemented to finance future AMR related management operations and activities**
AMR Plan Outputs	6.1. Prepare an inventory of infrastructure readiness and future funding needs (logistics, buildings, signage etc) 6.2. Develop a Fundraising strategy which is distributed and implemented successfully which considers budget allocated by the government to ASEZA and concessions obtained from the existing business 6.3 Establish operational guidelines for administration of reserve fund budgets (national, CSR or international) along with clarity over the role of the MOE.

4.3.2 Management Zones (AMR boundaries)

The AMRMP (2022-2026) sets out a series of sub-areas (zones) as follows:

1. **Coral Coastal Zone**: This includes the proposed AMR, starting from the Passengers Terminal extending south to the Royal Diving Club.
2. **Coral Reserves**: The Coral Reserves protect the magnificent coral reefs within the above defined Coral Coastal Zone (as part of the established AMP). These reserves represent the three heads of coral that include beach and connected reefs.
3. **Beach Protection Zone**: The Beach Protection Zone (BPZ) limits development within an area 50 meters to 150 meters landward from the MHWM. Examples of restricted development include natural landscaping and certain recreational facilities. These limits protect the natural environment, water quality, and health of the coral reefs.

Figure 17 outlines the current zoning strategy for the AMR based on the existing AMP Plan (2014-2018).

Figure 17: AMR Zones

A new zoning plan will need to be developed (see Table 25 – Output 1.1) which shall be based on existing information, and updating the original plan (see Figure 17). Once the AMR is established, and the AMRMP (2022-2026) is endorsed, a strong delivery emphasis should be placed on scientific research, marine biodiversity protection (via strong monitoring, regulation and enforcement) to enable more sustainable eco-tourism, and visitor management to take place (see Management Programs set out in Section 4.4).

To support the proposed new zoning strategy, the existing AMP rangers will need to be better supported with enforcement powers as they can also play an important role in visitor management on site if their numbers can be increased and if they receive the proper skills and knowledge through special training and capacity development. This actually should create better moral and financial incentives for them to undertake their difficult enforcement tasks. Rangers will also need to take on increased tasks whereby they can share their knowledge and experience with others in tandem with them protecting and managing the zones being proposed.

4.4 Management Programs

Management Programs are a means of grouping management objectives within related areas – for example, those related to natural resource management, or to public use. The strength of the combined Programs is greater than the sum of the individual Programs, as each supports the others over space and time, with synergies that strengthen the overall management of the AMR.

Five Management Programs have been identified for effective management of the AMR (Table 26) and are designed to embrace the six AMRMP (2022-2026) Objectives and corresponding outputs:

Table 26: AMR Management Programs (2022-2026)

AMR Management Programs (2022-2026)	AMRMP (2022-2026) Objectives (see Table 25)					
	1	2	3	4	5	6
A. Natural Resource Management Program	X	X	X			
B. Science Program	X	X	X		X	
C. Education and Outreach Program		X			X	
D. Infrastructure Program		X				
E. Administration Program			X	X	X	X

The conservation strategies outlined in Section 3 of this AMRMP (2022-2026) are integrated into the management Programs, as are the outputs of the climate change planning. These contribute towards the adaptive management process ensuring that the AMR fulfils its future role within the NPAS for Jordan.

4.4.1 Natural Resource Management Program

The Natural Resource Management Program focuses on delivering AMRMP Objectives 1, 2 and 3 (see Table 25). It is designed to ensure the maintenance of healthy, functional ecosystems (namely coral reefs, Seagrasses, terrestrial and open sea – see Section 3), to the agreed "desired status" in the face of current and future threats, including climate change,

through surveillance and enforcement, direct biodiversity management interventions and visitor management. This Program is recommended to address five supporting sub-Programs:

- Surveillance and Enforcement;
- Fisheries Management;
- Visitor Management;
- Coastal/Beach Management.

The Program (as per other Programs) need to consider monitoring and evaluation (performance measuring) activities which are needed to ensure effective implementation and outcomes of Natural Resource Management strategies (as implemented under the Administrative Program).

It shall be responsible for producing conservation and restoration strategies/interventions (including an updated AMR Zoning Strategy) to improve, protect or sustain existing and marine biodiversity levels; design and implement scientific research surveying/monitoring and citizen science Programs to support marine ecosystem management of threatened / endemic species; provide support to socio-economic sectors to help ensure strategic delivery in line with the principles of Jordan's Network of Protected Areas (JNPAs) and regulations assigned to the Protected Areas and National Parks Bylaw No. 29 (2005) plus finally, the mainstreaming of climate resilient strategies to support ecosystem service delivery and EbA project implementation.

The **Surveillance and Enforcement Sub-Program** within the AMR is focused on delivering Objective 3 of the AMRMP including identifying the necessary surveillance and enforcement capacity (equipment) needs to enhance implementation of the AMRMP Vision along with identifying the necessary operational patrol enforcement / surveillance team needs (human capacity and multi-agency support) to support implementation of the AMRMP Vision. This shall include undertaking patrols of the area to uphold the Marine Reserve zones and regulations, and to ensure that fishing, tourism and development regulations are enforced. The sub-Program falls under the remit of the AMR Manager, and is currently implemented through a collaborative partnership with supporting stakeholders.

Specific activities to address identified limitations under this Program include:

- Establishing an effective surveillance and enforcement presence in the AMR, with an optimum of three patrol units based from a reserve headquarters and two rangers stations;
- Employment of staff to support the AMR Manager (including rangers);
- Engagement of fishermen in surveillance and enforcement activities;
- Surveillance and enforcement of development regulations to support species protection.

The **Fisheries Management Sub-Program** focuses on ensuring a continued, sustainable fishery for the benefit of traditional fishermen using the area, and contributing towards the sustainability of the Aqaba fishing industry, through effective management of the fish stocks, diversification of fishing effort, and addressing the need for alternative livelihoods.

The **Visitor Management Sub-Program** focuses primarily tourism management and safety. Under current legislation, visitor management and safety is, to some extent, the responsibility of the tour guides and tour operators, with ASEZA regulations covering the need for certified guides and dive instructors, for tour guides/operators to ensure that all visiting divers are adequately qualified, and the expectation that boat captains and dive guides will explain the rules of the Reserve

to a diver. These regulations need to be enforced at site level, through the development of collaborative mechanisms with ASEZA, and training of rangers in enforcement of suitable regulations. Ongoing training of snorkel and dive tour guides in best practices has also been shown to mitigate visitor damage to the reef and for marine resource sustainability. It shall be responsible for producing standards and criteria for dive centres, glass bottom boat operators and lodge developments are established to support implementation of the Aqaba Ecotourism Plan and are in line with Global Sustainable Tourism Council (GSTC) Criteria for Sustainable Destinations, devise a set of "Limits of Acceptable Change" to determine carrying capacities set for tourism activities within the AMR (particularly dive sites) and the production of an innovative AMR Marketing Plan to help promote community engagement and associated product development.

The **Coastal/Beach Management Sub-Program** focuses directly on the implementation of key aspects of Objective 2, which includes (amongst others) the new ISO13009 Beach Standard to ensure public beaches are management in a safe and sustainable manner is also recommended (to complement existing Blue Flag Programs etc). Visitor impact mitigation through enforcement of new regulations and ISO13009 beach standard shall be the core focus. It also shall producing

4.4.2 Science Program

The Science Program helps to implement part of Objective 1 of the AMRMP to support delivery of all aspects of scientific research surveying/monitoring and citizen science Programs to support marine ecosystem management of threatened / endemic species. This shall be part of a new integrated and comprehensive Research and Monitoring Plan (produced in tandem with collaborative input from science stakeholders operating within the AMR (inside or outside of Aqaba). This is essential to ensure informed, effective management to assess the effectiveness of the AMR in achieving its objectives. This will need to be administered under the following five sub-Programs:

- Research;
- Monitoring;
- Data Management and Dissemination;
- Collaboration with National / International Partners.

The Program (as per other Programs) need to consider monitoring and evaluation (performance measuring) activities which are needed to ensure effective implementation and outcomes of Science Program related strategies (as implemented under the Administrative Program).

The **Research Sub-Program** focuses on those areas identified as information gaps during the management and conservation planning processes. Many of the research activities can be effectively met through engaging research partners for targeted project areas - particularly important in research for informing climate change adaptation within the AMR. The sub-Program calls for a more standardized focus for independent researchers, with priority given to research meeting identified research gaps, and research proposals reviewed by ASEZA and the MSS.

The **Monitoring Sub-Program** is the main focus of the Science activities. In addition to more scientific and technical monitoring work (coral health etc), social and economic monitoring should also be developed to determine the nature and distribution of benefits tied to marine resources coming from the proposed AMR. Routine follow-up monitoring from selected trainings (i.e. through a revised AMP Annual Training Program) should be performed immediately following the training program, to examine how the skills learned are being used within Aqaba. The development of a Limits of Acceptable

Change Program will also require monitoring of indicators at key visitor snorkel, dive and sport fishing sites, to be integrated into the overall Research and Monitoring Plan.

Effective management of conservation targets under the earlier Surveillance and Enforcement Program shall be guided by the research and monitoring outputs derived from the **Data Management and Dissemination of Information Sub-Program.** This ensures that information from research and monitoring is available for guiding management decision making and adaptation. Dissemination of the results is also identified as key, as effective management depends on ensuring clear understanding of the reasons behind targeted management or enforcement strategies by stakeholders.

The **Collaboration Sub-Program** recognizes that communication, cooperation and coordination with other conservation organizations, national and international research partners involved in management, research and monitoring on the Aqaba's reef is critical for the wider open ocean ecosystem in place within the Gulf of Aqaba and wider Red Sea Region (as the AMR does not exist in isolation).

Priorities for research and monitoring activities, either through the development of conservation planning actions, or in response to specific research or monitoring requirements, as set out below:

1. To develop standards for Limits of Acceptable Change (LAC) within the AMR and from this, implement a dedicated LAC monitoring Program;
2. To increase knowledge on connectivity and recruitment of corals and key commercial species in the marine environment of the AMR and wider Gulf of Aqaba area;
3. To increase information and understanding to input into strategy development towards greater sustainability of the fishery within and adjacent to the AMR;
4. To ensure effective dissemination of research results in formats that are accessible to a wide variety of stakeholders.

4.4.3 Education and Outreach Program

It is critical for the success of management implementation that the AMR has informed and supportive stakeholders, knowledgeable of the underlying threats to the marine reserve, management challenges, and the strategies being employed to address these threats (including the need for implementation of regulations, replenishment areas and Conservation Zones). This Program is designed to help implement Objective 5 of the AMRMP (2022-2026) and three sub-Programs are proposed to help achieve this as follows:

- Stakeholder Engagement;
- Alternative Livelihoods and Training;
- Education and Dissemination of information.

The Program (as per other Programs) also needs to consider monitoring and evaluation (performance measuring) activities which are needed to ensure effective implementation and outcomes of Education and Outreach related strategies (as implemented under the Administrative Program).

The Program shall be responsible for producing a Stakeholder communication strategy that follows best international and national Protected Area practice; an educational and awareness raising strategy (national and international level) to

demonstrate the global importance of AMR; and to promote national and international cooperation for the marine ecosystem conservation and biodiversity needs within the wider Gulf of Aqaba to support any future designation as a World Heritage Site, Biosphere Reserve etc.

Creating an environment of stakeholder stewardship should be a priority strategy, with integrated stakeholder participation in surveillance and enforcement, and research and monitoring. This should be matched with training for fishermen and tourism managers using the AMR in alternative livelihood skills, financial incentives, investment in supplemental income generation mechanisms and investigation of innovative potential marine resource opportunities.

Engaging land owners and developers is also of importance, with the potential impacts poorly managed coastal development can have on the AMR – clearance of the critically under-represented terrestrial vegetation (exacerbating flood risk etc), ecosystem, and residential developments, all with their associated potential sedimentation impacts on adjacent reefs and seagrass ecosystems - reducing the viability of already pressured conservation targets.

Broader environmental education is addressed through the development of booklets, leaflets, brochures, posters and audio visual materials for the Marine Reserve, and hence, targeted communication and outreach efforts (internationally, nationally and within the proposed AMR) needs to be strengthened. Strengths can be shared and weaknesses can be examined for possible ways in which they may be improved based on exchange of information and knowledge. The example of the Sanganeb Atoll MPA (Sudan) is proposed here as a possible exchange partner to better engage with.

Finally, local communities and stakeholder in Aqaba should also be assisted to define standards for environmental quality. These standards should be required to a) protect those ecosystem services that support human need and well-being in Aqaba, b) provide tangible benefits to local stakeholders and c) maintain environmental quality so that such benefits are sustained over time.

4.4.4 Infrastructure Program

The Infrastructure Program is managed under two sub-Programs:

- Operational Infrastructure and Equipment;
- Maintenance.

The Program (as per other Programs) need to consider monitoring and evaluation (performance measuring) activities which are needed to ensure effective implementation and outcomes of the Infrastructure Program related strategies (as implemented under the Administrative Program). In the initial phase, the priority is to:

- Establish a fully equipped, functional AMR headquarters and Visitor Centre including any new Ranger Stations as required;
- Purchase equipment and fuel for at least two functional patrol units, for effective surveillance and enforcement;
- Purchase administration equipment (communications, computer, office equipment) as required;
- Establish and implement green building and operation policies for all AMR infrastructure, with use of solar / wind powered electricity generation, following best practices guidelines during construction of infrastructure and operation of boats.

It shall be responsible the management of any new "infrastructure project" that helps support the implementation of the AMRMP Vision (i.e.: new aquarium etc).

4.4.5 Administrative Program (staffing and training)

This Program is set up to help implement AMRMP Objectives 4 and 6 respectively. To achieve this, the Administration Program activities fall under four sub-Programs:

- Administration Policies and Procedures
- Human Resource Management
- Financial Sustainability
- Timeline, Evaluation and Review

The Program sets in place the **Administration Policies and Procedures** for the staff employed by the Management Board, and all human resource issues and evaluation. It also seeks, in the first five years, to develop financial sustainability mechanisms to provide long term security for management activities. Such activities will include a review of legislative[135] and institutional organizational development needs to support delivery of the AMR Vision; setup, implement and manage a marine environmental information system to help support implementation of the AMRMP Vision and to introduce a new monitoring and evaluation system to improve the measurement and reporting of results based outcomes.
During the establishment phase, it is important to:

- Build the capacity of the Management Board to take on the management role;
- Ensure there are sufficient staff members employed, including a Reserve Manager and two patrol units;
- Ensure an effective, transparent accounting system is established;
- Plan for future financial sustainability.

Once the AMR is established, one of the first tasks will be the development of an Administration and Policies Manual to ensure that all AMR staff and members of the Steering Committee are aware of the administrative procedures and policies of the organization.

The Program will also be responsible for delivering Objective 6 (Sustainable Finance Mechanisms) which shall involve the need to prepare an inventory of infrastructure readiness and future funding needs (logistics, buildings, signage etc); develop a Fundraising Strategy which considers budget allocated by the government to ASEZA and concessions obtained from the existing business and establish operational guidelines for administration of reserve fund budgets (national, CSR or international) along with clarity over the role of the MOE.

With regard to the **Timeline, Evaluation and Review sub-Program**, it is suggested that the activities of each Program area be expanded to form an implementation matrix, including present and desired status, responsible parties, a timeline based on the 5-year implementation period (2022-2026), and highlighting any limitations or context conditions that would need to be taken into consideration for successful implementation.

[135] Including a review of the current AMP related ASEZA 2001 Bylaw (No.22)

4.5 Monitoring and Review

4.5.1 Monitoring and Evaluation

Monitoring and evaluation are integral components of any management system and annual evaluations of protected area management are recommended. In the development of this management plan, the action areas are relatively specific, simplifying the process of monitoring success of implementation, and providing a mechanism for continual tracking of management activities, through annual review by ASEZA.

Four main areas of performance evaluation are proposed as part of this AMRMP (2022-2026) as follows:

1. **Institutional coordination and coherence** to ensure that (i) the functions of administrative actors are properly defined, including through the establishment of a coordinating mechanism; a legal framework exists to support AMR implementation and the pursuance of coherent objectives; the impacts of sectoral plans, Programs and projects potentially affecting the AMR defined area are taken into account through procedures for environmental impact assessment (EIA), and carrying capacity assessment; and conflict resolution mechanisms are available to anticipate, resolve, or mitigate conflicts over the use of coastal areas and resources;
2. **Quality and effectiveness of managemen**t by (i) the formal adoption of the AMRMP (2022-2026); (ii) active implementation of these via agreed Action Plans (see Section 5); (iii) routine monitoring and evaluation of management and its outputs, outcomes and impacts, as well as the consideration of results in adaptive management; and (iv) the sustained availability of human, financial and technical resources to enable effective management;
3. **Improved knowledge, awareness and support** by ensuring (i) the production of results from scientific research, its use for management and its dissemination to a wider audience; (ii) the participation of stakeholders in decision-making processes; (iii) the activities of NGOs and CBOs; and (iv) the introduction of marine conservation and protected area related subjects into educational and training curricula for the formation of marine related cadres;
4. **Mainstreaming Marine Conservation and Ecosystem Management into sustainable development** by (i) the development and application of technologies that can enable and support protected areas management; (ii) the use of economic instruments to promote AMR defined objectives through the private sector; and (iii) the incorporation of AMR related objectives into broader sustainable development strategies.

4.5.2 Grievances

A formal Grievance Redress Mechanism (GRM) needs to be produced by the AMR Manager to ensure that any complaints or grievances may be formally recorded, monitored and actioned. This process needs to be included within the M&E process referred to above.

Any GRM adopted for the AMR needs to respond and address public concerns based on the following six core principles:

1. **Fairness:** Grievances are treated confidentially, assessed impartially, and handled transparently.
2. **Objectiveness**: The GRM is to operate in a fair, objective manner and give impartial treatment to each case.
3. **Simplicity and accessibility**: Procedures to file grievances and seek action are simple enough that community members can easily understand them. Community members will also have a range of contact options including,

at a minimum, a telephone number, an e-mail address, and a postal address. The GRM should not use complex processes that create confusion or anxiety.

4. **Responsiveness and efficiency**: The GRM should be responsive to the needs of all complainants. Accordingly, officials handling grievances should be trained to take effective action upon and respond quickly to grievances and suggestions.
5. **Speed and proportionality**: All grievances, simple or complex, should be addressed and resolved as quickly as possible. The action taken on the grievance or suggestion is swift, decisive, and constructive.
6. **Participatory and socially inclusive**: A wide range of stakeholders (community members, members of vulnerable groups, civil society, and the media) should be encouraged to bring grievances and comments to the attention of project authorities.
7. The GRM must be accessible to all stakeholders, irrespective of the remoteness of the area they live in, the language they speak, and any other characteristics. There should be no retribution for using the GRM. The above principles are used to assess the performance of the AMRs GRM approach that is to be adopted.

4.6 Financing

4.6.1 Overview

The AMR Manager is responsible for preparing the annual budget for the Marine Reserve and submitting it to ASEZA for consideration and possible approval. At present, all ASEZA's regulatory activities are funded from its own budget, that is, from funds received from economic activity in the Zone. This includes the operation of the AMP. However, ASEZA operates a polluter-pays policy, which requires those responsible for damage to the environment - including both accidental damages, and ongoing routine impacts, even if within legal limits -to contribute to its environmental management costs. The ASEZA Finance Directorate is responsible for the accounting of all revenues collected. However, for a financial stability and sustainability, ASEZA through its reserve management should diversify the income resources from a different funding mechanism.

4.6.2 International Best Practice

It is recommended that ASEZA help to support the AMR to formulate the mechanisms to set up a Protected Areas "fund" to help with maintenance and management of the AMR. An example of a proactive financing approach for Protected Areas which may be embraced by Aqaba, is most recently demonstrated by the Bahamas Protected Areas Fund (BPAF). Established in 2014, the Bahamas Protected Areas Fund (BPAF) and the Caribbean Biodiversity Fund (CBF) signed a Partnership Agreement on November 19, 2020. The agreement signifies a long-term source of support for BPAF to facilitate grant-making in conservation on the ground and in the waters of The Bahamas. Its general purpose being to ensure sustainable financing into perpetuity for the management of Protected Areas in The Bahamas.

The BPAF has already established itself as an implementer and facilitator of conservation projects throughout the islands through a CBF grant supporting The Bahamas' recovery from Hurricane Dorian. The CBF is an umbrella fund with a flexible structure to implement innovative solutions for resource mobilization at the regional level through a range of financial instruments. Currently, the CBF manages about USD125 million through its Conservation Finance and the Climate Change: Ecosystem-based Adaptation Programs. The Conservation Finance program focuses on the conservation and effective management of biodiversity and natural resources and is mainly supported through the CBF Endowment Fund.

4.6.3 Partnership Opportunities

The AMR will need to develop a diverse portfolio of funding sources to achieve sustainable financing. These sources will likely include direct subventions from government, entrance fees, grants from national and international sources and others. In an effort to reduce costs and yet achieve good management, the AMR Manager will need to explore possibilities of sharing certain management responsibilities with stakeholder groups through special agreements. For example, the maintenance of mooring buoys may be shared with dive or tour operators in the reserve. Collaboration with resort owners in monitoring activities, will also assist in sharing the financial burden, as will the involvement of fishermen in enforcement and catch data collection. This type of sharing of responsibility will also foster a greater sense of ownership by the users of the reserve. This could also be expanded to include sharing of specialized equipment and expertise of reserve staff within the national PAS network.

MSP Global Initiative

Although Marine Spatial Planning (MSP) adoption is increasing worldwide (in August 2018, about 70 countries were preparing or had prepared MSP plans at the regional, national or local scale), many regions, countries or municipalities still need support to adopt it, or to fully implement where the process has already started. In this context, UNESCO's Intergovernmental Oceanographic Commission (IOC-UNESCO) and the European Commission adopted in March 2017 a Joint Roadmap to accelerate Maritime/Marine Spatial Planning processes worldwide. As a result of this fruitful partnership, the International MSP Forum and the MSPGlobal Initiative were established one year later.

The results of this framework will be a joint contribution of the IOC-UNESCO and European Commission to the joint voluntary commitment #OceanAction15346 presented by both institutions during the United Nations Ocean Conference held in June 2017[136]. The project will also be a major contribution to the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) adopted by the 72nd UN General Assembly on 5 December 2017.

A series of Strategic Actions are proposed to help integrate the perspective that MSP should be a means for implementing Agenda 2030 and should demonstrate how MSP deliver on economic, social and environmental values in that context. These are divided into the following priority areas:

1. Transboundary MSP;
2. The Blue Economy;
3. Ecosystem based MSP;
4. Capacity building; and
5. Building mutual understanding and communicating MSP.

MSPGlobal covers actions 1-4 and the MSP Forum was implemented to achieve action 5. These were introduced in 2017 to bring together a clear forward-looking and global perspective towards 2030. MSPGlobal has many of the same aims and objectives as this AMRMP (2022-2026) and there could be much to learn in terms of regional and national development and delivery of ocean policy and MSP for Aqaba.

[136] https://oceanconference.un.org/commitments/?id=15346

United Nations 2030 agenda and the Sustainable Development Goals

In 2017 the high-level United Nations Conference to Support the Implementation of Sustainable Development Goal 14 (Ocean Conference) was convened at UN Headquarters. At this event over 1400 participants set concrete actions to advance implementation of SDG 14 and included governments, the United Nations system, civil society organizations, academia, the scientific community, and the private sector. These commitments, together with the Conference outcome document entitled "Our Ocean, Our Future: Call for Action", marked a global breakthrough on the path to sustainable management and conservation of our oceans, seas and marine resources.

Each of the Ocean Conference voluntary commitments addressed one or several of the SDG 14 targets, often with associated positive impact on other SDGs, including for example SDG 3 on good health and well-being and SDG13 on climate action, among others.

At the 2019 Ocean Conference, to follow-up on the implementation of these voluntary commitments to catalyse and generate new voluntary commitments, and to facilitate collaboration and networking amongst different actors in support of SDG 14, the UN launched nine thematic multi-stakeholder "Communities of Ocean Action". Each community is coordinated by designated focal points who work together with the UN Secretary-General's Special Envoy for the Ocean. The nine "Communities of Ocean Action - CoOA" are:

1. Coral reefs;
2. Implementation of international law (UNCLOS);
3. Mangroves;
4. Marine and coastal ecosystems management;
5. Marine pollution;
6. Ocean acidification;
7. Scientific knowledge, research capacity development and transfer of marine technology;
8. Sustainable blue economy;
9. Sustainable fisheries.

The UN's 2020 Ocean Conference in Lisbon, 5-9 June 2020, will further support progress to SDG 14, focusing on "Scaling up ocean action based on science and innovation for the implementation of Goal 14: stocktaking, partnerships and solutions". This will further target the development of partnerships and initiatives to share knowledge and support innovation in addressing SDG 14 and provides a wealth of opportunities for action to advance sustainable ocean use in the Gulf of Aqaba and Red Sea region (excluding the CoOA for Mangroves which are not relevant to Aqaba).

South South Global Thinkers

South-South Global Thinkers (SSGT), the Global Coalition of Think Tank Networks for SSC, provides an enabling environment for "think-tank" networks from the South to produce and share relevant knowledge for sustainable development and scale up the impact of South-South and Triangular Cooperation in the implementation of the SDGs. It plays a catalytic role in "South South Coordnation" (SSC) and a number of entities exist that may provide opportunities for future engagement in Aqaba. In addition, there are a number of tools/resources to enhance capacity in SSC.

A Network of Southern Think Tanks (NeST) is set up under the umbrella of SSGT. Its objective is to collaboratively generate, systematize, consolidate and share knowledge on SSC. It is a network of Southern think tanks that welcomes contributions from a diversity of stakeholders from the Global South, including governments, civil society, private sector and development practitioners, and provides valuable policy recommendations and insights on SSC, seeking to share understanding and an effective application of SSC. No relevant network exists for the Blue Economy specifically, and this may be something for future consideration. In spite of this, SSGT pursues a series of priority areas of relevant research of the coalition (regarding the Blue Economy and their usefulness to Aqaba and the AMR) may include the following:

(i) Policy coordination and legal environment for SSC

This research area examines policy and legal environments that are enabling or hindering countries engaging in South-South and Triangular Cooperation. It also examines interregional mechanisms and policy innovations that can be useful to countries with similar social, economic and political backgrounds.

(ii) SSC in economic structural transformation

This research area focuses on key indicators and variables of economic transformation. It includes country case studies, policy tools for economic transformation, and collaborative research on economic structural transformation with the aim to support the implementation of the 2030 Agenda for sustainable development.

(iii) SSC in science, technology and innovation

This area of research identifies and assesses existing science, technology and innovation strategies and policy frameworks at national, regional and global levels. It pinpoints gaps and provides guidance and recommendations to develop and strengthen science, technology and innovation frameworks through South-South and Triangular Cooperation.

(iv) South-South Trade, Investment and Financing

This research area analyses how South-South trade, investment and financing have contributed to human development and to the achievement of the Millennium Development Goals (MDGs), and how they are contributing to the achievement of the SDGs.

(v) SSC delivering results for the SDGs

This research area looks at good practices that demonstrate the contributions of South-South and Triangular Cooperation to the advancement of the SDGs and to other broader sustainable development areas.

(vi) SSC risk management in fragile context and disaster risk management

This research area focuses on mapping out South-South Cooperation good practices in countries facing conflict or natural disasters. It also proposes methodologies and policy tools for integrating risk management into SSC Programs in fragile context.

(vii) Regional/sub-regional mechanisms and neighbourhood SSC initiatives

This research area identifies trends, strategies, modalities, as well as good practices, policy tools and institutional mechanisms that enable the upgrading of SSC among neighbouring countries.

(viii) Multi-stakeholder engagement in SSC (youth, women groups, private sector, civil society, etc)

This research area analyses how multiple stakeholder engagement in SSC can contribute to the achievement of the SDGs, especially in addressing complex challenges that requires innovative solutions. It also looks at good practices of such partnerships.

Part Five: Strategic Plan (2022-2026)

Aqaba Marine Reserve is a model of effective planning and management that ensures that the unique ecological values and associated social and economic benefits are used sustainably for future generations through active stakeholder stewardship						
Objectives	**Outputs**	**Timeframe**				
		2022	**2023**	**2024**	**2025**	**2026**
Objective 1: Maintain and improve healthy, resilient, bio-diverse reefs and seagrass habitats within the AMR up to and beyond 2026	Output (1.1): Conservation and restoration strategies/interventions (including an updated AMR Zoning Strategy) are updated and introduced to improve, protect or sustain existing and marine biodiversity levels	Initiate				
	Output (1.2): Scientific research surveying/monitoring and citizen science Programs are implemented to support marine ecosystem management of threatened / endemic species.	Initiate				
	Output (1.3): Support provided to socio-economic sectors to ensure delivery is in line with the principles of Jordan's Network of Protected Areas (JNPAs) and regulations assigned to the Protected Areas and National Parks Bylaw No. 29 (2005).	Initiate				
	Output (1.4): Climate resilient strategies are mainstreamed to support ecosystem service delivery and EbA project implementation			Initiate		
Objective 2: Create and implement the necessary mechanisms to promote the AMR as a model for ecologically sustainable tourism, which complies with international principles and standards	Output (2.1): Guidance, standards and criteria for dive centres, glass bottom boat operators and lodge developments are established to support implementation of the Aqaba Ecotourism Plan and are in line with Global Sustainable Tourism Council (GSTC) Criteria for Sustainable Destinations.	Initiate				

	Output (2.2): Devise a set of "Limits of Acceptable Change" to determine carrying capacities set for tourism activities within the AMR (particularly dive sites).		Initiate			
	Output (2.3): Construction of key interventions proposed as set out within the Aqaba Ecotourism Plan (including an aquarium following international standards).	Initiate				
	Output (2.4): Develop the current Blue Flag initiative in Aqaba to embrace the requirements set out within the latest international beach standard (ISO13009).			Initiate		
	Output (2.5): An innovative AMR Marketing Plan is developed and implemented to help promote community engagement and associated product development		Initiate			
Objective 3: Effective surveillance and patrolling is being implementing to cover the entire AMR area	Output (3.1): Necessary surveillance and enforcement capacity (equipment) is enhanced to support implementation of the AMRMP Vision	Initiate				
	Output (3.2): Necessary operational patrol enforcement / surveillance teams (human capacity and multi-agency support) are enhanced to support implementation of the AMRMP Vision.	Initiate				
Objective 4: Improve and strengthen institutional/legal framework and associated management capacities	Output (4.1): Legislative and institutional organizational development needs are improved upon to support delivery of the AMR Vision	Initiate				
	Output (4.2): Setup, implementation and management of a marine environmental information system to help support implementation of the AMRMP Vision	Initiate				
	Output (4.3): Monitoring and evaluation systems are introduced to improve the measurement and reporting of results based outcomes	Initiate				

	Output (4.4): Human resources are secured and capacitated to cope with the AMR management requirements	Initiate				
Objective 5: Marine Conservation awareness and Education is improved at the International and National Level	Output (5.1): Stakeholder communication strategy is developed and implemented following best international and national Protected Area practice		Initiate			
	Output (5.2): Educational and awareness raising strategy (national and international level) is developed to demonstrate the global importance of AMR).	Initiate				
	Output (5.3): Promote national and international cooperation for the marine ecosystem conservation and biodiversity needs within the wider Gulf of Aqaba to support any future designation as a World Heritage Site, Biosphere Reserve etc			Initiate		
Objective 6: Sustainable financial mechanisms are established and implemented to finance future AMR related management operations and activities	Output (6.1): Prepare an inventory of infrastructure readiness and future funding needs (logistics, buildings, signage etc)	Initiate				
	Output (6.2): Develop a Fundraising strategy which is distributed and implemented successfully which considers budget allocated by the government to ASEZA and concessions obtained from the existing business		Initiate			
	Output (6.3): Establish operational guidelines for administration of reserve fund budgets (national, CSR or international) along with clarity over the role of the MOE	Initiate				

References

- Abu-Hilal, A. (1985). Phosphate pollution in the Jordan Gulf of Aqaba. Mar. Pollut. Bull., 16, 28-285.
- Abu-Jaber, M. (1991). Morpho-sedimentological controls on the environmental management of the Jordanian coast of the Gulf of Aqaba. Unpublished master thesis. Duke University, USA.
- Abu-Ouf, M., Al-Hazmi, Y.M., Al-Rousan, S., Arz, H.W., Donner, B., Felis, T., Kadi, K.A., Kuhlmann, H., Lqtzeler, T., Moammar, M.O., Moos, C. (2000). Meteor Berichte, cruise no. 44. In: P7tzold, J., Halbach, P.E., Hempel, G., Weikert, H. (Eds.), Leitstelle Meteor. Institut für Meereskunde der Universit7t Hamburg.
- ADC (2008). Aqaba Development Corporation. Ports Relocation and Development Project. Environmental Impact Assessment, Draft 6.0 2.10.2008. Environmental Impact Statement (EIS) Revised 7.0. Prepared by ECOConsult
- Al Farajat, M. (2001). Hydrogeo-Ecosystems in Aqaba –Coasts and Region; Natural Settings, Impacts of Land Use, Spatial Vulnerability to Pollution and Sustainable Management. Doctorate Thesis, Uni-Wuerzburg, Hydrogeologie und Umwelt, Würzburg-Germany. http://opus.bibliothek.uni-wuerzburg.de/opus/volltexte/2002/241/.
- Al Ouran, N. (2005). Environmental Assessment, Documentation and Spatial Modeling of Heavy Metal Pollution along the Jordan Gulf of Aqaba Using Coral. Doctorate Thesis Submitted to Department of Hydrogeology and Environment. Julius-Maximilians-University of Würzburg.
- Al-Rifaiy, I. A. and Cherif, O. H. (1988). The fossil coral reefs of Al-Aqaba, Jordan, Facies, 18, 219–230.
- Alsawair, J. and Solieman. A. (2013). Diagnosis of Air Quality in Aqaba. Report prepared for Project Governance of Air Quality in the Mediterranean Cities GOUV'AIRNANCE (Draft Report). ASEZA.
- Al Tawaha, M., Benzoni, F., Eid., and Abu Awali. A. (2019). The Hard Coral of Jordan: A Field Guide. The Royal Marine Conservation Society of Jordan. Amman, Jordan. ISBN: 978-9957-8740-4-9. Pp 432.
- Al Tawaha, M., Omar, K., El Haddad, K., Abu Awali, A., Abdelazeem, I. (2019). "Ecological Assessment of Coastal Ecosystems in Aqaba, Jordan - Marine Habitat Mapping". The Royal Marine Conservation Society of Jordan. Amman, Jordan. ISBN: 978-9957-8740-4-9. 400pp.
- Al-Weshah, R. and El-Khoury, F. (1999). Flood Analysis and Mitigation for Petra Area in Jordan, Journal of Water Resources Planning And Management, 125, (3), 170-177.
- Arz, H.W., Lamy, F.P., Patzold, J., Mqller, P.J., Prins, M. (2003). Mediterranean moisture source for an early-Holocene humid period in the Northern Red Sea. Science 300, 118– 121.
- Aqaba Ecotourism Development Plan (2014);
- Aqaba Marine Park Management Plan (2014-2018) (in Arabic);
- Aqaba Marine Park – Publicity Strategy (2014) (in Arabic);
- Assaf, G., and J. Kessler (1976). Climate and energy exchange in Gulf of Aqaba (Eilat), Mon. Weather Rev., 104, 381–385.
- Badran M.I. (2001). Dissolved oxygen, chlorophyll a and nutrient seasonal cycles in waters of the Gulf of Aqaba, Red Sea. Aquat. Ecosyst. Health Manage., 4, 139–150.
- Badran, M., and Foster, P. (1998). Environmental quality of the Jordanian coastal waters of the Gulf of Aqaba, Red Sea. Aquatic Ecosystem Health and Management 1, 83-97.
- Badran, M., Rasheed, M., Manasrah, R., and Alnajar, T. (2005).Nutrient flux, fuel of the summer primary productivity in the oligotrophic waters of the Gulf of Aqaba, Red Sea.Oceanologia 47, 47-60.

- Barjous, M., Mikbel, S. (1990). Tectonic evolution of the Gulf of Aqaba–Dead Sea transform fault system. Tectonophysics 180, 49–59.
- Ben-Avraham, Z. (1985). Structural framework of the Gulf of Elat (Aqaba), Northern Red Sea. J. Geophys. Res. 90 (B1), 703–726.
- Ben-Avraham, Z., Almagor, G., Garfunkel, Z. (1979). Sediments and structure of the Gulf of Elat (Aqaba)–Northern Red Sea. Sediment. Geol. 23, 239– 267.
- Ben-Avraham, Z., Garfunkel, Z. (1986). Character of transverse faults in the Elat-pull-apart basin. Tectonics 5, 1161–1169.
- Ben-Avraham, Z., Tibor, G. (1993). The northern edge of the Gulf of Elat. Tectonophysics 226, 319– 331.
- Berman, T., Paldor, N. and Brenner, S. (2000). Simulation of wind-driven circulation in the Gulf of Elat (Aqaba), J. Mar. Syst., 26, 349–365.
- Berman, T., Paldor, N. and Brenner, S. (2003). The seasonalty of the tidal circulation in the Gulf of Elat. Isr. J. Earth Sci., 52, 11-19.
- Biton, E. and Gildor, H. (2011). The general circulation of the Gulf of Aqaba (Gulf of Eilat) revisited: The interplay between the exchange flow through the Straits of Tiran and surface fluxes. Jour. Geophys. Res. 116, 1-15. C08020, doi:10.1029/2010JC006860, 2011.
- Bogdanova, A.K. (1974). Indirect estimation of the seasonal variation of the water exchange through Bab El Mandeb. Center National Pour L'exploitation des Ocean (CNEXO), no. 2, p. 253-265. 1974.
- Carlson, D., Fredj, E., Gildor, H. and Rom-Kedar, V. (2010). Deducing an upper bound to the horizontal eddy diffusivity using a stochastic Lagrangian model, Environmental Fluid Mechanics, 10, 499-520, DOI 10.1007/s10652-010-9181-0.
- Cazenave A., Dominh K., Gennero M.C., Ferret B (1998). Global mean sea level changes observed by Topex-Poseidon and ERS-1. Phys Chem Earth 23, 1069-75.
- Christiansen, E. H. and Hamblin,W. K. (2015). Transform Plate Boundaries. in: Dynamic Earth: An introduction to Physical Geology. Eric H Christiansen and W Kenneth Hamblin (Eds). Jones & Bartlett Learning; Pap/Psc edition (February 26, 2014). 838pp. ISBN-13: 9781449659844
- Chiffings, T. (2003). Marine Region 11: Arabia Seas. A Global Representative System of Marine Protected Areas.
- Coleman, R.G. (1974). Geological background of the Red Sea: Initial Repts. Deep Sea Drilling Project, 23, 813-820.
- Courtillot, V., Armijo, R., Tapponnier, P. (1987). Kinematics of the Sinai triple junction and a two phase model of the Arabia–Africa rifting. In: Coward, M.P., Dewey, J.F., Hancock, P.L. (Eds.), Continental Extensional Tectonics, Geological Society Special Publication 28, 559– 573.
- Cui, M., Storch, H., Zorita, E. (1995). Coastal sea level and the largescale climate state: A downscaling exercise for the Japanese Islands. Tellus 47A:132-144, DOI 10.1007/s12601-009-0013-4.
- Degens, E.T. and Ross, D.A. (1969). Hot Brines and Heavy Metal Deposits in the Red Sea; a geochemical and geophysical account, xii, 600pp. Springer-Verlag, Berlin, Heidelberg, New York.
- Douglas, B.C. (1992). Global sea level acceleration. J Geophys Res 97(C8): 12699-12706.
- DRMP-ASEZA. (2010). Disaster Risk Management Profile for Aqaba Special Economic Zone. Project: Support to Building National Capacity for Earthquake Risk Reduction at ASEZA in Jordan. May, 2010.
- ECO- Consult (2009) Ferry Terminal Relocation Environmental Impact Statement – Final Draft
- ECO- Consult (2008) Aqaba Ports Relocation and Development Project – (EIS – Version 7).

- ECO- Consult (2006) Aqaba Lagoon Tourism Development Environmental Impact Statement - Draft
- ECO- Consult (2006) Aqaba Lagoon Tourism Development Environmental Impact Statement – Annexes
- ECO- Consult (2005) Tala Bay Tourism Development project – Environmental Statement – Draft Report
- Edwards, F.W. (1987). Climate and Oceanography. In: Edwards AJ, Head SM (eds) The Red Sea, pp 45-68.
- Egypt, State Information Service (2014). http://www.sis.gov.eg/En/Templates/Articles/tmpArticles.aspx?CatID=22 (Accessed 29 May 2014).
- Egyptian-Israeli General Armistice Agreement, 24 February, (1949).
- Ehrhardta, A. Hqbschera, C. Ben-Avrahamb, Z. Gajewskia, D. (2005). Seismic study of pull-apart-induced sedimentation and deformation in the Northern Gulf of Aqaba (Elat). Tectonophysics 396, 59– 79.
- El Raey. M. (2010). Impact of Sea Level Rise on the Arab Region. United Nations Development Program - Regional Bureau for Arab States (UNDP RBAS). Pp 89.
- Emery K.O., Aubrey D.G. (1991). Sea Levels, Land Levels, and Tide Gauges. Springer-Verlag, New York, 237 p.
- Environmental Appraisal of the Jordanian Coast of the Gulf of Aqaba, Red Sea. Jordan's National Monitoring Program (2013).
- Eyal, M., Eyal, Y., Bartov, Y., Steinitz, G. (1981). The tectonic development of the Western margin of the Gulf of Elat (Aqaba) Rift. Tectonophysics 80, 39–66.
- Fouda M. and Gerges, M. (1994). Implications of climate change in the Red Sea and Gulf of Aden Region: an overview. UNEP Regional Seas Reports and Studies, No. 156, UNEP, 1994: p. 58.
- Friedman, G.M. (1965). A fossil shoreline reef in the Gulf of Elat (Aqaba), Israel Journal of Earth Sciences 14, 86-90.
- Friedman, G.M. (1985). Gulf of Elat (Aqaba) geological and sedimentological framework, in: Hypersaline ecosystems, G.M. Friedman and W.E. Krumbein, eds. Springer-Verlag, Berlin, pp. 39-71.
- Garfunkel, Z., and Ben-Avraham, Z. (1996). The structure of the Dead Sea basin. Tectonophysics 226, 155– 176.
- Geological-geophysical Atlas (1975). Indian Ocean (1975).
- Gildor, H. Fredj, E. and Kostinski, A. (2010). The Gulf of Eilat/Aqaba: a Natural Driven Cavity? Geophy. Astro. Fluid Dyn., doi: 10.1080/03091921003712842.
- Gildor, H., Fredj, E. Steinbuck, J. and Monismith, S. (2009). Evidence for submesoscale barriers to horizontal mixing in the ocean from current measurements and aerial-photographs, J. Phys. Oceanogr., 39, 1975-1983, doi:10.1175/2009JPO4116.
- Gornitz, V. (1993). Mean sea level changes in the recent past. In: Warrick RA et al. (eds) Climate and Sea Level Change: Observations, Projections and Implications, Cambridge University Press, Cambridge, pp 25-44
- Harress Pickel Consult AG (2008) "Aqaba Tourism Blue Flag Project (Blue Flag Criteria) - IS-ASEZA Project 2007/139085", produced by Jonathan McCue.
- Hashemite Jordan Kingdom – Israel: General Armistice Agreement, 3 April 1949, UN Security Council Official Records Document s/1302/Rev.1
- Heiss, G. A, Dullo, W., Joachimski, M., Reijmer, J. And Schumacher, H. (1999). Increased Seasonality in the Gulf of Aqaba, Red Sea, Recorded in the Oxygen Isotope Record of a Porites lutea coral. Senckenbergiana martitima, 30, pp. 17-26.
- http://www.sis.gov.eg/En/Templates/Articles/tmpArticles.aspx?CatID=22 (29 May 2014)
- Hulings, N. C. (1979). Currents in the Jordan Gulf of Aqaba. Dirasat, 6, 21–31

- Hulings, N.C. (1989). A review of marine research in the Gulf of Aqaba. Publications of the Marine Science Station, Aqaba, Jordan, No. 6. Jordan Department of Libraries, Documentation and National Archives Deposit Number 489/9/1989.
- ICRI (1995). State of the Reefs Regional and Global Perspectives: ICRI's Major Concern. International Coral Reef Initiative, 38p.
- IPCC (2007). Climate Change 2007-the scientific basis. In: Houghton JT et al. (eds) the third assessment report of the intergovernmental panel on climate change, United Kingdom and New York, 881 p.
- ISPAN (1992). Gulf of Aqaba Environmental Data Survey. Irrigation Support Project for Asia and Near East, unpublished report prepared for U.S. Agency for International Development (USAID),79p.
- IUCN (1993). Reefs at Risk: A program for action. International Union for Conservation.
- Kaplan, D. M., and F. Lekien (2007). Spatial interpolation and filtering of surface current data based on open-boundary modal analysis, J. Geophys. Res., 112, C12007, doi:10.1029/2006JC003984.
- Khalai, M and Kochzius, M (2002) "Changes in trophic community structure of shore fishes at an industrial site in the Gulf of Aqaba, Red Sea" Mar, Ecol Prog Ser (Vol. 239: 287–299);
- Khalaf, A (2015) "Establishment of Baseline and Development of Management Plan for Fisheries in Aqaba". Final Report.
- Khalek, A., Wahed, A., Sehim, A. (1993). Wrenching deformation and tectonic setting of the Northwestern part of the Gulf of Aqaba. Geol. Soc. Egypt, Sec. Publ. 1, 409–444.
- Klinker, J., Reisis, Z., Kropach, C., Levanon, I., Harpaz, H. (1978). Nutrients and biomas distribution in the Gulf of Aqaba (Elat), Red Sea, Marine Biology 45, 53-64.
- Klinker, J., Z. Reiss, C. Kropach, I. Levanon, H. Harpaz, E. Halicz and G. Assaf, (1976). Observation on the circulation pattern in the Gulf of Aqaba, Red Sea. Israel. J. Earth Sci., 25, 85–103.
- Labiosa, R. G. and Arrigo, K. R. (2003). The interplay between upwelling and deep convective mixing in determining the seasonal phytoplankton dynamics in the Gulf of Aqaba: Evidence from SeaWiFS and MODIS, Limnol. Oceanogr., 48 (6), 2355–2368.
- Lekien, F. and H. Gildor (2009). Computation and approximation of the length scales of harmonic modes with application to the mapping of surface currents in the Gulf of Eilat, J. Geophys. Res., 114, C06024, doi: 10.1029/2008JC004742, 2009.
- Lekien, F., C. Coulliette, R. Bank, and J. E. Marsden (2004). Open-boundary modal analysis: Interpolation, extrapolation, and filtering, J. Geophys. Res., 109, C12004, doi:10.1029/2004JC002323.
- Lindell, D. and Post, A.F. (1995). Ultraphytoplankton succession is triggered by deep winter mixing in the Gulf of Aqaba (Eilat), Red Sea. Limnol. Oceanogr., 40 (6), 1130-l 141
- L-Oeil d'Andromede (2011) "Multi-beam Bathymetry and Underwater Habitats: Pre-Mapping of the Jordan Coasts";
- Longhurst, A.R. (1998). Ecological Geography of the Sea. Academic Press, California, U.S.
- Manasrah, R. S., M. Badran, H. U. Lass, and W. Fennel (2004). Circulation and winter deep-water formation in the northern Red Sea, Oceanologia, 46, 5–23.
- Manasrah, R., (2002). The general circulation and water masses characteristics in the Gulf of Aqaba and northern Red Sea. Ph.D. dissertation, Physical department, Rostock University, Germany
- Manasrah, R., Hasanean, H.M. and Al-Rousan, S. (2009). Spatial and Seasonal Variations of Sea Level in the Red Sea, 1958-2001. Ocean Sci. J., 44(3), 145-159,

- Manasrah, R., Rasheed, M., Badran, M. (2006). Relationship between water temperature, nutrients and dissolved oxygen in the northern Gulf of Aqaba, Red Sea. Oceanologia 48, 237-253.
- Mansour, L (2012) "Capacity Needs Assessment and Capacity Development Plan for ICZM in Aqaba
- Maritime Agreement between the Government of the State of Israel and the Government of the Hashemite Kingdom of Jordan, 18 January 1996.
- Mohammad Al-Zibdah, Maroof Khalaf and Nidal Oda (2001) The Fishery Status in Jordan's Gulf of Aqaba, Red Sea
- Mohorjy A. and Khan A. (2006). Preliminary Assessment of Water Quality along the Red Sea Coast near Jeddah, Saudi Arabia. Water International 31, 109–115.
- Morcos, S. (1970). Physical and chemical oceanography of the Red Sea, Oceanogr. Mar. Biol., 8, 73–202.
- Murray, S., A. Hecht, and A. Babcock (1984). On the mean flow in the Tiran Strait in winter, J. Mar. Res., 42, 265–284.
- Nerem R.S. (1999). Measuring very low frequency sea level variations using satellite altimeter data. Global and Planetary Change, 20:157-171.
- Nerem, R.S., Haines, B.J., Hendricks, J., Minster, J.F., Mitchum, G.T. and White, W.B. (1997). Improved determination of global mean sea level variations using TOPEX/POSEIDON altimeter data. Geophysical Research Letters 24: doi: 10.1029/97GL01288. issn: 0094-8276.
- Niemann, H., Richter, C., Jonkers, H.M., Badran, M.I.(2004). Red sea gravity currents cascade near-reef phytoplankton to the twilight zone. Marine Ecology. Progress Series 296, 91–99.
- Nomination of Sanganeb Marine National Park and Dungonab Bay/Mukkawar Island Marine National Park (Sudan – Red Sea) For Inscription On the World Heritage List
- Opulithe (2014). Transform Plate Boundaries. Published by opulithe. Sep 27, 2014.
- Osman M.M. (1984). Variation of sea level at Port Sudan. Int. Hydrogr. Rev. Monaco, LXI, 137-144
- Osman M.M. (1985). Seasonal and secular variations of sea level at Port Sudan. J Faculty Mar Sci 4,15-25
- Paldor, N. and D. A. Anati (1979). Seasonal variation of temperature and salinity in the Gulf of Elat (Aqaba). Deep-Sea Res., 26, 661–672.
- PERSGA (2006). State of the marine environment. Report for the Red Sea and Gulf of Aden.
- Plähn, O., Baschek, B., Badewien, T.H., Walter, M. and Rhein, M. (2002). Important of the Gulf of Aqaba for the formation of bottom water in the Red Sea. J. Geophys. Res., 107(C8), doi:10.1029/2000JC000342.
- Poisson A., Morcos S., Souvermezoglou E., Papaud A., Ivanoff A. (1984). Some aspects of biogeochemical cycles in the Red Sea with special reference to new observations made in summer 1982, Deep Sea Res., 31, 707-718.
- Post, A.F, Dedej, Z., Gottlieb, R., Li, H., Thomas, D.N., El-Absawi, M., El-Naggar, A., El-Gharabawi, M. and Sommer, U. (2002). Spatial and temporal distributions of Trichodesmium spp. in the stratified Gulf of Aqaba, Red Sea. Mar. Ecol. Prog. Ser. 239, 241–250.
- Quadfasel, D. and Baudner, H. (1993). 'Gyre-scale circulation cells in the Red Sea' Oceanologica Act. 16, pp. 221-229.
- Rasheed M, Al-Trabeen K, Badran, M. (2012).Long-term water quality monitoring at an industrial site on the Nothern Gulf of Aqaba, Red Sea. Mediterranean Marine Science,13, 250-258.
- Rasheed, M., Al-Rousan, S., and Badran, M. (2005). Phosphate enrichment in the northern Gulf of Aqaba: Regulation by carbonate sediment and impact on nitrogen elevation. Chemistry & Ecology., 21, 199-208.
- Rasheed, M., Badran, M., Richter, C., and Huettel, M.(2002).Effect of reef framework and bottom sediment on nutrient enrichment in a coral reef of the Gulf of Aqaba. Marine Ecology Progress Series 239, 277-285.

- Rasheed, M., M. Badran, and M. Huettel(2003). Particulate matter filtration and seasonal nutrient dynamics in permeable carbonate and silicate sands of the Gulf of Aqaba, Red Sea. Coral Reefs. 22, 167-177.
- Rawber, 1974 both in Loya, (1988)
- Reches, Z., Erez, J., Garfunkel, Z. (1987). Sedimentary and tectonic features in the northwestern Gulf of Elat, Israel. Tectonophysics 141, 169– 180.
- Red Sea - Dead Sea Water Conveyance Study Program Additional Studies, Red Sea Study (2011).
- REEC (2015) Rehabilitation and Extension of Industrial Terminal in South Port /Aqaba Jetty Marine Work and Civil Works.
- Reiss, Z., and Hottinger, L. (1984). The Gulf of Aqaba: Ecological Micropaleontology. Ecological studies 50. Springer-Verlag, Berlin.
- Richter, C., and Abu-Hilal, A. (2006). Seas of the Arabian Region.Chapter 34. In: The Sea: The Global Coastal Ocean, Interdisciplinary Regional studies and Synthesis.Volume 14 Part B. Edited by Allan R. Robinson and Kenneth H. Brink. Pp 1373-1412. Harvard University Press, Cambridge, MA.
- Rushdi, A.I. (1996). Descriptive Chemical Oceanography of the Red Sea: Introductory Report, United Nations Development Program (UNDP).
- Saudi Arabia,2005; First National Communication, Kingdom Of Saudi Arabia, Submitted To The United Nations Framework Convention On Climate Change, (UNFCCC); Presidency Of Meteorology And Environment (PME)
- SCA (Suez Canal Authority) 2013 Annual Report.
- Shaikh, E. A., Roff, J. C., Dowidar, N. M. (1986). Phytoplankton ecology and production in the Red Sea off Jiddah, Saudi Arabia. Mar. Biol. 92, 405-41.
- Shaked, Y., Marco, S., Lazar, B., Stein, M., Cohen, C., Sass, E., Agnon. A. (2002). Late Holocene shorelines at the Gulf of Aqaba: migrating shorelines under conditions of tectonic and sea level stability. EGU Stephan Mueller Special Publication Series 2, 105–111.
- SMART (2005). Muhammad Shatanawi and Zain Al-Houri. (2005). Case Study Report: Aqaba, Jordan. C:\Users\MSS\Desktop\D013.docSustainable Management of Scarce Resources in the Coastal Zone (SMART). Project Deliverable: D08.1 Case Study Report: Aqaba, Jordan. Final Report (draft). European Commission, Research Directorate General. SDME 1/02. B-1049 Brussels, Belgium
- Sorkin, Y.I. (1995) Coral reef ecology. Ecological studies (Heldmaier, G., Lange, O.L, Mooney, H.A., Sommer U., Ed.), 192, Springer-Verlag, Berlin, 464 pp.
- Srebro, H. (2009). The Definition of the Israeli International Boundaries in the Vicinity of Eilat. TS 3A – New Challenges in Land Administration. The Definition of the Israeli International Boundaries in the Vicinity of Eilat. FIG Working Week 2009. Surveyors Key Role in Accelerated Development. Eilat, Israel, 3-8 May 2009
- Stambler, N. (2005). Bio-optical properties of the northern Red SEa and the Gulf of Eilat (Aqaba) during winter 1999. J. Sea Res., 45, 186-203.
- Sultan S.A.R., Ahmad F., El-Hassan A. (1995). Seasonal variations of the sea level in the central part of the Red Sea. Estuar Coast Shelf Sci. 40 (1), 1-8
- Sultan S.A.R., Ahmad F., Nassar D. (1996). Relative contribution of external sources of mean sea-level variations at Port Sudan, Red Sea. Estuar Coast Shelf Sci 42(1), 19-30
- The Palestine Order in Council (1922). The Official Gazette of the Government of Palestine, 1 September 1922.
- Thiel, H. and Karbe L. (1986). Risk assessment of mining metalliferous muds in the deep Red Sea.Ambio, 15, 34-4

- Thiel, H. (1990). 'Marine Biology' Red Sea, Gulf of Aden and Suez Canal: A Bibliography on Oceanographic and Marine Environmental Research, eds. S. A. Morcos and A. Varley, UNESCO.
- Titus J.G., Narayanan V. (1996). The Risk of Sea Level Rise. Climatic Change 33, 151-212
- Treaty of Peace (1979). Treaty of Peace between the Arab Republic of Egypt and the State of Israel, 26 March 1979.
- Treaty of Peace (1994). Treaty of Peace between the State of Israel and the Hashemite Kingdom of Jordan, 26 October 1994.
- Tsimplis M.N., Woodworth P.L. (1994). The global distribution of the seasonal sea level cycle calculated from coastal tide gauge data. J Geophys Res 99(C8):16031-16039
- UNDP (2014) "Jordan ICZM Country Report 2014 - Towards Sustainable Coastal Zone Development"
- UNDP (2011) "Mainstreaming marine biodiversity conservation into coastal zone management in the Aqaba Special Economic – Project Document" UNDP (2015) "State of the Coast Report, Aqaba", prepared by Professor Dr Ahmad H. Abu Hilal et al.
- UNDP (2015) "Development of Sea Use Master Plan Based on Marine Spatial Planning – the Master Plan".
- UNEP (1985). Regional Seas Reports and Studies No. 64: IUCN/ UNEP. Management and conservation of renewable marine resources in the Red Sea and Gulf of Eden region.
- Unnikrishnan A.S., Shankar D. (2007). Are sea-level-rise trends along the coasts of the north Indian Ocean consistent with global estimates? Global and Planetary Change 57, 301-307
- Vorhies, F and Ziad Samaha (2015) "Business Case for Conserving Aqaba's Coastal and Marine Resources", produced for the Mainstreaming Marine Biodiversity Conservation into Coastal Zone Management – UNDP & AZESA project funded by the GEF.
- Vorhies, F (2016) "The Economic Values of Aqaba's Coastal and Marine Resources" produced for the Mainstreaming Marine Biodiversity Conservation into Coastal Zone Management – UNDP & AZESA project funded by the GEF;
- Wdowinski, S., Zilberman, E. (1996). Kinematic modelling of larges cale structural asymmetry across the Dead Sea Rift. Tectonophysics 266, 187– 201.
- Weikert, H. (1987). Plankton and the pelagic environment. In: Edwards, A., Head. S. M. (eds.) Red Sea. Key Environmental Series. Pergarnon Press, Oxford, p. 90-1 11.
- Zhai, P. and Bower, A. (2013). The response of the Red Sea to a strong wind jet near the Tokar Gap in summer. Journal Of Geophysical Research: Oceans, 118, 422–434, doi:10.1029/2012JC008444, 2013.