Assessment of the Fish Biodiversity in the Vicinity of Sohar Industrial Area, Sultanate of Oman: A Proposal

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Abstract For any country in the world, it is important to take all actions to save its natural resources. With country like Sultanate of Oman that bordered three productive seas, it bounds to conserve all coastal areas in order to sustain such wealth for the future generations. In Oman, Sohar is a city that situated north of the capital Muscat. This city became an industrial area recently. With being an industrial area, the natural environment, both land and coastal areas, that neighboring to the industrial areas and even beyond will receive an unlimited of anthropogenic stress. Such an effect will lead to a gradual diminution of the marine and land species of animals and plants. Since the marine resources are very important to country like Oman, it has been suggested to propose a program to conserve the marine biodiversity of Sohar area. In the present chapter, a plan to conserve this biodiversity was given in form of a proposal for consideration by the policy makers in Sultanate of Oman in order to save the marine fauna and flora of this part of the world.

Keywords Marine diversity · Marine fauna · Coastal areas · Sea of Oman · Anthropogenic stress

1 Introduction

Recently, biological variety attracted the attention of scientists worldwide. Nevertheless, utmost investigations are linked to terrestrial habitats, and information of marine variety delays after that of land systems (Ellingsen 2002). Marine environments hold varied selection of macrobenthic groups that their presence is vital in the environment courses like recycling nutrients, detoxifying pollutants, dispersion and burial, and secondary production (Gray 1997; Snelgrove 1998; Gill 2005). Moreover, such creatures offer food for humans and are deliberated a significant supply of food for fishes and birds (Snelgrove 1999; Thrush and Dayton 2002). Human events

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are the main reason of current deviations to marine biological variety in coastal and subtidal regions (Naser 2011). Consequently it is vital to enhance our appreciation of both biodiversity in marine sediments and man-made influences upsetting these environments so that it is possible to implement an effective conservation issues.

2 Sohar City and Its Industrial Area

The Batinah coastal flat is situated in the northeastern part of Oman, positioned between the western Hajar Mountains and the Gulf of Oman. The Batinah coast is frequently sandy and categorized by longshore sand carrying along a low lying coastal zone rich with beaches and dunes. The coastal area is slender at its northern and eastern ends, while the maximum width at the middle is around 50 km (Al Hatrushi 2017).

Sohar is the main city of one of Oman's second most populous province, Al-Batinah. The Al-Batinah province is situated in the northwest of the country and sits on a plain in between the Al Hajar mountain range and the gulf of Oman. The Al-Batinah province, and more specifically Sohar, is economically important to the country for another reason. The city was selected for the development of an industrial port (Al Hatrushi 2017).

Thus far, the Port of Sohar may be called a success. Less than a decade after the first vessels docked at the port, it has positioned itself to become a strong competitor among other ports of the Middle East. The development of a special economic zone named the Free zone Sohar has also commenced. Together with the Sohar Industrial Estate, the Free zone aims to facilitate on shore industries with easy access to international markets by its location next to the port. All of the industrial areas in Sohar together are referred to as the Greater Sohar Industrial Zone.

In addition to Sohar industrial are constructions; several varieties of small and large-scale constructions, like fishing harbors, intakes for distillation plants, breakwaters, and ports, are located along the Batinah coast. The greatest important coastal engineering constructions are Navy Base Harbor at Widam, Majees Jetty, Sohar Industrial Area Water Intake, Al-Ghubra Desalination Plant Intake and Brine Disposal, and fishing harbors at Al-Khaburah, Soham and Sohar (Al Hatrushi 2017).

As a result of these projects and the construction of recharge dams, erosion is evident in several places, including Al Murayr, Bu Baqarah, Sohar, Al-Khaburah, Baraka, Seeb, and Al-Ghubra. The shoreline in the Batinah appeared to be withdrawing at a rate of about 60 cm/year. Without any counteractive act, the Batinah would lose several of its exceptional beaches within the next 10–30 years.

Sohar industrial area is one of the areas under the umbrella of the Public Establishment for Industrial Estates. Its size is approximately 21 million square meters. There are many industries in Sohar Industrial area, the most important of which are Sohar Aluminum, pipe industry, ceramic industry, glass industries, and number of food stuff industries (Al Hatrushi 2017).

3 The Impact of Industrial Areas on the Coastal Fish Fauna: Short Review of Previous Studies

Manufacturing and port events are likely to interrupt the coastal environment, which might cause variations in the fish societies (Khalaf and Kochzius 2002; Gill 2005). In addition, dilapidation of coral reefs may cause coral death and loss of the composite habitat assembly and reduce the related invertebrates (Naser 2011). Also, algal growth is improved due to open sea bottom instigated by coral death and, in some cases, eutrophication. Fishes that rely on corals or accompanying invertebrates as a supply of food are expected to be decreased, while planktivores, herbivores, and detritivores can upsurge in virtual abundance as the dead corals will remain to provide housing (Khalaf and Kochzius 2002; Gill 2005). These fluctuations are possibly the collaborative influences of coastal structures, sedimentation, nutrient input, algal growth, coral destruction, and heavy metal load.

Among the causes that lead to decreasing ichthyofauna diversity is habitat degradation such as margin erosion and demolition of the environment that are used as lodging and reproduction areas for large number of species (Khalaf and Kochzius 2002; Gill 2005; Pinto et al. 2006).

Main modifications to coastal environment are linked to human events. Large-scale oil and gas processes have been involved in the agitation of the coastal environment, and other industrial procedures caused bioaccumulation of contaminants, irregular development of invertebrates, endocrine disruption, nutrient enrichment, toxic algal blooms, and deoxygenation (Gill 2005; Pinto et al. 2006).

3.1 Noise

Basis building and cable lying showed to cause noise up to 260 dB re 1 μPa and 178 dB re 1 μPa, correspondingly (Nedwell et al. 2004). Such important causes of noise might lead to damage in the hearing systems of species within 100 m of the work region and are likely to affect the movement of those organisms that can move evade the area. Any influences of the noise will rely on the fragility of the species present and their capability to habituate to the noise and will reduce when the level of noise has reduced following achievement of the building phase (Gill 2005; Pinto et al. 2006).

Sound is involved in the contact between individuals of animals (Lugli et al. 2003), locating prey, and habitats (mainly by marine mammals; Tyack and Clark 2000), finding recruitment locations in fish (Simpson et al. 2016), finding possible mates, and evading predators (Popper and Fay 1993; Gill 2005).

3.2 Collision and Avoidance

Marine creatures can bump with or aggressively evade the industrial plants both above and below water, relying on the number, size, and spacing of the machineries and their moving parts. Coastal and migratory bird species are believed to be the greatest at hazard, mainly species that assume normal, short low-level flights between feeding and roosting areas (Dirksen et al. 1996; Gill 2005). Where large-scale migration routes concur with industrial areas, the possible influence will only happen at definite times of the year.

3.3 Food Availability

Changes in the food constituents in the working areas at ports might happened from the deep to the surface of the sea owing to changes that caused by construction in such areas. The resultants of such variation in the food contents in the water column are affecting organisms that live and feed in these areas (Gill 2005; Pinto et al. 2006). The indication from fishing and dredging proposes that unscrupulous group of animals will upsurge as they taking benefit in replacing those species that are eliminated from the area throughout physical disruption. The greatest elimination of ecosystem and species subsequent habitats' modifications probably can cause vital changes in the regional food web dynamics.

3.4 Predation

The important modifications in prey kind, size, and richness resulted from any industrial activities are predictable to disturb the predator group. Density-dependent and top-down predatory impacts might cause prey reduction and trophic cascade influence (Daskalov 2002). Any variations that influence the dynamic connection between a predator and its prey might cause a reduction in distribution of energy to other biological events and thus intensely impact the performance of the predator. With wide range industrial activities, we may then see reactions in the local predator group that are supplementary to direct influences allied with noise.

3.5 Reproduction and Recruitment

The noteworthy oscillations in food and habitat obtainability resulting from the industrial activities might disturb species reproduction, mainly species by this time under human impact. There are instances of parental attention species (e.g., seabirds

and marine mammals) with less breeding achievement ensuing from important decrease in prey richness as a result of fishing. Many species of fish, for instance, use exact spawning and nursery areas. Throughout various industrial activities on the seashore, building and destroying early life phases may be susceptible to burial and elimination. Water actions could alter as a result of the occurrence of a great number of constructions. This might reorganize new recruits locally or downstream and have broader effects for groups that are driven by species that scatter over regional level.

4 Impact of Human on Biota in the Arabian Gulf Area

4.1 Dredging and Reclamation

In several Arabian states, coastal and marine habitats are the main goal for utmost of the chief accommodation, entertaining, and business projects, which characteristically linked with exhaustive dig up and land retrieval events (Naser et al. 2008). Coastal retrieval is frequently performed in the Gulf area to encounter the request of fast coastal growths as sand and mud considered to have less biota and with poor presence (Naser 2011).

Dredging and land retrievals include the straight deletion of macrobenthos, and the outcomes will be a physical levelling in the coastal and subtidal ecosystems and deoxygenating the underlying sediments (Allan et al. 2008). Such actions will include also chemical changes that may decrease biota, richness, abundance, and biomass of macrobenthos (Naser 2011).

4.2 Industrial Effluents

Industrial areas in the Gulf States perceived a quick industrial development, mostly in the subdivisions of oil refining, aluminum, and petrochemical productions. Numerous corporations and industrial plants are manufacturing wastes that may comprise hydrocarbons, ammonia, phenols, phosphorous, and heavy metals. Effects of industrial wastes on faunal groups comprise altering the configuration of the group structure, growing the numbers of opportunistic species, and decreasing the general biota and species richness (Frouin 2000; Gill 2005).

4.3 Sewage Discharges

Waste water discharges are chief causes of coastal contamination in Gulf States. Numerous waste water management factories fluctuating in size and degree of handling are releasing sewages to the coastal and subtidal areas in these states.

Such wastes are categorized by high-suspended solid. Changes in coastal benthos fauna are linked with moderate organic enhancement and are characterized by an upsurge in species richness, abundance and biomass. Nevertheless, extreme organic upgrading decreases species wealth and upsurges bulks and numbers of few opportunistic species and their linked biomass (Savage et al. 2002). Certainly, certain regions near to the outlet that were branded by high levels of organic content (>60%) were lacking of macrobenthic groupings indicating cute sewage contamination.

4.4 Desalination Plants

Arabian Gulf states rely mostly on distillation seawater as a basis of drinkable water. One type of desalination factories produces waste to the marine habitat which contains large amount of brine water (Naser 2011). This salt water considered the reason to upsurge temperature of 7.5 °C above the natural water temperatures of summer and winter (Altayaran and Madany 1992; Gill 2005). Decreased levels of biota and richness were reported in places near to the vent of effluent water indicating serious influences on the coastal marine groupings owing to the salt wastewater releases, which are linked with high temperatures, salinities, and a range of chemical and heavy metal contaminants (Naser 2010, 2011). Usually, a weakening in groups of shoreline species is predictable in the incorporation zone of the waste release possibly related with toxic wastes. Endurance of species in the nearby areas of a mingling zone relies on their ability to face such harsh conditions and adaptation. This is confirmed by the supremacy of tube anemones (*Cerianthus* sp.) in the areas near to the vent, which proposes that these species could be resilient or adjustable to contaminants and variations in water standard.

Virtually no data is obtainable on the increasing continuing consequence of brine disposal from the distillation factories areas in the region. Distillation action has been mentioned as a main habitat stress on the Arabian Gulf ecosystem. Conferring to a study from Abu Dhabi, this increase has been attributed to the discarding of salt from the distillation factories in the Arabian Gulf coast. Ecologists have observed deviations in the species structure, removing of spawning periods and decrease in the spawning stock size of prawns owing to environmental strain in several oceanic zones.

5 The Importance and Aims of the Project

In the coastal vicinity of Sohar City and its industrial area found a unique fish fauna which is part of the fish fauna of the Sea of Oman. The fish fauna of Sohar City is considered unique from the ichthyological and zoogeographical point of views. It is considered as such due to the geographical location near Strait of Hormuz from one

side and its closeness to the fish fauna of the Iranian coasts of the Sea of Oman. This zoogeographical location made the fish fauna of Sohar City unique as its fish species composition is mixed between the Iranian fish fauna of the Sea of Oman and the Arabian Gulf. Therefore, the assessment of this fish fauna became important to detect the effect of industrialization on the biodiversity level in this important fish fauna.

The importance of the project can be envisaged in the following aims of the project:

1. To know the quantitative distribution of the fish species found in the studied area
2. To put a map showing the distribution of the population of the commercial species in the studied area
3. To compare the population of the commercial species found on the Iranian part of the Sea of Oman with those of the Omani ones to reveal the similarities and differences
4. To solve any taxonomic problems that might present in the fish populations inhabiting in the studied site

6 The Disadvantage of Non-performing the Project

Failing to proceed in performing the project will have several significant drawbacks on the fish fauna in particular and the fisheries in Oman in general. Such disadvantages are:

(a) The lack of information about the present status of the fish fauna in Sohar industrial area will lead to underestimate the effect of the industrial activities in the area which may lead to severe loss in important commercial fish species from the area.
(b) The lack of information about the interaction between the population of the commercial species present on the Iranian and Omani shores of the Sea of Oman will lead to exhaustion of fish population on the Omani side of the Sea of Oman.
(c) The failure to perform the project will lead to a significant loss in the ichthyological information from an important area such as Sohar industrial area.
(d) The present time is the ultimate time to perform the project especially it comes after the establishment of Sohar industrial area, and it is the time to assess the status of the fish fauna found in this area to reveal the effect of the industrial activities on this fauna.

7 The Benefit of the Project to Sultanate of Oman in General

(a) Indirectly, the Ordinary Omani fishermen will be among the people who will be benefited from the results of this project. Through the results of species composition and distribution along the coasts of Al-Batinah region and through the commercial stock identification, the Ministry of Agriculture and Fisheries Wealth will be able to control and put a better plan for fishing licensing in Al-Batinah region. On the basis of the results of the present project, the fishermen will be instructed by the ministry to where to find reasonable commercial fishing stock in Al-Batinah region and the time of the year and the duration he should stay in the area for fishing.
(b) The scientific sector of Oman will be benefited from the results of the project as it will be a great addition to the fisheries science in general and fisheries in Oman in particular.
(c) The results of the project will aid the Ministry of agriculture and Fisheries in monitoring the process of fishing licenses in Sohar area at least.
(d) It will be available at the end of the project information on the Iranian population of the commercial fish species. Such information will contribute to investigate the assembly configuration of fish species in the Sea of Oman.
(e) The project will assist in the process of upgrading the educational and research level of the Omani technical staffs. Such benefit is one of the aims that most of the industrial companies are seeking to achieve while they are operating in Oman.
(f) The project will take profound steps in the reservation of the fish biodiversity in Oman through the study of the status of the fish fauna in Sohar industrial area.
(g) The project will take part in the socioeconomic upgrading of the Omani society through the high level of training and work in the project.

8 Manpower

The different activities within the fish biodiversity project require at least four technical staff working on a full time basis in addition to the principle scientific officer. The technical staffs should be with an acceptable scientific background.

9 Framework and Methodology

The fish biodiversity assessment project has been divided into nine sections, each section aims to achieve a specific result within the project. The sections are:

(a) *Fish collection*: Four stations on the coast line of Sohar Industrial area and another four stations outside the vicinity of the industrial area will be assigned for fish collection. Fish specimens sampling will last for 1 year, and specimens from the eight stations will be collected seasonally.
(b) *Registration system*: Labels and data base – registration system to record fish specimens will be invented and used. The system should be similar to those systems used by leading world collections and museums. Usually, the initials of the name of the organization are used followed by the number of the specimen. At the moment, it possible to deposit the fish specimens in a reference room carry the code OMSOHR (Oman Sohar) followed the number of the specimen. Special paper for labels and specified six data housing the registration of the specimens will be used.
(c) *Record of biological data*: The following biological data will be recorded from the fish specimens:

1. Total, standard, and fork lengths
2. Weight
3. Record of the meristic characters
4. Record the morphometric characters

(d) *Photography*: Advanced digital camera will be used for the activity in this section.
(e) *Identification*: This section of the project should start after the photography, and the common species should be dealt with first in order to clear the back log of the specimens. In the section of the identification, a specific set of references should be used in order to resolve the taxonomic status of the species.
(f) *Documentation of the fish records*: The results of the survey will be written in a form of technical report to submit to the stakeholder who funded the project. After getting the appropriate permission, the results of the survey will be published in the form of scientific papers and atlas containing description, and photo of the fish species recorded in the area will be published at the end of the project. During the project, fish taxonomists from around the world will be invited to give their advice and assistant in solving the taxonomical problems that might arise.
(g) *Record of the fish distribution*: Fish species distribution in the studied area will be illustrated in a statistical distribution map showing the precise distribution of the species inside and outside Sohar industrial area.
(h) *Tissue sampling*: It is important to take tissue sample for further genetic analysis to confirm species identification. Small muscle tissue is required to be taken from the area below the pectoral fin on the right side of the fish.
(i) *Scale sampling*: Scales should be taken from 11 fish body regions for further study. A series of specimens of different lengths are required for this study. Small envelops are needed to house the scales which usually kept dry.
(j) *Otolith sampling*: Otolith from both sides of the head of the fish should be sampled. They need to be washed in 70% ethanol and store dry in glass

containers. Paper or wooden boxes are required for the storage of otolith containers.

(k) *Osteology*: The osteological characters of the fish species are amended for all fish species using the X-ray technique. These characters are important to reveal the differences between closely related species.

(l) *Fixation*: Formaldehyde solution 10% is usually used as a fixative agent for fish specimens. The duration of this procedure depends on the size of the specimen. For large specimens such as sharks, rays, and large teleosts, stepping up should be followed where gradual absorption of formaldehyde solution is maintained. To secure long fixation, formaldehyde solution should be buffered by sodium carbonate to reduce long-term effect of formaldehyde solution on specimens. Containers of different sizes are needed for this section of the project.

(m) *Preservation*: Ethanol 70% should be used in this process. The period of preservation depends on the size of the specimen. For sharks and rays, they should be preserved in IPA (isopropanol alcohol) as it is cheaper to buy than ethanol.

10 Time Frame

The total period of time allocated to complete the project is 15 months. This period is divided into five sub-periods of 3 months, and they are as follows:

(a) The first period or the first season will cover the preparation for the different activities of the project and obtaining fish sample for the first season of the year. This period also covers the process of the fish sample of the first season through the different steps of the project. At this period the first progress report will be available.

(b) The second period or the second season will have the same steps mention in "a" in addition to complete the identification process of fishes obtained in the first season. At this period the second progress report will be available.

(c) The third period or the third season will be a continuation of the second period with completion of the fish identification process of the second period. At this period the third progress report will be available.

(d) The fourth period or the fourth season will be the last period of fish sampling. It will be a continuation of the third period with completion of the fish identification process that might not finished in the first, second, and third periods. At this period the fourth progress report will be available.

(e) The fifth period is the final period that includes finishing up all the identification process and the initiation of writing up the final report which includes the results of the survey.

11 Expected Results

(a) The fish biodiversity and species composition in the vicinity of Sohar Industrial area in particular and the neighboring area of the Sea of Oman will be revealed. In addition, the spatial distribution of the commercial fish species population present in the studied area will be known.
(b) The biodiversity analysis data will make possible to compare the fish fauna of Sohar Industrial area with that of the neighboring area in order to reveal the effect of the industrial area activity on this fauna.
(c) Checklist of fish species present in Sohar Industrial area and neighboring area showing number of families and species as reference list for future ecological studies on the area.
(d) Build up a data base that contains information about the fish fauna of the studied area. This data base will assist in any biological study on the fishes of the area in particular and the Sea of Oman in general.
(e) The results of the survey will assist in resolving any taxonomical problems that might be present. Solving such problems will help in solving the problems present within the fish fauna of Oman.
(f) Distribution map of the commercial species in the studied area and the surrounding area will be available. Such map will be useful for fisheries purposes.

12 Type of Work and Requirements

In order to proceed with the different sections of the project, several items should become available. These are illustrated in the table below:

Type of work	Requirements
Human resources	• Contracting with technical staffs to process the fish samples
Field work	• Purchasing all the equipment needed for the project • Renting cars and fishing boats to collect fish samples from the stations in the studied area
Laboratory work	• Make available computers and computer programs to be used in the project • Make available the chemicals to be use in fish fixation and preservation processes • Make available glass ware and plastics for storage • Make available other laboratory instruments
Writing reports and publication	• Make available special data base • Stationary of general and particular types • Typing progress reports, final report • Scientific publication • Printing fish color photos • Make available fish X-ray • Typing and publishing any scientific leaflets out of the project results • Printing and distributing illustrated posters out of the project results

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