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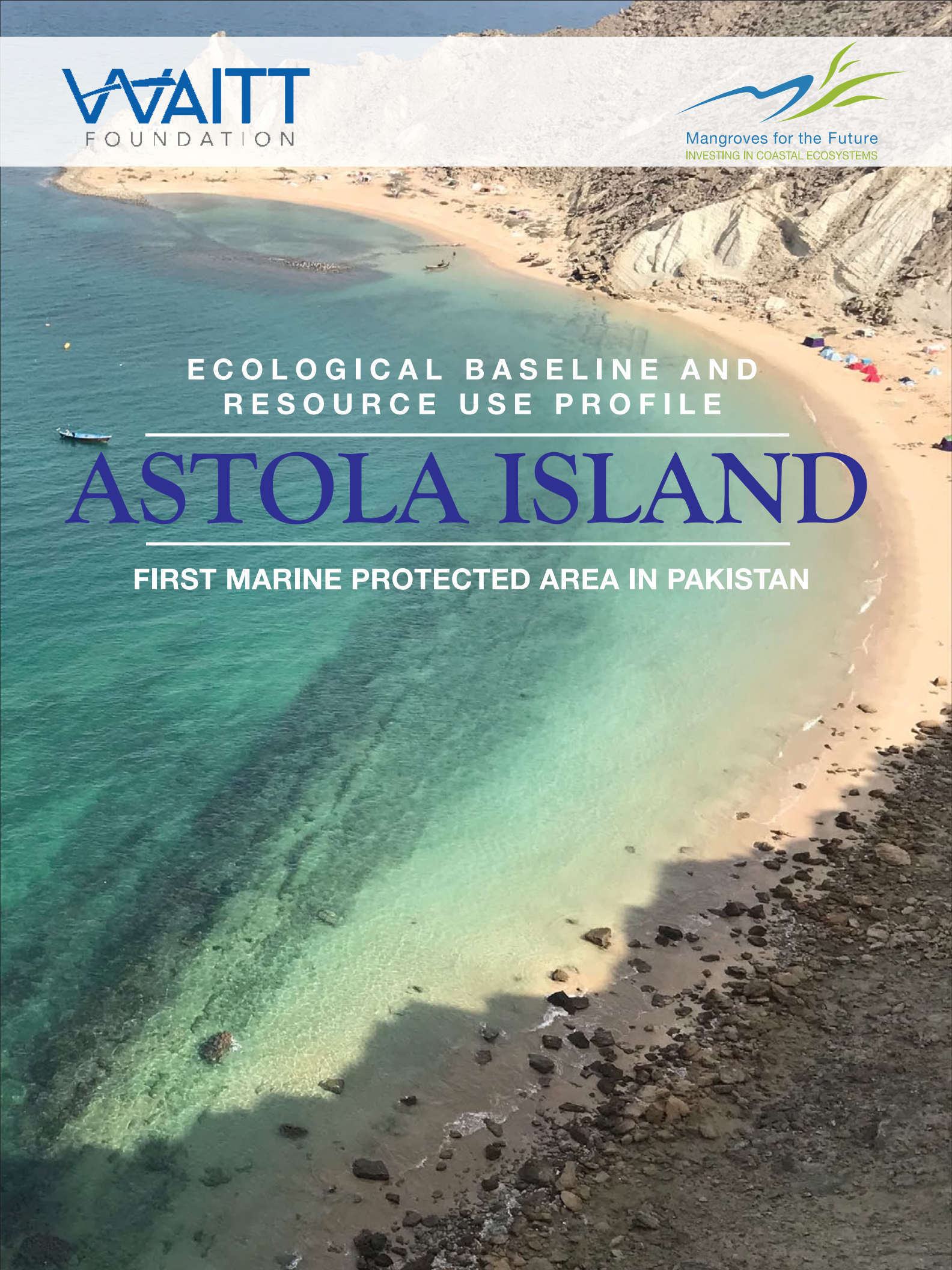

ECOLOGICAL BASELINE AND RESOURCE USE PROFILE

ASTOLA ISLAND

FIRST MARINE PROTECTED AREA IN PAKISTAN

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Table of Contents

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Abbreviations

ABTs	Aichi Biodiversity Targets
AIT	Asian Institute of Technology
ASRB	Advanced Study, Research Board
AWC	Asian Waterbird Census
BFD	Balochistan Fisheries Department
BMN	Balochistan Mahigir Network
CBD	Convention on Biological Diversity
CBTT	Capacity Building Task Team
CCP	Cetacean Conservation Pakistan Project
CEMB	Centre of Excellence in Marine Biology
CEM	Commission on Ecosystem Management
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
EBRU	Ecological Baseline and Resource Use Survey
EEZ	Exclusive Economic Zone

EIA Environmental Impact Assessment
EPA Environmental Protection Agency
GDA Gwadar Development Authority
GEF Global Environment Facility
GoP Government of Pakistan
GPS Global Positioning System
HEC Higher Education Commission
ICTP International Centre of Theoretical Physics
IDDV Integrated District Development Vision
IEE Initial Environmental Examination
IFS Integrated Farming Systems
IGBP International Geosphere-Biosphere Programme
IHDP International Human Dimensions of Global Environmental Change Programme
IJPP International Journal of Phycology and Phyco-chemistry
IMS Institute of Marine Science
IMTA Integrated Multi-trophic Aquaculture
IMBER Integrated Marine Biogeochemical and Ecological Research
IOTC Indian Ocean Tuna Commission
IOCINDIO Inter-governmental Oceanographic Commission for Indian Ocean Region
IOS Indian Ocean Sanctuary
IUCN International Union for Conservation of Nature
IVI Importance Value Index
LC Least Concern
LEAD Leadership Education/Action Development
LEMR Laboratory for Exploration of Marine Resources
LUAWMS Lasbela University of Agriculture, Water and Marine Sciences
Marine BioGIS Marine Bio-geographical Information Systems
MAB Man and Biosphere Reserves
MBRL Marine Biological Research Laboratory
MFF Mangroves for the Future
MFD Marine Fisheries Department
MoCC Ministry of Climate Change
MPA Marine Protected Area
MSA Maritime Security Agency
NBSAP National Biodiversity Strategy and Action Plan
NCB National Coordinating Body
NCCW National Council for Conservation of Wildlife
NCRTF National Coral Reef Task Force
NGOs Non-governmental Organizations
NIO National Institute of Oceanography
NRM Natural Resource Management
PACCD Pakistan Agriculture Cold Chain Development
PAHs Polycyclic Aromatic Hydrocarbons
PFHA Pasni Fish Harbour Authority
PWP Pakistan Wetlands Programme
REDD+ Reducing Emissions from Deforestation and Forest Degradation
ROC Rapid Ocean Conservation
RSMAS Rosensteil School of Marine and Atmospheric Science
SCOR Scientific Committee Ocean Research
SCUBA Self-Contained Underwater Breathing Apparatus
SDGs Sustainable Development Goals
SERD School of Environment, Resources, and Development
SPO Strengthening Participatory Organizations
SST Sea-surface Temperature
UNESCO United Nations Educational, Scientific and Cultural Organization
UNDP United Nations Development Programme
UN-FAO United Nations - Food and Agriculture Organization
UoK University of Karachi
UVAS University of Veterinary and Animal Sciences Lahore
WCRP World Climate Research Programme
WI Winrock International
WWF World Wide Fund for Nature
ZSP Zoological Survey of Pakistan

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Executive Summary

This report presents the first ever comprehensive research survey of Astola Island, located in east of Pasni district of Balochistan, Pakistan. With dazzling white shores and crystal clear waters, the island offers a fabulous destination for ecotourists. Due to its alluring rocky mountains, Astola is also called the Island of the Seven Hills. Being a rich biodiversity hotspot, the island was declared the first Marine Protected Area (MPA) in Pakistan on June 15, 2017. Through this, Pakistan has started complying with the Aichi Biodiversity Target 11, which requires that by 2020 at least 10 percent of coastal and marine areas are conserved. This declaration will also help conserve biodiversity of the area, ban illegal fishing and regulate sustainable recreational activities.

Giving an overview of the scope of survey, the report mentions that back in 2015, International Union for Conservation of Nature (IUCN) through its National Coordinating Body (NCB) of Mangroves for the Future

(MFF) Programme Pakistan, headed by Ministry of Climate Change (MoCC), Government of Pakistan decided to set up a Working Group to work towards possible MPAs. This group recommended four potential sites including Astola Island in Pakistan. Subsequently, a motion submitted by the Pakistan National Committee was adopted at the IUCN World Conservation Congress, 2016, calling for declaration of Astola Island as MPA in Pakistan. To support the management planning of Astola MPA, IUCN-MFF Pakistan conducted this Ecological Baseline and Resource Use Survey (EBRU Survey) financially assisted by Waitt Foundation under The Rapid Ocean Conservation (ROC) Grants Programme. This study is co-financed by Mangroves for the Future (MFF) Programme of IUCN Pakistan.

In order to undertake this comprehensive survey, a number of government agencies and academic institutes along with a team of 26 experts with diverse backgrounds and expertise participated. The survey team adopted a range of robust methods for assessing abundance of species and different habitat conditions. These methods helped to cross-check and ensure authenticity of the information.

The report outlines that the island is a home to unique wildlife as many of marine and terrestrial animals and plants have been reported from it. Report shows that the island supports large number of birds as 61 species were recorded during the survey. Moreover, 7 species of reptiles, have been recorded among them Sub-species of Saw-scaled vipe - endemic to the island and threatened species of green turtle nesting there are of special concern. It is worth mentioning that during the study 1745 nests were counted at three nesting beaches of the island in February. It also reveals 5 species of cetaceans are found in the area which include Indo-Pacific finless porpoise and endangered Arabian Sea humpback whale – a rarest marine mammal only found in Arabian Sea. Moreover, 27 species of fishes, 3 species of rodents and 11 species of hard corals were found at the island. The area is also home to 30 species of vegetation and 3 species of seaweeds. These weeds were found in a juvenile stage, therefore, they were not identified correctly.

Astola Island provides an important income generation opportunity to the fishermen who come from different areas of Balochistan and Sindh, mostly during August to May. It was observed that children also took part in fishing activities along with the elders. Generally, fishermen come to Astola for a week or ten days and setup their tents at the island. The major types of fishing gear used by fishermen were plastic gill nets, bottom set gill nets, ring nets and fishing guns.

The report highlights key threats to the species and their habitats. Oil pollution is considered one of the major threats to the natural resources at Astola Island. While, extraction of corals has emerged as one of the key threats to the biodiversity at the island. Rodents, domestic cats and gulls are reported to destroy turtle nests and prey upon the juveniles. In addition to this, report shows that the kitchen waste thrown away by fishermen at Astola damages the fragile ecosystem and disturbs the marine and terrestrial life. Increasing human activities coupled with unsustainable fishing practices including use of illegal fishing nets are degrading the fisheries resources. The nets of fishermen sometimes get stuck in the corals and thus damage them. Population of *Prosopis juliflora* – an exotic species, was observed to be increasing at the island and it is likely that its fast expansion could emerge a major biotic threat to the biodiversity at the island mainly to the shrub species. Report also warns that the corals could disappear due to ocean acidification and global warming.

To protect this island, report recommends regular monitoring and suggests for development of the Management Plan. It also proposes that the site should be managed as Ramsar Site due to presence of variety of birds. Survey emphasizes that cleanliness drive should be launched for removing ghost nets and solid waste from the area. It recommends that faunal studies with reference to insects, reptiles, fishes, mammals, birds and cetaceans should be continued.

This report is a living document that can be studied or referred for any specific or general information on Astola Island. This can help fill knowledge gaps and support researchers, policy makers, academicians and readers with interest in marine life especially in Pakistani waters.

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1. INTRODUCTION

In order to acquire, evaluate and present baseline data on the relevant ecological, socio-economic and environmental characteristics of the Astola Island MPA, Ecological Baseline and Resource Use Survey (EBRU Survey) was undertaken by the team of experts. The survey sought to achieve this aim through the review of previous literature, secondary data, and the collection and analysis of new information obtained through detailed field investigation. Further, the study sought to establish strong collaborative links between marine scientists of different universities, environmental non-governmental organizations (NGOs) and relevant federal and provincial departments so that compiled expert knowledge and collective wisdom could be used for the future management of MPA. The results of this study provide the basic reference material from which a future management plan would be developed, and upon which government policies pertaining to marine resource-use activities in and around the MPA might reasonably be based. The first chapter of this survey report presents context of the study by sharing an overview of the MPA and its key features. It also briefly discusses the scope of the study.

Subsequent chapters comprising methodology, results along with analysis of data and discussion deal separately with each of the major areas of investigation which include physical parameters and benthic sediment ecology; birds, reptiles, marine fish diversity, cetaceans, small mammals, corals, vegetation, seaweeds and socio-economic condition of fisher communities. The report is prefaced with summary that lists the key findings of the survey.

Overview of Astola Island Marine Protected Area

Located at a distance of 20 nautical miles east of Pasni along the north of the Arabian Sea, Astola is the largest uninhabited offshore island in Pakistan. It is also known as *Jezira Haft Talar* (Island of the Seven Hills) due to its small, rocky knolls that span the 6.7 km^2 island, rising to a height of about 240 feet above sea level. The

area around the island has been declared a marine protected area (MPA), including its buffer zone of 401.47 km^2. This largely unspoilt island has all the hallmarks of a tourist getaway – sandy beaches, crystal clear waters, and the sort of variety of marine life often found tucked away in remote, pristine corners of the world.

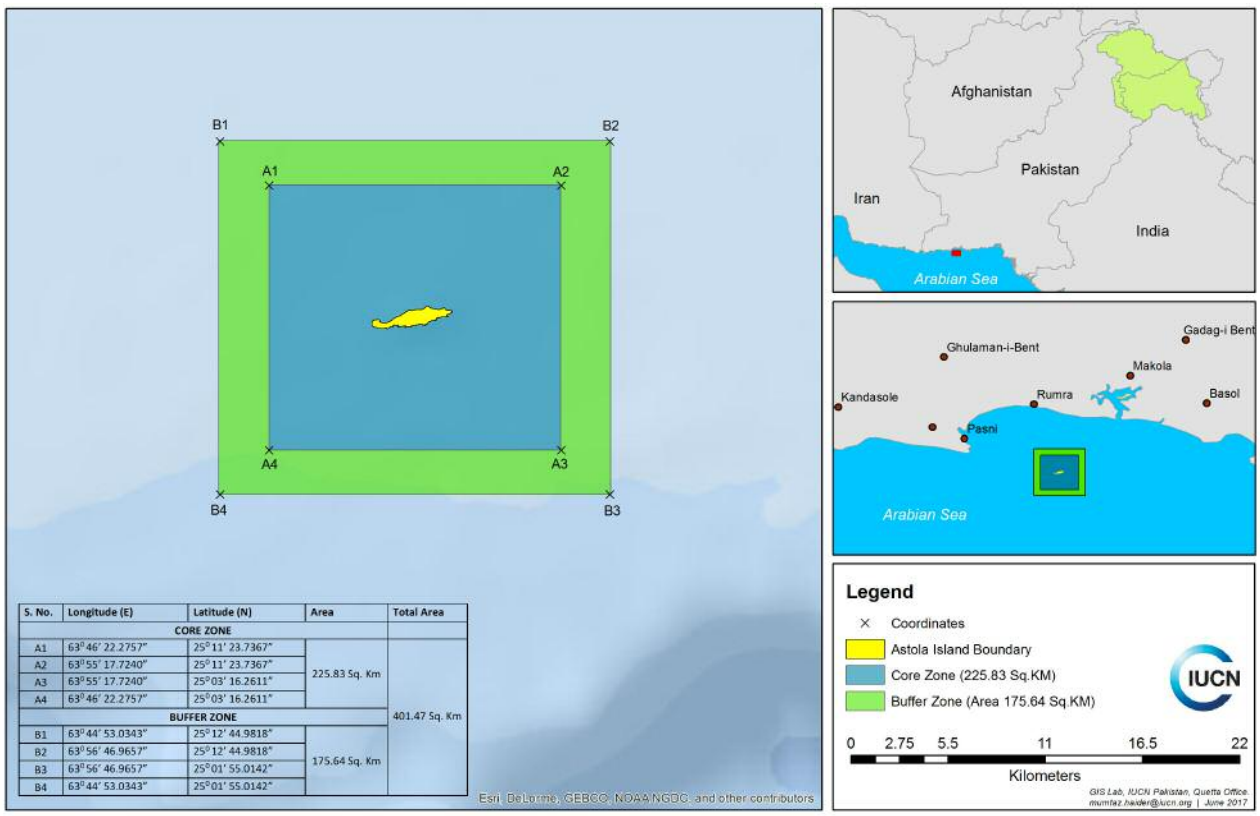
The island is used by local fishermen when they anchor their boats during the fishing season. Between September and May of every year, Astola becomes a temporary base for mainland fishermen for catching lobsters and oysters. From June to August, the island remains unpopulated due to the fishing off-season, the roughness of the sea and high tides.

Astola is an ecologically important site, as it is home to colonies of about 22 species of corals (Ali *et al*., 2014) and its sandy beach provides nesting grounds for many bird species such as coursers, gulls, and plovers, as well as the endangered green sea turtle (*Chelonia mydas*). Saw-scaled viper (*Echis carinatus astolae*) is endemic to the island. The waters surrounding the island support rich life in cetaceans including dolphins, whales and a variety of fish species.

The Arabian Sea humpback whale, one of the rarest marine mammals, has infrequently been sighted in the area around the island (Gore *et al*', 2012; Kiani, 2014; MS Kiani, pers. obs. 2007). The island is treeless, and due to the absence of freshwater sources, its vegetation consists of scrubs and large bushes (Khan 1989).

Pakistan is party to the UN Convention on Biological Diversity (CBD). Astola Island was declared the first ever MPA in Pakistan on June 15, 2017, by the Forest and Wildlife Department, Government of Balochistan. This was done in connection with the CBD, Sustainable Development Goals (SDGs) and National Biodiversity Strategy and Action Plan (NBSAP). The Aichi Biodiversity Targets (ABTs) were agreed upon by all parties of the CBD in 2010. Under target 11, each party has to declare at least ten percent of its coastal and marine areas to be MPAs, which are of particular importance for biodiversity and ecosystem services. Furthermore, the SDGs, agreed upon by the UN General Assembly in September 2015, call for conservation and sustainable use of the oceans, seas and marine resources for sustainable development under its goal 14. At the national

Map 1: Astola Island MPA Core and Buffer Zones



S. No.	Longitude (E)	Latitude (N)	Area	Total Area
CORE ZONE				
A1	63°46' 22.2757"	25°11' 23.7367"	225.83 Sq. Km	401.47 Sq. Km
A2	63°55' 17.7240"	25°11' 23.7367"		
A3	63°55' 17.7240"	25°03' 16.2611"		
A4	63°46' 22.2757"	25°03' 16.2611"		
BUFFER ZONE				
B1	63°44' 53.0343"	25°12' 44.9818"	175.64 Sq. Km	
B2	63°56' 46.9657"	25°12' 44.9818"		
B3	63°56' 46.9657"	25°01' 55.0142"		
B4	63°44' 53.0343"	25°01' 55.0142"		

level, the National Biodiversity Strategy and Action Plan formulated by the Ministry of Climate Change (MoCC), Government of Pakistan, specifies actions for expansion of the network of protected areas in the country with complete representation of ecosystems and habitats, especially areas of particular importance for biodiversity. Astola has been declared MPA as a result of all this.

Marine protected areas involve the protective management of natural areas so as to keep them in their natural state. MPAs can be conserved for a number of reasons: economic resources, biodiversity conservation, and species protection. They are created by delineating zones, with permitted and non-permitted uses within each zone.

1.1 Climate and Physiographic Profile

The island is made up of a sandy and rocky beach. A cliff rises nearby culminating in a plateau. There are deep chasms and crevices, several feet wide. Numerous natural caves and coves abound. The south face of the island slopes off gradually whereas the north face is cliff-like with a sharp vertical drop.

Astola Island has a humid climate. Winter lasts for merely three months (mid-November to mid-February) and there is not much difference in temperature between the two seasons. Days are hot, nights are cool. The maximum daytime temperature recorded at Astola Island has been 25.55° C (78° F) and the minimum nighttime temperature has been 69° F (20.55° C). Thus, temperature extremes during the coldest month of the year were 20.55° C and 25.55° C.

Astola is inaccessible by boat during the south-west monsoon season as the sea becomes rough. Sea breezes blow throughout the day and the colour of the water and pattern of the beach changes throughout the day depending upon the tide. The seabed is visible to about a depth of 20 feet.

1.2 Demographic Profile

Although the island is uninhabited, fishermen from Sindh and Balochistan come to this area from August to May. Usually, they stay for a week or ten days on their boats. Some come to Astola for up to a month. They live on the coast of the island where four wooden huts can now be seen. When damaged, these huts are either reconstructed or repaired by the fishermen visiting the area. To fish,

these fishermen use mostly fishing rods, ring nets, ordinary nets and guns. From August to May, at a time, there are approximately 60 fishermen in 10 to 15 boats fishing in the area. These fishermen mainly catch fish, crabs and lobsters, although some are also engaged in shell collection and coral mining activities.

1.3 Cultural Context

There is a small mosque on Astola Island, used by these fishermen. A shrine attributed to the Muslim saint Pir Khawaja Khizr exists, and ruins of an ancient Hindu temple attributed to Kali Mata, a Hindu goddess, can also be found there. The island was known to Hindus as *Satadip*.

1.4 Natural Resource Management and Threats

Astola Island is under the ownership of Balochistan Revenue Department and is guarded by Pakistan Coast Guards and Pakistan Navy. The Balochistan Fisheries Department is responsible for management of fisheries within 12 nautical miles from the coastline. As Astola Island is in the contiguous zone that is up to 24 nautical miles from the mainland the, Maritime Security Agency (MSA) is responsible for the enforcement of fisheries regulation within this zone. They manage illegal activities (including illegal fishing and coral mining) in the area. The Balochistan Forest and Wildlife Department is mandated for protection, conservation and rehabilitation of wildlife resources.

The survey team observed that the nesting sites of different birds and turtles were damaged in one way or the other due to human activities. For instance, the sooty gull (*Larus hemprichii*) which had a major breeding colony on the island, has been extirpated because of the introduction of rats. Marine turtles are facing multiple threats, especially habitat degradation, and entanglement in nets discarded at the beach. It was also found that the domestic cats that live on the island dig out turtle nests, eat the eggs and hatchlings and even harm mother turtles.

Although most fishermen stay in the waters of the island for only a few days, they dump damaged nets and other types of non-degradable waste on the coast. They lack awareness of sustainable fishing practices. The fishermen who live on the coast of the Island for about a month collect branches of shrubs and bushes which they use as fuelwood for cooking and heating. Corals are also damaged by ghost nets - discarded nets that get trapped in corals.

Apart from illegal fishing and coral mining, marine life is also being adversely affected by oil spills in the sea caused by trawlers. Big fish trawlers dump their crude oil bars in the sea. Small oil spills in the sea happen during the exchange of illegally smuggled oil from one boat to another.

1.5 Scope of the Study

In 2015, the International Union for Conservation of Nature (IUCN), through the National Coordinating Body (NCB) of its *Mangroves for the Future (MFF)* programme in Pakistan and headed by the Ministry of Climate Change (MoCC), Government of Pakistan discussed the need for the declaration of Marine Protected Areas (MPAs) in the country as Pakistan is party to the Convention on Biological Diversity (CBD). Under this Pakistan is obligated to declare at least 10% of its coastal and marine areas of particular importance for biodiversity and ecosystem services as MPAs. In this connection, a working group was constituted for identification of potential sites for MPA designation in Pakistan. The working group recommended four potential sites, Astola Island, Churna Island, Miani Hor, and Gwatar Bay for designation as MPAs. Subsequently, a motion (# 055) submitted by the Pakistan National Committee was adopted at the IUCN World Conservation Congress, 2016, calling for declaration of Astola Island as a MPA in Pakistan.

To support the process of establishment of Astola Island as an MPA, IUCN-MFF Pakistan took several steps in collaboration with its NCB members. These steps included initial feasibility assessments, field visits to undertake situational analysis, and a series of consultative stakeholder meetings.

Continuing its support for the sustainable management of Astola Island MPA, the need for establishment of an ecological baseline and resource use Survey (EBRU survey) was realized as the basis for its future conservation and management planning. In this regard, a small funding proposal was approved by Waitt Foundation under the Rapid Ocean Conservation (ROC) grants programme. The proposal is co-financed by Mangroves for the Future Programme.

It is worth noting that the EBRU was the first ever comprehensive survey of Astola Island conducted by a multi-disciplinary team of experts. It was designed to collect primary and secondary information on important biodiversity resources and resource use in Astola Island MPA. The survey was scoped to generate first hand, updated information on terrestrial and aquatic resources of coastal and offshore waters of Astola Island including flora phytoplankton, microalgae, seaweeds, herbs, shrubs and small trees and fauna (reptiles, birds, coral reefs, fish, cetaceans and benthic organisms) and the physical parameters. It also covered identification and mapping of sites of critical ecological importance. The resource use survey covered social aspects pertaining to extractive uses, existing fishing practices and livelihood dependencies associated with the island's resources.

The survey was designed to collect pre and post winter data on ecological resources. The EBRU survey was conducted from 16-18 December, 2017 and 15-17 February, 2018 respectively. In this regard, an orientation and plenary meeting of key stakeholder institutions and academia was held on November 29, 2017 at IUCN country office in Karachi to shape the scope of the EBRU survey and to constitute the team of experts. After field surveys, the individual reports on each study parameter were consolidated and rechecked with the authors. These were also shared with relevant experts for peer review. Following the peer review, a two-day international consultative workshop on Astola Island MPA was organized on 3 and 4 May, 2018 in Karachi. During this workshop survey findings were shared with stakeholders mainly relevant provincial and federal government departments, academia, civil society members and experts from MFF/IUCN Asia Regional Secretariat. The valuable input received from them was later on, incorporated in the report. The baseline information given in this report is intended at filling of knowledge gaps on biological and social resources of the area and contributing to the process of preparation of the management plan of Astola Island MPA. This can be achieved through identifying key biodiversity resources and threats coupled with defining a future course of action and prescribing co-management regime with clearly mentioned responsibilities of various stakeholders for the MPA's conservation and management.

2. METHODOLOGY

The survey team included twenty-six Ph.D scholars and professionals such as phycologists and phycochemists, plant and marine ecologists, herpetologists, ornithologists, marine fisheries and coral experts, foresters, wildlife management experts, and sociologists. The following government agencies and academic institutions partnered in the survey:

1. Pakistan Navy
2. National Institute of Oceanography (NIO), Government of Pakistan
3. Marine Biological Research Laboratory, Government of Pakistan
4. Marine Fisheries Department, Government of Pakistan
5. Centre of Excellence in Marine Biology (CEMB), University of Karachi
6. Institute of Marine Sciences, University of Karachi
7. Department of Zoology, University of Karachi
8. Faculty of Marine Sciences, Lasbela University of Agriculture, Water and Marine Sciences, Balochistan
9. Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Sciences, Balochistan
10. Fisheries Department, Government of Balochistan
11. Forest and Wildlife Department, Government of Balochistan
12. Gwadar Development Authority, Government of Balochistan
13. Sindh Wildlife Department, Government of Sindh
14. University of Veterinary and Animal Sciences, Lahore, Pakistan
15. Pakistan Wildlife Foundation
16. Balochistan Mahigir Network

Following the constitution of a team of experts, a planning meeting of all team members was held at the IUCN country office in Karachi. The main agenda of the meeting was to discuss the scope, seek confirmation of potential thematic experts and finalize terms of reference of the proposed baseline study. After collection of primary data by the experts during two field visits, the individual reports on each study parameter were

consolidated and rechecked with the authors. The consolidated report was peer reviewed by the experts.

Following the peer review, a two-day international consultative workshop on Astola Island MPA was organized on 3 and 4 May, 2018 in Karachi. During the workshop survey findings were shared with stakeholders mainly relevant provincial and federal government departments, academia, civil society members and experts from MFF/IUCN Asia Regional Secretariat. The valuable input received from them was later on, incorporated in the report. The following section describes the methods used for establishment of baseline of various physical and ecological aspects of the Astola Island MPA.

2.1 Physical Parameter and Benthic Sedient Ecology

The benthic ecology survey was carried out by experts from National Institute of Oceanography (NIO), Government of Pakistan.

The following methods were used to record the distribution and abundance of intertidal shore communities (i.e. rocky, sandy and muddy shores) of island. The quantitative information such as species richness, diversity, abundance and density was obtained through the transect method.

2.1.1 Transect Method: transect lines were set up on the beach, perpendicular to the shore. This area is a ~ 500 m stretch of rocky, bolder/ stony/ sandy substrate. An approximately regular interval was estimated and a three line transect was marked. The inter-tidal zones were classified as 0-1, 1-2, 2-3 m tidal heights.

2.1.2 Quadrat Method: quadrats (1x1 m-2) were placed 20 feet (6 m) apart on each of the three transect lines on the shore. The biota found within the quadrat were identified and counted. The top 10 cm sediments were also collected from the 0-1 m tidal height (low tide - December 16 2017, 0.4 m at 15:30) but were removed from the quadrate for assessment of macro-zoo benthos. The flora and fauna within the sediment were assessed for species diversity, after screening with sieves of 0.5 mm.

2.1.3 Ecological Parameters: the ecological parameters described in this report include:

- Inter- tidal zone, beach
- Plankton (phytoplankton and zooplankton), Stn 2 (offshore of Astola Island N 230758.4 E 635107.0)
- Core sample from the 0-1 m (low tide level) top 10 cm sediment layer.

The secchi disk depth was 5 m, the water was very clear and the light penetration was high. The phytoplankton net (44 um) was vertically hauled and the sample water was collected and preserved in 4% buffered formalin. It was observed in an inverted microscope (OLYMPUS) using the Sedgewick rafter (1 ml). The most common groups found were dinoflagellates and diatoms.

2.1.4 Sampling Site and Stations: the study site was a stretch of 0.5 km, which consisted of a sandy beach with pebble substrates and rocky formations that ranged from dark, blackish rock to soft shale stone (yellow) formations. Weathering, cracks, rocks and breaking cliffs were observed.

The inter-tidal observations were plankton samplings and offshore of Station-2, 100-150 m from the beach. The sampling for the phytoplankton was done as vertical hauls, while zooplankton sampling was a 10 minutes horizontal tow at 1-2 knots, between Station 2 and 4.

A standard ring net of 40 cm diameter was used with the 300um mesh size. The net was towed obliquely to sample the entire water column for ~10 minutes from Stn 2 to 4. The sample, preserved in 4% formalin (buffered), was stored in low light and temperature conditions, and taken to the NIO laboratory for further observation.

The zooplankton biomass was estimated through displacement volume (sample from 300 m) and presented as ml m-3 (Kidwai and Amjad 2000, Kidwai, 2005). The sample was further used for qualitative diversity.

Three 10 cm core samples were taken from the lowest low water mark (0.5 m at 1500 hrs) of the three transects. The sample was wet sieved (0.5 mm) and preserved in 10% formalin. This sample

was then placed under the binocular microscope for preliminary observation.

2.1.5 Rapid Ecological Assessment – visual account through pictures: a pictorial record of the 1 x 1 meter square quadrate was randomly placed on the beach, and photographed for a quick assessment.

2.2 Birds

The survey was carried out by a team of experts from the Department of Zoology, University of Karachi and the Marine Biological Research Laboratory, Government of Pakistan and independent bird experts.

The survey on the island itself focused on bird resting and nesting activities. A buffer zone was surveyed for complete species diversity covering all passage emigrants, immigrants, winter visitors and resident birds. Survey was conducted for recording pre-winter and post-winter variations in December 2017 and February 2018. The survey covered the island with its buffer zone. The following methods were used during the survey:

2.2.1 Reconnaissance Visit: during the reconnaissance visit, the transect routes were planned and habit information was recorded. The route comprised two parallel lines, each one kilometer in length and 500 meters apart. The one kilometer transects were divided into 200 meter sections each. Birds noted were either observed or heard within a 100 meter distance on both sides of the transect.

2.2.2 Point Transect: during the point transect, the observers travelled along the transect and stopped at a predefined spot, allowing the birds to settle. Then all the birds seen or heard during a predefined time ranging from 5 to 20 minutes were recorded. Points were randomly selected.

2.2.3 Direct Counting: direct counting is one of the most widely used methods for determining species diversity and abundance. This is done by taking randomly selected points and recording numbers of each species. During the survey, birds were identified in the field by experienced professionals and the field guides (Roberts, 1991-92 and Grimmett *et al*., 2008). Counting the number of birds precisely in the field was made possible with the use of binoculars and a spotting scope. Direct coast survey and counting of birds is useful in open coasts and oceans. In the open areas, birds are easy to observe, identify and count. In order to estimate diversity, richness and

abundance of bird species, direct counting was made at Astola beach and its promontory including the flying birds in the area. This was done by taking random points at different places within hotspots.

Bird counts were generally made in the early morning so that they coincided with maximum bird activity. The average visit time was about 90 minutes. Surveys were also made late in the afternoon for about an hour till dusk (Sutherland *et al.* 2005).

2.3 Reptiles

The reptilian survey was carried out by experts from the University of Veterinary and Animal Sciences (UVAS) Lahore; Pakistan Wildlife Foundation; Marine Biological Research Laboratory (MBRL), Government of Pakistan and Zoology Department, University of Karachi.

The survey was conducted on the island to record the existence, distribution and current status of reptilian fauna. It covered both diurnal and nocturnal species from 10:00 am to 3:00 pm. This included a survey 30 minutes before and one hour after the sunset and at midnight, to observe marine turtles. Potential habitats for marine turtle nesting were visited during the daytime, evening, late night and early morning. Pits of marine turtles and tracks were counted. GPS coordinates for the turtle nesting sites and top plain habitats were also recorded. Sea snakes were also observed during the daytime from a boat.

2.3.1 Habitat Searching / Transect Method: for several hours, a search was carried out to detect reptiles within a circular central zone, at the top edges and sandy beaches of the island. This search covered an area of approximately 20ha (within a 200 m radius of the observation/ sampling points). This method is very suitable for counting the number of reptiles. At first, a suitable place with suitable habitat was chosen considering that the lizards are mostly active at day time, while the terrestrial snakes are seen during the day and night.

2.3.2 Direct observation: high tide nighttime was chosen for the observation of female marine turtles as they visit the beach at nighttime for egg laying. Similarly, the hatchlings were also surveyed at night and early morning.

Track counts and active nest counting was made along the beaches of Astola Island as part of Direct Observations for marine turtles. It was also observed that how many green turtles lay eggs and how many return without egg laying. This was evident from the tracks and trails of the turtles on sandy beaches of the Island.

2.3.3 Incidental Sightings: incidental sightings are helpful in determining the presence and population status of any given species. In this way the numbers of species, date, time, location and habitat types were recorded on data sheets.

2.3.4 Collection Methods: stone turning, looking at and through bushes, searching basking agamas on cliffs and boulders and walking along microhabitats were various means used to find all possible reptiles in the area. Fast moving agamid and lacertid lizards were collected and/or observed by striking the ground with a stick. Some specimens were pulled out with the help of long forceps from crevices in stones while a few were collected by hand from under and among the stones.

2.3.5 Scale Counts and Measurements: during the laboratory study, the following pholidosic count and measurements were made: number of upper labials, number of lower labials, number of supra-ocular scales (scales on dorsal side of orbit outer to frontal and front-o-parietal), callose pre-anal scales (enlarged scales in front of anal slit), callose abdominal scales (a patch of enlarged scales on the mid abdomen), number of scales around mid-body, number of scales along the lateral side of the body, shape of the scales and pre-auricular lobes (small lobules at anterior of ear opening). Similarly, snout-vent length, caudal length, head length, head width, axilla to groin length, eye diameter, ear diameter and all other external characters were also recorded.

2.3.6 Field Records and Specimen Identification: information about each collected specimen such as locality, description of habitat of the collection site, time of collection, collection date and collector's name was recorded. Collected specimens were identified by using the keys given by Minton (1966) and Khan (2004 and 2006).

2.3.7 Preservation Techniques: collected lizards were killed by injecting concentrated formalin into the heart. Then the formalin was injected in belly, neck, legs and tail for preservation. A tag number was allotted to each specimen and tied to the left hind limb for identification and later detailed studies. Preserved specimens were stored in 10% formalin air tight plastic jars. Field notes were prepared.

2.3.8 Indirect Counting Methods: information from different sources such as the field staff of Balochistan Wildlife Department, local fishermen, boatmen, members of local community temporarily living on Astola Island and indigenous fishermen of Pasni town was collected. Footprints, tracks and trails were observed to find the species and to estimate their populations.

2.4 Marine Fish

The survey of marine diversity was carried out by experts from Lasbela University of Agriculture Water and Marine Sciences (LUAWMS), Marine Fisheries Department (MFD), Government of Pakistan (GoP) and Balochistan Fisheries Department.

The survey was conducted through the following methods to identify the diversity of fish species in two different seasons i.e. pre-winter in December and post-winter in February.

2.4.1 Interviews with Local Fishermen: identification of fish species was done through interviews with local fishermen operating around Astola Island. The fishermen were interviewed to get information on their catch in different seasons including species with their economic value, catch trends and fishing practices.

2.4.2 Species Observation at Fish Landing Jetty: a reconnaissance visit at Pasni Fish Landing Jetty was conducted to record the fish species being caught in the area and landed at the jetty, while species identification was confirmed with the help of the *"FAO species identification guide for fishery purposes, 2015".* The people involved in the fish trade at the jetty were also consulted to get information on fish species landing at the jetty in different seasons.

2.5 Cetacean

The cetacean survey was carried out by experts from the Institute of Marine Sciences, University of Karachi.

The following methods were used for survey:

2.5.1 Boat Survey: to conserve species, basic information on the type of species, where it is found and in what numbers is fundamental. Boat surveys provide an excellent platform to collect this data on cetaceans (eg. whales, dolphins and porpoises) and sea turtles. Associated predictive indicator factors such as presence of marine birds and density of fishing vessels are also important in drawing correlations. A boat survey for marine cetaceans was conducted on December 16, 2017 from a small fishing vessel of approximately 20 feet long and 0.5 metre high from sea surface during the day.

2.5.2 Line Transect Method: the line transect method was followed for this purpose in which the survey was planned in advance on an admiralty chart, keeping all the possible survey factors in consideration such as boat speed, available daylight hours, area of survey and type of habitat. Just one observer was used to scan the 180° angle on front of the boat for cetacean presence (Buckland *et al.,* 1992; Wade and Gerrodette, 1992; Barlow, 1995; Jefferson and Leatherwood, 1997). This observer was also acting as data recorder. It was pre-decided that the observer would observe the "off effort mode" when the animals were sighted so that identification, counting and recording of all required data could be completed in a calm manner. It was also pre-decided that the "off-effort" mode would remain in effect until all the required information in the cetacean recording form was filled out, including any other information of interest in the comments column. Only after that could the team go to "on effort mode" again. This method was followed to the end of survey. All the sheets were completed, cleaned and entered into the database soon after the teams returned from the survey.

Some supplementary data on sea birds such as indicators of food resources, potential proximity of cetaceans, marine traffic, their possible impacts on cetacean behavior and the potential threats was also collected. Details of "on survey" effort and marine bird and cetacean sightings were recorded on standard data forms. The

identification of the animals was confirmed only if enough evidence was available due to close observation of animals or pictures.

Weather conditions were recorded daily with sea state glassy, slight, choppy and rough. The surveys were truncated when the sea state exceeded level 3 as the conditions become too rough to carry out successful boat surveys for cetacean observations. Swell was recorded as (0 m), (<0.25 m), (0.25 m), (0.5 m), (0.75 m), (1 m), (1.5 m) and (2 m) and visibility categorized as poor (< 1 km), 'moderate' (1-5 km) or 'good' (> 5 km).

2.5.3 Beach Surveys: beach surveys were carried out on December 16 and 17, 2017 to record beach cast cetaceans, sea turtles and strandings to collect samples for future studies. The surveys were conducted using line transect method (Van Waerebeek *et al.,* 2000) with at least two observers at a time searching for cetacean and sea turtle remains on the beach between high and low tide marks while walking in a line. All observations were recorded on a standardized datasheet.

In case of full specimens, dead or alive, mainly the length was measured along with notes on sex (if possible) and general health condition of the animal. Skulls and other skeletal material, if found in good condition, was collected. Possible cause of death for dead specimens, signs of injury or interaction with fishing gear i.e. gear still entangled with the specimen, injuries or cuts, broken bones particularly rostra, ropes tied around the fluke, cut fluke, nets wrapped around the body of the animal and absence of fins and flukes was recorded (Tregenza and Collet, 1998; Read and Murray, 2000). Everything else that seemed as if it might be useful in future was noted in the comments column. No stomach contents were collected during this project. Any animals found dead were photographed, their gender verified (if possible) and measured. The samples were preserved in ethanol of analytical grade. Dry tissues e.g. skulls and bones, if found in good condition, were collected.

2.6 Small Mammals

The survey for the small mammals was carried out by an expert from the Marine Biological Research Laboratory, Government of Pakistan with the collaboration of a wildlife expert from Sindh Wildlife Department, Government of Sindh.

Different techniques were used during this small mammalian survey, which are given below.

2.6.1 Spotlighting Method: many small nocturnal mammals in the study area were found by using spotlights at night.

2.6.2 Folding Sherman Trap: small mammals were sampled by using bait of peanut butter mixed with honey, kept inside the traps which were set at two different locations. The traps were set before darkness in the evening and were left for the whole night. The locations were visited early in the morning before sunrise and trapped specimens were released after identification and recording of necessary data.

2.6.3 Observing Active Burrows, Fresh Feces and Tracks: by using this technique, active holes / burrows, fecal material and fresh tracks of small mammals were observed in different transects and the existence of the house rat *(Ratus ratus)* was confirmed on the bases of these indirect pieces of evidence.

2.7 Corals

The corals survey was carried out by a team of experts from Center of Excellence in Marine Biology, University of Karachi.

The study was directed on northern sheltered site of the Island. Surveys were conducted by SCUBA diver at two diving sites. The habitat at both diving sites was rocky, consisting of boulders, ridges and occasional sandy pockets. The rocks were covered with algal turf. The following techniques were used:

2.7.1 Video Transects: species abundance was recorded using video transects. A 30 meter measuring tape was laid at the bottom. Species within two meter range on each side of transect were recorded using a digital camera in underwater housing. Maximum species were identified *in situ*.

2.7.2 Laboratory Analysis: samples of species that could not be identified on site were collected using hammer and chisel. Samples were brought to the laboratory (Center of Excellence in Marine Biology, University of Karachi, Pakistan) and identified following Veron (2000).

2.7.3 Visual Estimation: visual estimations were made regarding determination of coral cover. GPS coordinates and respective depth at each site was determined.

2.7.4 Physical Parameters: temperature, salinity, pH and dissolved oxygen were recorded at both diving sites.

2.8 Vegetation

The phytosociological survey was carried out by experts from Lasbela University of Agriculture, Water and Marine Sciences, Uthal, Balochistan, with the field assistance from Pakistan Navy, Balochistan Wildlife and Forest Department, and a freelance plant ecologist.

The following methods were reported for the plant survey:

2.8.1 Point Centre Quarter Method: sampling of vegetation was made by Point Centre Quarter method as defined by Cottom and Curtis (1956). In this method a cross-bar tossed in a stand and the nearest plant species in each quarter was identified and circumference and distance of these plants were measured. There were ten stands with 10 point each were measured. Therefore, a total of 400 individual plants belonging to different species were studied during this survey. The density, circumference (the area covered by the canopy of plant) and frequency (the distribution of a plant species within the stand) were analyzed and used for constructing Importance Value Index (I.V.I.) following the practice of Curtis and McIntosh (1951). The formulas are as follows:

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$$\text{Density (D)} = \frac{\textit{Number of plant of a species}}{\textit{Number of Points used}}$$

$$\text{Relative density (D3)} = \frac{\textit{Number of individual of aspecies in all quarter}}{\textit{Number individual of all species}} \times 100$$

$$\text{Relative cover (C3)} = \frac{\textit{Sum of cover (cm) of all species in all points}}{\textit{Sum of cover (cm) of all species in all points}} \times 100$$

$$\text{Frequency (F1)} = \frac{\textit{Number of point which a species occurs}}{\textit{Total number of point taken}} \times 100$$

$$\text{Frequency (F3)} = \frac{\textit{F1 of species}}{\textit{F1 of all species}} \times 100$$

Important value index (IVI) = F3+D3+C3

2.9 Seaweed

The survey on seaweed carried out by an expert from the Institute of Marine Science (IMS), University of Karachi (UoK) with the assistance of research students of IMS, UoK.

The following methods have been used for seaweed survey:

2.9.1 Visual Observation and Collection of Sample: the samples were collected from different sites. For example, pebbles with traces of epilithic algae were packed in polyethylene ziplock bags for further study.

2.9.2 Laboratory Analysis: the samples collected from the island were brought to the Laboratory for Exploration of Marine Resources (LEMR), Institute of Marine Science, University of Karachi, for further identification.

2.10 Socio-Economic Aspects

The socio-economic baseline established by expert from Gwadar Development Authority with the assistance from Balochistan Mahigir Network.

Socio-economic baseline study conducted to obtain information regarding natural resources dependency and use in terms of income and social setup of various communities through the following methods:

2.10.1 Interviews with Local Fishermen through Questionnaire: a questionnaire on social and natural resource use indicators was developed and replies were obtained from the fishermen community fishing around Astola Island. First-hand information about natural resource use was gathered from the fishermen communities present within the island, who stay in their boats for short or long periods of time.

2.10.2 Interviews with Stakeholders: Information was obtained from various NGOs. Direct interviews and field observations helped in getting primary data about the natural resource use and management of Astola Island. Information about Astola Island was gathered from the following stakeholders: fishing community residing and fishing on Astola Island, officials belonging to Pasni Fish Harbour Authority (PFHA), Balochistan Mahigir Networks (BMN), Pasni, Directorate Balochistan Fisheries Department Pasni, Maritime Security Agency (MSA), Non-Government Organisation (NGO), Fishing agents, fish buyers, fisheries Inspector, Gwadar and other fishermen from Pasni and surrounding areas.

2.10.3 Literature Review: Prior to conducting field survey, available literature was consulted to gather some basic historical contextual information about the area.

3. RESULTS WITH ANALYSIS AND DISCUSSION

3.1 Benthic Sediment Ecology and Physical Parameters

3.1.1 Results of the Survey

The study carried out by the Zoological Survey Department, Karachi (2008) did not include inter-tidal invertebrate fauna, flora and plankton. So there is no available background literature.

The physical observations from the offshore Pasni stations and the near Astola stations where depths are from up to 17 m are available (NIO archives, 2010).

The physical parameter records during the survey conducted in December 2017 are shown in Table-1:

Table 1: Physical observations from Astola during the survey (16 December 2017)

No.	Latitude (N)	Longitude (E)	Depth (m)	Temp	Salinity	Dissolved Oxygen	Turbidity	pH	Total Chlorophyl
				(C)	PSU	mg/L	NTU		ug/L
1	25 0744.3	63 37741.6	0	24.01	38.16	6.47	0.6	8.25	0.6
			6.5	24.01	38.01	6.44	0.4	8.24	0.5
2	25 0758.4	63 5107.0	0	23.83	38.27	6.66	-1.2	8.27	0.6
			2.5	23.83	38.17	6.22	-0.7	8.27	0.6
3	25 0733.7	63 4954.2	0	23.55	38.17	6.69	1.1	8.25	0.6
			4.0	23.54	38.18	6.61	1.4	8.26	0.4
			7.5	23.46	38.19	6.52	0.1	8.26	0.5
4	25 0715.0	63 4924.7	0	23.65	38.09	6.40	1.8	8.22	0.2
			4.5	23.52	38.08	6.22	1	8.23	0.2
			5	23.50	38.08	6.15	0.6	8.23	0.6

3.1.2 Analysis and Discussion

The most dominant group are the molluscs; *Cellana radiata, Nodliltorina picta, Cerithium carbonarium, Patella granularis, Turbo intercostalis, Drupa spp, Astraca sulnicostat, Merita albicilla, Chiton oceanica.*

Map 2: Astola Island bathyal

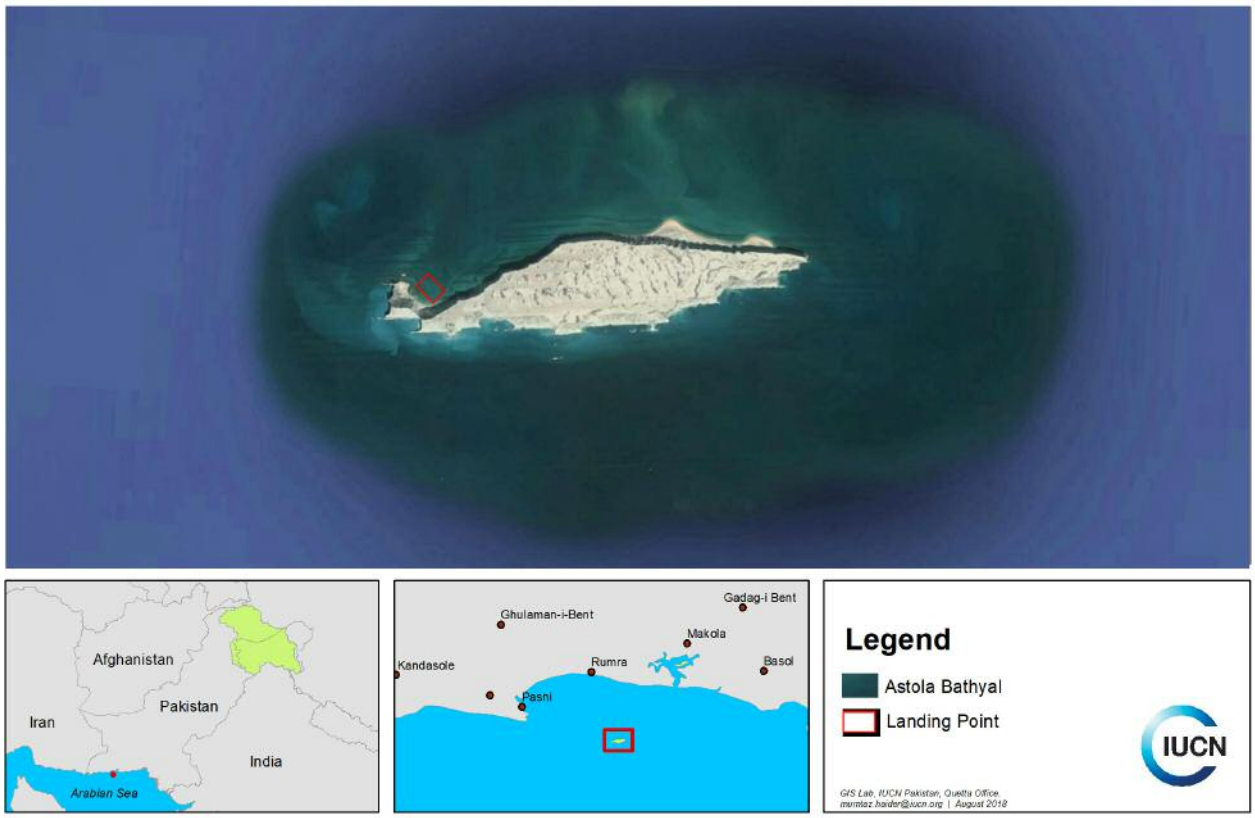


Table 2: Taxonomic groups present on the three transects

Taxonomic Groups	Species
Sponges	
Nemerteans	*Nematode*
Echiurids	*Ochetostome sp.*
Arthropoda	*Cirripedes (barnacles- Balanus*
Crustacean	*spp. Chalalamus spp.)*
	Hermit crabs
	Leptodius exaratus
	L. euglyptus quadrispinosus
	Acanthonyx elongates
	Alpheus inopoinatus
	Petrolisthes rufescens
	Grapsis spp.
Gastropoda	*Astaraea semicostata*
	Astraea stellaris
	Cellana radiata
	Cerithium spp.
	Conus spp.
	Cyprea spp.
	Drupa spp.
	Nerita spp.
	Nodililttorina picta
	Patella sp.
	Planaxis sulcatus
	Turbo coronatus
	Turbo intercostalis
	Thais spp.
Bivalvia	*Circe spp.*
	Gafrarrium spp.
	Saccostrea tuberculata
	Chama spinisa
	Pseudochama corrugate
Amphineurans	*Chiton oceanica*
Echinodermata	*Cucumaria spp.*
	Holothuria sp.
	Sea urchin
Opisthobranch	*Doris sp.*

Table 3: Taxonomic groups present in the sample

Taxonomic Groups
Amphipod
Appendicularia
Brachyuran larvae
Chaetognath
Cumacean
Cladoceran
Copepods
Cypris larvae
Fish egg
Fish larvae
Lucifer
Shrimp larvae

3.1.2.1 Phytoplankton and Zooplankton (Biomass and Biodiversity)

Phytoplanktons are microscopic unicellular plants that form the basic autotrophic unit of the food web. They are distributed in the top 200 m of the water column and are most abundant in the sub-surface layer. In the presence of sunlight and chlorophyll, in the marine environment also blue-green pigment (nano-pico plankton - Cyanobacteria) contribute to the primary production that sustains the subsequent higher live forms.

Zooplankton are an important component of pelagic ecosystems and play a pivotal role in aquatic food webs as they are important food for fish and invertebrate predators, and graze heavily on algae, bacteria, protozoa, and other invertebrates.

In terms of biomass and productivity, the zooplankton community ranges in size from a few tens of microns (Protozoa) to >2 mm (macro zooplankton). The dominant groups of zooplankton in the marine environment are crustacean – copepod that form the most dominant group.

Zooplankton biomass is generally patchy: the zooplankton biomass from the one station that was sampled was 50.94 ml *100 m-3.

Zooplankton productivity in the coastal waters of Pakistan is usually high and high biomasses from the coastal waters off Pakistan are generally observed (Huda *et al.* 1988; Kidwai 2005). The most dominant group is copepods, cirripede, cladoceran, crustacean shrimp larvae and post larvae, Cumacea.

It may however be noted that due to time and resource limitations full tidal range and seasonal variability could not be covered.

Table 4: Biota in the benthic core sample

TRANSECT 1	TRANSECT 2	TRANSECT 3
N 25 07 09.7 E 63 49 50.8	N 25 07 12.1 E 63 49 57.9	N 25 07 12.6 E 63 50.01.0
Coral/ shell rubble	Coral/ shell rubble	Coral/ shell rubble
Nematodes	Crustacean (cumacean shrimps)	Crustacean (cumacean shrimps)
Crustacean (sand shrimp)	Gastropods	Gastropods
Gastropods	Polycheate worms	Polycheate worms
Cypris (barnacle larvae)		
Amphipods		
Polycheate worms (annelid)		
Murex		

3.2 Birds

No baseline study or any feasibility report for declaring the site as an MPA is available for reference, nor does any Asian Waterbird Census (AWC) data on water bird counts on this site seem to have been collected to determine the trends in the water bird populations.

As regards the review of previous work done on the fauna of the area, it was found that there is very little information available on the subject such as Scott (1989), Khurshid *et al.,* (1995), Anon (2005), Siddiqui *et al,* (2008) and Begum *et al* (2016).

Previously, some avian species were recorded from the area which included: grey heron *(Ardea cinerea),* western reef egret *(Egretta gularis)*, grey plover *(Pluvialis squatarola)*, Eurasian curlew *(Numenius arquata)*, blacktail godwit *(L. limosa)*, little stint *(Calidris minuta)*, herring gull *(Larus argentatus)*, slender billed gull *(Larus genei)*, crested lark *(Galerida cristata)*, desert wheatear *(Oenanthe deserti)*, Rufous fronted prinia *(Prinia buchanani)* and Indian courser *(Cursorius coromandelicus)*.

Astola Island is reported to support large numbers of breeding sea birds, including *Larus hemprichi* and several species of terns. As many as 61 species of birds were recorded; mostly water birds (34 species), passerines (19 species), raptors (6 species), doves (1 species) and swifts (1 species). No threatened/ near threatened species of birds was recorded except the dalmatian pelican.

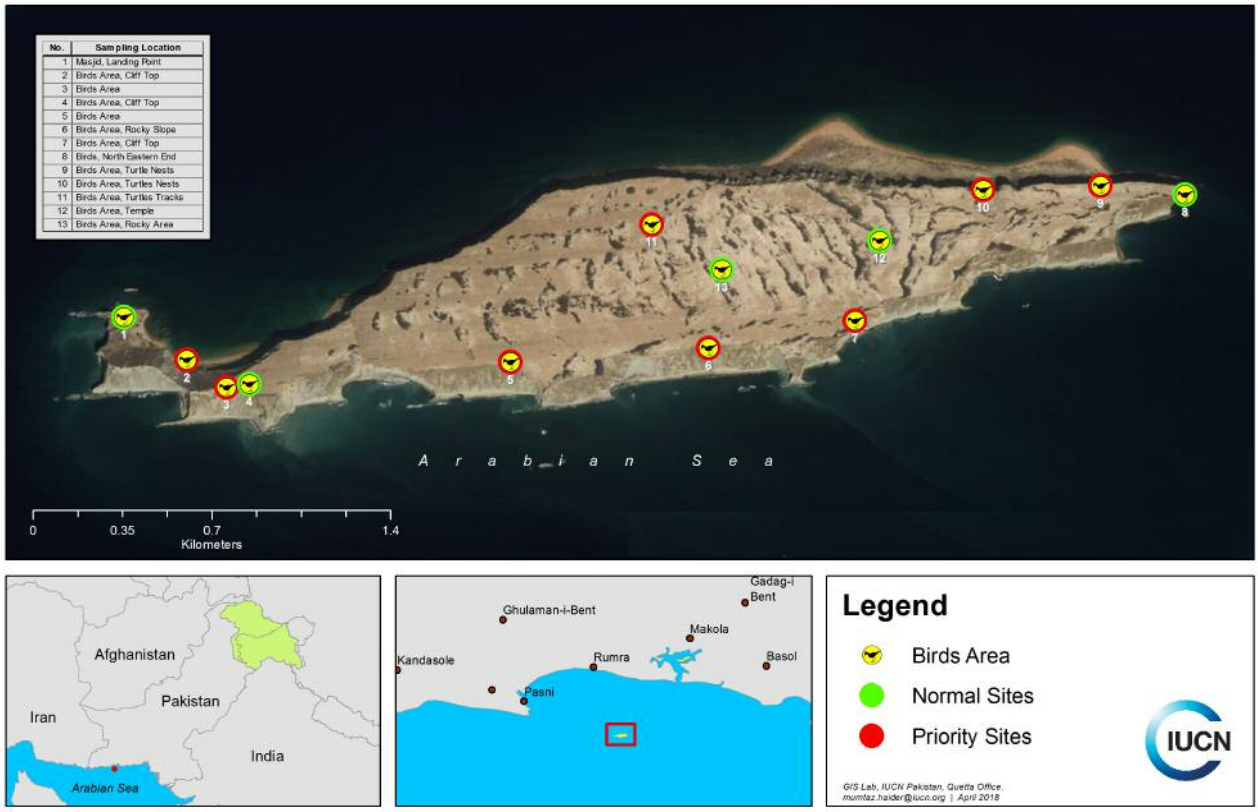
3.2.1 Results of the Survey

3.2.1.1 Prime Habitats for Birds

The sandy area at the base of the cliff on Astola Island is the most favored habitat for waders. The rocky habitats support large concentrations of water birds, particularly, the gulls and terns.

Thirteen sampling sites were selected, out of which five marked sites are the priority sites for bird study, as given in the Map 3.

Map 3: Important sampling locations for birds at Astola Island



3.2.1.2 Birds Observed and Species Composition

A total of 61 species of birds belonging to 8 orders and 23 families have been recorded during pre-winter and post-winter surveys (discussed in Table-6).

The species composition of birds at Astola Island MPA is as follows:

Water birds - pelicans, large cormorants, egrets, oystercatchers, red wattled lapwings, sandpipers, little stints, Arctic skuas, gulls and terns were recorded.

Birds of prey - Indian shikras, common kestrels, ospreys and short eared owls were recorded.

Passerines - larks, southern grey shrike, wheatears, warblers, house buntings and skylarks were recorded.

Others - pallid swift were recorded.

Table 5: List of bird species with their significance

S. No.	Species	Significance
1	Arctic skua	Less common seabird
2	Sooty gull	Summer visitor
3	Dalmatian pelican	Threatened species
4	Osprey	Typical coastal bird of prey
5	Short eared owl	Scarce winter visitor
6	Red necked phalarope	Abundant WV of coastal and offshore waters
7	Rufous-fronted prinia	Scarce resident coastal species of Makran Coast
8	Cream coloured courser	Scarce resident

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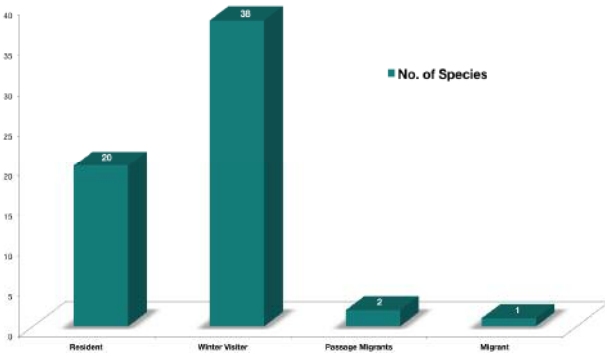
The species of birds mentioned in Table 5 have been selected as priority species in view of their significance. These need to be especially cared for in the future studies.

3.2.1.5 Important Findings

- The top of the cliff provides nesting grounds for the resident birds particularly the crested lark and the desert lark. The house bunting nests on the slopes while the house sparrow nests on trees on the ground near the mosque.

Figure 1: Seasonal status of bird species



- Ten black headed buntings were recorded in the post winter survey.
- Two Indian shikras were recorded in only pre-winter survey.
- The number of dalmatian pelicans has dropped from 175 to 26 in pre and post winter surveys.
- The number of red necked phalaropes has increased from 35 to 140 in pre and post winter surveys.

3.2.2 Analysis and Discussion

All the bird species reported during the present survey are usually found on other parts of the coastline. Astola, however, being an unpopulated place and not easily accessable by common people, may prove to be a potential site for breeding of some bird species. The month of December is not part of the breeding season for birds. However, breeding of the crested lark, kestrel and little tern was noticed in some areas. More research work is required on the breeding of threatened and priority species of birds in the area.

Table 6: Complete list of bird species recorded on Astola Island

S.No	Scientific Name	Common Name	Dec, 17	Feb, 18	Conservation Status	Seasonal Status	Population Status	
							Pre-Winter	Post-Winter
Order: Pelecaniformes								
Family: Pelecanidae								
1.	*Pelecanus onocrotalus*	White or Rosy pelican	20	42	LC	WV	C	C
2	*Pelecanus crispus*	Delmatian pelican	175	26	NT	WV	A	C
Family: Phalacrocoracidae								
3	*Phalocrocorax carbo*	Large cormorant	380	270	LC	WV	A	A
4	*Phalacrocorax niger*	Little cormorant	155	—	LC	WV	A	—
Family: Ardeidae								
5	*Egretta intermedia*	Intermediate egret	26	27	LC	R	C	C
6	*Egretta garzetta*	Little egret	2	—	LC	R	SC	—
7	*Egretta alba*	Large egret	12	9	LC	WV	C	LC
8	*Ardea cinerea*	Grey heron	09	20	LC	WV	LC	C
9	*Ardeola grayii*	Indian pond heron	5	—	LC	R	LC	—
10	*Egretta gularis*	Reef heron	09	15	LC	R	LC	C
Order: Accipitriformes								
Family: Accipitridae								
11	*Accipiter badius*	Shikra	02	—	LC	R	SC	—
12	*Milvus migrans*	Pariah kite	1	—	LC	R	SC	—
Order: Falconiformes								
Family: Falconidae								
13	*Falco tinnunculus*	Common kestrel	02	02	LC	WV	SC	SC
14	*Falco chiquera*	Red-headed merlin	1	—	NT	WV	SC	—
Family: Pandionidae								
15	*Pandion haliaetus*	Osprey	02	04	LC	WV	SC	SC
Order: Charadriiformes								
Family: Haematopodidae								
16	*Haematopus ostralegus*	Oystercatcher	35	10	NT	WV	C	C
Family: Recurvirostridae								
17	*Himantopus himantopus*	Blackwinged stilt	16	5	LC	R	C	LC
Family: Charadriidae								
18	*Vanellus indicus*	Redwattled lapwing	11	19	LC	R	C	C
19	*Charadrius dubius*	Little ringed plover	2	—	LC	R	SC	—

S.No	Scientific Name	Common Name	Dec, 17	Feb, 18	Conservation Status	Seasonal Status	Population Status	
							Pre-Winter	Post-Winter
20	*C. alexandriunus*	Kentish plover	15	—	LC	SBV/WV/PM	C	—
21	*C. mongolus*	Mongolian sand plover	1	—	LC	WV	SC	—
Family: Scolopacidae								
22	*Tringa hypoleucos*	Common sandpiper	04	12	LC	WV	LC	C
23	*Tringa stagnatilis*	Marsh sandpiper	1	—	LC	WV	SC	—
24	*Tringa totanus*	Redshank	04	18	LC	WV	LC	C
25	*Calidris minuta*	Little stint	305	320	LC	WV	A	A
26	*Phalaropus lobatus*	Rednecked phalarope	35	140	LC	WV	C	A
27	*Numenius arquata*	Curlew	2	—	NT	WV	SC	—
Family: Stercoraridae								
28	*Stercorarius parasiticus*	Arctic skua	38	44	LC	WV	C	C
Family: Laridae								
29	*Larus hemprichii*	Sooty gull	373	250	LC	WV	A	A
30	*Larus argentatus*	Herring gull	10148	—	LC	WV	A	—
31	*Larus fuscus*	Lesser blackbacked gull	8210	—	LC	WV	A	—
32	*Larus icthyaetus*	Great blackheaded gull	1	—	LC	WV	SC	—
33	*Larus ridibundus*	Blackheaded gull	1600	2300	LC	WV	A	A
34	*Larus cachinnans*	Caspian gull	3500	3500	LC	WV	A	A
35	*Larus heuglini*	Heuglin's gull	10400	6800	LC	WV	A	A
36	*Gelochelidon nilotica*	Common gullbilled tern	2568	35	LC	WV	C	C
37	*Hydroprogne caspia*	Caspian tern	26	29	LC	M	C	C
38	*Sterna albifrons*	Little tern	55	15	LC	R	C	C
39	*Sterna hirundo*	Common tern	10	—	LC	WV	C	—
Order: Columbiformes								
Family: Combumbidae								
40	*Streptopelia sengalensis*	Little brown dove	22	30	LC	R	C	C
Order: Strigiformes								
Family: Strigidae								
41	*Asio flammeus*	Short-eared owl	01	03	LC	WV	SC	SC
Order: Apodiformes								
Family: Apodidae								
42	*Apus pallidus*	Pallid swift	06	17	LC	WV	LC	C

S.No	Scientific Name	Common Name	Dec, 17	Feb, 18	Conservation Status	Seasonal Status	Population Status	
							Pre-Winter	Post-Winter
Order: Passerifromes								
Family: Hirundinidae								
43	*Riparia diluta*	Plain martin	16	16	LC	R	C	C
44	*Riparia paludicola*	Indian sand martin	88	35	LC	R	C	C
Family: Alaudidae								
45	*Galerida cristata*	Crested lark	12	32	LC	R	C	C
46	*Ammonanes deserti*	Desert lark	20	22	LC	R	C	C
47	*Alaemon alaudipes*	Greater Hoopoe lark	04	02	LC	R	LC	SC
48	*Alauda arvensis*	Common skylark	02	05	LC	WV	SC	LC
Family: Laniidae								
49	*Lanius meridionalis*	Southern grey shrike	06	11	LC	R	LC	C
50	*Lanius isabellinus*	Isabelline shrike	2	—	LC	R	SC	—
Family: Turdidae								
51	*Oenanthe picata*	Variable wheatear	04	08	LC	WV	LC	LC
52	*Oenanthe deserti*	Desert wheatear	10	16	LC	WV	C	C
53	*Oenanthe isabellina*	Isabelline wheatear	04	10	LC	WV	LC	C
Family: Sylviidae								
54	*Hippolais caligata*	Booted warbler	02	06	LC	WV	SC	LC
55	*Sylvia nana*	Desert warbler	02	04	LC	WV	SC	LC
56	*Phylloscopus collybita*	Common chiffchaff	04	—	LC	WV	LC	—
Family: Passeridae								
57	*Passer domesticus*	House sparrow	130	215	LC	R	A	A
Family: Motacillidae								
58	*Motacilla flava*	Yellow wagtail	13	20	LC	PM	C	C
59	*Matocilla alba*	White or pied wagtail	19	34	LC	WV	C	C
Family: Emberizidae								
60	*Emberiza striata*	House or striped bunting	14	26	LC	R	C	C
61	*Emberiza melanocephala*	Black headed bunting	—	10	LC	PM	—	LC

Legends: Seasonal Status: R= Residents, WV= Winter Visitors, PM= Passage Migrants, M=Migrant, SBV=summer breeding visitor,
Population Status: A = Abundant (>100), C = Common (10-99), LC = Less Common (3-9), SC = Scarce (1 – 2),
Conservation status: LC= Least Concern, NT= Near Threatened, VU= Vulnerable

3.3 Reptiles

Astola Island is characterized by different types of habitats, with a sandy beach towards the northern side of the Island which provides nesting areas for the threatened Green turtle *(Chelonia mydas)* and stony, rocky areas along the western side which, though they do not support any reptilian or amphibian species, offer good roosting sites for birds. Natural vegetation on Astola Island is made up of shrubs like *Cadaba sp., Maerva sp., Haloxylon stocksii, Convolvulus glomeratus, Sonchus sp., Cenchrus sp., Abutilon fruiticosum* and *Pentatropus sp.* that offer a suitable habitat for agamid as well as lacertid lizards.

The herpetological studies in southern Asia started during the second half of 19th century and the first general work was *The Reptiles of British India* by Albert Günther (1864), followed by George Boulenger's work in *Fauna of British India* series (1890). *Fauna of British India* was later revised by Malcolm Smith in three volumes (1931, 1935 and 1943). The revision updated the herpetological knowledge but it fell short in coverage of the area. Large parts of land in the subcontinent are even nowadays unknown in respect to the herpeto faunal composition. William Blanford (1874, 1876), James A. Murray (1886) and Ferdinand Stoliczka (1872) are among those who published herpetological papers prior to 1900 on the region that became Pakistan.

After 1947, Minton (1962 and 1966) and Mertens (1969, 1970 and 1974) were the only contributors to the herpetology of Pakistan, working on large areas not covered by previous work. Minton and Mertens are among the pioneers of the herpetological research in the country. *A Contribution to the Herpetology of West Pakistan* by Minton (1966) describes different herps in details. Minton's collections were made mainly in lower Sindh and Balochistan, whereas Martens' collections were of wider scope. Since then, several reports have been published on herpetological collections from different parts of Pakistan, adding much to our knowledge about the composition of herpetological assemblages in different parts of Pakistan.

The bulk of that work was produced by the first Pakistani herpetologist, Prof. Dr. Muhammad Sharif Khan followed by Dr. Khalid Javed Baig (Khan, 1968 a, 1972, 1979, 1980a, 1985, 1986, 1987, 1988, 1989, 1991c, 1992,1993 a,c, 1997, 1999 a, b, 2001, 2004, 2006; Khan and Ahmed, 1987; Khan and Baig, 1988, 1992; Khan and Tasnim, 1990; Baig, 1988 a,b,c, 1989, 1990, 1991, 1992, 1996, 1997, 1998a,b; Baig and Böhme, 1991, 1996; Dubois and Khan, 1979;). Several species have been recorded for the first time from Pakistan (Khan, 1974, 1977, 1984a, b, 1985b, 1986, 1989, 1992; Baig, 1988c, 2005; Baig and Gvozdik, 1998). New species of frogs, lizards and snakes have been described (Khan, 1980a, 1985b, 1988, 1991a, b, 1993a, 1997a, b, 1998, 1999c, d; Khan and Tasnim, 1989, 1990; Khan and Baig, 1992; Khan and Khan, 1997; Khan and Khan 2000; Baig 1989, 1992a, 1998b, 1999; Baig & Böhme, 1996; Dubois & Khan, 1979). Mohammad Sharif Khan has spent around 40 years of his life studying the herpetological fauna of Pakistan. He has compiled all his research work in the form of six books on herps of Pakistan with "*Amphibians and Reptiles of Pakistan*" (Khan, 2006) the most authentic book available on the herpetology of Pakistan.

Unfortunately, due to a vast barrier of 25 nautical miles of rough sea during peak herpetological activities (May-August), few herpetological expeditions have been made around Astola Island so far. The present study will be valuable in the sense that this herpetological expedition will add to the previously reported herps around Astola Island after a gap of around 20 years.

3.3.1 Results of the Survey

3.3.1.1 Reptiles Observed During the Study

A total of seven species of reptiles including one turtle species, four lizards species and two snakes species were recorded from the study area. Snakes included one terrestrial and one aquatic species. The recorded species belong to two different orders and six families. Only two out of the recorded seven reptilian species were found of special concern. These were the Green turtle (*Chelonia mydas*), a threatened species, and the saw-scaled viper (*Echis carinatus astolae*), a species endemic to Pakistan and found only Astola Island.

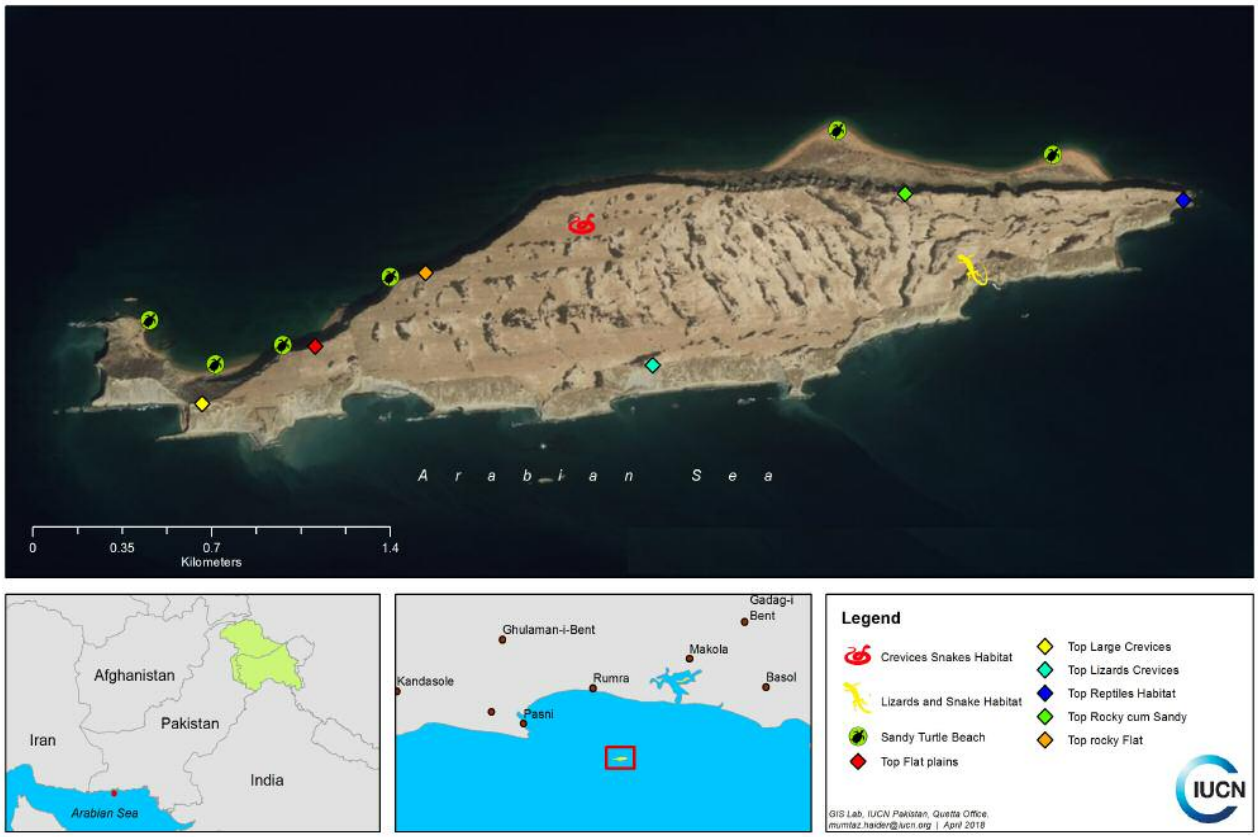
The isolated location of the island has helped maintain endemic lifeforms. The endangered Green turtle (*Chelonia mydas*) nests on the beach at the foot of the cliffs. Some Green turtles were found dead on the sandy beaches and during a early morning survey, a few hatchlings of same species were also found dead.

For lizards, all mountainous habitats were surveyed and most lizards were observed during daytime. Most of the reptiles were identified at

Table 7: List of recorded reptiles from Astola Island

#	Zoological Name	Common Name	Order	Family	Observation Records	
					Direct	Indirect
1	*Chelonia mydas*	Green turtle	Chelonia	Cheloniidae	✓	Nest, dead spacimen, eggs, tracks & trails
2	*Cyrtopodion kachhensis*	Spotted ground gecko	Squamata	Geckonidae	✓	-
3	*Mesalina watsonana*	Spotted lacerta	Squamata	Lacertidae	✓	-
4	*Ophisops jerdonii*	Rugose spectacled lacerta	Squamata	Lacertidae	✓	-
5	*Laudakia lirata*	Yellow headed spotted rock agama	Squamata	Agamidae	✓	-
6	*Microcephalophis gracilis*	Small headed sea snake	Squamata	Hydrophiidae	✓	-
7	*Echis carinatus astolae*	Saw scaled viper	Squamata	Viperidae	✓	molt

Map 4 GPS coordinates of turtle nesting sites and other reptile habitats.



first sighting, others were identified after consulting the guidebook for reptile identification (Khan, 2002; Khan, 2006). Conclusively, Astola Island was found to be significantly important from a reptile biodiversity point of view. The checklist for the species of reptiles is given in Table-7.

3.3.1.2 Marine Turtle Nesting Sites:

A detailed survey of various beaches, inter-tidal zones and rocky shores was carried out to classify coastal habitats present on the island. Generally, there are rocky pockets along both ends of Astola Island's main beach on the southwestern side. These are semi-reflective beaches with sandy supra-tidal areas. Female sea turtles frequent this section of Astola commonly, at night, for egg laying. One can observe several nests on this beach well above high tide mark. Turtle hatchlings are also commonly seen moving to the sea.

There are many small pocket beaches on Astola: however, by far the largest beach of the island on the northeastern side is 1.8 km long and is sandy with small rocky patches at both ends. The beach is semi-reflective in nature and one of the most significant beaches for the Green turtle *(Chelonia mydas)* nesting in Pakistan. The beach has a >2-2.5 m strandline and comprises two sandy platforms i.e. one sloppy platform till the high tide mark and then a more dissipative kind of sandy platform above it. Turtles generally visit this second platform for nesting and appear to reach these after strenuous uphill movement.

During the study, all nesting sites for the Green turtle were thoroughly surveyed and nests were counted to estimate the Green turtle population that nests on Astola Island. One hundred (100) nests were counted along the first nesting site located near the western end of the island, 45 nests were observed along the second nesting site and 1600 nests were counted at the third nesting site located towards the north-eastern end of the island.

Peak breeding season for Green turtles is from March to May but existence of freshly established nests in the study area suggested that females lay eggs throughout the year. Minton (1966) observed hatchlings from July to October with

the greater number during September and early October. However, during the present study, 1745 nests were counted at three nesting places along the sandy beach of the island during mid-February. Seventeen Green turtles were found that laid eggs during the present study. This suggets that during peak breeding season turtle nesting might be even greater. GPS coordinates for the turtle nesting sites and top plain habitats of reptiles are given in Map-4.

3.3.2 Analysis and Discussion

The island is characterized by different types of habitats including sandy beaches, which provide nesting areas for marine turtles; stony and rocky areas along western side of the island, which do not support any reptilian or amphibian species; plain area on top of the island supporting some agamid and lacertid lizards and the unique snake species of the island, the saw-scaled viper (*Echis carinatus astolae*).

Nesting and egg laying by thousands of green turtles each year at the sandy beach makes the island a unique breeding ground for green turtles.The existence of an endemic snake species on the island adds to the importance of the island.

The environment of this marine protected area is ideal for reptilian species but continuously increasing tourist activities and regular fishing practices by local fishermen may change the scenario and put the endemic and globally important reptilian elements at risk. Minton (1966) reported Olive Ridley turtles but no evidence of this turtle was recorded during recent studies. This shows the continuously increasing anthropogenic activities at the island.

Species Account

Echis carinatus astolae Mertens, 1969 (Dark-Blotched Saw-scaled Viper)

This subspecies of Saw-scaled Viper was reported for the first time by Mertens (1969) from Astola Island. This snake belongs to the family Viperidae that includes all deadly poisonous snakes. This subspecies; *Echis carinatus astolae* is also endemic to Astola Island and hence a key species for conservation point of view. Dorsum is whitish; dorsal patterns of dark brown blotches with 1-3 lateral longitudinal rows of dark brown spots. Head is broad and distinct from neck with small keeled scales. Head has 3 pronged light mark directed towards snout. A light stripe emerges from temporal region on each side which converge at frontal region and giving a branch to snout. This endemic species is more vulnerable to extinction as this does not exist anywhere else. During the study, one live specimen was observed and the molted skin of the snake was found at two different locations which also confirmed its existence in the study area.

Chelonia mydas (Linnaeus, 1758) Green SeaTurtle

This species of marine turtles belongs to the family Cheloniidae. It is a tropical species that concentrate around sandy beaches along islands and continental coasts. The nesting female excavates a deep pit on a sandy beach and lays her eggs at night. Clutch size varies from 9 to 173 eggs, diameter of eggs range from 41 to 52 mm. Hatchlings appear after 22 to 166 days depending upon the temperature of the nest (Das, 1991). The juveniles are carnivorous whereas adults are herbivorous feeding upon marine vegetation of different types. Carapace is oval in appearance, shell naked, dorsal shields juxtaposed, marginals sloping and vertebrals greater in width than length. There is a single pair of pre-frontals, 4 post-oculars, 25 marginals, 4 infra-marginals and 4 pairs of coastal. Limbs are modified into paddle-shaped flippers, with large scales, digits not distinct, a single claw in adults and 2 in young turtles. This species is sexually dimorphic with the males being comparatively smaller. Carapace length is 70 to 140 cm, weight is about 155 kg and it is olive or brown in color (Khan, 2006).

3.4 Marine Fish

The Pakistani coast extends approximately 1000 km, 320 km over the Sindh and rest extends toward the Balochistan coastline. The Exclusive Economic Zone (EEZ) extends to 200 nautical miles outwards to sea from the coast covers 240,000 km2 of the Arabian Sea.

The Balochistan coast, which includes Astola Island, provides ample resources of fisheries. Astola Island fishing is overall connected with the Pasni fish harbor. Most boats are registered in Pasni that were operational around Astola Island and a few come from Sindh. There is no certain statistical data available about fishing activities along Astola Island.

The previous diversity of fishes was reported by Pirzda Jamal Siddiqui and Shabir Ali Amir (2011). They were reported 75 species during their survey report in January 2011. Now this survey was done in December 2017 and identification was done by FAO (species identification guide for fishery purposes, 2015).

3.4.1 Results of the Survey

Small wooden fishing boats carrying 15 to 20 men known as *hora* are used for fishing. Multi monofilament and gill nets are used to fish. The types of fish species observed during the present survey are listed in Table-8.

3.4.2 Analysis and Discussion

Discussions were held between local fishermen who have been fishing for the last 30 to 40 years. According to fishermen, the situation of fisheries stocks 20 years ago (approximately 1997) was good. They could make one trip in 8-12 hours. Now the situation has totally changed and they spend 2-3 days out fishing. The fish catches have declined and sometimes catches are so low that the fishing communities are not able to recover the costs of the fishing trip. This situation has enhanced poverty amongst local fisher people who now live hand to mouth.

Table 8: Fish species at Astola Island				
S.No	**Scientific Name**	**English Name**	**Family Name**	**Local Name**
1	*Otolithes ruber*	Tigertooth croacker	Scinidae	Mushka
2	*Argyrosomus heinii*	Arabian Sea meager	Scinidae	Soli
3	*Rastrelliger kanagurta*	Indian mackerel	Scombridae	Bangra or Seem
4	*Scomberomorus guttatus*	Indo Pacific king mackerel	Scombridae	Surmai, kalgan
5	*Scarus zufar*	Dhofar parrotfish	Scaridae	Tota
6	*Sardinella longiceps*	Indian oil sardine	Clupeidae	Luar
7	*Epinephalus stoliczkae*	Epaulet grouper	Serranidae	Chuni
8	Scomberoides tala	Barred queen fish	Carangidae	Saram and Aal
9	*Panulirus polyphagus*	Mud spiny lobster	Palinuridae	Kikat
10	*Portunus sanguinolentus*	Three spot swimming crab	Portunudae	Tiki kakra
11	*Alectis indicus*	Indian threadfish	Carrandidea	Ushtar
12	*Alepes djedoba*	Shrimp scad	Carrandidea	Bakoi
13	*Cynoglossus puncticeps*	Speckled tonguesole	Cynoglossidea	Kukker jib or Sole
14	*Cynoglossus bilineatus*	Fourlined tonguesole	Cynoglossidae	Chah-ail
15	*Cynoglossus arel*	Largescale tonguesole	Cynoglossidae	Kukker jib (Sin)
16	*Scarus arabicus*	Arabian parrotfish	Scaridae	Tota machli
17	*Johnius dussumieri*	Sin croaker	Sciaenidae	Bora or Kangra
18	*Scomberomorus commerson*	Narrow-barred Spanish mackerel	Scombridae	Gore
19	*Lethrisnus nebulosus*	Nubnose emperors	Lethrinidae	Gadeer or Sin
20	*Leethrinus ramak*	Thumbprint emperor	Lethrinidae	Mullah
21	*Lutjanus fulviflamma*	Black spot snapper	Lutjanidae	Hira
22	*Lutjanus johnii*	John's snapper	Lutjanidae	Kanalcha
23	*Mugil cephalus*	Flathead grey mullet	Mugilidae	Phal or Boi
24	*Acanthopagrusberda*	Goldsilk seabream	Sparidae	Dandia
25	*Negaprion acutidens*	Sicklefin lemon shark	Carcharhinidae	Ham or Jagri
26	*Chelon parsia*	Gold-spot mullet	Mugilidae	Chowdi
27	*Scomberoides commersonnianus*	Talang queenfish	Carangidae	Aal

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3.5 Cetaceans

The order Cetacea includes whales, dolphins and porpoises, who evolved approximately 50 million years ago from terrestrial animals to an aquatic mode of life (Gingerich *et al*., 2001; Reeves *et al*., 2002). This order comprises two sub-orders: Mysticeti (baleen whales) and Odontoceti (toothed whales) and are thought to be descendants of archaeoceti (an extinct sub-order). There are at least 89 known species of cetaceans recognized to date (after the classification by Rice, 1998; IWC, 2001; Mead and Brownell, 2005) in the world's oceans, seas and rivers. The suborder Odontoceti is larger and more diverse than the mysticeti. Mysticetes are filter feeders which feed on plankton, other tiny organisms and fish as well, while, odontocetes mainly feed on fish, squid, and crustaceans. The larger species also eat aquatic birds and mammals, including their own kind (Bowen, 1997; Nowak, 1999). Thus, cetaceans play a key role in ensuring the stability and health of their ecosystem as consumers. Cetaceans are also important for entertainment and tourist industries: whale and dolphin watching ecotourism is becoming increasingly popular in many parts of the world and earning huge amounts of revenue (Hoyt, 1995 and 2001). Countries that have well preserved cetaceans earn a large amount of money by whale and dolphin watching.

Marine mammal population is, however, declining worldwide due to accidental entanglements, degradation of habitats, pollution and targeted hunting in localized areas of the world. Indian Ocean Sanctuary (IOS) was established by the International Whaling Commission in 1979 to conserve large whales although no such provision was made available for small cetaceans (i.e. dolphins and porpoises). Pakistan is part of the Indian Ocean Sanctuary for whales. Research on cetaceans has developed considerably in last decade. Recent studies by Cetacean Conservation Pakistan Project (CCP) and some localized small scale projects indicate that significant previously unstudied populations of around 20 species of whales and dolphins occur within the Pakistani Exclusive Economic Zone (EEZ) in the North East Indian Ocean.

3.5.1 Results of the Survey

Only 01 boat based survey was completed on December 2017 during daylight hours. No live sighting of cetaceans was recorded during the survey. Data on location, time of day, heading, boat speed, sea state and swell were recorded every 10 minutes. Information on types of marine birds and marine traffic was also recorded as ancillary data on same datasheet. The general boat survey information is given in Table 9.

3.5.2 Analysis and Discussion

Not much information could be collected on large whales and offshore species in this study due to time limitations. Therefore, comprehensive surveys in offshore areas of Astola Island are required to get as much information on these as possible, particularly the endangered Arabian Sea humpback whale. More work can be accomplished if strong, purposeful and consistent collaborations are established between different indigenous departments working on wildlife in general and marine environment in particular.

However, the baseline information provides a useful reference based on which a comprehensive study on key cetacean distribution areas around the island can be designed in future. Fine scale studies are needed in which real time environmental data including information about depth, slope, sea-surface temperature SST, salinity, turbidity and chlorophyll-A should be collected to understand the habitat preferences of local marine cetaceans and sea turtles. Collection and analyses of phytoplankton and zooplankton samples can provide useful information on the status of local habitats. Spatial and temporal distribution, relative/absolute abundance and data about prey availability will be required to produce an efficient conservation strategy for marine cetaceans around Astola Island.

Table 9: General boat survey results

No. of surveys	Survey hours	Total effort distance (km)	No. of sighting	Cumulative no. of dolphins seen	No. of sightings/hour	No. of dolphins/hour
01	05	39.4	0	0	0	0

Table 10: Cetacean species reported through Indirect Methods of Survey

S. No.	Species	Scientific Name	IUCN Red List Status
1	Indo-Pacific finless porpoise	*Neophocaena phocaenoides*	Vulnerable
2	Bottlenose dolphin	*Tursiops spp. i.e. Tursiops aduncus/ Tursiops truncates*	Data Deficient/ Least Concerned
3	Risso's dolphin	*Grampus griseus*	Least Concerned
4	Killer whale	*Orcinus orca*	Data Deficient
5	Arabian sea humpback whale	*Megaptera novaeangliae*	Endangered

3.6 Small Mammals

Small mammals are well represented in Pakistan which has 118 species making up nearly 65% of the total mammalian fauna of the country. Being non-game wildlife, the small mammals have received very little attention. However, they form an indispensable component of the fauna of any ecosystem. Small mammals play an important role in determining the holding capacity and maintaining the number of animals in the higher trophic level of an ecosystem. The rodents, insectivores, bats, mongooses and pikas not only maintain ecological balance in the interlocking system of nature but also play a specific role in a self-sustained ecosystem. These small animals have a variety of feeding habits and depend upon the submerged roots, fallen seeds, rhizomes, bulbs, insects, snakes, scorpions, spiders and beetles for food. They are in turn eaten up by large carnivores like foxes, wolves, jackals, cats and raptors like eagles, falcons and owls. Unless better data on the small mammals is available, it is not possible to determine the status of the carnivores in an ecosystem.

The small mammals are usually nocturnal, frequently fossorial (burrowing) and always difficult to observe and therefore, their importance and even their existence remains obscure for an ordinary person in spite of the fact that they are most important and essential component of the ecosystem. The mainstream knowledge about the small mammals of Pakistan is mainly restricted with the species considered agricultural pests.

A voluminous literature on the small mammals of Pakistan has been published over the years (1990; Ellerman, 1961; Roberts, 1977, 1997, 2006). Most of the work is concise on small mammals of agricultural importance or the species found in the southern areas, having affinities with west or south Asia.

No literature is available on the distribution and status of small mammals of coastal areas of Pakistan, especially Ormara, although some work has been published previously on the individual species by Arshad, 1991; Phillips, 1969; and Rossolimo, 1989. The data of these species

mainly depends on surveys of the study sites but the information on different aspects was also been obtained from previously published literature by Siddiqi (1961), Mirza (1969), Roberts (1977, 1997). Taxonomy of many species of small mammals has been changed in the past decades. In the present report, these changes are reviewed following Corbet and Hill (1992), Hoffmann (1996) and Wilson and Reeder (1992, 2005).

3.6.1 Results of the Survey

3.6.1.1 Mammal species observed in the study area

Based on direct and indirect observation methods, three species of small mammals belonging to the order Rodentia and family Muridae were recorded in Table-11.

All the recorded small mammals were observed directly in the daytime as well as during nighttime using spot lights. The recorded species were also trapped using folding Sherman traps. There is no direct or indirect indication observed for the presence of any other species of small mammals at the island.

3.6.2 Analysis and Discussion

Mice and rats have become invasive species on islands to which they have spread during the period of colonization (King, 1995). They likely got access to Astola Island through the boats of local fishermen. Leftover food and food wastes of the fishermen and visitors is also supportive to this household pest here on Astola Island.

House mice are responsible for a reduction in native bird species since they eat the same foods as birds. They are also known to kill lizards and have a large effect on native insects (King, 1995): however, the house mouse is not a prohibited or restricted invasive animal under the Bio-security Act 2014. Gough Island, in the South Atlantic, is used by 20 species of seabirds for breeding, including almost all of the world's Tristan albatross (*Diomedea dabbenena*) and Atlantic petrel (*Pterodroma incerta*). Until house mice arrived on the island in the 19th century with sailors, the birds did not have any mammalian predators. The mice have since grown unusually large and have learned to attack albatross chicks, which can be nearly 1 m tall, but are largely immobile, by working in groups and gnawing on them until they bleed to death (Wanless *et al.* 2007).

Rattus rattus fed on seedlings, adversely affecting the ecology of the islands. Even after eradication of *R. rattus*, the negative effects may take decades to reverse. When consuming these seabirds and seabird eggs, these rats reduce the pH of the soil. This harms plant species by

Table 11: Small mammals found around Astola Island

#	Zoological Name	Common Name	Order	Family	Location on G.P.S	Status
1	*Mus musculus*	House mouse	Rodentia	Muridae	N 25 07 164 E 63 49 801	Common
2	*Ratus ratus*	House rat	Rodentia	Muridae	N 25 07 164 E 63 49 801	Common
3	*Tatera indica*	Indian gerbil	Rodentia	Muridae	N 25 07 168 E 63 49 900	Less Common

Table 12: Observation records of small mammals found around Astola Island

#	Zoological Name	Common Name	Direct Observation	Indirect Observations			
				Body Parts	Tracks	Burrows	Fecal Material
1	*Mus musculus*	House mouse	√	-	√	√	-
2	*Ratus ratus*	House rat	√	√	√	√	√
3	*Tatera indica*	Indian gerbil	√	√	√	√	√

reducing nutrient availability in soil, thus decreasing the probability of seed germination. For example, research conducted by Hoffman indicates a large impact on 16 indigenous plant species directly preyed on by *R. rattus*. These plants displayed a negative correlation in germination and growth in the presence of black rats (Grant-Hoffman *et al*. 2009). Rats prefer to forage in forest habitats. In the Ogasawara islands, they prey on the indigenous snails and seedlings. Snails that inhabit the leaf litter of these islands showed a significant decline in population alongside the introduction of *Rattus rattus*. The black rat shows a preference for snails with larger shells (greater than 10 mm), and this led to a great decline in the population of snails with larger shells. A lack of prey refuges makes it more difficult for the snail to avoid the rat (Chiba, 2010).

The black rat is a complex pest, defined as one that influences the environment. In many cases, after the black rat is introduced into a new area, the population size of some native species declines or the species goes extinct. This is because the black rat is a good generalist with a wide dietary niche and a preference for complex habitats.This causes strong competition for resources among small animals. This has led to the black rat completely displacing many native species in Madagascar, the Galapagos, and the Florida Keys. In a study by Stokes *et. al*., habitats suitable for the native bush rat, *Rattus fuscipes*, of Australia, are often invaded by the black rat and are eventually occupied by only the black rat. When the abundance of these two rat species were compared in different micro-habitats, both were found to be affected by micro-habitat disturbances, but the black rat was most abundant in areas of high disturbance: this indicates it has better dispersal ability (Vernes & Mcgrath 2009). Preliminary studies indicated that marshes are preferred over other coastal habitats (Wolfe, 1985).

The *Tatera indica* consume large quantities of insects which are potential agricultural pests. These animals feed on seeds, sprouts, mature plants, ears of corn, and saplings in orchards (Kumar, *et. al*. 1997). They significantly impact populations of plants and arthropods throughout their range. They also serve as an important prey base for birds of prey and other small to medium-sized predators. Their burrowing activities aid in soil turnover and the re-distribution of soil nutrients.

Species Account

House Rat *(Ratus ratus)*

This is the most common type of rat species found in Pakistan. Quite variable in color overall, populations found in Pakistan are grayish brown dorsally and creamy in color ventrally. Average size of the adults varies from 16 to 17 cm with around 20 cm long tails. Their average weight is 165 gms. This species is commonly found around human habitations and is considered a serious pest of stored grains as well as a vector of human diseases through its contamination of grain stocks. It is an omnivorous rat and being an excellent climber, can exploit a number of habitats. Females are capable of breeding when they are 12 weeks old and produce 6 to 7 liters per year with up to 14 young per litter (Roberts, 2006).

According to the IUCN Red List of Threatened Species (IUCN 2011) and IUCN Red List of Pakistan Mammals (Sheikh and Molur, 2005), all the recorded species from Astola Island have been categorized as of least concern (LC). All three species have stable population trends. None of the recorded two species is protected in Balochistan i.e. not included in 2nd or 3rd Schedule under the Balochistan Wildlife Preservation Act 1975 (Shafiq, 2005).

The population of the house rat (*Ratus ratus*) is now posing a threat to the endangered Green turtle (*Chelonia mydas*) nesting along the sandy beaches of Astola Island. Therefore the house rat (*Ratus ratus*) can be considered as a species of special concern as it is damaging the virgin habitat of Astola Island.


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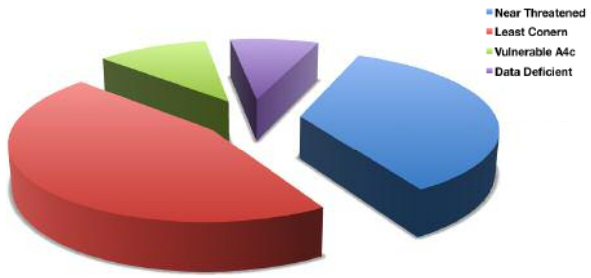
3.7 Corals

Corals are a diverse group of organisms belonging to the Phylum *Cnidaria*. At Astola Island, the hard corals are common. Though no true coral reefs have been found in Pakistan, there is evidence of a proto-reef (a reef in its early stages of formation) at Astola Island (Ali *et. al*., 2014). There are different forms of corals i.e. Antipatharia, Scleractinia, hydrocorals and Octocorallia. Corals are an important source of species diversity because they structure complex habitats. They serve as a home for a great number of fish species (Freiwald *et. al*., 2002; Stocks, 2004; Veron *et. al*.", 2009). The offshore islands are considered hot biodiversity spots while uplifted strata especially along the Balochistan coast have rich fossil coral diversity.

3.7.1 Results of the Survey

In the present study, 11 species of hard corals belonging to 5 families and 7 genera were recorded (Table 13). Diving was done at two potential sites with two different depths with GPS Coordinates at 3 meters (N 25 07.493 E 63 50.479) and at 4 meters (N 25 07.555 E 63 50.556). No significant differences were noted in physical parameters at either diving site. Comparison to the previous study, conducted by Ali *et. al*. (2014), shows a marked reduction in coral cover. Fragile colonies have been damaged on a large scale. The reduction in coral cover was mainly due to careless recreational SCUBA and skin diving. Colonies have been uprooted on a large scale. The other factors, for example,. different types of pollution, are also responsible for the decrease in coral cover. Studies have proved that careless tourism is a major cause of

Figure 2: Diversity of corals with conservation status.



reef destruction (Salvat 1987; Prior *et. al*., 1995). Although tourism is a source of income for the local community, there should be some guidelines for tourists.

3.7.2 Analysis and Discussion

Increasing anthropogenic activities (diving, fishing, boat anchorage, fish dumping) at the island are the main reason of the declining coral cover. Studies have proved that careless tourism is a major cause of reef destruction (Salvat 1987; Prior *et. al*., 1995). To understand the effects in depth, further studies are recommended.

Table 13: List of hard corals recorded from 2 sites of the Astola Island

S #	Hard coral species	Family	Conservation Status	Astola Island	
				Diving Site=1 Depth= 3 M	Diving Site=2 Depth= 4 M
1	*Favite scomplanata*	Faviidae	Near threatened	10	
2	*Favitespentagona*	Faviidae	Least concern	9	
3	*Favitesspinosa*	Faviidae	Vulnerable A4c	4	
4	*Plesiastreaversipora*	Faviidae	Least concern	2	
5	*Poritesharrisoni*	Poritidae	Near threatened	11	8
6	*Poritesnodifera*	Poritidae	Least concern	10	2
7	*Porites lobata*	Poritidae	Near threatened	6	
8	*Coscinaraeamonile*	Siderastreidae	Least concern	8	
9	*Psammocora albopicta*	Siderastreidae	Data deficient	2	
10	*Acanthastreahillae*	Mussidae	Near threatened	3	
11	*Pocilloporadamicornis*	Pocilloporidae	Least concern	20	

3.8 Vegetation

A majority of the species of Astola Island are small shrubs and perennial herbs. The largest shrub reported in the sand dunes near the beach was *Prosopis juliflora* which was accidently introduced in this pristine area. On the other hand, at the promontory of Astola, the majority of species are perennial herbs with scattered populations of large bushy shrub *Cadaba farinosa ssp rariflora*. New plant species are also thriving. For instance, we identified more than ten species which had previously been unknown to the island.

To our knowledge this was the first phytosociological survey of vegetation at Astola Island. A thorough study, based on molecular biology of these plants, is needed which may help our understanding the evolutionary processes more precisely.

Dr. D. Khan was the first to conduct a phytosociological survey of vegetation on the Makran coast in 1989. However, during his survey, which extended from Karachi to Jiwani, he missed Astola Island. In 1992, a multidisciplinary group of international scientists from France and Italy surveyed different aspects of the Makran region including archaeology, history, paleobotany and paleozoology along with a floral survey of the Makran coast. Results obtained from this published in the form of an exhaustive research paper by Leporatti and Lattanzi (1999).

3.8.1 Results of the Survey

Based on phytosociological and reconnaissance surveys of vegetation of Astola Island, 30 plant species were listed on top of the hill as well as on the seashore. Majority of the species are distributed on the top of the tip compared with narrow strip of sea-shore where only *Anabasis setllera, Suaeda fruticosa, Prosopis juliflora*, *Urochondra setulosa* and the parasitic plant *Cistanche tubulosa* were recorded. Interestingly, excluding *Anabasis setllera,* none of these species are found at the top of the hill. These plants were categorized into twenty-one main families of which one belonged to Gymnosperm, one monocot and nineteen dicotyledonous

groups of angiosperms. Poaceae and Amaranthaceae are the major families which are represented by three species each while majority of the families are represented by single species or occasionally by two species.

Based on longevity it is observed that majority of the plants were annual (33.33%), compared with soft wood herbs (23.33%), small shrubs (26.66%) and large shrubs (16.66%). The presence of a large number of annuals, particularly during second survey carried out in February 2018, was mainly due to the onset of winter showers that had taken place 30 days prior to the survey. Astola Island normally receives precipitation during the winter: this was one of the main reasons that during the survey the majority of plant species were blooming and producing fruits and seeds. When we compare these plant species on the basis of lifeform classes it is observed that the majority of them are Chamaephyte (33.33%), followed by Therophyte (26.66%), and Phanerophyte (23.33%).

The results of the phytosociological attributes are mentioned in Table 15. *Anabasis setllera* is one of the most dominant plant species on this island which was found on the top of the hill as well as on a narrow strip of shoreline. *A. setllera*is one of the only species found in all ten stands and showed on average the highest importance value index (I. V.I.) of 49.86. This is mostly because this species is a halophyte which can tolerate the higher saline environmental condition. The presence of *A. setllera* is raising some questions if we compare it with *Suaeda fruticosa*, also one of the true halophytes and belonging to the same Chenopodiaceae family found only on the seashore. It was completely absent from the top of the hill. One of the reasons for this might be the later coming of *S. fruticosa* to Astola island compared with *A. setllera* which is one of the oldest residents. However, this puzzle becomes more complicated if we keep in mind the early phytosociological reports of the Makran coast. For instance, Khan (1987) reported that, unlike *S. fruticosa, A. setllera* is a new addition to the list of coastal flora.

Lycium edgeworthii is the second largest species found on the shoreline as well as on the top of the hill. However, on the shoreline this species is found in a totally dry condition compared with that on the hill. One of the interesting features of this species is that it exhibits heterogeneity in foliage morphology i.e., the leaves on the lower branches are comparatively larger and broader compared with those at the tip of lateral branches. However, based on size and at a glance, when an immature nature lover reaches the top of the hill it is not *Lycium edgeworthii* which attracts his/her attention; rather it is *Cadaba farinosa* subspecies *rariflora,* which seems to be the dominant species filling the empty patches of the horizon. However, *Cadaba farinose,* subspecies *rariflora*, though found in seven stands, became dominant first only in one stand and second dominant in three stands.

Interestingly *Pentatropis spiralis*, a perennial climber, which carpeted the ground as well as climbing the neighbouring shrubs also exhibit its dominance at the top of hill and found in all stands of the top of the mountain with an average of 27.07 of total I.V.I. values. The presence of unmolested creeping plant species at the top of the hill are clear evidence that the natural vegetation of Astola Island is still safe

Figure 3: Longevity of plant species

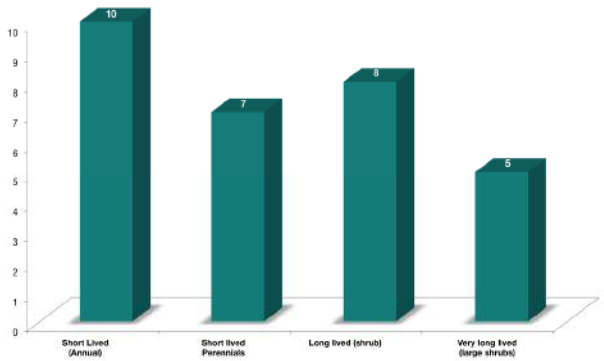


Figure 4: Life Forms of plant species

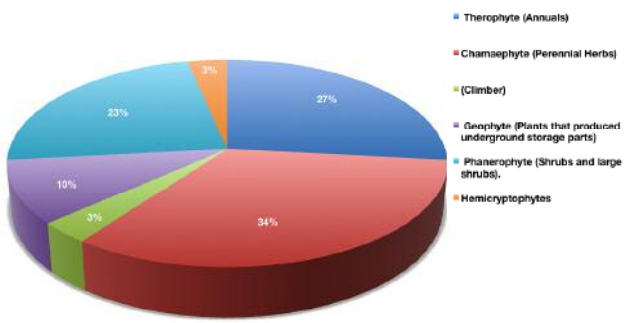


Table 14: List of plant species with family, longevity and life-form as recorded at Astola				
#	Species Name	Family	Longevity*	Life Form**
1	*Anabasis setllera*	Chenopodiaceae	SLP	CH
2	*Cadaba farinosa ssp rariflora*	Capparidaceae	LL	PH
3	*Pentatropis spiralis*	Asclepiadaceae	VLL	CL
4	*Lycium edgeworthii*	Solanaceae	VLL	PH
5	*Launaea procumbens*	Astraceae	SL	CH
6	*Zaleya pentandra*	Aizoaceae	SLP	CH
7	*Suaeda fruticosa*	Chenopodiaceae	LL	CH
8	*Convolvulus glomeratus*	Convolvulaceae	SLP	CH
9	*Ephedra foliate*	Ephedraceae	VLL	PH (Gymnosperm)
10	*Medicago laciniata var brachycantha*	Papilionaceae	SL	TH
11	*Prosopis juliflora*	Mimosaceae	VLL	PH
12	*Cassia italic ssp micrantha*	Caesalpinaceae	LL	CH
13	*Sida asp.*	Malvaceae	SLP	CH
14	*Senecio glaucus ssp coronopifolius*	Astraceae	SL	TH
15	*Dactyloctaenium aegyptium*	Poaceae	SL	TH
16	*Pennisetum divisum*	Poaceae	LL	GE
17	*Abutilon fruticosum var. fruticosum*	Malvaceae	SLP	CH
18	*Tribulus terrestris*	Zygophyllaceae	SLP	HE
19	*Convolvulus pentapetaloides*	Convolvulaceae	SL	TH
20	*Oligomeris linifolia*	Resedaceae	SL	TH
21	*Atriplex leucoclada*	Chenopodiaceae	SLP	CH
22	*Salvadora persica*	Salvadoraceae	LL	PH
23	*Aizoon canariense*	Aizoaceae	SL	TH
24	*Spergularia diandra*	Caryophyllaceae	SL	TH
25	*Commicarpus stenocarpus*	Nyctaginaceae	LL	CH
26	*Salvadora oleoides*	Salvadoraceae	LL	PH
27	Amaranthus hybridus	Amaranthaceae	SL	TH
28	*Tamarix sp*	Tamaricaceae	VLL	PH
29	*Urochondra setulosa*	Poaceae	LL	GE
30	*Cistanche tubulosa*	Orobanchaceae	SL	GE (Parasite)

* = SL = Short Lived (Annual); SLP = Short lived Perennials; LL = Long lived (shrub); VLL = Very long lived (large shrubs)

** = TH = Therophyte (Annuals); CH = Chamaephyte (Perennial Herbs); CL = (Climber); GE = Geophyte (Plants that produced underground storage parts); PH = Phanerophyte (Shrubs and large shrubs); HE = Hemicryptophytes (the vegetative part half hidden).

Table 15: Phytosociological survey of vegetation at Astola Island						
#	Species name	Presence in number of stands (total 10)	# of stands in which it appears 1st dominant	# of stands in which it appears 2nd dominant	# of stands in which it appears 3rd dominant	Average IVI**
1	*Anabasis setllera*	10	3	3	–	49.86
2	*Cadaba farinose ssp rariflora*	7	1	3	–	35.22
3	*Pentatropis spiralis*	9	1	2	1	27.07
4	*Lycium edgeworthii*	9	1	1	1	35.80
5	*Launaea procumbens*	6	–	–	3	18.96
6	*Zaleya pentandra*	7	1	–	1	17.45
7	*Suaeda fruticosa*	1	1	–	–	13.61
8	*Convolvulus glomeratus*	1	1	–	–	5.17
9	*Ephedra foliate*	1	1	–	–	7.75
10	*Medicago laciniata var brachycantha*	8	–	1	1	15.68
11	*Prosopis juliflora*	1	–	–	1	3.94
12	*Cassia italic ssp micrantha*	1	–	1	–	3.69
13	*Sida sp.*	1	–	–	1	3.47
14	*Senecio glaucus ssp coronopifolius*	5	–	–	–	10.31
15	*Dactyloctaenium aegyptium*	5	–	–	–	8.95
16	*Pennisetum divisum*	4	–	–	–	6.02
17	*Abutilon fruticosum var. fruticosum*	3	–	–	–	5.53
18	*Tribulus terrestris*	3	–	–	–	5.25
19	*Convolvulus pentapetaloides*	4	–	–	–	4.47
20	*Oligomeris linifolia*	3	–	–	–	2.91
21	*Atriplex leucoclada*	3	–	–	–	2.70
22	*Salvadora persica*	1	–	–	–	2.48
23	*Aizoon canariense*	2	–	–	–	1.96
24	*Spergularia diandra*	2	–	–	–	1.92
25	*Commicarpus stenocarpus*	1	–	–	–	1.52
26	*Salvadora oleoides*	1	–	–	–	1.45
27	*Amaranthus hybridus*	1	–	–	–	1.25
28	*Tamarix sp*	1	–	–	–	1.22
29	*Urochondra setulosa*	1	–	–	–	0.94
30	*Cistanche tubulosa*	1	–	–	–	0.89

* = The numbers of dominant are based on ten sampling stands.

** = The average I.V.I. value is the summation of individual Importance Value Index divided by ten sampling stands.

from anthropogenic interference. Another interesting feature is the presence of *Ephedra foliata* on the northeast cliff of the island. This species is only found on that particular spot and was not listed by Leporatti and Lattanzi (1999), who surveyed the island during the earlier years of the last decade of the previous century.

In general, no endemic plant species were observed at Astola. For the first time, *Anabasis setllera* and *Convolvulus pentapetaloides* have been reported from the island. The rare species included *Aizoon canariense, Spergularia diandra, Commicarpus stenocarpus, Amaranthus hybridus, Cistanche tubulosa,* and *Tamarix sp.*

3.8.2 Analysis and Discussion

From a floristic composition perspective, Astola Island is an ideal place for studying the evolutionary process particularly in plant species because plants are non-mobile and have the potential to evolve in this desolate place and eventually adapt to it. However, the evolutionary processes in these plant species are facing threats from anthropogenic interferences.

For example, these shrubby plants are seen near the tomb where devotees from the nearby coastal town of Pasni come to pay their respects to the saint annually and they also bring sacrificial goats and cattle. These sacrificial animals mostly feed on legumes of *P. juliflora* and it is likely that these plants grew due to the faeces of these animals. Another possibility is that these plants were deliberately planted by fishermen who use this island as their resting place, and due to lack of shelter, these plants were grown. In our opinion, the presence of *P. juliflora* should be taken seriously because, unlike the already mentioned plant species, this plant is opportunistic, highly competitive, aggressive in nature and has the potential to outnumber well adopted plant species. Fortunately, *P. juliflora* only grows in an area where it is disturbed due to anthropogenic activities. However, this plant species cannot compete with well adapted and undisturbed local vegetation. At the time of the writing of this report, *P. juliflora* did not show any real threat to these plant species but in near future when anthropogenic interferences on Astola Island accelerate, there is a possibility that this species will outnumber the already evolving plant species.

New Species Reported from Astola Island

The above listed plant species were recorded by Maria Lucia Leporatti and Edda Lattanzi during their 1992 survey of floristic composition of Makran division, however, during recent survey the following new species were found at Astola Island which were not reported in previous survey.

Prosopis juliflora (Swartz) DC.
One of the notorious shrubby species of mainland as well as coastal area of Makran, belongs to family Mimosaceae. During our recent survey, there were five small shrubby plants were recorded near the tomb of *Khawaja Khizar* on sand dune area of island. These plants were not mentioned in Leporatti and Lattanzi (1999) comprehensive report, therefore they are listed as newly arrivals on the island which means they are not older than 25 years. One of main reasons of their migration to the island is through anthropogenic activities.

Suaeda fruticosa (L.) Forssk. ex J. F. Gmelin
It is a halophyte which is commonly found in alkaline and sodic soil of both coastal as well as mainland areas. It belongs to family Chenopodiaceae and a perennial herb.

Cistanche tubulosa (Schenk) R. Write
It is a parasitic plant which belongs to family Orobanchaceae. It is only found underneath of *Suaeda fruticose* plants on sand dunes area near tomb of *Khawaja Khizar* as well as on Turtle Beach. The morphological characteristics of this parasitic plant are as follows: yellowish to yellow-brown, fleshy herb, (15-) 30-60 (-150) cm tall, often with a purplish tinge, simple, erect, glabrous to puberulous, often broader (up to 5 cm) at base. Scales (1-) 2-3 (-4) cm long, (7-) 10-15 (-20) mm broad, triangular to broadly linear, acute.

Other newly reported species are as follows:

- *Pentatropis spiralis*
- *Zaleya pentandra*
- *Ephedra foliata*
- *Tribulus terrestris*
- *Oligomeris linifolia*
- *Atriplex leucoclada*
- *Spergularia diandra*
- *Commicarpus stenocarpus*
- *Amaranthus hybridus*
- *Tamarix sp*
- *Urochondra setulosa*

3.9 Seaweed

Algae are organisms capable of preparing their own food material, like photoautotrophic plants, but differ from them by displaying a variety of other modes of nutrition such as photolithotrophy, photo-organotrophy, chemotrophy, mixotrophy, phagotrophy, amphitrophy *etc.* They further differ from plants by lacking sterile layer of jacket-cells around their sexual and asexual reproductive organs and do not exhibit true embryogenesis (Shameel and Tanaka, 1992; Shameel, 2003). Algae are distributed in three kingdoms and nineteen phyla as they are remarkably different from plants and have their own entity. The names of algal phyla include Cyanophycota and Prochlorophycota among the kingdom Monera; Glaucophycota, Volvophycota, Euglenophycota, Dinophycota, Cryptophycota, Chrysophycota, Prymnesiophycota, Bacillariophycota, Xanthophycota, Eustigmophycota, Raphidophycota, Porphyridiophycota among kingdom Protista; Cholorophycota, Charophycota, Vaucheriophycota, Phaeophycota and Rhodophycota among kingdom Phycota have been characterized by Shameel (2012). They have extensively studied for their fatty acid composition (Valeem and Shameel, 2005a,b; 2006a,b; 2007a,b; 2008a,b,c; 2009a,b). Algae entangled in the nets of fishermen are known as seaweed, plant-like marine organisms attached to a hard or rocky substrate and are well known for their economic, medicinal, biological and environmental significance (Rizvi and Shameel, 2003; Valeem and Shameel, 2005a; Diaz-Pulido and McCook 2008; Chopin and Sawhney, 2009; El Gamal, 2010; Kilinc *et al.,* 2013). Seaweed are mainly classified into six main groups *i.e.* Cyanophycota (blue-green micro algae), Chlorophycota (grass green algae), Vaucheriophycota (yellow brown algae), Phaeophycota (brown algae), Porphyridiophycota (red micro algae) and Rhodophycota (red macro algae) but common macro algae are also known as seaweed (Shameel, 2001, 2008, 2012). The colours of the seaweed are mainly due to the presence of chlorophyll type, ß-carotene, fucoxanthin, phycoerythrin and phycocyanin. Seaweed play an important role in maintaining the food web as they are the primary producers (Adey, 1998). Seaweed beds are considered an

important nursery and feeding grounds for invertebrate and vertebrate fauna due to habitat complexity, shelter and abundant food supply (Levin and Hay 1996; Epifanio *et al.*, 2003; Okuda, 2008; Win, 2010).

Seaweed are important indicators of biodiversity changes either natural or manmade (Chopin and Sawhney, 2009). They are also regarded as an important carbon sink. The ratio of carbon dioxide absorbed by marine plants is higher than terrestrial plants (Adam *et al.,* 1998; Sinha, 2008). On a global scale, seaweed are used to make cosmetics, as animal fodder, to make human food, and seaweed extracts as used as alginates, medicines, fertilizers, agar and carrageenans (Chapman, 1980; Chopin and Sawhney, 2009; Rizvi and Valeem, 2012, Selvam and Sivakumar, 2014). A sustainable use of seaweeds can provide alternative livelihoods for coastal communities (Rebours, 2014).

Zooplankton samples were collected on four cruises with *PNS Zulfiquar* with the IIOE net, except for cruise 1 in which a smaller standard net 13 with a 30 cm mouth diameter was employed (Haq *et al.,* 1973). Ahmad (1997) stated that natural stresses include high wave action, high temperatures and salinity, and seasonal spread of oxygen-poor waters that ascend from deeper depths. Man-made stresses include the lack of replenishing sands and water discharge from the Indus River that have contributed to accelerated beach erosion and increased turbidity. Marine fauna were studied by Kazmi and Kazmi (1998) and Khan and Ghalib (2006). With respect to a five-class evaluation system, results indicated that Jiwani, Miani Hor and Pasni-Astola Island are extremely attractive natural sites with very high landscape value (Ullah *et al.,* 2010).

3.9.1 Results of the Survey

Since the algae found at Astola Island were in the juvenile stage, we were unable to identify the species correctly, as identification of algal specimen is a complex process for which juvenile to adult stages of whole life cycle of a particular alga are required. Morphological and anatomical studies are part and parcel of studying the gametophytic and sporophytic generations. There is no regular or fixed alternation of generations in algae as found in higher plants. In the case of *Bryopsis* and Siphonales, there is an alternation of generations of one-celled haploid phase with diploid coenocyte or siphonous filament, which is supposed to be morphologically equivalent multicellular diplont or diploid generation. In the life cycle of certain Ulvaceae and Cladophoraceae, there is an alternative of many-celled haploid generation with a many-celled diploid generation. In such cases, the two alternating generations are morphologically identical, which is known as isomorphic, and cannot be distinguished from each other until the time of reproduction.

However, broadly predicting, we can say that there were two green seaweed (*Bryopsis* sp. and *Ulva* sp.) as well as brown seaweed (*Sargassum* sp.). These seaweed have started growing on boulders. If phycologists plan to stay on the island for a long time or scholars deputed for collection obtain samples on regular basis only then the phycologists will be able to identify the algae through the available standard literature.

3.9.2 Analysis and Discussion

Since we collected unidentified algae in their juvenile stage, discussion without having results is meaningless. It is apparent that when there are traces of green algae on nearby rocky shores in northeast monsoons, there is a likelihood of the occurrence of grown seaweeds during the southwest monsoon, which will be revealed in future surveys.

3.10 Socio-Economic

In this research study, the primary and secondary data were collected and analysed to determine socio-economic dependency of fishermen community on the natural resources of Astola Island. Local fishermen and authorities were consulted to document existing patterns for practices of communities dependent on natural resources of Astola's MPA. The role played by Government Departments like Maritime Security Agency (MSA), Pak Navy, Pakistan Coast Guards and local and international NGOs in natural resource management individually and in liaison with fishermen was also identified.

3.10.1 Result of the Survey

Information gathered in meetings with officials of different organisations is discussed in the following sections.

3.10.1.1 Socio-economic Dependency of Fishermen on the Natural Resources of Astola

Astola Island is inaccessible in June and July, since the sea becomes rough and fishing activity seizes.

The age distribution among the fishermen is variable. Most of them are adults which includes a few elderly ones as well. There are a couple of children engaged in fishing activities who usually work with their elder brothers or fathers. The estimated ages of about 35 fishermen resident on the island was also noted (maximum age = 50, minimum = 15).

All fishermen invest most of their time in fishing activities which start from early in the morning. In their free time, they get together to have general gatherings or play cards in their huts. The children also take part in fishing activities with their elders and unfortunately do not have any opportunity for recreational activities like playing sports/games on the island.

At the time of survey, there were 22 boats in the sea near the northern shore of Astola and on the shore, fishermen from one boat were living in a wooden hut. Fishermen from fourteen (14) different boats were interviewed. These boats had come from Pasni, Ormara, Taak, Basol, Mubarak village and Karachi. Except the Sindhi fishermen living in the huts, all of the other fishermen interviewed were Bengali mostly came from Karachi.

3.10.1.2 Fishing Gear

The fishing boats in the area were of medium size and ranged from 18 to 40 feet. The average size

of boats was 25 feet. The major types of fishing gear used by fishermen were Plastic gill nets for sardine and Indian mackerel, Bottom set gill nets for lobster, fishing rods with 200-300 hooks, ring nets, nets and fishing guns. Four sample boats had one fishing rod for each fisherman. The average number of fishing rods for each sample boat was three. Below is a record of the numbers of fishing gear owned by the sample fishing boats and an estimate for all boats present at a time near Astola Island.

The fishing gillnets used by fishermen near Astola are around 250-300 feet in length and the length of ring nets ranges from 300 to 400 feet.

According to the sample, there are five fishermen per boat for lobster fisheries on average. Thus, at a time there are around 64 fishermen fishing in the sea near Astola. Every boat has a *Nakhuda* (also referred to as *Nakho,* person in-charge of the boat), a boat operator, a cook and *Bandari and Khalasi* (fishermen). Boat owners may give their boat to fishermen for fishing and hire a Nakhuda or he may himself work as a Nakho on the boat. In small boats Nakhuda also works as a boat operator.

The total fish catch and the net income is distributed between boat owner, Nakho, boat operator, cook and Khalasi. The system of division of net income is known as *Patti* system where one share is known as a Patti. Half of the net income (Gross Income – Expenses = Net Income) is given to the boat owner, the rest of the net income is divided amongst fishermen through Patti system. The share given to each is given in the Table 17.

A Nakho gets either 1.25 Patti or 2 Patti. If the Nakho is also operating the boat, his share would be 2 Patti and other crew members or fishermen get only one Patti.

Table 17: System of division of net income in a fishing trip

Designation	Share / Patti
Nakhuda/ Nakho	1.5 to 2
Boat perator	1
Cook	1
Khalasi	1
Boat engine	1
Gears	1

3.10.1.3 Income and Expense

Since most of the boats come from Karachi, the total expense of a trip is fairly high. The average net monthly income of a sample boat is Rs 69,556. Table 18 gives the total and average monthly expense and income for a boat.

A single boat on average contains 5 men (1 *Nakhuda,* 1 driver and 3 *Khalasi*). According to the Patti system the net income is distributed amongst all. The share that goes to each when Nakho and driver have 2 and 1.25 Pattis respectively is given below:

Share of owner:	Rs 34,778	or	(Rs 69,556 / 2)
Nakhuda:	Rs 13,911	or	{(Rs 34,778 / 5) *2}
Boat operator:	Rs 8,695	or	{(Rs 34,778 / 5) * 1.25}
Khalasi:	Rs 6,956	or	(Rs 34,778 / 5)

Thus, on average in a month, a Khalasi coming to Astola Island earns Rs 6,956.

3.10.1.4 Fish Production

Major fish species caught by fishermen are *dohtar*, *ghor* (Spanish mackerel), lobster, *aal*,

Table 16: Fishing gears used for fishing at a time near Astola

Fishing Gear	Sample Number		Estimated Number for all Boats
	Total	Average	
Fishing rods	29	3.2	42
Ring net	4	0.4	6
Pelagic gillnet	20	1.9	18
Bottom-set gillnet	16	1.8	16
Fishing gun	1	0.2	3

Table 18: Total and average monthly income and expense of sample boats

	Monthly Gross Income (Rs)	Monthly Expense (Rs)	Monthly net Income (Rs)
Total of sample boats	1,350,000	724,000	626,000
Average of sample boat	150,000	80,444	69,556

Table 19: Quantities of Fish, Lobster and Shells caught from Astola

Local Name	English Name	Fishing Months	Average Monthly Catch per Boat (kg)	Average Price (Rs/Kg)
Dohtar	Grimit	August to May	6,667	300 – 400
Aal	Leather jack	August to May	3,000	500 – 600
Kalancho (small size)	Grouper	August to May	2,042	350
Ghisr (large size)		September to November		250
Bangra	Indian mackerel	August to May	20,667	60 – 80
Gund	N/A	August to May	3,000	200
Lobster	Lobster	September to November & March to May	50 – 60	2,700
Sipian	Shells	August to May	2,479	40 – 100

kalancho (*ghisr*), *bangra* and *gund*. Apart from fish, fishermen collect seashells to sell in Pasni. According to some fishermen they are not allowed to catch lobsters as fishermen of Pasni do not let them. If any boat from Sindh is caught with lobsters, fishermen of Pasni take the whole catch without paying. Thus the Karachi fishermen sell fish catches in Pasni and seashells in Karachi.

The average fish catch of different species in a month by a boat is given in Table 19. The number of fish caught by a boat is variable and depends on the fishing season. For example, according to the information provided by fishermen *dohtar* is available from August to May, but increases in numbers from September to January.

On average, in a month, a boat catches 6,667 kg of *dohtar*. The price of fish highly varies with its size. Grouper fish of small size are known as *kalancho* and its price is Rs.350 per kg while large size Grouper known as *ghisr*by the locals is sold for Rs.250 per kg. *Gund* is a mixture of various types of fish which is sold as poultry feed. Around 3,000 kg of *gund* is caught by boats monthly. Lobster is more commonly found from September to November and from March to May.

On average, a boat collects around 2,479 kg of seashells. As seashells are available throughout the year, the number of seashells collected by 12 fishing boats in nine months are 267,732 kg (2,479*9*12). The price of shells varies with their size and colour. Larger shells are sold for around Rs 40 per kg while smaller shells are sold for Rs100 per kg. The price for some shells is:

Small white shell: >Rs 120 per kg
Big white shell: Rs 50 per kg
Small red shell: Rs 150 per kg
Big red shell: Rs 70 per kg

Fishermen also catch crabs and other types of fish such as *qud* (barracuda), *sanglo*, *heera* (snapper), *dawan* and *sourap* in small numbers.

3.10.1.5 Fuelwood Use

People living on the coast of Astola Island collect plants (shrubs and bushes) to use as fuelwood

for cooking and heating purposes. Fishermen staying in their boats anchor for short times at Astola and use methane gas in a cylinder for fuel. They usually use 10 to 15 kg methane gas per month. At the time of the field survey, five fishermen from one boat were living in one of the huts. According to the information provided by them, there are around 20 to 35 people living in the huts on the Coast of Astola Island from September to November and from March to May. The average yearly consumption of fuel wood by fishermen staying at Astola Island is around 700 kilograms.

3.10.1.6 Dependence on Natural Resources of Astola Island

Astola Island has natural resources of high economic value. Fishermen of Sindh and Balochistan are dependent on them for their livelihood. Use of these natural resources within the carrying capacity of the ecosystem can provide them with long term economic benefit. However, lack of awareness amongst the fishermen results in excessive and unsustainable use of natural resources. Dumping of non-degradable waste such as fishing nets, plastic bags, water bottles and other leftovers degrade the natural habitat of various marine species and the beauty of the island.

Fishermen coming from Sindh and Balochistan not only catch fish, lobsters and crabs but also collect seashells for commercial purposes. Seashells are an integral part of the ecosystem as they provide a home to hermit crabs and snails (shell making animals). Hermit crabs do not have a shell of their own and to protect themselves from predators they live in shells left by dead snails. During their lifetime, hermit crabs change shells a number of times. They change when the shell gets damaged or when the hermit crabs outgrows it. Collecting excessive amounts of seashells for commercial purposes can result in reduction in hermit crab populations, in addition to depleting a major $CaCO_3$ providing source to the sea, thus affecting the whole aquatic life. The field survey revealed that on average a fishing boat collects 2,479 kg of seashells in a month which is a fairly high amount.

3.10.1.7 Governance Regimes at Astola Island

The following key agencies/organisations are involved in the governance of natural resources within Astola MPA.

3.10.1.7.1 Balochistan Fisheries Department (BFD)

BFD is responsible for management of fishing activity within 12 nautical miles. Any fishing

activity beyond 12 nautical miles is managed by marine mercantile department. Thus fishing activity conducted at Astola is not under the management of Fisheries Department.

Fisheries Department's boats patrol within 12 nautical miles area for effective management. Their major roles and responsibilities are:

- Issuing and renewal of fishing license
- Prevent illegal fishing activity and patrolling
- Provide support to stranded boats in the sea
- Provide support to fishermen in case of emergency

Fisheries Department issues fishing licenses renewable on an annual basis. Amount of license fees depends on the size of the boat and a fishing boat without a license is illegal. Fisheries Department prevents illegal fishing by patrolling within 12 nautical miles. The department has 2 patrolling boats for Ormara, Pasni and Gwadar, while one patrolling boat is for Jiwani. These speedboats (for patrolling) have been provided with guns that have rubber bullets to stop illegal fishing.

In contrast to fishing boats, fish trawlers are huge and equipped with guns. Fisheries Department faces a lot of difficulty and cannot not perform its duty effectively: due to their huge size, trawlers easily escape and can even open fire on the patrolling speedboats.

Any boat caught illegally fishing is fined based on the mode of illegal fishing activity and type of illegal fishing gear used. For example, a boat using *gujju* (local name for a small sized mesh size shaped like a bag) or wire net (local name for a nylon net with a mesh size less than 1 cm) is fined Rs 600,000. According to the information provided by Fisheries Department officials, every year Fisheries Department gives Balochistan Government more than Rs. 25 million, collected as fine money from illegal fishing activities.

Apart from issuing license and ensuring only legal fishing practices in the sea, Fisheries Department also provides support to fishermen if their boat gets stranded in the sea.

3.10.1.7.2 Maritime Security Agency (MSA)
Maritime Security Agency, established in 1987, is a civil force in which naval officers are deployed in MSA on a temporary basis for a specific time period. Apart from performing major responsibilities related to defence it has also been given additional tasks such as anti-smuggling (for example, oil smuggling), anti-narcotics, eradication of illegal fishing, etc. On routine basis MSA patrols the sea in helicopters or boats/ships to perform its monitoring duties. Its area of responsibility extends upto 200 nautical miles; however, only for search and rescue of stranded boats it manages 840 nautical miles in the sea from the coast. The Maritime zones upto 200 nautical miles of Arabian Sea are:

- Territorial Waters (12 Nautical Miles)
- Contiguous Zone (24 Nautical Miles)
- Exclusive Economic Zone (up to 200 Nautical Miles)

Apart from Maritime Security Agency, Fisheries Department is also present in the area and plays a role in natural resources management of the sea.

The Contiguous Zone is up to 24 Nautical Miles from the coast. It is subject to freedom for navigation, overflight, military exercises etc. However, Pakistan can take necessary measures within this area to prevent and/or punish infringement of its customs, fiscal immigration, laws and regulations.

The Exclusive Economic Zone (EEZ) is up to 200 nautical miles in the sea. In this area only Pakistan has the right to explore, use, conserve and manage natural resources, both living and non-living, present in the sea on the seabed, subsoil, and subjacent waters. All economic activities can only be conducted by Pakistan and any foreign boat or people caught conducting any economic activity in the EEZ can be caught by MSA.

3.10.1.7.3 Pasni Fish Harbour Authority (PFHA)
Pasni Fish Harbor Authority is the custodian authority for operation and maintenance of Pasni fish harbor. This harbor is the only one in the Pasni area. All fishing activities are operated from Pasni fish harbor and the PFHA also maintains the statistics of fisheries catch and boats etc.

Although this harbor has the severe issue of being silted up with heavy sand particles, large

fishing boats can enter when high tides occur and the water channel gets filled with water.

3.10.1.7.4 Balochistan Mahigir Network
Balochistan Mahigir Network is a fishermen community organization formed with technical support of SPO Pakistan and representing all fisher community of Balochistan coast. The organization is formally established for raising the voices to ensure fishermen basic rights, promoting sustainable fishing and advocacy of indigenous fisherfolk. The organization is working with various development and government organizations in the coastal districts of Gwadar and Lasbella.

3.10.1.7.5 International Union for Conservation of Nature (IUCN) Pakistan
The International Union for Conservation of Nature (IUCN) Pakistan has played a very important role in the management of natural resources of Makran coast. The IUCN Pakistan also has developed Integrated District Development Vision (IDDV) for District Gwadar and Lasbella. IUCN played a potential role in designation of Astola Island MPA by facilitating the stakeholders and dialogue process of field for consensus.

3.10.1.7.6 World Wide Fund for Nature-Pakistan (WWF-Pakistan)
Under the Pakistan Wetlands Programme, WWF-Pakistan has also worked in specific sites along the Makran Coast. To avoid overlapping of activities and for effective natural resource management these organizations are working in coordination and supporting each other.

3.10.2.1 Pressures and Threats
Each pressure and threat to Astola Island has been ranked according to the information provided by the respondents.

3.10.2.2 Oil Pollution
Oil pollution has been identified as the greatest pressure and threat on the natural resources of Astola Island. It results from dumping of crude or used oil bars and used oil into the sea, washing of tankers in the sea and leakage of oil into the sea while transferring smuggled oil out of Iran from one boat to another.

According to the respondents, oil pollution is likely to occur over a widespread area in the next five years and in the future also have a severe impact on the marine life. The impact is likely to be long term, if not permanent.

As reported by the residents of the nearby villages, the fish production has decreased over the last five years due to usage of banned fishing nets by the fishing trawlers. According to local fishermen, this pressure has sharply increased over the last five years and is occurring over a widespread area. Its impact is severe and permanent. There is a high probability that this activity shall continue to be practiced in the future due to which fish production could decrease severely or adversely impacting the economic conditions of the local fishermen apart from damaging marine ecology permanently.

3.10.2.3 Coral Extraction

As reported during an interview with Pasni fish harbour authority's focal person, it was also found that few Bengali fishermen collect corals or Coral branches from under water and they sell corals to Karachi aquarium market. Few fishermen were also found conducting fishing by fishing gun in coral areas which would result in the coral breaking.

3.10.2.4 Use of Harmful Nets

According to fishermen, illegal fishing is also practiced by the locals due to lack of awareness. Some locals fish in the months of June and July i.e. fish breeding season throughout the area. As a result, they catch fingerlings, decreasing fishing production. There is now a high threat that illegal fishing is still being done by Sindh based fishermen and local fishermen in off seasons. The impact of catching fish during fish breeding season is severe and permanent, disturbing the whole ecology of the island. Some of the other pressures and threats identified by the respondents are sea water pollution, coral mining and ghost nets. There are lots of corals near the coast of Astola Island. The nets of fishermen sometimes get stuck in these corals and thus damage them.

3.10.2.5 Solid Waste

In addition, fishermen who come and fish in the waters of Astola Island mostly dump their solid waste including empty plastic packets of food, damaged nets and plastic bottles among other things on its coast which ultimately enter into the sea. This activity has sharply increased over the last five years and it shall have a moderate and long term impact.

An overall picture of the scores allotted to pressures and threats by all respondents is given in graph. Oil pollution of the sea has been ranked as the greatest pressure (Score = 28) and threat (Score = 29) to the marine ecology of Astola Island by the respondents.

After identifying and prioritizing pressures and threats, the other sections of the RAPPAM questionnaire focus on socio-economic importance, objectives, legal security, management planning, management decision making, staffing, finances, research evaluation and monitoring. Questions were asked regarding each of these aspects. The answers to these are Mostly Yes (score = 4), Yes (Score = 3), Mostly No (Score =2) and No (Score = 1). The highest score given to any question is (4 * 2 = 8).

3.10.2.6 Socio-Economic Importance

Astola Island is a source of employment to fishing communities and they depend on the natural

Figure 5: Assessment of illegal fishing by local fishermen

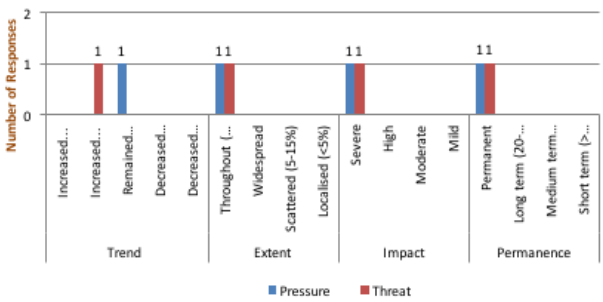
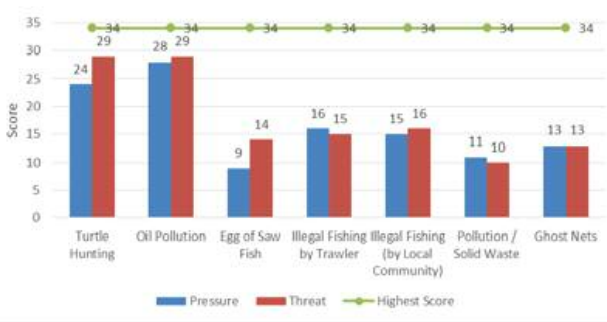
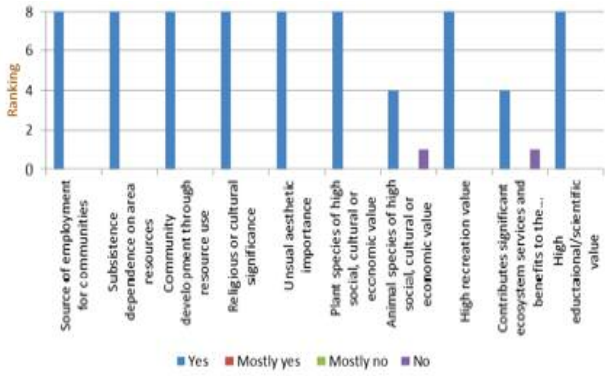


Figure 6: Scores given to pressures and threats



resources of the area for their subsistence. The area provides community development opportunities through sustainable resource use. There is a Hindu worship place and two shrines for Sunni Muslim and for Zekri Community on the island and thus it has high religious importance. The area has high unusual aesthetic importance and high recreation value. Astola Island has plant and animal species of high social, cultural, economic, scientific and educational value. Figure 7 assessment of Socio-economic importance.

Figure 7: Assessment of Socio-economic importance



3.10.2.7 Analysis and Discussion

Astola Island has high ecological and socio-economic importance. However, it is facing numerous pressures and its natural resources are at threat due to various anthropogenic activities. Oil pollution of the sea seems to be a major threat to marine ecology. Oil pollution along with illegal fishing practices is resulting in tremendous decline in fish production.

Turtle egg hunting is one of the major pressures existing in the area. Corals present near the island add tremendous beauty and increase its ecological value. However, coral mining for commercial purposes and ghost nets are excessively damaging them. All of these pressures on the island are due to lack of any protection status and absence of management plan for the area. Lack of staff and financial resources make it difficult to monitor the illegal activities. Recruitment and retention of employees is also difficult. Market value of the area's resources is high that make it more vulnerable.

Astola Island is an important source of employment for fishing communities. It has high religious, cultural and aesthetic importance. Plant and animal species have high social, cultural and

economic value. Research on key social and ecological issues is not according to the needs of the area and further research should be conducted for its effective management.

3.10.2.8 Limitations of the Study

Astola Island is facing degradation due to a number of anthropogenic activities and lack of any management programme.

Astoal has a diversity of corals, there are about 25 species of hard and soft corals reported earlier near the Island. Some fishermen are engaged in coral mining activity. However, a study needs to be conducted to determine the level of coral mining activity done in the area and its impacts. Corals are also damaged by ghost nets (nets that get trapped in corals). Near corals there are a lot of fish. Sometimes, the nets thrown by fishermen in such areas get entangled with corals.

Apart from illegal fishing and coral mining, marine life is also being adversely affected by oil being spilt in the sea by trawlers. Big fish trawlers dump their crude oil bars in the sea. However, details about its impact cannot be clearly stated as it depends a lot on ocean currents and a detailed study needs to be conducted to assess the damage caused by it. Another source of oil spill in the sea is during exchange of illegally smuggled oil from one boat to another in an inappropriate way.

Astola Island has high ecological importance: however, research conducted on key ecological and social aspects is not sufficient with its needs. Critical research and monitoring needs have not been identified and prioritized either. Although Astola Island is now considered a protected area, a management plan should be implemented.

4. CONCLUSION

An orientation and plenary meeting of key stakeholder institutions and academia was held on November 29, 2017 at IUCN country office in Karachi to shape the scope of the EBRU survey and to constitute the team of experts of total twenty six (26) Ph.D. scholars and professionals including; phycologists and phycochemists, plant ecologists, marine ecologists, herpetologists, ornithologists, marine fisheries, corals and scuba diving experts, foresters, wildlife management experts, and sociologists. Following the collection of primary data and its consolidation, an international consultative workshop was organized with key stakeholders where survey findings were shared with them. The feedback received from them was incorporated in the final report.

The survey was designed to collect the pre and post winter data on ecological resources of Astola Island MPA. The EBRU surveys were conducted from 16 - 18 December, 2017 and 15 - 17 February, 2018 respectively. The purpose of this ecological baseline survey was to collect primary and secondary information on important biodiversity resources of Astola, to obtain updated information on terrestrial and aquatic resources in onshore and offshore waters of Astola Island including flora phytoplankton, microalgae, seaweeds, herbs, shrubs and small trees and fauna - reptiles, birds, corals reef, marine fish diversity, cetaceans, small mammals and benthic organisms, as well as, the physical parameters. It has also covered identification and mapping of sites of critical ecological importance. Resource use survey covered social aspects pertaining to extractive uses, existing fishing practices and livelihood dependencies associated with the island's resources.

Astola has a rich biodiversity with an endemic species of reptile; a highly venomous Saw-scaled Viper (*Echis carinatus astolae*). Sandy beaches are a nesting ground for Green turtles while the plain area on top of the island is supportive to some agamid and Lacertid lizards and the unique snake species of the Island. It has resting and nesting places for many seabirds like gulls and

terns and the base of the cliff are the most favored habitats for waders. Previously, 75 species of fishes were reported in the month of January 2011. Previously, 25 species of coral have been found in the ocean around Astola. The Arabian Sea humpback whale, one of the rarest marine mammals, has occasionally been sighted in its surrounding area. By using different methods for diverse groups, there are some findings of this survey showing in Map- 5 and Table 20.

Map 5: Overall Map of Fauna at Astola Island.

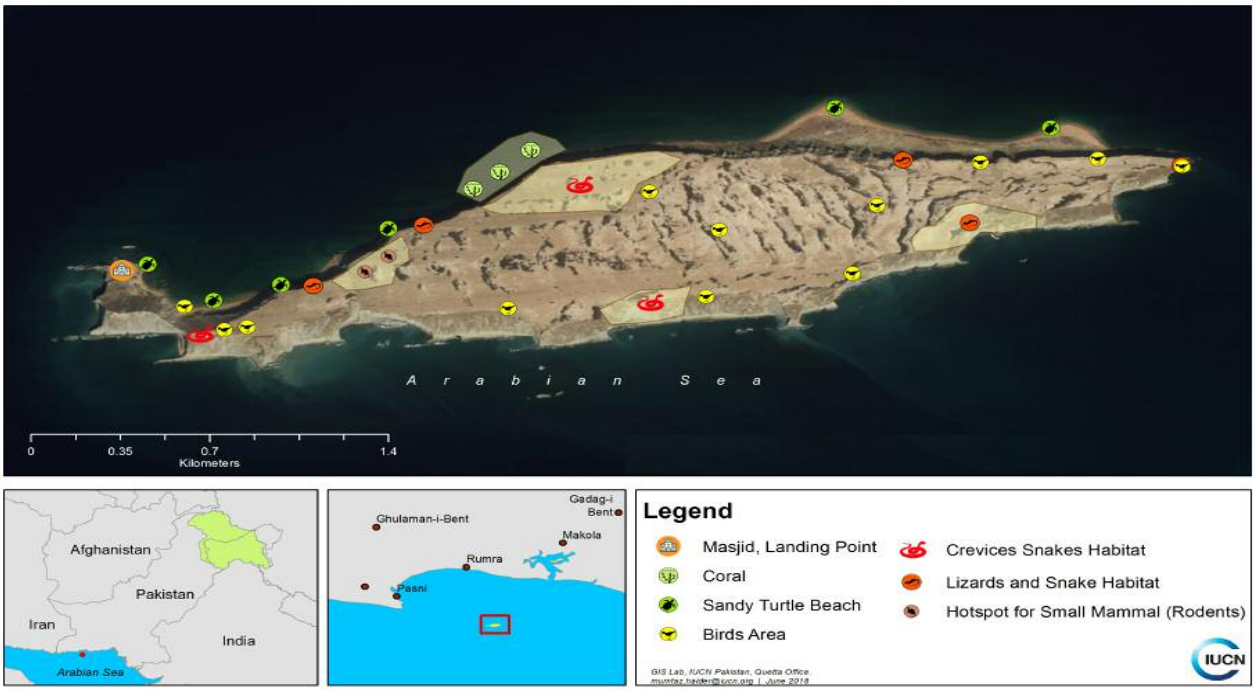


Table 20: Concluded group of species with its significance

#	Thematic Area	Brief description of findings/results
1	Physical parameters	Five different parameters (temperature, salinity, dissolve oxygen, turbidity, pH and total chlorophyll) were recorded on different depths from the offshore Pasni stations and the near Astola stations.
2	Birds	Sixty one species of birds were recorded including 34 Water birds, 20 Passerines, 6 Raptors and 1 Swift. No threatened or near threatened species of birds was recorded except Dalmatian pelican. The Astola Island is reported to support large numbers of breeding sea birds, including *Larus hemprichi* and several species of terns. A total of 61 bird species 38 winter visitor, 20 resident, 2 passage migrants and 1 migrant.
3	Reptiles	Seven species of reptiles were recorded including 1 turtle, 4 lizards and 2 snakes. Only two species out of the recorded seven species were found of special concern; Green turtle (*Chelonia mydas*), a threatened species and Saw-scaled viper snake (*Echis carinatus astolae*) which is an endemic species of Pakistan being only found at Astola Island. A total of 1745 nests of Green turtles were counted at three nesting places along the sandy beach of Island during mid-February. Seventeen Green turtles were found that laid eggs.
4	Marine fish	Twenty seven species of fishes were recorded. No threatened species of fish was recorded except "*Vulnerable"* Sicklefin lemon shark (*Negaprion acutidens)*.

#	Thematic Area	Brief description of findings/results
5	Cetaceans	Five species of cetaceans were recorded, in which two species are threatened i.e "Vulnerable" Indo-Pacific finless porpoise (*Neophocaena phocaenoides) and "*Endangered" Arabian Sea humpback whale (*Megaptera novaeangliae),* one of the rarest marine mammals.
6	Small mammals	Three species of rodents including; House mouse (*Mus musculus)*, House rat (*Ratus ratus)* and Indian gerbil (*Tatera indica*) are very common at Astola Island. These rodents pose the major threat to the green turtle population at Astola Island. The population of House rat (*Ratus ratus*) is posing a threat to the endangered Green turtles (*Chelonia mydas*) that use to nest along sandy beaches of Astola Island. Therefore, House rat (*Ratus ratus*) can be considered as a species of special concern as it is damaging the virgin habitat of the Astola Island. Predation of domestic cats, present at the island. Notably, 10 cats observed in this survey.
7	Corals	Eleven species of hard corals were recorded from 6 different families in which only one species is "Vulnerable" such as *Favites spinosa,* 5 species are "Near Threatened", while others are "Least Concern" and Data Deficient".
8	Vegetations	A total of 30 species of vegetation were recorded in which 14 species were newly identified during the survey.
9	Seaweed	Three species of seaweeds are found in juvenile stage, therefore, experts were unable to identify them correctly. However, broadly predicting green seaweeds (*Bryopsis* sp. and *Ulva* sp.) as well as brown seaweeds (*Sargassum* sp.) have likely started growing on boulders and pebbles of Astola Island.
10	Socio-economics	The primary and secondary data was collected and analyzed to determine socio-economic dependency of fishermen community on the natural resources of Astola Island. The responses of local fishermen and authorities were evaluated for this first marine protected area, whereas sustainable and non-sustainable practices of communities dependent on its natural resources were also assessed. The role played by Government Departments such as Maritime Security Agency (MSA), Pakistan Navy, Pakistan Coast Guards and local and international NGOs in natural resource management independently or in liaison with other organizations.

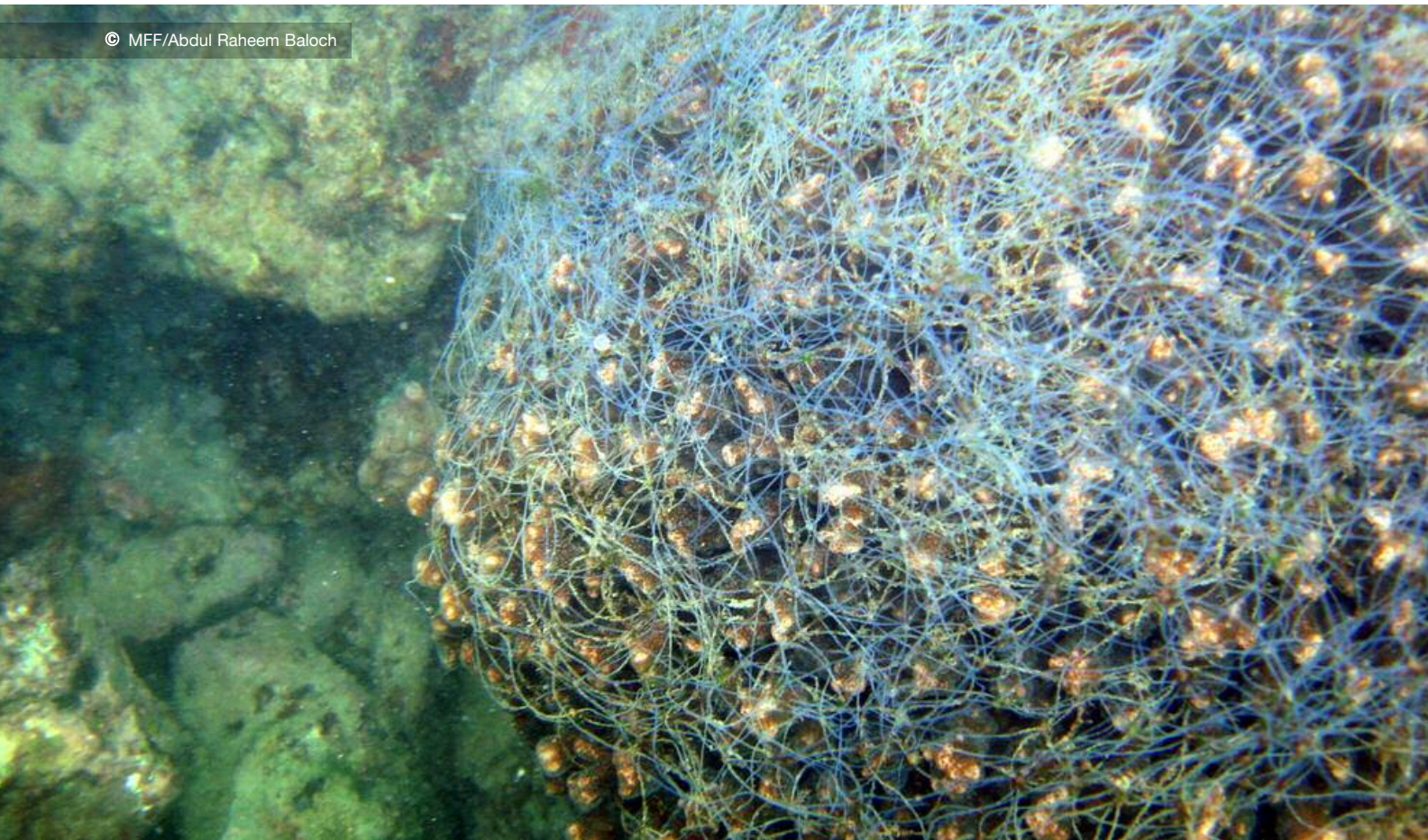
4.1 Threats

The potential threats to the species and their habitats include:

- Thirty-three (33) turtle nests were found destroyed by rodents. Similarly, turtle egg shells were also found near active burrows of the House rat (*Ratus ratus*) which were frequently found on the island and their tracks and trails were visible around the turtle nests. These house rats that got access to the island most likely through fishermen's boats, seem to be one of the major threats to Green turtles. The former major breeding colony of Great crested tern (*Sterna bergii*) in Astola Island has now been extirpated due to the introduction of rats (Grimmett *et al.*, 2008). Ten domestic cats (*Felis domesticus*) were also observed which prey upon turtle eggs and occasionally attack the turtles. These cats were introduced in the past to eradicate the growing populations of rats on the island but now they themselves have become a problem for the turtles. The other natural threat to the hatchlings is the presence of a huge number of gulls and other resident birds that roost along the beach. Whenever the hatchlings come out of the nest in the daytime, they rarely find their way to the water as they get picked up by gulls.

- A number of fishermen and some tourists use to spend 1-3 weeks at the Island for fishing purposes. In this way, on average, 40 to 50 fishermen are present all the time at the island. The kitchen waste, solid waste and regular day and night activities along the sandy beach by these resident fishermen also added to the disturbance to the fauna. It was also observed that many female turtles cannot find suitable nesting and egg laying place due to continuous disturbance along the sandy beach. A number of tracks and trails of turtles revealed that many females returned to the sea without laying egg.

- General observations made during field visits highlighted the fact that a number of threats are prevalent along Astola Island that threaten the existence of local cetacean fauna *viz.* accidental entanglement in fishing gear short nets and pollution particularly plastic litter among others.



- Ocean acidification and global warming is another major threat to corals. It is expected that during the current century, corals will disappear from many reef systems. Climate change also increases local pressure on corals by altering water quality. Increasing carbon dioxide will insert serious impacts on marine communities (Hoegh-Guldberg *et. al.*, 2007; Hofmann *et. al.*, 2010). Reportedly, extraction of corals is also prevalent at Astola.

- During the survey, it came to notice that due to anthropogenic interference, *Prosopis juliflora* population is expending on sand dunes close to seashore.

- There are over six individual plants species recorded which are concentrated in and around the area near Khwaja Khizar Shrine. However, one individual plant was recorded at turtle beach of Astola Island. Fortunately, on main promontory of Island, *P. juliflora* was absent, but there is a possibility that in future this species might occupy that area.

- The soil texture and availability of rainwater on promontory are two attracting features for this aggressive, opportunistic and weedy shrub to occupy this region. Therefore, the future expansion of *P. juliflora* in this region might be one of the major biotic threats which otherwise intact shrub species may face in the near future.

- Reduction in fish population due to illegal fishing practices by Sindh based trawl netters, wire netters and illegal fishing gear of very small mesh size is adversely impacting fish population.

- Seawater pollution particularly caused by oil spillage is major cause of concerns to the biodiversity of the area. .

- Erosion of the Island due to sea level rise and formation of caves in muddy beaches of island.

4.2 Recommendations

Following are recommendations for the conservation of fauna and flora and its surrounding waters of a protected habitats of Astola Island.

- Regular monitoring of Astola Island is recommended in order to protect the virgin habitat as well as to ensure safe breeding grounds for threatened fauna.
- Conservation and a management plan need to be developed and implemented to protect important biodiversity of area. This will also help to promote ecotourism.
- The present site needs to be revisited, studied and managed as a Ramsar Site at least with reference to water birds.
- Faunal studies need to be continued with special reference to cetaceans, reptiles (marine turtles and marine snakes), fishes and invertebrates (particularly the corals).
- Falcon trapping needs to be controlled in the area during the migratory season (October – March).
- Birds of prey, sea birds and oceanic migrants need to be surveyed in the migratory seasons (autumn and spring) over the area, as these species have not been well represented in the preceding studies.
- The camping site at Astola Island should be protected and the tourists' activities should be regulated by the custodian department.
- Domestic and feral cats *(Felis domesticus)* and rodents should be removed and eradicated from the Island.
- There is a need of regular visits to observe the growth cycle of different algae for which prolonged stay in the field station is recommended.
- The government and relevant NGOs need to help in aquaculture and restocking of fish which can reduce the burden of over-exploitation.

- Awareness sessions should be conducted with local fishers about threats of ghost nets. They should be sensitized on this issue of grave concern. Spatial and temporal distribution, relative/absolute abundance and data about prey availability will be required if Pakistan has to produce an efficient conservation strategy for marine cetaceans around Astola Island. More work can be accomplished if strong, purposeful and consistent collaborations are established between different indigenous departments working on wildlife in general and marine environment in particular. Use of platforms of opportunity for collection of data could enhance geographical and temporal coverage, therefore options in this regard should be explored as well.

- It is strongly recommended that the house rat *(Ratus ratus)*, a serious pest as well as a vector of human diseases should be eliminated from the island.

- Insects serve as food for small mammals, reptiles and many other species. They work as pollinators for various plants and play an important role in balancing the ecosystem. . It is suggested a detailed seasonal survey should be conducted to assess the population dynamics, species composition and status of important insect species.

- A cleaning programme of solid waste and ghost nets should be done at the visiting sites of Astola for the conservation of valuable species.

- Nesting by thousands of green turtles at the Island is a unique feature of the Island. The existence of an endemic snake species on a small island adds to the importance of the island. Therefore, the environment of this marine protected area should be kept natural and any kind of developmental activities disturbing the area should be avoided.

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Annex: Profiles of Experts

Dr. Samina Kidwai

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Dr. Kidwai began working as a marine scientist in 1991.. Her educational qualifications include a PhD and MPhil in Marine Biology, two MScs in Marine and Fisheries Sciences (Scotland, United Kingdom) and Zoology Early Research in Ocean Sciences which incldues studying the effect of excessive nourishment (eutrophication) and its effect on the macrozoobenthos on a tidal estuary in Scotland. She has also studied the effect of heavy metals and oils concentration on the intertidal fauna of Karachi coast (anthropogenic drivers).

She has been affiliated with the National Institute of Oceanography, Pakistan since 1996 as a research scientist. She has more than 22 years of research experience in Marine Sciences (Biological Oceanography) and has been involved in various research activities of the Institute. She has been part of the NIO teams that carried out international and national consultancy projects. Her geographic area of research is the Arabian Sea (Northwest Indian Ocean) and she conducted a research project in the Sargasso Sea (North Atlantic) as well. Her research interests include biological oceanography, mainly focusing on (zoo) plankton ecology, bio-physical interactions, coastal deep sea interface and its effects on plankton ecology, food-web dynamics using biomarkers, developing Marine Biogeographical Information Systems (Marine BioGIS) for Pakistan and the Northwest Arabian Sea, raising efficiency in marine resource management, Marine Protected Areas (MPAs), island and deltaic ecosystems and coastal zone management. She has more than 200 days of sea time experience in the Atlantic, , Baltic, Thai ,Gulf Stream and Arabian Sea and has done numerous surveys of coastal waters. She had been a member of National Committee of Pakistan in SCOR (Scientific Committee Ocean Research) since 2005 and National Coral Reef Task Force (NCRTF), IIOE-2 ST 3 "Monsoon variability and ecosystem response". She is also representative of Pakistan at the IOCINDIO (Inter-governmental Oceanographic Commission for Indian Ocean region). She became a member of the IMBER (Integrated Marine Biogeochemical and Ecological Research) working group CBTT (Capacity Building Task Team) in 2010.

Dr. Kidwai has published extensively in international scientific journals and also contributed to national status data and cruise reports, consultancies, and articles of immense public interest. She has been the lead scientist in several scientific projects. She is a recipient of the Start Young Scientist Certificate of Commendation IHDP, IGBP, WCRP, Washington, USA and winner of several international fellowships. She has been a visiting scientist at the Rosensteil School of Marine and Atmospheric Science (RSMAS), University of Miami, USA; Danish Institute of Fishery Research, Charlottenlund, Denmark; International Centre of Theoretical Physics (ICTP), Trieste, Italy and NF-POGO Centre of Excellence in Observational Oceanography, Bermuda.

Dr. Tariq Mahmood

Research Officer
National Institute of Oceanography (NIO), Karachi
Ph.D. (State Key Laboratory of Estuarine and Coastal Research, ECNU, China),
M.Sc. (University of Karachi)

Dr. Tariq Mahmood has been working on marine biogeochemistry and aquaculture for the past 18 years. Dr. Tariq has been awarded Ph.D. degree on environmental engineering (marine biogeochemistry) from State Key Laboratory of Estuarine and Coastal research, East China Normal University Shanghai, China in 2016. He was involved in various national and international oceanographic cruises, carried out for marine biology and environmental study.

Dr. Tariq has vast experience in marine aquaculture, particularly in the field of shrimp farming including water quality, maturation, hatchery, grow-out and feed management, phytoplankton and zooplankton culture. He also has experience in Integrated Multi-trophic Aquaculture (IMTA) systems in coastal waters. He is working on ecology, food web dynamics, nutrient, organic matter and constructed wetland treatment and has vast experience of oceanographic sampling and operating analytical instrument such as IRMS, CHN analyser, Nutrient Autoanalyser, TOC autoanalyzer and spectrophotometer.

Dr. Tariq has 9 publications in peer reviewed national and international journals and also a reviewer of international journals. He has studied trophic relationship among the cultured species in IMTA system on the basis stable isotopes. He has reported the anthropogenic impacts on the coastal water quality and role of environment friendly system of aquaculture in the reduction of nutrient and organic matter. In nutshell, he has a great contribution in the development of shrimp farming in Pakistan.

Dr. Syed Ali Ghalib

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Dr. Ghalib is a Zoologist, Consulting Wildlife Ecologist, Environmental Specialist and Visiting Faculty, Department of Zoology, University of Karachi. He has served the Zoological Survey Department, Government of Pakistan, Karachi, for thirty-seven years in various capacities dealing with research, surveys and administration. He has been trained in taxonomy of birds from France, wildlife conservation from England and wetland and waterbird conservation from Japan.

He has been working with various environmental consulting firms and NGOs for studies regarding IEE, EIA, Baseline Studies and Wildlife Monitoring Projects, particularly in Sindh and Balochistan. He is a resourceful person for training courses and workshops in Ecology, Wildlife Conservation and Management. He has a total of 80 publications in wildlife, ecology, wetlands, waterbirds, protected andcoastal areas.

Abrarul Hasan

Marine Biological Research Laboratory, Ports and Shipping Wing
MSc. Natural Resource Management (Norway)
MSc. Zoology, Karachi

Abrarul Hasan has been working in Marine Biological Research Laboratory, Zoological Survey Department since 1983. Presently he is working in Marine Biological Research Laboratory, Ports and Shipping Wing. He has more than thirty five years of experience in marine vertebrate diversity research. Mr. Hasan started his carrier with an assignment on vertebrate diversity of mangrove swamps of Sindh and Balochisan coast. His fields of interest are coastal birds, turtles and sea snakes. Mr. Hasan got a chance in 1991 to improve his education from Agricultural University of Norway and was awarded with Master's Degree in Natural Resource Management (NRM). He also completed his thesis on fisheries management in Norway.

Mr. Hasan has completed several important assignments on various parts of coast of Pakistan from creeks of Indus Delta to Jiwani near Iranian border. He was a part of survey team of WWF-Pakistan working on Makran Coastal Wetland Complex. Later, he conducted several surveys of west coast of Pakistan. Hasan performed several surveys in collaboration with Pakistan Wetlands Programme and gave recommendations to overcome the threats to biodiversity of west coast of Pakistan in general and Astola Island in particular. He has worked on Bhoola and Katra fishing nets in collaboration with IUCN Pakistan. On the recommendations of Mr. Hasan, first time ban was imposed on these nets. Hasan was a focal person on Dugong from Pakistan to Convention on Migratory Species (CMS) and participated in several international workshops on the formulation of its management plan in Bangkok. Mr. Abrarul Hasan has more than 35 research publications in various national and international journals, mostly on the fauna of coastal areas of Pakistan.

Dr. Ehsan Elahi Valeem

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Dr. Ehsan Elahi Valeem did his M.Sc in Botany (Plant Pathology) in 1988 from the University of Karachi , while secured M. Phil. in Marine Biology (Physical Oceanography) and Ph. D. in Marine Biology (Phycochemistry) in 2005 from the Centre of Excellence in Marine Biology, University of Karachi. Dr. Valeem worked as Junior Research Fellow in the Centre of Excellence in Marine Biology, University of Karachi from Jul. 1989 to Jul. 1991. He also worked as Assistant Professor Botany Government Degree College North Nazimabad. Besides teaching and research, Dr. Valeem also worked in different capacities in administration, media, education and reseach organizations. He has been a resource person of Intel Corporation of Pakistan to motivate young students of K12 to become emerging scientists. He joined Institute of Marine Science, University of Karachi as Assistant Professor on Jan. 29, 2013 and working there to date. He has been a subject

editor of Bioscience Research and managing editor, editor and chief editor of International Journal of Phycology and Phycochemistry (IJPP). He published five articles and more than100 scientific research papers in magazines and journals of international repute both at home and abroad. Apart from that he published seven books simultaneously from Germany, UK and USA. His research areas include Marine Science (Biological/ Physical Oceanography, Phycology & Phycochemistry, Algae Culture & Marine Resources); Agricultural Science (Plant Pathology and Mineral Nutrition); and Social Science (Applied Education, Community Development and Public Private Partnership). Dr. Valeem has been a member of various academic and professional societies. He has also etablished a laboratory for Exploration of Marine Resources (LEMR) in the Institute of Marine Science, University of Karachi to develop cosmetic marine products by utilizing marine resources.

Dr. Muhammad Shoaib Kiani

Assistant Professor
Institute of Marine Science,
University of Karachi
Ph.D. (University of Karachi),
M.Sc. (University of Punjab)

Dr. Muhammad Shoaib Kiani is working on cetaceans (whales, dolphins and Porpoises) and some other large marine vertebrates (marine birds, turtles and sharks) for the past 12 years. Dr. Kiani earned his Ph.D. on marine cetaceans of Pakistan from University of Karachi in 2014. He completed a postgraduate level Marine Mammal Course from the University of London Marine Biological Station Millport, Scotland (UK). He is a member of IUCN Cetacean Specialist Group, Scientific Committee of Pakistan as well as Whale and Dolphin Society. He is also focal person of Pakistan in the Arabian Sea Humpback Whale Network. Dr. Kiani has been part of 4 previous survey expeditions to Astola Island. Dr. Kiani has more than 10 years of experience in conducting cetacean research.

Dr. Kiani has 10 publications in peer reviewed national and international journals. He has reported 3 previously unrecorded dolphin species from Pakistan while two more unrecorded whale species are being reported in his upcoming publications. He is the lead author in a most recent review chapter on “Indo-Pacific humpback dolphin in Pakistan” in the widely read Advances in Biology Book Series. Dr. Kiani is actively involved in the regional efforts for conservation of one of the world’s most endangered sub-population of the humpback whale -the Arabian Sea humpback whale and joins various expeditions in the Arabian Sea and Gulf of Oman for collection of biopsies and satellite tagging aimed at better understanding of this globally significant sub-population.

Dr. Waseem Ahmad Khan

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Dr. Waseem Ahmad Khan is a qualified professional with Ph.D and M. Phil degrees in Zoology (Wildlife Ecology) and Master’s degrees both in Zoology and Applied Environmental Sciences. He is a wildlife ecologist and biodiversity specialist with a good understanding of wildlife conservation, environmental management, natural history museology, project planning and management. He has supervised and managed seven conservation and research projects during the last five years and is currently managing three projects. He has experience in community based conservation and has over 22 years of conservation, administration and research experience with different government and non-government organizations. He has published 43 research papers in peer reviewed research journals, 31 of which have impact factor. Seven popular articles have been published and three

books are under the process of publication. He also supervised many students in different fields such as Ecology, Herpetology, Ornithology and Mammalogy. He has conducted more than 150 International and national wildlife surveys and ecological baseline studies to study herpetological, ornithological and mammalian fauna and produced more than 200 survey reports.

A number of Threatened and Economically Important wildlife species are being kept, reared and managed under his supervision at the UVAS Wildlife Breeding Farm, Pattoki. He has organized more than 30 workshops, field trainings, seminars etc. for Pakistan Wildlife Foundation and Department of Wildlife and Ecology, UVAS, Lahore. He has good drafting skills having reviewed and commented on several EIA, IEE and general reports from different organizations sent by Pak EPA. Country Representative and Deputy Asian Coordinator of IUCN, Otter Specialist Group and *Species Contact* for Smooth-coated Otter *(Lutrogale perspicillata)* out of the 13 Species Contacts worldwide. He is a member of Academic Council, Advanced Study, Research Board (ASRB) of UVAS, Lahore and National Curriculum Revision Committee of HEC Pakistan.

Muhammad Wasim Khan

Director General, Marine Fisheries Department
(Government of Pakistan)
Education: M. Phil in Zoology (University of Karachi)
Diploma in Fisheries Biology and Fisheries Management (University of Bergen, Norway)
M. Sc Zoology, Specialized in Marine Zoology (University of Karachi)

Muhammad Wasim Khan is an experienced Marine Zoologist and has been working in the fishing industry for a number of years. In the Marine Fisheries Department, Government of Pakistan, Mr. Wasim has worked as Director General, Director (Research and Assessment), Deputy Director, Project Director and Assistant Director (Research).. He has also worked as Project Director for FAO UTF PAK/108/PAK, Senior Counterpart Officer MFD/MINFAL with the FAO TCP/PAK/0167, and as In-charge of the Quality Control section and Hatchery Complex Development Project. Furthermore, he has dealt with matters pertaining to Law of the Sea of United Nations, worked in Liaison with FAO, IOTC and other international agencies and written several technical papers and reports on various aspects of fisheries. Throughout his career, Mr. Wasim has conducted, participated and supervised a noteworthy amount of foreign and in country training sessions, surveys, workshops, events and study tours. To be precise, hehas been a part of 8 surveys, 12 nationaltraining courses/workshops. Moreover, he has supervised 5 events and participated in 5 study tours and foreign workshops. He has received2 certificates for his extensive efforts. Mr. Wasim has played a pivotal role in the production of 4 books such as “Handbook of Fisheries Statistics of Pakistan. All four books address different aspects concerning the situation of fisheries in Pakistan.

Dr. Muhammad Shafi

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Dr. Muhammad Shafi was working on gene cloning, gene characterization and gene expression in Black Rock Fish *(Sebastes schlegelii)* in College of Marine Life Sciences, Ocean University of China. After getting Ph.D in 2012 and he joined Lasbela University of Agriculture Water and Marine Sciences as Assistant Professor. Dr Muhammad Shafi availed chance for Post Doctratein 2016 to study Environmental Science. During his Post Doctrate, he conductedresearch sudies on distribution and ecological risk assessment of polycyclic aromatic hydrocarbons (PAHs) in the sediments of mangroves around the Leizhou Peninsula, china.

Dr Muhammad Shafi has twenty-three publications in reputed journals and has submitted three gene sequences in NCBI.)

He has been working as Dean / Associate professor in Faculty of Marine Sciences since 2017. He is also a member of IUC team for Fish survey reports for the first Marine Protected Area (MPA) of Pakistan.

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Dr. Abdul Hameed Baloch achieved his M.Sc. degree in Botany (Plant Ecology) from University of Karachi in 1991. He is PhD in Agronomy from McGill University, Canada in 2001. Dr. Abdul Hameed Baloch is an Assistant Professor in the Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Sciences, Uthal, Pakistan. He was a lecturer in Department of Botany, University of Balochistan, Quetta. He also worked as a researcher in University of Karachi to analyze the impacts of salinity on germination of different verities of local cereal crops in 1992.

He has more than a decade of research experience. He has also remained a member of Balochi Academy, Quetta. In recent years, he attended workshops and received certificates from different organizations such as “MFF Pakistan National Training Course on Project Cycle Management with emphasis on proposal writing and appraisal” by IUCN (MFF) International. Dr. Hameed completed his projects on “Ecology and sScio-economic role of *Prosopis juliflora* and *Prosopis cineraria* in Lasbela” and “Introduction and Demonstration of Integrated Farming Systems (IFS) to enhance farm sustainability and poverty alleviation in Lasbella”. He has published about 20 research papers in different journals and also compiled, edited and monographed about 8 books.

Dr. Amjad Ali

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Dr. Amjad Ali is a marine biologist who obtained his PhD degree from Centre of Excellence in Marine Biology, University of Karachi. His current research interests are ; assessment of underwater biodiversity (coral, seaweeds, fish, invertebrates) with particular emphasis on hard corals, palaeodiversity of corals, molluscs andstudy the impacts of climate change on corals and other calcareous organisms and excavation and protection of underwater cultural heritage.

Dr. Ali is the only certified diver in the country with a PhD degree in Marine Biology. He also attended some training and short courses on protection and conservation of underwater cultural heritage from Thailand.

Dr. Naveed Ahmed

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Dr. Ahmed completed his PhD from Centre of Excellence in Marine Biology, University of Karachi. His field of interest is aquaculture, especially to grow fin fish in cage culture. Currently he is involved in various fin-fish cage culture related projects running at Centre of Excellence in Marine Biology.

Abdul Rahim

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Abdul Rahim is a marine biologist with Masters of Science (MSc) degree from University of Karachi

and has more than fifteen years of professional experience with national and international developmental organizations working for community development, integrated coastal zone development, planning, conservation and sustainable use of marine and coastal resources. He is member of Cohort 19 Fellowship Programme of LEAD Pakistan. He has published8 scientific publications in peer reviewed national and international journals. He reported unrecorded species from Pakistan i.e Leatherback sea turtle and Sawfish, Shark fish among others. Currently, he is working as Assistant Director Environment in Gwadar Development Authority (GDA), and is looking after various initiatives of Environment Department.

Earlier, he had worked with Winrock international (WI) under Pakistan Agriculture Cold Chain Development (PACCD) project and facilitated the fisher community for safe handling of catch, strengthening of Fisher Organization (GEWS), modification of fish holds, provision of insulated boxes and flake ice units for fishing boats. Additionally, he organized advocacy campaigns to maintain the cold chain in the fisheries sector. Rahim worked with Ministry of Environment's Pakistan Wetlands Programme (PWP) and WWF-Pakistan as Site Manager at Makran Coast. He also worked with IUCN Pakistan as District Coordinator and supported District Government Gwadar for development of Integrated District Development Vision (IDDV) and mangrove rehabilitation plan. He completed his international course on Competing claims on natural resources at Wageningen University, Netherlands, PADI Dive certification course and underwater survey of coral and coral reef fishes with Millport University UK at Sharm- el-Sheikh, Egypt.

Naeemullah Kazi

Deputy Director
Sindh Wildlife Department
M .Sc Forestry (University of Peshawar), M.Phil. Marine Sciences (University of Karachi)

Naeemullah Kazi is working on l mammals; small rodents and reptiles. He has also been working on a few marine vertebrates (marine birds, turtles) for the past 10 years. As team leader and field biologist, he has served for more than a decade in research work i.e. census of migratory birds, baseline studies of khirthar National Park and a number of EIAs related to wildlife resources of Sindh. As a marine biologist, he had been working under a reputed Government Research Institute, Marine Biological Research Laboratory, Zoological Survey Department of Pakistan for the past 3 years. He had worked as research officer in wildlife management at Pakistan Forest Institute, Peshawar.

Mr. Kazi has earned a Masters degree in field of forestry from University of Peshawar in 2007. He completed a postgraduate in Integrated Coastal Management from the Asian Institute of Technology (AIT), Bangkok (Thailand). At present he is pursuing M.Phil degree from University of Karachi.

He plays a pivotal role in high level scientific and management committees such as Pakistan National Vulture Conservation Committee. He is also a focal person of Man and Biosphere Reserves (MAB) UNESSCO from Sindh. Mr. Kazi has been part of baseline survey expeditions to Astola Island.

Moreover, he has been actively involved with relevant government agencies and international organization working on wildlife and marine conservation i.e. National Council for Conservation of Wildlife (NCCW), WWF-Pakistan, IUCN, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and National Institute of Oceanography (NIO).

Mr Kazi is also part of the regional efforts for conservation and protection of wildlife resource through developing a road map to establish a wildlife crime monitoring network for adopting zero-poaching strategies.

Syed Muhammad Shamim Fakhri

Specialization: Reptiles and Small Mammals
Senior Research Assistant
Marine Biological Research Laboratory, (ZSP) Government of Pakistan

Shamim Fakhri is a Senior Research Assistant in Marine Biological Research Laboratory. He has conducted more than 500 wildlife surveys throughout Pakistan to study the reptilian and mammalian fauna, especially rodents and small mammals. He has attended 2 workshops and conducted 2 national and international trainings.

Mr. Shamim has published more than 500 survey reports and 100 research articles as co-author, of which half are quite popular. Currently, he is assisting Mr. Kurt Auffenberg of Florida State Museum, USA, to compile an updated book on Herpetology of Pakistan.

Nadeem Mirbahar

Ecologist
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Mr. Nadeem Mirbahar is an Ecologist by profession. He holds two Masters degrees; one in Environmental Biology and another in Sociology. Additionally, he has completed a postgraduate diploma from School of Environment, Resources, and Development (SERD), Asian Institute of Technology, Thailand. Currently he is doing an M.Phil from Institute of Marine Science, University of Karachi. In his career, he has received various national and international professional certificates in related disciplines. Besides this, he is actively involved with one of IUCN's Commissions on Ecosystem Management (CEM) since 2007. Mr. Mirbahar has been part of survey expeditions to the first Marine Protected Area (MPA) of Pakistan, Astola Island. Luckily, since the inception phase, he was part of planning and technical deliberation process on the establishment of Marine Protected Areas in Pakistan. He has more than 16 years of experience in planning, management and conservation of natural, wild resources, and biological diversity.

He has worked closely with communities and departments to develop and demonstrate the potential of protected areas management at Miani Hor, Hingol National Park, Khirthar National Park, Pai Forest, Chotiari Weltands Complex, Murree Biodiversity Park, Shah Bundar and Hajamro Creek Indus Delta.

He has published a number of articles in environmental magazines and papers on marine and landbased species, ecosystem management and related issues. Mr Mirbahar is currently working with Switzerland based South Pole Carbon Group as Senior Forestry and Climate Change Expert. He worked on numerous projects during his 7 years of stay with IUCN Pakistan. Most recently, he completed a project with the Pakistan Navy on "Constructed Wetlands" at Karachi and Pakistan Forest Institute on "Designing REDD+ & Payment for Environmental Services". He has previously worked with Mangroves for the Future, WWF-Pakistan, UNDP GEF and environmental consultancy groups as well. He assisted IUCN Pakistan in development and implementation of a monitoring protocol for monitoring newly raised plantations of Sindh Forest Department over 10,000 ha. Currently, he is also providing technical support to civil society on Urban Forestry and biodiversity restoration projects in Megapolis Karachi and other towns.

Abdur Razzaq Khan

Wildlife (Ornithologist)
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Mr. Khan is a well known Wildlife Biologist. He has over 28 years of experience in surveying of wildlife particularly waterbirds and wetlands. He has worked on various biodiversity and conservation projects in protected areas, coastal and inlands wetlands and mangrove forests all over Pakistan. He is well acquainted with different wildlife survey methods including rapid biodiversity surveys, camera trapping, line transect censuses and habitat analysis. He has collaborated with several national and international organizations working on

biodiversity conservation in protected areas (National Parks, Wildlife Sanctuaries and Game Reserves) and also participated in waterfowl census for birds all over Pakistan and in Indus Dolphin Population Census Surveys during 2001, 2006 and 2011 (organized by WWF-Pakistan).

Ubaid Ullah

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Ubaid Ullah is a qualified professional/PhD scholar with eight years of research experience in the field of wildlife and fishries. He is a wildlife ecologist and biodiversity specialist with a good understanding of baseline survey techniques and current trends of community-based wildlife conservation and management. He has good experiencee in community-based conservation of coastal resources and has conducted different sessions and activities in schools and colleges located in the coastal belt of Karachi. He arranged training sessions for local fishermen on fish landing jetties and has over 8 years of coordination, administration and research experience with different government and non-government organizations. He has conducted more than 24 wildlife surveys to study mammalian, ornithological, herpetological fishes and other fauna in the national parks, wildlife sanctuaries, Ramsar sites and coastal areas of Sindh. He is an active member and Coordinator of "Pakistan Scientific and Cultural Society" and actively participated in more than 17 conferences, seminars, symposia, workshops and hands-on-trainings arranged from the platform of the Pakistan Scientific and Cultural Society.

Muhammad Uzair

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Muhammad Uzair is a qualified professional / PhD scholar with an M Phil degree in Marine Biology and MSc in Zoology with specialization in wildlife and fisheries. He is a wildlife ecologist and biodiversity specialist with a thorough understanding of project planning, management and community-based conservation. He has coordinated and managed different projects and is currently managing and coordinating a government funded project titled, "Development of Ostrich Farming in Punjab". In community-based conservation and coordination amongst local communities, he has over 12 years of experience in coordination, administration and research with different government and non-government organizations. He has conducted more than 20 wildlife surveys to study herpetological, ornithological and mammalian fauna in the country. He is a coordinator of Pakistan Wildlife Foundation for Karachi and has participated in more than 30 conferences, seminars, symposia, workshops and hands-on-trainings sessions.

Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS

About Mangroves for the Future

Mangroves for the Future (MFF) is a unique partner-led initiative to promote investment in coastal ecosystem conservation for sustainable development. Co-chaired by IUCN and UNDP, MFF provides a platform for collaboration among the many different agencies, sectors and countries which are addressing challenges to coastal ecosys-tem and livelihood issues. The goal is to promote an integrated ocean-wide approach to coastal management and to building the resilience of ecosystem-dependent coastal communities.

MFF builds on a history of coastal management interventions before and after the 2004 Indian Ocean tsunami. It initially focused on the countries that were worst affect-ed by the tsunami – India, Indonesia, Maldives, Seychelles, Sri Lanka and Thailand. More recently it has expanded to include Bangladesh, Cambodia, Myanmar, Pakistan and Viet Nam.

Mangroves are the flagship of the initiative, but MFF is inclusive of all types of coastal ecosystem, such as coral reefs, estuaries, lagoons, sandy beaches, sea grasses and wetlands.

The MFF grants facility offers small, medium and regional grants to support initiatives that provide practical, hands-on demonstrations of effective coastal management in action. Each country manages its own MFF programme through a National Coordinat-ing Body which includes representation from government, NGOs and the private sec-tor.

MFF addresses priorities for long-term sustainable coastal ecosystem management which include, among others: climate change adaptation and mitigation, disaster risk reduction, promotion of ecosystem health, development of sustainable livelihoods, and active engagement of the private sector in developing sustainable business practices. The emphasis is on generating knowledge, empowering local communities and advo-cating for policy solutions that will support best practice in integrated coastal manage-ment.

Moving forward, MFF will increasingly focus on building resilience of ecosystem-dependent coastal communities by promoting nature based solutions and by showcas-ing the climate change adaptation and mitigation benefits that can be achieved with healthy mangrove forests and other types of coastal vegetation.

MFF is funded by Sida, Norad, Danida and the Royal Norwegian Embassy in Thailand.

Learn more at: www.mangrovesforthefuture.org