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Journal of The Arab Institute of Navigation

Semi Annual Scientific Journal
Issue 45 (volume 1) January 2023
ISSN (2090-8202)
INDEXED IN (EBSCO)

Contents

The Red Sea Fisheries - Threats and Proposed Solutions

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المستخلص

تقسم البحار والمحيطات في العالم الي ٦٦ نظام بيئي والبحر الاحمر رقم ٣٣ وتوفر هذة الانظمة البيئية البحرية ملايين فرص عمل للناس وتنتتج ثلاثة ارباع انتاج السمك سنويا. والبحر الاحمر يعتبر واحد من املح وادفئ الانظمة البيئية الموجودة.

الهدف الرئيسي من هذة الورقة البحثية هو اقتراح حلول سياسية للتخطيط الاستراتيجي الملائم لدول البحر الاحمر وذلك لاستعادة المخزون السمكي الطبيعي المستنفذ وكذلك لاستدامة المخزون السمكي الطبيعي وذلك لتحقيق الاهداف الاجتماعية-الاقتصادية والبيئية في السنوات القليلة القادمة.

ومنهجية البحث المستخدمة هي مزيج من النهج التحليلي والوصفي. والنهج التحليلي بيوضح الاسباب الرئيسية التي ادت الي استنفاذ المخزون الطبيعي من الثروة السمكية في البحر الاحمر علي سبيل المثال (الصيد الجائر , الصيد الغير قانوني والغير منظم والغير مقرر , التنمية الساحلية وتغير المناخ). وباستخدام SWOT التحليللي والبيانات المجمعة لتحديد الوضع الراهن والحلول البديلة المقترحة لاستعادة للثروة السمكية المستنفزة في البحر الاحمر.

Abstract

The global oceans and seas are broadly balkanized into 66 large Marine Ecosystems (LMEs), and the Red Sea is the number 33 of these LMEs. Moreover, they provide job opportunities for millions of people and generate about three-quarters of the world fish production annually. The Red Sea (LME#33) is believed to be the saltiest and warmest sea among these LMEs.

The main aim of this paper is to suggest policy solutions as proper planning strategies for the Red Sea countries to restore the depleted naturally fish stocks and to sustain natural fisheries stocks to achieve socio-economic and environmental goals in the coming years.

The methodology used in this research is a merge of descriptive and analytical approach. The analytical research focusses on the main causes and losses that led to depleting natural fisheries stocks in the Red Sea such as (overfishing, Illegal, Unreported, and Unregulated (IUU) fishing, coastal development, and climate change). This research analyses the data collected from the literature and the SWOT analysis outcomes to investigate the current status-quo and to propose alternative solutions for the natural fish stock depletion in the Red Sea.

Keywords: The Red Sea, Fisheries, SDG 14.4, Socioeconomic, Overfishing, IUU fishing.

1. Introduction

Oceans represent almost three-quarters of the total fish production globally, and they yield about $13 US trillion yearly (Sherman, 2019).

The Red Sea is number 33 (LME #33) and it is one of the youngest, warmest, and saltiest seas in the world due to the high evaporation rate, also because no rivers flow into it, and the low rainfall quantity (Sheppard, 2019). In addition, it is a semi-enclosed basin, also located between Africa and the Arabian Peninsula, the length of the Red Sea is approximately 2250 km, and its maximum width in the South about 355 km, and its average depth about 500 m (Binnaser, 2021). Moreover, in the South of the Red Sea is linked with the Indian Ocean via Bab al Mandeb, whereas in the North, it is separated by the Sinai Peninsula to the Gulfs of Aqaba and Suez. Also, there are eight countries located along the Red Sea, namely Djibouti, Egypt, Eretria, Israel, Saudi Arabia, Sudan, and Yemen (See Figure 1). About 28 million people live along the Red Sea Coastline, which is deemed as a low population rate. While, Jeddah is the highest city of the Red Sea in terms of population density with about 4 million people (Zeeshan Habib & Thiemann, 2022).

Fisheries in the Red Sea have existed for thousands of years. In addition, the Red Sea is characterized by low fish productivity or oligotrophic ecosystem and has about 1200 species of fish (Al-Rashada et al., 2021). Furthermore, the fish production in the Red Sea is distributed according to the variations of water salinity and temperature (Maiyza et al., 2022). Moreover, it has high biodiversity and a relevant environment for many marine species because the LME #33 has coral reefs and mangroves forests (Gardens, 2021). In addition, natural fisheries play a significant role in raising countries' Gross Domestic Product (GDP), food security, and saving job opportunities. Furthermore, the Red Sea natural Fisheries are divided into three main fishing types, small scale fishing where fishers use small fishing boats and fish near the coastline (artisanal), commercial (purse seiners, and trawling), and sport or entertainment fishing.

On the other hand, human activities such as overfishing, IUU Fishing, marine pollution, and climate change has a significant impacts in depleting the natural fisheries stocks in the Red Sea. Furthermore, the world economic crisis may lead to some Red Sea countries to change their priorities and policies from fisheries economy to shipping and harbors optimization industry (Fine et al., 2019) .

This research analyses the data collected from the literature. Moreover, the SWOT analysis is a strategic tool in hand decision-makers to evaluate the natural fish stocks of the Red Sea. In addition, SWOT analysis determines the internal and external impacts that are depleting the natural fish stocks of the Red Sea and making it a healthy and more productive ecosystem to meet the objectives.

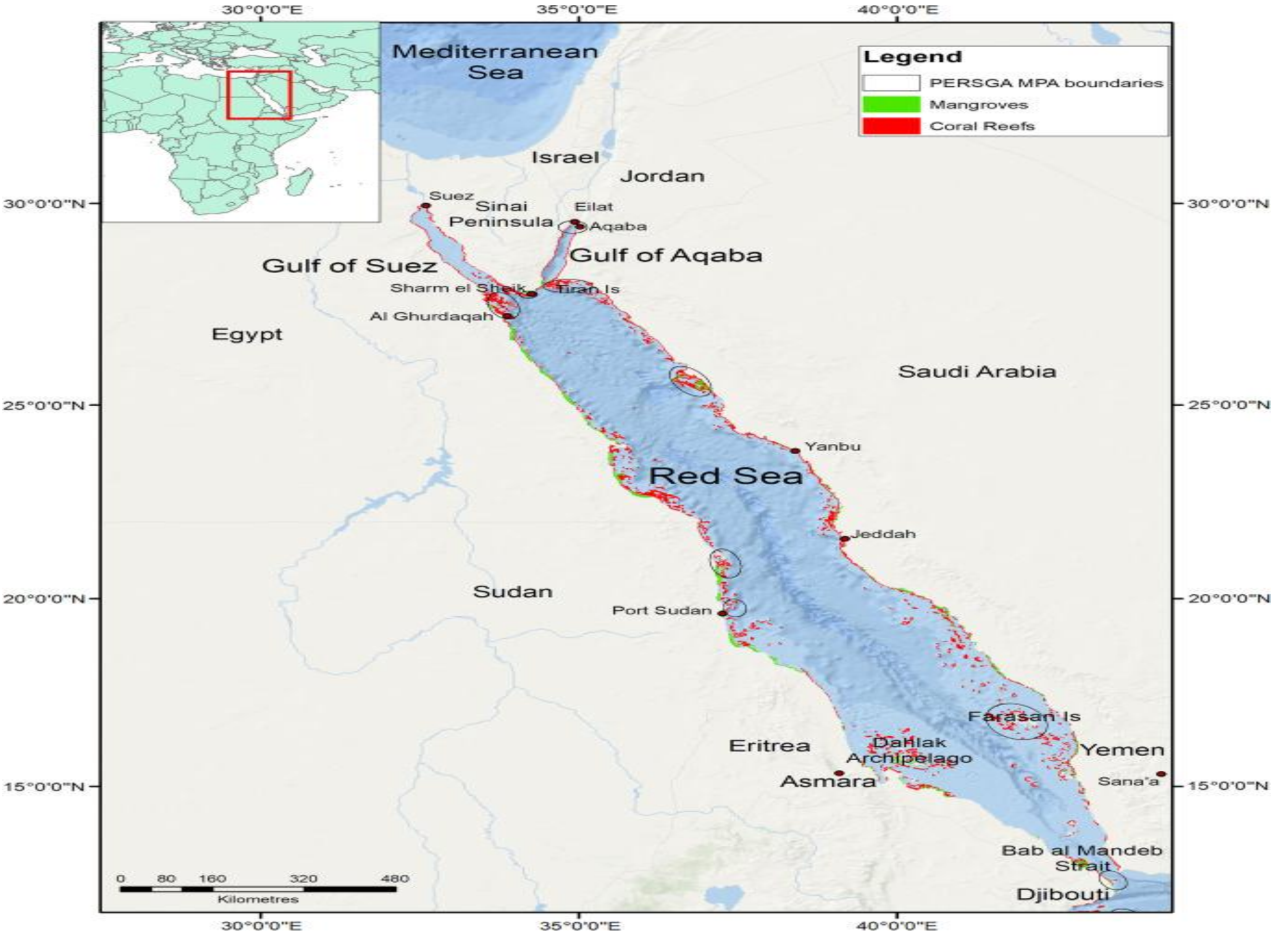

Figure (1): The Red Sea
Source: (Sheppard, 2019).

2. Fisheries

There are five countries of the Red Sea operate fisheries fleet in the region namely Egypt, Eritrea, Saudi Arabia, Sudan, and Yemen. Moreover, the fish production increases in the direction of the South. Egypt and Yemen have the oldest fleets and represent about two-thirds of the total Red Sea fish catching, Saudi Arabia has the most modern fleet. Furthermore, Eritrea and Sudan are not exploiting their marine resources optimally (Sheppard, 2019).

Artisanal fishing (small scale fishing) in comparison to commercial fishing (trawling and purse seiners) where the artisanal fishing enhances the sustainability of marine resources, and the economic return is almost the same for the Red Sea countries (Sheppard, 2019).

On the other hand, blast fishing using dynamite or destructive fishing methods, especially along the Egyptian coastline, has affected coral cover, and reduced fish quantity and biomass. Moreover, shark finning is endangered sharks in the Red Sea because fishers take shark's fins, and through the rest to the sea. Moreover, bycatch threatens sea turtles in the Red Sea despite the fact they are not targeted by fishers, and all of these practices have affected food chain and damaged biodiversity of the Red Sea (Sheppard, 2019).

There are some threats that cause adverse impacts on fisheries stocks they are as following:

2.1 Overfishing

In the beginning of the 1990s, the issue of overfishing has begun in the Red Sea due to the absence of states control, and noncompliance to fishing laws by fishers including the use of modern fishing techniques. Moreover, they use destructive methods such as dynamite or bombing fishing and they use poison in fishing such as cyanide so fishing rates are quicker than reproduction. On the one hand, some marine species have slow growth rates and late sexual maturing such as serranidae and sharks (Shellem et al., 2021). In addition, sea cucumber has been reported as overexploited in the Egyptian Red Sea coastline and along Saudi Arabia western coastline and in the gulf of Aqaba (Hasan, 2019), also overfishing deplete fisheries resources from reefs ecosystem (Solami, 2020).

On the other hand, Marine Protected Areas (MPAs) are one of the most powerful techniques for protecting vulnerable fisheries resources from human activities, but they are not sufficient in all the Red Sea regions. Furthermore, they are not suitable for highly movement marine species (Akhmadeeva, 2021). Thus, all of the mentioned reasons have depleted the natural fisheries stocks in the Red Sea.

However, concerned authorities can use some methods to habilitate the exhausted natural fisheries stockpiles in the Red Sea such as by determining the catch size and quantity, and using specific fishing methods, as well as detecting no take zones and seasons.

2.2 Illegal, Unreported and Unregulated (IUU) fishing

IUU Fishing represents about 20 percent and may reach 50 percent of the total fish catch in some regions globally due to the absence of the political will for law enforcement and monitoring. In the last decade, the illegal fishing has increased in the Red Sea especially in the Southern region (Djibouti, Eritrea, and Yemen) as a result of the Yemeni civil war and due to the absence of Yemeni state control over its fisheries resources. Therefore, the conflict in the southern region over fisheries stocks between alien fishing boats and global navy ships have increased (Devlin et al., 2021).

The main function of MPAs in the Red Sea is to protect marine species from extinction either targeted or non-targeted (Gajdzik et al., 2021). However, the size of MPAs in the Red Sea is insufficient and the absence of enforcement to fishing laws are significant hindrances to guard all endangered or threaten marine species (Akhmadeeva, 2021).

In this regard the Egyptian authorities seek to protect its fisheries stock and endangered or threatened marine species in the Red Sea such as (Dugong, shark, and sea turtles) by expanding mesh sizes of trammel nets to prevent bycatch in the Gulf of Suez (Saber et al., 2022), preventing fishing during spawning season (Gewida et al., 2021) and detecting no-take zones (Akhmadeeva, 2021), preventing issuing new licenses for fishing boats and preventing fishing for 3 months in the Red Sea. However, there is a regional issue regarding fisheries laws enforcement and management to sustain natural fisheries stock (Sheppard, 2019).

According to IUCN Red List, some marine species in the Red Sea such as dolphins (Mahdy et al., 2021) and dugongs are listed as vulnerable due to sharks, rays attacks, and gill nets (Nasr et al., 2019).

3. Climate Change

The LME#33 is situated between the Arabian Peninsula and the North of Africa and both of them accounts for approximately seventy percent of world dust emissions. Moreover, the whole LME#33 is located in the world dust belt region. Furthermore, the Red Sea receives almost six million tons of storms dust yearly. Therefore, the LME#33 warms three folds faster than the world oceans warming average. The central area of the Red Sea suffers from nutrients scarcity. So, the dusts play key roles in nutrients enrichments that may support biological productivity. Meantime, the global dust belt bears heavy loads of microbes, virus, and bacteria cells that discharge over the LME # 33 (Aalismail et al., 2020) especially over the southern region and during summer season (Osipov & Stenchikov, 2018).

The LME#33 coral reefs suffer of impacts of both climate change and extreme dust storms and which increases the bleaching (all corals turn to white) and mortality. On the other hand, the coral in the northern region (Gulf of Aqaba) experienced high tolerance to high temperature and no registered huge bleaching cases and mortalities (Blanckaert et al., 2022).

3.1 Harmful Algal Blooms (HABs)

In recent years, Harmful Algal Blooms (HABs) or Red Tide have expanded in the Red Sea especially in the Southern part and in summer season as a result of marine pollution and climate change. Moreover, HABs have damaged ecosystem services and caused biodiversity loss. HABs have increased fish mortality, expel native species, and changed food chain (Gokul et al., 2020).

Human activities such as overfishing and eutrophication have increased Filamentous algae (Sheppard, 2019). Furthermore, climate change has boosted the concentration of nutrients such as ammonium, nitrate, phosphate, and silicate contributing to the growth of the Red Tide that appear at the water surface. In addition, climate change has facilitated the expansion of some phytoplankton species which rendered unfavorable effect on fisheries, socioeconomics, and harm the important and valuable shore habitats because dinoflagellate is detrimental and poisonous (Mohamed, 2018).

3.2 Coral Reefs

Coral reefs provide beneficial ecological benefits to the fisheries. Moreover, it protects the coastline from wind storms and ocean level rise. Furthermore, it prevents thriving toxic algal blooms such as dinoflagellates (Fine et al., 2019).

Coral reefs are expected to decrease from 70% to 90% globally by the end of the twenty-first century if temperatures rise 1.5^0C higher than the usual and the coral reefs will completely disappear at 2^0C warming. While, samples taken from the northern Red Sea region have proved that coral reefs are able to tolerate temperatures up to 6°C higher than normal without bleaching or mortalities (Kleinhaus et al., 2020).

However, coral reefs in the LME #33 suffers from human activities impacts such as dredging activities, overfishing, runoff, oil pollution, and climate change impacts(Smith et al., 2021). In addition, the LME#33 water surface temperature is about 32º C in the summer and salinity more than 40 ppt in the Northern region. Moreover, the potential interactions and conflicts between coral reefs and the Red Sea coasts may occur in the future due to the expected increase in population and urbanization along the coastline (Fine et al., 2019).

Even though the coral reefs in the LME#33 adapt and live in these harsh environment and exaggerated conditions, the coral reefs in the central and southern regions suffer from coral bleaching and mass mortalities after exposed to El Niño Southern Oscillation (ENSO) event in 1997–1998, followed by a heatwave in 2010 and which prolonged for ten weeks and have registered high expanded mortalities in Farasan banks and extended to Farasan Island in Saudi Arabia in the southern area (Berumen et al., 2019).

Coral reefs suffers from local stressors such as pollution and about 55% of all coral reefs are affected by overfishing (Fine et al., 2019). In addition, coral reefs in the LME #33 are encompassed by three arid desserts namely Arabian, Negev, and Sinai that witnessed multi dust storms yearly (Blanckaert et al., 2022).

Threats either indirect or direct cause severe impacts on coral reefs. Moreover, tourists sports such as diving and snorkeling have indirect impacts on many tourist regions for example Eilat, Aqaba, Jeddah, Sharm El Sheikh, Hurgahda, Marsa-Alam, Musha, and Maskali islands (Romaniv & Yarmolyk, 2021).

Secondly, direct impacts, for instance, overfishing, shipping, eutrophication, oil explorations, desalination plants, resorts, plastic debris, and man-made lagoons along the shoreline. Thus, all of which have raised predators species, and increased coral bleaching and mortality especially in the center and south areas of the LME#33 (Genevier et al., 2019). Furthermore, the LME #33 sea surface temperature (SST) warming rate is very fast and has gradual increased by approximately 0.5ºC every ten years especially in the Northern areas in the Gulfs of Aqaba and Suez (Chaidez et al., 2017).

3.3 Mangroves Forests

The Red Sea has only two types of mangroves (Avicennia marina and Rhizophora Mucronata), which are located along the Egyptian and Sudanese borders, also on Saudi Arabia (Farasan Islands), and Yemen (Kamaran Island) coasts. The majority of mangroves bushes are situated in the southern region of the Red Sea (Gajdzik et al., 2021). Moreover, mangrove trees could thrive in extremely harsh conditions such as high levels of salinity above 40 ppt, and in ocean surface temperatures of more than 31ºC in the summer season (Aljahdali et al., 2021). In addition, mangroves trees sequestrate the Carbon (El Hussieny et al., 2021), and it is a more convenient ground for the nursery and shelter of fish larvae (Gajdzik et al., 2021).

Despite climate change, saline water, coastal development, and overfishing, mangrove forests in the LME # 33 increase and thrive at a very low average compared to its other regions of the world. This is due to the interest of some the Red Sea countries such as Egypt, and Saudi Arabia in planting mangrove forests and protecting them from external factors such as logging, and overgrazing. Moreover, mangrove forests work as a green barrier protecting the ecosystem and people's health, and shelter, spawning ground, and nursery for different types of fish. It also, protect coral reefs, reduce overfishing impacts, filtering the water of marine pollution, and mangrove bushes as traps for marine pollution (plastic, solid wastes, and oil) (Martin et al., 2019)

On the other hand there are many major factors that cause negative impacts and degradations of mangroves bushes productivity and the Red Sea ecosystem such as deforestation, fish farms (shrimp), overgrazing by camels, pollution, and coastal development along the Egyptian coastline (Afefe, 2021) and Saudi Arabia coasts (Aljahdali et al., 2021). In addition, the degradation of mangroves forests in Eritrea is due to logging (wood cutting) and in Yemen due to cattle grazing (overgrazing) (Chanda et al., 2022).

4. Marine Pollution

Marine pollution is one of the most serious threats from human activities on the marine environment. Despite tremendous efforts to eliminate plastic debris from the oceans, and preventing people dumping it at sea, quantities of plastic litter is are still increasing in some regions. Furthermore, it is expected to be more than the fish after 2050 in terms of weight (Dabrowska et al., 2021).

The sources of plastic in the Red Sea come from fishing gears, tourists' activities, and approximately eighty percent of plastic at sea come from land-based sources (See Figure 2). Moreover, in 2010, Egypt was ranked seventh globally, representing about 3 percent of the discharge of plastic debris into seas (*World Bank Group*, 2022). In addition, some of marine species such as marine turtles consume them because they cannot differentiate between plastic and their natural food. So, they harm sea turtles' gut and become main reason of their death (Al-Tawaha & Geiger, 2019).

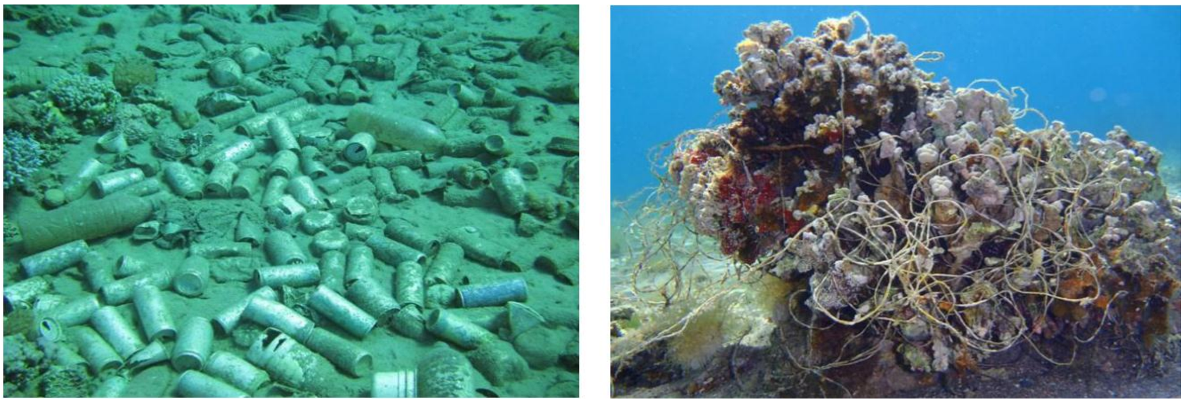

Figure (2): Plastic Bottles & Cans at the Red Sea Bottom
Fishing Lines Attached To Coral Reefs at The Aqaba Gulf
Source: (Al-Tawaha & Geiger, 2019).

The micro plastics pollutants (MPs) considered as a modern environmental pollution. Furthermore, the MPs are generated at the Red Sea from sewage treatment plants because of the growing number of inhabitants along the coastline, engaged in aquaculture, and discarding fishing gears. In addition, MPs come from coastal development along the Red Sea coasts at the Gulf of Suez in Egypt, at Asseb in Eritrea and at Yanbu, Jeddah, Rabigh, and Jazzan in Saudi Arabia. Also, MPs are generated from desalination plants in Dahab, Sharm Elshiekh, and Hurghadha in Egypt and at Yanbu, Jeddah and Rabigh in Saudi Arabia as a result of the quick population growth along the coastlines recently. Moreover, plastic waste at the Red Sea comes from ships because the Red Sea has a heavy vessels traffic due to the Suez Canal (Zeeshan Habib & Thiemann, 2022) (See Figure 3).

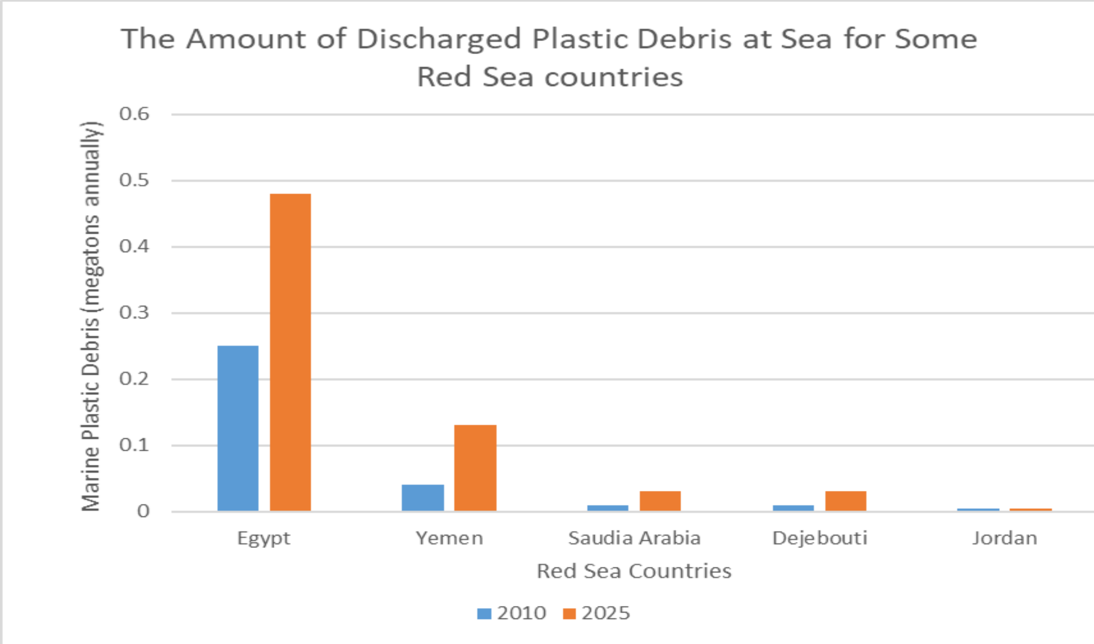

Figure 3: The Amount of Discharged Plastics Debris at Sea for Some Red Sea Countries. Source: (*World Bank Group*, 2022).

On the other hand, the Red Sea has the lowest quantities of floating MPs globally. In addition, both coral reefs and mangrove forests eliminate micro plastics from the water column. Furthermore, there are no rivers flowing into the Red Sea, and there is a relationship between the quantity of micro plastics and population along the Red Sea shoreline (Zeeshan Habib & Thiemann, 2022).

Solid waste is a critical issue with large amounts of plastic bags, fishing lines, and plastic bottles being found in Saudi Arabia's coastline, salt marshes, mangroves, coral reefs, and seagrass regions. One of the main problems is the fact that there is little awareness among the people and so, there are not interested in recycling their waste. Approximately 15 percent of the plastic waste is recycled, and the rest goes to the landfills (Sheppard, 2019). In addition, about 80 percent of sea pollution comes from the shore side (Bates, 2020).

The MPs have been found in fish larvae and sediment samples along Saudi Arabia's coastline because the MPs were generated from human activities on the coast and densely populated coastal areas such as Jeddah and Jazan (Zeeshan Habib & Thiemann, 2022). Moreover, the quantity of accumulated plastic in the marine environment is caused by human activities, the wind and sea direction, and recreation facilities along the coastline at for instance, Hurghadha Egypt and Jeddah in Saudi Arabia. Furthermore, the entangled and ingested MPs cause harm to marine species (Hassan et al., 2022). Subsequently, when marine litter associates with other human activities impacts, they harm people and collapse marine environment biodiversity.

5. Aquaculture

In last decades, some Red Sea countries such as Egypt, and Saudi Arabia have constructed fish farms. Moreover, aquaculture industry have decreased the gap between supply and fish demand, mitigate overfishing impacts, and increased the fish production per capita with reasonable prices for needy. In addition, Egypt is a successful example of aquaculture production, where Egypt annual production of aquaculture is about 1.6 million tonnes represents about 80 percent of the total fish production and it is expected to set on growth and the average rate of aquatic food consumption in Egypt is approximately 20 kg per capita and close to the world average 20.2 kg in 2020. Moreover, Egypt comes in the first place in Africa in aquaculture production, sixth globally, and the third place in the world in the production of tilapia fish (FAO, 2022). On the other hand, fish farms are considered the main reason for coastal eutrophication, and marine invasive species. In addition, it has increased viruses, bacteria, protists, and metazoans which have damaged natural fisheries stocks and habitat loss of the Red Sea.

6. Desalination Plants

Some countries of the Red Sea such as Egypt, Jordan, Israel, and Saudi Arabia rely on desalinated water to fill the gap between the increase in water need and natural water supply sources. Furthermore, in recent years, the need for freshwater along the Red Sea coastline has increased to meet the population increase, coastline development, and tourism sector activities. In addition, according to the United Nations report by 2050 more than 60 million people from the Red Sea countries will rely on desalinated water so the amount of desalinated water produced will be more than 12 billion m^3 (BCM) yearly (Chenoweth & Al-Masri, 2022).

Saudi Arabia is the world lead in desalinated water production by approximately 12 million m^3 per day and produces about a quarter of desalinated water annually. Moreover, about two-third (65 percent) of drinking water comes from desalination plants in Saudi Arabia (Alobireed, 2021)

On the other hand, the brine water disposed at the Red Sea of the desalination plants have caused severe environmental impacts because they have increased the water salinity. In addition, the brine water disposed of desalination plants may equal twice the salinity of standard seawater (Aljohani et al., 2022), and have increased seawater toxicity, and temperature. Furthermore, the desalination plants increased the harmful algal blooms. Moreover, HABs have attached on the desalination plants' drainage pipes is channeled to the coral reefs ecosystem (Nasr et al., 2019). Therefore, depending on desalination plants as an optimal alternative to solve the scarcity of fresh water inputs will negatively impact the coastal ecosystem services and goods of the Red Sea with influences on biodiversity, fisheries, shoreline communities, and the possibility of habitats loss and death of marine species from the LME#33.

SWOT Analysis:

SWOT	
STRENGTHS	**WEAKNESSES**
❖ Coral reefs ❖ Mangrove forests ❖ Artisanal Fishing ❖ Low population rate	❖ Overfishing ❖ IUU Fishing ❖ Harmful Algae Blooms ❖ Entertainment Fishing ❖ Political instability ❖ Oil pollution and sewage ❖ Climate Change
OPPORTUNUITES	**THREATS**
❖ Remote sensing and satellite telemetry ❖ Marine Protected Areas ❖ Regional cooperation ❖ National and international fisheries Law	❖ Coastal development ❖ Commercial fishing (trawling and purse seine) ❖ Increasing Desalination Plants numbers ❖ Coral reefs bleaching ❖ Mangrove forests logging and overgrazing ❖ Aquaculture

Table.1. SWOT analysis diagram, showing the main reasons for natural fish stock sustainability of the Red Sea

Strengths elements such as coral reefs and mangroves forests have been identified in the Red Sea, they suitable grounds for fish productivity and thermal refuge of climate change impacts.

In addition, the low population rate along the red sea coastline produce a low pressure of human activities impacts on fish stocks. Moreover, using artisanal fishing method in fish catching (small fishing boat and low technology) decrease stresses on fish stocks.

Weakness elements such as overfishing and IUU fishing represent the main reasons of the natural fish stocks depletion in the Red Sea, as a result of political instability especially in the last decade. Moreover, a legally binding regarding decreasing oil pollution and climate change impacts is needed because a lack of regional coordination.

Opportunities of an effective regional cooperation, a legally binding of fisheries laws both national and international, effective marine protected areas, and using modern technologies in fishing boats tracking, all of which can limit and mitigate fish stock depletion in the Red Sea.

Some threats put natural fish stocks in the Red Sea at risk Such as coastal development, coral reefs bleaching, and mangrove forests logging. However, a regional cooperation, and proper strategies can limit and mitigate these future threats.

7. Discussion and Potential Solutions

The population of the eight countries bordering the Red Sea benefits from the services and goods that the Red Sea possesses. Therefore, LME#33 provides great opportunities for socio-economic progress and prosperity. While, the natural fish stock of the Red Sea suffers from significant impacts such as climate change impacts, IUU fishing, overfishing, marine pollution, coral reefs bleaching, mangrove forests (overgrazing and logging), population growth, tourists' activities, political instability, and coastal development, all of these impacts have depleted the fishery stocks in the red sea and endangered some marine species and made them on the brink of extinction.

The LME #33 sea surface temperature (SST) and salinity vary between the North (Gulf of Suez and Aqaba) and the south (Bab-el-Mandeb) where the highest SST in the North is considered the minimum in the South region. Furthermore, overfishing, and IUU fishing represent the bulk of the fish stock deterioration in the Red Sea, as a result of political instability in the last decade, especially in the southern region, due to the absence of fishing vessels tracking, and fisheries laws enforcement. Moreover, both low quantity and quality of fish stock near the coast have enforced commercial fishing vessels such as (trawling and purse seiners) to fish away from the coastline, and fish transshipment overseas. In addition, the assessment of aquaculture and desalination plants impacts on the natural fish production degradation in the Red sea are still very limited. Actions to restore the depleted naturally fisheries stock in the Red Sea, the following suggested solutions are categorized as follow:

7.1 Environmental Solutions

MPAs play an important role in sustaining marine environment resources and decreasing climate change impacts. Moreover, Ras-Mohamed MPA in Egypt is considered as one of the best marine protected area in the globe and it is characterized as no-take zone and located away from shipping lines. However, establishing MPAs need continuous monitoring and special care by concerned authorities. Furthermore, MPAs do not cover large areas of the Red Sea, which means that unprotected marine areas can be damaged or depleted by fishers In addition, some developed countries such as England and Scotland use MPAs in generating wind energy but this process needs a regional cooperation, and how wind farms affect marine species.

7.2 Socioeconomic Solutions

Catching large quantities of fish has an economic return and a high profit for fishers but at the expense of damage to the ecosystem and biodiversity of the Red Sea. Moreover, the natural fish stock in the Red Sea populations is not managed according to scientific advice and best practices. Therefore, tracking fishing boats from port- to-port, preventing transshipment at sea, and report the amount of catch all of which actions to mitigate IUU fishing and overfishing impacts.

7.3 Political Potential Solutions

The length of the coastline for the Red Sea countries also varies from country to another. Furthermore, there is a lack of regional coordination between the Red Sea countries regarding environmental issues. Therefore, the Red Sea countries' policies and agendas in protecting their marine environment resources are quite different (there is no one size fits all). Thus, third parties such as the United Nations Environment Program (UNEP), nonprofit organizations, and the Programme for the environment of the Red Sea and Gulf of Aden (PERSGA) have a good opportunity in activating and monitoring the regional coalitions between the Red Sea countries to mitigate marine environment regional issues.

7.4 Technological Solutions

the Red Sea countries can achieve the united nation agenda for sustainable development especially SDG 14.4 regarding eliminating overfishing, IUU fishing, and using destructive methods in fish catching. Depending on modern technology in monitoring and survellience fishing boats by using the combination between satellite remote sensing and synthetic aperture radar (SAR). Moreover, it provides digital images with spatial resolution from 30 cm to 50 cm per pixel. Therefore, it will restore the depleted natural fish stock in appropriate time. However, this application needs High-Resolution Satellites such as Worldview, GeoEye, and QuickBird.

The remote sensing can locate small fishing vessels position in high seas with more details and high resolution images while in case of darkness, heavy weather, and clouds cover, the SAR can survey wide regions and not affected by weather conditions. While, the most optimal way to surveillance IUU fisheries is using SAR in targets detection, and remote sensing for visual recognition, and with Automatic Identification System (AIS), Vessel Monitoring System (VMS), and Long Range Identification and Tracking (LRIT) onboard fishing boats. However, the regional cooperation and coastal states political will are required

Satellite telemetry: depending on modern technology in eliminating IUU fishing , for example, satellite telemetry can provide the concerned authorities with data for tracking endangered marine species, and evaluating their movements, seasonal dispersal, and spawning positions (Baridi et al., 2021). Furthermore, remote electronic monitoring installed on board purse seiners to mitigate IUU fishing and control fish catching in Europe countries

Conclusion

To sum up, there are many threats combat the natural fish stock sustainability of the Red Sea such as overfishing, IUU fishing, marine pollution, and lately the global warming and coastal development.

However, the Red Sea which is one of the lowest oceans in the world has micro-plastics quantities because there are no river inputs and low population rate along the coastline. In addition, coral reefs, and mangrove forests work as a trap for marine pollution. Moreover, they are considered a nursery ground for spawning and fish larvae. Therefore, they play a significant role in sustaining the food chain protecting biodiversity and preserving the balance in the red sea ecosystem.

There are significant discrepancies between the Red Sea countries because the red sea includes the wealthiest, poorest, and lower-middle-income countries of the globe. Therefore, fisheries management plans and policies in terms of fisheries sustainability will not be the same. Moreover, fisheries law enforcement either national legislation or international conventions will be quite different between them. Thus, the united nation intervention is required to prevent the improper exploitation of fisheries resources. Furthermore, regional cooperation and coordination between the Red Sea countries are required to maintain marine resources in the Red Sea for now and coming generations.

References

- Aalismail, N. A., Díaz-Rúa, R., Ngugi, D. K., Cusack, M., & Duarte, C. M. (2020). Aeolian Prokaryotic Communities of the Global Dust Belt Over the Red Sea. https://doi.org/10.3389/fmicb.2020.538476
- Afefe, A. (2021). Linking Territorial and Coastal Planning: Conservation Status and Management of Mangrove Ecosystem at the Egyptian - African Red Sea Coast. Aswan University Journal of Environmental Studies, 0(0), 0–0. https://doi.org/10.21608/aujes.2021.65951.1013
- Akhmadeeva, I. A. S. (2021). Fish Movement in the Red Sea and Implications for Marine Protected Area Design.
- Al-Rashada, Y., Al-Saady, A. B., & Hassanien, H. A. (2021). Status of commercial fisheries in the Umluj, Red Sea, Saudi Arabia. Fresenius Environmental Bulletin, 30(1), 494–503.
- Al-Tawaha, M. S., & Geiger, C. (2019). THE EFFECT OF MARINE LITTER ON MARINE LIFE IN THE RED SEA. http://www.ncbi.nlm.nih.gov/pubmed/27548788%5Cnhttp://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00124278-20160800000010%5Cnhttp://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00124278-900000000-96763%5Cnhttp://con
- Aljahdali, M. O., Munawar, S., & Khan, W. R. (2021). Monitoring mangrove forest degradation and regeneration: Landsat time series analysis of moisture and vegetation indices at Rabigh Lagoon, red sea. Forests, 12(1), 1–19. https://doi.org/10.3390/f12010052
- Aljohani, N. S., Kavil, Y. N., Shanas, P. R., Al-Farawati, R. K., Shabbaj, I. I., Aljohani, N. H., Turki, A. J., & Salam, M. A. (2022). Environmental Impacts of Thermal and Brine Dispersion Using Hydrodynamic Modelling for Yanbu Desalination Plant, on the Eastern Coast of the Red Sea. https://doi.org/10.3390/su14084389
- Alobireed, A. N. (2021). Global Water Desalination: A Comparison Between Saudi Arabia and The United States of America.
- Baridi, F. R., Sea, R., Al-mansi, A. M., Sambas, A. Z., Abukaboos, B. A., Zahrani, A. H. Al, Abdulaziz, A. S., Almasabi, A. A., Alkreda, R. S., Miller, J., Hays, G. C., Hart, K. M., & Esteban, N. (2021). Satellite Tracking of Post-nesting Green Sea Turtles (Chelonia mydas). 8(November), 1–12. https://doi.org/10.3389/fmars.2021.758592
- Bates, A. (2020). Dark Side of the Ocean: The Destruction of Our Seas, why it Matters, and what We Can Do about it.

https://books.google.com.eg/books?hl=en&lr=&id=81D4DwAAQBAJ&oi=fnd&pg=PT5&dq=overfishing,+shipping,+eutrophication,+oil+exploration,+desalination+plants,+resorts,+plastic+debris,+and+man-made+lagoons+coral+reefs+red+sea&ots=W4lMgFwi8M&sig=wDqwO-2eKZK-0k2H

- Berumen, M. L., Arrigoni, R., Bouwmeester, J., Terraneo, T. I., & Benzoni, F. (2019). Corals and Coral Reefs of the Red Sea. In Red Sea. https://doi.org/10.1016/b978-0-08-028873-4.50012-8

- Binnaser, Y. S. (2021). Global warming, marine invertebrates, and saudi arabia coast on the red sea: An updated review. Egyptian Journal of Aquatic Biology and Fisheries, 25(4), 221–240. https://doi.org/10.21608/ejabf.2021.187702

- Blanckaert, A. C. A., Omanović, D., Fine, M., Grover, R., & Ferrier-Pagès, C. (2022). Desert dust deposition supplies essential bioelements to Red Sea corals. Global Change Biology, 28(7), 2341–2359. https://doi.org/10.1111/GCB.16074

- Chaidez, V., Dreano, D., Agusti, S., Duarte, C. M., & Hoteit, I. (2017). Decadal trends in Red Sea maximum surface temperature. August, 1–8. https://doi.org/10.1038/s41598-017-08146-z

- Chanda, A., Das, S., & Ghosh, T. (2022). Blue Carbon Dynamics of the Indian Ocean. In Blue Carbon Dynamics of the Indian Ocean. https://doi.org/10.1007/978-3-030-96558-7

- Chenoweth, J., & Al-Masri, R. A. (2022). Cumulative effects of large-scale desalination on the salinity of semi-enclosed seas. Desalination, 526, 115522. https://doi.org/10.1016/J.DESAL.2021.115522

- Dabrowska, J., Sobota, M., Swider, M., Borowski, P., Moryl, A., Stodolak, R., Kucharczak, E., Zieba, Z., & Kazak, J. K. (2021). Marine Waste — Sources , Fate , Risks , Challenges and Research Needs.

- Devlin, C., Glaser, S. M., & Lambert, J. E. (2021). The causes and consequences of fisheries conflict around the Horn of Africa. 2017. https://doi.org/10.1177/00223433211038476

- El Hussieny, S. A., Shaltout, K. H., & Alatar, A. A. (2021). Carbon sequestration potential of Avicennia marina (Forssk .) Vierh . and Rhizophora mucronata Lam . along the Western Red Sea Coast of Egypt. Rendiconti Lincei. Scienze Fisiche e Naturali, 32(3), 599–607. https://doi.org/10.1007/s12210-021-01005-0

- FAO, . (2022). World Fisheries and AquacultureFine, M., Cinar, M., Voolstra, C. R., Safa, A., Rinkevich, B., Laffoley, D., Hilmi, N., & Allemand, D. (2019). Coral reefs of the Red Sea — Challenges and potential solutions. Regional Studies in Marine Science, 25, 100498. https://doi.org/10.1016/j.rsma.2018.100498

- Gajdzik, L., DeCarlo, T. M., Aylagas, E., Coker, D. J., Green, A. L., Majoris, J. E., Saderne, V. F., Carvalho, S., & Berumen, M. L. (2021). A portfolio of climate-tailored approaches to advance the design of marine protected areas in the Red Sea. Global Change Biology, 27(17), 3956–3968. https://doi.org/10.1111/GCB.15719

- Gardens, B. (2021). Environment, Biodiversity & Soil Security (EBSS). 5, 221–234.

- Genevier, L. G. C., Jamil, T., Raitsos, D. E., Krokos, G., & Hoteit, I. (2019). Marine heatwaves reveal coral reef zones susceptible to bleaching in the Red Sea. Global Change Biology, 25(7), 2338–2351. https://doi.org/10.1111/gcb.14652

- Gewida, A. G. A., Yassien, M. H., Hussein, M. S., Mamoon, A., & Branch, S. (2021). Some reproductive aspects of the Indian squid Loligo duvauceli in the Gulf of Suez, Egypt. 25(3), 367–382.

- Gokul, E. A., Raitsos, D. E., Gittings, J. A., & Hoteit, I. (2020). remote sensing Developing an Atlas of Harmful Algal Blooms in the Red Sea: Linkages to Local Aquaculture. https://doi.org/10.3390/rs12223695

- Hasan, M. H. (2019). Destruction of sea cucumber populations due to overfishing at Abu Ghosoun area, Red Sea. 6.

- Hassan, I. A., Younis, A., Al, M. A., Almazroui, M., Basahi, J. M., El-sheekh, M. M., Abouelkhair, E. K., Haiba, N. S., Alhussaini, M. S., Hajjar, D., Abdel, M. M., & El, D. M. (2022). Contamination of the marine environment in Egypt and Saudi Arabia with personal protective equipment during COVID-19 pandemic : A short focus. Science of the Total Environment, 810, 152046. https://doi.org/10.1016/j.scitotenv.2021.152046

- Kleinhaus, K., Al-Sawalmih, A., Barshis, D. J., Genin, A., Grace, L. N., Hoegh-Guldberg, O., Loya, Y., Meibom, A., Osman, E. O., Ruch, J. D., Shaked, Y., Voolstra, C. R., Zvuloni, A., & Fine, M. (2020). Science, Diplomacy, and the Red Sea's Unique Coral Reef: It's Time for Action. Frontiers in Marine Science, 7, 90. https://doi.org/10.3389/FMARS.2020.00090/BIBTEX

- Mahdy, A., Ghallab, A., Madkour, H., & Osman, A. (2021). Status of indo-pacific bottlenose dolphin, tursiops aduncus (Family delphinidae: Order cetacea) in the northern protected islands, hurghada, red sea, Egypt. Egyptian Journal of Aquatic Biology and Fisheries, 25(1), 681–697. https://doi.org/10.21608/EJABF.2021.149307

- Maiyza, S. I., El-Geziry, T. M., & Maiyza, I. A. (2022). Relationship between Temperature and Salinity Variations and the Fish Catch in the Egyptian Red Sea. Egyptian Journal of Aquatic Biology and Fisheries, 26(1), 273–286. https://doi.org/10.21608/ejabf.2022.217474

- Martin, C., Almahasheer, H., & Duarte, C. M. (2019). Mangrove forests as traps for marine litter. Environmental Pollution, 247, 499–508. https://doi.org/10.1016/j.envpol.2019.01.067

- Mohamed, Z. A. (2018). Potentially harmful microalgae and algal blooms in the Red Sea: Current knowledge and research needs. Marine Environmental Research, October 2017, 0–1. https://doi.org/10.1016/j.marenvres.2018.06.019

- Nasr, D., Shawky, A. M., & Vine, P. (2019). Status of Red Sea Dugongs (Issue July). Springer International Publishing. https://doi.org/10.1007/978-3-319-99417-8

- Nasr, H., Yousef, M., & Madkour, H. (2019). Impacts of Discharge of Desalination Plants on Marine Environment at the Southern Part of the Egyptian Red Sea Coast (Case Study). International Journal of Ecotoxicology and Ecobiology, 4(3), 66. https://doi.org/10.11648/j.ijee.20190403.12

- Osipov, S., & Stenchikov, G. (2018). Simulating the Regional Impact of Dust on the Middle East Climate and the Red Sea. https://doi.org/10.1002/2017JC013335

- Romaniv, O., & Yarmolyk, D. (2021). THE RED SEA AS TOURIST DESTINATION. 76–102.

- Saber, M. A., El-ganainy, A. A., Shaaban, A. M., Osman, H. M., & Ahmed, A. S. (2022). Trammel net size selectivity and determination of a minimum legal size (MLS) for the haffara seabream , Rhabdosargus haffara in the Gulf of Suez. The Egyptian Journal of Aquatic Research, xxxx. https://doi.org/10.1016/j.ejar.2022.02.005

- Shellem, C. T., Ellis, J. I., Coker, D. J., & Berumen, M. L. (2021). Red Sea fish market assessments indicate high species diversity and potential overexploitation. 239.

- Sheppard, C. (2019). World Seas: An Environmental Evaluation (Vol. 4, Issue 1).

- Sherman, K. (2019). Large Marine Ecosystems. Encyclopedia of Ocean Sciences, 709–723. https://doi.org/10.1016/B978-0-12-409548-9.11117-0

- Smith, G., Id, A., Shore, A., Jensen, T., Ziegler, M., Work, T., & Voolstra, C. R. (2021). A comparative baseline of coral disease in three regions along the Saudi Arabian coast of the central Red Sea. https://doi.org/10.1371/journal.pone.0246854

- Solami, L. Al. (2020). Status analysis of the red sea fisheries in the Kingdom of Saudi Arabia. Egyptian Journal of Aquatic Biology and Fisheries, 24(7-Special issue), 825–833. https://doi.org/10.21608/ejabf.2020.129183 World Bank Group. (2022).

- Zeeshan Habib, R., & Thiemann, T. (2022). Microplastic in the marine environment of the Red Sea – A short review. The Egyptian Journal of Aquatic Research, 2025(xxxx). https://doi.org/10.1016/j.ejar.2022.03.002