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Ecosystem-Based Integrated Assessment for Shrimp Sustainable Management in the Kingdom of Bahrain

A Thesis Submitted in Partial Fulfillment of the Requirements for the Ph.D. Degree in Environment and Sustainable Development

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☐ Without making any changes to the thesis.

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Abstract

The Green tiger shrimp (*Penaeus semisulcatus*) is, in economic and social terms, the most common shrimp species in the Bahraini waters and the Arabian Gulf as well. The shrimp fishery is limited to artisanal vessels and operates under the supervision of the Agency for Agriculture and Marine Resources. The rapidly growing population needs increasing per capita of commercial shellfish (shrimps, molluscs, and crabs) and finfish. However, illegal fishing and destructive fishing methods have threatened the sustainability of the fishery. Therefore, this resource has biologically and ecologically based management actions that include regulation measures. Nevertheless, the shrimp population has suffered intense fishing pressure, complicating the governance of the shrimp fishery. This study assessed the shrimp fishery dynamics in the Kingdom of Bahrain from 1990 to 2020 through the ecosystem-based integrated assessment using Driver-Pressure-State-Impact-Response (DPSIR) conceptual framework and the ecosystem-based shrimp management (EBSM) approach. EBSM focuses on ecosystems, involves stakeholders, and addresses environmental issues in an adaptive, integrated, and holistic manner while also including societal aspects. Two questionnaires have been designed based on the five EBM steps, the first for decision-makers and the second for fishers, and then data were analyzed using the SPSS program. Field data was collected from August 2020 to January 2021. A total of 1695 intact *P. semisulcatus* were isolated. The shrimp were measured (total length in cm). The length frequency on monthly basis were input in FISAT II program to find out the shrimp cohorts by Bhattacharya routine. The impacts of the Covid-19 pandemic on shrimp catches have also been considered. The results showed that the shrimp fishery dynamics were affected by high demand, which has promoted the fishing effort (pressure) in response to economic and social factors (driving forces). This scenario indicated that the shrimp catch was exposed to a tendency towards resource overexploitation, negative effects on the state of benthic marine ecosystems, and negative economic impacts that result from reduced fishers' revenues, social conflicts, and ineffective fishery governance. According to decision-makers and fishers, the COVID-19 pandemic has negatively affected the quantity of shrimp caught, the number of shrimping boats, and fishers. The study recommends more efforts to incorporate all EBM principles into national rules, regulations, and procedures. In addition, the study focuses on future efforts that map out a new interdisciplinary research agenda for sustainable shrimp aquaculture in Bahrain. Finally, the assessment of the fishery management of the shrimp *P. semisulcatus* through the ecosystem-based integrated framework allowed to identify the main components that explain the trend towards the deterioration of this fishery over the last decade and propose sustainable management strategies.

Keywords: Ecosystem-based management, Marine ecosystems, DPSIR framework, Shrimp fishery management, Overexploitation, Sustainable development, Kingdom of Bahrain.

Dedication

I dedicate this thesis to those who have loved and supported me through my educational journey. I hope my love for learning will inspire you to put forth your best effort to achieve your life ambitions and goals. There is no end to education. Never stop learning. To my parents for providing me with loving support and believing in me. The pride and the appreciation you have for me have encouraged me to keep going despite the obstacles I have met. I love being the best daughter in your eyes. I can't thank you enough. I'm happy to share this journey and accomplishment with you. I love you both. Without your love and support, this ambition would not be a reality. Finally, to my wonderful mother - may Allah rest her soul in peace - your memories continue to regulate my life and push me to do my best. You have been a source of encouragement and inspiration to me throughout my life.

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Acronyms

BFC	Bahrain Fishing Company
CBD	Convention on Biological Diversity
CL	Carapace Length
COMPASS	The Communications Partnership for Science and the Sea
CPUE	Catch Per Unit Effort
DPSIR	Driver-Pressure-State-Impact-Response
EBFM	Ecosystem-Based Fisheries Management
EBM	Ecosystem Based Management
EBSM	Ecosystem-Based Shrimp Management
EEA	European Environment Agency
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPI	Environmental Performance Index
EVI	Ecological Value Index
FAO	Food and Agriculture Organization of the United Nations
FiSAT II	FAO-ICLARM Stock Assessment Tools II
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GEO	Global Environment Outlook
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
GIS	Geographic Information System
GPS	Global Positioning System
ICZM	Integrated Coastal Zone Management
IEA	Integrated Ecosystem Assessment
IFQ	Individual Fishing Quota
IGA	Information & eGovernment Authority

IUU	Illegal, Unreported, and Unregulated fishing
KSA	Kingdom of Saudi Arabia
L_c	Length at First Capture
L_m	Length at Maturity
LMRA	Labor Market Regulatory Authority
MAEBR	Management Exploitation Areas for Benthic Resources
MOH	Ministry of Health
MOI	Ministry of Interior
MOIC	Ministry of Industry and Commerce
MPAs	Marine Protected Areas
MT	Metric Ton
MUN	Ministry of Municipalities Affairs & Agriculture
NAO	National Audit Office
NBSAP	National Biodiversity Strategy and Action Plan
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NSSA	National Space Science Agency
OECD	Organization for Economic Cooperation and Development
OHI	Ocean Health Index
RECOFI	Regional Commission for Fisheries
ROPME	Regional Organization for the Protection of the Marine Environment
ROWA	Regional Office for West Asia
RS	Remote Sensing
SCE	Supreme Council for Environment
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
SPSS	Statistical Package for Social Science
TAC	Total Allowable Catch

TL	Total Length
UAE	United Arab Emirates
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNGA	UN General Assembly
VECs	Valued Ecosystem Components
VMS	Vessel Monitoring Systems

Chapter One: Introduction to the Study

1.1 Introduction

In light of a growing world population, food security is considered one of humanity's biggest challenges (Rabbitt et al., 2019). Therefore, food self-sufficiency gained increased attention in the Kingdom of Bahrain, as it was translated into royal directives to develop and implement a strategic project for national food production by allocating sites for aquaculture and plant production (BNA, 2020). In particular, the fisheries sector is vital in ensuring food security globally and in Small Island Developing States (SIDS) such as Bahrain. One of the most important commercial fisheries in Bahrain and the Arabian Gulf is the shrimp fisheries, especially the green tiger shrimp (*Penaeus semisulcatus*).

Several decisions have been issued to regulate fishing machinery, equipment, methods, conditions, procedures, licensing, and closed season to protect marine life in Bahrain. The regulation of fishing was initiated by Legislative Decree No. 5 of 1981. Then it was replaced by Legislative Decree No.20 of 2002 on regulating fishing, exploiting, and protecting marine wealth. Before 1967, landings were entirely artisanal, and shrimps were caught solely by the artisanal fishery (no trawling). In 1971, an artisanal trawl fishery was launched. Twenty-six wooden trawlers, locally known as ‘Banoosh’, were operated in 1976, which almost tripled in number during the next seven years. The Banoosh trawlers evolved from non-motorized trawlers in the 1970s to fully equipped industrial boats (Abdulqader, 2001). By 1978, the shrimp catches became unprofitable due to meager shrimp yields. A short-term ban was then enforced on shrimp fishing in August 1979. A second permanent ban was imposed on industrial trawlers in 1998. This ban, however, only involves the industrial steel trawl fishery consisting of large steel trawlers (Ali & Abahussain,

2013; Abdulqader, 2001). Banoosh trawlers had been progressively replacing the steel trawlers and generating most of the shrimp landings (Morgan, 2006; Abdulqader, 2001; Abdulqader & Naylor, 1995). A seasonal ban on all shrimp fishing is in effect every year when the shrimp fishing season closes. In 2020, the shrimp closed season was six months, from 1st February to 31st July. In addition, the bottom trawl net was prohibited following resolution No.205 for 2018. However, an attempt has yet to be made in Bahrain on shrimp stock assessment considering the growth and mortality rates, recruitment pattern, length at first capture, and exploitation rates (actual, optimum, and maximum). On the other hand, there is also a need for regular and continuous reporting on the status of shrimp catch based on scientific indicators and analysis of related policies for sustainable exploitation, conservation, and management of shrimp stock in Bahrain.

Bahrain shares most of its fish and shrimp stocks with neighboring countries such as Kingdom of Saudi Arabia (KSA) and Qatar (Morgan, 2006). Because of the heavy exploitation of shrimp stocks in the Arabian Gulf (Ali & Abahussain, 2013), there is a need to coordinate shrimp management of adjacent fisheries. Overexploitation has led to the restriction of fishing efforts by limiting fishing licenses, regulating fishing gear (for example, mesh size) and capture size, closing fishing areas, and restricting fishing season. However, fisheries management was hindered by a lack of appropriate management regulations, enforcement, and data on most stocks (Siddeek et al., 1999). In that regard, reliable shrimp fishery data are needed for stock assessment and proper fishery management (Al-Abdulrazzak & Pauly, 2014). The seasonal shrimp fishing closure has been implemented for up to six months in Bahrain, Kuwait, and Saudi Arabia. Additionally, action has been taken to prevent

the use of bottom trawl nets in Bahrain, Qatar, and United Arab Emirates (UAE).

The UNCLOS of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, Annex 1, Article 7, defined the primary role of regional fisheries management organizations in collecting data required for the management of shared fish or shrimp stocks (Mahon, 1996). As a result, RECOFI was established in 1999 within the FAO framework; its membership includes Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and UAE (FAO, 2022a; Al-Abdulrazzak & Pauly, 2014). In addition, RECOFI agreed to a mandatory requirement (effective 1st January 2012) on minimum data reporting that includes catch and effort data separated by gear (FAO, 2011a). Accordingly, most member countries have improved, or newly established catch monitoring systems based on observations at landing sites. Therefore, they have substantially improved the quality and quantity of data submitted. Furthermore, the data submitted have been used to develop management advice for the Commission (Lovatelli & Crespi, 2016; Al-Abdulrazzak & Pauly, 2014; FAO, 2013). However, RECOFI still needs to consider regional fisheries management initiatives. Therefore, Bahrain has yet to be required to incorporate regional fisheries management issues into its national legislation (Morgan, 2004).

The collapse of many marine fisheries is widely believed to result from mismanagement (Costello et al., 2016). The mismanagement of marine fisheries is not only due to poor enforcement but also because marine fishery management traditionally focuses on managing a single target species and often ignores habitat, predators, the prey of the target species, and the physical components of marine ecosystems (Pikitch et al., 2004). The conventional single-species fishery management approach has been replaced by ecosystem-based fishery management (EBFM). The

latter approach seeks to include in the management plan not only all affected species but also abiotic factors such as pollution, the effects of changes in climate on the ecosystem, and the effects of fishing activity on the habitat itself (Hilborn, 2011). International organizations and agreements have adopted ecosystem-based management (EBM) frameworks in recognition of these connections. For example, the FAO provides guidance on an ecosystem approach to fisheries (Marshall et al., 2018).

The ecosystem approach is a strategy for the integrated management of land, water, and living resources that enables conservation and sustainable use in an equitable way. It is the preliminary framework for action under the Convention on Biological Diversity (CBD). CBD has developed 12 principles organized into five steps for implementing the ecosystem approach (CBD, 2004). The CBD integrates ecological, social, and governance objectives and describes EBM. Despite variability in the terminology of ecosystem approach (such as ecosystem-based management, ecosystem approach to fisheries, ecosystem-based shrimp management, ecosystem management, and ecosystem-based ocean planning), the general merit of EBM approaches is that they include the interactions among ecosystem components, humans, and the cumulative impacts of multiple activities, promoting conservation and sustainable use of resources (Gelcich et al., 2018; Nguyen, 2012; Vihervaara & Kamppinen, 2009).

There is an emerging paradigm shift in marine management, a move towards explicit consideration of the impacts of all sectors on the marine environment, both separately and in aggregate. This comes from an increasing awareness of the cumulative effects of human activities on the ecosystem and the need to take a holistic and integrated approach to management to ensure the sustainability of marine ecosystems (Ottersen

et al., 2011). As a result, there is an increasing demand for more integrated ecosystem-based management.

The importance of sustainable management of marine resources is emphasized by the United Nations Sustainable Development Goals 2030 (SDGs) through SDG 14 (Life below water), which aims to conserve and sustainably use the oceans, seas, and marine resources (Haas et al., 2020; Cook et al., 2019; Pinheiro et al., 2019). Many SDG 14 targets are linked to or dependent on implementing sustainable fisheries management, for instance, 14.2, 14.4, 14.5, 14.6, 14.7, 14.B, and 14.C. Furthermore, the ecosystem-based approach has been incorporated as an indicator for SDG 14.2 on sustainable management and protection of marine and coastal ecosystems. The achievement of SDG 14 can also contribute to the achievement of SDG 1 (on ending poverty), SDG 2 (on ending hunger, achieving food security and improved nutrition), and SDG 8 (on sustained, inclusive, and sustainable economic growth, full and productive and decent employment) as reported by Kenny et al., (2018) and Diz et al., (2019). On the other hand, it was reported that Bahrain needs to exert more effort to achieve SDG 14 as it has remained a significant challenge for the country for three years (Sachs et al., 2022; Sachs et al., 2021; Sachs et al., 2020).

The purpose of the present study is to evaluate the shrimp fishery management in Bahrain using ecosystem-based integrated assessment to determine to which extent the management is effective in meeting the principles of SDG 14.

1.2 Research Problem

Commercial fisheries in Bahrain considerably contribute the food security. Consequently, several decisions have been issued to protect

marine life. The most recent is the banning of shrimp fishing by trawling and adopting a closed season for six months to maintain spawners and enhance the shrimp stock and commercial fish species. The data mostly focused on fish landing in the annual reports, however, no attempt has been made on fish stock assessment to highlight the growth and mortality parameters and the exploitation rate, neither for commercial finfish nor shrimp. Moreover, there is a lack of regular and continuous reporting on fish catch analysis and policy analysis to determine the effectiveness of legislation and regulations of fishery status. The shrimp fishery represents a shared stock with adjacent countries particularly KSA on the west and northwest and Qatar on the east. The fisheries authorities in the GCC countries and the Arabian Gulf also adopt management policy that differs somewhat in the application of fishing season and allowable fishing methods, which is potentially reflected in the sustainable exploitation of commercial catch in general and shrimp in particular.

1.3 Research Questions

This study seeks to answer the following questions addressed to achieve research objectives:

1. What is the status of shrimp fisheries in the Kingdom of Bahrain?
2. What are the impacts of prolonging the ban of shrimping from four months to six months (starting from 2020) on shrimp stock?
3. To which extent the prohibiting of using bottom trawl net revive both shrimp and other commercial finfish species?
4. How is the shared shrimp stock managed in concern with the adjacent countries?
5. Which suitable applicable scenarios and policy options could be applied to sustainably manage the shrimp fishery?

1.4 Research Objectives

The ecosystem-based integrated shrimp management was designed to:

1. Assess exploitation sustainability of shrimp fisheries using DPSIR (Driver-Pressure-State-Impact-Response) framework.
2. Determine the effectiveness of policies to manage the shrimp fisheries sector.
3. Identify 'business-as-usual' scenario, the Ecosystem Based Management (EBM) scenario of shrimp fisheries and policies options to be applied for sustainability.
4. Find out the impacts of regional shrimp fisheries policies particularly of adjacent GCC countries on the sustainability of shrimp fisheries in Bahrain.
5. Determine the ratio of allowable lengths to be captured (larger than lengths of maturity) of green tiger shrimp (*P. semisulcatus*) during 2020 open season.

1.5 Research Significance

Food security and sustainable exploitation of marine resources play an essential role as part of the SDGs. Therefore, the sustainable management of shrimp fishery can promote the maintenance of the quality, diversity, and availability of shrimps in adequate quantities for present and future generations in the context of food security and sustainable development. Therefore, it is crucial to investigate the exploitation status of shrimp fisheries in the Kingdom of Bahrain using an integrated assessment approach.

The research will support the decision-makers and specialists in fisheries affairs to effectively manage the shrimp fisheries sustainably by

developing a fishery management plan. The management procedure in the study plan will provide details on how management decisions are to be effective in accordance with fishery development. Moreover, the study provides an opportunity to find out the feedback of fishers to support decision-making fisheries management.

The research will make a timely contribution to fishery authority to initiate preliminary stock assessment studies, particularly on Bahrain's most commercially important finfish and shellfish species. A solid analytical, system-oriented modeling technique was used to analyze the cause-effect relationships between interacting components of socioeconomic and environmental factors using the DPSIR framework and EBM model, which are strongly recommended by the National Oceanic and Atmospheric Administration (NOAA) (Harvey et al., 2021). Hence, this research will support the national reports on fisheries status and Bahrain's rank in related international indices such as Environmental Performance Index (EPI), SDG Index, and Ocean Health Index (OHI).

1.6 The study's setting

The shrimp fishery is Bahrain's most important fishery resource (Ali & Abahussain, 2013). Green tiger shrimp, *P. semisulcatus*, is the dominant shrimp species in Bahrain (Abdulqader, 1999) and is constituted 70% of the catches (Bishop et al., 2008). However, the other shrimp species (*Penaeus latisulcatus*, *Metapenaeus stebbingi*, *Metapenaeus kutchensis*, *Trachypenaeus curvirostris*, *Metapenaeopsis stridulans*, and *Metapenaeopsis mogiensis*) are of minor commercial importance (Abdulqader, 1999, 2010).

Several policies were issued in Bahrain to protect marine resources. The government has regulated the catching, trading, or selling of shrimp

since the 1980s. The shrimp closed season was first declared in 1980 (decree No. 26 for 1980). That decree set the closed season from 1st March to 30th June. A Ministerial decree opens and closes the shrimp season annually. In 2018 was a five-month closed season from mid-March to mid-July. The closed season then has been increased from four to six months, from 1st February to 31st July, according to resolution No. 18 for 2020. The closed season is mainly imposed to safeguard the spawning stock of commercially important shrimp and fish species. Furthermore, the bottom trawl net was prohibited based on resolution No.205 for the year 2018 due to its adverse impact on lowering the biodiversity of the marine habitat. However, no studies have been performed to assess the fishery stock status after implementing these resolutions.

The Kingdom of Bahrain has been ranked 110th in the 2022 EPI fisheries indicators among 180 countries and 5th in the GCC region. The Environmental Performance Index (EPI) ranks countries on eleven priority environmental issues with three objectives: environmental health, ecosystem vitality, and climate change mitigation. The fisheries category consists of three performance indicators; fish stock status, Marine Trophic Index, and fish caught by trawling and dredging (EPI, 2020, 2022). Bahrain scored 17.6 (rank 43) on Marine Trophic Index and 6.8 (rank 69) for fish caught by trawling and dredging. However, no data is available regarding the fish stock status (EPI, 2022). Another comprehensive index that measures the impact of human activities on marine ecosystems is the Ocean Health Index (OHI). This index is based on several indicators comparing the ocean systems in 221 exclusive economic zones (Gulseven, 2020). One of the indicators is the food provision index. This index measures the amount of seafood captured or raised sustainably. The goal score is higher when the seafood harvested or cultured sustainably is increased. The ideal score is 100; Bahrain scored 30 in 2019 (OHI, 2020).

According to OHI, Bahrain needs to make more efforts to ensure fisheries' sustainability and protect its marine resources.

It is crucial to assess shrimp fisheries management toward sustainable exploitation by linking the status of shrimp fisheries to the stakeholders' social, economic, and legal responses. Such a link could best be demonstrated using relevant indicators. Indicators act as information tools and could help in characterization the status of the shrimps and provide an objective system of information and evaluation. Over the past decades, efforts to expand understanding of the interaction between social systems and environmental variability have improved. It has been achieved by using socio-economic indicators that link the state of the environment to the social and economic drivers and responses (Mangi et al., 2007). Lieberknecht (2020) has used the ecosystem-based integrated assessment as an adaptive approach for governing human activities in the marine environment, rooted in the EBM approach, guided by the SDGs 2030. It strongly focuses on improving the marine ecosystems' ecological status and strategic integration across governance, knowledge, and stakeholders through an integrated environmental assessment. This study evaluates the exploitation status and the sustainable management practices in the shrimp fishery in the Kingdom of Bahrain using ecosystem-based integrated assessment. The flowchart presented in Fig. 1.1 illustrates the scope of the study indicating the input and the expected outputs.

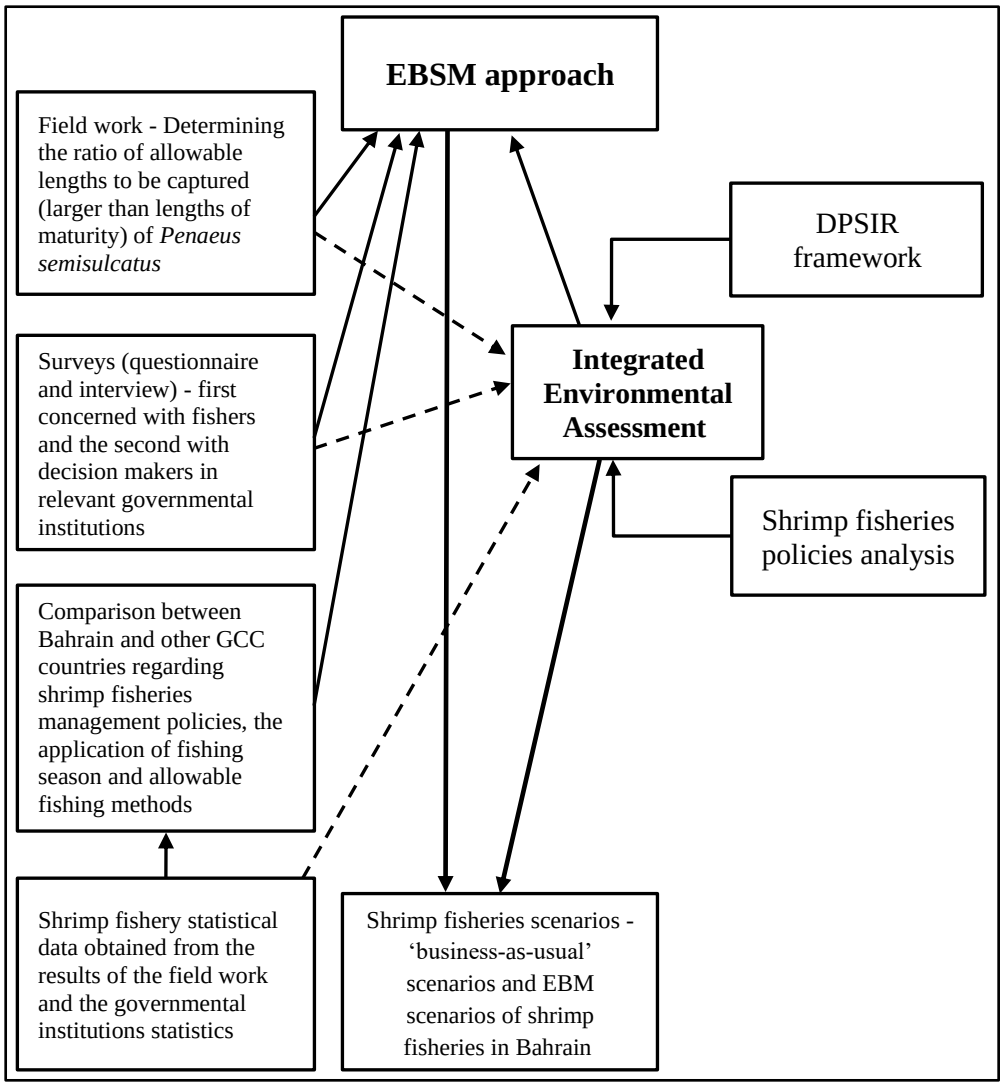


Fig. 1.1: Flowchart of ecosystem-based integrated assessment.
Source: Designed by researcher

1.7 Research Terminology

- **Biodiversity**: defined in CBD Article 2 as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Morgera, 2018).
- **Bycatch**: catch that is either unused or unmanaged (Davies et al., 2009).

- **Catch Per Unit Effort (CPUE)**: the total catch in a specific period (such as year, month, or season) divided by the total amount of effort used to gather the catch in the corresponding period. CPUE is often used for fishery stock assessments and as an index for measuring the abundance variation of fishery resources (Zhu & Wang, 2016).
- **Cohort**: a set of individuals of a fishery resource born from the same spawning (Cadima, 2003).
- **Consumer Price Index**: measures differences over time in the general prices of goods and services that a population acquires, uses, or pays for consumption (OECD, 1998).
- **Driver-Pressure-State-Impact-Response (DPSIR) framework:** an adaptive management tool developed in the late 1990s and was proposed by the Organization for Economic Co-operation and Development as a means of structuring and organizing variables in a way that is meaningful for decision-makers. It helps to identify cause-effect relations and understand, analyze, and identify solutions to environmental problems (Ramos-Quintana et al., 2018; Tscherning et al., 2012; Atkins et al., 2011).
- **Ecological Value Index**: a tool used to measure and assess a particular ecosystem's ecological health and diversity. It considers various factors such as species richness, habitat quality, and ecosystem services to determine the overall value of an ecosystem (Fanfarillo & Kasperski, 2021).
- **Ecosystem services**: define as the benefits which humans obtain from ecosystem functions and resources include provisioning, regulating, cultural and supporting services (Fontana et al., 2013; MEA, 2005).
- **Ecosystem**: a dynamic complex of biotic or living organisms such as plant, animal, and microorganism communities and the nonliving or abiotic environment interacting as a functional unit (MEA, 2005).

- **Ecosystem-Based Fishery Management (EBFM)**: The US National Research Council defines EBFM as an approach that considers significant ecosystem components and services, including structural and functional components, in managing fisheries. It values habitat, adopts a multispecies perspective, and is devoted to understanding ecosystem processes. Its goal is to rehabilitate and sustain species, populations, communities, and marine ecosystems at high levels of productivity and incredible biodiversity to not threaten various goods and services from marine ecosystems while providing food, revenues, and recreation for humans (Karim et al., 2020).
- **Ecosystem-Based Management (EBM)**: a term used to describe a balanced way of managing resources while considering the surrounding ecosystem (de Jonge & Schückel, 2021).
- **Ecosystem-Based Shrimp Management (EBSM)**: a holistic way of managing shrimp is by considering the entire ecosystem of the species being managed (Clark et al., 2022).
- **Finfish:** defined as cold-blooded aquatic craniate vertebrate with fins for locomotion and gill for respiration. Its skeleton is made up of either bone or cartilaginous (Bharti, 2017).
- **Fisheries management**: the integrated approach of data gathering, analysis, planning, consultation, decision-making, distribution of resources, and formulation plan and implementation, with enforcement as necessary, of fisheries regulations or rules to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives (Cochrane & Garcia, 2009).
- **Fishery:** the place or act of taking fishes or shrimp or other sea organisms for human use (Nybakken, 2001).
- **Fishing effort:** is a measure of the amount of fishing and is defined with respect to the number of vessels, the number of hours or days

spent fishing, the number of hooks used, kilometers of nets used, etc. (Guillen et al., 2017).

- **Governance**: defined as the process of decision making and the process by which decisions are implemented (or not implemented), which is designed to ensure accountability, transparency, responsive to people's needs, presence of the rule of law, stability, equity, and inclusiveness, openness, empowerment, broad-based participation (Ali, 2015).
- **Habitat**: the place where an organism or population naturally occurs (Mitchell, 2005).
- **Indicator**: A variable or index related to a criterion or system attribute. Its fluctuations reveal the variations in those critical elements of sustainability in the ecosystem, the fishery resource or the sector, and social and economic well-being. The trend of an indicator in relation to reference points indicates the system's present state, which forms the basis for decision-making (FAO, 1999).
- **Input-control measures**: If fishery managers aim to constrain any aspect of fishing effort directly, they seek to implement an input control measure. It includes four matters: who does the fishing, when they can fish, where they can fish, and how they can fish (Morison, 2004).
- **Integrated Ecosystem Assessment (IEA)**: A formal synthesis involving both a qualitative and quantitative analysis of information related to environmental, social, and economic factors that are relevant to specific ecosystem management objectives (Levin et al., 2009). It is adopted by the National Oceanic and Atmospheric Administration (NOAA) in the United States; the IEA framework represents a process by which management goals are defined, indicators to track performance against these goals are developed, the indicators are

assessed to identify the highest risks to attaining management goals, mitigation strategies are tested through a management strategy evaluation, and the most effective strategies are implemented by managers (Harvey et al., 2017).

- **Integrated Environmental Assessment**: an assessment that includes social, economic, and environmental aspects in analyzing environmental state and trends, including policy analysis. It usually covers a broad scope of topics and policies and all elements of the environment, such as habitats, species, biological, physical, and chemical processes. It may incorporate global, regional, and national perspectives as well as historical and future perspectives in an integrated examination of environmental change and human and societal well-being (Baker & Beaudoin, 2019).
- **Legislative decree**: a statement issued by the top of the legal system. It aims to command, prohibit, or allow certain behaviors (Gelcich et al., 2018).
- **Length-weight relationship**: indicating the rate of weight gain relative to growth in length or the rate at which weight increases for a given increase in length (Datta et al., 2013).
- **Marine Protected Area (MPA)**: any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all the enclosed environment (Kelleher & Kenchington, 1991).
- **Monitoring, control, and surveillance**: Activities undertaken by the fishery enforcement system to ensure compliance with fishery regulations (FAO, 2023a).
- **Overcapitalization:** the employment of capital at a level above the optimal level (Lancker, 2018). In simple terms, overcapitalization is

more capital than is required, and the funds are not properly used (Swathi, 2016).

- **Overexploitation**: the rate of exploitation where the fish or shrimp stock is drawn below the size that on average, would support the long-term maximum potential yield of the fishery (Murawski, 2000; OECD, 1998).
- **Recreational fishing**: all fishing activities not conducted for commercial or subsistence purposes (Kleiven et al., 2016).
- **Resolution**: a statement issued by the executive authority that specifically contains rules, descriptions of ways, and instruments, among others, which allow the implementation of a decree (Gelcich et al., 2018).
- **Shrimp landings**: represents the shrimp caught and brought to shore by commercial fishers (O'Connor & Matlock, 2005).
- **Size at first capture (L_c)**: the length at which 50% of individuals in the population entering a trawl net are retained by the gear (Pauly, 1984).
- **Size at first sexual maturity**: the length at which 50% of individuals in the population are sexually mature (Ismaila et al., 2021).
- **Small Island Developing States (SIDS)**: a distinctive group of 38 United Nations (UN) member states and 20 non-UN members or associate members of regional commissions facing unique social, economic, and environmental vulnerabilities, including small size, remoteness, susceptibility to climate change, sea-level rise and biodiversity loss, and limited resource base. In addition to other environmental challenges, such as degradation of natural coastal and marine resources, food security, coastal urbanization, pollution, and waste management, which can delay the efforts to achieve national targets of United Nations Sustainable Development Goals 2030 (Naser,

2022; Winters et al., 2022; Zitoun et al., 2020; Sietchiping & Kago, 2017; Hay, 2013).

- **Stakeholder**: Any individual, group, organization, or sector in society that has an identifiable interest in the outcome of a policy or decision-making situation. The interest may be in the form of a specific management responsibility, a commercial interest, a subsistence need, or other commitments as a member of civil society (FAO, 1999).
- **Stock**: a set of survivals of the cohorts of a fishery resource at a particular instant or time. It may involve the biomass or the number of individuals (Cadima, 2003).
- **Sustainable development**: defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Emas, 2015). The United Nations have adopted it as a guiding principle for economic, environmental, and social development (Hansmann et al., 2012).
- **Trawling**: is the operation of towing a net to catch fish, shrimp, or shellfish. The trawls are towed either with bottom contact or in midwater (FAO, 2023b).
- **Unmanaged catch**: individual species or groups of different species that do not have specific management to ensure their sustainability (Davies et al., 2009).
- **Unused catch**: catch that is not used for consumption or reused by the fisher as bait. It includes discards (that portion of the catch thrown overboard) and wasted catch after landing that is neither sold nor directly consumed (Davies et al., 2009).

Chapter Two: Literature Review and Theoretical Framework

2.1 The State of Shrimp Fisheries in the World and GCC Countries

Shrimp resources are very diversified and support a large variety of fisheries (Gillett, 2008). Shrimp fisheries take place all over aquatic ecosystems, and it has had considerable economic and social significance (Rodrigues-Filho et al., 2020). Recently, the global production of shrimp species has risen from about 3.6 million tons in 2017 to approximately 6.5 million tons in 2019, mainly due to the high commercial value of these resources in the market, to the increased population and demand for the seafood market (Lee et al., 2022; FAO, 2020a; FAO, 2019), contributing to intense shrimp fishery pressure.

The GCC region (Bahrain, KSA, Kuwait, Oman, Qatar, and UAE) is rich in fisheries and diverse in marine resources, making it a region with a high level of biodiversity and ecosystem complexity (Alshubiri et al., 2019). Fisheries resources in the Arabian Gulf are second to oil and natural gas productions in their economic importance, contribute to the national food security (Ben-Hasan & Christensen, 2019; Al-Baz et al., 2018). According to the latest published FAO Fisheries Statistics, the total fisheries in the GCC countries was estimated by 726,985 tons in 2018 (FAO, 2020b). The shrimp fishery is among the most productive and valuable fisheries in the Arabian Gulf (Hassanien & Al-Rashada, 2019) and Bahrain as well. On the other hand, several studies have reported that fish stocks and fisheries in the Arabian Gulf suffer from overexploitation, overcapitalization, and extremely high discarded bycatch rates – all presenting a serious threat to fisheries productivity in the GCC region (Ben-Hasan & Christensen, 2019; Al-Salim & Jassim, 2015; Ali & Abahussain, 2013).

Mechanisms for communication between governments and fishers through unions and associations exist in most GCC countries (except for KSA and Qatar). However, government agencies predominantly make fisheries decisions (Ben-Hasan & Daliri, 2022). On the international level, there are few fishing arrangements among countries to harvest transboundary fish stocks. RECOFI recently agreed to implement a seasonal closure for the Kingfish (*Scomberomorus commerson*) from 15th August to 15th October (RECOFI, 2021).

Most fisheries in the Arabian Gulf are unassessed, partly explaining the scarcity of management actions like catch limits or rebuilding plans (Ben-Hasan & Christensen, 2019). Imposing a science-based limit on the total annual catch requires long-term data, for example, historical information sources on relative abundance indices and conducting stock assessment models that use such data to estimate a sustainable harvest level. The limited or lack of data collection programs and stock assessment also complicates designing and setting rebuilding plans, which, along with catch limits, are essential instruments in sustaining fisheries worldwide (Melnychuk et al., 2021). Nevertheless, fish stocks in Abu Dhabi (in UAE) are continuously assessed (EAD, 2021).

The Arabian Gulf countries (Bahrain, Iran, Iraq, KSA, Kuwait, Oman, Qatar, and UAE) shared many valuable fish stocks, for example, the silver pomfret, hilsa shad (*Tenualosa ilisha*), orange-spotted grouper (*Epinephelus coioides*), javelin grunter (*Pomadasys kaakan*), sailfish (*Istiophorus platypterus*), narrow-barred Spanish mackerel (*S. commerson*) and the green tiger shrimp (*P. semisulcatus*) (Al-Husaini et al., 2015; Hoolihan et al., 2006; Hoolihan, 2004; Ye et al., 2003). In addition, several studies have emphasized the need for effective management of shared stocks (Grønbæk et al., 2018; Bailey et al., 2010; Munro et al., 2004). Still, there are limited effective collaborations to

manage shared fish stocks in the Arabian Gulf. In addition, the biology and fishery dynamics of most shared fish stocks remain largely unknown (Ben-Hasan & Daliri, 2022).

The biggest issue facing the sustainability of the Arabian Gulf fisheries is weak enforcement of the management actions (Ben-Hasan et al., 2021; Jabado et al., 2018; Jabado & Spaet, 2017; Al-Abdulrazzak et al., 2015; Al-Abdulrazzak & Pauly, 2014; Al-Abdulrazzak, 2013). For example, illegal fishing occurs during seasonal closures in Bahrain and Kuwait, and undersized fish and shrimp are captured despite legal minimum size limitations (Ben- Hasan et al., 2021). The currently applied management actions can effectively rebuild and sustain fisheries, but the lack of strict enforcement potentially undermines their benefits (Prince & Hordyk, 2019). For instance, continued fishing during seasonal closure is expected to threaten the protection of the spawning stock (through recruitment overfishing) and reduce the maximum potential catch (through growth overfishing) (Ben-Hasan & Daliri, 2022; Ben-Hasan et al., 2021). On the other hand, if high minimum size limits were to be enforced rigorously, projections of fish or shrimp catch and biomass trends tend to a substantial recovery over the long term (Ben-Hasan et al., 2021).

The coastal area of the Arabian Gulf comprises a range of productive habitats such as rocky shores, mudflats, mangroves, and coral reefs which are considered an important nursery area for various commercial fish and shrimp (Al-Yamani et al., 2021; Edmonds et al., 2021; Lin et al., 2021; Al-Husaini et al., 2015). In most Arabian Gulf countries, the coastal area has experienced extensive changes due to urbanization and industrialization (Burt, 2014). A significant part of coastal development projects is dredging and land reclamation activities (Naser, 2015). Because coastal developments have often been associated with little

environmental considerations, there has been a fast and widespread degradation of vital coastal habitats (Burt, 2014). Moreover, dredging and reclamation activities can be environmentally deleterious since they generally involve removing and burying sensitive habitats (Van Lavieren et al., 2011). Such coastal developments have caused severe impacts on many crucial habitats in the Arabian Gulf, such as fragmentation and degradation of thousands of hectares of seagrass beds; burial of coral reef habitats; and a significant decline in mangroves areas in some countries (Burt, 2014; Burt et al., 2013; Erftemeijer & Shuail, 2012; Van Lavieren et al., 2011).

The modification and deterioration of habitats are among the biggest threats to fish and shrimp species in the Arabian Gulf (Buchanan et al., 2019). Even if there is reasonable control of fishing pressure, the destruction of essential habitats can affect stock productivity and ultimately fisheries production (Brown et al., 2019; Ben-Hasan et al., 2017). Therefore, restoration and protection of important habitats are critical, at least for the continued supply of recruitment to fisheries; however, protection is usually more effective than restoration (Brown et al., 2019). Although marine protected areas (MPAs) are implemented in all GCC countries, their coverage is less than the 10% of coastal and marine areas indicated in SDG14.5, except for UAE, where it reached around 12% (Andriamahefazafy et al., 2022; Van Lavieren & Klaus, 2013).

For degraded habitats, many countries in the Arabian Gulf are conducting restoration interventions, and where development cannot be prevented, countries are establishing environmental compensation programs such as experiments to replant mangroves (Edmonds et al., 2021; Van Lavieren et al., 2011). However, restoration activities are generally costly, even for reasonably accessible habitats like mangroves

and coral reefs, and complete failure of restoration projects is common (Bayraktarov et al., 2016).

2.2 Shrimp Fisheries in Bahrain

In Bahrain, fishery catches consist of a wide variety of finfish species, in addition to shrimp fishery and crab fishery (Ali & Abahussain, 2013). In 2018, the total capture fisheries landings were estimated at 15,000 tons (FAO, 2020b). However, there is some indication that fisheries populations are reducing in Bahrain, as catch per unit effort has decreased, even though absolute catch quantities increased from 2010 to 2012. Commercial fisheries in Bahrain netted approximately 13 million BD in 2012 (Bin Daina et al., 2015). Traditionally, the shrimp fishery is the most critical in Bahrain. From 1980 to 2001, the lowest shrimp landing was 754 tons in 1992, which resulted from the Gulf War (Abdulqader, 2002). The highest was 3,565 tons in 1996, declining from 2,530 tons in 1998 to 1,359 tons in 2001 (Morgan, 2006). From 2004 to 2018, the shrimp catches showed an oscillation pattern with an increasing tendency in the shrimp fishery (IGA, 2019; Ali & Abahussain, 2013).

The green tiger shrimp *P. semisulcatus* is one of the most productive and commercially important fisheries in the Arabian Gulf and the Sea of Oman (Rabaoui et al., 2017) and is the dominant shrimp species in Bahrain (Abdulqader, 1999), which constituted 70% of the catches (Bishop et al., 2008). Despite its economic importance as a fisheries resource, there has yet to be a formal stock assessment of the green tiger shrimp stocks in Bahrain. In the Bahraini territorial waters, management is solely based on input-control measures, specifically licensing and seasonal closures, as the basic biological knowledge necessary to conduct the stock assessment and

design policies for sustainability-oriented management needs to be present.

2.3 Green Tiger Shrimp *Penaeus semisulcatus*

Penaeids are decapod crustaceans that belong to the largest class of crustaceans called Malacostraca, in the sub-order Dendrobranchiata (Mathew et al., 2020). They shed demersal eggs which hatch as nauplii, and moult into a protozoea that uses antennal locomotion and feeds on phytoplankton (van der Velde et al., 2021). Penaeid shrimps are generally found in tropical and sub-tropical latitudes in shallow waters (Dall et al., 1990). They are fast growing, short lived and fecund, with a complicated life cycle that includes offshore spawning followed by a coastal post-larval and juvenile phase. Juveniles then recruit back to the offshore fishery grounds (van der Velde et al., 2021; Gulland & Rothschild, 1984). Environmental factors affecting the penaeid shrimps' survival during the early life cycle stages, and during movement between these stages, will affect variability in recruitment to the nursery ground, the offshore subadult and adult population, and ultimately catch. Therefore, factors affecting larval survival, including food availability, have significant implications for fishery production (van der Velde et al., 2021). Hoang et al., (2002a) emphasized that ovarian maturation and spawning of penaeid shrimps are influenced by environmental factors. Water temperature is considered one of the environmental factors that strongly influence its reproduction, in which increasing temperature and day length were found to stimulate ovarian maturation and spawning (Hoang et al., 2002b). Ghamrawy (1990) indicated earlier to the influence of water temperature and seasonal change on reproductive activities in penaeid shrimps. Franco et al., (2006) discussed the environmental factors that affect the penaeid

shrimps' growth such as food quantity and quality, water temperature and salinity.

P. semisulcatus is widely distributed across the continental shelf in the Indian Ocean, the West Pacific Ocean, and the Eastern Mediterranean Sea (Rabaoui et al., 2017). Its commonly have a life cycle of about one year. Natural mortality rates are therefore high and determination of the optimum sizes at capture is sensitive to estimates of growth and mortality (Gulland & Rothschild, 1984).

In the western Arabian Gulf, spawning of the *P. semisulcatus* was reported to take place during winter and spring (Price & Jones, 1975). The spawning period for the *P. semisulcatus* in Bahrain waters was from December towards March (Muhammad, 1978). It was observed by Abdulqader & Naylor (1995) that from October onwards *P. semisulcatus* move further northwards for spawning, and from May onwards move from shallow nursery areas on the east and north coasts of Bahrain to a deeper main fishing ground to the northeast. Additionally, the main recruitment period of *P. semisulcatus* juveniles to fished stocks is from April to July. Ali & Abahussain (2013) found that shrimp catch seasonally fluctuated between the northern and eastern fishing grounds following its spawning migration cycle. Accordingly, the fishers transfer their fishing operations from/to these two fishing grounds, particularly during April-May and September-October. The growth patterns studies suggested that there is a degree of spatial discontinuity in population structure (Ye et al., 2003). In the north-east Arabian Gulf, analysis of length frequency data for *P. semisulcatus* that was obtained from the fishery catch samples and trawl survey data, have revealed a stock with a rapid seasonal growth, fast maturation, undergoing over-exploitation (Niamaimandi et al., 2008a; Niamaimandi et al., 2007).

The gonad maturity analysis performed by Niamaimandi et al., (2007) has shown that the significant spawning periods of *P. semisulcatus* were in winter and early spring. Also, there is a minor peak in autumn, characterized by rainy seasons in the Bushehr area. The mature shrimps were aggregated in 20-30m depth during the period from December to March. Furthermore, the gonad maturation analysis by Moradi et al., (2009) showed that the adult and mature females of *P. semisulcatus* accumulate in northern Bushehr waters at the end of autumn, while the immature species, with the least, mean length collected in the southern area. However, Al-Sayed (2010) indicated that *P. semisulcatus* has two spawning seasons, peak spawning in September and December.

In Bahrain, several shallow areas were known for their importance to penaeid shrimps, such as Fasht Al-Adhom, Tubli Bay, Qumais, Umudood, Fasht Al-Jarim, Khur Fasht, Bouyat Salisil, and others marine habitats (SCE, 2009). The role of these shallow waters in Bahrain penaeid shrimp life cycle was studied in Tubli Bay by Abdulqader (1999). The results indicated that *P. semisulcatus* have offshore spawning, which confirmed similar findings reported by several previous studies carried out by Price (1979), Rothlisberg et al., (1987), Crocos (1987) and Grabe & Lees (1992). Moreover, *P. semisulcatus* juveniles and sub-adults were abundant in shallow water from February onwards (Abdulqader, 1999). Seagrasses are common in shallow areas (<10 m), forming the base of trophic pyramid. At least three seagrass species are known for the region, but most communities are dominated by *Halodule uninervis* (Alkhathlan, 2020; ROPME & IUCN, 2016; Abdulqader & Naylor, 1995). Seagrasses are also an important habitat for *P. semisulcatus* nurseries, as described by Price et al., (1993), Price (1976) and Coles et al., (1987). FAO (1978) suggested that Tubli Bay is a nursery ground for *P. semisulcatus*, while Abdulqader

(1995) indicated that Fasht Al-Adhom is the main nursery ground for this species as part of the Bahraini coastal area, which considered as key nursery habitats for the *P. semisulcatus* (Abdulqader, 1999).

2.4 Shrimp Fishing in Bahrain: Gears and Legislation

Traditional method of hand push-net in shallow muddy bottoms was the main shrimp fishing method along the Red Sea coasts (Neve & Al-Aiidy, 1973). In Bahrain, the tidal barrier trap, locally known as Hadhrah was traditionally used for shrimp fishing. These traps are usually placed against the direction of shrimp migration (Abdulqader, 2001). The importance of these traps in shrimp fishery was reduced after the introduction of trawling in 1967 (FAO, 1978). Bottom trawl nets are responsible for most shrimp landings in Bahrain up to 15 November 2018, the date for issuing resolution No. 205 of prohibiting shrimp trawling.

Bahrain Fishing Company (BFC) was the first established company for shrimp fishing. This company started its fishing operations in March 1967 (Morgan, 2006; Abdulqader, 2001). The export-aimed fishing activity started with shrimp fisheries in 1967 (Abdulqader, 2007). American and Japanese markets were the purchasers of Bahraini shrimp catches (Boerema & Job, 1968). Bahrain's shrimp export was discontinued in August 1979 after sharp declines in the shrimp catches, resulting in the closure of this company. Industrial fishing was re-started in 1980/81 season, with four steel-hulled vessels (Abdulqader, 2007; Abdulqader, 2001). The artisanal trawl fishery started in 1971 by fishers previously involved in the barrier trap fishing. Shrimp trawl fishing was practiced through using steel-hulled, wooden and fiberglass boats. The artisanal vessels initially pulled trawl nets by hand and then mechanically by hydraulic winches starting from 1990/91 season. Shrimp fishing is

mainly conducted at night. Industrial trawlers have been banned in Bahrain since 1998, and artisanal vessels have carried out all shrimp fishing (Morgan, 2006; Abdulqader, 2001).

The basis of marine resource and fisheries law in the Kingdom of Bahrain is the No. 5 of 1981 Amiri Legislative Decree. In addition, other ministerial resolutions have been issued to clarify or specify issues presented in the Legislative Decree No. 5 of 1981 on regulating fishing practices. After the implementation of the registration and a licensing scheme in 1982, shrimp trawlers increased to 68 boats. In 1998, the number of licensed shrimp trawlers increased to about 400 boats (Abdulqader, 2010; Morgan, 2006; Abdulqader, 2001). The increased number of boats involved in shrimp fishing has caused an overfishing problem and increased the bycatch, thereby threatening marine species accidentally caught in shrimp trawlers (Abdulqader, 2010). Trawling is regarded as the most destructive fishing method because trawlers unselectively capture marine organisms, irrespective of their commercial or ecological values. In particular, bottom trawlers seriously damage and disturb benthic habitats essential to benthic and demersal communities (Tao et al., 2018).

Moreover, in many areas of the world, shrimp exploitation is a significant problem (FAO, 2000), associated with growth overfishing that causes reduction and depletion of spawners; as a result, the recruitment process and stock recovery are greatly hindered (Ahamed et al., 2022). Bahrain's fishery resources and marine habitats remain increasingly threatened by various stressors such as marine dredging and reclamation activities, fishing operations, and industrial effluents. Overfishing poses the most significant environmental threat, representing a major adverse pressure on fisheries productivity in the GCC region (Van Lavieren et al., 2011). Accordingly, Legislative Decree No. 20 of 2002 was issued to

regulate the exploitation of fishery resources in the Kingdom of Bahrain. Nevertheless, there is historical evidence of overexploitation and stock declines of many commercial species in the Arabian Gulf in general and Bahrain in specific. So that, the assessment status of fishery resources especially shrimp is sorely needed (Ali & Abahussain, 2013).

To mitigate the problem of overfishing and the adverse effects of trawling, the Government of Bahrain imposed a permanent ban on shrimp trawling over all the fishing grounds starting on 15th November 2018 (Resolution No. 205 of 2018). This ban aims to rehabilitate the marine benthic ecosystem and associated marine biodiversity and fisheries resources in Bahrain's territorial waters. Similar trawl ban policies have been adopted in other GCC countries and other parts of the world with varying degrees of success. For example, trawl nets are banned in Oman, Qatar, and UAE. In KSA, Kuwait and Iran, trawl nets are regulated by limiting the mesh size, depth, and area in which trawl nets are deployed (Ben-Hasan & Daliri, 2022). Trawling for shrimp has been banned in UAE since 1980 to safeguard spawning grounds (Aspinall, 2001), while in Oman and Qatar, the use of bottom trawling has been banned since 1992 (Al-Shehhi et al., 2021; Al-Ansi & Priede, 1996). Walton et al., (2018) study demonstrates high biodiversity in benthic habitats in the central and southwestern of the Arabian Gulf, which may in part be due to the absence of trawling activity in Qatari waters.

From a global perspective, Fiorentino et al., (2008) reported increases in the biomass of most demersal species in the Gulf of Castellammare (northwestern Sicily, central Mediterranean) after a 14-year trawl ban. In addition, the implementation of restrictive management brought notable increases in catches in Indonesia (Buchary, 1999; Bailey,1997) and Kenya (Munga et al., 2012) within two years of the introduction of trawl bans; through using other legal, non-trawling fishing

methods (Swaleh et al., 2015). Furthermore, Tao et al., (2018) studied the recoveries in ecosystem structure and function following the trawl ban in Hong Kong waters; Hong Kong Government implemented a permanent territory-wide trawling closure on 31st December 2012. This study investigated shrimp population dynamics before and after the trawl ban. They found that their mean weight, mean carapace length, and proportion of large-sized individuals increased significantly 3.5 years after the trawl ban. Such a trawl ban creates a unique opportunity to investigate recoveries in ecosystem structure and function following a significant shift in disturbance regime by removing impacts from bottom trawl nets (Sinopoli et al., 2022). A study performed by Alms et al., (2022) in the Gulf of Nicoya (Costa Rica) aimed to test the effectiveness of fisheries management policies and the ban on shrimp trawling, which showed that the ban on trawling is an important measure to allow for the recovery of certain target species, such as shrimp and demersal fish. However, more than this ban would be required to substantially rebuild the biomass of all key species in the system. This study exemplified how holistic ecosystem models can be used for management advice, future policymaking and how stakeholders can be engaged in this process.

In Bahrain, the government has regulated the fishing, trading, or selling of shrimp through seasonal closure. A shrimp closed season was first declared in 1980 (decree No. 26 for 1980). This decree set the closed season from 1st March to 30th June. The closed season was extended gradually from four to six months, from 1st February to 31st July, according to resolution No. 18 for 2020. Regionally, there is an effort to harmonize shrimp closed seasons in the GCC to six months annually to maintain the shrimp stock and fishing practices; however, this has yet to be met (Ali & Abahussain, 2013; Morgan, 2006).

2.5 Shrimp Fisheries Management

Competent government institutions have faced significant challenges in safeguarding the sustainability of the shrimp fishery due to the shortage of skilled specialists and monitoring manpower, the large number of shrimp vessels and fishers, and conflict with illegal fishing activities, among other factors. The combination of these challenges has generated economic problems and social conflicts in the shrimp fishing sector, complicating the governance of this activity. In general, the management framework for the shrimp fishery is based on centralized management decisions with low attention given to the importance of governance (Gelcich et al., 2008). Currently, governance is of great importance for the efficient management of artisanal fisheries, based in large part on the self-determination of fishers at the local level (FAO, 2022b).

To improve governance in shrimp fisheries, systemic changes are required in addition to institutional changes, including management models, regulatory frameworks, underlying norms and values, knowledge production systems, equity, and power distribution (FAO, 2022b; Ortiz & Levins, 2017; Olsson et al., 2010; Gelcich et al., 2005). This indicates that the operational complexity of this fishery emerges from environmental, economic, and social interactions, and these factors cannot be treated separately because the socioeconomic and ecological-environmental systems are strongly interconnected (Liu et al., 2007; Rammel et al., 2007). Further, ecosystem services and human well-being have received increasing scientific interest due to their importance in influencing sustainability (UNEP, 2022; Wang et al., 2021, UNEP, 2019; MEA, 2005). So, sustainable management of shrimp and the ecosystems must adopt an integrated approach that considers the mechanisms of the interactions between and within the socioeconomic and ecological

systems (Hamilton et al., 2022; Berrios et al., 2021; Greenhill et al., 2021; Cavanagh et al., 2016). Consequently, an adaptive management approach based on a comprehensive management framework has emerged as an alternative to traditional fishery resources management to address current and emerging problems such as overexploitation (Berrios et al., 2022). Furthermore, the adaptive management approach allows the effectiveness of management policies to be evaluated within an adaptive learning process that consists of examining the system's response as a whole and recognizing the uncertainties (ecological, economic, social, and governance) inherent in the system (Jorgensen, 2009). In this context, the ecosystem-based integrated assessment is a tool developed for that purpose. It is a conceptual model that merges the DPSIR modeling framework with EBSM.

2.6 DPSIR Framework

The DPSIR framework originates from the State-Response framework developed by Statistics Canada in the late 1970s (Svarstad et al., 2008). The State-Response framework was later developed into the Pressure-State-Response (PSR) framework by the Organization for Economic Cooperation and Development (OECD) and the United Nations Environment Programme (UNEP) (Patrício et al., 2016; Atkins et al., 2011). In addition, several international organizations, such as US Environmental Protection Agency (EPA) and the European Union, have adopted the framework, the latter noting that this was the most suitable way to structure and report environmental information (Patrício et al., 2016). However, because of the shortcomings in the PSR framework that focused mainly on direct anthropogenic pressures, in additionally to lacked consideration for their drivers as well as the dual aspect of impacts

(both positive and negative) on humans, it was further developed into the DPSIR framework (Lin et al., 2009; Niemeijer & de Groot, 2008).

The DPSIR framework for integrated environmental assessment, developed by the European Environmental Agency (EEA) in 1999, has since been widely adopted in the study of environmental problems (Carr et al., 2007). This framework links cause-effect relationships among the drivers that generate pressures on the ecosystem that change its state and produce impacts on the society that may have positive or negative implications and to which administrative/government entities can respond. The main objective of this framework is to clarify multi-sectoral relationships and to highlight the dynamic characteristics of the ecosystems and socio-economic changes (Mangi et al., 2007).

According to the EEA, one of the aims of the development of the DPSIR framework is to think analytically about the interaction between the environment and socio-economic activities (Ehara et al., 2018). EEA uses the framework to help design assessments, identify indicators, and communicate results and can support environmental monitoring and information collection (Stanners et al., 2007). The framework concept comprises five components, as illustrated in Fig. 2.1. First, indirect pressure on the environment and society is triggered by social and economic development labeled as Drivers (D) (Rounsevell et al., 2010; Maxim et al., 2009). Then, Pressure (P) causes changes in the State (S) of the environment. This State may refer to natural systems alone, such as a description of the quantity and quality of physical, biological, and chemical variables in a particular area (Ehara et al., 2018) or ecosystem services or benefits (Albert et al., 2016; Poppy et al., 2014; Carvalho-Santos et al., 2014), or individual's livelihoods, socio-economic conditions, and societal system (Nassl & Löffler, 2015; Suckall et al., 2014; United Nations, 2007). Consequently, these changes in the State

will create Impacts (I) on human health, ecosystem functioning, society, and the economy, which may elicit societal and political Responses (R) that feeds back on Drivers, Pressure, State, or Impacts via various mitigation, adaptation, or corrective actions (Kyere-Boateng & Marek, 2021; Tscherning et al., 2012; Maxim et al., 2009).

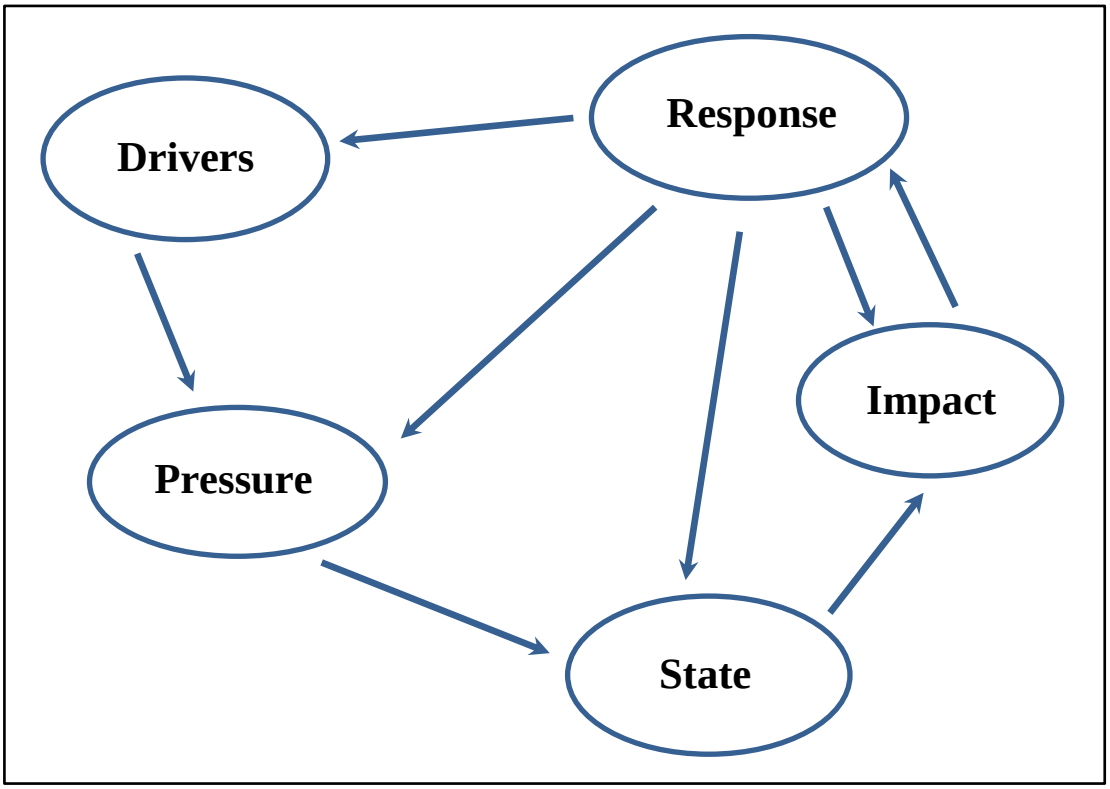


Fig. 2.1: The drivers-pressure-state-impact-response (DPSIR) assessment framework (Smeets & Weterings, 1999).

Currently, the DPSIR framework is used widely for various environmental issues, such as in studies supporting policymaking, the development of interdisciplinary indicators for environmental problems (UNEP, 2022; UNEP, 2019; Ehara et al., 2018; UNEP, 2012), the conceptualization of the system, assessment studies, and developing case studies (Bezlepkina et al., 2014; Wolfslehner & Vacik, 2011), and urban biodiversity (Kohsaka, 2010). In addition, the relevant indicators to monitor the relationships between ecosystems and society in the DPSIR

concepts can facilitate communication among stakeholders and their conservation activities in different regions of the world (Uchiyama et al., 2015).

Environmentalists most commonly use the DPSIR framework for identifying, analyzing, and evaluating different environmental issues that are considered to be complex (Liu et al., 2019; Sarmin et al., 2016). Several studies have investigated the application of the DPSIR framework, especially in the fields of marine environmental issues (Liu et al., 2018), coastal ecosystems (Lewison et al., 2016), climate change (Bär et al., 2015; Omann et al., 2009), microplastics pollution (Miranda et al., 2020), agricultural systems (Zhou et al., 2013), river ecosystem (Lu et al., 2019), and air quality (Liu et al., 2019).

This framework has been used to explore, analyze, and evaluate socio-ecological problems in different coastal marine systems affected by various anthropogenic activities (Delgado et al., 2021; Griffiths et al., 2020; Liu et al., 2019; Lu et al., 2019; Patrício et al., 2016; Sarmin et al., 2016; Azevedo et al., 2013; Tscherning et al., 2012; Atkins et al., 2011), such as fisheries management (Campos et al., 2021; Dzoga et al., 2020; Gebremedhin et al., 2018; Martins et al., 2012; Knudsen et al., 2010; Mangi et al., 2007), and integrated management of marine protected areas (Wu et al., 2017; Xu et al., 2015; Ojeda-Martínez et al., 2009). However, many studies criticized the absence of ecosystem services within the DPSIR framework (e.g., Ehara et al., 2018; Burdon et al., 2017; Müller & Burkhard, 2012; Rehr et al., 2012; Atkins et al., 2011; Rounsevell et al., 2010; Kohsaka, 2010).

The DPSIR approach has been increasingly used in specific issues of marine fisheries sector. For instance, Mangi et al., (2007) used the DPSIR framework to analyze the socioeconomic issues, environmental changes, and policy responses of coastal fisheries in Kenya on selecting appropriate

indicators to evaluate the overfishing problem and the use of destructive fishing gear. Camanho et al., (2010) applied the DPSIR framework to describe the artisanal fisheries in the Atlantic Arc, particularly the dredge fisheries on the Portuguese south coast, by defining and using a set of indicators. In addition, Martins et al., (2012) study aimed to highlight the effectiveness of the DPSIR framework in selecting appropriate indicators to assess the sustainability of fishery systems and clarify the meaning of DPSIR categories under the fisheries context. Furthermore, Dzoga et al., (2020) applied the DPSIR framework in assessing coastal and marine fisheries management in Kenya to identify existing gaps or flaws and recommend better approaches for managing coastal and marine fisheries resources in Kenya.

2.7 EBM and EBFM Approaches

In another modification used by environmentalists, DPSIR is related to ecosystem services through EBM-DPSIR, where Ecosystem-Based Management (EBM), also called Ecosystem Approach or Ecosystem Approach for the Management of Human Activities, is directly related to DPSIR (Kelble et al., 2013) or the ecosystem services and societal benefits linked to the DPSIR approach (Atkins et al., 2011).

More broadly, EBM is a multidisciplinary approach that balances environmental, social, economic, and governance principles at appropriate temporal and spatial scales to achieve sustainable resource use (Guilhon et al.,2021; Long et al., 2015). Furthermore, EBM considers humans part of an integrated system that handles all sectors, including fisheries and other ecosystem services (Link & Browman, 2014). There is no single agreed-upon definition for EBM. A typical definition of EBM acknowledges the complexity and interspecies relationship within

ecological systems. Still, many also account for social and governance objectives, with the latter broadening descriptions (Long et al., 2015). McLeod et al., (2005) define EBM as an integrated approach to management that aims to maintain a healthy, productive, and resilient ecosystem to provide the services humans want and need (Fig. 2.2). The United Nations Convention on Biological Diversity (CBD) in 2004 integrates ecological, social, and governance objectives, describing the ecosystem approach as "a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way" (Curtin & Prellezo, 2010, p.826). The Communications Partnership for Science and the Sea (COMPASS) define EBM as an integrated approach to management that considers the whole ecosystem, including humans (Aburto et al., 2012). Additionally, EBM describes a balanced way of managing resources while considering the surrounding ecosystem (de Jonge & Schückel, 2021).

It has been around two decades since the idea that EBM is the ideal implementation of fisheries management acquired concrete basing. It is expressed in global documents, such as the UNCLOS, the CBD, and the FAO document on the Ecosystem Approach to Fisheries (Woods, 2022; Fulton, 2021; Cormier et al., 2017). Since then, extensive progress has been made in formalizing national programs that focus on ecosystem assessments (such as the National Oceanic and Atmospheric Administration Integrated Ecosystem Assessment (NOAA IEA) program (Harvey et al., 2021). EBM has gained increasing attention in marine management initiatives, particularly in the fisheries sector (de Andrés & Muñoz, 2022; Mateos-Molina et al., 2021; O'Higgins et al., 2019; Christensen & Maclean, 2011; Link, 2010; Sinclair et al., 2002). EBM is theoretically a holistic and inherently adaptive approach to fisheries management that recognizes humans as part of a more extensive cross-

sectoral social-ecological system. It includes many societal goals and has a greater focus on accounting for ecological networks and a precautionary approach to account for uncertainty in ecosystem research (Long et al., 2015; Marasco et al., 2007).

Across the globe, EBM is currently in a phase of implementation trial and error in fisheries (Ramirez-Monsalve et al., 2016; Aswani et al., 2012; Berkes, 2012; Sievanen et al., 2011; Österblom et al., 2010). In addition, the policies in many countries call for EBM implementation to improve the management of coastal and marine ecosystems and resources (Policy, 2010; McFadden & Barnes, 2009; European Commission, 2008; Ricketts & Harrison, 2007). As a result, EBM principles commonly appear in high-level marine resource policies (for example, Sievanen et al., 2011). However, there is often no guidance on implementing them and sometimes no way to do so, given the governance structures in place (van Hoof, 2015; Raakjaer et al., 2014). Some studies suggest that fisheries are already managed by using the EBM approach (Marshall et al., 2019). In contrast, it is suggested that a significant reconstruction of institutional structures and boundaries is needed (Berkes, 2012).

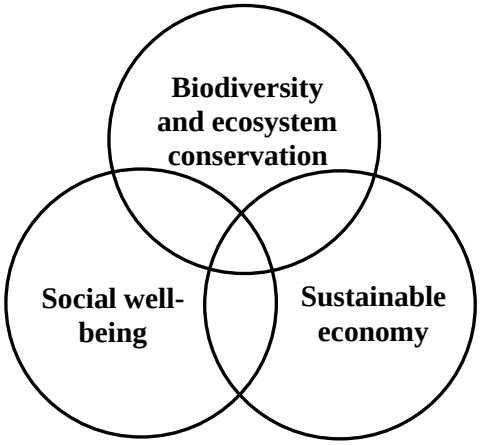


Fig. 2.2: The concept of ecosystem-based management covers the ecological, economic, and social aspects of environmental issues, aiming for sustainable development by acknowledging their interplay (Laurila-Pant et al., 2015).

For the last several decades, there has been a growing realization among decision-makers, scientists, and stakeholders on the need to expand fisheries management beyond single-species considerations. The rationale for this broader approach stems partly from the poor performance of single-species management in many fishery systems worldwide (Pikitch et al., 2004). Still, it more broadly includes a general appreciation for the importance of socio-economic components, climate, species interactions, and the direct and indirect effects of fishing on target species, bycatch species, and habitats (Rosellon-Druker et al., 2019). Ecosystem-Based Fisheries Management (EBFM) endeavors to manage fisheries in a manner that handles the multiple objectives of stakeholders without threatening the options of future generations to benefit from the full range of ecosystem goods and services (Marasco et al., 2007).

EBFM has been widely acknowledged as a more sustainable way to manage fisheries than single-species management (Bryhn et al., 2021). For example, Link & Browman (2017) concluded that the overall academic and political EBFM discussion is now moving slowly from "what is it?" to "how do we do it?". There are many different definitions of EBFM. All include the need to maintain the ecosystem resources for their sustainable use and recognize that humans are an integral part of the process (Gullestad et al., 2017). The overall objective of the EBFM, adopted by many governments and international organizations and contained in agreements since the 1990s, is to sustain healthy marine ecosystems and the fisheries they support (Gullestad et al., 2017; Pikitch et al., 2004). Leite & Gasalla (2013) conducted a study to assess fishers' ecological knowledge of issues focusing on the importance to EBFM initiatives, including identifying potential essential fish habitats, fishing grounds, and bycatch species per fishing gear, as well as to provide suggestions for sustainable management. The information has been

collected by applying several rounds of interviews with the critical fishers selected, and the questions for interviews were designed under an EBFM framework. Another study in Norway applied EBFM, which follows the steps for implementing the ecosystem approach to improve fisheries management to obtain sustainable fisheries (Gullestad et al., 2017). According to Pikitch et al., (2004), EBFM should avoid the degradation of ecosystems, minimize the risk of irreversible change to species assemblages and ecosystem processes, obtain and maintain long-term socioeconomic benefits without compromising the ecosystem, and generate knowledge of ecosystem functions sufficient to understand the potential effects of human actions.

FAO Committee on Fisheries has adopted the EBFM as a reasonable and practical way to fully implement the code of conduct for responsible fisheries. The principal purpose of the EBFM process is to develop and implement an integrated set of arrangements and tools for a fishery to generate more acceptable, sustainable, ecosystem-concerned, and beneficial community outcomes (Gullestad et al., 2017). The core principles for EBFM should meet the following (1) science-based management, (2) use suitable and applicable ecosystem connections and scales, (3) handle uncertainty (precautionary and adaptive management), (4) consider long-term socio-ecological well-being, and (5) have a collaborative and interdisciplinary decision-making process (Engler, 2015; Long et al., 2015). These principles are consistent with FAO guidelines (Garcia, 2003; Garcia, 2000) and are universally applicable (Hornborg et al., 2019).

EBFM is a way of implementing management that involves a broad set of objectives and a participative and adaptive process. FAO presents four main steps as one way forward in planning and implementing EBFM (Gullestad et al., 2017). These are initiation and scope, identification of

assets, issues and priorities, management system development, implementation, monitoring, and performance review (as depicted in Fig. 2.3).

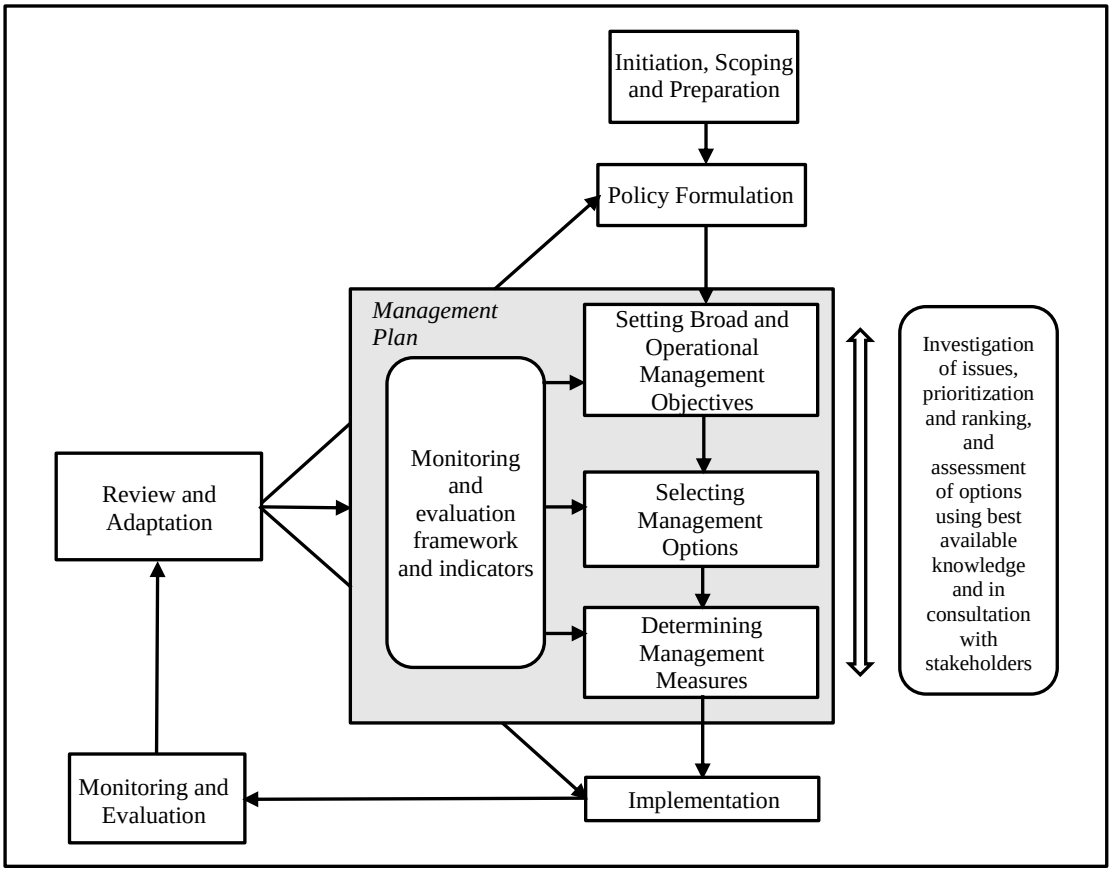


Fig. 2.3: Steps in the EBFM process (FAO, 2009).

EBFM has become a cornerstone of NOAA Fisheries' efforts to manage marine resources sustainably. NOAA Fisheries defines EBFM as "a systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals" (NOAA, 2023). EBFM takes a system-level perspective on fisheries in an ecosystem. EBFM differs from Ecosystem Approach to Fisheries Management (EAFM) because it focuses on

multiple or all fisheries within an ecosystem and takes a coordinated and strategic approach (Fig. 2.4; Dolan et al., 2016).

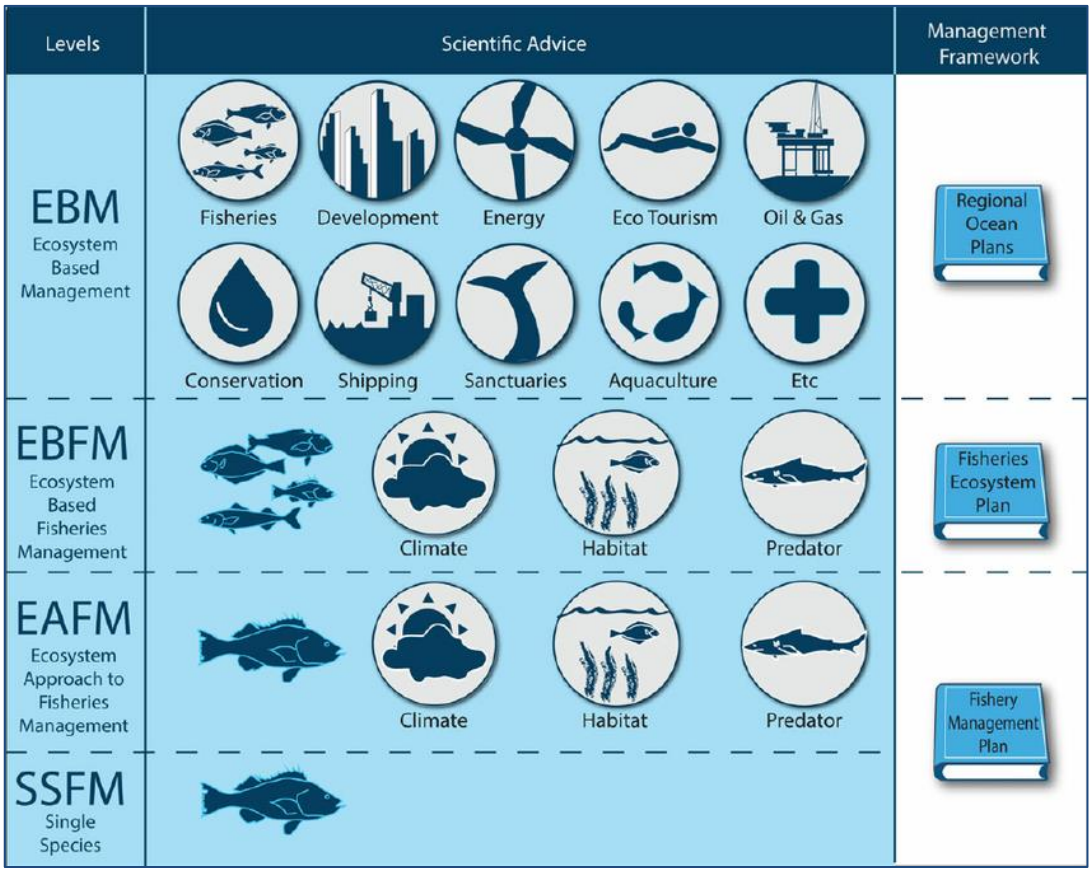


Fig. 2.4: The paradigms of Ecosystem management, building upwards from single-species management to Ecosystem-Based Management (EBM) (Dolan et al., 2016).

The rise in popularity of EBM has led to sector-specific variations, such as the Ecosystem Approach to Fisheries or EBFM and Ecosystem-Based Shrimp Management (EBSM). Each version of EBM has differing underlying principles (with some also providing frameworks for their implementation), and no single approach currently dominates the field of natural resource management (Bianchi, 2008; Short et al., 2008).

Although EBFM is an increasingly identified approach to improve management outcomes, there is a need to be more concurrence on the extent to which management decisions are based on EBFM principles

(Bryhn et al., 2021; Marshall et al., 2019). On the one hand, management authorities worldwide have developed frameworks that widen concerns in fisheries management decisions to enclose the human-biophysical systems in fisheries (NOAA, 2016; European Commission, 2008; FAO, 2003). Even so, other researchers have claimed that the practice of EBFM has lagged despite the expansion of EBFM frameworks (Essington et al., 2016; Berkes, 2012; Cowan et al., 2012; Pitcher et al., 2009; Arkema et al., 2006).

CBD developed 12 principles for the ecosystem approach as following: (1) the objectives of management of land, water and living resources are a matter of societal choice; (2) management should be decentralized to the lowest appropriate level; (3) ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems; (4) recognizing potential gains from management in an economic context; (5) conservation of ecosystem structure and functioning, in order to maintain ecosystem services; (6) ecosystems must be managed within the limits of their functioning; (7) the ecosystem approach should be undertaken at the appropriate spatial and temporal scales; (8) recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term; (9) management must recognize that change is inevitable; (10) the ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity; (11) the ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices; (12) the ecosystem approach should involve all relevant sectors of society and scientific disciplines (CBD, 2004).

The 12 principles have been organized into five steps for the implementation of the ecosystem approach as follows: (1) determining the stakeholders and defining the ecosystem area; (2) characterizing the structure and function of the ecosystem; (3) identifying the critical economic issues that will affect the ecosystem and its inhabitants; (4) determining the likely impact of the ecosystem on adjacent ecosystems; (5) deciding on long-term goals, and flexible ways of reaching them (Shepherd, 2004).

Today's ecosystems are widely recognized as highly impacted and extensively modified by anthropogenic activities. To balance the aspirational goals of sustainable management, specifically SDG 14, "Conserve and sustainably use the oceans, seas, and marine resources," with exponentially growing populations, holistic ecosystems-based marine management is required. Improved knowledge and recognition of many anthropogenic pressures affecting natural ecosystems have resulted in broad acceptance that EBM is essential for effective conservation and management to maintain ecosystem services (Pedreschi et al., 2019). EBM requires considering all the anthropogenic pressures affecting entire ecosystems rather than focusing on individual components (Harvey et al., 2017; Borja et al., 2016; Hilborn, 2011; Levin et al., 2009; Halpern et al., 2007).

2.8 IEA Framework

Efforts have ranged in scale, from simply incorporating some ecosystem knowledge into single species assessment models at one extreme to building complex ecosystem models incorporating the DPSIR framework (Burdon et al., 2017; Borja et al., 2016) to deliver holistic, integrated ecosystem assessment. In 2010, NOAA launched the Integrated

Ecosystem Assessment (IEA) program to provide science that supports EBM (Harvey et al., 2021). Integrating ecosystem services with the DPSIR framework in a way consistent with EBM could assist in understanding these concepts and present basic postulates for managing the marine environment, which integrates the concepts and provides a specific framework for supporting decision-making in the marine environment (Atkins et al., 2011; UNEP, 2007; MEA, 2005).

IEA has been proposed as a framework to facilitate EBM and to guide management efforts to achieve multiple objectives (Harvey et al., 2017; Dickey-Collas, 2014; Levin et al., 2014; Levin et al., 2009). IEA takes an overall view to assess the pressures, identify the driving forces, and the status of ecosystem components affected by them, thus providing the context in which the sectors and pressures operate. Conceptually, IEA is simple and practical, yet its implementation is more complex (Dickey-Collas, 2014; Walther & Möllmann, 2014). In addition, the data collecting, monitoring, and modeling requirements of complete ecosystem-based integrated assessment are many and challenging (Harvey et al., 2017; Borja et al., 2016; McQuatters-Gollop, 2012; Hilborn, 2011; Hobday et al., 2011).

The IEA is a holistic framework involving a qualitative and quantitative analysis of information related to ecological, social, and economic factors relevant to specific ecosystem management objectives (Rosellon-Druker et al., 2021). It is transparent in that effective stakeholder involvement is foundational to the process, intending to provide timely and relevant scientific advice to decision-makers and inform the public on the status of natural resources. The IEA comprises goals, indicators, and analyses that must be refined and reviewed over time to capture scientific progress and shifting priorities. The approach is

scalable to serve the ecosystem and manage issues of interest (Muffley et al., 2021).

A primary IEA goal is to inform and engage managers, policymakers, scientists, stakeholders, and other citizens. The size and scope of an IEA vary depending on (1) the number of participants, (2) the size of the ecosystem, and (3) stakeholder and management needs. The IEA process involves defining ecosystem-based goals and targets, developing indicators, assessing ecosystem status, analyzing uncertainty and risk, and evaluating management strategies (Levin et al., 2009).

National and international marine science organizations have moved toward implementing IEA to support EBM (Harvey et al., 2020; Rosellon-Druker et al., 2019; Harvey et al., 2017; Fletcher et al., 2014). For example, the IEA framework was applied to build consensus on the ecosystem components and processes characteristic of a sustainable South Florida coastal ecosystem. The process consists of meetings to conceptualize the ecosystem, develop indicators, and conduct a risk analysis. Resource managers, researchers, academics, and non-governmental organizations have been participated in these meetings to contribute scientific research on transferring information to decision-makers and the public (Fletcher et al., 2014).

The IEA framework aimed to organize science to inform management decisions in EBM at multiple scales and across diverse sectors (Levin et al., 2009). IEA evaluates ecosystem status based on objectives by considering the holistic impacts of management decisions and helps to guide the evaluation of management alternatives (Levin et al., 2009). IEA is multisectoral but can also be applied to sector-specific such as fisheries (Link & Browman, 2014).

Levin et al., (2009) summarized a five-steps process for IEA, as shown in the NOAA IEA loop (Fig. 2.5). The five-steps process are

represented by: (1) scoping to identify specific ecosystem goals and threats, (2) indicator development where relevant indicators of ecosystem status are specified and validated, (3) risk analysis to assess the risk to indicators posed by anthropogenic activities and natural processes, (4) management strategy evaluation using an ecosystem modeling approach to evaluate the possibility for different management actions to impact the status of natural and human system indicators, and (5) continued monitoring and evaluation of ecosystem indicators. Fig. 2.6 illustrate the incorporation of the DPSIR framework with the EBM approach.

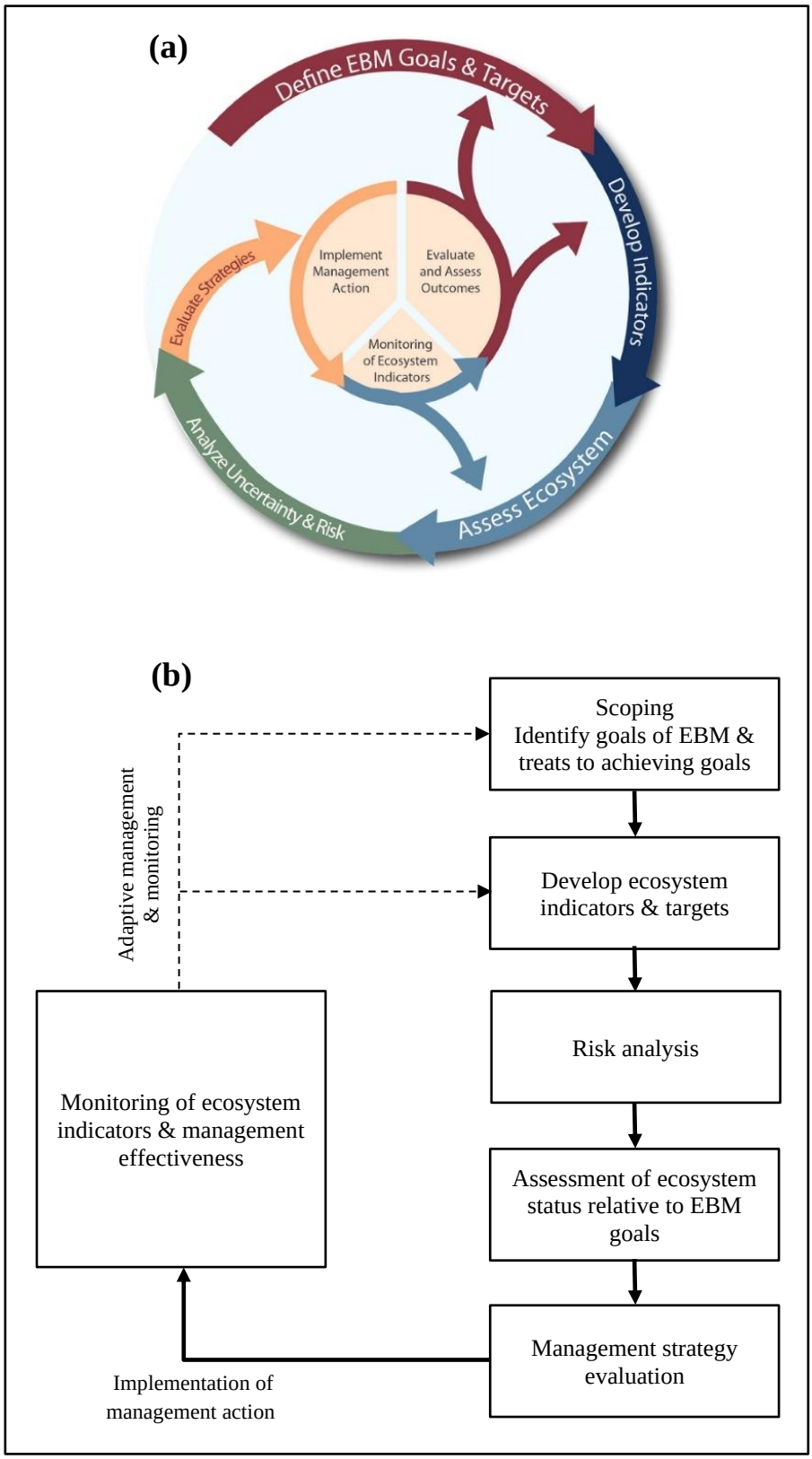


Fig. 2.5: The NOAA IEA framework. (a) IEA framework as originally depicted by Levin et al., (2009). (b) as depicted with additional detail in the management implementation steps by Samhouri et al., (2014).

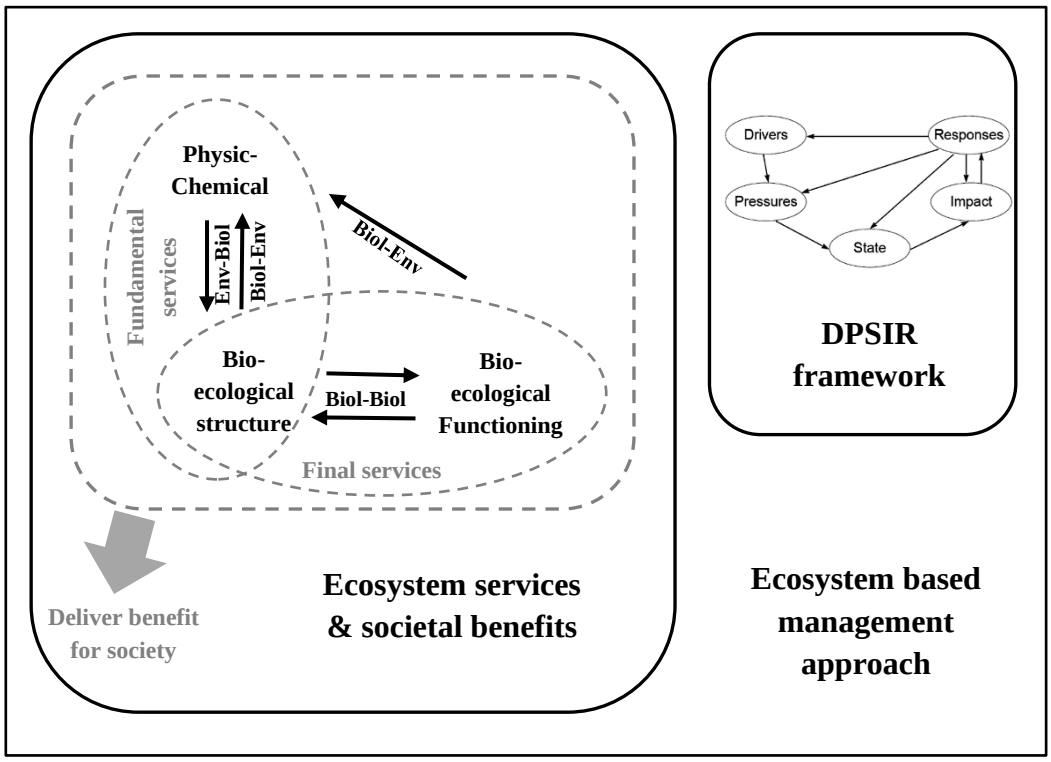


Fig. 2.6: The DPSIR framework and the ecosystem services and societal benefits set with the EBM approach (modified from Atkins et al., 2011).

2.9 Theoretical Framework

This study examined the development of the ecological and socioeconomic implications of the management objectives of the shrimp fishery in the Kingdom of Bahrain. Shrimp fishing in Bahrain has been integral to its culture for centuries. It provides employment and income opportunities and nourishment for a wide part of the population. However, the shrimp fishery in Bahrain has the same problems as the regional and global fishery. Under the Government Plan (2019-2022), the Ministry of Municipalities Affairs and Agriculture (MUN) has suggested vital strategic approaches to protect the marine environment and achieve SDG 14. Additionally, the Government Plan (2023-2026) emphasizes the importance of developing future strategic plans for a specific period to achieve sustainable development goals, preserving and developing natural

resources and wealth to ensure their sustainability, and activating the protection of protected areas and wildlife and their sustainability.

The current research aimed to assess shrimp fishery management employing ecosystem-based integrated assessment using the DPSIR conceptual framework and EBM approach. These approaches allowed to (1) identify the main controlling factors (socioeconomic, ecological, and regulatory) influencing the development of the resource, (2) assess the current management measures adopted to mitigate fishing pressure, and (3) propose new management measures based on the detection of unsustainability factors found through examining the integrated ecosystem analysis.

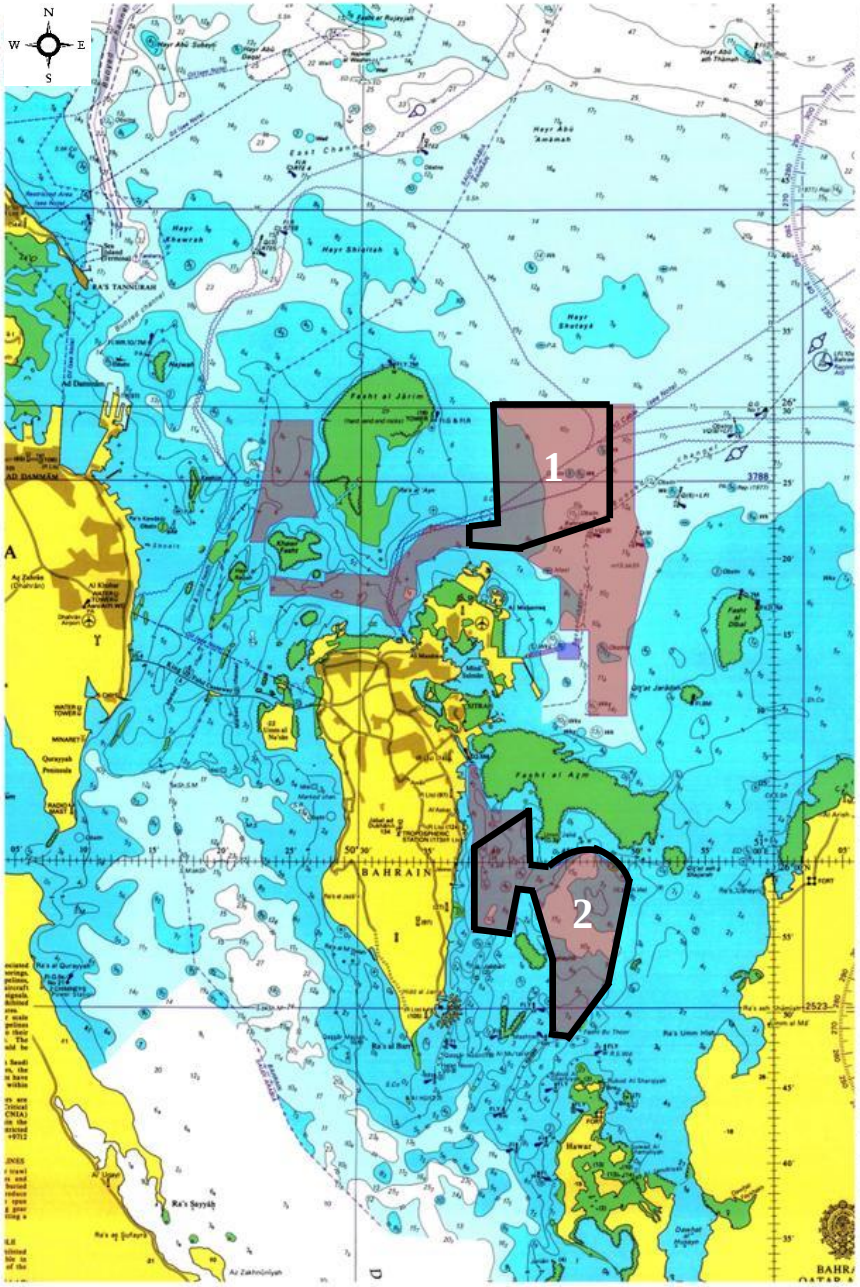
Moreover, the present study investigates and describes how the 12 EBM principles are followed in managing shrimp fishery in Bahrain. Accordingly, the study proposes guiding EBM principles and action items to implement EBSM in the Kingdom of Bahrain by evaluating five sources of information: (1) the scientific literature on Bahrain's marine ecosystems, (2) the scientific literature on the biology and ecology of *P. semisulcatus*, (3) the information gathered from several governmental institutions, (4) monthly length frequency data of the shrimp collected during the present study, and (5) the stakeholder opinions on the status of shrimp fishery and its sustainability, management approaches, and potential threats to marine habitats.

Chapter Three: Methods and Procedures

The ecosystem-based integrated approach was used through a set of methods described in detail in this chapter.

3.1 Study Area

The Kingdom of Bahrain is an archipelago composed of 40 islands (NIC, 2018) with a total area of 8,269 km^2, 9.5% of it is a land area (786.5 km^2) (IGA, 2022). The coastal length is more than 537 km (Aljenaid et al., 2022). Bahrain is located on the southern coastline of the Arabian Gulf between longitudes 50° 20 and 50° 50 easting, and latitudes 25° 32 and 26° 20 northing; because of its location, Bahrain shares water borders only with neighboring countries (IGA, 2022). Saudi Arabia flanks it on its western and southern sides and Qatar peninsula on its eastern. Bahrain's territorial waters area is 7482.5 km^2 (IGA, 2022). The shrimping is associated within 55 fishing grounds as illustrated in (Fig. 3.1), which vary in their total areas. Shrimp fishing grounds are found in areas where the average sediment particle size is less than 400 µm located at depth extends from 2 to 20 m (Abdulqader, 2010). The total area of Bahrain's shrimp fishing grounds is estimated at 871 km^2 based on FAO Fisheries Circular No. 974 (FAO, 2001), and it increased to 1,500 km^2 in 2014, according to the fisheries directorate statistic. Local names are used to identify these grounds by fishers. Qumais fishing ground at the south of Fasht Al-Adhum, is the most considerable fishing ground (163 km^2), followed by Umudood ground (105 km^2), which is located in the north (ICES, 2005) (Fig. 3.1). Most of the shrimp catch is sourced from the northern area of the country (Ali & Abahussain, 2013).



المناطق الشمالية وأم الدود		
No	N	E
N1	26 18.800	50 23.500
N2	26 17.500	50 23.500
N3	26 17.500	50 26.500
N4	26 16.500	50 31.600
N5	26 15.500	50 32.000
N6	26 15.500	50 33.000
N7	26 17.800	50 34.200
N8	26 19.400	50 34.100
N9	26 20.700	50 36.700
N10	26 20.400	50 41.200
N11	26 18.500	50 44.600
N12	26 15.200	50 44.600
N13	26 15.200	50 46.700
N14	26 09.600	50 46.700
N15	26 09.600	50 49.500
N16	26 13.300	50 49.500
N17	26 20.000	50 51.000
N18	26 23.000	50 50.000
N19	26 30.000	50 50.000
N20	26 30.000	50 40.000
N21	26 22.100	50 40.000
N22	26 22.100	50 35.000
N23	26 18.000	50.32.000
N24	26 19.000	50.27.500
N25	26 18.400	50.27.500
المناطق الشمالية الاصلاح والكاش		
No	N	E
W1	26 29.000	50 23.500
W2	26 29.000	50 26.600
W3	26 27.000	50 26.600
W4	26 24.600	50 26.300
W5	26 22.600	50 27.000
W6	26 22.700	50 24.800
W7	26 22.000	50 23.400
W8	26 21.000	50 23.000
W9	26 21.000	50 22.000
W10	26 23.000	50 22.400
W11	26 27.300	50 23.400
المناطق الجنوبية		
No	N	E
S1	26 06.400	50 38.000
S2	26 06.400	50 38.500
S3	26 03.400	50 39.400
S4	26 03.400	50 42.400
S5	25 59.600	50 42.400
S6	25 59.600	50 44.000
S7	26 01.000	50 46.600
S8	25 59.200	50 49.600
S9	25 52.600	50 48.400
S10	25 48.400	50 45.400
S11	25 48.400	50 44.200
S12	25 53.800	50 44.200
S13	25 58.200	50 42.600
S14	25 58.200	50 41.600
S15	25 55.400	50 41.400
S16	25 55.400	50 38.200
S17	26 00.600	50 38.200
S18	26 02.500	50 38.400
S19	26 03.400	50 38.000

Fig. 3.1: Location map of shrimp fishing grounds in the Kingdom of Bahrain (highlighted in red). The location of the most important shrimp fishing grounds (indicated by number) Umudood ground (1) and Qumais ground (2).

Note: The latest update in 2017, as provided by Maritime Control Directorate.

3.2 Bahrain's Marine Ecosystems

Marine and coastal ecosystems represent one of the most heavily exploited ecosystems worldwide (Barbier, 2017), are among the most productive, and provide a range of social, ecological, and economic benefits to humans (Naser, 2016; MEA, 2005). People of the Kingdom of Bahrain and the Arabian Gulf are related economically, culturally, and socially to the sea. Despite the harsh environmental condition and the limited land area of Bahrain, waters surrounding its islands support several ecosystems such as seagrass beds, algae, coral reefs, mangroves, mud and sand flats (Table 3.1, Figs. 3.2 & 3.3) based on the Marine Atlas of Bahrain (Loughland & Zainal, 2009). These ecosystems are considered Valued Ecosystem Components (VECs) to be protected (Naser, 2015; Olagunju & Gunn, 2015). Most of these habitats are rich in highly valued species, such as economically important fish species, crustaceans, turtles, dugongs, and a variety of commercial marine organisms (Abdulla & Naser, 2021; Naser & Thomason, 2008). Furthermore, these ecosystems maintain biological diversity, including genetic, species, and ecosystem diversity (Kenchington et al., 2003).

Bahrain's marine environment provides several economic, social, ecological, and cultural benefits. The marine environment also contributes to food security and supports many sectors, including industry, trade, shipping, tourism, power production, and water desalination (Naser, 2022). Ecosystem benefits are not limited to the direct consumptive value of food but extend to other services ranging from primary production and nutrient cycling to erosion and sedimentation control (Naser, 2014). For example, it provides nursery grounds for a range of fish, shellfish, and crustacean species, sand extraction for building and construction purposes, feeds water for desalination plants, cooling water for industrial

processes, sink for wastewater treatment, means for maritime navigation, spaces for aquaculture and land reclamation for creating new land from the sea. In addition to recreation, tourism, and water transport services (Abdulla & Naser, 2021; Barbier, 2017; Ruiz-Frau et al., 2017; Naser, 2014). However, these ecosystems are under increasing pressures from human activities associated with the rapid economic, social, and industrial developments resulting in biological, physical, and chemical impacts on water and sediment quality, degrading their state, and eroding their resilience (Abdulla & Naser, 2021).

Table (3.1): Example of Bahrain's main marine ecosystems.

Ecosystem	Description
1. Seagrass beds	Seagrass ecosystems in Bahrain contribute enormously to the productivity of fisheries and provide food sources and nursery grounds for many types of marine organisms of commercial significance (Al-Jenaid et al., 2017; Al-Wedaei et al., 2011). Seagrass beds extend through a large area of the sea bottom and are distributed along Bahrain's southeast and west coasts. Dense seagrass beds (>75 coverage) mainly occur on sandy substrates (Naser, 2016). Most seagrass habitats are found in the eastern subtidal waters, mainly from the south of Fasht Al-Adhom to Hawar Islands (ARC-WH & SCE, 2017). The second largest seagrass beds are found in the western subtidal areas, with patches recorded to the northwest at Fasht Al-Jarim (Zainal et al., 2006). Additionally, the densest seagrass locations surround the dead coral areas and towards the southwestern part of Bahrain's main island. Seagrasses occur mainly on sandy and muddy substrates (Naser, 2014). Seagrasses in Bahrain are represented by three species, *Halodule uninervis*, *Halophila ovalis*, and *Halophila stipulacea*. These species were classified as Endangered in 2015 based on National Red List (ARC-WH & SCE 2017).

Ecosystem	Description
2. Algal beds	Algae cover the rocky shores and the shallow subtidal zones of the coast. It locates between seagrasses and coral reefs. It occurs in the eastern intertidal and subtidal areas of the Bahrain main island and Hawar islands (SCE, 2016; SCE, 2009). There are more than 90 species of marine algae in the water around Bahrain, distributed among the main groups of algae, namely green, red and brown, and Coralline algae (Al-Jenaid et al., 2017). The most commonly occurring macro-algae species belong to the brown algae. The most dominant is the *Sargassum sp*. and the *Hormophysa sp* (SCE, 2016).
3. Coral Reefs	Coral reef ecosystems provide various ecological services, such as providing food and maintaining genetic, biological, and habitat diversity (Naser, 2014). Coral reefs are an essential habitat for fisheries that support more than 71 fish species in Bahrain and serve as nursery areas for shrimp, crabs, and other marine organisms (Al-Jenaid et al., 2017). Coral reefs are locally known as 'Fasht.' Most of the coral reef areas are located in the offshore shallow marine water surrounding the islands of Bahrain (SCE, 2016). Coral reefs mainly abounded on the northern and eastern coast of Bahrain. These include Fasht Al-Adhom to the east of Bahrain (the largest reef in Bahrain, 200 km^2), Fasht Al-Jarim and Khur Fasht 20 km to the north, and Bulthama, 75 km northeast of Bahrain (Naser, 2016). Additionally, several other smaller reefs are scattered around eastern areas of Bahrain (SCE, 2009). The healthiest and most diverse coral reefs are in Najwat Bulthama, which is classified as a marine protected area based on Resolution No. 2 of 2017. About 30 marine species and 19 genera of corals are found in territorial waters. Despite the harsh environmental conditions, corals exhibit remarkable resilience and vitality (SCE, 2009).
4. Mangroves	Mangroves are considered the most productive and biologically diverse coastal ecosystems that provide food, shelter, and nursery areas for various terrestrial and marine organisms (Jakovac et al., 2020). In addition, it supports many important species of fish, shrimps, turtles, and birds (Naser, 2014). *Avicennia marina* is the

Ecosystem	Description
	only species of mangroves found in Ras Sanad, Tubli Bay, Sitra, and Al-Aker (SCE, 2009). However, mangroves in Bahrain are severely subjected to continuous anthropogenic threats by reclamation activities, which have drastically reduced the total area of Tubli Bay from 25 km^2 to less than 12 km^2 in 2008 (ARC-WH & SCE, 2017). The bay area had gone down to 10 km^2 in 2017 (Kaminski et al., 2021). In addition, several anthropogenic activities are continuously damaging the health of mangrove ecosystems, including wastewater discharges from sand-washing factories, secondary treated sewage water discharges from the major outfall (Tubli Water Pollution Control Centre), illegal dumping of solid wastes and fishing activities in the Bay (Naser, 2014; Naser & Thomason, 2008). As a result, the mangroves in Bahrain were classified as Critically Endangered in 2015 based on National Red List (ARC-WH & SCE, 2017), which needs urgent conservation actions to sustain the remaining mangrove ecosystem. Other mangroves are found in Dawhat Arad in Muharraq, situated northeast of Bahrain. On this small intertidal mudflat, Bahrain's Fisheries Department transplanted Mangrove seedlings in the mid-1990s to create an artificial habitat (SCE, 2009).
5. Mud and sand flats	Due to the sedimentary nature of the Arabian Gulf, sand and mud are the most common sediment types. These habitats are the most-favored areas for colonization by mangroves, and algal and cyanobacterial mats, which play essential roles in primary productions and food chains (Naser, 2014). Intertidal mudflats in Bahrain are highly productive and serve as feeding and roosting grounds for many important shorebird populations, including wintering and migratory birds (Al-Sayed et al., 2008). In addition, subtidal and tidal muddy habitats are extremely rich in macrobenthic assemblages, contributing significantly to fisheries and marine productivity (Naser, 2014). Low-energy locations on the northern and eastern coasts of Bahrain and patches of sheltered lagoons within Hawar Islands represent mudflats in Bahrain (Naser, 2016).

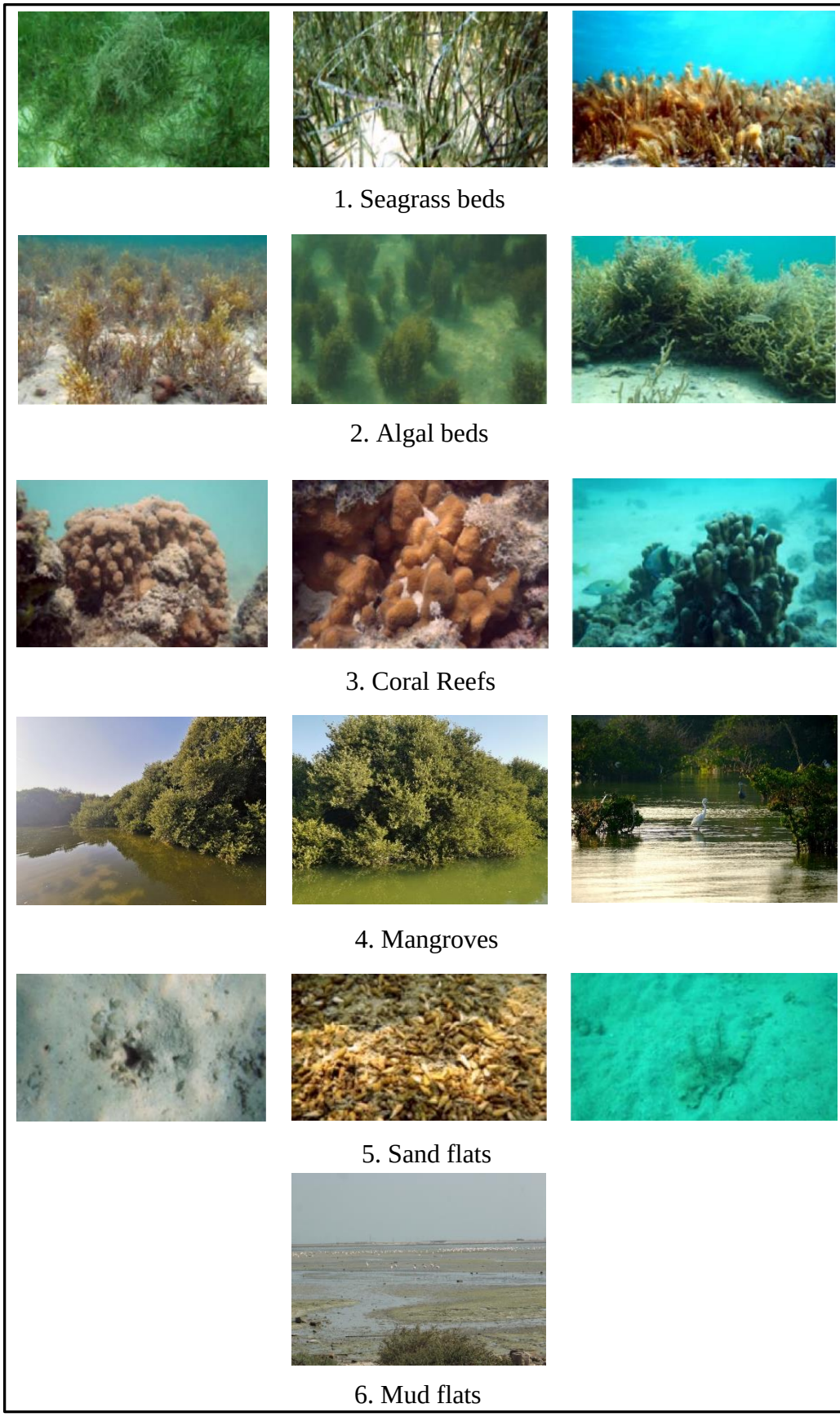


Fig. 3.2: Bahrain's main marine ecosystems.
Source: Al-Jenaid et al., 2017 (photo no.1,2,3 and 5), BTEA, 2020 (photo no.4), Naser, 2014 (photo no.6)

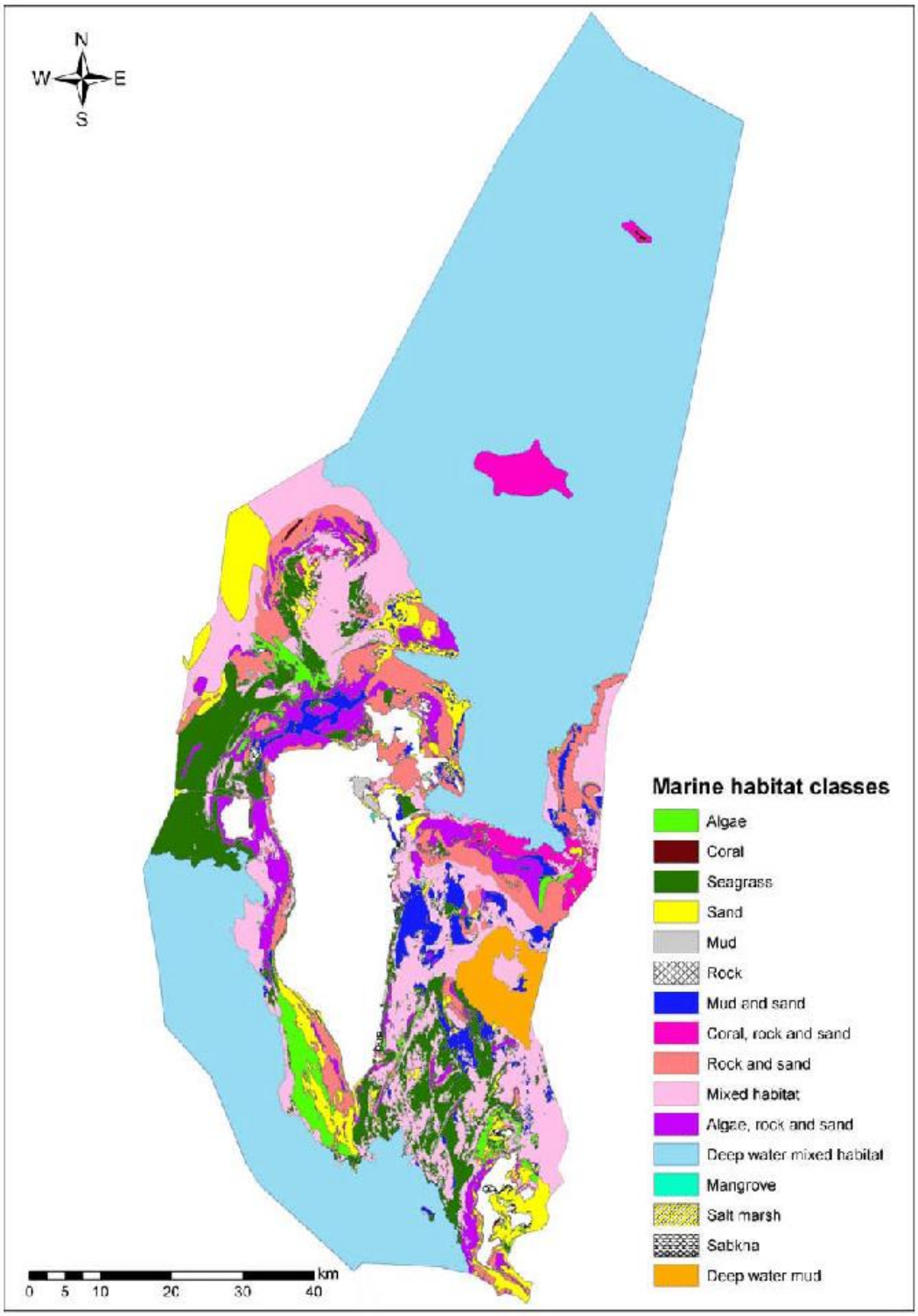


Fig. 3.3: Distribution of marine and costal habitats in the Kingdom of Bahrain (Loughland & Zainal, 2009).

3.3 Green Tiger Shrimp, *Penaeus semisulcatus*

Bahrain's shrimp fishery targets single penaeid shrimp, namely, the green tiger shrimp *P. semisulcatus* (De Haan 1844) (Tamadoni Jahromi et al., 2019; Abdulqader, 2010). *P. semisulcatus* is one of the economically important penaeid shrimp due to its larger body size compared with other shrimps in the Penaeidae family (Zhong et al., 2019). In addition, *P. semisulcatus* is an ecologically and commercially important marine shrimp throughout the Indo-West Pacific regions and also south and east Africa to India and Sri Lanka, including the Red Sea, Arabian Gulf, and Western Madagascar (Tamadoni Jahromi et al., 2019; Zhong et al., 2019). This species inhabits muddy and sandy bottoms to depths of about 130 m and is most abundant in waters shallower than 60 m (Tamadoni Jahromi et al., 2019; Zhong et al., 2019; Abdulqader, 2010). *P. semisulcatus* can form small shoals and is mainly nocturnal, which buries itself in the substrate during the daytime. Thus, it is mainly fished at night (Holthuis, 1980).

P. semisulcatus is a marine invertebrate belonging to decapod crustaceans (Table 3.2) with an elongated body, two pairs of long antennae, and well-developed pleopods (Johnson et al., 2022; Thorp & Covich, 2009). Similar to crustaceans, as indicated in Anderson (2001), the body is divided into distinct tagmata, typically with recognizable head and trunk regions. The trunk differentiated into cephalothorax and abdomen. The head and thorax are covered by a carapace that encloses the gills. The gills are characterized by being dendrobranchiate. The cephalothorax consists of the rostrum and two stalked eyes, the sensory reception appendages (the antennules and antennae), and the feeding appendages (the mandibles, maxillules, and maxillae), followed by five pairs of thorasic appendages known as pereiopods which used for walking.

The pereiopods are tubular elongated and segmented. The first three pairs of pereiopods are chelate which is used to catch and hold food. The elongated portion of the body behind the cephalothorax is the abdomen, which is round dorsally and laterally compressed. The abdomen consists of six segments, and in each segment of the abdomen is a pair of appendages known as pleopods, which are used for swimming. All the pleopods are similar and segmented. The sixth abdominal segment bears the telson and a pair of uropods attached beside the base of the telson and make up the tail fan. The telson is the pointed portion at the end of the abdomen. The telson and uropods are used in locomotion. An external skeleton covers a shrimp's outer surface, called a cuticle, composed of chitin and protein complexes. These morphological features are shown in Fig. 3.4.

P. semisulcatus is distinguished from the other species of Penaeus by having characteristic teeth on the rostrum (rostrum has 5–7 teeth on the top and 2–4 teeth on the ventral side), and the rostral groove reaching beyond the last tooth. *P. semisulcatus* has reddish brown to pale brown body color, sometimes showing a greenish tint on the carapace. The abdomen is banded with reddish-brown or brownish-grey transverse bands. The carapace is a reddish-brown color with brown transverse lines. Some specimens have white and brown colored transverse stripes alternating, present as bands in the antennae, and others are with non-banded antennae (Fig. 3.4). All of these specifications for samples collected in the present study are in complete agreement with morphological characteristics of *P. semisulcatus* described in FAO species catalogue (Holthuis, 1980).

Table (3.2): Scientific Classification of *P. semisulcatus* (Holthuis, 1980).

Infrakingdom:	Eukaryote
Kingdom:	Animalia
Sub Kingdom:	Bilateria
Super Phylum:	Ecdysozoa
Phylum:	Arthropoda
Subphylum:	Crustacea
Class:	Malacostraca
Sub class:	Eumalacostraca
Super order:	Eucarida
Order:	Decapoda
Suborder:	Dendrobranchiata
Super family:	Penaeoidea
Family:	Penaeidae
Genus:	Penaeus
Species:	*Penaeus semisulcatus* (De Haan 1844)

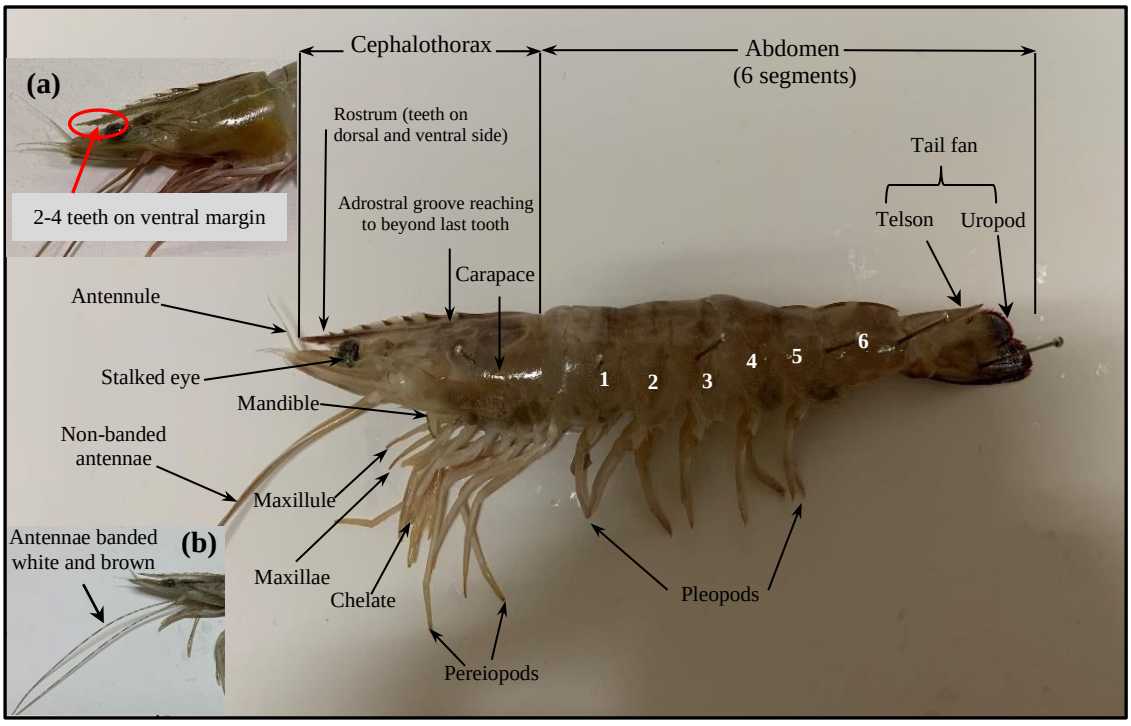


Fig. 3.4: Morphological features of the *P. semisulcatus*. (a) having characteristic teeth on the ventral margin of the rostrum, (b) with banded antennae.

3.4 Length Frequency

3.4.1 Data collection

The sampling was conducted for six months representing the fishing season August 2020 - January 2021 at 10 days intervals from random fishing vessels berthing at Al-Hidd Fishing Harbour in Muharraq Governorate. Shrimp samples, about 2 kg for each, were collected. Each sample was placed in a separate plastic bag labeled with the sample's identification number (that distinguishes it from other samples) and the collection date, then transported in a cooler containing ice to prevent it from being damaged. The sample was frozen in the freezer if the specimen measurement was not run almost immediately after collection. The frozen specimen was fully and wholly melted at room temperature before measurement.

Green tiger shrimp (*P. semisulcatus*) individuals were identified and sorted out based on visible common morphological and anatomical characteristics such as the shape of the rostrum, rostral teeth, and other characteristics mentioned by Abdulraheem et al., (2021), Tamadoni Jahromi et al., (2019), Piratheepa et al., (2016) and Rahnama et al., (2011) as well as by referring to FAO species identification guide (Carpenter et al., 1997). Shrimp individuals cut on the tail, rostrum, or head region were excluded from further analysis. Therefore, only intact, uninjured shrimps were selected (Fig. 3.5).

A total of 1695 specimens of intact *P. semisulcatus* were isolated during the study period. Each individual’s total length (TL) was measured using a metric ruler from the tip of the rostrum to the end of the telson, with the abdomen fully stretched. The total length was determined to the nearest 0.1 centimeters and then assorted in successive length groups of 0.5-centimeter intervals. To the nearest 0.01 gram, the total body weight

was measured with an electronic weighing balance (Brand: GDEALER) (Fig. 3.6). Measurements were carried out without differentiating by sex. The measurement data for each sample was recorded separately.

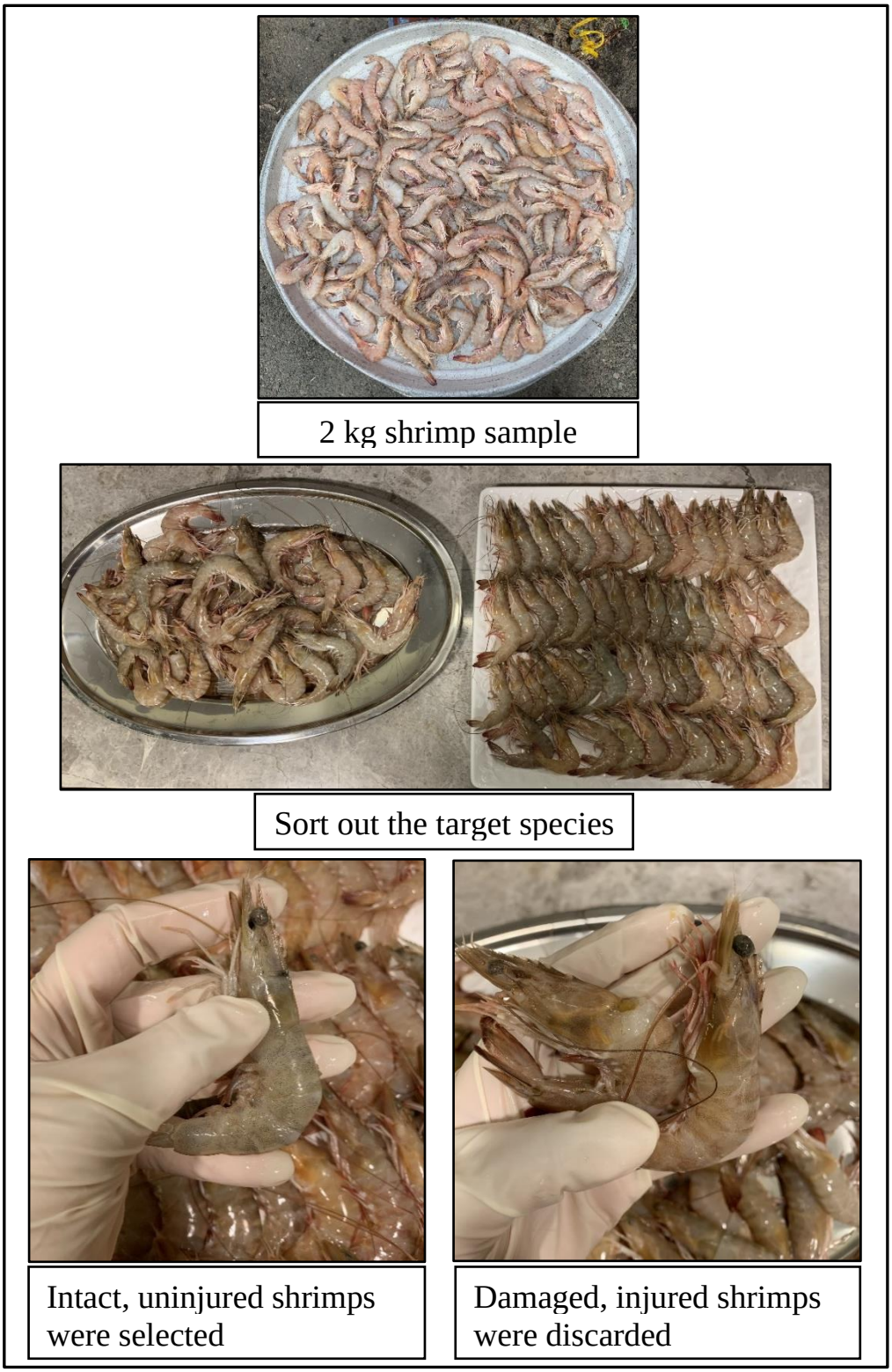


Fig. 3.5: Sorting out the target shrimp species for study.



Fig. 3.6: Measurements taken on *P. semisulcatus* (total length in cm and total body weigh in gram).

3.4.2 Data analyses

Length measurements were categorized into length classes by 0.5 intervals (for example, 9.0-9.4, 9.5-9.9, 10.0-10.4, etc.). Each class is represented by the total number of specimens within the class size. Then the length classes were analyzed using the Bhattacharya routine, incorporated in the FiSAT II software (version 1.2.2) (Gayanilo & Sparre, 2005). The Bhattacharya routine was employed to split the composite distribution of length into separate normal distributions to identify different cohorts contained in the samples. The average length was determined to find whether the average length by each monthly cohorts is

less than or more than the average length at maturity (L_m). The length at maturity (L_m) and length at first capture (L_c) have been adopted from the literature using either the average or range.

The results of length frequency can be used as input to estimate the growth parameters of the von Bertalanffy growth model ($L\infty$ and K), where $L\infty$ is the asymptotic total length and K is the growth constant. Additionally, the growth performance index (∅), longevity, total mortality coefficient (Z), natural mortality coefficient (M), fishing mortality coefficient (F), exploitation ratio (E), length at first capture (L_c), relative yield per recruit and relative biomass per recruit and Thompson and Bell analysis can be estimated by applying the FAO-ICLARM Fish Stock Assessment Tools (FiSAT II). Unfortunately, the study did not calculate these because bottom trawling has been banned since 2018.

3.5 DPSIR Framework

3.5.1 Selection of indicators

The ultimate objective of integrated environmental assessment for shrimp fisheries management is to assess, retain, restore, and improve particular characteristics of the ecosystems and environments and their related societies. Therefore, shrimp fisheries management was assessed toward sustainable exploitation by linking the status of shrimp fisheries to the social, economic drivers, and legal responses of stakeholders. According to these characteristics, the selected indicators tend to meet the following criteria (1) sustainable for an extended period, (2) and suitable to adapt to the continuous changing in conditions (Alegre et al., 2016; Olsen, 2003). The DPSIR framework was used for undertaking Integrated Environmental Assessment, which has been adopted in the UNEP IEA/GEO process (UNEP, 2022; Baker & Beaudoin, 2019; UNEP, 2019).

The issues related to the fishing activity of *P. semisulcatus* in the territorial waters of the Kingdom of Bahrain were evaluated through the construction of a conceptual DPSIR model. Fig. 3.7 illustrates the cause-effect interactions between the components Driver, Pressure, State, Impact, and Response derived from the exploitation of the shrimp resource. This model is based on information selected, analyzed, and compiled from the respective governmental institutions, scientific journal articles, and technical reports appropriate for this study. Based on their temporality, representativeness, relevancy, and data availability, all selected indicators were acknowledged and adequately cited in Table (3.3).

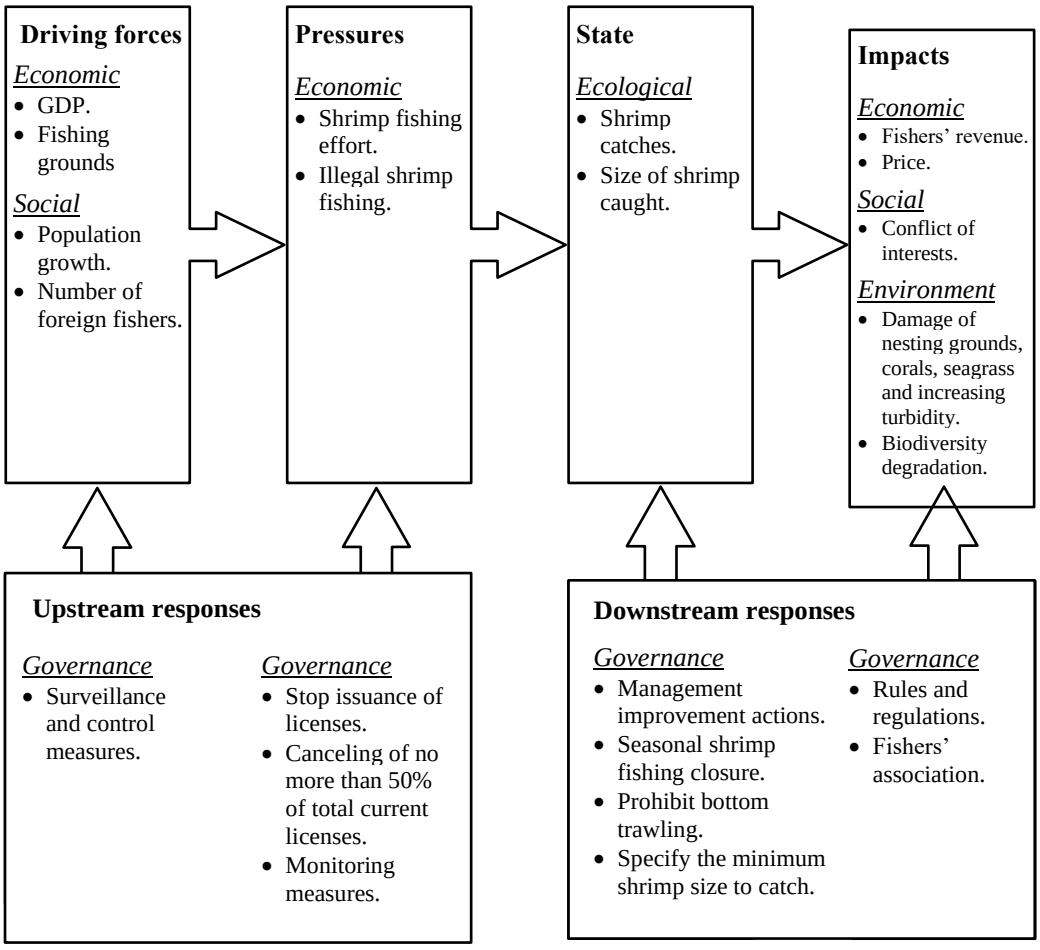


Fig. 3.7: DPSIR conceptual framework determined for the period 1990-2020 based on current shrimp management in Bahrain.

Table (3.3): Indicators and description related to shrimp fisheries obtained from data of different literature reviews, governmental reports, and field sampling.

Dimension	Indicator	Description
Driving forces		
Economic	GDP	Increase of GDP (BD)
	Fishing grounds	- The annual rate of increase in Bahrain land. - Reduction in total area of shrimp fishing grounds.
Social	Population growth	The increase in the number of individuals in a population
	Number of foreign shrimp fishers	Number of foreign shrimp fishers
Pressures		
Economic	Shrimp fishing effort	1- Landing 2- CPUE based on number of shrimping boats
	Illegal shrimp fishing	Violations recorded on illegal shrimp fishing
State		
Ecological	Shrimp catches	Total shrimp catch
	Size of shrimp caught	Mean size of shrimp
Impacts		
Economic	Fishers' revenue	Change in revenue for fishers
	Price	Increase of shrimp price (BD/kg)
Social	Conflict of interests	Increased conflicts between commercial and recreational fishers
Environment	Deterioration of fishing ground	- Damages of nesting ground, corals, seagrass and increasing turbidity. - Biodiversity degradation.

Dimension	Indicator	Description
Responses		
	Upstream responses	Shrimp fisheries management measures implemented to control the effects of the driving forces and pressures component
	Downstream responses	Shrimp fisheries management measures implemented to reduce the effect of the state and impact components

The data series was considered up to 2020, depending on the availability of the databases. Pressure component indicator data were obtained directly from the tables reported in the technical report (No. 95) on the annual fishery statistics issued in 2011 covering the shrimp fishing effort for the period 1983-2009, published scientific journal articles and the portal for Open Government Data (https://www.data.gov.bh/). Some of the data of interest has not been made available to allow it to be used for research , including the number of shrimp licenses, number of licenses for amateurs, number of fishers (Bahraini and foreign), number of fishing boats, shrimp price (monthly), shrimp catch data from 1998/1999 to 2002/2003 and in a monthly basis, and the impacted marine habitats by bottom trawling and dredging (total area).

DPSIR analysis was used to classify information about the shrimp fisheries management plan in Bahrain and identify causal interactions between natural shrimp development and anthropogenic interactions, such as socioeconomic and environmental impacts derived from overfishing and the use of destructive illegal shrimp trawl nets.

The main factors (demography, economy, shrimp price in the market, fishing effort, shrimp maturation, ecological conditions of the ecosystem,

illegal shrimp fishing, profit or loss of fishers' revenues, and conflict of interests) influence the sustainability of shrimp fishery first defined and then selected to build the model. The response component (shrimp fisheries management measures) of the model was separated into upstream (driver and pressure) and downstream (state and impact) responses, according to Miranda et al., (2020). Table (3.4) shows the source of data and the units of measurement for each DPSIR input.

Table (3.4): DPSIR indicators, units of measurement, and their data sources

DPSIR component	**Indicators**	**Unit**	**Source of data**
Driving forces	GDP	BD	Information & eGovernment Authority
	Reduction in fishing grounds	km^2	Zainal et al., (2012)
	Population growth	%	Information & eGovernment Authority
	Foreign shrimp fishers	Number	MUN. (2011); MUN. (2022)
Pressures	Shrimp fishing effort (CPUE)	kg/ shrimping boats	Calculated [Catch / number of shrimping boats]
	Illegal shrimp fishing	Number	Coast Guard Directorate
State	Shrimp catches	kg	Fisheries Directorate
	Size of shrimp caught	cm	Study fieldwork
Impacts	Fishers' revenue	BD	Calculated [Catch × Average Shrimp Price]
	Price	BD/kg	Agriculture and Marine Resources Agency and Information & eGovernment Authority, fishers' association
	Conflict of interests	-	Survey (interview)
	Deterioration of fishing ground	-	Zainal et al., (2012)
Responses	Shrimp fisheries management measures	-	Legislation and legal opinion commission

The main Driving forces (D) detected with the DPSIR framework in the shrimp fishery in Bahrain were (1) the economic dimension (sale value and reduction in fishing grounds) and (2) and the social dimension (population growth and number of foreign shrimp fishers). For purposes of comparison between years, for example, the percentage of change in land mass was calculated through:

% change = [(Final Value - Initial Value) ÷ Initial Value] × 100

The population growth% was calculated by finding the difference (subtracting) between the initial population and the population at Time 1, then dividing by the initial population and multiplying by 100.

To quantify the fishing effort, the number of shrimping boats and landings (catch) were applied as the main factors potentially influence the sustainable shrimp fisheries development in the economic dimension, and it was introduced to quantify the Pressure (P) component within the DPSIR framework. These indicators were used to calculate the Catch Per Unit Effort (CPUE) as follows: Catch (kg) was divided by the number of shrimping boats. Illegal shrimp fishing is expressed in terms of number of illegal shrimp fishing boats (without a license), illegal shrimp catch, shrimp fishing during closed season, shrimp trawling, shrimp fishing in marine protected areas or prohibited area.

Shrimp size and quantity were selected to identify changes in the ecological dimension caused by the pressure of fishing effort (number of boats) and illegal shrimp fishing under the State (S) change component of the DPSIR framework. The Impacts (I) detected by the changes in the state component with the DPSIR framework in the shrimp fishery were (1) the economic dimension (gain or loss of fishers' revenues) and (2) the social dimension (conflict of interests). First, fishers' revenues were estimated by multiplying shrimp catch (kg) by the average shrimp price (BD/kg). Then, the annual price index% was calculated using the 2020 base year,

dividing the shrimp price of the year of interest by the base year's price and multiplying by 100.

In the Response (R) component of the DPSIR framework, the existing shrimp fisheries management measures implemented to control the socioeconomic effects of the driving forces and pressures component were categorized as the upstream responses. In addition, the management strategies implemented to reduce the social-ecological effect of the state and the impact components were categorized as downstream responses.

3.5.2 Data collection

Shrimp fishery statistical data for the DPSIR model was obtained from this study fieldwork and information documented from several governmental institutions such as the Fisheries Directorate and Maritime Control Directorate of the Agriculture and Marine Resources Agency, Coast Guard Directorate, SCE, Information & eGovernment Authority and Ministry of Transportation & Telecommunication as well as published scientific journal articles.

Relevant literatures of the study area were reviewed, coupled with data obtained from the above governmental institutions, to generate information to populate the indicators. These data have been analyzed to describe the exploitation status of the shrimp fishery in the Kingdom of Bahrain based on:

- The annual shrimp catches landed by artisanal fisheries during 1980/1981 – 2020.
- Catch Per Unit Effort (CPUE) during 1990/1991 – 2020.
- The total number of shrimping boats from 1990/1991 – 2020.
- The total number of Bahraini and foreign fishers working on shrimping boats from 1983-2018.
- The sale value of shrimp (BD/kg) from 2004-2020.

- Total Revenue from shrimp fishing from 2004-2020.
- Number of violations recorded on illegal shrimp fishing before and after 2018.

3.6 Ecosystem-Based Shrimp Management (EBSM) Approach

The input and output of the DPSIR framework were used to feed into EBSM, contributing to the sustainable management of the shrimp fishery. The action items for the 12 EBM principles against the five steps (Tables 3.5 & 3.6) are identified. The specific questions to be based on for this model were formulated. Accordingly, the survey instruments were designed according to the EBM 5 steps and 12 principles.

Table (3.5): EBM principles developed by the Convention of Biological Diversity (CBD).

Principle Number	Shorthand	Definition
1	Social choices	The objectives of management of land, water and living resources are a matter of societal choices
2	Decentralization	Management should be decentralized to the lowest appropriate level
3	Adjacent effects	Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems
4	Economic context	Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context
5	Conservation of functioning	Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach
6	Appropriate limits	Ecosystem must be managed within the limits of their functioning

Principle Number	Shorthand	Definition
7	Appropriate scale	The ecosystem approach should be undertaken at the appropriate spatial and temporal scales
8	Long term	Recognizing the varying temporal scales and lag-effects that characterize ecosystem
9	Inevitable change	Management must recognize the change is inevitable
10	Balance use/ conservation	The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity
11	All relevant information	The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices
12	Multidisciplinary	The ecosystem approach should involve all relevant sectors of society and scientific disciplines

Source: Gelcich et al., 2018

Table (3.6): Practical actions carried out through the EBM steps to implement EBSM in the Kingdom of Bahrain.

Step		Principles related to step	Action items
A	Determining the main stakeholders, defining the ecosystem area, and developing the relationship between them	1. Social choices 7. Appropriate scale 11. All relevant information 12. Multidisciplinary	• Identify and involve stakeholders. • Identify ecosystem values.
B	Characterizing the structure and function of the ecosystem, and setting in place mechanisms to manage and monitor it	2. Decentralization 5. Conservation of functioning 6. Appropriate limits 10. Balance use/ conservation	• Gain a clear understanding of the management context. • Define the institutional roles and responsibilities. • Evaluate the cooperative management practices.

Step		Principles related to step	Action items
C	Identifying the important economic issues that will affect the ecosystem and its inhabitants	4. Economic context	• Determine the regulatory concern about the shrimp fishery from economical aspects to improve ecosystem health and sustainability of shrimp fisheries.
D	Determining the likely impact of the ecosystem on adjacent ecosystems	3. Adjacent effects 7. Appropriate scale	• Determine the impacts of the human activities on target ecosystems. • Determine the impacts of the target ecosystem on neighboring ecosystems.
E	Deciding on long-term goals, and flexible ways of reaching them	7. Appropriate scale 8. Long term 9. Inevitable change	• Propose a management plan. • Develop a proposed procedures for shrimp fishery management.

3.6.1 Data collection procedures

The target sample in this research is the decision-makers at several governmental institutions and fishers. Samples selected for this study were directors, chiefs, heads, and senior specialists at the Fisheries Directorate, Maritime Control Directorate, Coast Guard Directorate, and SCE. Moreover, the heads of fishing societies, skipper or Bahraini captain locally known as Nokhatha and Bahraini and foreign fishers are also involved. The sample size was represented by 50 decision-makers and 100 fishers. These selections were based on senior officers' recommendations in governmental institutions and chairpersons of the fishers' associations.

Data collection was conducted in the period running from October 2021 to January 2022. This research used self-administered structured questionnaires and structured interviews to collect the data despite the differences in data collection, analysis, and interpretation methods. Similarly, Harris and Brown (2010) used questionnaires and interviews in

mixed-method studies investigating educational assessment. While questionnaires can provide more quantifiable data amongst large populations, qualitative interview data often get more in-depth answers on participant attitudes, thoughts, and actions (Kendall, 2008). In a structured questionnaire, participants were asked to select an answer on a 5-point Likert-type response scale, and these responses were then analyzed quantitatively. In a structured interview, a set of open-ended questions were used in a standardized order, but also (if needed), the interviewer spent considerable time probing participant responses, encouraging them to provide detail and clarification, and these data were analyzed qualitatively. The study used the survey method adopted by Al-Qishawe (2021), but it has been modified to fit the country's situation.

The survey instruments were prepared, reviewed, and approved by the Vice President for Community Service and Alumni Affairs and the Dean of Graduate Studies and Scientific Research at the University of Bahrain. Two sets of structured questionnaires (one for decision-makers and the other for fishers) were designed, in which the majority of questions in both templates were similar. Each questionnaire covers the EBM's five steps and twelve principles, focusing on shrimp fisheries status. The questionnaire for fishers was designed to survey the opinion of a random sample of fishers. On the other hand, the decision-makers' opinions were surveyed on possible management to protect shrimp stock, increase catchability, identify the pressures on the shrimp fisheries, and plan to conserve this important marine resource.

Questionnaires are divided into three sections (Appendix 1 and Appendix 2). Section A is the demographic profile of respondents. Section B pertains to EBSM. Lastly, Section C contains an open-ended question regarding the respondent’s suggestion for improving the sustainability of shrimp fisheries. Section B of the questionnaire utilized a five-point Likert

scale. The Likert scale is mainly used in such surveys (Bougie & Sekaran, 2019). According to Sekaran & Bougie (2013), data collection using questionnaires helped researchers to obtain data quickly and effectively. Further, the information from questionnaires is accessible to code.

Data collection administration was applied personally to decision-makers to ensure that researcher was able to collect all completed responses within a short time. In addition, any doubts about the questions can be clarified on the spot, and also researcher can clearly explain the purpose of the study. The researcher read the questions to all fishers, including the skipper (Nokhatha), regardless of their reading level, as they all need to understand the questions equally. Additionally, the researcher asked the skipper to read the questions to other fishers who could not read them independently. A translated questionnaire was prepared for non-Bahraini fishers, and the researcher read the questions for them. In this study, a mixed-mode method has been used, allowing participants to use either a Web-based (online) questionnaire or a paper questionnaire. Guise et al., (2010) used a similar approach, which yielded a higher response rate and reduced non-response bias.

Before distributing the questionnaires, the researcher obtained permission from the Undersecretary for Agriculture and Marine Resources at the MUN. Following approval by the office of the Vice-President for Alumni Affairs and Community Service, an email was sent to 14 decision-makers, informing them about the study purpose and the expected start date of the interviews. Interviews took place from October through December 2021 (Table 3.7, Figs. 3.8 & 3.9). Out of the 150 questionnaires (50 decision-makers and 100 fishers) distributed, 65 (43%) questionnaires were collected representing 16 decision-makers and 49 fishers filled out the questionnaire.

Demographic information was collected verbally. Every interview lasted between 30 and 45 minutes and was conducted via telephone, Zoom, or face-to-face meetings. According to Dörnyei (2007), as cited in Alshenqeeti (2014), an excellent qualitative interview has two key features: (a) it flows naturally, and (b) it is rich in detail. It is essential to create an appropriate, safe and comfortable interview atmosphere in which participants feel more at ease and thus talk freely (Meloy & Hoffmann, 2021). Fourteen individuals from the decision-makers believed the topic was relevant to their practice and wanted to share their views. However, only four fishers agreed to be interviewed. Only the participants and the interviewers were present during the interview. Interviews were tape-recorded with the respondent's permission. Brief notes were made during the interviews. Anonymity and confidentiality were maintained by identifying data forms and tapes only by numbers, date, and workplace.

Two sets of structured interviews (one for decision-makers and the other for fishers) were designed to elicit data specific to the study and allow participants to address topics related to shrimp fishery management. Most of the open-ended questions in both templates were similar, such as 'Tell me about the activities practiced by fishers that negatively affect shrimp fisheries' and 'How do current procedures and policies participate in shrimp fisheries sustainability?' In addition, some survey items resulted from qualitative research published on shrimp fisheries status in the Kingdom of Bahrain.

Each survey tool (interviews and questionnaires) was pilot tested on four academic faculty, four marine science experts, one fisheries director (former), and two fishers to test the accuracy of the questionnaire items addressed. As a result, some questions that seemed incomprehensible were modified following feedback comments.

Table (3.7): Interviews schedule with key participants in fisheries field.

#	Name of the interviewee	Occupation/ workplace	Date of interview
1	Mr. Abdul Amir Al-Mughni	Head of Fishing Society (Sitra)	October 26, 2021
2	Mr. Abdulla Edhrabooh	Fishers	October 26, 2021
3	Mr. Khaled Al-Shirawi	Director of the Maritime Control Directorate	November 4, 2021
4	Mr. Jassim Al-Qaseer	Director of Fisheries Directorate (former)	November 4, 2021
5	Dr. Ibrahim Abdel Qader	Fishery consultant	November 7, 2021
6	Dr. Muhammad Al-Rumaid	Marine science expert	November 9, 2021
7	Mrs. Nouf Al-Wasmi	SCE	November 10, 2021
8	Mr. Ali Issa	SCE	November 10, 2021
9	Mr. Ali Mansour	SCE	November 10, 2021
10	Mr. Ali Shuaib	SCE	November 10, 2021
11	Anonymous	Fishers	November 10, 2021
12	Mr. Walid Al-Mahmeed	Chief - Maritime Control Directorate	November 14, 2021
13	Mr. Mohammed Abdul Razzaq	Coast Guard Directorate	November 23, 2021
14	Ms. Laila Al Muftah	National Aquaculture Center	November 25, 2021
15	Mr. Nayef Issa A-Sheikh	Chief - Coast Guard Directorate	November 28, 2021
16	Mr. Jassim Al-Jeran	Head of Fishing Society (Muharraq)	November 28, 2021
17	Mr. Jassim Alaradi	National Aquaculture Center (former)	November 30, 2021
18	Mr. Bassam Al-Shuwaikh	Senior specialist – Fisheries Directorate	December 6, 2021



Fig. 3.8: Interviewing with key participants in fisheries field from governmental institutions.



Fig. 3.9: Interviewing with fishers.

In order to assess if EBM principles were present in the regulatory responses, 45 documents issued between 1981 and 2021 were reviewed. These included laws, decrees, and resolutions. The regulatory responses

list was qualitatively assessed to identify the presence/absence of EBM principles throughout the EBM' five steps. The Legislation and Legal Opinion Commission website, which records all legislation (https://www.lloc.gov.bh/), was used to find and download the regulatory responses. Regulatory response documents were registered with the date on which they were published and the presence/ absence of specific EBM principles within their content. This study only assessed the existence of EBM principles. The study period was divided into two time periods. These periods were determined considering important benchmarks in the development of the national legislation. In this way, the 1st time period corresponds to the years 1981–2001 (begins with the establishment of the first fisheries regulation decree in Bahrain) and the 2nd period covers the years 2002-2021 (begins with the establishment of a new and amended decree for regulation of fishing, exploitation, and protection of marine wealth).

3.6.2 Statistical analysis

This research used Cronbach's alpha to test the reliability of the questionnaire. Cronbach's alpha is the most commonly used measure of internal consistency reliability (Henson, 2001). Cronbach's alpha reliability coefficient typically ranges from 0 and 1. In terms of reliability, if the alpha value is less than 0.6, it is considered unacceptable; while the alpha value is over 0.6, the result (questionnaire) is acceptable (Rahim et al., 2016). Hair et al., (2003) provided a rule of thumb about the Cronbach alpha value, as shown in Table (3.8).

Table (3.8): Rule of Thumb on Cronbach Alpha.

Alpha Coefficient Range	Strength of Association
<0.6	Poor
0.6 to < 0.7	Moderate

Alpha Coefficient Range	Strength of Association
0.7 to < 0.8	Good
0.8 to < 0.9	Very Good
0.9	Excellent

For the decision-makers questionnaire, the 69 items used in this questionnaire obtained Cronbach's alpha value of 0.688, while the 57 items in the fisher's questionnaire have Cronbach's alpha of 0.755. As these values are greater than 0.6, the questions prepared are acceptable and reliable for data analyses applied.

As for the analysis of the results, all data were put in an Excel file, and then Statistical Package for Social Science (SPSS) technique computer software version 22.0 was used to test significant differences. Moreover, descriptive statistics were employed such as frequency, percent and mean.

Chapter Four: Results, Discussion, and Recommendations

4.1 Length Frequency Distribution

The total number of shrimp specimens collected during the fishing season (August 2020 to January 2021) was ranged from 171 to 355 per month (Fig. 4.1) with an overall of 1,695. The monthly length frequency data of the *P. semisulcatus* are plotted in (Fig. 4.2). The smallest individuals (≤ 6 cm TL) were observed in October, and January, while the largest sizes (≥ 20 cm TL) were found in January. Most individuals, however, fell within the range of 10 - 14 cm TL, with weights varying between 7 g and 20 g.

The length-frequency histograms for both sexes indicated that the population at any one time was composed of, at most, two-year classes. Mostly, 2-3 cohorts occurred with different peaks except the sample of November (a) where only one cohort was found and the sample of January (a) in which four cohorts were observed (Fig.4.2).

In comparison with previous studies carried out in the Arabian Gulf, the length frequency data in this study covered most of the size classes for *P. semisulcatus* from the coastal waters of adjacent GCC countries. However, *P. semisulcatus* females tend to be larger than males (Al-Qishawe, 2021; Abdul-Wahab, 2014; Hosny, 2007).

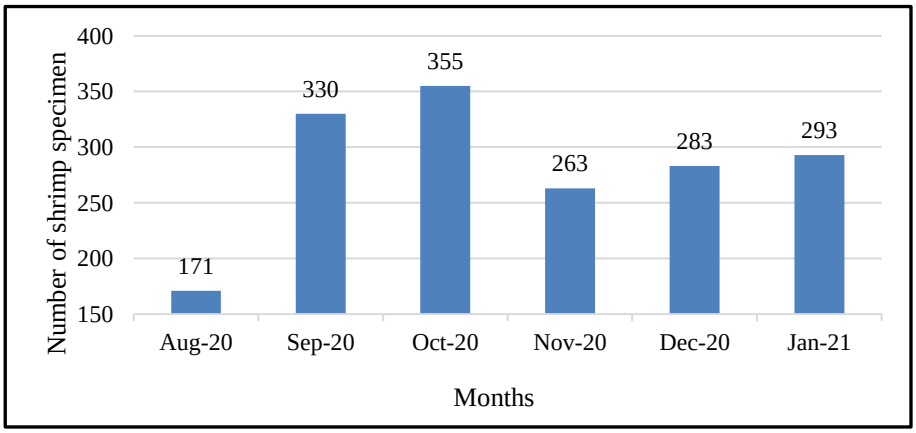
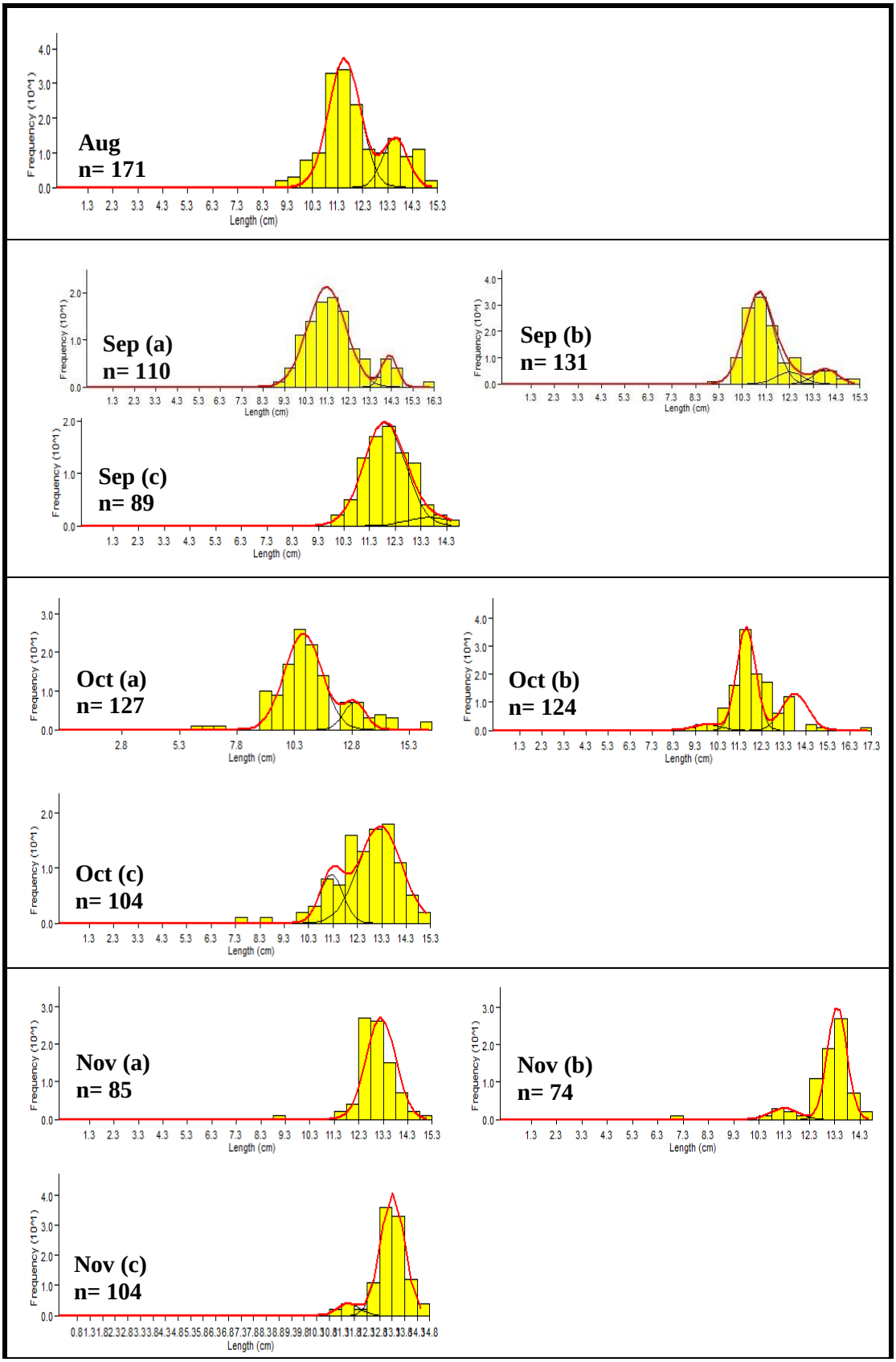


Fig. 4.1: Total number of *P. semisulcatus* collected during the fishing season (August 2020 - January 2021).


Aug
n= 171
Sep (a)
n= 110
Sep (b)
n= 131
Sep (c)
n= 89
Oct (a)
n= 127
Oct (b)
n= 124
Oct (c)
n= 104
Nov (a)
n= 85
Nov (b)
n= 74
Nov (c)
n= 104
Frequency (10^1)
Length (cm)

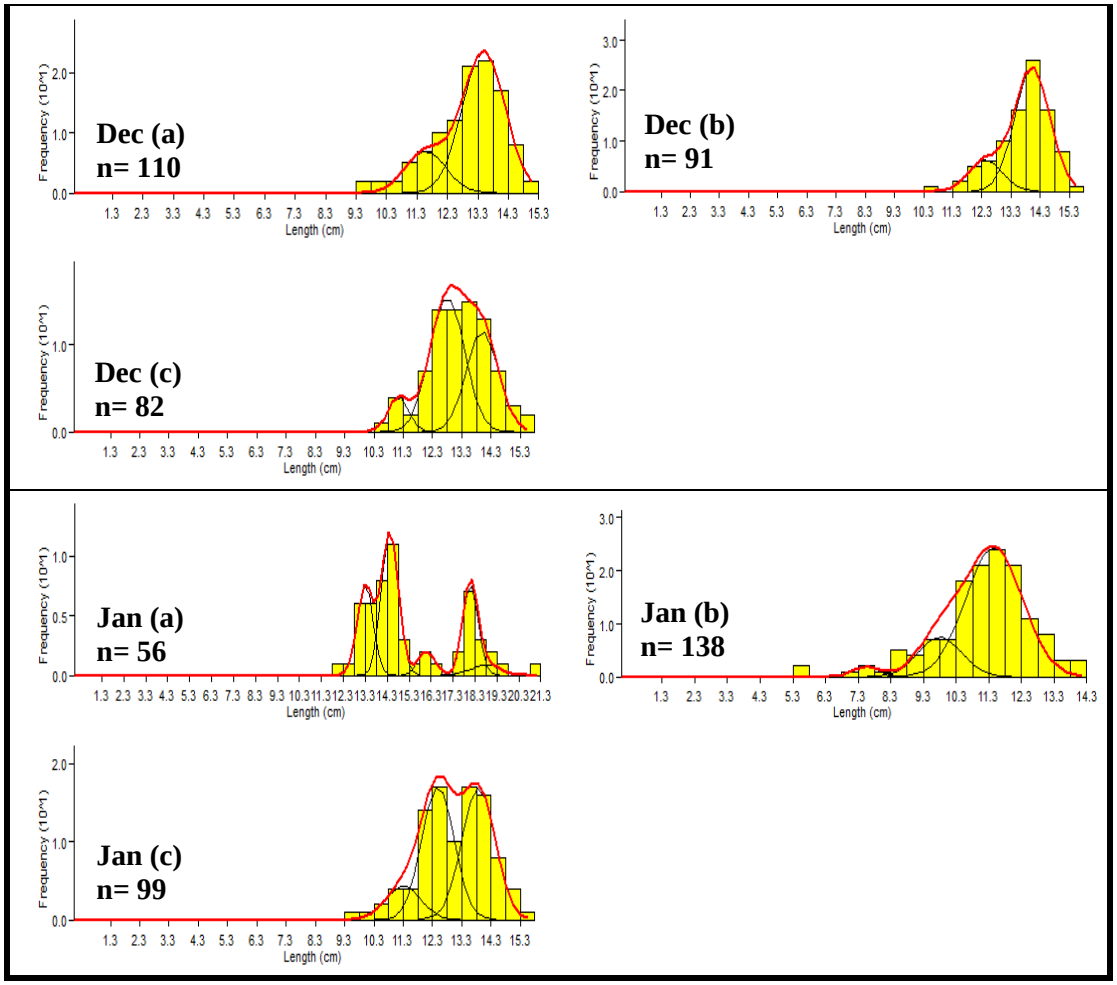


Fig. 4.2: Monthly length frequency distribution by three intervals of *P. semisulcatus* from August 2020 through January 2021.

4.2 Length-weight relationship

A positive correlation has been indicated between the body weight and the total length; since the correlation coefficient is close to 1 (R^2 = 0.9527) as presented in (Fig. 4.3), it suggests that the growth in size or length induces an increase in body weight. The relationship obtained in the present study was similar to that obtained by Sarada (2010) on the Puthiappa coast in India. Furthermore, similar results were found by Niamaimandi et al., (2008b) in Bushehr waters (Arabian Gulf), in which positive and high values of the correlation coefficients obtained between the total length and weight in males and females of *P. semisulcatus* (R^2 =

0.9781 and 0.9795, respectively). In addition, Hosny (2007) showed a noticeable difference in size between males and females, in which the females exhibited allometric growth in weight relative to length. In the present study, the minimum weight encountered in the *P. semisulcatus* population was 1.20 g for a minimum TL of 5.8 cm in January 2021. However, the maximum weight was 68.96 g for a TL of 21 cm during the same month.

The length-weight relationship is the most commonly used approach in fisheries management, as it provides information on the status of fishery stocks. In addition, fisheries researchers often use the length-weight relationship to estimate the weight from the length when assessing fisheries yields (Ouahb et al., 2021).

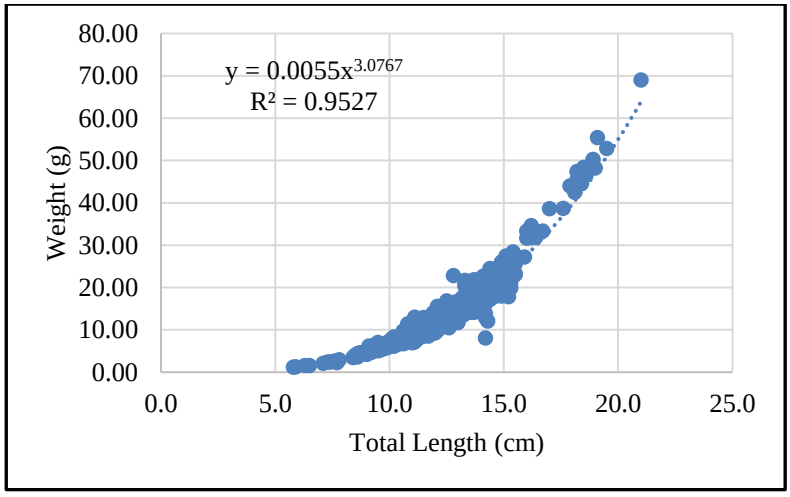


Fig. 4.3: Length-weight relationship of *P. semisulcatus* in territorial waters of the Kingdom of Bahrain, from August 2020 to January 2021.

4.3 Sexual Maturity

The length at first sexual maturity (L_m: represents the length at which 50% of sample is mature) helps determine the minimum legal length that must be avoided in fishing to preserve an adequate spawning stock (Alsolami & Jastania, 2016). Moreover, the length at first capture (L_c) is of great importance to sustain the spawners. Several studies estimated the

length at sexual maturity of *P. semisulcatus* in the Arabian Gulf (Table 4.1) to be more than 10 cm.

Table (4.1): Size at sexual maturity for *P. semisulcatus* in the Arabian Gulf based on previous studies.

Study Areas	**Size at sexual maturity (L_m) (TL in cm)**	**Length at first capture (L_c) (TL in cm)**	**References**
Saudi Arabia	5-16	6.7- 12.3	Al-Qishawe, (2021)
Saudi Arabia	6.2	8.9	Rabaoui et al., (2017)
Jizan area, Saudi Arabia	10.7	10.1	Alsolami & Jastania (2016)
Qatif area, Saudi Arabia	12.4 (males) 14.0 (females)	8.6-10.7	Boqursain (2016)
Bushaher, Iran	15.7	-	King (2013)
Bushaher, Iran	11.3	7.8	Niamaimandi, et al., (2008a)
Bushaher, Iran	15.3	-	Khorshidian (2004)
Arabian Gulf	12.6	-	Badawi (1975)

Al-Qishawe (2021) showed that the length of *P. semisulcatus* at first capture (L_c) was ranged between 6.68 cm and 12.2 cm TL on the Saudi Arabia coast, and this primarily overlapped with the length at sexual maturity (L_m) (5-16 cm) estimated in the Saudi Arabia coast, which potentially affects the sustainable exploitation. According to Garcia (1988), the maturity lengths of Penaeid shrimps usually fall between 8 and 10 cm TL. Therefore, it was proposed by Rabaoui et al., (2017) that *P. semisulcatus* on the western side of the Arabian Gulf tend to reach sexual maturity at a relatively small size (5 - 6 cm TL) regardless of having the same age as other locations in the Gulf.

Moreover, the estimated values of length at sexual maturity of *P. semisulcatus* reported in the Arabian Gulf were within the range of those obtained by Kaka et al., (2019) and Munga et al., (2013) in Malindi-

Ungwana bay in Kenya (L_m =23.3-45.1 mm CL i.e. about 6.2-12.8 cm TL and 17-58 mm CL i.e. about 4.3-16.7 cm TL, respectively), as well as El-Ganainy & Yassien, (2012) in the Gulf of Suez and Abdel Razek et al., (2008) in Bardawil lagoon of the northern Sinai coast, Egypt (L_m = 3.54 cm CL i.e. about 10.0 cm TL and 11.0-16 cm TL, respectively).

The size of *P. semisulcatus* in some previous studies was determined using carapace length (CL) measurement. In contrast, other studies measured the total length (TL) as used in the current study. Therefore, a comparison between the studies was made after converting the carapace length to total length referring to Boqursain (2016) study by using the following regression formula: y = 0.3318x + 0.2608.

The change in monthly length distributions of *P. semisulcatus* was used to estimate maturity stages as follows: Stages I and II represent immature and maturing individuals respectively, whereas Stage III represents mature ones (Figs. 4.4 & 4.5). In Penaeid shrimps, five ovarian maturation stages were recognized by the variations in color and the development and arrangements of cells. These stages were designated as Immature, growth, ripening, ripe (fully mature), and spent (Amanat & Qureshi, 2011).

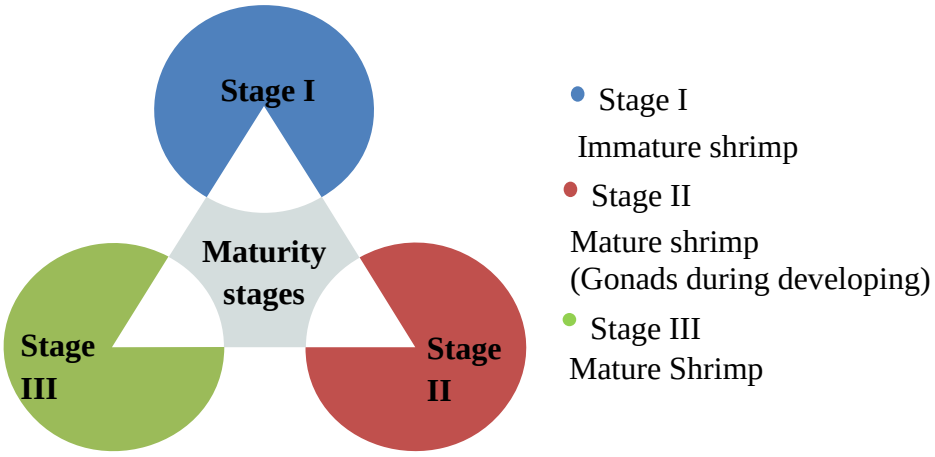


Fig. 4.4: Maturity stages of *P. semisulcatus* from territorial waters of the Kingdom of Bahrain during fishing season (August 2020 - January 2021).

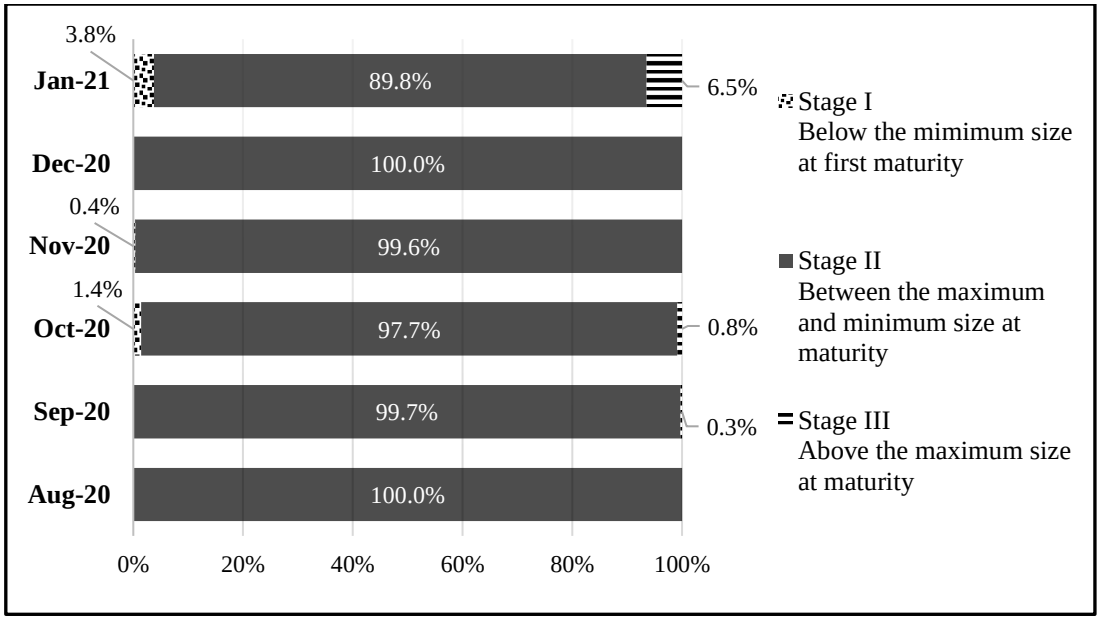


Fig. 4.5: Percentage of maturity of *P. semisulcatus* in the territorial waters of the Kingdom of Bahrain during fishing season (August 2020 - January 2021).
Note: Minimum and maximum size at sexual maturity was obtained from literature.

The present results demonstrate that the length of the captured *P. semisulcatus* was between 5.8 cm TL and 21 cm TL. The average length at first capture (L_c) as obtained from previous studies, described in Table (4.1), was 9 cm TL. Furthermore, a comparison of length at first capture and length at first maturity for the *P. semisulcatus* obtained from previous studies in the Arabian Gulf with the total length of *P. semisulcatus* caught from the territorial waters of the Kingdom of Bahrain showed that the majority of captured shrimp were classified as immature (Fig. 4.6). Immature specimens indicate that fishers in Bahrain's territorial waters are already getting smaller shrimps without allowing them to reach sexual maturity. From the average of L_m and L_c, it seems that shrimp catch has been affected during all the months of fishing season from August 2020 through January 2021 as the captured shrimp length falls below the

average length at first capture (L_c), which was categorized as immature shrimp.

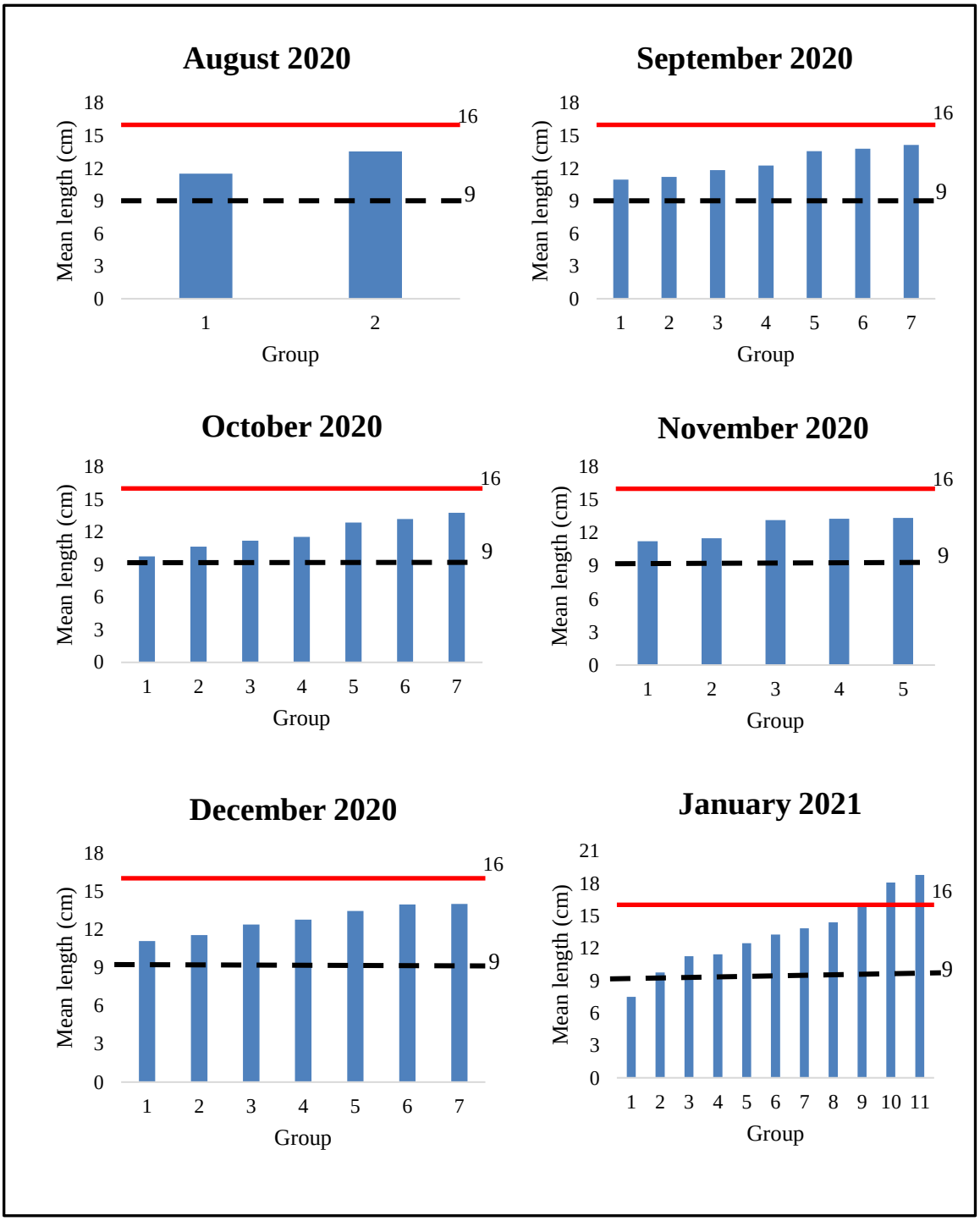


Fig. 4.6: Monthly mean length of *P. semisulcatus* in territorial waters of the Kingdom of Bahrain. The red solid line represents the (L_m) and the dotted line represents the (L_c).

According to previous research on sexual maturity in the Arabian Gulf, described in Table (4.1), *P. semisulcatus* become sexually mature within a small size at 5 cm TL but also reaches maturity at a much larger size at 16 cm TL. Thus, *P. semisulcatus* are being caught at sizes smaller than the recorded size at sexual maturity, indicating a poor opportunity for the *P. semisulcatus* in Bahrain's territorial waters to spawn before fishing, which is considered an important parameter that leads to the overexploitation of the stock. Furthermore, fishers are still using bottom trawl nets, which were banned as per Ministerial Resolution No. (205) of 2018, as small sizes of shrimps, have occurred in significant numbers in the collected samples. Additionally, from time to time, the newspapers announced several exceedances reported by Maritime Control Directorate and Coast Guard Directorate regarding fishing and selling shrimp during the closed season, shrimp trawling, shrimp fishing in marine protected areas or prohibited area, and shrimp fishing without a license. Hence, the fishers need to be educated about the impact of unsustainable fishing practices on shrimp stock in Bahrain.

4.4 Assessment of Shrimp Fishery Status and its Sustainability

The assessment of the shrimp fisheries management through the DPSIR framework allowed us to identify the main components that explain the trend of shrimp fishery in Bahrain over the last two decades. The increased demand and prices for shrimp, explaining the increase in illegal fishing practices by fishers and the use of unsustainable fishing methods, despite the government's efforts to manage the fishery. Consequently, the current state of the shrimp fishery generates ecosystem degradation and high control costs. The DPSIR framework was adopted by the United Nations Environment Program (UNEP) in 1995, and the Global Environment Outlook Reports until the latest GEO 7 (UNEP, 2022). This study used this framework to assess the shrimp fishery status (S) in an integrated way. It was used to identify the drivers (D) and pressures (P), address their impact (I), and comprehensively analyze the existing shrimp fishery responses (R), consequently setting the outlook or the future scenarios to develop policy options and suggestions for sustainable shrimp fisheries in Bahrain.

This part of the study answers the five Integrated Environmental Assessment questions (UNEP, 2012, 2019) shown in (Fig. 4.7), implemented in several studies (Al-Omran et al., 2023; Elliott et al., 2017; Maunder & Punt, 2013; Leadbitter & Ward, 2007), related to the two issues of shrimp overexploitation: increased in the quantity of shrimp caught and mismanagement of shrimp fisheries and illegal shrimp fishing practices.

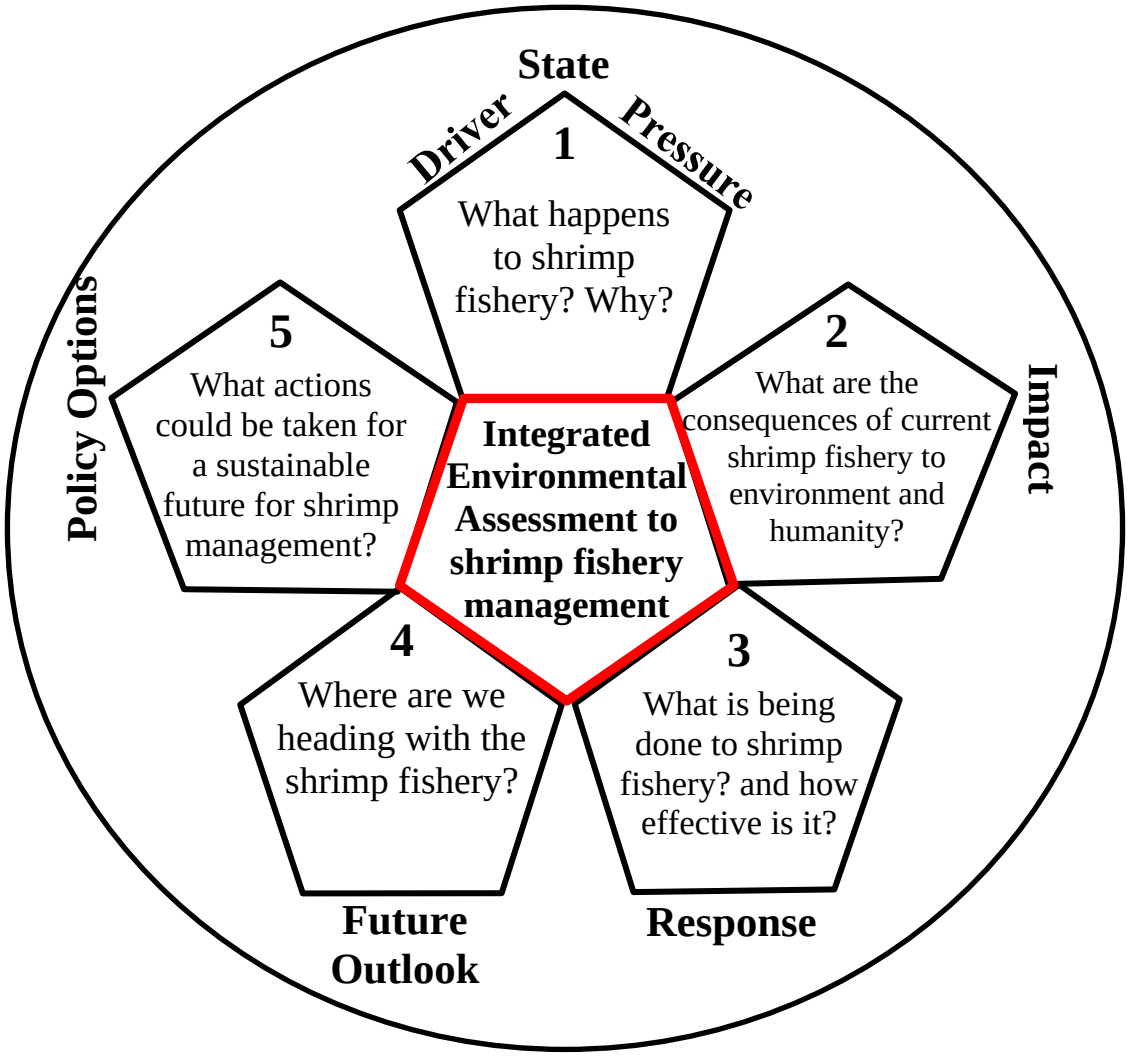


Fig. 4.7: Integrated Environmental Assessment approach to shrimp overexploitation in Bahrain (modified from Al-Omran et al., (2023)).

4.4.1 What Is Happening to Shrimp Fishery in Bahrain and Why?

To answer this question and demonstrate the status of shrimp fishery, the collected data from Ministry of Municipalities Affairs & Agriculture (MUN) was used to figure out the trend of shrimp exploitation in Bahrain from 1990 to 2020 (Figs. 4.8, 4.9 & Appendix 3).

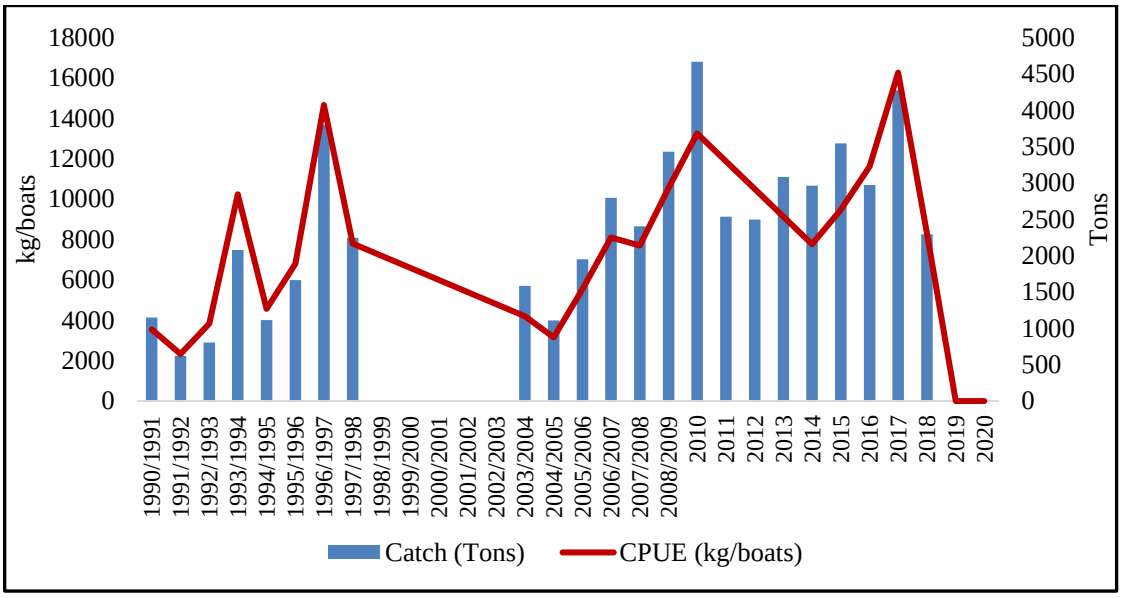


Fig. 4.8: Annual catch (tons), Catch per unit effort (CPUE) (kg/boats) during 1990/1991-2020.
Source: Fisheries Directorate in Bahrain.

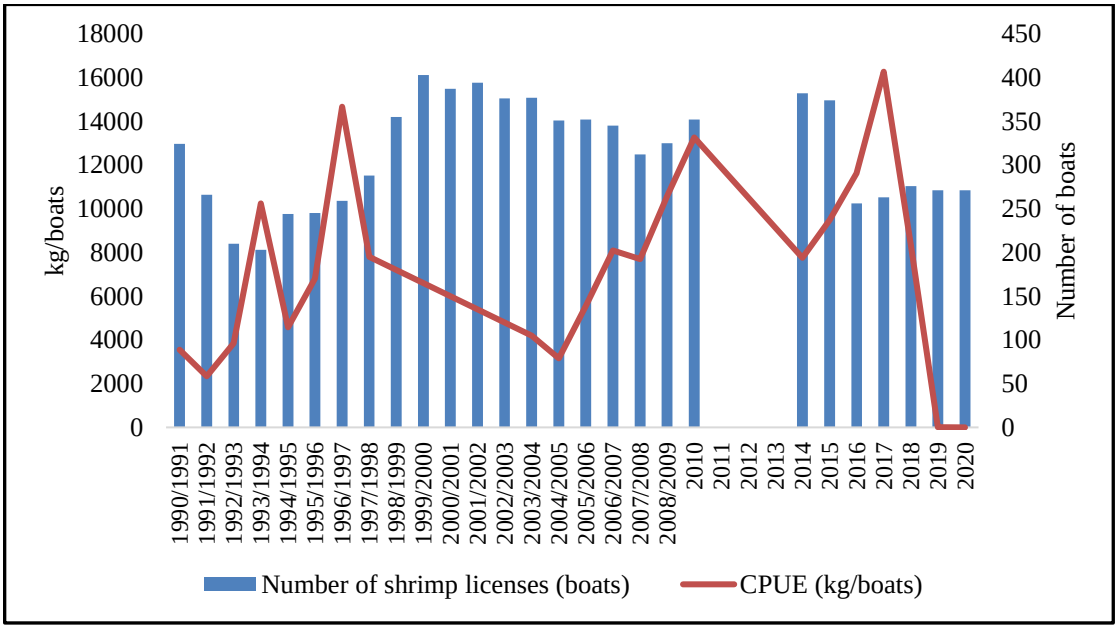


Fig. 4.9: Number of shrimp licenses (boats), Catch per unit effort (CPUE) (kg/boats) during 1990/1991-2020.
Source: MUN, 2022; MUN, 2011; Fisheries Directorate in Bahrain.
Note: Number of boats licenses from 2010-2020 were collected from news archives published on the MUN website.

Shrimp landing exhibited a progressive increase from 2006, with two maximum landings in 2010 (4,667 tons) and 2017 (4,278 tons), followed by a strong decrease in 2020 to 2.17 tons (Fig. 4.8). This decrease in shrimp catch was associated with following regulations:

1. Banning fishing by trawling nets.
2. The annual six-month mandatory ban on catching, trading, and selling shrimp.
3. A decrease in the number of big and medium-sized boats (known locally as Banoosh).
4. A decrease in fishing effort (i.e., through control over illegal fishers).
5. An increase in monitoring, control, and surveillance function through Maritime Control Directorate and Coast Guard Directorate.
6. COVID-19 affected the shrimp catch in 2020 because fishing practices mostly ceased.

Furthermore, the shrimp fishing licenses have been canceled or converted to fishing licenses for fish, according to the cabinet decision taken in September 2019. This pressure component could generate instantaneous changes in the state of the shrimp populations and their habitat.

The number of licensed shrimping boats and catch statistics were used for computing CPUE, which, in a data-poor situation or absence of stock assessment, represents a good alternative for detecting stock and long-term trend monitoring of fisheries (Belhabib et al., 2018; Stamatopoulos, 2002). Moreover, it is helpful if fisheries management actions are either absent or ineffective (Zeller et al., 2021). CPUE is expected to be proportionate to shrimp population utilized as the relative abundance index to evaluate the population trends. A decrease in CPUE indicates a situation of over-exploitation, a steady CPUE value points out

sustainable exploitation of the fishery resources, and an increase in its value corresponds to a healthy and growing population (Tikadar et al., 2021; Adibi et al., 2019; Grafton et al., 2007).

Fig. 4.9 revealed that CPUE fluctuated significantly from 1990 to 2020. There were decreases in CPUE value over several years. Alongside an expansion of the shrimping fleets, the effective CPUE has consistently decreased since 1990, showing the increasing pressure of fisheries on sea resources. The decline in CPUE (about 2 ton/boat) recorded in 1991-1992 were not related to the fishing effort, but in 1990/1991, fishing activities in the Arabian Gulf were suspended because of the Gulf war. For example, the effect of the 1991 Gulf war on the Saudi shrimp (*P. semisulcatus*) stocks was preliminarily assessed by Mathews et al., (1993), in which Saudi shrimp landings fell from nearly 4000 tons in 1989 to nearly 25 tons in the first half of 1992.

Similarly, Bahraini shrimp landings decreased from nearly 1695 tons in 1987/1988 to nearly 620 tons in 1991/1992. On the other hand, the CPUE declined to levels as low as 3 tons/boat in 2004-2005 due to the increased number of shrimping boats. The CPUE has declined significantly since 1997/1998, resulting in a decline in total catch despite firstly a substantial increase in total trawling hours, which indicates that shrimp trawling is unsustainable, and secondly the implementation of management measures such as seasonal closure and a ban on steel-hulled fish trawlers in 1998 (Erftemeijer et al., 2004). It is evident from the results in Fig. 4.9 & Appendix 3 that the shrimp caught per boat decreased as the total number of boats increased, even though there is fluctuation in the results. The least value of CPUE was observed in 2019 and 2020, which could be related to prohibiting shrimp trawling as well as the shrimp catch in 2020 could be exceptional due to COVID-19. The decline in the shrimp

catch is expected to continue during 2021 due to the shrimp trawling ban in Bahrain.

The fluctuation of CPUE affects the stability of shrimp prices because shrimp prices are affected by the total supply and demand of shrimp. Thus, fisher is forced to raise the shrimp price when the catch amount decreases to compensate for the fishing trip's expenses, which affects the per capita shrimp consumption. Therefore, determining the appropriate number of shrimping boats, fishing hours, and average catches per boat is necessary to ensure the sustainable exploitation of shrimp fishery.

Fig. 4.10 & Appendix 4 illustrate the changes in the shrimp catches in Bahrain compared with Saudi Arabia (Arabian Gulf coast), showing fluctuations over the last 30 years for both countries. However, both countries showed a similar trend. In Bahrain, the first half of the 1990s showed an increasing pattern up to 1994, where the catch reached 2,079 tons, followed by a steady decline, and then the catch increased again to reach 3,800 tons in 1997. Moreover, a gradual increase could be observed during 2005 – 2017, with the highest level (4,667 tons) in 2010, followed by a sharp drop to its lowest level in 2019 and 2020. It appears that the shrimp landings in Saudi Arabia (Arabian Gulf coast) recorded a higher rate compared to Bahrain. The catches showed an increasing pattern up to 2012 when the rate attained 10,670 tons, followed by a steady state of decline, achieving 6,586 tons in 2020 in Saudi Arabia (General Authority for Statistics, 2023).

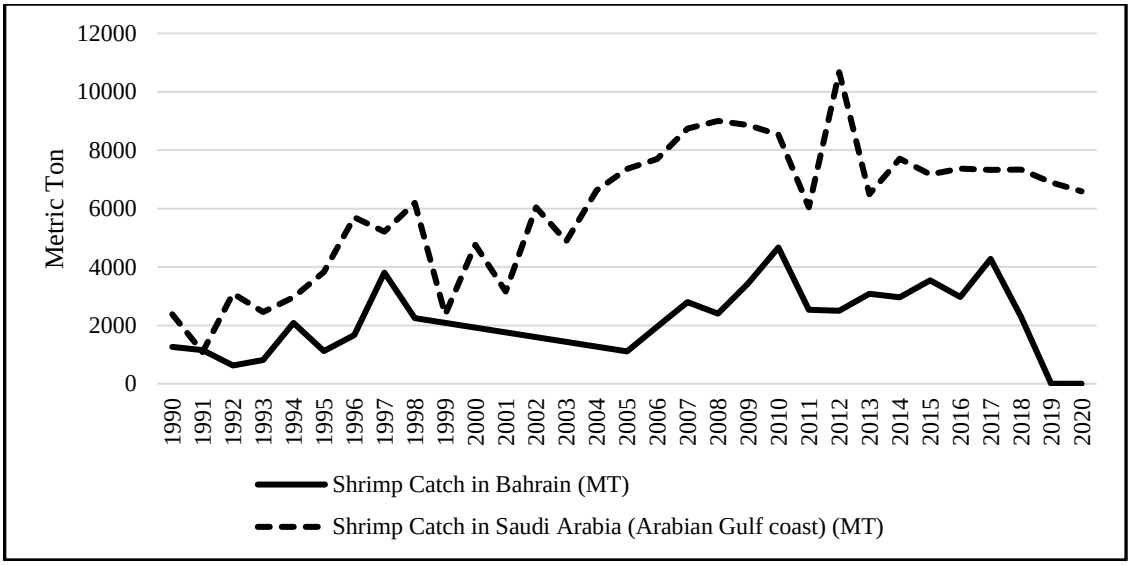


Fig. 4.10: A comparison of shrimp catches (MT) in the Kingdom Bahrain and Saudi Arabia (Arabian Gulf coast) from 1990-2020.
Note: Shrimp catch data in Saudi Arabia was obtained from General Authority for Statistics (https://www.stats.gov.sa/en).

Several drivers could lead to the issue of increasing quantity of shrimp caught, mainly the increasing demand for shrimp consumption (Abbas & Ghazi, 2021). Unfortunately, the data about Bahrain's per capita shrimp consumption were unavailable. Fig. 4.11 illustrates the changes in the rate of annual per capita fish consumption in Bahrain. A gradual decline could be concluded over the 21 years since 1995, followed by a strong increase in which the per capita achieved 23.7 kg/person in 2020, with little improvements for a few years in between, dropping to its lowest level in 2015 where the rate attained 4.7 kg/capita/year, due to a reduction in the number of fishers working on the Banoosh from eight to six fishers and from three to two fishers for speed boats, in addition to prohibiting shrimp fishing by speed boats. It appears that the rate of per capita has fluctuated over the 26 years (1995-2020), ranging between 19 and 24 kg.

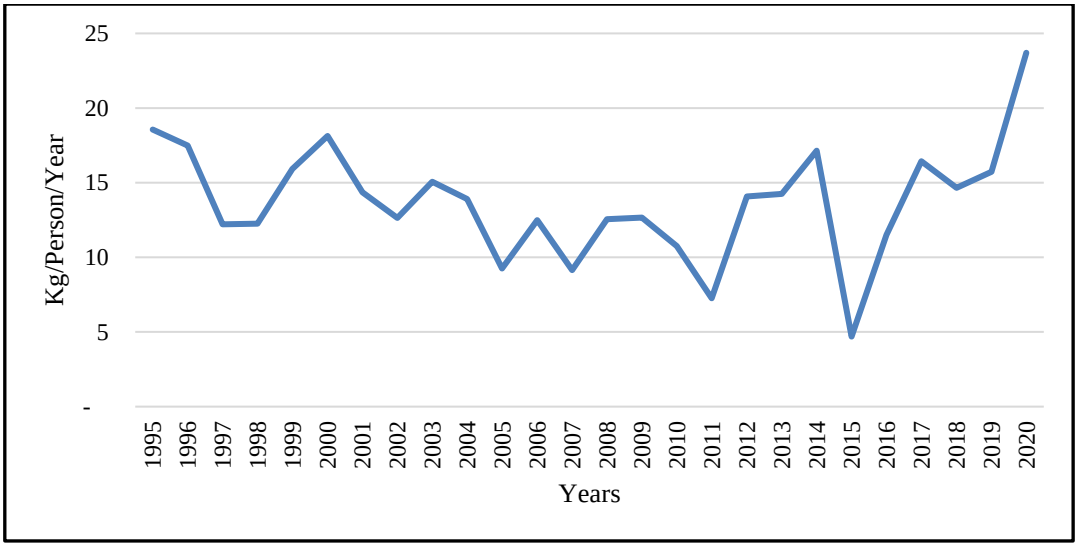


Fig. 4.11: Fish per capita in the Kingdom Bahrain.
Source: IGA (2020) and Fisheries Directorate

Furthermore, the population in Bahrain in 2021 was increased to 1,504,365, with an annual growth rate of 2%. The expatriates comprising around 52% of the total population in Bahrain (IGA, 2022). Bahrain's total area is 787 km^2, and its population is more than 1.5 million, resulting in one of the world's highest population densities (IGA, 2022), at more than 1900 people/km^2 (Alsabbagh, 2019). As the population continues to rise, so will the demand for food and other fisheries products (Fig. 4.12).

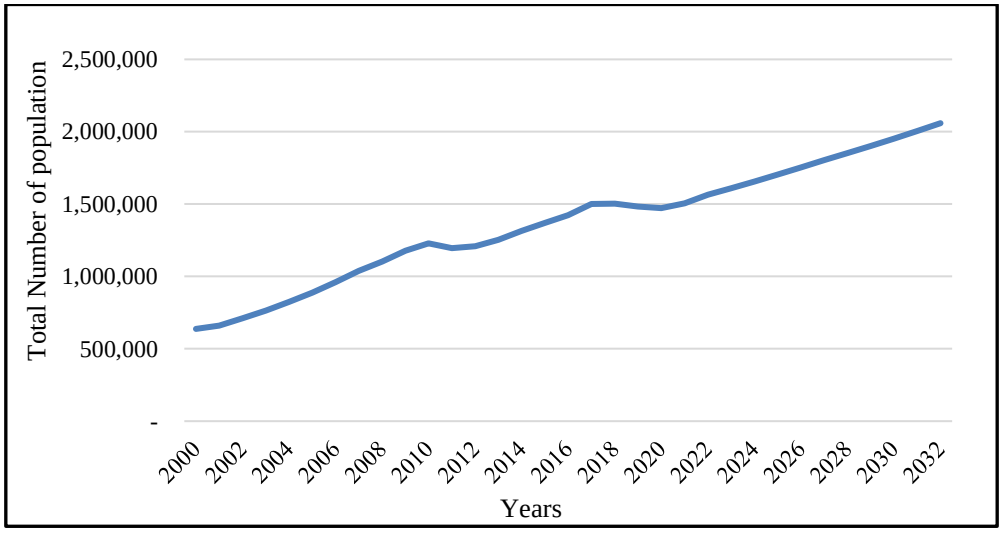


Fig. 4.12: Bahrain's population growth from 2000-2032 (IGA, 2022).

The sale value of the shrimp could also be considered a significant driver because the shrimp price is an impact of supply-demand trend. Attracting more new fishers (Bahraini or foreign) leads to an increase in fishing licenses. The sale values of the shrimp showed progressive growth between 2004 and 2020; the price increase started in 2014, with the maximum recorded price in 2020. The changes in the price range between 1.91 and 3.5 BD per kilogram (Fig. 4.13). From 2011 to 2020, the consumer price index has increased by 16% (Fig. 4.14), while shrimp prices have increased by 54%. While the general price level of all consumer goods has steadily increased, shrimp prices have advanced erratically. A reduction in shrimp catches due to the trawling ban may be responsible for increasing its price. Thus, the increasing demand and steadily rising prices of shrimp are considered an encouraging factor to cultivate more shrimp in Bahrain.

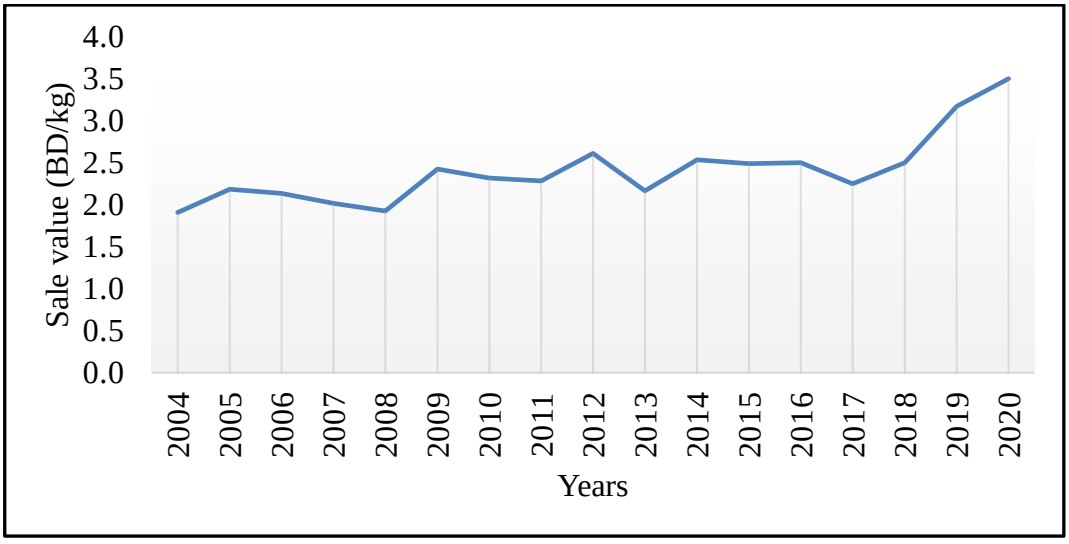


Fig. 4.13: Sale value of shrimp (BD/kg) in Bahrain from 2004-2020.
Source: Agriculture and Marine Resources Agency and IGA (2020).
Note: The data from 2016 -2020 were obtained from the fishers' association.

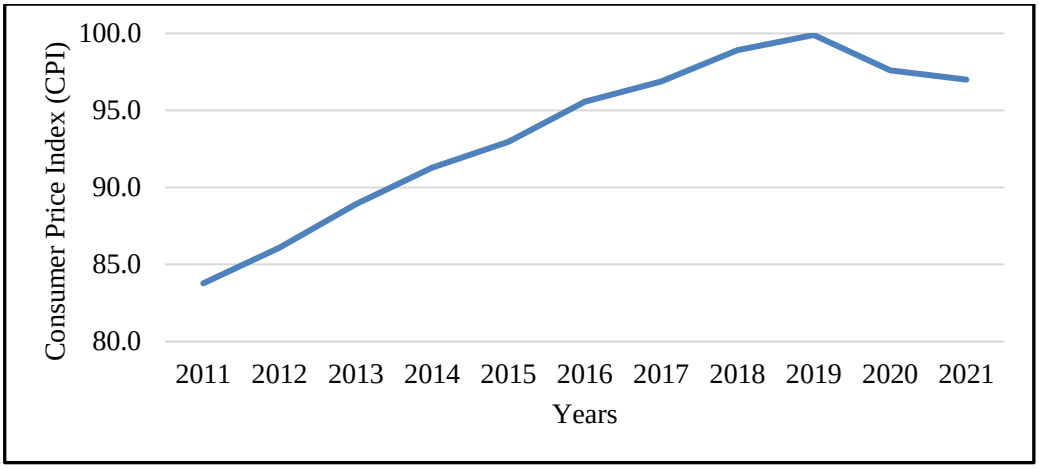


Fig. 4.14: Consumer Price Index in Bahrain from 2011 to 2021. (Base: April 2019 (=100)) (IGA, 2022).

The high market value of shrimp, the continuous population growth, and the conditions of higher national unemployment (Fig. 4.15) are encouraging the involvement of new and illegal fishers for the fishery. This situation generated an increasing social pressure on the fishery.

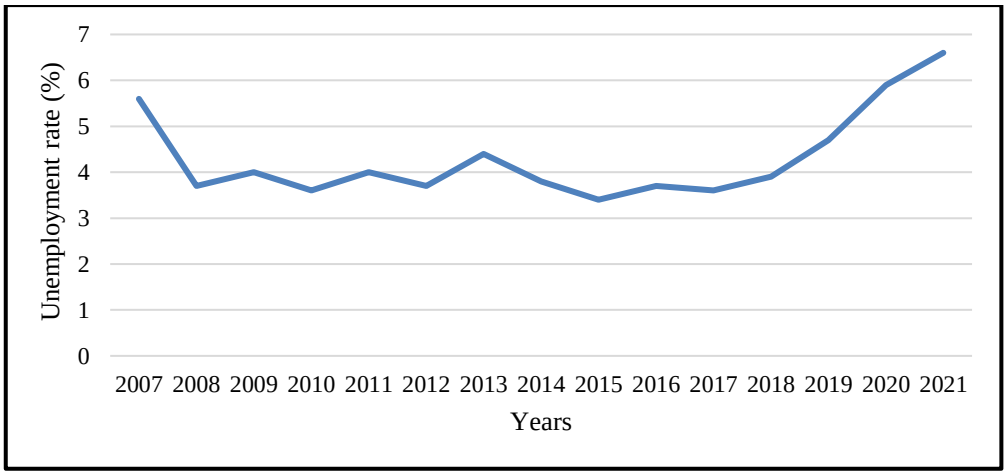


Fig. 4.15: Bahrain Unemployment Rate from 2007-2021 (IMF, 2022).

Additionally, changes of marine habitats are considered a strong driver for decreasing the shrimp population. The original land mass of Bahrain increased from 668 km^2 in 1963 to 787 km^2 in 2021, with an increase of 18.3% in 2021 (Appendix 6). The calculated reclaimed coastal

areas from 1963 to 2021 reached a total of ~119 km^2. The period from 1997 to 2011 has recorded a higher rate (9 km^2 /year). From 2014 to 2021, Muharraq is larger than its original size by about 12%, which is the highest compared with other governorates (Table 4.2). This increase was attributed to the increasing need for land. The reclaimed land has been used mainly for roads, houses, industrial areas, parks, and green areas (Zainal et al., 2012). In addition, reclamation for housing will likely continue to grow to meet the requirement for population growth (Naser, 2011). Bahraini National Land Use Strategy 2030 recognizes reclamation as the primary option for securing future needs for land (Naser, 2011). Further, the government plan (2019-2022) includes a government housing program to deliver 25,000 new housing units (PMO, 2023). The budget for the fiscal years 2023-2024 includes a project of implementation of 131 housing units and 360 apartments in Salman Town, in addition to 280 housing units in Khalifa Town (Housing, 2023).

Table (4.2): Area of Kingdom of Bahrain by governorates.

Year	Governorate Area (km^2)				
	Capital	Muharraq	Northern	Southern	Total Area
2014	77.4	65.3	145.7	486.1	774.4
2015	78.1	65.7	145.8	488.8	778.3
2016	78.5	66.2	145.9	488.8	779.4
2017	78.6	66.5	146.0	488.9	780.0
2018	78.7	66.7	145.7	488.9	780.0
2019	78.9	69.6	145.7	488.8	783.0
2020	78.9	72.1	145.7	488.5	785.1
2021	79.0	73.3	145.6	488.6	786.5

Source: IGA (2022)

Marine habitats in the national water of Bahrain impacted by dredging were mostly mixed sands/seagrass/algae (34%), seagrass (24%), deeper water gravels (22%), and medium to fine sands (12%) as presented in Table (4.3). In addition, land reclamation and dredging have affected Tubli Bay (mangrove ecosystem) and other shrimping grounds (Zainal et al., 2012; Abdulqader, 1999).

Table (4.3): Marine habitats in the national water of Bahrain (Zainal et al., 2012).

#	Habitat type	Area (km^2)	Damaged area in km^2	Damage percentage (%)
1	Deep water gravels	4343.00	82.18	21.79
2	Deep water mud	925.15	-	-
3	Seagrass	890.72	88.93	23.58
4	Mixed sands/seagrass/algae	504.07	128.38	34.03
5	Medium to fine sands	408.50	45.05	11.94
6	Rock/sand with coral/algae/seagrass	390.11	9.79	2.60
7	Rock with soft veneer	263.89	15.04	3.99
8	Algal dominated	218.20	2.27	0.60
9	Coarse sand	129.71	2.86	0.76
10	Shallow water mud	123.04	2.71	0.72
11	Coral dominated	25.39	-	-
12	Mixed sands/coral	14.19	-	-
	Total	8235.98	377.21	

An estimated cumulative loss of significant habitats for the *P. semisulcatus* (seagrass, algal beds, and corals or 'Fashts' (dead corals) resulting from reclamation and dredging projects was around 229 km^2 (Zainal et al., 2012). *P. semisulcatus* associated with these habitats are affected due to the elimination of their habitats and nursery or breeding grounds. According to Rabaoui et al., (2017) and Al-Maslamani et al., (2007), *P. semisulcatus* mainly inhabit shallow, soft-sediment, coastal habitats, while the primary habitat for post-larval and juveniles are inshore

seagrass and algal beds as affording protection to them from predation. Tubli Bay and shallow areas south of Fasht Al-Adhom are the critical nursery habitats for *P. semisulcatus* (Abdulqader, 1999).

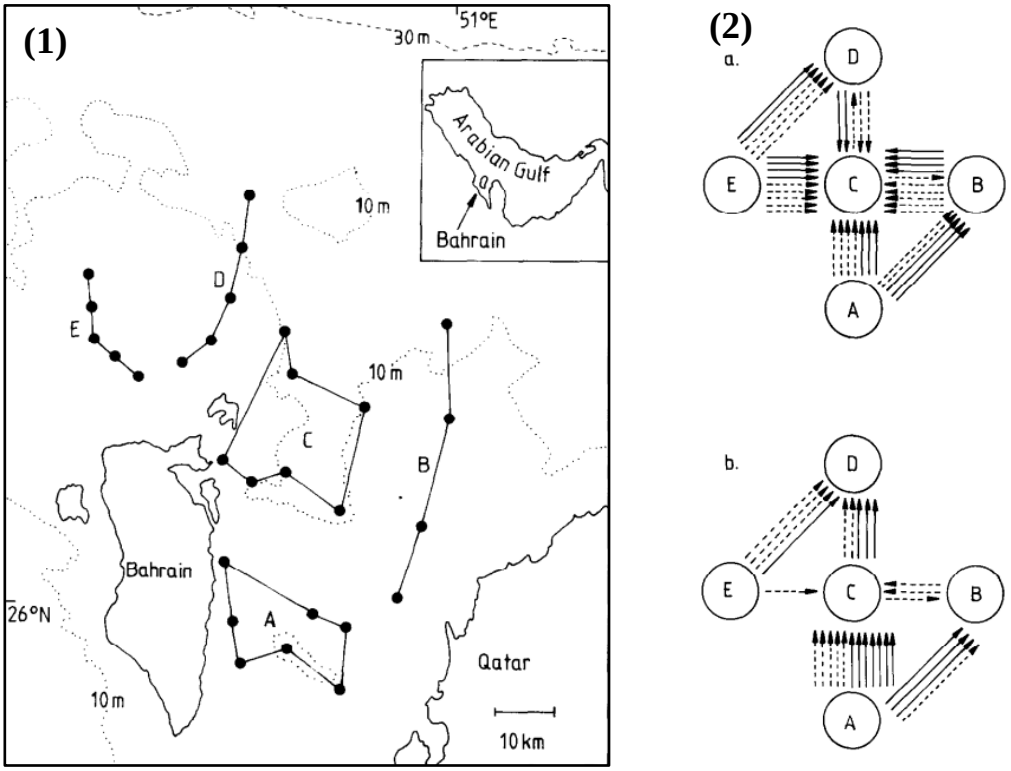


Fig. 4.16: (1) Twenty-eight sampling stations into five shrimp fishing areas (A-E). (2) movement patterns of *P. semisulcatus* among adjacent pairs of areas (a) May to September, (b) October to April (Abdulqader & Naylor, 1995).

Fig. 4.16 shows that shrimp migrated from one area to another. From May through September (Fig. 4.16 (a)), shrimp move from shallow nursery areas (less than 10 m depth) in areas A and B, D and E on the east and north coasts of Bahrain to a deeper main fishing ground (area C) to the northeast. From October through April (Fig. 4.16 (b)), they move further northwards for spawning, which probably begins in December. The population of *P. semisulcatus* in the main Bahrain fishing ground (area C) appears to recruit from two main grounds, namely area A and E. Area A is influenced strongly by inshore tidal currents, which transport

larvae and postlarvae from the northern part of the Bahrain fishing grounds where spawning takes place (Abdulqader & Naylor, 1995).

A study by Zainal et al., (2012) estimates the resource damage associated with land reclamation in Bahrain using the adjusted benefit value approach based on Costanza et al. (1989, 1997). The available data to support the non-market valuation for the lost habitats is limited. The ecological damage for the reclaimed coastal areas from 1963 to 2008 was estimated by US$ 49 million (Zainal et al., 2012). The total economic value of the services provided by the coastal and marine environment in the Arabian Gulf is worth US$ 1.88 billion per year (Sheppard, 2007). This figure is significant compared to the estimated GDP of Bahrain in 2006, which was 4.1 BD billion (approximately 10.8 US$ based on 2001 price) (Loughland & Zainal, 2009), which increased up to 14.5 BD billion in 2019 and dropped by 11.88 % in 2020. The percentage of contribution of the fishing sector to GDP from 2016 to 2020 was only 0.1% (Table 4.4). Estimating costs related to the coastal development and the extent of the environmental impacts helps assign a monetary value to the marine ecosystem services. The coastal ecosystems' services, such as nutrient storage and cycling, filtering pollutants from inland discharge systems, erosion regulation, climate regulation, wastewater treatment, and providing food and material, can be affected by the reclamation (Zainal et al., 2012).

Table (4.4): Comparison of added value of fishing sector to Gross Domestics Product (GDP) from years 2008 to 2020 (IGA, 2022).

Year	Added value of fishing sector (BD M)	GDP (BD M)	Percentage of GDP
2008	9.81	9,667.29	0.10
2009	10.83	8,624.77	0.13
2010	9.28	9,668.19	0.10

Year	Added value of fishing sector (BD M)	GDP (BD M)	Percentage of GDP
2011	9.87	10,820.01	0.09
2012	9.91	11,561.75	0.09
2013	10.58	12,234.87	0.09
2014	11.55	12,553.77	0.09
2015	10.31	11,675.04	0.10
2016	12.86	12,120.350	0.11
2017	12.48	13,338.143	0.09
2018	12.95	14,213.547	0.09
2019	13.08	14,533.650	0.09
2020	13.10	13,055.980	0.10

BD M = BD Million at current price

The second issue is mismanagement and illegal shrimp fishing practices. The Maritime Control Directorate and Coast Guard Directorate reported fishing violations from 2012 to 2020, mainly in shrimp fishing during the closed season, shrimp trawling, shrimp fishing in marine protected areas or prohibited area, and shrimp fishing without a license (Fig. 4.17), which implies a serious issue in sustainable managing of shrimp fishery in Bahrain.

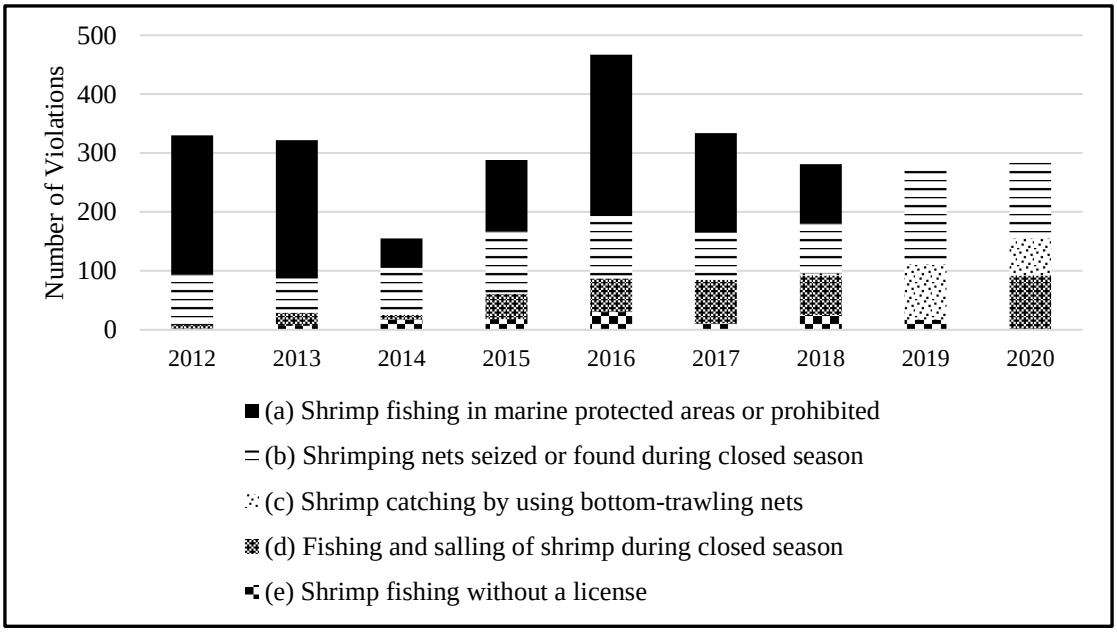


Fig. 4.17: Illegal shrimp fishing activities in Bahrain (2012-2020).
Source: Coast Guard Directorate

The sustainable exploitation of shrimp fisheries is confronted with a critical challenge of illegal shrimp fishing, which is one of the most challenging problems facing fisheries management in Bahrain. In recent years, especially after the implementation of a complete ban on shrimp trawling, total shrimp catch has decreased. However, at the same time, an increase in illegal shrimp fishing was observed. For example, shrimp fishing in marine protected areas or prohibited areas was reported during the shrimp season from 2012 to 2018, and the highest value was recorded in 2016 (274 violations) (Fig. 4.17a). In addition, the number of shrimping nets found on the board of the boats during the ban season was 161 in 2019 and decreased to 138 in 2020 (Fig. 4.17b). Further, shrimp fishing using the bottom trawling nets was reported during the shrimp season, and the highest was recorded in 2019 (94 violations) (Fig. 4.17c). The number of violations reported for shrimp fishing and selling during the closed season in 2020 was 92 compared with 2018, which was 67 (Fig. 4.17d). The number of illegal shrimp fishing boats (without a license) was estimated to be 17 in 2019, which showed a reduction compared with the year 2018 (25 boats) (Fig. 4.17e). Moreover, the illegal shrimp catch during the closed season was 13,150 kg in 2019 and 19,321 kg in 2020 (Fig. 4.18), which is higher than the reported shrimp catch during the open season by 88-90%.

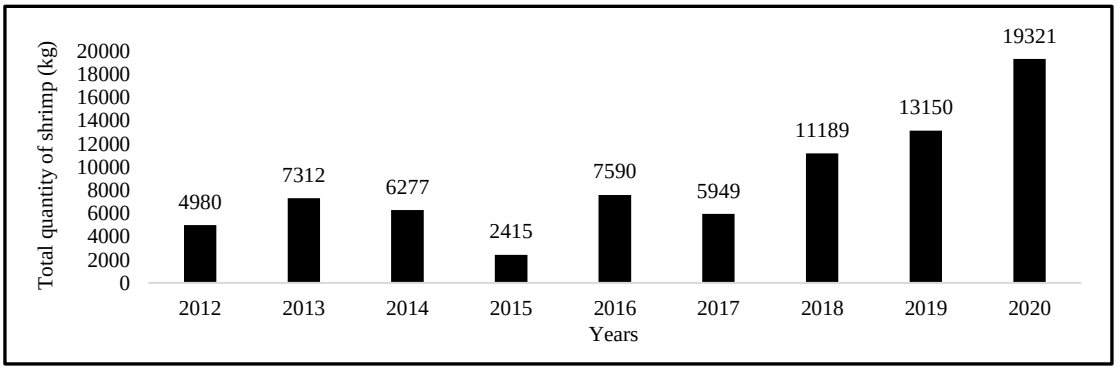


Fig. 4.18: Quantity of shrimp caught illegally during closed season in Bahrain from 2012 – 2020.

Source: Coast Guard Directorate

Thus, illegal shrimp fishing generates a considerable level of by-catch, which was not recorded. The state of world fisheries and aquaculture report of the FAO states that most fish stocks are entirely or over-exploited in the Arabian Gulf (FAO, 2011b). Hosseini et al., (2015) also argued that because of the increasing overfishing, the juvenile commercially important species are mostly fished in the coastal areas of southern Iran in Hormozgan Province. Furthermore, Daliri et al., (2015) debated that illegal, unreported, and unregulated shrimp fishing severely affects the sustainability of fisheries through ecosystem degradation and economic losses.

Additionally, the length of the targeted shrimp species (*P. semisulcatus*) collected in this study from August 2020 to January 2021 was between 5.8 cm TL and 21 cm TL, most of which were classified as immature. Indicating that shrimps are currently overexploited in Bahrain and are affected by the deterioration of aquatic habitats caused by improper human practices.

The most significant pressure for the issue of shrimp fishery management is the high number of fishing licenses (shrimp and fish) and fishers. The number of fishing licenses (shrimp and fish) was not restricted to a specific number of boats in the sea. The total number of licenses for boats in Bahrain reached 13,713 licenses till 22nd May 2022 as obtained from the Registration of Ships and Seamen Affairs in the Ministry of Transportation and Telecommunications (Fig.4.19).

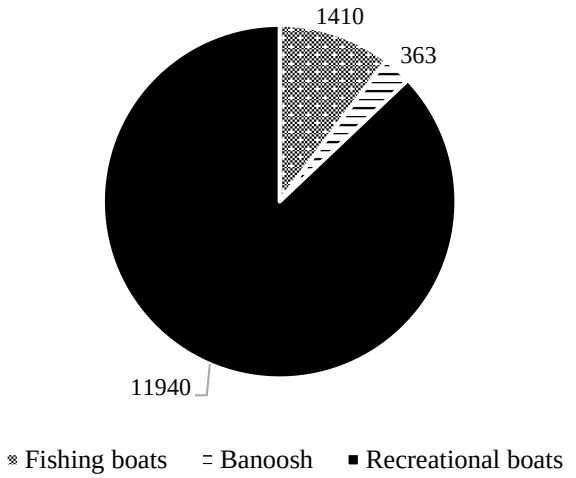


Fig. 4.19: Total number of licenses for boats in Bahrain in 2022.
Source: Ministry of Transportation and Telecommunications

According to Article 9 of Legislative Decree No.20 of 2002, a fisher can possess up to three licenses. This meant an increase in the pressure on fish and shrimp stock in limited fishing grounds, often increasing the initial problem of too many fishers engaged in the fishery. Based on the study conducted by the Ministry of Municipalities Affairs & Agriculture in 2017, 73 fishing licenses is indicated to be the ideal number of fishing licenses, and above that number could threaten marine wealth (MUN, 2022).

On the other hand, the foreign fishers have grown from 2993 in 2004 to 6400 in 2018, and the number of foreign shrimp fishers was increased by 5% from 2017 to 2018 (Table 4.5). The number of foreign shrimp fishers constitutes about 22% of the total number of foreign fishers in the fishing sector. The number of licenses for shrimp boats was 271 in 2019, and it was owned by 197 fishers. Some shrimp fishers own three licenses (16 fishers), two licenses (42 fishers), or one license (139 fishers) (MUN, 2022).

Table (4.5): Total number of fishers.

Year	Total number of Bahraini fishers (full time)	Total number of foreign fishers	Number of foreign shrimp fishers	Source
1983	1822	314	NA	A
1988	1121	970	NA	A
1993	2321	1906	NA	A
1998	1655	2649	NA	A
2004	1714	2993	NA	A
2007	NA	3000	NA	A
2017	NA	NA	1315	B
2018	NA	6400	1380	B

NA: Not Available
Source: A: MUN (2011); B: MUN (2022).

The socioeconomic factors, “GDP”, “fishing grounds”, “population growth” and “number of foreign shrimp fishers”, identified in the “driving forces” component of the conceptual DPSIR model, have been proposed as relevant factors explaining the exploitation of the shrimp fishery. On the other hand, the increased fishing effort caused by the increase in the number of shrimping boats and the increase in fishers could increase pressure on shrimp populations. Therefore, economic factors, “shrimp fishing effort,” and “illegal shrimp fishing,” are recognized in the “pressures” component of the DPSIR model.

4.4.2 What Are the Consequences of Current Shrimp Fishery to the Environment and Humanity?

Shrimp overexploitation has biological, social, and economic consequences (Mohsin et al., 2021). Clark (1973) stated that overexploitation results in social chaos through fishery resource exploitation competition and profit maximization phenomenon. Thus, the

urge to catch the highest quantity of shrimp may result in the depletion of this resource.

The socio-economic impact generated by the trawl ban and the government's decision in 2019 to counteract the overexploitation of the shrimp resource by advising shrimp fishers to convert their shrimping licenses to fishing licenses and to sell their trawl equipment or assets (Banoosh) to the government; has resulted in decreasing fishers' revenues. Furthermore, another negative impact on fishers arises from catching shrimp by recreational fishers, characterized by an increase in the number of legal and illegal fishers.

During the period 2004-2010, fishers earned cumulative profits of over 200%, followed by a decrease in revenue of about 46% in 2011, then cumulative earnings of over 200% (2004-2017), to finally accumulate earnings losses of over 100% in the period 2004–2020 as calculated from Table (4.6). After implementing the trawl ban in Bahrain, the fishers' revenue decreased to its lowest rate. The price rise was measured using a price index to show whether inflation is present (Juraev, 2020; Bullard, 2011). A price index measures the average price change of shrimp over 17 years (2004–2020). The prices of shrimp have risen during the past three years (2018-2020), at a rate ranging between 10% to 40%. Moreover, referring to the year 2004, there has been a price increase of over 80% relative to 2020 (Table 4.6 & Fig. 4.20). Bullard (2011) indicated that the price index rises as a result of inflation in the economy. Even though the increase in shrimp prices during 2019-2020, the amount of income generated by shrimp sale has decreased because of the dramatic reduction in the shrimp landings. From the fisher's perspective, decreased revenue (e.g., lower catch rates) coupled with high expenses (fuel expense, fishing equipment, vessel maintenance and repair, worker salaries) result in losses to fishers. The monthly expenditure amounted to 2500 – 3000 BD or more

when the boat engine damaged. The shrimp trawler owner attempts to compensate for the loss in profits caused by the expenses and low catch by increasing the sales price for the shrimp catch. This could return benefits to fishers when catches are low, demand is high, and consumers pay the increased prices.

Table (4.6): Shrimp fishery status in the Kingdom of Bahrain.

Year	Shrimp catch (kg)	Average shrimp price (BD/kg)	Shrimp fishers' revenue (BD)	Price index (2020=100)	Change in price %
2004	1,584,691	1.91	3,022,710	55	83
2005	1,107,097	2.18	2,416,670	62	61
2006	1,951,420	2.14	4,167,583	61	64
2007	2,793,958	2.02	5,634,792	58	73
2008	2,402,937	1.92	4,621,916	55	82
2009	3,431,675	2.42	8,319,238	69	45
2010	4,666,968	2.32	10,812,976	66	51
2011	2,536,554	2.28	5,791,714	65	54
2012	2,494,667	2.61	6,513,326	75	34
2013	3,083,157	2.16	6,670,924	62	62
2014	2,964,860	2.54	7,518,292	73	38
2015	3,544,857	2.49	8,820,786	71	41
2016	2,973,350	2.50	7,433,375	71	40
2017	4,277,944	2.25	9,625,374	64	56
2018	2,292,506	2.50	5,731,265	71	40
2019	1,315	3.17	4,168	91	10
2020	2,170	3.50	7,595	100	

Source: Fisheries Directorate

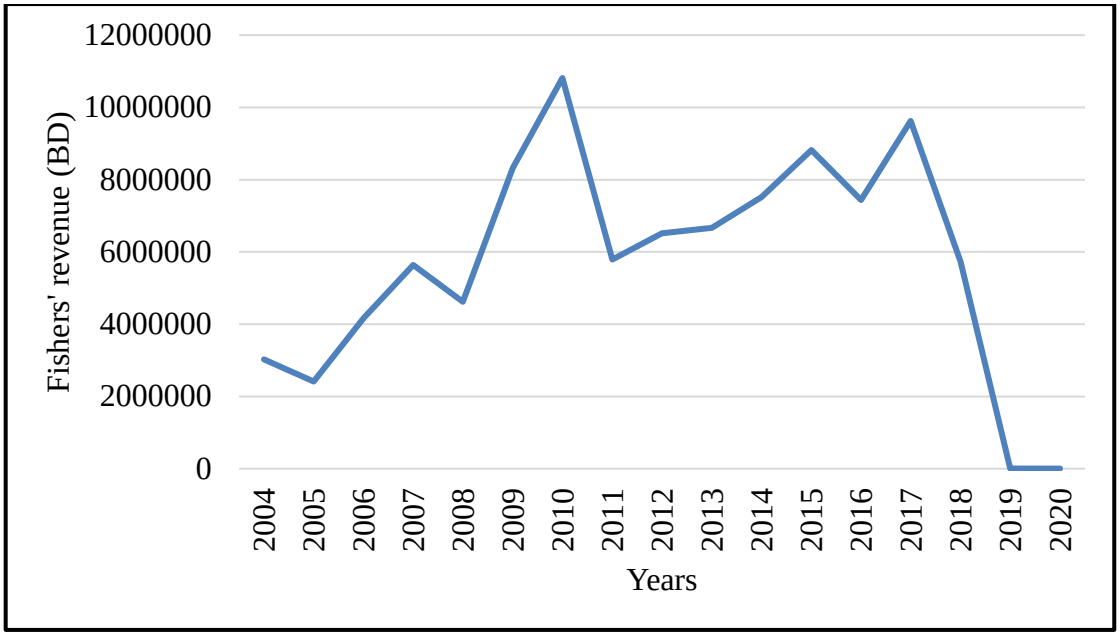


Fig. 4.20: Shrimp fishers' revenue in the Kingdom of Bahrain (2004 – 2020).

Two groups of fishers share the shrimp resource: recreational and professional fishers. The increase in number of recreational fisheries creates conflicts with commercial fishery, and the competition between them drives overexploitation, and the resources cannot withstand extra fishing effort without being threatened. Murshed-e-Jahan et al., (2014) argued that conflicts occur in fisheries when groups or individuals seek the same resource using different fishing methods or utilize the same space for their activities, with either party seeking dominance. Likewise, Bennett et al., (2001) found that fisheries conflict is often triggered by the perception that one group gains at the expense of another. The conflict among the professional and recreational fishers in the shrimp fishery is due to many unregistered fishers who break the fisheries laws. In addition, illegal shrimp fishing practices increase strongly during the close season. The over-exploitation of shrimp resources represents one cause for conflict. McClanahan et al., (2015) used the frameworks of conflict, food security, and vulnerability to evaluate the status of global marine fisheries.

The results revealed that there is a high possibility of food insecurity and fisheries conflicts due to issues such as (1) declining fishery resources, (2) changing consumption patterns, and (3) increasing reliance on fishery resources. These socio-economic impacts trigger a response from fishery resource decision- makers.

Shrimp fishery (*P. semisulcatus*) is currently subjected to an ecological system that is under stress due to the socioeconomic importance of the species, which has been caused by increased fishing efforts and illegal shrimp fishing, resulting in the decline of the population. Therefore, this impact directly affects fishers' communities by causing a reduction in the shrimp quantity (overexploitation) and indirectly impacting the ecosystems where the communities live, such as damage of nesting ground, corals, seagrass and increasing turbidity as well as biodiversity degradation.

4.4.3 What Is Being Done to the Shrimp Fishery? and How Effective Is It?

Since 2002, the Kingdom of Bahrain has implemented administration and control measures to promote sustainability in the shrimp fishery. These measures were classified in the response aspect of the DPSIR framework, according to the criteria of each component, which are described as follows in response to socio-economic drivers, pressures, state, and impacts derived from shrimp fishing activity (Table 4.7).

Table (4.7): Shrimp fishery rules and regulations in the Kingdom of Bahrain.

Area of classification	Issuance Year	No.	Type	Effectivity Yes/No	Context	DPSIR category
Fisheries management	1981	5	Legislative Decree	**No**	Regulating fishing	
	2002	20	Legislative Decree	Yes	Regulation of fishing, exploitation, and protection of marine wealth	D & P
	2012	45	Amended			D & P
Shrimp fishing areas	2009	12	Resolution	**No**	Identification of the shrimp fishing areas	
	2011	3	Amended	**No**		
	2013	41	Amended	Yes		S
Licenses	1981	17	Resolution	**No**	Fishing license included license renewal and fees	
	1988	11	Amended	**No**		
	1994	15	Resolution	**No**	Stopping the issuance of licenses for fishing for the years 1995 and 1996	
	2005	15	Resolution	**No**	Procedures for obtaining or renewing a fishing license	
	2009	11	Resolution	Yes	Stopping the issuance of licenses for fishing of shrimps and fishes	D & P
	2016	53	Resolution	Yes	Prohibiting shrimp fishing by speedboats	D
	2021	322	Resolution	Yes	Transferring the fishing license from	P

Area of classification	Issuance Year	No.	Type	Effectivity Yes/No	Context	DPSIR category
					one person to another	
Termination of the fishing license	2006	19	Law	Yes	Regulating the labor market	D
Reclamation	2017	77	Resolution	Yes	Marine reclamation projects licensing	D
Seasonal shrimp fishing closure	1989	2	Resolution	**No**	From 15 March 1989 until the date determined by another decision to open the fishing season for the year 1989-1990	
	2008	1	Resolution	**No**	From 15 March to 15 July 2008	
	2009	3	Resolution	**No**	From 15 March to 17 July 2009	
	2010	2	Resolution	**No**	From 15 March to 15 July 2010	
	2011	4	Resolution	**No**	From 15 March to 15 July 2011	
	2012	2	Resolution	**No**	From 15 March to 15 July 2012	
	2013	7	Resolution	**No**	From 15 March to 15 July 2013	
	2014	18	Resolution	**No**	From 15 March to 15 July 2014	
	2015	13	Resolution	**No**	From 15 March to 15 September 2015	
	2016	55	Resolution	**No**	From 15 March to 15 July 2016	

Area of classification	Issuance Year	No.	Type	Effectivity Yes/No	Context	DPSIR category
	2017	27	Resolution	**No**	From 15 March to 15 September 2017	
	2018	18	Resolution	**No**	From 1 March to 31 July 2018	
	2020	18	Resolution	Yes	Prohibiting catching shrimp from February 1 to July 31 of each year	P
Shrimp fishing violations	2009	7	Resolution	**No**	Establishing a committee to monitor and follow up violations by fishers and sea-goers	
	2017	24	Resolution	**No**	Granting the capacity of judicial officers to some employees of the Fisheries Directorate and Maritime Control Directorate	
	2019	88	Resolution	Yes		P
	2022	38	Resolution	Yes	Granting the capacity of judicial officers to some employees of the Maritime Control Directorate	P
Minimum shrimp size	1994	17	Resolution	**No**	Banning fishing, selling, and trading of small fish and crustaceans	
	1997	3	Resolution	**No**		
	2021	195	Resolution	Yes		S

Area of classification	Issuance Year	No.	Type	Effectivity Yes/No	Context	DPSIR category
Protection of marine wealth	2018	205	Resolution	Yes	Prohibition of fishing by bottom trawl nets	S
	2018	204	Resolution	Yes	Banning the export of some types of local production of fish, shrimp, and other aquatic species	S
Recreational fishing	2005	12	Resolution	**No**	Temporary licenses for amateur fishers	
	2009	8	Resolution	Yes	Fishing by amateurs on sea trips	I
	2010	48	Resolution	Yes	Licensing for registration of the Budaiya Association for recreational fishing	I
Fishers' society	1999	20	Resolution	**No**	Licensing for registration of the Bahraini fishers' association	
	2007	47	Resolution	Yes	Licensing for registration of the professional fishers' association - Muharraq Governorate	I
	2009	4	Resolution	Yes	Licensing for registration of the Sitra fishers' association	I

Area of classification	Issuance Year	No.	Type	Effectivity Yes/No	Context	DPSIR category
	2010	53	Resolution	Yes	Licensing for registration of the Bahrain fishers' association	I
	2013	6	Resolution	Yes	Licensing for registration of the cooperative association for professional fishers	I
	2014	12	Resolution	Yes	Licensing for registration of the Galali fishers' association	I

Source: Compiled by researcher
D: Drivers, P: Pressures, S: State, and I: Impacts

4.4.3.1 Driver-based upstream responses

In response to the substantial increase in landings, fishery regulation, exploitation, and protection of marine wealth was implemented in 2002 by Legislative Decree and continued till now. In addition, to control the entry of new fishers to the shrimp fishery, Resolution No.15 of 2005 regulates the fishing licenses, in which all fishers should have a fishing license for shrimp valid for one year. The issuance of new shrimp fishing licenses was halted in 1995 and 1996 and then again in 2009 to ensure the sustainability of shrimp fisheries. However, the National Audit Office (NAO) observed in 2019/2020 that granting new fishing licenses is continuing till 2020, despite Article 1 of Resolution No.11 of 2009, the ban on issuing fishing licenses (shrimp and fish). Besides that, according to Resolution No. 53 of 2016, shrimp fishing using speed boats (locally known Tarad) has been prohibited in Bahraini territorial waters starting

from March 2016 to date. Article 2 of this resolution stated that licensed fishers for shrimp fishing who registered on speed boats are granted permanent fishing licenses for fish, or their licenses can be registered on Banoosh to practice shrimp fishing. Moreover, the Cabinet issued a decision in 2019 to purchase the shrimp fishers' assets of big and medium size boats (Banoosh) for those who wish to do so or convert the shrimping licenses to fishing licenses and purchase their trawl equipment from them.

Furthermore, Article 14 of Legislative Decree No.20 of 2002 obliged the skipper to provide statistical data on fishing operations on board (recorded in the ship's logbook) to competent administrative authorities. Also, Article 36 of the same Legislative Decree stated that the Minister should issue the necessary decisions to implement the provisions of this law, such as determining the data needed by the competent department and concerned authorities that must be collected and organized by fishers or who engaged in the fishing operation in logbooks. These logbooks with any attached documents must be kept. However, the concerned Minister issued no resolution to specify the needed data that must be collected and organized by the fishers. Thus, such logbooks are not available.

Based on clause (b) of Article 26 of Law No.19 of 2006 regarding the regulation of the labor market, which stated that the Labor Market Regulatory Authority (LMRA) should cancel work permits issued to workers prior to their expiry in case of termination of the license to practice the commercial activity. Thus, the Agriculture and Marine Resources Agency is responsible for coordinating with the LMRA to cancel the work permits for foreign workers when the fishing licenses are expired, as failure to notify the LMRA regarding the marine fishing licenses that have been canceled contributes to exacerbating the phenomenon of irregular or illegal workers in the Kingdom. Moreover, Resolution No. 201 of 2018 specifies the number of foreign workers

authorized to work on board fishing vessels (six workers for Banoosh and two workers for Tarad). However, no resolution has been issued to decrease the number of foreign workers on board shrimping vessels, and still, the number of foreign workers is relatively high.

The land reclamation or landfill was regulated according to Resolution No.77 of 2017 of marine reclamation licensing. Therefore, marine reclamation projects are controlled and supervised by the municipality and SCE. SCE's role is to register environmental consulting offices, evaluate their efficiency and performance, determine their specialists' ability to conduct surveys and measurements to prepare specialized studies, and find solutions limiting project environmental impacts. At the same time, the municipality provides the license for reclamation according to the condition specified in resolution No. 77 of 2017.

Regulating and controlling entry to the fishery is a complex issue, despite administrative efforts to manage the fishery by controlling registration and monitoring fisheries through law enforcement and environmental protection. However, illegal fishers or fishing practices have increased dramatically in recent years in response to the greater demand synchronized by increasing shrimp prices. In this context, implementing fisheries co-management strategies based on a consistent set of overall fisheries policy objectives and supportive conditions is imperative to generate a sustainable artisanal fishing system for the exploited resource and the ecosystem in general.

4.4.3.2 Pressure-based upstream response

To regulate the fishing effort being exerted by an increase in the number of fishing boats, several management decisions have been issued, including Article 1 of Resolution No. 11 of 2009 decrees the ban on the

issuance of licenses for fishing shrimps and fish, Article 9 of Legislative Decree No.20 of 2002, which stated that it is not permissible to possess more than three fishing licenses for one person, and the Minister of Municipalities Affairs & Agriculture may reduce this number if the competent department deems that this constitutes a detriment to the marine wealth, and a seasonal closure program (the fishing ban is started from 1989 onward). In addition, the annual mandatory ban on catching, trading, and selling shrimp was gradually extended until it reached six months (from 1 February to 31 July), as in Saudi Arabia (Al-Qishawe, 2021).

Additionally, to reduce fishing efforts and control the overexploitation of fisheries resources, a recommendation issued by the ministerial committee for development and infrastructure projects in memorandum No. 4 of 2018 to develop a program aimed at canceling no more than 50% of the total current licenses by reviewing the number of granted licenses periodically with the gradual implementation of licenses cancellation. However, despite that, new fishing licenses were issued to some individuals from January 2017 to November 2019 by transferring unwanted licenses from one person to another, which was not aligned with the Article 12 of Legislative Decree No.20 of 2002 (NAO, 2020). On the other hand, Resolution No.322 of 2021 was issued to permit the transfer of fishing licenses from one person to another, specifically second-degree relatives, under the approval of the Maritime Control Directorate, this resolution in line with the country's efforts to reduce fishing efforts (NAO, 2020). However, some fishers have more than three licenses (NAO, 2020), incompatible with Articles 9 of Legislative Decree No.20 of 2002.

During data collection in December 2021, the following was observed:

1. The automated system for fishing licenses needs much improvement, and the licenses' printing system is not connected to the system for entering and renewing licenses. As a result, the authorized specialist uses the old and new automated systems to print, enter and renew license data. Therefore, the presence of two separate systems weakens the internal auditing procedures on the automated systems and may lead to administrative abuse.
2. The fishing license data were incomplete and needed to be updated in the system. Thus, it was difficult to get the exact number of active licenses.

It was also observed during the surveying in this study that there was a shortage in the number of specialists in which one employee would perform all the licensing procedures, starting from revising, issuing, renewing, printing, terminating the licenses, and entering the data in the system.

Article 36 of Legislative Decree No.20 of 2002 stated that the Minister should issue the necessary decisions to implement the provisions of this law including determining the quantities allowed to be caught in the specified seasons and according to their types. However, no resolution was issued by the Minister to specify the quantities of shrimp allowed to be caught. The fisheries specialists suggested, during the interview, that it is practically impossible to determine the quantities of shrimp allowed to be caught during the open season. However, no proposal has been submitted to amend Article 36 of the Legislative Decree following the appropriate legal tools.

To control shrimp fishing violations, the Maritime Control Directorate plays a vital role in monitoring fishing violations in accordance with the controls set forth by virtue of Legislative Decree No.20 of 2002, more specifically Article 31, which stated that the

competent employees entrusted to implement provisions of this law, who are designated by a decision of the Minister, shall have the authority to control violations that are against the provisions of this law or the decisions implementing it. This could be achieved following to the effectiveness of the Maritime Control Directorate to intercept, stop and inspect the fishing vessel as the authority has the right to enter ships, fisheries, and places where there are marine species and fishing gear and tools on sea or land, and have the right to view and check the licenses, books, and documents related to the fishing sector and to prepare. They have the authority to write the necessary reports to refer them to the competent authority to initiate criminal cases. According to Article 1 of the Resolution No.38 of 2022 and Resolution No.88 of 2019, some employees of the Maritime Control Directorate and Fisheries Directorate whose names are stated in these resolutions are granted the capacity of a judicial officer to record actions in violation of the provisions of Legislative Decree No.20 of 2002 and to take the necessary actions and measures to maintain all pieces of evidence related to the violations to be transferred to the public prosecution, which in turn takes the legal measures and raises cases to the competent criminal court. Any person who violates any provision of the Legislative Decree No.20 of 2002 shall be punished by imprisonment for no less than fifteen days and no more than six months or a fine of no less than BD100 and no more than BD 5000, or by both following Article 33 of this Legislative Decree. Based on NAO annual report for the year 2019/2020, the actions taken by the Maritime Control Directorate in dealing with the violations observed by the inspectors and the existing penalty structure were not completely followed as stated in Article 33 (NAO, 2020). The fishers propose amendments to this article to provide harsher penalties to control violators.

Table (4.8) illustrates the scope of monitoring the shrimp fishery by the Maritime Control Directorate.

Table (4.8): The scope of monitoring the shrimp fishery by Maritime Control Directorate.

Scope of control	**Target**	**Related regulating articles from Legislative Decree No.20 of 2002 and the decisions regulating them**	**Relevant governmental entity**
Places for trading and selling Shrimp	- Selling shrimp in specified places that meet the health and commercial conditions. - Not trading and selling shrimp during the ban period.	- Article 26 and 27 of the Legislative Decree No.20 of 2002. - Resolution No.18 of 2020 regarding the ban on fishing and selling shrimp.	- MOIC - MUN - MOH - Public Health Directorate
Shops for selling and importing fishing equipment for shrimp and local workshops to manufacture such equipment	Ensure not possessing unauthorized or unlicensed shrimping gear	- Article 20 & Clause (d) of Article 36 of the Legislative Decree No.20 of 2002.	- MOI – Coast Guard Directorate and Customs Affairs - MOIC - MUN - MOH - Public Health Directorate
Inspections for Coast	Monitor and control illegal shrimp fishing activities	- Articles 3, 6, 8, 14, 15, 16, 17, 19, 20, 30 of the Legislative Decree No.20 of 2002. - Resolution No.18 of 2020. - Resolution No.205 of 2018 regarding the prohibition of fishing by bottom trawl nets. - Resolution No.195 of 2021 regarding banning fishing, selling, and trading	- MOI - Coast Guard - MUN - Fisheries Directorate and Maritime Control Directorate

Scope of control	Target	Related regulating articles from Legislative Decree No.20 of 2002 and the decisions regulating them	Relevant governmental entity
		of small fish and crustaceans. - Resolution No.53 of 2016 regarding prohibiting shrimp fishing by speedboats.	

Source: Designed by researcher

In November 2019, the Maritime Control Directorate launched a telephone service named the **Fishers' Service**, which aimed to create channels for feedback and communication with communities, including fishers, citizens, and sea-goers, through responding to inquiries about licenses and seaports, and receiving fishing violation notices from fishers. This service was also used to inform the public and society about the problems related to the impacts of overfishing and other vital issues affecting the marine environment.

Although these actions and the measures implemented will allow better management of the shrimp fishing activity by acting as a pressure-based upstream response to shrimp fishing, inspection is complex, given the total area of shrimp fishing grounds and the limited number of human resources for monitoring purposes. The government has proposed increasing inspection capacity, especially during critical periods of closure, and optimizing the technological tools used in reporting (i.e., the internet, visual reports, and hotline). Training programs are recommended to regulate fishing and protect marine wealth (Richardson et al., 2018; Gelcich et al., 2005). Simultaneously, it is necessary to implement training programs to strengthen the Bahraini skipper's capacities, resulting in

greater control over violators among the fishers and reducing reliance on foreign workers.

4.4.3.3 State-based downstream responses

Measures were carried out to determine the status of the shrimp fishery in terms of catch quantity and shrimp size. In addition, several regulatory decisions have been issued to improve marine resource management by reducing destructive fishing practices and increasing commitment to marine conservation. These include:

(1) Resolution No.205 of 2018 regarding the ban on marine fishing by bottom trawl nets in Bahraini territorial waters and
(2) Resolution No.204 of 2018 concerning the ban on the export of some types of local production of fish, shrimp, and other aquatic species. Article 1 of this resolution states that it is prohibited to export local production of fresh, chilled, or frozen shrimp starting from 1 December 2018.

Additionally, Article 3 of the Legislative Decree No.20 of 2002 clarified that the license should specify the locations of the vessel to work, the seasons in which fishing is permitted, and the types and quantities of fish or shrimp or other marine species that will be caught in each region and each season.

Further, Article 36 of the Legislative Decree No.20 of 2002 stated that the Minister should issue the necessary decisions to implement the provisions of this law, including determining the minimum size of fish and other marine species. Accordingly, the Minister issued the Resolution No.195 of 2021, which specifies the shrimp size that is not allowed to catch, with a total length of less than 10cm. In addition, another resolution was issued on 20 August 2013 to specify the shrimp fishing grounds. However, the fishing seasons were not determined for all commercial fish

species, which does not help tighten control over the types and catch quantity. This may lead to overexploitation of marine fisheries, which can have an enormous effect on marine ecosystems as its impacts range from species-specific population depletion (in extreme cases to extinction) to dramatic alterations at the ecosystem level (Neeman et al., 2015).

In order to solve the issue of overexploitation of shrimp resources, several measures have been executed by the government and are valid till now, including:

1- Adoption and formulation of regulations on marine fishing relating to overfishing and seasonal fishing.
2- Introduction of regulations on shrimp fishing suspension during the mating season.
3- Introduction of the mangrove culture natural ecosystems and artificial wetland (Dawhat Arad) to rehabilitate the protection and spawning grounds.
4- Enhancement of management of environmental problems to ensure the highest level of protection and sustainability of marine resources and the surrounding environment in compliance with government program (2023-2026).
5- Constant increase of people's awareness of marine environmental protection.

However, although these measures provide more opportunities for the sustainable development of shrimp, the effect is less apparent than expected because benefits drive fishers. Those fishers who depend on fishing are most interested in actual benefits rather than overfishing, generated by their practices, will harm the sustainable development of marine resources. Therefore, as an unavoidable requirement of human's pursuit of a better life, the exploitation of marine resources and the protection of marine ecosystems are the necessary route (Zhong, 2019) to

achieve the sustainable use of Bahrain's marine resources, as well as strengthening the cooperation among adjacent GCC countries to ensure the sustainability of shrimp fisheries.

According to article 2 of FAO's Code of Conduct for Responsible Fisheries, overexploitation issues should be effectively controlled (FAO, 2015). The public and private institutions (including fishers associations) are striving to control overexploitation in Bahrain. However, to control overexploitation effectively, increased inter-departmental coordination is needed. Furthermore, fishery-responsible entities need to enhance their role in controlling illegal fishing, mainly related to small mesh size trawling nets used during closed seasons, which have been banned since 2018.

Furthermore, there are shared fishing grounds among some of the GCC countries (e.g., Bahrain-Saudi Arabia, Bahrain-Qatar, Kuwait-Saudi Arabia) located with the adjacent territorial waters. Each country exercises its authority to manage shrimp fisheries within its territorial boundaries, and each country's shrimp fisheries management regulations are relatively different (Ye et al., 2003). For example, Kuwait usually opens its shrimp fishing season from the first of September through January based on maximum yield per recruit analysis (Al-Baz et al., 2018; Al-Baz & Chen, 2015; Ye et al., 2003). In Saudi Arabia, the season starts on August 1 through January (Al-Qishawe, 2021). Kuwait closes the shrimp fishing season when a spawning biomass indicator falls below a certain level in order to prevent recruitment overfishing in shrimp fisheries (Morgan, 1989; Ye et al., 2003), but there is no such reference point exists in neighboring Saudi Arabia (Ye et al., 2003). Differences also exist between Saudi Arabia and Bahrain. Bahrain opens its shrimp fishing season from August 1 to January 31, and fishing by bottom trawl nets has been prohibited throughout the year since 2018. However, shrimp trawling is

permitted in neighboring Saudi Arabia (Abdulqader et al., 2020). Qatar and Bahrain closed their industrial shrimp fisheries in 1993 and 1998, respectively (Al-Abdulrazzak et al., 2015). In Qatar, Bottom trawling has been banned since 1992 (Resolution No.86 issued by the Ministry of Municipal Affairs and Agriculture in 1992). Prior to that, a closed shrimp fishing season (from February 1 to June 30) had been in effect since 1981 (Resolution No.30 issued by the Council of Ministers, 1981) as presented in Table (4.9).

Table (4.9): Shrimp fisheries policies of GCC countries.

1- Bahrain	
Responsible entity for fisheries	Agriculture and Marine Resources Agency in the Ministry of Municipalities Affairs & Agriculture (https://www.mun.gov.bh/)
Applicable rules and regulations	- Legislative Decree No.20 of 2002 on the regulation of fishing, exploitation and protection of marine wealth. - Decision No. 322 of 2021 regarding transferring fishing licenses from one person to another. - Resolution No. 205 of 2018 regarding the prohibition of fishing by bottom trawl nets. - Resolution No. 53 of 2016 prohibiting shrimp fishing by speedboats. - Resolution No. 41 of 2013 on the identification of the shrimp fishing areas. - Resolution No. 8 of 2009 on fishing by amateurs of sea trips.
Fishing licenses	Issuance of new shrimp fishing licenses has been halted since 2009.
Shrimp fishing season	1 August to 31 January every year.
Fishers	- Only Bahraini citizens can obtain permits for fishing according to Article 9 of Legislative Decree No. 20 of 2002. - Decision No. 1 of 2003 requires a Bahraini skipper (Nokhatha) to be on board fishing boats.

Fishing by trawling nets	Prohibited based on Resolution No. 205 of 2018.
2- Kuwait	
Responsible entity for fisheries	The Public Authority of Agriculture Affairs and Fish Resources (https://www.gfar.net/organizations/public-authority-agriculture-affairs-and-fish-resources-kuwait-city)
Applicable rules and regulations	- Decree No. 11 of 1983 prohibiting fishing within 3 miles from the coasts of Kuwait. - Law No. 46 of 1980 on the conservation of fish resources.
Fishing licenses	Issuance of new fishing licenses to the shrimp trawlers is halted.
Shrimp fishing season	1 September to 31 January every year
Fishers	- Does not require the presence of a Kuwaiti fisher on-board fishing boat. - The number of workers on the boat is not specified.
Fishing by trawling nets	Permitted during open season.
3- Oman	
Responsible entity for fisheries	The Ministry of Agriculture and Fisheries (https://www.maf.gov.om/)
Applicable rules and regulations	- Royal Decree No. 20 of 2019 promulgating the Law on Living Aquatic Wealth. - Ministerial Decree No. 209/2019 amending some provisions of the regulation to support the fisheries sector. - Ministerial Resolution No. 189/2018 amending some provisions of the Executive Regulations of the Law of Maritime Fishing and Protection of Live Aquatic Wealth. - Ministerial Decision No. 106/2013 amending some provisions of the Implementing Regulation of the Law on Marine Fishing and Protection of Living Aquatic Resources.

	- Ministerial Resolution No.4/94 Implementing Regulation of the Law on Marine Fishing and Protection of Living Aquatic Resources.
Fishing licenses	The license period is three years.
Shrimp fishing season	Only artisanal fishers can catch shrimp from 1 September to 30 November every year.
Fishers	Shrimp fishing is limited to Omani fishers operating small fiberglass boats, and only hand-casting nets are used to catch shrimp as an alternative to trawling in the Sea of Oman.
Fishing by trawling nets	Bottom trawling has been prohibited since 2013.
4- Qatar	
Responsible entity for fisheries	Fisheries Department in the Ministry of Municipality and Environment (https://www.mme.gov.qa/ https://www.almeezan.qa/)
Applicable rules and regulations	- Resolution No. 86 of 2015 on regulating the practice of some marine fishing activities. - Resolution No. 2 of 1985 regarding the executive regulations of Law No. 4 of 1983 about the exploitation and protection of living aquatic resources in Qatar. - Resolution No. 19 of 1994 amending some provisions of Resolution No. 2 of 1985 in the executive regulations of Law No. 4 of 1983.
Fishing licenses	The fishing license is valid for two years and then must be renewed, while the license for the fishing vessel must be renewed annually.
Shrimp fishing season	- Not specified. - The commercial shrimp fishery was closed in 1993, and periodic re-assessments of shrimp stocks in Qatar have not warranted its re-opening (Al-Abdulrazzak, 2013).
Fishers	Qataris must own all fishing vessels, and it is mandatory to have one national or worker of a Qatari mother as a crew member.

Fishing by trawling nets	Prohibited since 1992.
5- Saudi Arabia	
Responsible entity for fisheries	Fisheries Agency in the Ministry of the Environment, Water and Agriculture (https://mewa.gov.sa/ar/Pages/default.aspx)
Applicable rules and regulations	- Royal Decree No. M/9 of 1987 issuing the Cabinet Resolution No.14 of 1987 approving the Act on Fishing, exploitation, and protection of the marine life in the territorial waters of Saudi Arabia. - Implementing Regulations of the Act on Fishing, exploitation, and protection of the marine life in the territorial waters of Saudi Arabia issued by Resolution No.21911 of 1988.
Fishing licenses	- Three years license to practice the profession of fishing in the territorial waters and then must be renewed. - There are two kinds of licenses issued: crafter and investor.
Shrimp fishing season	1 August to 31 January every year.
Fishers	Fishing boats can be owned by a Saudi national, and at least one national should be part of the crew. The number of the crew (workers) of any nationality on the boat depends on its size, according to this formula: Number of workers = fishing vessel length (in meter) * fishing vessel width (in meter)/4 The preference for Saudi national workers
Fishing by trawling nets	Permitted during open season.
6- United Arab Emirates	
Responsible entity for fisheries	The Ministry of Climate Change and Environment (https://www.moccae.gov https://u.ae/ar-ae)
Applicable rules and regulations	- Federal Law No. 23 of 1999 Concerning the Exploitation, Protection and Development of Living Water Resources in The United Arab Emirates.

	- Federal Law No. 7 for the year 2016 amending some provisions of Federal Law No. 23 of 1999. - Ministerial Resolution No. 21 for the year 2018 regarding the executive regulations of Federal Law No. 23 of 1999. - Ministerial Resolution No. 212 of 2021 on new fishing boat licensing.
Fishing licenses	The boat and fishing license shall be valid for two years and renewed no later than sixty days from the expiry date.
Shrimp fishing season	- The shrimp fishing season was not specified. - The first shrimp culture trial in the UAE was initiated in the mid-1980s by the Marine Resources Research Center at Umm Al Qaiwain, Ministry of Agriculture and Fisheries (Yousif et al., 2003). - The UAE relies on imports to cater to local shrimp demands (Kumar, 2019; Sharif et al., 2014).
Fishers	- Only UAE nationals can obtain a fishing license and must pass a fishing exam to do so. - The boat owner may assign a skipper who is a citizen licensed to operate the boat. - The skipper must be on board fishing boats. - The number of workers on the boat is not specified.
Fishing by trawling nets	Trawling for shrimp has been banned since 1980 (Aspinall, 2001).

Source: Compiled by researcher

Shrimp fishery management can be more effective based on a single stock. Nevertheless, suppose two countries share a stock; in that case, coordinated regulations or regional shared management are the only way for successful fishery sustainable management. However, no attempt has been made to address the issue of shared stocks among the GCC countries, as the regulatory measures for shrimp fisheries in the participating countries are neither consistent nor fully supported by scientific evidence. The difficulties in establishing effective management for shrimp fisheries may be related to the need for more knowledge about the stock structure to formulate suitable management strategies (Ye et al., 2003).

The state-based downstream responses in Bahrain, which were mediated by the implementation of the Legislative Decree No.20 of 2002, aim to outline the overall legislative framework regulating the exploitation of fisheries and other marine resources and identify the responsibilities of the competent Authority.

4.4.3.4 Impacts-based downstream responses

Measures were carried out to organize fishers to manage the shrimp resource effectively in Bahrain. In 1999, Bahrain initiated a governance transformation in the fishery system in which the first fishers' association was established to support effective communication between competent authorities in the government and fishers. There are five fishers' associations (professional fishers' association at Muharraq Governorate, Sitra fishers' association, Bahrain fishers' association, cooperative association for professional fishers, and Galali fishers' association), and each of them is concerned with the following duties:

(1) Safeguarding fisher's rights and interests,
(2) Disseminating fisheries laws and regulations,
(3) Mediating fisheries-related disputes,
(4) Representing fishers' community to discussing their needs and social status with competent authorities,
(5) Cooperating with the competent government entities to conserve and rationally utilize marine resources,
(6) Clarifying and explaining the fisheries decisions and laws issued by the relevant competent authorities, and
(7) Encouraging fishers to practice authorized fishing methods.

Following this, the management committee for the fishery resources was formalized and implemented in 2009 (Resolution No.7 of 2009), followed by a discussion of the fisheries issues in the National Assembly.

For example, Representatives Council's public utilities and environment committee organized several meetings with fishers to discuss critical issues for the conservation and sustainability of shrimp, fish, and marine species and their habitats before proposing amending and developing laws.

In addition, recreational fishing was regulated in 2005 (Resolution No.12 of 2005) and 2009 (Resolution No.8 of 2009). Article 1 of Resolution No.8 of 2009 prohibits amateurs of sea trips from commercial fishing using traditional or artificial methods and means, except fishing using threads. However, that decision did not establish the rules and procedures to regulate fishing by an amateur, such as licenses, as expressed in Article 5 of Legislative Decree No.20 of 2002. For example, the absence of regulating rules for granting licenses for amateur fishing and recording these licenses in a system for that purpose may lead to the inability to enumerate and tighten control over them. Furthermore, Resolution No.12 of 2005 concerning temporary licenses for amateur fishers was canceled by issuing Resolution No.11 of 2009 regarding stopping the issuance of fishing and shrimp fishing licenses, including temporary licenses for amateurs. In order to facilitate cooperation with the competent entities in the government, only one association for recreational fishing (Budaiya Association) was established in 2010 (Resolution No.48 of 2010), which aimed to end overfishing and conserve the marine ecosystem.

4.4.3.5 Policies analysis of shrimp exploitation

The policies and regulations related to shrimp exploitation in Bahrain, including decrees, resolutions, initiatives, and guidelines, are analyzed in Table (4.10) to find out whether addressing drivers, pressures,

state, or impacts by referring to training module 5 (integrated analysis of environmental trends and policies) (Pintér et al., 2008).

Table (4.10): The summary of policies analysis of shrimp exploitation.

Issue	D/P	S	I
Increase quantities of shrimp caught	Legislative Decree No.20 of 2002 (Legislative, Proactive, Regulatory, Economic, +++) Resolution No.11 of 2009 (Regulatory, Reactive, Enhance +++) Resolution No. 53 of 2016 (Regulatory, Reactive, +) Memorandum No. 4 of 2018 (Regulatory, Reactive, Enhance +++) Cabinet decision of 2019 (Regulatory, Reactive, +) Resolution No.18 of 2020 (Regulatory, Reactive, Enhance +++) Resolution No.322 of 2021		RECOFI Agreement in 2012 (Institutional, Reactive, +)

Issue	D/P	S	I
	(Regulatory, Reactive, - - -)		
Shrimp fishery mismanagement	Legislative Decree No.20 of 2002 (Legislative, Proactive, Economic, +++) Resolution No.88 of 2019 (Reactive, Economic, Enhance +++) Resolution No.38 of 2022 (Reactive, Economic, Enhance +++)	Resolution No.41 of 2013 (Proactive, Regulatory, +++) Resolution No.204 of 2018 (Reactive, Economic, +++) Resolution No.205 of 2018 (Reactive, Economic, Enhance +++) Resolution no.195 of 2021 (Reactive, Economic, Enhance +++)	Resolution No.47 of 2007 (Regulatory, Reactive, ++) Resolution No.4 of 2009 (Regulatory, Reactive, ++) Resolution No.53 of 2010 (Regulatory, Reactive, ++) Resolution No.6 of 2013 (Regulatory, Reactive, ++) Resolution No.12 of 2014 (Regulatory, Reactive, ++) Resolution No.8 of 2009 (Regulatory, Reactive, +++) Resolution No.48 of 2010 (Regulatory, Reactive, 0)

Source: Designed by researcher

D: Drivers, P: Pressures, S: State, and I: Impacts

Highly positive effect (+++), Moderately positive (++), Slightly positive (+), Neutral (0), Slightly negative effect (-), Moderately negative (- -) Highly negative (- - -)

Proactive environmental policies focus on eliminating and preventing the occurrence of environmental problems before they have a chance to appear (Yang et al., 2019). However, reactive environmental policies are responses to environmental problems after they have already happened (Tanwar et al., 2017). The data summarized in Table (4.13) reveal that the policy instruments used to manage shrimp fishery in Bahrain are regulatory, economic, and institutional instruments. Some of the policies were proactive, and others were reactive. Most of them aim to enhance the environment (Enhance). Some are strongly positively effective (+++), one policy is highly negative (- - -), and one policy is neutral (0). It can also be noted that most policies are directed at the drivers and pressures. In contrast, no policy tackles the state of increasing shrimp caught quantities. There is a lack of policies tackling the negative impacts of both issues.

Economic instruments such as charges, fees, and fines put a price on environmentally harmful behavior (Ring & Barton, 2015). The economic instruments are considered an effective policy tool in minimizing, preventing, and managing shrimp catches. Moreover, the charges, fees, and fines are deemed economic instruments that can be used to recover shrimp fishery and support the coastal and marine habitat restoration, ensuring the sustainability of shrimp fisheries.

The Rio Declaration on Environment and Development and Agenda 21 of the Sustainable Development Goals and UNEP-GEO reports, especially GEO5 (2012) and GEO6 (2019), emphasized the importance of economic instruments for environmental policy (Al-Omran et al., 2023). Economic instruments represent a policy tool for national authorities to encourage violators of environmental laws and users of environmental resources to adopt more environmentally friendly behavior, support the internalization of environmental costs to integrate economic profits and

environmental protection (Yang et al., 2019; Long et al., 2012; Youli & Xiongyi, 2010).

Policy analysis of shrimp fishery management reveals that the current policies are sufficient to moderate the pressures and drivers, reduce the two main issues (shrimp caught quantity and management) and mitigate their adverse impacts. However, these policies are not implemented properly. For example, although there are policies on cancellation of shrimping licenses, stopping the issuance of them, and prohibiting shrimp fishing by speed boats (Tarad), they are not fully implemented or in a proper way.

4.4.4 Where Are We Heading with Shrimp Fishery? (Future Outlook)

Two future scenarios (Scenarios for Outlooks) were predicted for determining strategic solutions to help the decision-makers achieve sustainable shrimp fishery in Bahrain, as summarized in Table (4.11).

Table (4.11): Proposed scenarios for shrimp fishery management.

Scenarios	Actions	Assumptions
Business as usual -BAU	Conventional	Shrimp fishing violations are increasing, and shrimp fishery policies are not followed strictly including shrimping licenses. The shrimp catch is increasing.
Sustainability Scenarios		

Scenarios	Actions	Assumptions
Reduction in shrimp catch	• Use innovative digital monitoring, control and surveillance technologies to monitor shrimp fishing activity.	Many countries have used digital technologies as a surveillance system to ensure that fishers comply with fishery rules and regulations. Around 80% reduction in fishing effort would be recorded using a Vessel Monitoring System (VMS). Illegal fishing could easily be detected.
	• Reduce the number of shrimping licenses by strictly implementing shrimping licenses regulations.	Around 50% reduction in number of shrimping licenses by gradual cancellation of current licenses.
Efficient shrimp fishery management	• Establish co-management system. • Increase penalties for repeated violations.	High commitments and legal obligations for sustainable shrimp fishery. Illegal shrimp fishing violations would be decreased.

Source: Designed by researcher

The first scenario is a business-as-usual prediction, corresponding to the current situation without government intervention or policy reforms. As a result, there will be a continuous increase in the shrimp catch and heavy exploitation of shrimp stocks. The second scenario, the sustainability scenario, assumes that the decision-maker would be stricter in monitoring, controlling, and surveillance of shrimp fisheries and implementing the policies to manage the shrimp fishery efficiently. The sustainability scenario focuses on implementing policies and regulations to reduce the quantities of shrimp caught and improve shrimp fishery

management. This minimizes the adverse impacts on ecosystems, the environment, society, and the economy. It was found that introducing digital monitoring, control, and surveillance technologies, such as Vessel Monitoring Systems (VMS), led to a significant reduction in fishing efforts in no-trawl areas, about 80% (Thoya et al., 2019). Digital technologies and solutions can enhance the ability to collect, store, analyze, and visualize data, monitor fisheries and habitats, and for conservation management (such as fighting illegal activities). The obtained data can make better and quicker decisions, leading to more effective policy delivery and enforcement (Lahoz-Monfort & Magrath, 2021). For example, Geographic Information System (GIS) and Remote Sensing (RS) technologies could be used in various stages of monitoring, conservation, management, sustainable development, and environmental protection. In addition, GIS and RS technologies are potential tools for fisheries management, especially in decision-making processes, as they could give clear visualization of the data and information in place and time (Pangsorn, 2022). In the United States, electronic technologies in fisheries were adopted in policy in 2013 and in New Zealand, electronic monitoring and reporting became mandatory for all commercial fisheries from 2019 (Zhu et al., 2021).

Additionally, unmanned aircraft systems, commonly called drones, have been used widely in fishery monitoring (Harris et al., 2019). Drones represent a new and innovative pathway for monitoring fishery dynamics, spatial–temporal practices, and potential conflicts with management and conservation purposes (Reis-Filho et al., 2022). Technological advances such as increasing battery life and decreasing payload weight and costs make drones an affordable and valuable resource for fishery monitoring (Colefax et al., 2018).

It is expected to practice co-management-fisher participation in shrimp fishery management rather than centralized management. For example, fishers have advocated for the benefits of more collaborative decision-making practices, and one-way policymakers have responded is by sharing responsibilities through co-management—a form of participatory governance (Cadman & Bailey, 2022). Although co-management and fisher's participation are governance elements particularly interrelated, differences exist between the involvement of fishers in decision-making (co-management) and their participation in the monitoring, control, and surveillance (fisher's participation). Nevertheless, it was found that co-management and fisher's participation in monitoring and surveillance promote sustainability (Aguión et al., 2022).

4.4.5 What Actions Could Be Taken for a Sustainable Future for Shrimp Management? (Policy Options)

Increasing the quantities of shrimp caught and shrimp fishery mismanagement is a long-term problem. Therefore, these issues need root solutions to the drivers and pressures. Additionally, these issues need economic instruments such as forming policies for sustainable shrimp fishery management, reforming some regulations, and encouraging or discouraging specific behaviors and actions through introducing initiatives, incentives, or disincentives. Focusing more on implementing strict policies regarding efficient shrimp fishery management is crucial. However, as indicated in the statistical data provided by Coast Guard Directorate, the illegal shrimp catch during the closed season in 2020 was much higher than the violations in 2019 because of an intensive monitoring system.

This study recommends that the legislations should be applied more firmly, reasonable penalties against violations can also have a positive impact, and the violators' license must be permanently withdrawn when the offence is repeated. Furthermore, Resolution No.11 of 2009 must be activated to stop the issuance of fishing, shrimp fishing licenses, and licenses for amateur fishers.

Education, awareness, capacity building, and training to fishers are required to be part of a policy and to be included within the strategic plan of the Fisheries Directorate with dedicated human and financial resources to oversee and carry out such initiatives. It was found that training of fishers should not be restricted to tools and technologies of fishing. Rather it should be made holistic and should cover issues, such as displaying appropriate attitude and behavior (Richardson et al., 2018).

Moreover, it was found that an enhanced national policy framework that empowers and engages local governments, universities, NGOs, fishers, and community groups who are adequately trained and funded would significantly strengthen fisheries science through improved data collection, processing, and interpretation to manage fisheries effectively (Jaya et al., 2022).

This study proposes a policy requiring the Fisheries Directorate and Maritime Control Directorate to train fishers regularly about new shrimp fishery management, ecosystem restoration, or other EBM initiatives.

Certain countries legally bind fishers to take basic training courses. The fishing sector in the UK considers training vital in ensuring fishermen work safely and efficiently (http://www.seafish.org). Delivered usually by a host of approved training institutions, these training programs also comply with National Occupational Standards. Organizations in the Danish fishing sector offer fishers relevant educational programs (The Fisheries Circle) (Belwal et al., 2015).

Additionally, the study suggests that the Fisheries Directorate (its name changed in the year 2023 based on Decree No.15 of 2023 of reorganizing the Ministry of Municipalities Affairs and Agriculture to Fish Stock Protection and Development Directorate) as specialized staff to be under the umbrella of the Ministry of Municipalities Affairs and Agriculture permanently. Inclusion of the Fisheries Directorate from time to time under different ministries and agencies may confuse the programs and activities (Table 4.12). The stability of the work system is a priority for success in implementing effective planning, organizing, directing, and monitoring.

Table (4.12): Fisheries Directorate under the umbrella of different ministries.

#	Decree		Ministry	Fisheries issues belong to	Responsible agency
	Number	Year			
1	15	2023	Municipalities Affairs and Agriculture	Fish Stock Protection and Development Directorate	Marine Resource
2	50	2019	Ministry of Works, Municipalities Affairs and Urban Planning	Fisheries Directorate	Agriculture and Marine Resources
3	68	2012	Ministry of Municipalities Affairs and Urban Planning	Fisheries Directorate	Marine Resources
4	23	2009	Ministry of Municipalities Affairs and Agriculture	Animal Wealth Resource Directorate	Plant and Animal Care
5	70	2003	Ministry of Municipalities Affairs and Agriculture	Animal Wealth Resource Directorate	Agricultural Production

#	Decree		Ministry	Fisheries issues belong to	Responsible agency
	Number	Year			
6	33	2003	Ministry of Municipalities Affairs and Agriculture	Animal Wealth Resource Directorate	Plant and Animal Care
7	21	1996	Ministry of Housing, Municipalities and Environment	Environmental Control Directorate	Environmental affairs

Source: Compiled by researcher

Furthermore, the study proposes fisheries co-management in which fishers, other stakeholders, and government share responsibility for making and enforcing rules around fishery resource and area use. Table (4.13) provides a list of nine targets across four SDGs supported by effective and equitable fisheries co-management.

Table (4.13): Sustainable Development Goal (SDG) targets that support effective fishery co-management, related objectives for marine management from Jupiter et al., (2014), and assumptions about expected management outcomes.

SDG	Specific SDG targets	Objective from Jupiter et al., (2014)	Assumption about what management will achieve by implementing co-management
 SDG 1 No Poverty	1.2 Reduce poverty in all its dimension	Enhance economy and livelihoods	Improve income and livelihood security
	1.4 Ensure equal rights and access to natural resources	Assert access rights	Increase equal rights and access to natural resources

SDG	Specific SDG targets	Objective from Jupiter et al., (2014)	Assumption about what management will achieve by implementing co-management
 SDG 2 Zero Hunger	2.1 Ensure sufficient access to food	Achieve food security	Changes in fishery resources availability will lead to change in catch, and that changes in catch will alter patterns of consumption
	2.2 End all form of malnutrition	Achieve food security and improve nutrition	Changes in patterns of consumption will lead to change in nutrition
	2.4 Ensure sustainable and resilient food production systems	Increase long-term sustainable yield	Improve the sustainability of marine resources, resulting in increased long-term yields
 SDG 5 Gender equality	5.5 Ensure full and effective participation and equal opportunities for leadership	Increase community organization, cohesiveness, and empowerment	Improve participation and inclusion in governance for all
 SDG 14 Life below water	14.2 Protect marine and coastal ecosystems and strengthen their resilience for healthy and productive oceans	Maintain/ restore biodiversity, habitats, and ecosystem function; improve resilience	Improve the sustainability of resources, and that this will improve biodiversity and conservation impacts
	14.4 Regulate and manage overharvesting to restore fish and shrimp stocks	Maintain or restore the biomass and breeding populations of target species	Improve the sustainability of resources, and that this will improve biodiversity and conservation impacts

SDG	Specific SDG targets	Objective from Jupiter et al., (2014)	Assumption about what management will achieve by implementing co-management
	14.B Provide access for small-scale artisanal fishers to marine resources and markets	Assert access rights	Increase equal rights and access to marine resources

Source: Designed by researcher by referring to Smallhorn-West et al., (2022)

4.5 Ecosystem-Based Shrimp Management

4.5.1 Demographic characteristics of respondents

Questionnaires were administered to 50 respondents from four different governmental institutions. A total of 16 questionnaires were returned filled. The number of employees specialized in the field of marine science or marine biology, or environmental science is low in these respective institutions. The demographic characteristics of participants are presented in Table (4.14). All the participants were Bahraini nationals. The findings indicate that many of participants (56%) have between 11 and 15 years of work experience in the marine environment and fisheries field, followed by an equally high number (31%) of those with 16-20 years of work experience. Very few (6%) participants have over 36 years of work experience. The academic specializations of the respondents are mostly postgraduates, however the majority of them are out of the field of fisheries sciences or marine biology (Fig. 4.21). Most participants have been in supervisory roles (chiefs and heads), as most participants held postgraduate qualifications (56%).

Table (4.14): Characteristics of the participated decision-makers.

Items	Number of respondents	(%)
Nationality		
▪ Bahraini	16	100
▪ Non-Bahraini	0	0.0
Work experience in marine environment and fisheries		
▪ 5-10	1	6.3
▪ 11-15	9	56.3
▪ 16-20	5	31.3
▪ Above 36	1	6.3
Academic Qualification		
▪ Secondary certificate	2	12.5
▪ Bachelor	5	31.3
▪ Master's	8	50.0
▪ PhD	1	6.3
Academic Specialization		
▪ Fisheries science	0	0.0
▪ Marine biology	3	23.1
▪ Environmental science	3	23.1
▪ Biology	1	7.7
▪ Others	6	46.2
Employer		
▪ Fisheries Directorate	3	18.8
▪ Maritime Control Directorate	3	18.8
▪ Supreme Council for the Environment	4	25
▪ Coast Guard Command	6	37.5
Occupation		
▪ Director	1	7.1
▪ Chief of Department	5	35.7
▪ Head of division/group	4	28.6
▪ Senior specialist	2	14.3
▪ Others	2	14.3

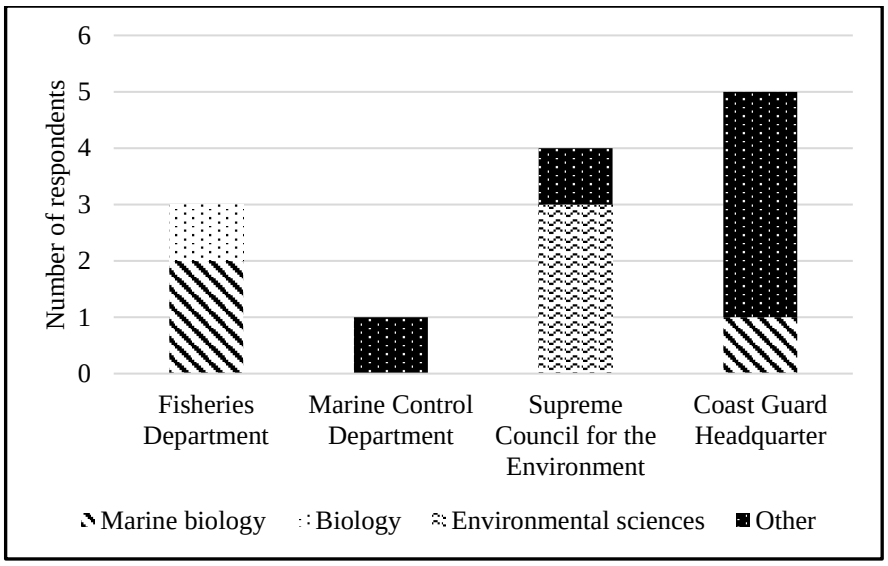


Fig. 4.21: Cross tabulation of decision-makers academic specialization and their workplace.

Table (4.15) describes the characteristics of the fishers that took part in the survey. The questionnaires were administered to 100 respondents selected by the fishers' associations. A total of 49 questionnaires were returned filled. The majority of fishers are Bahraini nationals. Fishers had quite a wide range of ages (from 30 years to 81 years). Most of the fishers are between 40-70 years old (76%). Their age groups indicate that 18% are between the ages of 30-41 years, 29% between 42-51 years, 23% between 52-61 years, 24% between 62-71 years and 6% over the age of 72 years. In line with the notable high age amongst the majority of participants, the findings indicate that a large number of participants (64%) have over 21 years of experience in fishing activity, and (36%) had less than 20 years of experience. Most fishers were skippers in which practiced shrimp fishing through trawler crews registered under their license (78%), and almost all of them (96%) owned the vessel operated. Most fishers were married, and the majority had dependent children in the household. Almost half of fishers (52%) had a low level of formal education.

The total household income for fishers comes from fishing, where 72% of fishers reporting 90-100% of the total household income is coming from fishing. Around 48% of fishers reported that they were the sole contributor to the household income, with 52% their wives or children had a job. Most fishers had limited professional experience outside of the fishing sector, with most reporting to have never had another job since they started fishing (72%) categorized by 47% based on shrimp and fish, and 47% based on shrimp.

Regarding fishing operation, most fishers (83%) operate large wooden fishing vessels (Banoosh), and 17% use speed boats. Around 67% of the fishers have only one fishing vessel, mainly Banoosh with an average age of about 16 years, while for the speed boats is nearly 9 years.

Family tradition played a significant role in fishers' choice of job, with many fishers (59%) reporting to have entered fishing and continued in this profession due to family tradition. However, 35% of fishers also reported joining the fishing sector due to a lack of alternative employment. Furthermore, fishers reported the lack of qualifications, alternative employment opportunities, and experience outside the fishing field as the main reasons to choose the fishing sector. Only 6% of fishers considered fishing as an additional source of income. According to Holland et al., (2020), fishing is not just a source of income to many fishers but also a source of enjoyment and fulfillment and is considered part of social identity to many.

Table (4.15): Demographic, employment characteristics, attitudes, and perceptions of the fishers' sample.

Items	Response
Demographic	
Nationality (%)	
Bahraini	93.6
Non-Bahraini	6.4
Age (%)	
30-41	17.6
42-51	29.4
52-61	23.5
62-71	23.5
Over 72	5.9
Academic Qualification (%)	
Primary certificate	22.7
Intermediate certificate	29.5
Secondary certificate	45.5
Diploma	2.3
Governorate (%)	
Capital	53.5
Muharraq	34.9
Northern	11.6
Southern	0
Housing Ownership (%)	
Owner	77.1
Tenant	8.3
Others	14.6
Support a family (%)	100
Mean number of people in the household	6.2
Job related	
Mean number of contributors to household income	2.0
Family members works (%)	52.3
Fisher (head of the family) is the main contributor to the household income (%)	47.7
No other job experience since start fishing (%)	72.3
Household income is coming from fishing (%)	72.3
Fishing activity	
Job on board of vessel (%)	
Skipper practice shrimp fishing through trawler crews registered under their license	77.6
Vessel ownership (%)	95.8
Shrimping vessel (%)	
Wooden fishing vessels (Banoosh)	83.3
Speed boats (Tarad)	16.7
Average age of shrimping vessel (year)	
Wooden fishing vessels (Banoosh)	16.1
Speed boats (Tarad)	9.1

Items	Response
Number of shrimping vessels (%)	
One shrimping vessel	67.4
Two shrimping vessels	32.6
Target species (%)	
Shrimp only	46.8
Shrimp and Fish	46.8
Fish only	6.4
Mean experience from fishing (years)	28.1
Number of years of work experience in shrimp fisheries (%)	
10-20	36.2
21-30	34.0
31-40	17.0
41-50	12.8
Attitudes and perceptions	
Motives to get started and continue on the fishing activity (%)	
Family tradition	59.2
Lack of alternative employment	34.7
Additional source of income	6.1

4.5.2 The steps for implementing EBSM

Step A: Defining ecosystem area and identifying key stakeholders and the relationship between them

The first step of the EBSM includes four principles (1, 7, 11, 12), which are concerned with determining the stakeholders and defining the ecosystem area. The preferred habitats of penaeid species are diverse and include mangroves, seagrasses, macroalgae, mudflats, and sand flats (Macia, 2004). Within coastal systems, seagrasses are key components that provide vital ecosystem services and are essential shrimp habitats. Seagrasses are highly productive habitats that provide important ecological functions and economic services (Duffy, 2006; Duarte, 2002). Ecologically, seagrasses provide food sources and function as nursery grounds for a variety of fish, shellfish, and crustacean species, including juveniles of several species of penaeid (Hewitt et al., 2020; Brewer et al., 1995). In addition, seagrasses protect coastal areas by protecting the

shoreline (Boudouresque et al., 2016), diminishing wave energy, and improving water quality by stabilizing sediment and filtering water by removing pollutants (Ondiviela et al., 2014; Al-Wedaei et al., 2011). In Bahrain, several shallow areas are important to penaeid shrimps, such as south of Fasht Al-Adhom and Tubli Bay (Abdulqader, 1999). Alkhathlan (2020) reported that seagrass habitat in Bahrain specially the high-density classes are subjected to degradation over the last 15 years, where several coastal developments have been implemented associated with huge amount of sand dredging/reclamation process particularly within the southeastern area. Economically, seagrasses significantly affect the productivity of local fisheries (Abdulqader, 1999). Despite the importance of marine ecosystems, seagrass ecosystems globally are susceptible to increasing anthropogenic stressors such as direct destruction of physical habitat, overexploitation, and pollution (Ruiz-Frau et al., 2017). Therefore, several resolutions have been issued to protect coastal and marine ecosystems in Bahrain, including (1) Resolution No. 16 of 1996 considering the Hawar islands and the surrounding territorial sea a protected area following provisions of Decree Law No. 2 of 1995 on the protection of the wildlife, (2) Resolution No. 1 of 2002 that declared Mashtan Island as a protected area, (3) Resolution No. 4 of 2003 that declared the zone of Dawhat Arad as a marine protected area, (4) Law No. 53 of 2006 considering Tubli Bay as a natural protected area, (5) Resolution No. 2 of 2017 that declared the zone of Najwat Bulthama a marine protected area, and (6) Resolution No. 3 of 2017 of designating Hayr Bulthama, Hayr Shttayah, and Hayr Bu Amamah as marine protected areas (Fig. 4.22).

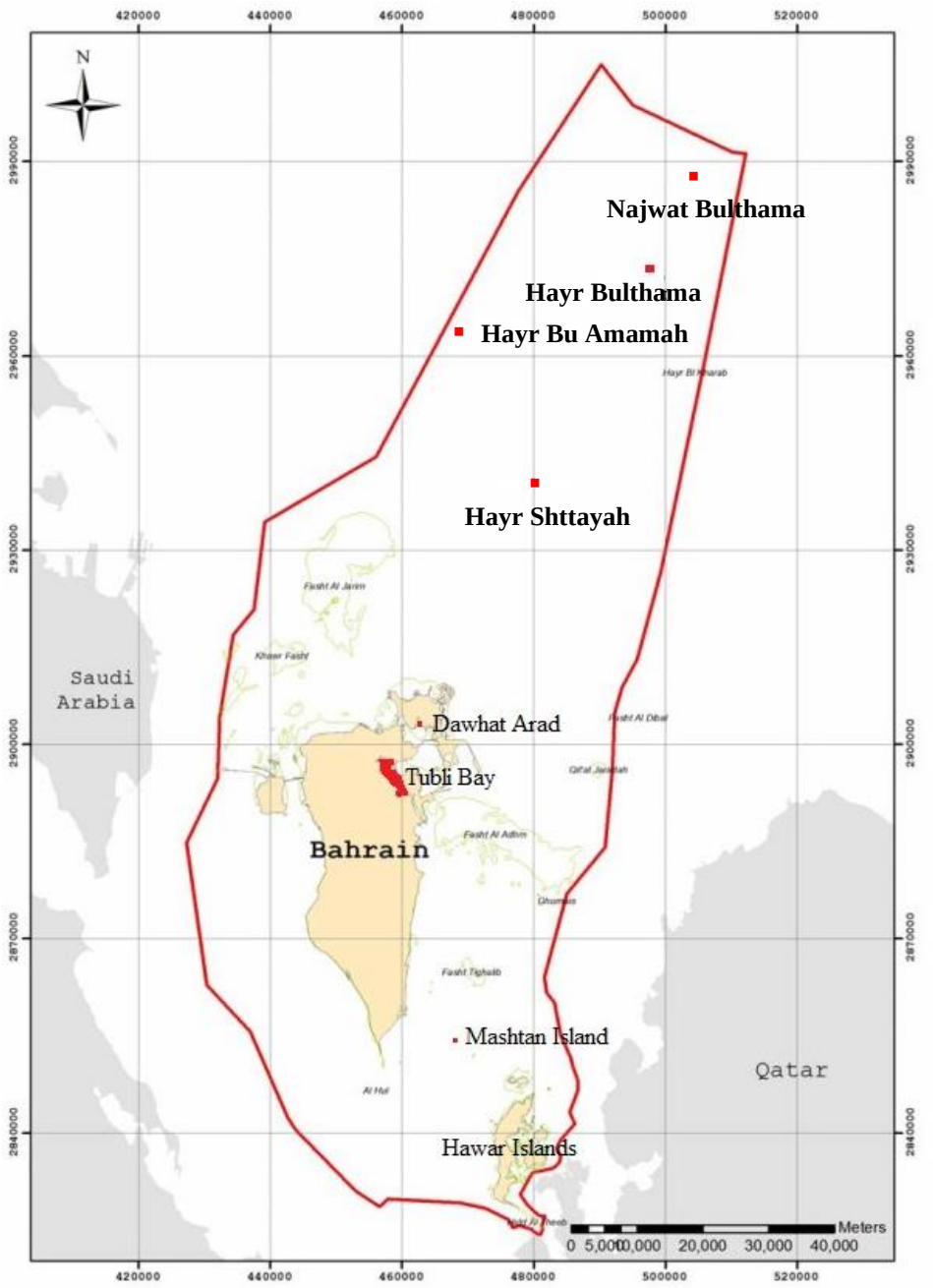


Fig. 4.22: A map showing marine protected areas in Bahrain; Hawar Islands, Tubli Bay, Mashtan Island, Dawhat Arad, Najwat Bulthama, Hayr Bulthama, Hayr Shttayah, and Hayr Bu Amamah (Loughland & Zainal, 2009).

Bahrain's seagrass ecosystem serves as a habitat for penaeid shrimps and provides essential services that support human health, livelihoods, wellbeing, and survival (Toth, 2003). These include provisioning,

regulating, cultural, and supporting services, which directly affect human wellbeing (UNEP, 2007; MEA, 2005) as shown in Table (4.16).

Table (4.16): Seagrass ecosystem services in shrimp fishing grounds of Bahrain.

Type of value	**Service type**	**Benefit/value category**	**Examples of specific benefits**
Direct use (consumptive)	Provisioning	Food	Fish, shrimps, crabs
		Shelter/ nursery areas	Juveniles of fish and shrimps Shellfish
Direct use (non-consumptive)	Cultural	Recreation	Traditional and recreational fishing
		Cognitive development	Education, Research
		Aesthetic	Biodiversity Dugong and sea turtle
Indirect use	Regulation	Disturbance prevention	Reducing wave energy and trapping sediments
		Contaminant control	Clean water and air
		Carbon sequestration (Blue Carbon)	Reducing the carbon footprint, mitigate climate change
Future use		Option	Shrimp aquaculture
Sustainable	Supporting	Nutrients cycling	Transfers, chemical transformations, and recycling of nutrients

Type of value	Service type	Benefit/value category	Examples of specific benefits
		Primary production	Creation of new organic matter by photosynthesis

Source: Designed by researcher by referring to Ahmad et al, 2022; Blanco-Martínez et al., 2020; McKenzie et al., 2021; Nordlund et al., 2018; Ruiz-Frau et al., 2017; Naser, 2014; Al-Wedaei et al., 2011; Eric et al., 2008

The diverse links between ecosystem services and the determinants and constituents of human wellbeing are illustrated in Fig. 4.23. This Figure depicts the linkages between categories of ecosystem services and components of human well-being. Environmental factors as well as economic, social, technological, and cultural factors influence human well-being. Ecosystems are in turn affected by changes in human well-being. Ecosystems like seagrass and mangroves provide different services to society. These include provisioning, regulating, and cultural services that directly affect people. They also include supporting services needed to maintain all other services. Some ecosystem services are local (provision of food or nursery area), others are regional (water purification), and others are global (climate regulation). Ecosystem services affect human well-being and all its components, including basic material needs such as food and shelter, individual health, security, good social relations, and freedom of choice and action.

The relationship between ecosystem conditions and the flow of services to human wellbeing is diverse and complex. Many ecosystem changes are planned, but many are unintentional consequences of human activities (Reid et al., 2005). Therefore, sustainable wellbeing depends heavily on links with ecosystem services (UNEP, 2007; MEA, 2005; Toth, 2003).

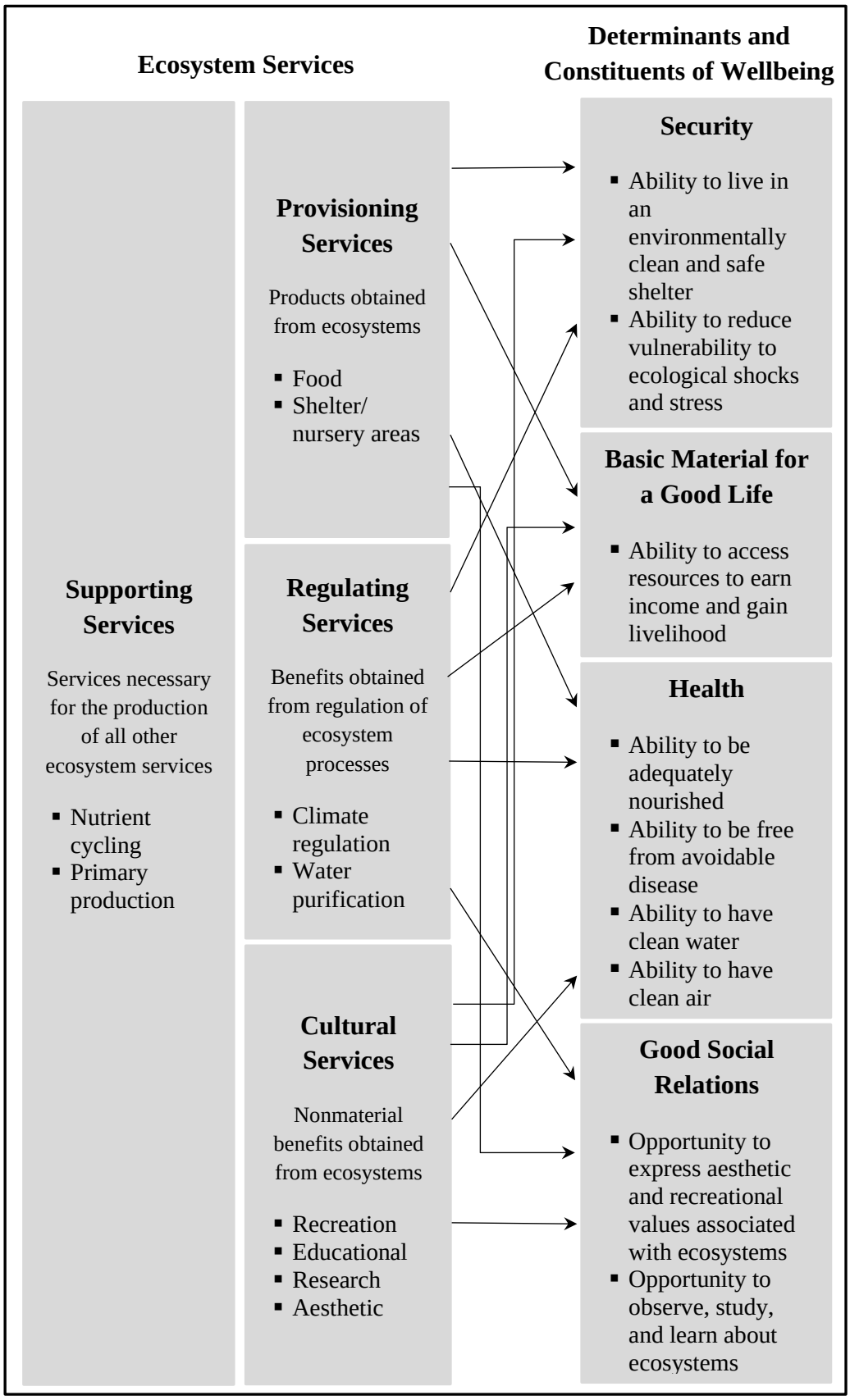


Fig. 4.23: Ecosystem services and their links to human wellbeing. Source: Designed by researcher by referring to MEA (2005) and Toth (2003).

The changes in ecosystem services because of human interventions such as shrimp overexploitation affect human wellbeing through impacts on food security, economic, health, and good social relations. Table (4.17) presents the impact of shrimp overexploitation on human wellbeing and all its components. Shrimp overexploitation has an ecological impact on marine ecosystems, affecting food webs and ecosystem functions and damaging marine benthic habitats leading to habitat loss.

Table (4.17): The impact of shrimp overexploitation on human wellbeing.

<table>
<tr><td colspan="4">Issue from DPSIR:
Shrimp Overexploitation</td></tr>
<tr><td colspan="4">Ecological Impact:
Negatively impacts the marine ecosystems through effects on food webs and ecosystem functions.
Damaged the marine benthic habitats.
Habitat loss.</td></tr>
<tr><td colspan="4">Determinants and Constituents of Wellbeing</td></tr>
<tr><td>Food Security</td><td>Economic</td><td>Health</td><td>Good Social Relations</td></tr>
<tr><td>Food security at risk.
Decline in shrimp landings.
Conflicts between different users of the fisheries.</td><td>Threaten the livelihoods of people.
Loss of revenue and income.</td><td>Declines in shrimp populations.
Biodiversity loss.
Changes in species composition and functional loss of key species.</td><td>Increased conflicts between commercial and recreational fishers.
Limited amount of knowledge about the damaged and disturbed ecosystems.</td></tr>
</table>

Source: Designed by researcher

EBSM seeks to address the full range of activities affecting the health of Bahrain's seagrass ecosystem. Therefore, information on stakeholder perspectives is a critical requirement for EBSM, but the detail is often unavailable (Cavanagh et al., 2016). The survey analysis provides insight

into the detailed views of a diverse and relevant sample of stakeholders. Although stakeholders' opinions differ, a common purpose of maintaining and protecting the coastal and marine ecosystems has been concluded. In attempting to balance different stakeholders' perspectives or aspirations for ecosystems, the approach engaged diverse interest groups to determine their interest to the ecosystem. Significant stakeholders of shrimp fishery are fishers (skipper and crew), relevant governmental institutions employees, suppliers, and customers, as well as the beneficiaries of other ecosystem services that the fishery could impact, in addition to regional fisheries management organizations and global environmental organizations. The government represents stakeholders' interests through its membership in CBD, ROPME, RECOFI, and UNEP (ROPME, 2016; SCE, 2016).

The analysis of shrimp fisheries governance shows the direct and indirect involvement of all sectors in shrimp fishery management with various weights and interests (Fig. 4.20). It defines four categories of contributors based on the degree of capacity to manage shrimp fisheries and the degree of influence by the key stakeholders on sustainable shrimp fishing. The four types of contributors are:

- Critical contributors are the lead agencies that closely manage shrimp fisheries' sustainability and are involved primarily in strategic development.
- Primary contributors are the main actors in fisheries management, monitoring, control, and surveillance, building capacity, and raising awareness.
- Secondary contributors are partners to collaborate for lobbying, political influence, and support at financial, technical, and managerial levels.

- Tertiary contributors are those who must be kept informed of activities and emerging issues because they can provide support in the control of shrimp fishing grounds and law implementations.

<table>
<tr><th></th><th colspan="4">Degree of influence by the key stakeholder on sustainable shrimp fishing</th></tr>
<tr><th>Degree of capacity of the stakeholder to manage shrimp fisheries</th><th>1
Low</th><th>2
Moderate</th><th>3
High</th><th>4
Very high</th></tr>
<tr><td>1
Low</td><td colspan="2" rowspan="2">Stakeholder type: Tertiary contributors

• Fishers' association
• Fishers</td><td colspan="2" rowspan="2">Stakeholder type: Primary contributors

• Ministry of Municipalities Affairs & Agriculture
• Agriculture and Marine Resources Agency
• Registration of Ships and Seamen Affairs - Ministry of Transportation and Telecommunications
• Direct users (Fishers, amateurs, seafarers)</td></tr>
<tr><td>2
Moderate</td></tr>
<tr><td>3
High</td><td colspan="2" rowspan="2">Stakeholder type: Secondary contributors

• National Assembly (the Shura Council and the Council of Representatives)
• University of Bahrain
• Arabian Gulf University
• IGA
• Tamkeen
• Budget Directorate – Ministry of Finance
• Environmental NGO (bnature, Bahrain Environment Society, Bahrain Youth and Environment Society)
• Donors (Bahrain Development Bank)</td><td colspan="2" rowspan="2">Stakeholder type: Critical contributors

• Maritime Control Directorate
• Fisheries Directorate
• Directorate of Coast Guard
• Supreme Council for Environment</td></tr>
<tr><td>4
Very high</td></tr>
</table>

Fig. 4.24: Key national stakeholders and their influence and capacity.
Source: Designed by researcher

Principles related to Step A:

The results for step A for implementing EBSM were presented in Table (4.18) and Fig. 4.25.

Table (4.18): Participants' responses (in percent %) to the step A of EBSM.

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Step A						
A-1: Shrimp fisheries are in good condition.	Decision Makers	6.3	25.0	50.0	18.8	0.0
	Fishers	18.4	57.1	14.3	8.2	2.0
A-2: The current rate of exploitation of shrimp fisheries and the natural shortage of shrimp quantities leads to a decrease in shrimp stock in the future.	Decision Makers	37.5	31.3	25.0	6.3	0.0
	Fishers	6.1	55.1	12.2	26.5	0.0
A-3: Marine charts and coordinates are provided to fishers to determine the permitted areas for shrimping.	Decision Makers	43.8	37.5	0.0	18.8	0.0
	Fishers	18.4	16.3	28.6	30.6	2.0
A-4: Fisher's benefit from all shrimping areas.	Decision Makers	**	**	**	**	**
	Fishers	16.3	32.7	24.5	20.4	6.1
A-5: It is necessary to conduct periodic evaluations of shrimp fisheries jointly with fishers according to scientific indicators.	Decision Makers	43.8	43.8	12.5	0.0	0.0
	Fishers	**	**	**	**	**
A-6: Fishers or their representatives from fishers' associations are involved in meetings, seminars or workshops on issues related to shrimp fisheries management.	Decision Makers	6.3	68.8	12.5	12.5	0.0
	Fishers	0.0	14.3	12.2	46.9	24.5
A-7: It is important for research centers in government entities concerned with preserving marine resources to cooperate with higher	Decision Makers	56.25	37.5	0.0	6.3	0.0
	Fishers	**	**	**	**	**

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
education institutions.						
A-8: Researchers of higher education institutions are involved with relevant government entities in making resolutions related to the sustainable exploitation of shrimp fisheries.	Decision Makers	12.5	37.5	37.5	12.5	0.0
	Fishers	**	**	**	**	**
A-9: Citizens and residents who are seafarers (amateur and marine clubs) are involved - to seek their opinions - with the relevant government entities in addressing and resolving issues related to shrimp fisheries management.	Decision Makers	0.0	31.3	18.8	18.8	12.5
	Fishers	**	**	**	**	**
A-10: There is cooperation between practitioners in the shrimping sector and policymakers to manage shrimp fisheries sustainably.	Decision Makers	0.0	18.8	56.3	18.8	6.3
	Fishers	**	**	**	**	**
A-11: Legislation provides for fishers' participation in policymaking related to shrimp fisheries management.	Decision Makers	0.0	18.8	62.5	0.0	12.5
	Fishers	**	**	**	**	**

(5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly disagree)
** The question was not asked to the sample

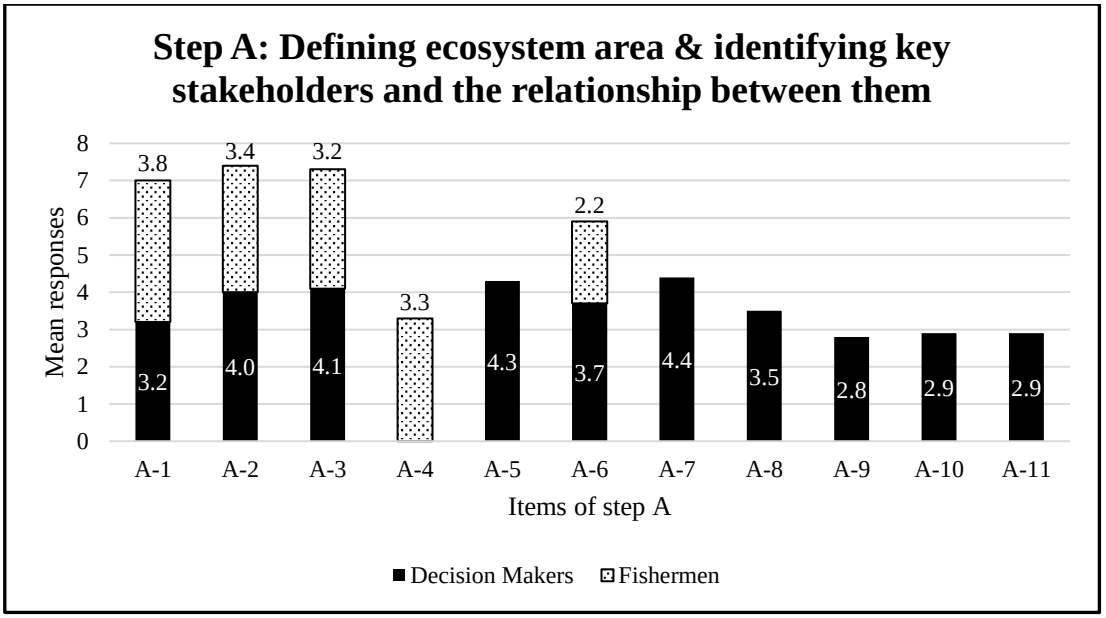


Fig. 4.25: Mean responses of decision makers and fishers to step A of the EBSM.

Principle 1: The objectives of management of land, water, and living resources are a matter of societal choice.

The objectives for managing shrimp resources depend on societal choice, determined through negotiations and trade-offs among stakeholders with different perceptions and interests. In this regard, the following was noted:

- Each group views the sustainable shrimp management issue in different ways reflecting their own economic, cultural, and societal interests and needs. For example, there were different views from both fishers and decision-makers regarding shrimp fisheries, as 76 % of the fishers stated that shrimp fisheries are still in good condition. In comparison, only 31 % of the decision-makers agree, reflecting their fear and skepticism regarding those fisheries and the possibility of their deterioration in the future. Furthermore, 69 % of the decision-makers believed that the current rate of exploitation of shrimp fisheries and the natural shortages of shrimp will lead to a decrease in its

quantity in the future; 61 % of the fishers also agreed. Thus, all relevant parties must work together toward meeting the needs of the present while ensuring future generations can meet their own needs.

- Around 71% of the fishers reported that they do not participate in meetings, seminars, or workshops on issues related to shrimp fisheries management. On the other hand, the majority of the decision-makers (63%) were neutral about the existence of legislation that stipulates the participation of fishers in making policies related to the management of shrimp fisheries, and 19 % of them acknowledged the existence of such legislation. According to CBD guidelines as mentioned in Mueller and Geist (2016); CBD (2004); Shepherd et al., (2004); Smith and Maltby (2003), a good decision-making process should incorporate the following:
  - All stakeholders (interested parties) should be involved in clearly expressing, defining, and agreeing upon the goals of shrimp fisheries management, defining problems, and making choices. If stakeholders cannot directly represent themselves, they should be adequately represented by someone else.
  - All stakeholders should have equitable access to information to participate in the process effectively.
  - Decisions should be based on intersectoral communication and coordination at the institutional/organizational level.
  - The criteria for decisions should be transparent in that they specify the responsible decision-makers for each decision and how the decisions will be taken.
  - An assessment at the national level should be undertaken to analyze the effects of ecosystem management practices in society to manage the possible conflicts between stakeholders in the implementation phase.

Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.

Spatial and temporal scales bounded the approach to meet the shrimp management objectives as follows:

- The professional fishers were provided with marine charts and coordinates to determine the permitted locations for shrimping. However, about 51% of fishers stated that they only benefit from some shrimping areas because trawl fishing is permanently prohibited.
- From the interview, the preferred/best shrimping areas (Fig. 4.26) for fishers are:
  1. Qumais
  2. Umudood
  3. Fasht Al-Jarim
  4. South of Fasht Al-Adhom
  5. Khur Fasht
  6. East of Khalifa Bin Salman Port
  7. Bouyat Salisil
  8. The area between Umm Jileid and Qumais

  The decision-makers added that traces of bottom trawling operations were observed in some areas surrounding Hawar Islands. Moreover, the fishers clarified that shrimps are captured in shallow waters using speed boats.

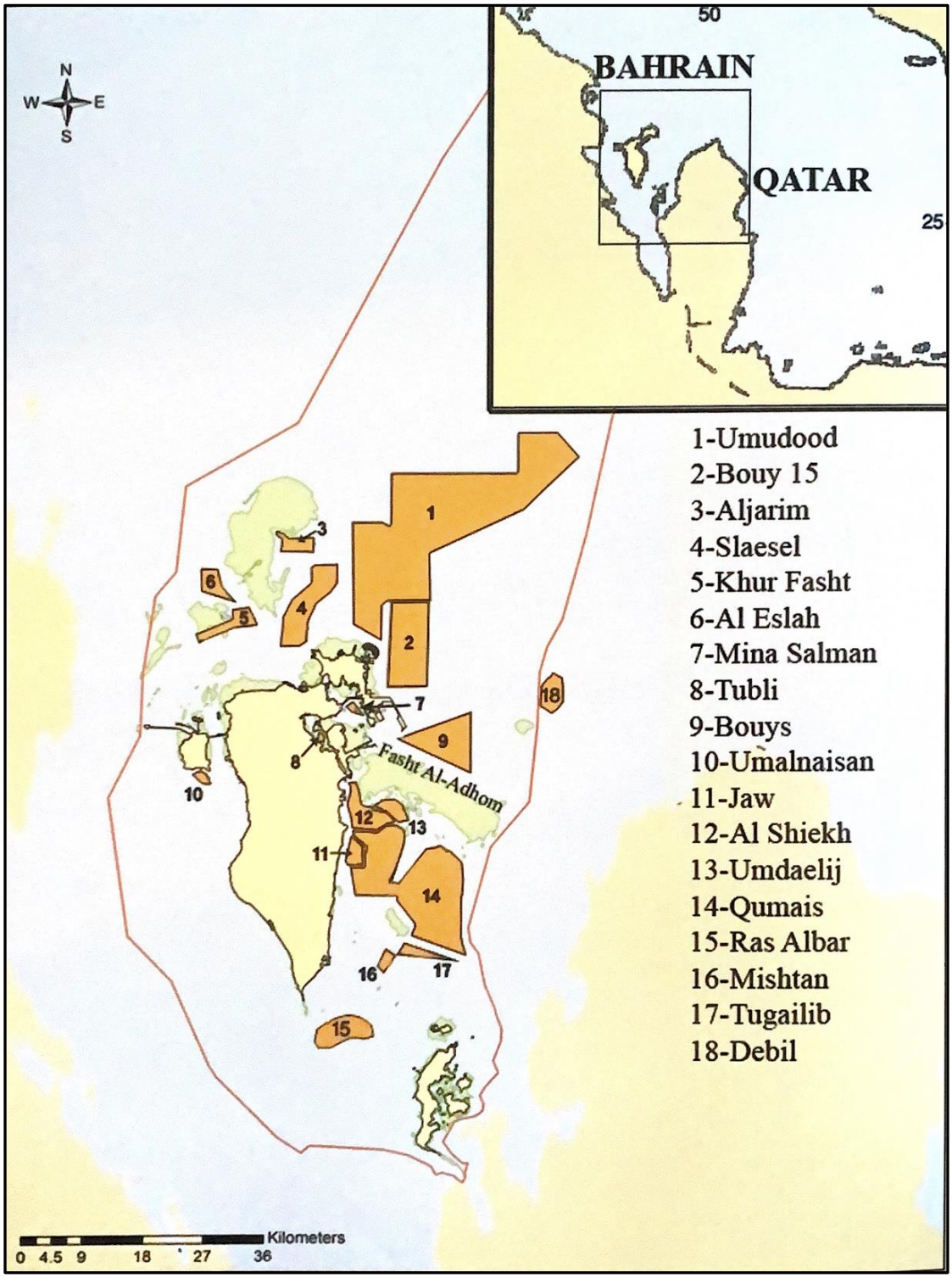


Fig. 4.26: Location of shrimp fishing areas (indicated by number) (Abdulqader, 2010).

- One shrimping season extends for six months from 1 August to 31 January every year.
- The permitted shrimp size to be caught was specified, which is 10cm TL and above.
- The most common shrimp species in the territorial waters with the highest percentage is *Penaeus semisulcatus*, followed by other species in small quantities as indicated by Abdulqader, 1999, 2010 and Carpenter et al., 1997:
  - *Penaeus latisulcatus*
  - *Metapenaeus stebbingi*
  - *Metapenaeus affinis*
  - *Trachypenaeus curvirostris*
  - *Metapenaeopsis stridulans*
  - *Metapenaeus kutchensis*
  - *Metapenaeopsis mogiensis*

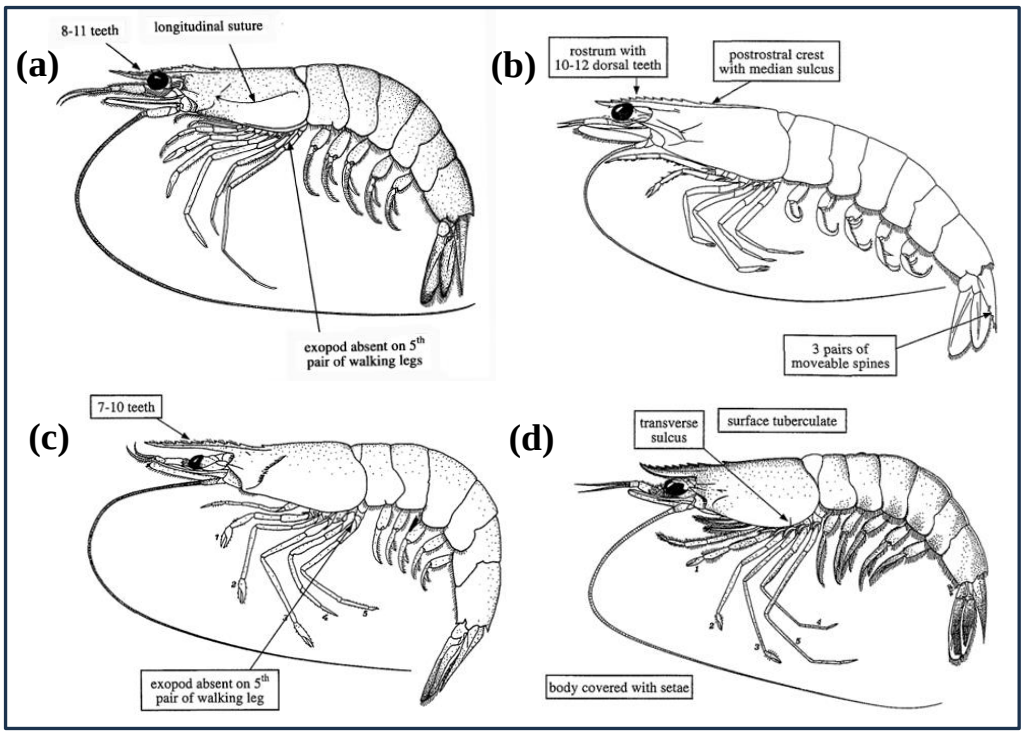


Fig. 4.27: Some of the shrimp species in Bahrain with less marketable value and are of minor importance (a) *Metapenaeus affinis* (b) *Penaeus latisulcatus* (c) *Metapenaeus stebbingi* (d) *Trachypenaeus curvirostris* (Carpenter et al., 1997).

- No resolution has been issued to specify the quantities of shrimp allowed to be caught and the number of boats to be operated and fishing effort to be exerted during the fishing season. Both fishers and decision-makers emphasized that there is no limit on the quantities of shrimp caught in a single fishing trip at a time, as the fishers reported that the catch ranged between 60-240 kg at a single trip. However, during the past ten years, fishers estimated the shrimp catch between 100-120 tons per season, which decreased significantly in the year 2020 to 10-50 tons. Furthermore, the number of shrimping trips undertaken by the fisherman per season was ranged from 140 to 200, depending on the weather.

Principle 11: The ecosystem approach should assume all kinds of relevant information, such as scientific, local knowledge, innovations, and practices.

This principle deals with the information from all sources that are considered critical to achieve effective ecosystem management strategies for penaeid shrimp. Successful shrimp fishery management is a collaborative process that requires a high degree of ongoing communication and participation of all those involved in the management process, particularly the relevant governmental institutions, associations representing fishers, and other interested parties that will be affected by fishery management decisions.

Involving fishers in the gathering, interpreting, and reporting of shrimp fisheries management data is considered an entry point to more comprehensive forms of collaborative management (Trimble & Berkes, 2013). Fishers' involvement in the shrimp fishery management process will reflect the value of their participation as direct recognition by government institutions of the importance fishers' input has in sustainably

managing the fishery. Unfortunately, the fishers did not effectively participate in the management process as 84% of the fishers reported that they are not involved with the relevant government entities in decision-making related to the sustainable shrimp fishery management, which indicates that the management is centralized. There is also a significant difference between the responses of the two samples (decision-makers and fishers), as 71% of the fishers reported that they do not participate in meetings, seminars or workshops on issues related to shrimp fisheries management, while 69% of the decision makers denied this. Additionally, the competent directorates did not benefit from fishers in providing shrimp fisheries statistics and data, which contrasts with Article 36 of Legislative Decree No. 20 of 2002 because no resolution has been issued to specify the needed data that must be collected and organized by the fishers.

Furthermore, developing collaborative partnerships with researchers provides the opportunity to scientifically analyzed the past and present situation and the perspective view for the status in future that may support the decision-makers to manage and overcome the challenges. The responses of most of the decision-makers emphasized the importance of cooperation between research centers in government entities and institutions of higher education. Decision-makers were aware of the need to benefit from scientific and research expertise in higher education institutions to manage shrimp fishery resources sustainably. Decision-makers could encourage fishers to work collaboratively with government institutions and scientists through incentives (such as increased fishing opportunities, economic incentives, and honoring). Costello et al., (2016) showed that economic incentives could benefit fishers and align with the societal interest of sustainably managing fish and shrimp stocks. Lubchenco et al., (2016) reported that behavioral incentives driven by self-image and intrinsic motivation, such as altruism, ethical values, and

reciprocity, can lead individuals to engage in activities that support sustainability because it allows them to derive personal satisfaction.

Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

The complexity of marine ecosystem management for sustained use of shrimp fishery requires integrating the activities and actions of many stakeholders. In this regard, it was noted from surveying:

- The activities of all sectors affect the sustainability of shrimp and can contribute to, or detract from, the achievement of the desired objectives. Thus, it is required to increase communication and cooperation between stakeholders in government institutions, civil society, and the private sector and increase communication with international and regional relevant organizations. Such collaboration exists but needs further improvement. Since there is no action plan to follow up on the achievement of shrimp fisheries initiatives within the strategic plan, as well as appropriate performance indicators and timelines were not identified to measure the progress toward identified goals and objectives, in addition to the lack of clarity of responsibilities and roles of different directorates, sections or sectors concerned with the implementation. Consequently, it will affect the efforts toward achieving and maintaining sustainable fisheries. Furthermore, the lack of fisheries experts in government institutions and inadequately trained employees (based on the NAO annual report for 2015/2016) may constrain communication (NAO, 2016).
- Most decision-makers (88%) are convinced of the necessity and importance of periodic evaluation of shrimp fisheries jointly with fishers according to scientific indicators. However, the obstacle is that the number of foreign fishers exceeds the number of Bahraini fishers,

and the shrimp fishing vessels are sailed without their Bahraini owner or skippers (Nokhatha) on board fishing.

Step B: Characterizing the structure and function of the ecosystem and setting in place mechanisms to manage and monitor it.

The second step of the EBSM includes four principles (2, 5, 6, 10) and is related to the structure and function of the ecosystem. It aims to preserve and manage the ecosystem within the limits of its functioning and to find a balance between preserving ecological diversity and using its components, which requires the application of decentralization in management. The results for step B were presented in Table (4.19) and Fig. 4.27.

Table (4.19): Participants' responses (in percent %) to step B of EBSM.

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Step B						
B-1: Amateur fishing affects shrimp stock.	Decision Makers	43.8	37.5	0.0	18.8	0.0
	Fishers	55.1	22.4	8.2	14.3	0.0
B-2: Unlicensed shrimping affects shrimp stock.	Decision Makers	56.3	37.5	6.3	0.0	0.0
	Fishers	57.1	20.4	18.4	4.1	0.0
B-3: Seafarers and amateur fishers benefit from marine biodiversity in marine reserves	Decision Makers	18.8	50.0	18.8	12.5	0.0
	Fishers	**	**	**	**	**
B-4: Shrimp fishing is carried out in accordance with the laws and regulations.	Decision Makers	0.0	12.5	18.8	37.5	31.3
	Fishers	0.0	34.7	8.2	20.4	34.7
B-5: Fishers are currently using new allowed methods for shrimping.	Decision Makers	**	**	**	**	**
	Fishers	0.0	4.1	6.1	34.7	55.1
B-6: Communication between government entities concerned with marine	Decision Makers	**	**	**	**	**

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
resources and fishers is done through fishers' associations.	Fishers	26.5	16.3	8.2	8.2	40.8
B-7: Fishers or their representatives from the fishers' associations are involved with the relevant government entities in making/issuing resolutions related to the sustainable exploitation of shrimp fisheries.	Decision Makers	6.3	37.5	43.8	6.3	6.3
	Fishers	0.0	6.1	10.2	46.9	36.7
B-8: The government is considered the only authority responsible for managing shrimp fisheries and issuing resolutions to preserve the shrimp stock and its sustainability and exploitation.	Decision Makers	18.8	37.5	12.5	25.0	6.3
	Fishers	46.9	24.5	22.4	2.0	2.0
B-9: There are disagreements and disputes between fishers over shrimping areas.	Decision Makers	18.8	37.5	37.5	6.3	0.0
	Fishers	6.1	6.1	38.8	42.9	6.1
B-10: Climate change contributes to a decrease in the productivity of shrimp fisheries.	Decision Makers	6.3	43.8	18.8	31.3	0.0
	Fishers	**	**	**	**	**
B-11: Some fishers and amateur fishers do not abide by the resolution of shrimping ban period.	Decision Makers	56.3	37.5	6.3	0.0	0.0
	Fishers	67.3	14.3	8.2	0.0	4.1
B-12: Some fishers still use bottom trawl nets (carafe).	Decision Makers	56.3	43.8	0.0	0.0	0.0
	Fishers	59.2	26.5	0.0	12.2	2.0
B-13: Some fishers are still not obliged to implement the regulations and laws related to shrimping in areas where shrimping is prohibited.	Decision Makers	56.3	43.8	0.0	0.0	0.0
	Fishers	51.0	20.4	4.1	22.4	2.0
B-14: Fishers are made aware of the negative effects of unauthorized shrimping.	Decision Makers	18.8	25.0	37.5	12.5	0.0
	Fishers	0.0	2.0	18.4	16.3	63.3

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
B-15: The appropriate means for shrimping as an alternative to bottom trawling nets (carafe) are explained to fishers.	Decision Makers	6.3	31.3	31.3	25.0	0.0
	Fishers	0.0	2.0	8.2	34.7	55.1
B-16: Restoration of Tubli Bay contributes to the recovery of shrimp stock.	Decision Makers	37.5	37.5	18.8	6.3	0.0
	Fishers	**	**	**	**	**
B-17: The preservation of the ecosystems in Fasht Al-Adhom contributes to the enhancement of the supply of shrimp stock.	Decision Makers	37.5	43.8	18.8	0.0	0.0
	Fishers	**	**	**	**	**
B-18: Restoration of mangrove environments contributes to the sustainability of shrimp stock.	Decision Makers	18.8	50.0	25.0	6.3	0.0
	Fishers	**	**	**	**	**

(5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly disagree)
** The question was not asked to the sample

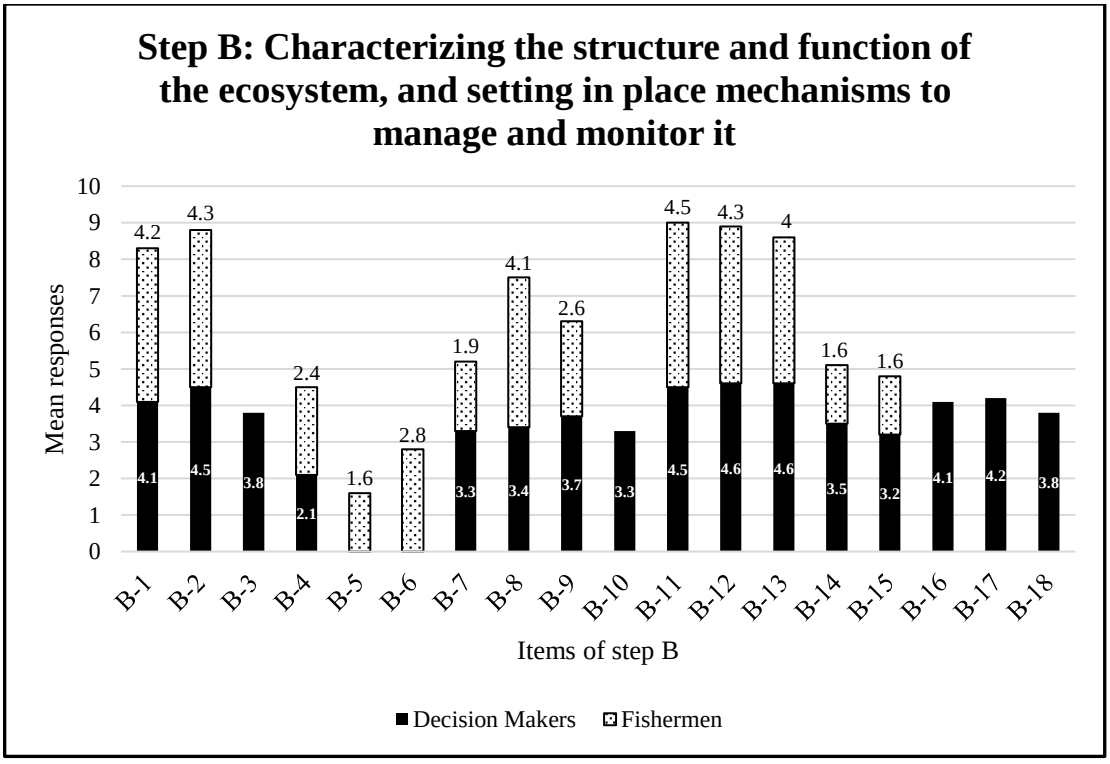


Fig. 4. 28: Mean responses of decision makers and fishers to step B of the EBSM.

Principles related to Step B:

Principle 2: Management should be decentralized to the lowest appropriate level.

This principle focuses on decentralized systems that may lead to greater efficiency, effectiveness, and equity. Accordingly, decisions should be carried out by those who represent the appropriate communities of interest. In contrast, management should be taken up by those with the capacity to implement the decisions. In this regard, it was noted that:

- The multiple communities of interest were identified in step A, and the decisions about shrimp fishery management are subdivided between the community of interest. For example, strategic decisions are taken by the cabinet (the Government Programme of Action 2023-2026, more specifically Initiative 3 (conserve and protect natural resources) in Pillar 3: Infrastructure and the environment) (PMO, 2023), and operational decisions by Agriculture and Marine Resources Agency at the Ministry of Municipalities Affairs & Agriculture. Fishers' associations are considered a link and communication point between government institutions and fishers. Since the decisions are taken at a higher level, this creates an enabling and supportive environment. Thus, the government is working toward achieving an appropriate level of decentralization. Around 56 % of the decision-makers believe that managing shrimp fisheries and issuing resolutions to preserve the shrimp stock and sustain its exploitation is the responsibility of the government alone, and 71 % of the fishers agreed on this as well. Furthermore, around 84% of the fishers reported that they are not involved with the relevant government entities in decision-making related to the sustainable exploitation of shrimp fisheries.

- The Institutional structure for each relevant governmental entity supports and coordinates the decision-making process. When the functions are moved to another level, it is necessary that the body receiving the responsibility has sufficient capacity to fulfill that responsibility (such as resources, systems, and authority) and that any risks arising from the transition can be managed. Thus, capacity-building is necessary to allow decentralization to be in place. Competent government institutions need well-trained employees specializing in fisheries sciences or marine biology.
- According to CBD guidelines, suitable governance arrangements are essential, particularly in clear responsibilities and accountabilities of competent authorities or persons. The proper fishery management is audited by an independent body known as the National Audit Office (NAO). NAO was established by Decree-Law No. (16) issued on the 3rd of July 2002, as amended by Decree-Law No. (49) issued on the 14th of November 2010.

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.

Ecosystem functioning and resilience depend on a dynamic relationship among species and between species and their environment. Therefore, the conservation and restoration of these interactions and processes are of greater importance for the long-term maintenance of biological diversity. In this regard, it was noted that:

- Ecosystem services were discussed in step A, including Seagrass which provides biological importance to shrimp fishery and mangroves that are considered a shelter and feeding ground. These services depend on maintaining and, where appropriate, restoring

particular ecological structures and functions. The seagrass and algal beds of western Arabian Gulf were reported to be nursery habitats for *P. semisulcatus* (Al-Maslamani et al., 2007).

- Several factors affect the shrimp stock in Bahrain. Both fishers and decision-makers agreed that (1) amateur fishing negatively affects shrimp stock, (2) shrimping without a license negatively affects shrimp stock, as well decision-makers thought that climate change has an impact in decreasing the productivity of shrimp fisheries.
- On 1 March 2019, the UN General Assembly (UNGA) declared 2021–2030 the "UN Decade on Ecosystem Restoration" for preventing, halting, and reversing the degradation of ecosystems worldwide (Abhilash, 2021; Dudley et al., 2020; Waltham et al., 2020). It offers crucial opportunities to fight the climate heating crisis, enhance food security, provide clean water, and protect biological diversity (Waltham et al., 2020). From decision makers' views, the following coastal habitats are proposed to start restoring degraded ecosystems:
  1. Seagrass areas on the east coast, which is heavily degraded.
  2. Mangroves in Tubli Bay.
  3. Coral reefs, particularly Fasht Al-Adhom, Fasht Al-Jarim, Khur Fasht and the coral reefs on the northern coasts.
  4. Mashtan area.
  5. Territorial sea surrounding Hawar Islands, Al-Sahaylah Island, Nurana Island and Qit'at Jaradah.
  6. Coasts of Sitra and Zallaq.

Based on the Ecological Value Index (EVI), which provides an effective decision support tool for assessing and reporting the relative ecological significance of environmental areas in geographical space

(GEOMATEC, 2006), the following areas are identified as being ecologically most important (Fig. 4.28):

- Hayr Bulthama
- Hayr Shtaya
- Fasht Al-Jarim
- Fasht Al-Adhom
- Areas south of Fasht Al-Adhom to Hawar island.

The importance of these areas is associated with the diversity of their habitats, the fisheries production, and their significance as feeding areas for endangered species and sea birds (Loughland & Zainal, 2009).

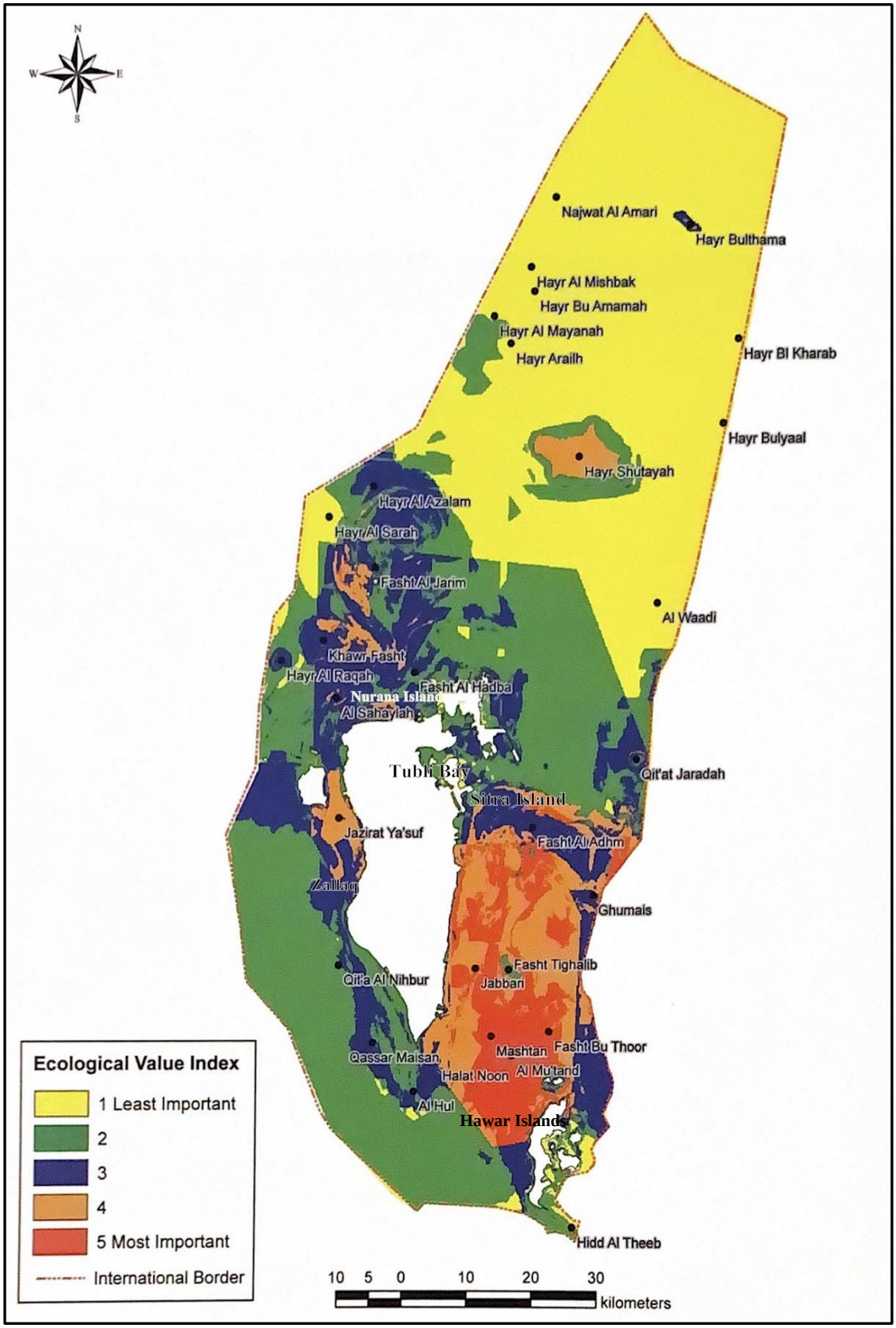


Fig. 4. 29: Ecological Value Index (EVI) map generated for the territorial waters of Bahrain (GEOMATEC, 2006).

Principle 6: Ecosystems must be managed within the limits of their functioning.

There are limits to the level of demand that can be placed on the seagrass ecosystem while maintaining its integrity and capacity to continue providing the benefits and services that provide the basis for the human wellbeing and sustainability of shrimp fisheries. In this regard, it was noted that:

- The results of the questionnaire for this principle showed a consensus between the answers of the fishers and decision-makers, as most of them believed that some fishers still practice fishing without considering the legislation and laws that regulate shrimp fishing (69% of the decision-makers and 55% of the fishers agreed). Also, all the decision-makers and most of the fisher's sample (71%) unanimously agreed that some fishers did not comply with the regulations and laws related to shrimping in areas where shrimp fishing is prohibited.
- Most of the fishers (90%) agreed that they are not currently using new methods for shrimp fishing, which indicates that they are still using bottom trawling for shrimp.
- There is broad agreement between fishers and decision-makers indicating that professional fishers and amateur fishers violate the decision of the shrimping ban period.
- Both fishers and decision-makers agreed that the most common method of shrimp fishing is the bottom trawling, which is prohibited by the Ministerial Resolution No. 205 of 2018. The fishers justified using bottom trawl nets because it is the appropriate means for catching shrimp, and the Hadhrah is unsuitable for shrimping.

Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

Shrimp habitats play a vital role in providing benefits and services on which humans ultimately depend. In this regard, it was noted that:

- Policy, legal, institutional, and economic measures were developed to enable the sustainability of shrimp resources; for example, several decisions have been issued to regulate fishing machinery, equipment, methods, conditions, procedures, licensing, and closed season.
- Sustainable use and management depend on participatory integrated planning, ensuring that the use or delivery of ecosystem benefits and services are optimized to meet human requirements and ensure environmental quality. The MUN issues decisions on protecting and developing shrimp fisheries involving punishment on violator fishers. For instance, the Maritime Control Directorate is responsible for renewing fishing licenses and monitoring and observing shrimp fisheries in collaboration with the Fisheries Directorate and the Coast Guard Directorate.
- Most decision-makers stated that professional fishers, seafarers, and amateur fishers benefit from marine biodiversity in marine reserves.

Step C: Identifying the important economic issues that will affect the ecosystem and its inhabitants.

The third step includes one principle (principle 4) of the EBSM. The results for step C were presented in Table (4.20) and Fig. 4.29.

Table (4.20): Participants' responses (in percent %) to step C of EBSM.

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Step C						
C-1: There is currently an increase in the demand for shrimp.	Decision Makers	37.5	56.3	6.3	0.0	0.0
	Fishers	71.4	26.5	2.0	0.0	0.0
C-2: About 30% of the caught shrimp are exported outside Bahrain.	Decision Makers	0.0	18.8	31.3	37.5	12.5
	Fishers	4.1	26.5	30.6	26.5	12.2
C-3: Shrimping is costly because the shrimping site is far away.	Decision Makers	6.3	25.0	37.5	31.3	0.0
	Fishers	36.7	38.8	16.3	8.2	0.0
C-4: Shrimping costs are relatively high due to the high fuel prices.	Decision Makers	6.3	37.5	31.3	12.5	12.5
	Fishers	85.7	10.2	2.0	2.0	0.0
C-5: The cost of shrimping is relatively high due to the long time it takes to catch them.	Decision Makers	0.0	25.0	37.5	37.5	0.0
	Fishers	55.1	32.7	6.1	6.1	0.0
C-6: Shrimp prices are rising due to the lack of supply and increased demand.	Decision Makers	18.8	43.8	18.8	6.3	6.3
	Fishers	51.0	38.8	4.1	2.0	2.0
C-7: Increased monitoring vessels help fishers comply with shrimp fisheries management laws and legislations.	Decision Makers	43.8	50.0	6.3	0.0	0.0
	Fishers	28.6	22.4	14.3	18.4	16.3
C-8: Affordable services are provided to fishers to encourage them to comply with shrimping regulations.	Decision Makers	6.3	25.0	50.0	12.5	0.0
	Fishers	6.1	4.1	26.5	44.9	18.4
C-9: There is a need for shrimp farming in the Kingdom of Bahrain.	Decision Makers	56.3	18.8	6.3	12.5	0.0
	Fishers	2.0	0.0	10.2	44.9	42.9

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
C-10: An economic evaluation of shrimp fisheries is carried out periodically.	Decision Makers	6.3	18.8	37.5	18.8	12.5
	Fishers	**	**	**	**	**
C-11: The cost of the environmental damage caused by shrimping using bottom trawling nets (carafe) has been estimated.	Decision Makers	6.3	12.5	56.3	18.8	0.0
	Fishers	**	**	**	**	**
C-12: Control programs are in place to prevent violations in shrimp fisheries.	Decision Makers	6.3	68.8	18.8	0.0	6.3
	Fishers	0.0	6.1	6.1	30.6	57.1
C-13: The quantity of shrimp was affected during the Covid-19 pandemic.	Decision Makers	0.0	6.3	37.5	25.0	25.0
	Fishers	51.0	10.2	2.0	26.5	6.1
C-14: The shrimping effort (number of days and hours) significantly decreased during the Covid-19 pandemic.	Decision Makers	0.0	18.8	50.0	0.0	25.0
	Fishers	20.4	28.6	8.2	34.7	6.1
C-15: The number of fishers working on a shrimping boat has been reduced (exceptionally) during the Covid-19 pandemic	Decision Makers	0.0	12.5	37.5	12.5	31.3
	Fishers	14.3	30.6	12.2	34.7	6.1
C-16: Shrimp prices increased during the Covid-19 pandemic due to the lack of shrimping activities	Decision Makers	0.0	31.3	31.3	12.5	18.8
	Fishers	30.6	16.3	8.2	36.7	6.1
C-17: Some fishers were recorded as affected by Covid-19.	Decision Makers	6.3	18.8	62.5	6.3	0.0
	Fishers	6.1	30.6	26.5	32.7	2.0
C-18: Some fishers were recorded among the death cases of Covid-19.	Decision Makers	6.3	18.8	62.5	6.3	0.0
	Fishers	6.1	22.4	26.5	34.7	2.0
C-19: The shrimping sector has applied the preventive and precautionary measures issued by the National Taskforce for Combating the Coronavirus and the concerned authorities while shrimping.	Decision Makers	6.3	25.0	56.3	6.3	0.0
	Fishers	4.1	28.6	32.7	32.7	2.0

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
C-20: The concerned authorities conduct field inspection visits to ensure the precautionary measures to combat Covid-19 are followed.	Decision Makers	6.3	18.8	50.0	6.3	12.5
	Fishers	8.2	8.2	38.8	38.8	2.0
C-21: The living conditions of fishers have been affected during the Covid-19 pandemic.	Decision Makers	6.3	43.8	31.3	12.5	6.3
	Fishers	53.1	26.5	8.2	10.2	2.0

(5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly disagree)
** The question was not asked to the sample

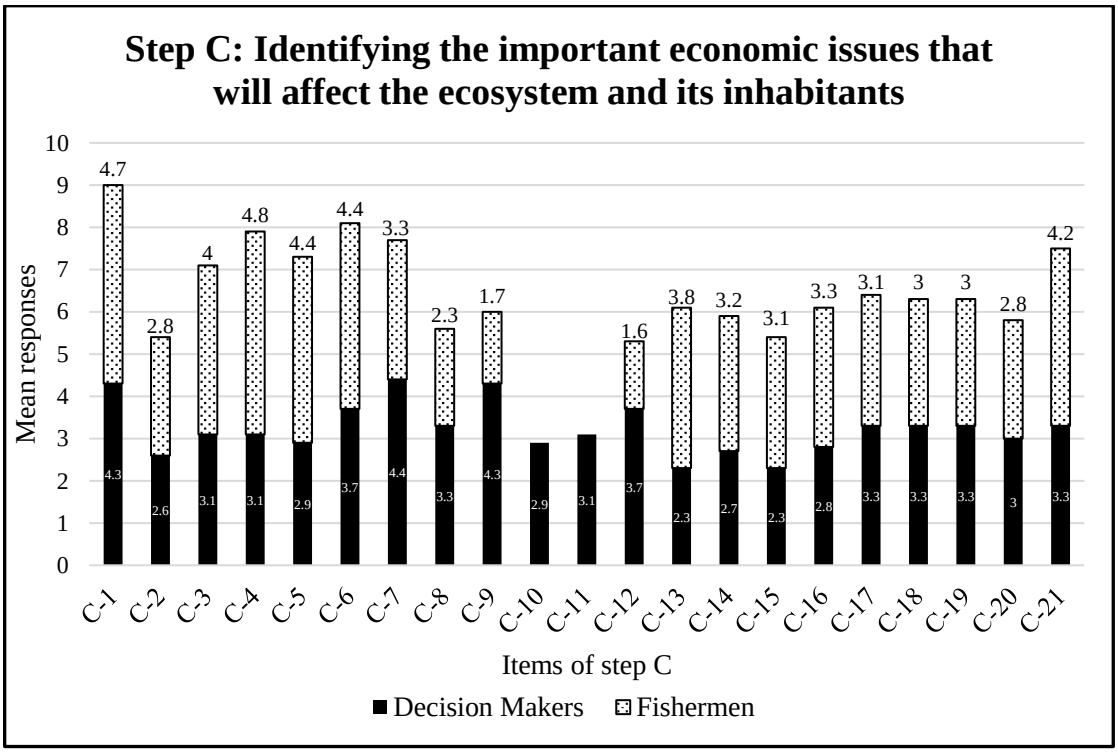


Fig. 4. 30: Mean responses of decision makers and fishers to step C of the EBSM.

Principles related to Step C:

Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management program should:

I. Reduce those market distortions that adversely affect biological diversity.
II. Align incentives to promote biodiversity conservation and sustainable use.
III. Internalize costs and benefits in the given ecosystem to the extent feasible.

Bahrain's seagrass ecosystem provides economically valuable services; therefore, it is necessary to be managed in an economic context. In this regard, it was noted that:

- Most fishers (86%) are not interested in protecting and preserving seagrass ecosystems and other habitats (e.g., mangrove and coral reefs) that play a multi-functional role in human wellbeing. Human activities increasingly threaten the benefits that humans derive from ecosystems through the following:
  - Bottom trawling is still being practiced despite being prohibited in Bahrain since 2018 as indicated by violations registered at the Maritime Control Directorate.
  - Fishers are still practicing shrimp fishing activities during the closed season and in marine protected areas or prohibited areas.
  - Illegal fishing and non-compliance with regulations.

  These illegal catches may adversely impact shrimp populations and ecosystems at which these populations are associated causing unsustainability in terms of economic, environmental, and social aspects.
- The Maritime Control Directorate has developed a monitoring system to control shrimp fishing violations. It is carried out in coordination with the Coast Guard Directorate due to the presence of an integrated radar system. In addition, some employees of the Maritime Control Directorate and Fisheries Directorate have the capacity of a judicial

officer to record fisheries violations and to take the necessary actions by transferring all evidence related to the violations to the public prosecution. Whoever does not comply with shrimp fisheries rules and regulations shall be punished by imprisonment, fine, or both. The criminal justice fines could be used to restore the damaged ecosystems. However, in the questionnaire results analysis, both fishers and decision-makers agreed that there is a need to increase monitoring vessels to urge fishers to comply with the shrimp fisheries management laws and regulations. On the other hand, 63% of the fishers denied providing affordable services to them to encourage them to comply with shrimping regulations. In comparison, 31% of the decision-makers stated that such services are provided. However, half of the sample of decision-makers did not approve or deny the provision of these services.

- Fishers strive to maximize the catch to make the most profit, even using illegal fishing methods and destructive practices with no attention to the marine ecosystem deterioration, as their main objective is to maximize their target catch.
- Regarding the economic evaluation of shrimp fishery, 31 % of the decision-makers determined that it is not carried out regularly, whereas 38% of the sample have not approved or denied this. Additionally, 19% of the decision makers affirmed that the cost of the environmental damage caused by shrimping using bottom trawl nets is being estimated, however, 56% were neutral.
- The responses of the fishers and decision-makers reflected a broad agreement that there was an increase in the demand for shrimp, resulting in increased prices due to the low supply.
- Regarding shrimp farming in Bahrain, the attitudes of the two samples varied greatly, as 88% of the fishers disagreed, while 75% of the

decision-makers agreed. The opportunity of farmed shrimps will compensate the lack of shrimps in fish market during the closed season. Currently, shrimps were imported from Saudi Arabia shrimp farms during the closed season, which partially compensate the local shrimp.

- Decision makers and fishers had different attitudes towards the causes around shrimping operations costs, as 76% of the fishers believe that the cost of shrimping has become high due to the remoteness of the shrimping site. In contrast, the two samples agreed that the cost of shrimping has increased due to the increase in fuel prices. However, the views of both fishers and decision-makers towards the high cost of shrimping due to the time it takes to capture shrimp differed again (88% of the fishers agreed, while 75% of decision-makers disagreed).
- The views of both fishers and decision-makers towards the aid provided by the government to fishers were similar. However, the decision-makers suggested that, currently, shrimp fishers are not distinguished with special aid due to the cancellation of shrimping licenses. These aids include:
    1. Free parking at the harbors.
    2. Providing soft loans by Bahrain Development Bank to fishers depending on their needs (buying a boat, engines, etc.), which may reach an amount of BD 15,000.
    3. Governmental offer to purchase shrimp fishers' assets from fishing boats for those who wished to do so or convert shrimping licenses to fishing licenses (licenses to capture fish only) and buy their trawl equipment.
    4. Supporting fishers through Fisheries Directorate in repairing ships and engines.

- Concerning the impact of the Covid-19 pandemic on the shrimping sector, the two samples agreed that the pandemic did not affect fishing periods and shrimp prices. However, both agreed that the pandemic had affected the captured shrimp quantity, the number of shrimping boats, and fishers.
- The responses of the fishers and decision makers were of a similar view regarding the proposed procedures and measures to protect and enhance shrimp stock, such as setting awareness programs for fishers, increasing control over shrimping operations, strict accountability for violators, tightening penalties for violators, limiting the number of boats, and organizing amateur fishing by granting them licenses. In addition, the decision-makers added proposals for other measures to regulate the shrimping process and protect marine resources, including shrimp farming, implementing Decision No. 1 of 2003 regarding the presence of a Bahraini skipper (Nokhatha) on the board of the boats, reducing the number of foreign workers, and studying suitable alternatives to bottom trawl nets. Table (4.21) reveals the suggested procedures and measures for ensuring sustainable shrimp fishery management.

Table (4.21): Decision makers and fishers' suggestions to ensure sustainable management of the shrimp fishery.

Item	**Decision makers' suggestions**	**Fishers' suggestions**
1. Fishing violations	- Tightening the financial penalty for violators (because the current penalties, especially financial ones, were approved in 2002, the amount in 2002 was a deterrent, but now this amount is no longer a deterrent).	Tightening the financial penalty for breaking fishing regulations and rules.

Item	Decision makers' suggestions	Fishers' suggestions
	- A strict application of the law on violators.	
2. Monitoring, control, and surveillance function	Increasing maritime control patrols.	Increasing maritime monitoring patrols.
3. Fishing licenses	- Reducing the number of licenses and fishers. - Reducing the number of boats to no more than 50 while adhering to the fishing regulations and requirements.	- Restoring the license to professional shrimp fishers and tightening control over them. - Reducing the number of licenses so that each fisher is given one license to contribute to reducing the fishing effort. - Reducing the number of boats.
4. Awareness, education and research	- Raising awareness of fishers about sustainable fishing techniques and practices and the harmful effects of illegal fishing - Develop awareness programs for fishers. - Preparing a study concerned with the following: 1. Suggest alternatives to Bahraini shrimp (in terms of abundance and size), such as importing from abroad and providing them in the markets for consumers at prices lower than local shrimp. 2. Suggest a method for catching shrimp that is environmentally friendly and, at the same time, feasible. 3. The number of licenses allowed for the sustainability of shrimp fisheries. 4. Preparing biological studies for fish and shrimp.	Awareness campaigns for fishers.
5. Skipper and crew	Enabling a Bahraini skipper (Nokhatha) on every fishing boat and reducing the number of foreign workers.	
6. Fishing gear for shrimp	Studying suitable alternatives to bottom trawl nets.	Setting controls for net sizes, engine power, and reducing the weight of the net door by no more than 75 kg.

Item	Decision makers' suggestions	Fishers' suggestions
7. Amateur fishing	Organizing fishing for amateur fishers so that they are given a license and are controlled according to terms and conditions.	Regulating amateur fishing
8. Shrimp fishing season	- Studying the possibility of reducing the duration of the shrimping ban in a way that does not conflict with the start of shrimp mating, incubation period, and egg laying. - Specify a season for shrimping not to exceed (30 days) and specify the shrimp quantities for each fisher. - Determining the fishing seasons for all types of fish.	Reducing the shrimping ban period to 4 months.
9. Development projects	Suspending dredging activities in shrimp areas.	Suspension of dredging and reclamation activities in shrimp areas.
10. Reporting	Engaging fishers to document the fishing quantities through self-report and providing the concerned authorities with such a report to include it in the annual statistics on fishing quantities.	
11. public–private partnership	Restricting shrimping to public legal companies or privatizing them with the participation of the private sector under standards, conditions, and legal control to preserve marine resources, especially shrimp, and to regulate the trading and provision of shrimp in local markets through agents licensed in the kingdom, which ensures the process of trading, selling, and exporting them legally.	
12. Cooperation	- Increasing coordination between the Maritime Control Directorate and the Coast Guard Directorate in monitoring and detecting violations.	

Item	Decision makers' suggestions	Fishers' suggestions
	- Consulting Fishers when adopting any law, resolution, or procedure. - Cooperating with some GCC countries, such as the Sultanate of Oman, to benefit from their experience in shrimping methods. - Developing a joint strategy for the GCC countries related to shared shrimp stock.	
13. International agreement	Signing the IUU Fishing Agreement (illegal, unreported, and unregulated fishing).	
14. Bycatch	Establishing a system to get rid of damaged and small fish so that they are reported and are not thrown into the sea.	
15. Investment	Shrimp aquaculture	

Step D: Determining the likely impact of the ecosystem on adjacent ecosystems

The fourth step of the EBSM includes two principles (3 and 7) and is related to the adaptive management over space and aims to determine the potential impacts of the target ecosystem on neighboring ecosystems. The results for step D were presented in Table (4.22) and Fig. 4.30.

Table (4.22): Participants' responses (in percent %) to step D of EBSM.

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Step D						
D-1: The resolution to ban shrimping by bottom trawling nets (carafe) helps increase the fish supply.	Decision Makers	25.0	50.0	12.5	6.3	6.3
	Fishers	10.2	4.1	6.1	14.3	61.2
D-2: Some fishers practice shrimping outside the territorial waters of the Kingdom of Bahrain.	Decision Makers	18.8	56.3	12.5	6.3	6.3
	Fishers	8.2	36.7	18.4	30.6	4.1

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
D-3: Some fishers from neighboring countries are shrimping in the territorial waters of the Kingdom of Bahrain.	Decision Makers	6.3	43.8	31.3	6.3	6.3
	Fishers	32.7	16.3	12.2	36.7	2.0
D-4: The specifications of the permitted shrimping method are considered appropriate.	Decision Makers	0.0	31.3	25.0	37.5	6.3
	Fishers	8.2	18.4	4.1	26.5	40.8
D-5: Selective shrimping nets are used to separate shrimping from other marine organisms (bycatch) during shrimping activities.	Decision Makers	0.0	18.8	37.5	31.3	12.5
	Fishers	0.0	12.2	20.4	40.8	24.5
D-6: Human activities such as dredging and reclamation on the coasts affect shrimp fisheries and stock.	Decision Makers	68.8	31.3	0.0	0.0	0.0
	Fishers	71.4	16.3	2.0	8.2	2.0
D-7: Pollution of coastal environments contributes to the decrease in shrimp stock.	Decision Makers	43.8	43.8	6.3	6.3	0.0
	Fishers	61.2	16.3	10.2	6.1	2.0
D-8: There are damaged and neglected nets in shrimping areas.	Decision Makers	37.5	62.5	0.0	0.0	0.0
	Fishers	4.1	4.1	44.9	40.8	4.1
D-9: Unauthorized shrimping practices affect seagrass and coral reef environments near shrimping areas.	Decision Makers	75.0	25.0	0.0	0.0	0.0
	Fishers	59.2	16.3	12.2	10.2	0.0
D-10: Cases of turtles getting caught in shrimping nets have been reported.	Decision Makers	43.8	31.3	12.5	12.5	0.0
	Fishers	12.2	10.2	8.2	26.5	42.9
D-11: Cases of dolphins getting caught in shrimping nets have been reported.	Decision Makers	18.8	25.0	50.0	6.3	0.0
	Fishers	2.0	10.2	12.2	24.5	49.0
D-12: Cases of dugongs getting caught in shrimping nets have been reported.	Decision Makers	18.8	18.8	56.3	6.3	0.0
	Fishers	2.0	2.0	14.3	30.6	49.0
D-13: The environmental impact	Decision Makers	12.5	31.3	37.5	12.5	6.3

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
of coastal and marine development projects on shrimp fisheries is being evaluated.	Fishers	**	**	**	**	**

(5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly disagree)
** The question was not asked to the sample

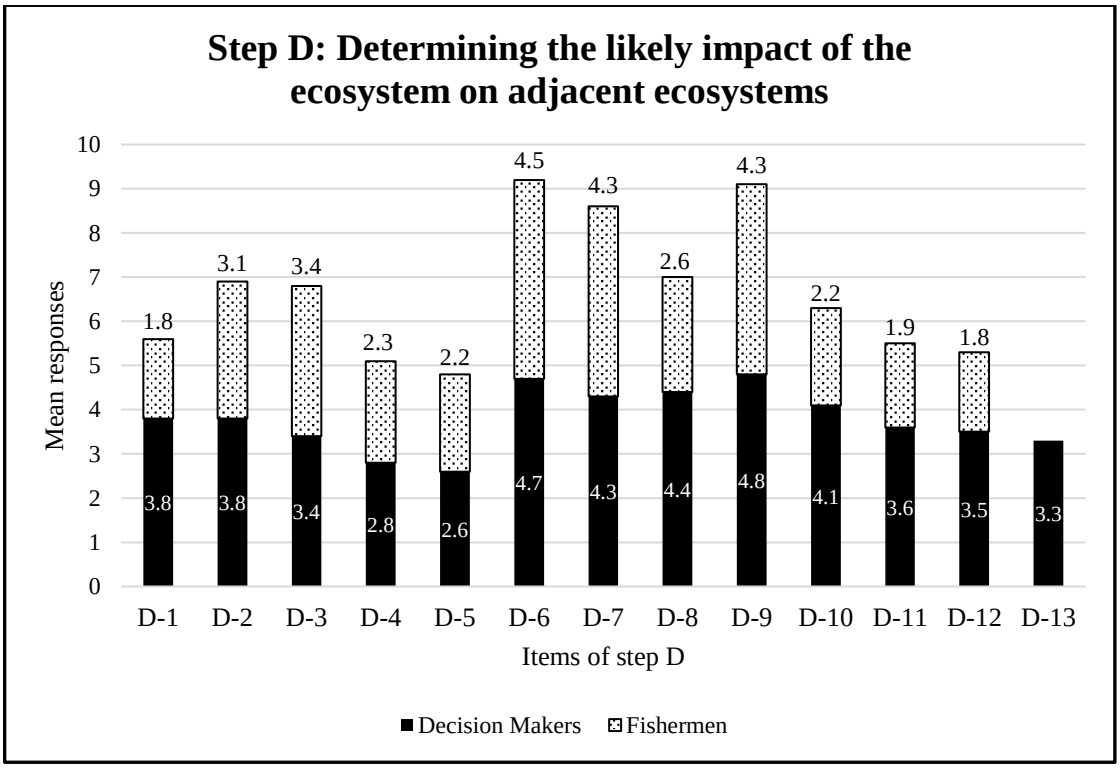


Fig. 4. 31: Mean responses of decision makers and fishers to step D of the EBSM.

Principles related to Step D:

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

Ecosystems are open systems connected to other ecosystems that affect each other. In this regard, it was noted that:

- The shrimp fishing activity is affected by the activities of the surrounding environments. For example, some fishers still use bottom trawl nets despite their negative effect. The bottom trawling activity often leads to overfishing because the gear is not selective, and many

economically important marine organisms are unintentionally caught during towing the net on the sea floor. For example, both decision-makers and fishers reported that turtles, dolphins, Rabbitfish *Siganus canaliculatus* (Saffy), Spangled Emperor *Lethrinus nebulosus* (Sha'ree), and other small fish, crabs, cuttlefish, and dugongs (very rare) are getting caught accidentally by trawling nets. Moreover, the analysis of the result showed that 67% of the fishers and 44% of the decision-makers agree that the specifications of the current permitted shrimping method are not appropriate.

- Most fishers (76%) and all the decision-makers believed that illegal shrimp fishing affects the seagrass and coral reefs near shrimping areas. Coral reefs, seagrasses, and other benthic habitats are especially vulnerable to disturbance by bottom trawling and can be extremely slow to recover (Stiles et al., 2010).
- Furthermore, both fishers and decision-makers agreed that some fishers practice shrimping outside the territorial waters of the Kingdom of Bahrain at fairly high rates (75% of the decision-makers, 45% of fishers). Both samples also agreed that some fishers from neighboring countries practice shrimping in the Bahraini territorial waters, which indicates the presence of violations by some fishers regarding that matter.
- An apparent discrepancy was observed between the responses of fishers and decision-makers; where 75% of the decision-makers believe that the decision to ban bottom trawling contributes to increase the supply of fish, and 76% of fishers believe that it does not. This is a logical contrast to the conflict of interests between the two samples.

Principle 7: The ecosystem approach should be undertaken at the appropriate **spatial** and temporal scales. In this regard, it was noted that:

- Most fishers (88%) agreed with the whole sample of decision-makers that human activities such as dredging, and reclamation projects negatively impact shrimp fisheries and their stock. The dredging activities negatively affect marine ecosystems, especially in turbidity-sensitive habitats such as coral reefs and seagrasses (Fisher et al., 2015). Additionally, most respondents of both samples also agreed that the pollution of coastal environments contributes to the decrease in shrimp stock. In addition, throwing damaged nets or other marine debris can seriously damage marine habitats and living organisms.
- An environmental impact assessment needs to be conducted for developments that may have substantial environmental impacts considering all the components of biological diversity and the potential threats to the ecosystem. The results revealed that 44% of the decision-makers indicated that the environmental impact of coastal and marine development projects on shrimp fisheries is being assessed, while 19% of them denied, and 37% did not provide an answer.

Step E: Deciding on long-term goals, and flexible ways of reaching them

The last step of EBSM aims to define long-term objectives and flexible management methods, identify solutions to the problems faced by the ecosystem, and find solutions that preserve the system through monitoring, licensing, and enforcement of sanctions. It includes three principles (7, 8, 9). The results for step E were presented in Table (4.23) and Fig. 4.31.

Table (4.23): Participants' responses (in percent %) to step E of EBSM.

Item	Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Step E						
E-1: It is necessary to reduce the number of shrimping boats by which shrimping effort lessens.	Decision Makers	31.3	62.5	6.3	0.0	0.0
	Fishers	46.9	18.4	6.1	18.4	10.2
E-2: There is a need to reduce the number of fishers working on a shrimping boat.	Decision Makers	12.5	43.8	18.8	18.8	6.3
	Fishers	38.8	16.3	14.3	20.4	10.2
E-3: Extending the shrimping ban for six months contributes to the growth of shrimp stock.	Decision Makers	43.8	37.5	6.3	12.5	0.0
	Fishers	24.5	18.4	20.4	22.4	14.3
E-4: The shrimping ban period is usually announced to fishers within an appropriate time.	Decision Makers	**	**	**	**	**
	Fishers	6.1	44.9	22.4	16.3	8.2
E-5: Workshops are arranged to educate fishers and amateur fishers about the approved legislation.	Decision Makers	18.8	12.5	43.8	12.5	6.3
	Fishers	0.0	12.2	8.2	28.6	51.0
E-6: Workshops are arranged for fishers before the start of the shrimping season to educate them about the permitted shrimping practices.	Decision Makers	12.5	18.8	43.8	12.5	6.3
	Fishers	0.0	2.0	8.2	32.7	57.1
E-7: The authorities concerned with marine resources inform the fishers of the shrimping season annually.	Decision Makers	56.3	37.5	6.3	0.0	0.0
	Fishers	28.6	18.4	4.1	12.2	36.7
E-8: The policies and resolutions to ensure the sustainability of shrimp resources are effective and achieve the desired purpose.	Decision Makers	0.0	25.0	43.8	25.0	0.0
	Fishers	**	**	**	**	**
E-9: Penalties against violators of shrimping laws are strictly enforced.	Decision Makers	6.3	50.0	31.3	12.5	0.0
	Fishers	14.3	6.1	4.1	36.7	38.8
E-10: Unifying the shrimping ban period in the GCC states contributes to improving the shrimp stock.	Decision Makers	31.3	50.0	18.8	0.0	0.0
	Fishers	**	**	**	**	**

(5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly disagree)

** The question was not asked to the sample

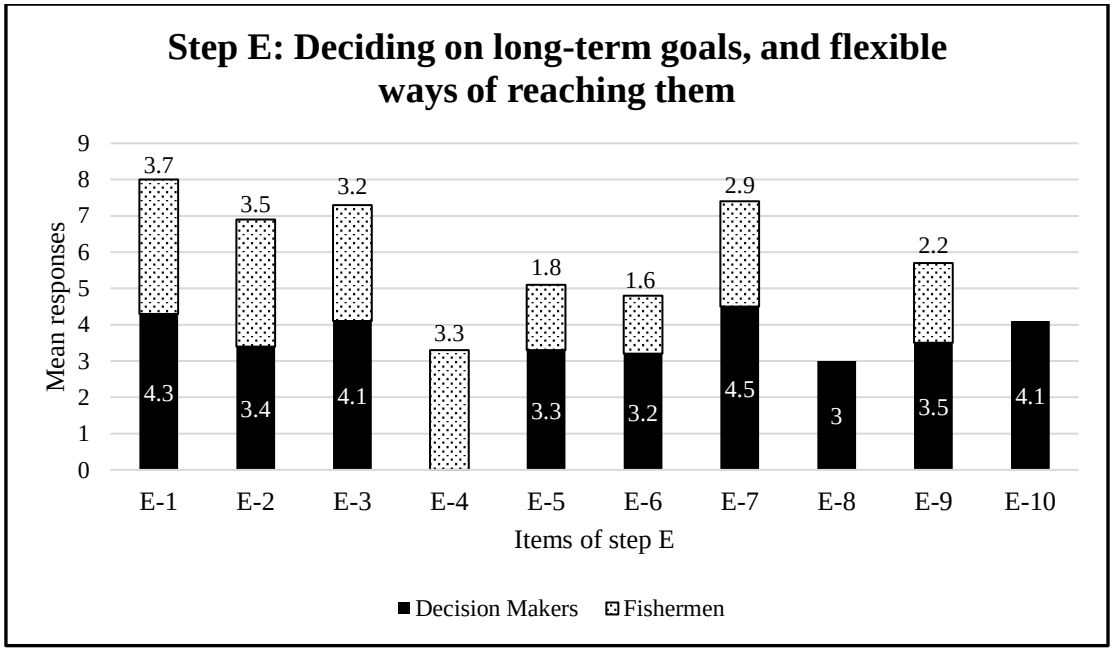


Fig. 4. 32: Mean responses of decision makers and fishers to step E of the EBSM.

Principles related to Step E:

Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and **temporal** scales.

Adaptive management over time requires the capacity to diagnose the reasons for a problem, understand the root causes of a problem, and obtain a solution, drawing on all the other EBSM principles to understand what is going wrong and how to design new responses to reach goal.

Overfishing can impact the balance of the ecosystem (Shakouri et al., 2010). Overfishing causes significant changes in species composition and functional loss of key species and can result in long-term community changes (Sumaila & Tai, 2020; Murawski, 2000). In this regard, it was noted that:

- CPUE fluctuated significantly over time for annual catch per boat. CPUE declined to levels as low as 3 tons/boat in 2004-2005 due to the increased number of shrimping boats. The most negligible value of

CPUE was observed in 2019 and 2020, which could be related to resolution No. 205 for the year 2018 prohibiting shrimp trawling.

- The fluctuation of CPUE affects the stability of shrimp prices. The fishers are forced to raise the shrimp price due to catch decrease.
- Both fishers (43%) and decision-makers (81%) consider that extending the ban period for six months contributes to restore the shrimp stock. Moreover, both decision makers (94%) and fishers (65%) believe that reducing the number of shrimping boats is necessary to reduce the shrimping effort. In addition, the two samples also agreed on the need to reduce the number of fishers working on shrimping boats.

Principle 8: Recognizing the varying temporal scales and lag effects that characterize ecosystem processes, objectives for ecosystem management should be set for a long term.

Time scale needs to be considered clearly in formulating shrimp management plans. A good management plan requires excellent monitoring methods so that indications of potential problems are spotted early. It also needs collaborative stakeholders who act with consistency and integrity to discuss fishing. In this regard, it was noted that:

- The fishers affirmed that the shrimping ban period was announced at an appropriate time to inform fishers. In addition, 94% of the decision-makers confirmed that fishers are being informed on the shrimping season (date of opening and closing) annually.
- The results demonstrate the fishers' opinions about the optimal period for shrimping. Most of the fishers reported that the best period for shrimping extends from July to February due to the shrimp's maturity and availability in large quantities. In addition, some fishers clarified that the best shrimping season is Albareh, which falls during the first

three weeks of July. However, July is among the six months of closed season. Additionally, most fishers believe that the period from March to June is the appropriate period to ban shrimping because it is the incubation and breeding period of shrimp, and the size of shrimp is small during that period. In the Saudi waters of the Arabian Gulf, it was found that the abundant occurrence of *P. semisulcatus* juveniles in the bycatches within the shallower part of Safaniya embayment (nursery ground for *P. semisulcatus* juveniles) indicated that the ban period which extends over a period of six months (February to July) is not enough to provide full protection to *P. semisulcatus* juveniles (Abdulqader et al., 2020; Rabaoui et al., 2017). A similar observation was made in Bahrain, where *P. semisulcatus* juveniles were found during the first few months of the trawling season in the shallow coastal grounds and an abundance of larger individuals of *P. semisulcatus* from October to December (Abdulqader, 1999). The main recruitment period for *P. semisulcatus* in Bahraini waters was determined to be from April to July (Abdulqader & Naylor, 1995). These dates are consistent with the spawning period for *P. semisulcutus* from December to March (Muhammad, 1978). Abdulqader (1999) observed two periods of high abundance of *P. semisulcatus*; the first one extended from February to June, with the major abundance occurring from April to June, and the second period was from October to December. From February to April, *P. semisulcatus* are migrated to spawn (Abdulqader & Naylor, 1995).

- The decision-makers indicated that there are no plans to manage the shrimp incubation or hatchery areas or to manage the shrimping areas.

Principle 9: Management must recognize that change is inevitable.

Change in ecosystems is an inevitable natural change; therefore, management objectives should be flexible and adaptive. In this regard, it was noted that:

- There is a monitoring system for shrimp fisheries to protect the area, prevent violations, and arrest violators. However, some elements need to be clearly defined in the management of fisheries, for example, the allocated quantity of shrimp catch, number of shrimping trips, number of days and hours of shrimp fishing, and the appropriate means for shrimping as an alternative to bottom trawl nets.
- No study has addressed the issue of shared stocks between GCC countries for their optimal shrimp fisheries management. The difficulties in establishing such management may relate to the need for more knowledge about stock in some GCC countries. Therefore, fish and shrimp stock assessment process in the Kingdom of Bahrain is necessary. Most decision-makers (81%) supported the unification of the shrimping ban period among the GCC countries because it contributed to the development of shrimp stock around the region.
- Awareness-raising measures are essential to enhance public knowledge about marine ecosystems and build support and adaptive management capacity. However, the study found that 80% of the fishers confirmed that they are not involved in awareness workshops on the approved legislation nor awareness workshops on permitted shrimping practices before the start of the shrimping season, nor being educated about harmful effects of unauthorized shrimping.
- Capacity-building activities and continuous learning programs are needed to strengthen the governmental infrastructure and the skills and abilities of the employees, especially in the fisheries field. Therefore, coupling knowledge with practices will help better detect and

understand ecosystem change and develop appropriate adaptation measures.

Table (4.24) summarizes the results, containing the objectives, key findings, and the proposed actions required in the shrimp ecosystem-based management for each of the five steps discussed.

Table (4.24): A summary of key findings for the EBSM steps.

Step	**Objectives**	**Key findings**	**Proposed management actions**
Step A Determining the stakeholders and defining the ecosystem area	- Determine the main stakeholders. - Define the ecosystem area. - Develop a relationship between the stakeholders and the ecosystem area.	- Seagrasses (primary shrimp habitat) provide valuable ecosystem services but are now not in good condition due mainly to anthropogenic stressors. - Both study samples believe that the current rate of exploitation of shrimp fisheries and the natural shortages of shrimp will lead to a decrease in their quantity in the future. - Fishers are not involved with the relevant government institutions in decision-making related to the sustainable exploitation of shrimp fisheries. - Fishers only benefit from some shrimp fishing grounds. - Decision-makers emphasized the importance of researchers' and scientists' involvement in management processes. - Most decision-makers are convinced of the necessity and importance of periodic evaluation of shrimp fisheries jointly with fishers according to scientific indicators. **The principles of step A needed to have been better implemented.**	- Collaboration, ongoing communication, and participation between all relevant stakeholders are essential for successful shrimp fishery management. - All stakeholders must be involved in assessing the shrimp fishery and its stock.
Step B Ecosystem structure,	- Achieve decentralization to the lowest appropriate level.	- The government is working toward achieving an appropriate level of decentralization.	- The necessity to work toward restoring degraded marine habitats.

Step	Objectives	Key findings	Proposed management actions
function and management	- Conserve of ecosystem structure and functioning. - Manage Ecosystem within the limits of its functioning. - Find a balance between conservation and use of biological diversity.	- Several factors negatively affect shrimp stock, such as amateur fishing, shrimping without a license, and climate change. - Several decisions have been issued to regulate shrimp fishing. - Some fishers did not comply with the fishing regulations and laws. - Fishers are not currently using new methods for shrimp fishing; they are still using bottom trawl nets (carafe). - Some fishers violate the decision of the shrimping ban period. - Most decision-makers stated that professional fishers, seafarers, and amateur fishers benefit from marine biodiversity in marine reserves. **The principles of step B needed to be better implemented.**	- Induce a strong fishery monitoring system. - Sustainable shrimp fishing is a shared responsibility among fishers, fisheries management authorities, fishery scientists, and the local community. - Fishers should participate with the fishery authorities in preparing and implementing the action plan for shrimp fishery management.
Step C Economic issues	- Identify the important economic issues that will affect the ecosystem.	- The study showed that many economic issues negatively affect the seagrasses ecosystem and the shrimp fisheries and cause their deterioration. - Environmental damage caused by illegal fishing or using bottom trawl nets is not evaluated. - The economic evaluation of shrimp fishery was not conducted. - There is a need for shrimp aquaculture to meet the growing demand. **The principles of step C needed to be better implemented.**	- The necessity to conduct studies to assess environmental damage to shrimp fishing grounds. - The necessity to assess the environmental management practices to combat overfishing in Bahrain. - The necessity to carry out an economic evaluation of shrimp fishery regularly. - Encourage investment in shrimp aquaculture as a possible sustainable solution for food security.
Step D Adaptive management over space	- Determine the impact of the ecosystem on adjacent ecosystems.	- The permitted locations for shrimping are known and specified for the fishers. - Study samples believe that illegal shrimp fishing affects the seagrass and coral reefs near shrimping areas. - There are fishing violations by some fishers outside the territorial waters and from	- Conducting an environmental impact assessment for projects with substantial environmental impacts is vital. - Intensify the monitoring, control, and surveillance of the shrimp fishing grounds.

Step	Objectives	Key findings	Proposed management actions
		neighboring countries in the territorial waters. - Study samples believe dredging and reclamation projects harm shrimp fisheries and their stock. In addition, they think that pollution of coastal environments contributes to the decrease in shrimp stock and throwing damaged nets or any other marine debris has the potential to damage marine habitats and living organisms seriously. - Both samples agreed that the specifications of the current permitted shrimping method are not appropriate. **The principles of step D needed to be better implemented.**	- Conducting a discussion panel with the interested parties to discuss the suitable method of catching shrimp is essential.
Step E Adaptive management over time	- Develop a flexible management plan with long-term goals. - Diagnose the causes of problems and identify solutions to them using all the other EBM principles.	- There is one shrimping season extending from 1 August to 31 January yearly. - There is a monitoring system for shrimp fisheries to protect the area, prevent violations, and arrest violators. - There are no plans to manage shrimp incubation, hatchery areas, or shrimping areas. - No study has addressed the issue of shared stocks between GCC countries for their optimal shrimp fisheries management. - Professional and amateur fishers are not involved in awareness workshops on the approved legislation, nor awareness workshops on permitted shrimping practices before the start of the shrimping season, nor are they being educated about the harmful effects of unauthorized shrimping. **The principles of step E needed to be better implemented.**	- Developing action plans for managing shrimp incubation or hatchery areas and shrimping areas is a requirement for successfully managing shrimp fishery. - Assessing shared stock fishery for shrimp and other commercial fish in the GCC waters is necessary. - Conducting awareness-raising programs for fishers and the local community is a necessity. - Capacity-building activities and continuous learning programs are needed to strengthen the governmental infrastructure and the skills and abilities of the employees, especially in the fisheries field. - It is required to establish stricter measures and procedures to sanction any fisheries laws and regulations infringement.

EBM recognizes the need to (1) address the multiple, overlapping, and cumulative stressors in which humans use and impact the environment (Link & Browman, 2014), (2) examine the interdependence between the physical, biological, and socioeconomic components within and among systems (Douvere, 2008), and (3) better understand how society can support the resilience, robustness, and vulnerability of ecosystem goods and services (Levin & Lubchenco, 2008). To accomplish these goals, EBM requires a diversity of specialties, from environmental science, ecology, economics, and mathematics, as well as the physical, earth, social, and political sciences (Humphries et al., 2022). In addition, Olsen et al., (1997) have strongly argued that the main challenge of marine and coastal management is governance (objective, process, and structures). Accordingly, a learning-based approach to marine and coastal management has been recommended.

The proposed EBSM framework will address the processes of governance and outline in an adaptation of the learning cycle the sequence of actions that trace the sustainable management of shrimp fishery from issue definition and goals setting, through the preparation of a plan and program, to its formal adoption and on to its implementation (Table 4.25). This cycle has been widely used in integrated coastal zone management (ICZM) since it was put forward by the GESAMP (GESAMP, 1996) and has been further elaborated and adapted to organize the sequence of actions for a diversity of initiatives (Olsen et al., 2011; Olsen, 2003; Von & Turner, 2001). The GESAMP cycle has been used as a roadmap for sustainable shrimp management. It consists of five sequential stages forming an ongoing, interactive process, as shown in Fig. 4.32. The process may undergo several cycles before the program is sufficiently refined to produce effective results (Von & Turner, 2001).

The integrated planning and management cycle for sustainable shrimp management (Fig. 4.32) relies upon two fundamental features: First, it sets the stage for preparing strategic and action plans for shrimp fishery initiatives by identifying the strengths and weaknesses of the existing programs and the reforms that are needed if desired future conditions are to be achieved. It places current pressures and threats in the context of long-term ecosystem change. The careful documentation and analysis of the existing governance system provide important insights into how best to design an effective management and governance initiative for the shrimp fishery in Bahrain.

Analyzing the change for such variables as shrimp stocks or shrimp fishing activity in greater detail will provide answers to such questions as:

- To what degree are the EBSM principles present; what are the barriers?
- What priorities and strategies does the EBSM framework suggest when addressing current ecosystem management issues?
- What variables should be monitored for assessing progress and adapting the program to manage shrimp fishery sustainably?

Second, it outlines a strategic approach to designing a sustainable shrimp management program and records the goals, objectives, and strategies. In addition, the selection of the stakeholders plays the most central role in achieving the program's objectives and identifying the variables that will be used to monitor and assess progress. This cycle is useful because it can help identify the factors that enable or resist the successful implementation of the EBSM framework.

Many coastal and marine management programs are only fragments of unconnected cycles (Olsen et al., 2011). Particularly for integrating planning and management, the cycle will reveal a major gap between repeated efforts at issue analysis and planning (Steps 1–3) and

implementation of a plan or program of action (Step 4). Table (4.25) lists the action items associated with each step in the cycle to implement EBSM in the Kingdom of Bahrain. It traces how the degree to which each step and associated actions have been completed can be documented during preparation. This format eases the visualization of progress and identifies differences in the sequencing of actions and the emphasis placed on different elements when comparing countries. The subsequent initiatives must build strategically on a careful assessment of what can be learned from earlier attempts to address the same or similar issues (Step 5) (UNEP, 2007; Olsen, 2003).

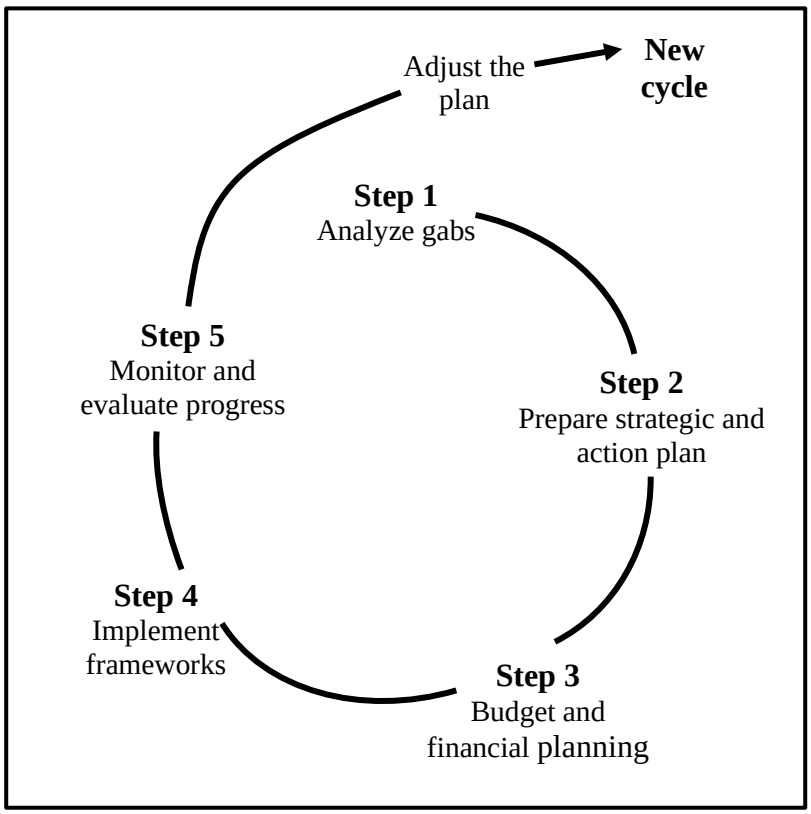


Fig. 4. 33: The integrated planning and management cycle for shrimp sustainable management (adapted from GESAMP, 1996).

Table (4.25): Proposed actions to implement EBSM in the Kingdom of Bahrain.

Step	Indicators 0 = not initiated 1 = underway 2 = completed	Progress		
		0	1	2
Step 1: Issue identification and assessment	• Significant stakeholders and their interests identified. • The ecosystem area is defined. • Principal environmental issues and their implications assessed. • Factors impacting ecosystems identified. • Management potentials and constraints identified. • Issues are selected by using an appropriate scientific tool. • Goals are defined. • Stakeholders are actively involved in the assessment and goal-setting process.			
Step 2: Preparation of the plans	• Focus on the initiatives in the government plan (2019-2022) that originated from economic vision 2030. • Related Sustainable Development Goals identified. • National, regional, and international policies are reviewed and assessed. • Institutional roles and responsibilities defined. • Best practices for incorporating ecosystem considerations into management decisions are identified. • Scientific research on selected management questions is conducted. • Boundaries of the areas to be managed are defined. • Baseline conditions documented. • The action plan and the institutional framework by which it will be implemented are defined. • Institutional capacity for implementation developed. • Commitment to actions (stakeholders' acceptance) achieved. • Stakeholders are actively involved in planning.			
Step 3: Budget and financial planning	• Plans and initiatives formally endorsed and authorities necessary for their implementation provided. • Funding required for initiative implementation obtained.			
Step 4: Implementation	• Behaviors of key partners conform to the plan. • Ecosystem trends are monitored and interpreted. • Investments in necessary physical infrastructure are made. • Progress and attainment of goals documented. • Major stakeholder groups sustain participation.			

Step	Indicators 0 = not initiated 1 = underway 2 = completed	Progress		
		0	1	2
	• Funding, and authorities sustained. • Core data and information streams are maintained and updated. • Program learning and adaptations documented.			
Step 5: Evaluation	• Indicators of progress measured. • Initiatives outcomes documented. • Management issues were reassessed. • Priorities and policies adjusted to reflect the experience and changing environmental conditions. • External evaluations conducted (if required). • New issues are identified for future inclusion in the plan. • Routine and regular reporting of fishery status established.			

Source: Designed by researcher

4.5.3 Assessing the Implementation of EBSM into National Policies

In this study, the inclusion of EBSM principles into national decrees and regulations was assessed (Fig. 4.33) by referring to shrimp fishery rules and regulations in the Kingdom of Bahrain.

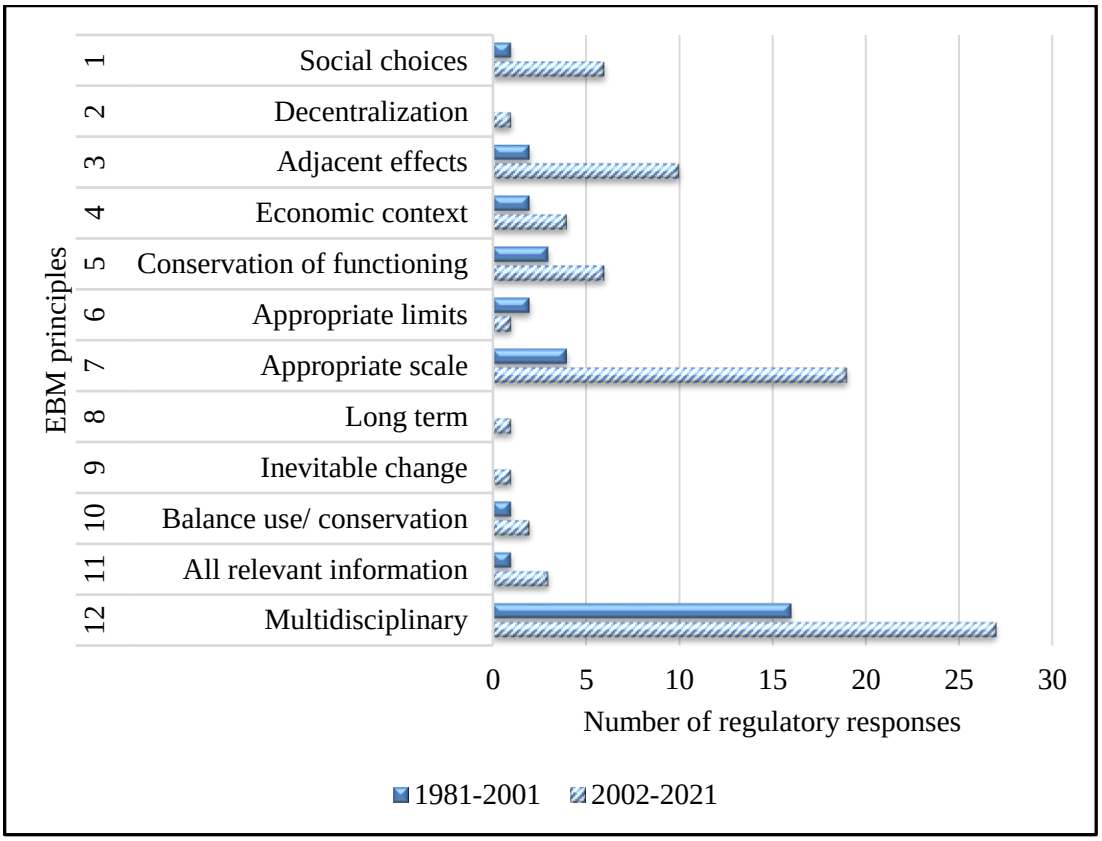


Fig. 4. 34: Number of regulatory responses which include EBM principles for specific time periods in Bahrain.

The analysis shows that during the 1981–2001 period, one Legislative Decree and six resolutions were issued to regulate fishing, which included some EBM principles. The focus during that period was on Principle 12 (the involvement of all sectors in the management process), which concentrates on the communication and cooperation between different government institutions and sectors to regulate the fisheries. The role of sectors other than the primary sectors (directly

related to fishing activity) is also mentioned. For example, the judicial sector, which affects governance, urban development, education, industry, and transport, is managing or affecting resources directly or indirectly. However, more efforts were directed in that period to maintain the sustainability of fisheries. In addition, in 1998, Environmental Impact Assessment (EIA) was formally adopted by the Kingdom of Bahrain in its environmental system to protect the environment and reduce the environmental degradation associated with significant developmental projects (Naser, 2012). Nonetheless, several measures are needed to enhance stakeholder participation, improve capacity building, and integrate environmental concerns into higher-level policymaking through national environmental strategies. Additionally, environmental monitoring must be introduced to manage and minimize an organization's activities impact on the environment.

During the 2002–2021 period, results show new EBM principles included within the Legislative Decree and its implementing regulations (36 resolutions). For example, during 2001-2002, Bahrain reviewed and considerably updated the fisheries Law; new articles were added that addressed ecosystem-based management. Chapter 3 in the new law (Legislative Decree No. 20 0f 2002 on the regulation of fishing, exploitation, and protection of marine wealth) aimed to protect the marine environment and preserve marine species and wildlife, which represent the first time using the principles of EBM. This chapter includes the interactions among ecosystem components, humans, and the cumulative impacts of multiple activities, promoting conservation and sustainable use of resources. Moreover, article 36 defines the national fisheries policy, explicitly mentioning an ecosystem approach. In this way, Decree No. 20 0f 2002 is considered as the first real contribution of legislation towards the inclusion of EBM.

Furthermore, the Economic Vision 2030 for Bahrain (adopted in 2008) focuses on shaping the vision of the government, society, and the economy based on three guiding principles: sustainability, fairness, and competitiveness. Additionally, environmental issues were given special attention by emphasizing the necessity for conserving and protecting natural resources in the Bahrain 2030 National Planning Development Strategy. The Government Plan (2023-2026) also includes a unique initiative concerning environmental protection and sustainable development. The Agriculture and Marine Resources Agency translated this initiative into a strategic plan, specifically, the strategic goal of improving food security through regulation of marine fisheries.

The 2009 fisheries policy sets a new institutional structure termed management committee to be responsible for developing a management plan to protect marine habitats, which characterized multi-stakeholder arenas, providing opportunities for fisheries management to become a matter of social choice. In addition, the Kingdom of Bahrain ratified the CBD in 1996. In 2007, Bahrain developed the first National Biodiversity Strategy and Action Plan (NBSAP) in collaboration with the United Nations Development Program (UNDP) that aimed at reversing the loss of biodiversity within Bahraini terrestrial, marine, and freshwater ecosystems (SCE, 2016). Furthermore, between November 2012 and March 2014, SCE, and the Ministry of Culture, in collaboration with UNEP-ROWA, implemented the first EBM project. This project aimed to evaluate the economic value of ecosystem services provided by Najwat Bulthama, Hayr Bulthama, Hayr Shttayah, and Hayr Bu Amamah and to identify the communities that benefit from the direct services supplied by the marine resources in these four areas. This project resulted in the production of the environmental management plan for Najwat Bulthama, Hayr Bulthama, Hayr Shttayah, and Hayr Bu Amamah (SCE, 2016).

The analysis of regulatory responses shows that there has been a shift towards implementing some EBM principles in national-level decrees and regulations. However, more efforts are needed to incorporate EBM for different environmental issues such as fisheries management, mangrove conservation and management (restoration of mangroves), and sustainably managing Bahrain's coral reefs and seagrass beds ecosystems. To target broader EBM implementation, better recognition of legal priorities at a national scale from an EBM perspective may generate more significant support and aid the implementation (Gelcich et al., 2018). In essence, efforts should be placed on coupling specific national fishery management needs to each EBM principle. In doing so, it is essential to define all stakeholders' roles clearly and responsibilities, embrace transparency and generate co-learning techniques.

National implementation of EBM is significantly dependent on inter-sectorial coordination (Prellezo & Curtin, 2015). Government programs must clearly state the goal of achieving EBM pointing out the level at which need to incorporate ecosystem concerns into marine management. The consideration of existing governance structure, an understanding of how specific fishery management issues in existing policies influence the application of EBM, and the development of an effective learning environment are key features to initiate the implementation of EBM in national policies.

From the above analysis, this study proposes EBSM principles for the Kingdom of Bahrain (Table 4. 26). The key principles defining EBSM may differ between countries but typically focus on ecological integrity and complexity, the inclusion of humans in the ecosystem, and sustainability (Leslie, 2018). Effective implementation of EBSM and its principles relies on estimating how ecosystems respond to intense and cumulative stressors generated by human activities (Clark et al., 2022).

Table (4.26): Proposed EBSM principles for the Kingdom of Bahrain.

	EBSM principle
1	Humans are considered part of the marine ecosystem and the main contributor to sustainability.
2	Decisions are based on science and knowledge, are collaborative, and involve all stakeholders.
3	Quantify the ecological complexities and present cumulative and multiple stressors induced by human activities, as well as those that might occur with new uses
4	Collaborative and participatory decision-making processes are essential, involving all interested parties from all sectors, fishers, and local communities.
5	Governance structure provides an important aspect of collaboration and partnership, as the strategic group is responsible for achieving allocated targets and complying with the desired standards.
6	Healthy marine environments and sustainable uses of its resources are safeguarded for future generations.
7	Flexible, adaptive management over space and time with appropriate monitoring.
8	The sustainable management of fishery resources is the key contributor to national economic growth.
9	Ecosystem restoration can provide ecological, social, and economic benefits.
10	Economic analysis of the costs of overexploitation of shrimp resources is the key driver for the fisheries department to take immediate action to regulate the fishery.
11	Management rules are effective with active efforts to promote compliance, monitoring, surveillance, and enforcement.
12	Well-planned education and communication programs such as raising awareness of ecosystem values, threats, and contributing factors; encouraging behavioral or policy change; and building capacity play a vital role in effectively implementing management responses.
13	The need to promote the development of skills for evaluating the nature and impact of interactions between species that are directly or indirectly affected by fisheries.

Note: These principles generally align with those applied internationally. Included in these principles is reference to practices that provide for the interests and knowledge of Bahraini people.

4.6 Potential Scenarios on EBSM

The present study suggests the following scenarios on implementing ESMB in Bahrain, which may be helpful for the decision-makers in perspective fisheries plan.

4.6.1 Proposed Shrimp Fishery Management Strategies

To promote sustainable shrimp fisheries, monitoring of shrimp fishing grounds through the Maritime Control Directorate in cooperation with the Coast Guard Directorate, based on the principles of co-management for shrimp resources, has been implemented. In addition, commercial fishing is restricted to licensed artisanal fishers to contribute to the socio-ecological sustainability of fisheries ecosystems. Thus, licensed artisanal fishers and legally constituted artisanal fishers' associations should have a participatory role with the relevant organizational institutions to administer the shrimp fishing grounds within a management and exploitation plan. Moreover, the implementation of the management plan needs to periodically be reported and evaluated by the Maritime Control Directorate. Establishing a management plan should involve all the relevant stakeholders to provide a fund for the necessary studies to implement the management plans. Besides, monitoring of shrimp stock and its recovery is required to ensure the sustainability of the resource. The fish market must also be involved to ensure marketing of the allowable size. In Chile, a territorial user right for the fishery system, known as Management Exploitation Areas for Benthic Resources (MAEBR), was created as a fishery co-management tool to achieve sustainable exploitation of benthic resources by establishing an access regime. This tool assigns exclusive fishing rights for exploiting benthic

resources, in defined coastal stretches, to legally constituted fishing organizations (Aburto et al., 2013).

It is also necessary to implement restoration measures for shrimp fishery. The shrimp fishery areas could be spatially divided into management units. Identifying spatial management units could be particularly important for supporting fishery management policies, but this requires robust data gathering on benthic habitats, assemblages, and the associated fishing pressure (Lauria et al., 2020). Additionally, implementing individual quotas could be a suitable mechanism of regulation against bad practices (Copes, 2019). The distribution of spatially allocated catch quotas by the governorate based on the abundance of the resource and the number of fishers is an appropriate measure for the spatially explicit allocation of the fishery. Implementing the catch quota will result in an effective tool for controlling the overexploitation of fishery resources (Berrios et al., 2022).

Lubchenco et al., (2016) revealed that using the right economic or social incentives can achieve fishery sustainability. For example, the introduction of Individual Fishing Quota (IFQ) or secure-access fisheries, in which fishers have a guaranteed fraction of the catch, benefit directly from a well-managed, healthy fishery, and are incentivized to ensure the catches are not too high within the permitted limit. As a result, the ecosystem is healthy, and cheaters are not tolerated by their peers to keep. the economic incentives in a positive behavior. Thus, it is important to identify the quantity of catches legally. Moreover, through the flexibility of estimating the shrimp's CPUE for each shrimping boat, the fishers can plan their fishing timing during the season by agreement with other fishers assigned in the same fishing zone, making reasonable financial and business decisions, and fishing under safe weather conditions. Further, the allocation must be sensitive to various considerations, including equity.

However, there is a challenge in implementing the catch quota in Bahrain, due to large part of non-Bahraini fishers, and agreement with them might be complicated.

The secure access fisheries lowered the race-to-fish or shrimp that was harmful to fish or shrimp stocks and habitat and provided more predictable financial security (Barner et al., 2015). In addition, IFQ resulted in reductions in bycatch and depleted species, increases in fishery profits, and scientists have documented faster recoveries of many of the species associated with the fishery (Lubchenco et al., 2016).

In order to ensure the sustainability of shrimp fishery, in addition to improving regulatory measures, fishery management should be complemented with actions such as promoting conservation, restoration, and the development of sustainable aquaculture (Berrios et al., 2022; Campos et al., 2021; Westermeier et al., 2016; Gianni et al., 2013). Moreover, accountability by fishers and good monitoring is the key to sustainability.

In February 2020, the King of Bahrain issued royal directive to develop and implement a "Strategic Project for National Food Production" by allocating sites for aquaculture, raising the proportion of local production, and developing national capabilities in food industries. In 2023, a new directorate was established named Fish Farming Directorate. Additionally, the Government Plan (2023-2026) focuses on initiatives and projects that enhance food security levels, working to confront climate change and preserve the environment, enabling procedures that attract investment, and achieving financial sustainability and economic stability. According to Bahrain Voluntary National Review 2023, it was stated that Bahrain has good potential for fish farming, considering the advantages offered by the climate, location, coastal area, and market. Many types of aquaculture activities are feasible, and a wide range of aquatic species

could be cultured. The Government worked on multiple initiatives, including launching training programs in partnership with Tamkeen and several international training centers to train Bahrainis in fish farming in 2019, allocating multiple sites for fish farming, setting up a new fish farm in the Southern Governorate near the National Aquaculture Centre in Ras Hayyan in 2020, and inviting private sector investment in the sector (VNR, 2023). Thus, there is a need to develop detailed operational plans to encourage investment in sustainable aquaculture of fish and shrimp.

4.6.2 Fishery Governance

Monitoring, controlling, and surveillance of illegal fishing activities is a critical issue for managing marine resources (Marzuki et al., 2017). Two technologies could be used for monitoring, control, and surveillance in Bahrain, including drones and space-based monitoring of fishing vessel activities known as vessel monitoring systems (VMS) as shown in (Fig. 4.34).

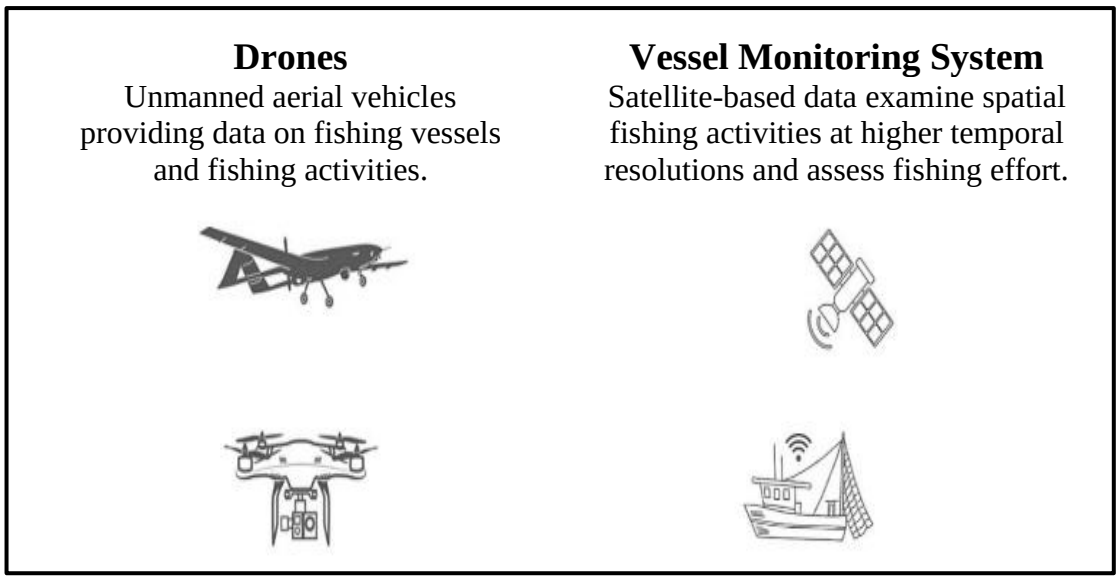


Fig. 4. 35: Two cases of monitoring, control, and surveillance technologies. Note: pictures adapted from Toonen & Bush (2020)

4.6.2.1 Using Drones in Fishery Surveillance

Drones have been used in many applications, such as monitoring and spraying of crops (Peña et al., 2013), anti-poaching strategies in protected areas (Mulero-Pázmány et al., 2014), and forest management and ecology (Anderson & Gaston, 2013). In fisheries, drones operate under radio frequencies and pre-programmed GPS-guided flight scripts, currently used to support fisheries management, and provide a cost-effective solution for collecting data on fishing activities (Reis-Filho et al., 2022; Provost et al., 2020; Clarke, 2014).

Camera-equipped drones can spot fishing vessels and detect whether registered and licensed (Miller et al., 2013). This technique can also observe the use of fishing gear (permitted and prohibited) and relay near-real-time data on their location and movement (Kopaska, 2014). For example, the government of Belize used drones with live video streaming to extend the monitoring, control, and surveillance systems' capacity to detect Illegal, unreported, and unregulated (IUU) fishing (Toonen & Bush, 2020). Palau, Jamaica, and Costa Rica are also adopting similar technologies to detect illegal fishing activities (Zamora Chung, 2018).

The spatial extent of drone use is determined by its design. For example, large drones with a payload of 200–900 kg can fly within 500 km over two days at an altitude of between 3 and 20 km. These drones can cover a large distance of coastline. Micro or nano drones, with a payload of less than 5 kg and a range of fewer than 10 km, a maximum flight time of one hour, and an altitude of 250 m useful for close scans but are costly (Anderson & Gaston, 2013). Using multiple drones from the coast guard or maritime control ships is possible. This technology is effective but may only be able to give a snapshot of the fishery grounds at any given moment and may provide limited insight into specific behaviors related to non-

compliance (Lancaster et al., 2017). Furthermore, technical expertise is required regarding the design and programming of these drones.

The main advantage of drones is their stealth – given their speed and size, they are difficult for fishers to see them coming, especially those who are using illegal gear or fishing in prohibited areas (Zamora Chung, 2018). In the Fernando de Noronha Archipelago, drones have been used to map and detect several aspects of fishing activities and shallow seabed characteristics to demonstrate their utility for fishery management (Reis-Filho et al., 2022).

4.6.2.2 Vessel Monitoring System (VMS)

The application of satellite-related monitoring systems is widespread in fishery management, exemplified by the massive and intensive use of VMS (Schulte et al., 2020; Toonen & Bush, 2020; Bueno-Pardo et al., 2017). VMS is mainly based on satellite-based GPS, with data fed into maps and models to describe and analyze the spatiotemporal dynamics and assessment of fishing efforts (Thoya et al., 2019). Satellite-based VMS technology has been operating in many fisheries around the world for several years (e.g., Chang, 2011; Hanich et al., 2010; Deng et al., 2005). Like drones, satellite instruments also include radar altimeters and sensors collecting data to indicate the presence or absence of marine creatures and fishing (Toonen & Bush, 2020).

Satellites are vital for visualizing illegal fishing in inaccessible parts of the sea and expose the great potential for monitoring. Australian Fisheries Management Authorities have used it as a surveillance system to ensure that fishers comply with seasonal and spatial closures (Deng et al., 2005). Additionally, VMS has been used to examine spatial fishing activities at higher temporal resolutions, leading to more precise estimates of fishing effort for improving inputs to stock assessments (Thoya et al.,

2019; Watson et al., 2018; Joo et al., 2013; Peel & Good, 2011; Mills et al., 2007; Deng et al., 2005), validation of fisher-reported logbooks (Bastardie et al., 2010; Palmer & Wigley, 2009), delineation and planning of fishing grounds (Stelzenmüller et al., 2008), assessment of benthic impacts from fishing (Lambert et al., 2011), and evaluation of regulatory or other (such as climatic) impacts on fishing performance (Watson et al., 2018). Satellite-based monitoring improved the fishers' behavior toward management actions (Watson et al., 2018).

Furthermore, the synergic utilization of data from different sources, either ground-based or space-borne, can lead to effectively monitoring fishing activities and help tackle the issue of overfishing. For example, integration of VMS data, ships reporting information about themselves (e.g., identification, position, and speed) with data from systems employing radar and optical sensors (coastal, shipborne, airborne, and space-borne) could result in the quantification and additional mapping of the vessels that are not reporting their positioning data (intentionally or not), giving a complete picture of vessels' activity, including Illegal, Unreported and Unregulated fishing (Galdelli et al., 2020).

VMS should become mandatory on all fishing vessels in Bahrain to enhance monitoring. Satellites are owned/operated by the National Space Science Agency (NSSA), which is responsible for responding to national needs of space information and earth observation data, providing high-resolution multispectral images and processing satellite data, providing data for scientific research, environment, and agriculture, conducting studies to monitor land change and trends and more initiatives about space technologies for national development (NSSA, 2022). The Agriculture and Marine Resources Agency, in collaboration with NSSA and universities, could conduct studies to effectively monitor fishing

activities, including illegal fishing, assess shrimp stock, and improve fisheries management by using satellite-based monitoring systems.

4.6.3 Shrimp Fishing Method Alternative to Bottom Trawling

As an example, according to fishery legislation in the Sultanate of Oman, shrimp fishing is limited to Omani fishers operating small fiberglass boats (lengths ranging from four to five meters) using only fishing nets because bottom trawling is prohibited since 2013. All artisanal fishers are shrimping using haul seines or cast nets only (known locally as Ghul or Al Taraha), as illustrated in Fig. 4.35, which is specific to shallow depths between five and seven meters (ONA, 2022; Al-Mamry et al., 2015). Standard nets are used in Oman and are spread out into a conical shape when cast (ONA, 2022). The suitable cast net is mainly selected based on the target species' size, the fisher's fitness, and the fishing area's physical characteristics (Edo, 2007).



Fig. 4. 36: The hand casting nets in Oman (ONA, 2022).

The permitted hand-casting net comprises three parts: the upper part (net band), the middle part (a conical-shaped net mesh), and the lower part, which is weighted. The fisher casts utilizing both hands and the shoulder, hurling the net onto the water's surface in an area likely to have the shrimp (permitted shrimping area). When thrown into the air, the net spreads out into a circular shape and expands; as the net strikes the water surface, the weighted edges of the net drop into the water in a circular shape like a parachute and trap the shrimp within the circular section. Finally, when the weighted parts of the net reach the bottom, the top band of the net is pulled, cinching the net closed into a sack-like shape within the water. With the weights dragging along the bottom, the net is slowly drawn back to the fisher's hands, collecting the captured shrimp within the net. The cast net is used on flat bottoms so that shrimp do not escape from its sides (ONA, 2022; Edo, 2007). The haul seine is pulled either by hand or power to capture and confine shrimp by encirclement (Orth et al., 2017). The purse seines are usually operated in the open sea to target dense schools of single species, fish, or shrimp. A vertical net surrounds the targeted species, the bottom of which is then pulled together to enclose them (Fig. 4.36). This method is generally considered an efficient form of fishing as it has no contact with the sea floor and can have low levels of bycatch. In addition, the well-managed seine fishing method has minor ecosystem impacts (Ceballos-Santos et al., 2023; Suuronen et al., 2012).

The Kingdom of Bahrain could benefit from this fishing technique for catching shrimp using haul seines or cast nets.

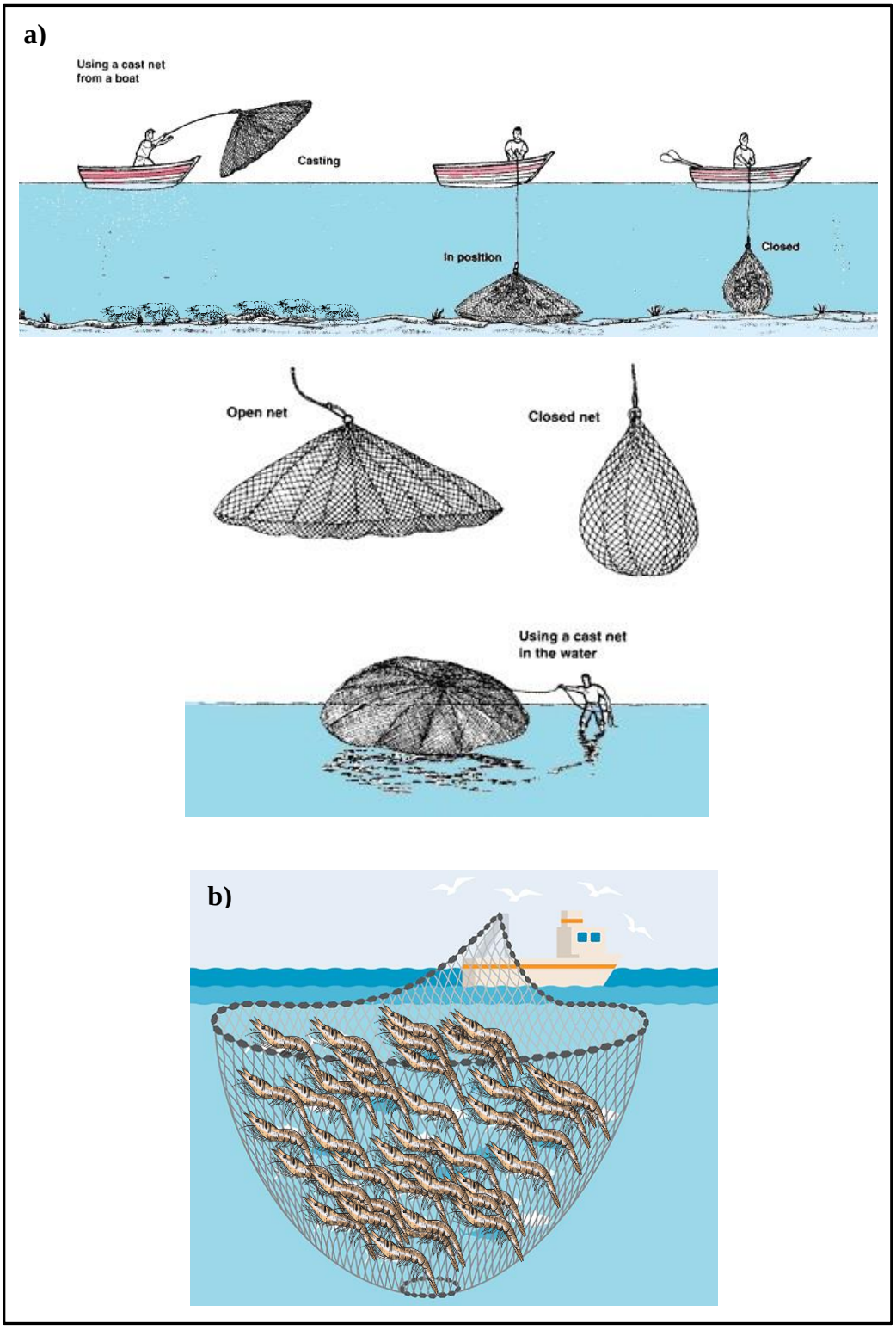


Fig. 4. 37: Simplified graphical representation of the two fishing techniques: a) casting by hand or boat b) purse seine fishing.
Photo modified from a) Coche & Muir (1998) and b) Ceballos-Santos et al., (2023).

4.6.4 Co-management: Fishers' Participation in Fisheries Management

Co-management is "the sharing of power and responsibility between government and resource users" (Berkes et al., 1991), which reflects a governance shift towards decentralization and more collaborative decision-making between fishers and government institutions (de Vivero et al., 2008). Co-management may improve efficiency and equity in fisheries management (Puley & Charles, 2022). Co-management is currently a core subject of fishery governance, as many governments recognize the importance of considering the voice of fishers and, in some cases, the voices of civil society in fishery management (Nielsen et al., 2004). Studies of co-management have become ubiquitous around the world (Léopold et al., 2019; Linke & Bruckmeier, 2015).

Despite the benefits of co-management, there are a diversity of possible arrangements in practice. The most commonly addressed is a "ladder of participation" reflecting the degree to which decision-making is shared between the government and fishers (Berkes et al., 1991). According to Pomeroy & Berkes (1997) and Sen & Nielsen (1996), the co-management could be practiced in two ways: (1) centralized government, where fishers are only instructed about decisions that the government has already made, or (2) the power is delegated to fishers to make decisions, and the government is only informed of the decisions. On the other hand, Puley & Charles (2022) discussed a more comprehensive approach to reflect how co-management is implemented across the "management spectrum" by assessing fishers' involvement in fishery management based on six management components: (1) direction-setting, planning, and policy development, (2) harvest management, (3) compliance and enforcement, (4) ecosystem management, conservation,

rehabilitation, (5) research, and (6) organizational management and development (Table 4.27). These six fishery management components were compatible with a review of the broad fisheries resource management literature. They are also incorporated into various fishery assessment and monitoring tools (Boyd & Charles, 2006; Pomeroy & Rivera-Guieb, 2005; Pinkerton & Weinstein, 1995).

This approach could be utilized in Bahrain to highlight co-management and thereby illustrate a path towards achieving meaningful fishers' involvement throughout the management spectrum to achieve strong governance. It comprehensively assesses co-management based on jointly examining participation and the management spectrum. Disaggregating fishery co-management into management components and assessing fisher participation for each component provides a better understanding of the nature and extent of fisher involvement in management and greater insight into the extent to which fishers are, and wish to be, involved. It also provides a more comprehensive approach to designing and evaluating co-management rather than focusing on fisher participation in only one part of the management component, such as fish or shrimp catches and landings. A key aspect of this is to assess the level of fisher satisfaction with current participation within each management component to detect the engagement or involvement gap. Thus, fishers' cooperation is essential. Finally, this approach seeks to explore the governance implications of co-management to identify the effective strategies for appropriate participation in management and to address the two co-management choices: 'participation by whom?' and 'how much participation?'.

Table (4.27): Components of fishery management.

Fisheries Management Components	Management functions
1: Direction-Setting, Planning & Policy Development	a. Problem identification. b. Setting policy objectives - defining what should be achieved. c. Developing policy. d. Evaluating the effectiveness of the plan and related policies. e. Assessing actual and potential impacts of policies. f. Creating long-term fisheries management plan (i.e., goal and objective setting, and identifying indicators). g. Monitoring the implementation of the management plan.
2: Harvest Management	a. Monitoring and assessing stock status to determine catch levels (e.g., tracking and documenting catches and landings). b. Setting the catch level (i.e., Total Allowable Catch (TAC), quota). c. Managing/authorizing fishing seasons (i.e., setting openings and closings). d. Managing/authorizing areas for fishing (i.e., fishing zones). e. Managing/authorizing fishery access—for example, membership criteria (for licensing). f. Assigning allocation and distribution of catch (arranging internal distribution of catch).
3: Compliance & Enforcement	a. Developing fishing rules to support management objectives. b. Educating stakeholders/building awareness about the rules to improve compliance. c. By-law and regulation enforcement (e.g., patrolling for violators, monitoring/verifying fishing or other resource use activities, and compliance). d. Imposing penalties and sanctions for non-compliance/penalizing violators.

Fisheries Management Components	Management functions
4: Ecosystem Management, Conservation, Rehabilitation	a. Planning for habitat rehabilitation, enhancement, or management (setting strategies). b. Conducting habitat rehabilitation/ enhancement. c. Planning for stock rehabilitation, enhancement, or management (setting strategies). d. Conducting stock rehabilitation/ enhancement (e.g., running hatcheries). e. Conducting habitat or ecosystem assessment/ monitoring.
5: Research	a. Developing a research plan/setting the research scope. b. Conducting data collection. c. Analyzing data collected. d. Managing access and ownership over data and research results. e. Applying findings to support fisheries management.
6: Organizational Management & Development	a. Building capacity—creating new mechanisms to support fisher involvement in fisheries management. b. Managing interpersonal conflict within the fishery. c. Managing conflict with outside interests.

Note: Designed by researcher by referring to Puley & Charles (2022)

4.7 Conclusions and Recommendations

The present study applied on ecosystem-based integrated assessment as an adaptive approach for governing human activities in marine ecosystems. This approach adopted the DPSIR framework to present the most current knowledge about recent shrimp management plans for the shrimp fishing grounds in the Kingdom of Bahrain and the problems identified with their implementation. Green tiger shrimp (*P. semisulcatus*) is currently subjected to an ecological system exposed to considerable stress due to the socioeconomic importance of this species, which has been caused by increased shrimp exploitation, resulting in the decline of its

population. Therefore, this impact directly affects the local fishers' communities through shortage of shrimp catch (overexploitation) and indirectly impacting the ecosystems where the shrimp population are associated. All these factors are triggered by the commercial importance of the shrimp and economic and social conditions that promote illegal exploitation and, accordingly, catch decline. Consequently, the MUN has implemented different management measures (stop issuing fishing licenses, forming committees to monitor and follow up violations by fishers, extending closed season to six months, and suggesting optimum shrimp size to catch, among other approaches) to safeguard the resource's sustainability. The application of the DPSIR approach on the shrimp fishery highlighted the following considerations:

(1) The shrimp fishery (*P. semisulcatus*) presents a high socio-economic and ecological importance. However, despite governmental efforts, problems still occur with resource sustainability and governance.

(2) Due to illegal shrimp fishing practices, bottom-up strategies that involve collaboration from all relevant stakeholders and adaptive management approaches are required based on up-to-date information.

(3) A holistic management approach for the governance of the shrimp fishery is suggested to be implemented through co-management scenario based on decision-making, where fishers are to be participated.

The study also applied the EBSM, in which the EBM principles and opportunities driving actual implementation have been explained within national policy. Three issues were pointed regarding national-level implementation. First, EBM must be incorporated appropriately and clearly into existing governance arrangements. Second, time is critical in generating an action plan to implement EBM. Third, it is important to understand how specific fishery management issues in existing policies or

legislations influence or impede the application of EBM. Using EBM principles as lens to evaluate policies or regulatory responses has proven helpful in identifying progress, gaps, and possible scenarios for the future development of EBM in Bahrain.

This study represents an essential first step in engaging stakeholders across various government institutions, sectors, and from multiple levels of society, providing an opportunity to increase awareness of the importance of seagrasses and other habitats for shrimp and to which extent these habitats are under stress. With such awareness, applying EBM approaches to other important ecosystems is far more likely to be successful. However, success in ecosystem management in Bahrain will also be contingent on success of ecosystem management in surrounding GCC countries, particularly the shared fishing grounds, given the transboundary nature of many of pressures affecting marine and coastal ecosystems in the Arabian Gulf. Thus, developing an integrated, region-wide EBM is essential to ensure the future sustainability of important marine and coastal ecosystems.

4.7.1 Concluding Points

Several conclusions and recommendations that may help advance ecosystem-based integrated shrimp fishery management incorporation can be addressed in this study, which at the same time covers several identifiable gaps, namely:

- Special attention is required to include wording that reflects EBM principles related to management, stakeholders, participation, and spatial and temporal scales categories in the policies or regulatory responses.
- EBM elements are all interlinked; accordingly, the approach can only be successful when applied in an integrated manner.

- Applying the DPSIR framework as an integrated environmental assessment tool effectively illustrates the cause-and-effect relationships for sustainable shrimp fishery management and is the stepping stone to EBSM.
- The shrimp population, specifically the dominant species in Bahrain (*P. semisulcatus*) seems to be overexploited.
- *P. semisulcatus* is being caught at sizes smaller than the recorded size at sexual maturity in previous studies in the Arabian Gulf. The permitted shrimp size to be caught was specified in Resolution No.195 of 2021 to be not less than 10 cm TL.
- There is no attempt made to find out potential changes in the structure and function of marine ecosystems due to shrimp fishing, especially the bottom trawl nets that still be used illegally by some fishers.
- The issuance of new shrimp fishing licenses has been halted since 2009, but the number of shrimping boats and fishers is still high.
- There is a necessity to issue regulatory measures to specify the data need to be collected and organized by the fishers in logbooks.
- It is of great importance to regulate the shrimp catch by suggesting IFQ and to regulate amateur fishing.
- Data collection that enables the characterization of ecosystem functions and services and how the activities will impact them should be prioritized and strengthened.
- There should be explicit incorporation of the terms associated with ecosystem services in the policies.
- Communication with stakeholders should be improved to promote more inclusive participation in decision-making processes.
- There is a necessity for continuous training and capacity building for key stakeholders, including fishers, managers, and specialists within

the relevant government institutions, etc., or even the creation of a specialized expert group to enhance the incorporation of EBM into the regulatory framework and the implementation process.

- Management plans still need to be developed for the shrimp fishery, and integrative studies are still scarce despite few accounts published on biology and life cycle of Bahrain penaeid shrimps or specific management programs for some protected areas.
- A dedicated guide to EBM incorporation in all steps of the shrimp fishery management process could support how EBM recognition can be improved. Such guide should contain a detailed step-by-step mechanism of the management process represented in a flowchart. It should also present possibilities of EBM incorporation (opportunities rather than only limitations) for each process step.
- The barriers to implement EBM must be identified and overcame with solutions acknowledging resource limitations.
- The lack of strict enforcement of legislations regulating the shrimp fishery may render its protection merely aspirational.

4.7.2 Recommendations for future research

Some key recommendations are suggested that could be integrated into policy, management, and decision-making, include:

- Developing a framework for sustainable shrimp aquaculture through stakeholders' involvement will provide policymakers with helpful information on how to shape effective aquaculture strategies. In addition, training and education are essential to fill the technical-knowledge gap associated with high-tech aquaculture methods considering new feeding and breeding techniques.

- Regular and continuous reporting of the up-to-date statistical data of catches, CPUE, fishing licenses, number of fishers, amateur fishing licenses, and other fisheries data on the Bahrain Open Data Portal of the Information & eGovernment Authority is essential.
- Specifying the best fishing method for catching shrimp in a participatory approach involving fishers.
- Reviewing the status of shared marine resources stock (shrimp and commercial finfish) with adjacent countries.
- Development of an appropriate suite of indicators to test the efficacy of fishery management and to create frameworks against which improvements in marine ecosystems can be judged.
- Conduct a periodic assessment of fishery status and stock by involving all the respective stakeholders.
- Assessing the impacts of bottom trawl nets on different fishing grounds seafloor.
- Developing and integrating innovative technologies to monitor, improve and restore fisheries.
- Research on marine biodiversity and ecosystem function relationships needs to be extended and scaled up to broaden understanding of the linkages between ecosystem functions and services. Many ecosystem services are directly relevant to fisheries management as they support productivity, sustainability, and recovery following disturbance.

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Appendices

Appendix (1): Questionnaire and interview questions for decision maker

University of Bahrain
College of Science

جامعة البحرين
كلية العلوم

التاريخ: ...../ ...../2021م

استطلاع رأي أصحاب القرار والاختصاصيين في الثروة السمكية ومراقبة البيئة البحرية حول القضايا المتعلقة بمصائد الروبيان في مملكة البحرين

المشارك العزيز،

تهدف هذه الدراسة إلى تقييم مصائد الروبيان في مملكة البحرين وذلك باستخدام منهجية التقييم البيئي المتكامل القائم على نهج النظام الإيكولوجي سعياً لتحقيق الهدف الرابع عشر من أهداف التنمية المستدامة (الحياة تحت الماء).

إن المشاركة في هذه الدراسة طوعية تمامًا، ولن تستغرق الإجابة أكثر من 15 دقيقة. وأود التأكيد على أن جميع المعلومات ستبقى سرية تمامًا ولن يتم استخدامها إلا في هذه الدراسة الأكاديمية، كما ولا توجد أجوبة صحيحة أو خاطئة لهذه الأسئلة.

يمكنكم التواصل مع الباحثة عبر البريد الإلكتروني: (20036180@stu.edu.gov.bh) أو عبر الواتساب على هاتف 38409317.

وأشكر لكم مقدماً مشاركتكم القيّمة في هذه الدراسة.

شيماء الوسواسي
طالبة دكتوراه / برنامج البيئة والتنمية المستدامة / جامعة البحرين

الجزء الأول: البيانات الديموغرافية للمشاركين

1.1 الجنسية

☐ بحريني ☐ غير بحريني

1.2 عدد سنوات الخبرة في مجال البيئة البحرية والثروة السمكية

..... سنوات

1.3 أعلى مؤهل أكاديمي

☐ دكتوراه ☐ ماجستير ☐ دبلوم الدراسات العليا

☐ بكالوريوس ☐ أخرى، يرجى التحديد .....

1.4 التخصص الأكاديمي

☐ علوم مصائد الأسماك ☐ علم الأحياء البحرية ☐ علوم الحياة

☐ علوم بيئية ☐ أخرى، يرجى التحديد .....

1.5 جهة العمل

☐ وكالة الزراعة والثروة البحرية ☐ إدارة الثروة السمكية ☐ إدارة الرقابة البحرية

☐ المجلس الأعلى للبيئة ☐ قيادة خفر السواحل ☐ المركز الوطني للاستزراع البحري

☐ جامعة البحرين ☐ جامعة الخليج العربي ☐ أخرى، يرجى التحديد

.....

1.6 المسمى الوظيفي

☐ مدير ☐ رئيس قسم ☐ رئيس شعبة / مجموعة

☐ اختصاصي أول ☐ اختصاصي ☐ أستاذ

☐ أستاذ مشارك ☐ أستاذ مساعد ☐ أخرى، يرجى التحديد

.....

الجزء الثّاني: نهج النظام الايكولوجي

هي استراتيجية للإدارة المتكاملة للاراضي والمياه والموارد الحية، تعزز الحفظ والاستخدام المستدام بطريقة منصفة[1]

ما هو رأيك حول كلٍ من العبارات التالية، يرجى توضيح ما إذا كنت موافق تماماً ،أو موافق أو محايد، أو غير موافق أو غير موافق إطلاقاً.

حالة مصائد الروبيان **Status of shrimp fisheries**

#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
S1	تعتبر مصائد الروبيان بحالة جيدة	☐	☐	☐	☐	☐
S2	يؤدي معدل الاستغلال الحالي لمصائد الروبيان والنقص الطبيعي في كميات الروبيان إلى نقص كمية الروبيان مستقبلاً	☐	☐	☐	☐	☐
S3	يؤثر صيد الهواة في مخزون الروبيان	☐	☐	☐	☐	☐
S4	يؤثر الصيد بدون ترخيص في مخزون الروبيان	☐	☐	☐	☐	☐
S5	يتم توفير الخرائط البحرية والاحداثيات للصيادين لتحديد المواقع المسموح بها لصيد الروبيان	☐	☐	☐	☐	☐
S6	يستفيد مرتادو البحر وهواة الصيد البحري من التنوع البيولوجي البحري في المحميات البحرية	☐	☐	☐	☐	☐

[1] **منظمة الأغذية والزراعة**. 2019. استراتيجية منظمة الأغذية والزراعة الخاصة بتعميم التنوع البيولوجي عبر مختلف القطاعات الزراعية. روما. www.fao.org/3/m2518ar.pdf

Status of shrimp fisheries						حالة مصاند الروبيان
غير موافق إطلاقاً	غير موافق	محايد	موافق	موافق تماماً	البيان	#
☐	☐	☐	☐	☐	من الضروري عمل تقييم دوري لمصاند الروبيان بالاشتراك مع الصيادين وفق مؤشرات علمية	S7

Management of shrimp fisheries						إدارة مصاند الروبيان
غير موافق إطلاقاً	غير موافق	محايد	موافق	موافق تماماً	البيان	#
☐	☐	☐	☐	☐	يتم صيد الروبيان من قبل الصيادين بكل مسؤولية ووفق التشريعات والقوانين	M1
☐	☐	☐	☐	☐	من الأهمية تعاون مراكز الأبحاث في المؤسسات الحكومية المعنية في الحفاظ على الثروة البحرية مع مؤسسات التعليم العالي	M2
☐	☐	☐	☐	☐	يتم إشراك الأكاديميين بمؤسسات التعليم العالي مع المؤسسات الحكومية ذات العلاقة في اتخاذ القرارات المتعلقة بالاستغلال المستدام لمصاند الروبيان	M3
☐	☐	☐	☐	☐	يتم إشراك الصيادين أو من يمثلهم من جمعيات الصيادين مع المؤسسات الحكومية ذات العلاقة في اتخاذ القرارات المتعلقة بالاستغلال المستدام لمصاند الروبيان	M4
☐	☐	☐	☐	☐	يتم إشراك الصيادين أو من يمثلهم من جمعيات الصيادين في اجتماعات أو ندوات أو ورش عمل حول القضايا التي تتعلق بإدارة مصاند الروبيان	M5
☐	☐	☐	☐	☐	يتم إشراك المواطنين والمقيمين من مرتادي البحر (الهواة والنوادي البحرية) - للاستئناس بآرائهم - مع المؤسسات الحكومية ذات العلاقة في معالجة وحل القضايا التي تتعلق بإدارة مصاند الروبيان	M6
☐	☐	☐	☐	☐	يوجد هناك تعاون بين العاملين في قطاع صيد الروبيان وواضعي السياسات لإدارة مصاند الروبيان على نحو مستدام	M7
☐	☐	☐	☐	☐	تعتبر الحكومة وحدها الجهة المسؤولة عن إدارة مصاند الروبيان وإصدار القرارات للمحافظة على مخزون الروبيان وإستدامة إستغلاله	M8

القضايا الاقتصادية المرتبطة بمصائد الروبيان		Economic issues related to shrimp fisheries				
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
E1	توجد زيادة في الطلب على شراء الروبيان حالياً	☐	☐	☐	☐	☐
E2	يتم تصدير حوالى (30%) من الروبيان المصطاد إلى خارج البحرين	☐	☐	☐	☐	☐
E3	يسهم قرار منع الصيد بشباك الجر القاعية (الكراف) في زيادة المعروض من الأسماك	☐	☐	☐	☐	☐
E4	تعتبر تكلفة صيد الروبيان مرتفعة بسبب بُعد موقع الصيد	☐	☐	☐	☐	☐
E5	تعتبر تكلفة صيد الروبيان مرتفعة نسبياً بسبب ارتفاع أسعار المحروقات (الوقود)	☐	☐	☐	☐	☐
E6	تعتبر تكلفة صيد الروبيان مرتفعة نسبياً بسبب طول المدة الزمنية التي يستغرقها صيده	☐	☐	☐	☐	☐
E7	ترتفع أسعار الروبيان بسبب قلة المعروض وزيادة الطلب عليه	☐	☐	☐	☐	☐
E8	تأثرت كمية صيد الروبيان بشكل واضح خلال فترة جائحة كورونا	☐	☐	☐	☐	☐
E9	شهد جهد الصيد (عدد أيام وساعات الصيد) انخفاضاً ملحوظاً خلال فترة جائحة كورونا	☐	☐	☐	☐	☐
E10	تم خفض عدد الصيادين العاملين على قارب صيد الروبيان (بشكل استثنائي) خلال فترة جائحة كورونا	☐	☐	☐	☐	☐
E11	ارتفعت أسعار الروبيان خلال فترة جائحة كورونا بسبب قلة عمليات الصيد	☐	☐	☐	☐	☐
E12	سجلت إصابات مؤكدة لبعض الصيادين بفيروس كورونا	☐	☐	☐	☐	☐
E13	تم تسجيل حالات وفيات بفيروس كورونا بين الصيادين	☐	☐	☐	☐	☐
E14	طبق قطاع الصيد التدابير الوقائية والإجراءات الاحترازية الصادرة من الفريق الوطني للتصدي لفيروس "كورونا" والجهات المعنية عند ممارسة الصيد	☐	☐	☐	☐	☐
E15	تقوم الجهات المعنية بعمل زيارات تفتيشية ميدانية للتأكد من تطبيق الإجراءات الاحترازية للتصدي لفيروس كورونا	☐	☐	☐	☐	☐
E16	تأثرت الحالة المعيشية للصيادين خلال فترة جائحة كورونا	☐	☐	☐	☐	☐

القضايا الاقتصادية المرتبطة بمصائد الروبيان	Economic issues related to shrimp fisheries					
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
E17	يقوم بعض الصيادين بممارسة الصيد خارج المياه الإقليمية لمملكة البحرين	☐	☐	☐	☐	☐
E18	يقوم بعض الصيادين من دول الجوار بالصيد في المياه الإقليمية لمملكة البحرين	☐	☐	☐	☐	☐
E19	يُساعد زيادة سفن الرقابة على إلتزام الصيادين بتشريعات وقوانين إدارة مصائد الروبيان	☐	☐	☐	☐	☐
E20	يتم تقديم خدمات مُيسرة التكاليف للصيادين لتشجيعهم للالتزام بضوابط صيد الروبيان	☐	☐	☐	☐	☐
E21	توجد خلافات ونزاعات بين الصيادين حول مناطق صيد الروبيان	☐	☐	☐	☐	☐
E22	يعد خفض عدد قوارب صيد الروبيان ضرورياً لخفض جهد الصيد البحري	☐	☐	☐	☐	☐
E23	توجد ضرورة لخفض عدد الصيادين العاملين على قارب صيد الروبيان	☐	☐	☐	☐	☐
E24	هناك حاجة لاستزراع الروبيان في مملكة البحرين	☐	☐	☐	☐	☐
E25	يتم إجراء تقييم اقتصادي لمصائد الروبيان بشكل دوري	☐	☐	☐	☐	☐

الآثار البيئية المترتبة على عمليات صيد الروبيان	Impacts of shrimp fishing					
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
I1	تعتبر مواصفات وسيلة صيد الروبيان المسموح بها مناسبة	☐	☐	☐	☐	☐
I2	تستخدم الشباك الانتقائية لفرز مصيد الروبيان عن الأحياء البحرية الأخرى (الصيد الجانبي) أثناء عملية الصيد	☐	☐	☐	☐	☐
I3	تؤثر الأنشطة البشرية كالحفر والردم في السواحل على مصائد الروبيان ومخزونها	☐	☐	☐	☐	☐
I4	يسهم تلوث البيئات الساحلية في إنخفاض مخزون الروبيان	☐	☐	☐	☐	☐
I5	توجد شباك تالفة ومهملة في مناطق صيد الروبيان	☐	☐	☐	☐	☐
I6	تؤثر ممارسات صيد الروبيان غير المرخص به على بيئات الأعشاب البحرية والشعاب المرجانية القريبة من مناطق صيد الروبيان	☐	☐	☐	☐	☐

الآثار البيئية المترتبة على عمليات صيد الروبيان					Impacts of shrimp fishing	
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
I7	تم تسجيل حالات وقوع سلاحف في شباك صيد الروبيان	☐	☐	☐	☐	☐
I8	تم تسجيل حالات وقوع دلافين في شباك صيد الروبيان	☐	☐	☐	☐	☐
I9	تم تسجيل حالات وقوع بقر البحر في شباك صيد الروبيان	☐	☐	☐	☐	☐
I10	يسهم تمديد فترة حظر صيد الروبيان لمدة ست أشهر في تنمية مخزون الروبيان	☐	☐	☐	☐	☐
I11	تسهم التغيرات المناخية في تناقص إنتاجية مصائد الروبيان	☐	☐	☐	☐	☐
I12	تم تقدير تكلفة الضرر البيني الذي نجم عن صيد الروبيان باستخدام شباك الجر القاعية	☐	☐	☐	☐	☐
I13	يتم تقييم الأثر البيني للمشاريع التنموية الساحلية والبحرية على مصائد الروبيان	☐	☐	☐	☐	☐

القوانين والأنظمة للمحافظة على مخزون الروبيان					Rules and regulations to preserve shrimp stocks	
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
R1	عدم تقيّد بعض الصيادين وهواة الصيد بقرار منع صيد الروبيان خلال فترة حظر الصيد	☐	☐	☐	☐	☐
R2	لايزال بعض الصيادين يستخدمون شباك الجر القاعية (الكراف)	☐	☐	☐	☐	☐
R3	لايزال بعض الصيادين غير ملتزمين بتطبيق الأنظمة والقوانين المتعلقة بالصيد في مناطق يحظر فيها صيد الروبيان	☐	☐	☐	☐	☐
R4	يتم تنظيم ورش عمل لتوعية الصيادين وهواة الصيد بالتشريعات المعتمدة	☐	☐	☐	☐	☐
R5	يتم تنظيم ورش توعوية للصيادين قبل بدء موسم صيد الروبيان حول ممارسات الصيد المسموحة	☐	☐	☐	☐	☐
R6	يتم توعية الصيادين بالآثار السلبية لممارسة الصيد غير المصرح به	☐	☐	☐	☐	☐
R7	يتم شرح الوسائل المناسبة لصيد الروبيان البديلة عن شباك الجر القاعية (الكراف) للصيادين	☐	☐	☐	☐	☐

القوانين والأنظمة للمحافظة على مخزون الروبيان		Rules and regulations to preserve shrimp stocks				
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
R8	تقوم الجهات المختصة بشؤون الثروة السمكية بإبلاغ الصيادين بموسم صيد الروبيان سنويا	☐	☐	☐	☐	☐
R9	توجد برامج رقابة لمنع الانتهاكات في مصائد الروبيان	☐	☐	☐	☐	☐
R10	تنص التشريعات على مشاركة الصيادين في صنع السياسات ذات العلاقة بإدارة مصائد الروبيان	☐	☐	☐	☐	☐
R11	تعد سياسات وقرارات ضمان استدامة موارد الروبيان فاعلة وتحقق الغرض المطلوب	☐	☐	☐	☐	☐
R12	تطبق العقوبات على مخالفي قوانين صيد الروبيان بصرامة	☐	☐	☐	☐	☐
R13	يسهم توحيد فترة حظر صيد الروبيان في دول الخليج في تنمية مخزون الروبيان	☐	☐	☐	☐	☐
R14	يسهم إعادة تأهيل خليج توبلي في انعاش مخزون الروبيان	☐	☐	☐	☐	☐
R15	يسهم الحفاظ على النظم البيئية في فشت العظم على تعزيز امداد مخزون الروبيان	☐	☐	☐	☐	☐
R16	يسهم إعادة تأهيل بيئات أشجار القرم في استدامة مخزون الروبيان	☐	☐	☐	☐	☐

R17	برأيك ما الإجراءات الأخرى التي تقترح اتخاذها للمساعدة في إستدامة مصائد الروبيان في مملكة البحرين؟	....
R18	بمناسبة عقد الأمم المتحدة لاستعادة النظم الايكولوجية 2021-2030، ما المواقع ذات الأولوية في البيئات الساحلية بمملكة البحرين والتي تقترح البدء في استعادتها ضمن جهود المملكة في استعادة نظمها البيئية المتدهورة؟	....

مقابلة شخصية مع أصحاب القرار والاختصاصيين في الثروة السمكية ومراقبة البيئة البحرية

1- ما المناطق المسموح بممارسة مهنة صيد الروبيان فيها؟

.....

2- من هم المستفيدون المباشرون من مصائد الروبيان الآن؟ (اختيار أكثر من إجابة)

الصيادون ( )	الهواة ( )	أخرى ( )

3- هل يسمح بأن يكون للصياد رخصة لصيد الروبيان وأخرى لصيد الأسماك في آن واحد؟ □ نعم ، □ لا

4- ما هي المناطق الغنية بمصائد الروبيان في مملكة البحرين؟ الرجاء ذكر الاسماء المحلية للمناطق.

.....

.....

.....

5- ما هي المناطق المفضلة لصيادي الروبيان ؟

.....

.....

6- ما هي أنواع الروبيان المتوافرة في المياه الاقليمية البحرينية؟

.....

.....

7- ما الكائنات البحرية المهمة اقتصادياً التي تُصاد بشكل عرضي أو جانبي أثناء صيد الروبيان؟

(ضع دائرة حول تلك الكائنات البحرية)

السلاحف	الدلافين	بقر البحر	الصافي	الشعري	القبقب	الخشاق

أخرى (حددها رجاءً): .....

8- ما هي المناطق البحرية التي يمنع فيها صيد الروبيان؟ وحدد أسباب المنع.

اسم المنطقة التي يمنع صيد الروبيان فيها	أسباب منع صيد الروبيان في المنطقة		
	بيئية	أمنية	أخرى (حدد رجاءً)

9- ماهي أكثر وسائل صيد الروبيان شيوعاً في البحرين حالياً؟

.....

.....

10- كيف تتم مراقبة عمليات صيد الروبيان في البحرين؟

.....

.....

11- ما هي مدة صلاحية ترخيص صيد الروبيان؟

.....

12- أذكر الإجراءات والسياسات المطبقة في قطاع الصيد حالياً لضمان استدامة مصائد الروبيان؟

أ .....

ب .....

ج .....

13- ما هي الأنشطة التي يمارسها الصيادون وتؤثر سلباً على مصائد الروبيان؟

أ .....

ب .....

ج .....

14- حسب اطلاعك وخبرتك، ما مصادر دخل صيادي الروبيان خلال فترة حظر صيد الروبيان؟

.....

15- ما كمية الروبيان المسموح بصيدها في المرة الواحدة؟ (إن وجدت)

.....

16- حسب معلوماتك، كم تستغرق رحلة صيد الروبيان عادة (بالأيام)؟ ..... يوم

17- ما المساعدات التي تقدمها الدولة لصيادي الروبيان؟

.....

18- هل يتم منح صيادي الروبيان قرض من الجهات الحكومية المعنية؟

نعم ( ) ومقداره ..... دينار	لا ( )

19- كم عدد المخالفات التي تم ضبطها في عامي 2019 و2020م مع تحديد نوعها وكمية الروبيان الذي تم مصادرته؟

السنة	إجمالي عدد المخالفات	نوع المخالفات	مجمل كمية الروبيان المصادر بالكيلو
2019			
2020			

20- هل تأثرت المتغيرات التالية لصيد الروبيان بسبب جائحة كورونا؟

المتغير	لا	نعم	السبب
كمية الصيد			
عدد قوارب الصيد			
رخص صيد الروبيان			
فترات الصيد			
عدد الصيادين			
أسعار الروبيان			

21- هل توجد خطة لإدارة مناطق حضانة الروبيان؟

نوع الخطة	غير موجودة	موجودة مطبقة	موجودة غير مطبقة	لا أعلم
خطة قصيرة				
خطة طويلة				

22- هل توجد خطة لإدارة مناطق صيد الروبيان؟

نوع الخطة	غير موجودة	موجودة مطبقة	موجودة غير مطبقة	لا أعلم
خطة قصيرة				
خطة طويلة				

23- ما الخطط والإجراءات التي تقترحها والتي تعتقد أنها تساعد في استدامة مصائد الروبيان؟

	على المدى القصير	على المدى الطويل
أ		
ب		
ج		

24- بمناسبة عقد الأمم المتحدة لاستعادة النظم الايكولوجية 2021-2030، ما المواقع ذات الأولوية في البيئات الساحلية بمملكة البحرين والتي تقترح البدء في استعادتها ضمن جهود المملكة في استعادة نظمها البيئية المتدهورة؟

.....

.....

Appendix (2): Questionnaire and interview questions for fishers

University of Bahrain
College of Science



جامعة البحرين
كلية العلوم

التاريخ: ...../ ...../2021م

استطلاع رأي صيادي الروبيان حول القضايا المتعلقة بمصائد الروبيان في مملكة البحرين

المشارك العزيز،

تهدف هذه الدراسة إلى تقييم مصائد الروبيان في مملكة البحرين وذلك باستخدام منهجية التقييم البيئي المتكامل القائم على نهج النظام الإيكولوجي سعياً لتحقيق الهدف الرابع عشر من أهداف التنمية المستدامة (الحياة تحت الماء).

إن المشاركة في هذه الدراسة طوعية تمامًا، ولن تستغرق الإجابة أكثر من 15 دقيقة. وأود التأكيد على أن جميع المعلومات ستبقى سرية تمامًا ولن يتم استخدامها إلا في هذه الدراسة الأكاديمية، كما ولا توجد أجوبة صحيحة أو خاطئة لهذه الأسئلة.

يمكنكم التواصل مع الباحثة عبر البريد الإلكتروني: (20036180@stu.edu.gov.bh) أو عبر الواتساب على هاتف 38409317.

وأشكر لكم مقدماً مشاركتكم القيّمة في هذه الدراسة.

شيماء الوسواسي
طالبة دكتوراه / برنامج البيئة والتنمية المستدامة / جامعة البحرين

الجزء الأول: البيانات الديموغرافية للمشاركين

1.1 الجنسية

☐ بحريني ☐ غير بحريني

1.2 سنة الميلاد

.....

1.3 أعلى مؤهل أكاديمي

☐ ابتدائي ☐ اعدادي ☐ ثانوي

☐ دبلوما ☐ بكالوريوس ☐ أخرى، يرجى التحديد

.....

1.4 المحافظة

☐ العاصمة ☐ المحرق ☐ الشمالية ☐ الجنوبية

1.5 مكان السكن

.....

1.6 ملكية السكن

☐ مُلك ☐ مستأجر ☐ أخرى، يرجى التحديد

.....

1.7 هل تُعيل أسرة؟

☐ نعم ☐ لا

1.8 العدد الكلي لأفراد الأسرة القاطنة في نفس المنزل

.....

1.9 عدد الأشخاص العاملين في الأسرة

.....

1.10 هل تقوم بصيد

☐ الروبيان فقط ☐ الروبيان والأسماك ☐ الأسماك فقط

1.11 أنت تصطاد من خلال البحارة المقيدين ضمن الترخيص التابع لك

☐ نعم ☐ لا

1.12 الصيد هو مصدر رزقك الوحيد

☐ نعم ☐ لا، لدي عمل آخر

1.13 حالة العمل (إذا كان لديك عمل آخر بجانب الصيد)

☐ موظف بدوام كامل ☐ موظف بدوام جزئي ☐ أخرى، يرجى التحديد

.....

1.14 سبب ممارستك للصيد (التأشير على أكثر من إجابة)

☐ تقليد عائلي متوارث ☐ مصدر دخل إضافي ☐ مصدر دخل رئيس

☐ هواية ☐ أخرى، يرجى التحديد .....

1.15 لديك قارب خاص بك للصيد

☐ نعم ☐ لا

1.16 إن كنت أنت المالك، ما عدد القوارب التي تملكها؟

.....

1.17 حدد نوع وعدد قوارب الصيد التي تملكها أو تعمل عليها

عدد القوارب	نوع القارب	محرك القارب	الطول الكلي (بالمتر)	عمر القارب
القارب الأول				
القارب الثاني				

1.18 عدد سنوات خبرة العمل في مصائد الروبيان

.....

1.19 هل سبق وإن سُجلت عليك مخالفة تتعلق بمهنتك كصياد أو كمالك لقارب صيد خلال الخمس سنوات الماضية؟

☐ لا ☐ نعم

عدد المخالفات: .....

سببها هو .....

الجزء الثاني: نهج النظام الايكولوجي

هي استراتيجية للإدارة المتكاملة للاراضي والمياه والموارد الحية، تعزز الحفظ والاستخدام المستدام بطريقة منصفة[1]

ما هو رأيك حول كلٍ من العبارات التالية، يرجى توضيح ما إذا كنت موافق تماماً ،أو موافق أو محايد، أو غير موافق أو غير موافق إطلاقاً.

حالة مصائد الروبيان	Status of shrimp fisheries					
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
S1	تعتبر مصائد الروبيان بحالة جيدة	☐	☐	☐	☐	☐
S2	يؤدي معدل الاستغلال الحالي لمصائد الروبيان والنقص الطبيعي في كميات الروبيان إلى نقص كمية الروبيان مستقبلاً	☐	☐	☐	☐	☐
S3	يؤثر صيد الهواة في مخزون الروبيان	☐	☐	☐	☐	☐
S4	يؤثر الصيد بدون ترخيص في مخزون الروبيان	☐	☐	☐	☐	☐

[1] **منظمة الأغذية والزراعة**. 2019. استراتيجية منظمة الأغذية والزراعة الخاصة بتعميم التنوع البيولوجي عبر مختلف القطاعات الزراعية. روما. www.fao.org/3/m2518ar.pdf

Status of shrimp fisheries						حالة مصائد الروبيان
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
S5	يستفيد الصيادون من جميع مناطق صيد الروبيان	☐	☐	☐	☐	☐
S6	يتم توفير الخرائط البحرية والاحداثيات للصيادين لتحديد المواقع المسموح بها لصيد الروبيان	☐	☐	☐	☐	☐

Management of shrimp fisheries						إدارة مصائد الروبيان
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
M1	تتم عمليات صيد الروبيان وفق التشريعات والقوانين	☐	☐	☐	☐	☐
M2	يستخدم الصيادون حالياً طرق جديدة مسموح بها لصيد الروبيان	☐	☐	☐	☐	☐
M3	يتم التواصل بين المؤسسات الحكومية المعنية بالثروة السمكية والصيادين من خلال جمعيات الصيادين	☐	☐	☐	☐	☐
M4	يتم إشراك الصيادين أو من يمثلهم من جمعيات الصيادين مع المؤسسات الحكومية ذات العلاقة في صناعة القرارات المتعلقة بمصائد الروبيان	☐	☐	☐	☐	☐
M5	يتم إشراك الصيادين أو من يمثلهم من جمعيات الصيادين في اجتماعات أو ندوات أو ورش عمل حول القضايا التي تتعلق بإدارة مصائد الروبيان	☐	☐	☐	☐	☐
M6	تعتبر الحكومة وحدها الجهة المسؤولة عن إدارة مصائد الروبيان وإصدار القرارات للمحافظة على مخزون الروبيان وإستدامة إستغلاله	☐	☐	☐	☐	☐

Economic issues related to shrimp fisheries						القضايا الاقتصادية المرتبطة بمصائد الروبيان
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
E1	توجد زيادة في الطلب على شراء الروبيان حالياً	☐	☐	☐	☐	☐
E2	يتم تصدير حوالي (30%) من الروبيان المصطاد إلى خارج البحرين	☐	☐	☐	☐	☐
E3	يسهم قرار منع الصيد بشباك الجر القاعية (الكراف) في زيادة المعروض من الأسماك	☐	☐	☐	☐	☐

القضايا الاقتصادية المرتبطة بمصائد الروبيان		Economic issues related to shrimp fisheries				
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
E4	تعتبر تكلفة صيد الروبيان مرتفعة بسبب بُعد موقع الصيد	☐	☐	☐	☐	☐
E5	تعتبر تكلفة صيد الروبيان مرتفعة نسبياً بسبب ارتفاع أسعار المحروقات (الوقود)	☐	☐	☐	☐	☐
E6	تعتبر تكلفة صيد الروبيان مرتفعة نسبياً بسبب طول المدة الزمنية التي يستغرقها صيده	☐	☐	☐	☐	☐
E7	ترتفع أسعار الروبيان بسبب قلة المعروض وزيادة الطلب عليه	☐	☐	☐	☐	☐
E8	تأثرت كمية صيد الروبيان بشكل واضح خلال فترة جائحة كورونا	☐	☐	☐	☐	☐
E9	شهد جهد الصيد (عدد أيام وساعات الصيد) انخفاضاً ملحوظاً خلال فترة جائحة كورونا	☐	☐	☐	☐	☐
E10	تم خفض عدد الصيادين العاملين على قارب صيد الروبيان (بشكل استثنائي) خلال فترة جائحة كورونا	☐	☐	☐	☐	☐
E11	ارتفعت أسعار الروبيان خلال فترة جائحة كورونا بسبب قلة عمليات الصيد	☐	☐	☐	☐	☐
E12	سجلت إصابات مؤكدة لبعض الصيادين بفيروس كورونا	☐	☐	☐	☐	☐
E13	تم تسجيل حالات وفيات بفيروس كورونا بين الصيادين	☐	☐	☐	☐	☐
E14	طبق قطاع الصيد التدابير الوقائية والإجراءات الاحترازية الصادرة من الفريق الوطني للتصدي لفيروس "كورونا" والجهات المعنية عند ممارسة الصيد	☐	☐	☐	☐	☐
E15	تقوم الجهات المعنية بعمل زيارات تفتيشية ميدانية للتأكد من تطبيق الإجراءات الاحترازية للتصدي لفيروس كورونا	☐	☐	☐	☐	☐
E16	تأثرت الحالة المعيشية للصيادين خلال فترة جائحة كورونا	☐	☐	☐	☐	☐
E17	يقوم بعض الصيادين بممارسة الصيد خارج المياه الإقليمية لمملكة البحرين	☐	☐	☐	☐	☐
E18	يقوم بعض الصيادين من دول الجوار بالصيد في المياه الإقليمية لمملكة البحرين	☐	☐	☐	☐	☐
E19	يُساعد زيادة سفن الرقابة على إلتزام الصيادين بتشريعات وقوانين إدارة مصائد الروبيان	☐	☐	☐	☐	☐

القضايا الاقتصادية المرتبطة بمصائد الروبيان		Economic issues related to shrimp fisheries				
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
E20	يتم تقديم خدمات مُيسرة التكاليف للصيادين لتشجيعهم للالتزام بضوابط صيد الروبيان	☐	☐	☐	☐	☐
E21	توجد خلافات ونزاعات بين الصيادين حول مناطق صيد الروبيان	☐	☐	☐	☐	☐
E22	يعد خفض عدد قوارب صيد الروبيان ضرورياً لخفض جهد الصيد البحري	☐	☐	☐	☐	☐
E23	توجد ضرورة لخفض عدد الصيادين العاملين على قارب صيد الروبيان	☐	☐	☐	☐	☐
E24	هناك حاجة لاستزراع الروبيان في مملكة البحرين	☐	☐	☐	☐	☐

الآثار البيئية المترتبة على عمليات صيد الروبيان		Impacts of shrimp fishing				
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
I1	تعتبر مواصفات وسيلة صيد الروبيان المسموح بها مناسبة	☐	☐	☐	☐	☐
I2	تستخدم الشباك الانتقائية لفرز مصيد الروبيان عن الأحياء البحرية الأخرى (الصيد الجانبي) أثناء عملية الصيد	☐	☐	☐	☐	☐
I3	تؤثر الأنشطة البشرية كالحفر والردم في السواحل على مصائد الروبيان ومخزونها	☐	☐	☐	☐	☐
I4	يسهم تلوث البيئات الساحلية في إنخفاض مخزون الروبيان	☐	☐	☐	☐	☐
I5	توجد شباك تالفة ومهملة في مناطق صيد الروبيان	☐	☐	☐	☐	☐
I6	تؤثر ممارسات صيد الروبيان غير المرخص به على بيئات الأعشاب البحرية والشعاب المرجانية القريبة من مناطق صيد الروبيان	☐	☐	☐	☐	☐
I7	تم تسجيل حالات وقوع سلاحف في شباك صيد الروبيان	☐	☐	☐	☐	☐
I8	تم تسجيل حالات وقوع دلافين في شباك صيد الروبيان	☐	☐	☐	☐	☐
I9	تم تسجيل حالات وقوع بقر البحر في شباك صيد الروبيان	☐	☐	☐	☐	☐
I10	يسهم تمديد فترة حظر صيد الروبيان لمدة ست أشهر في تنمية مخزون الروبيان	☐	☐	☐	☐	☐

القوانين والأنظمة للمحافظة على مخزون الروبيان		Rules and regulations to preserve shrimp stocks				
#	البيان	موافق تماماً	موافق	محايد	غير موافق	غير موافق إطلاقاً
R1	يتم الإعلان عن فترة موسم حظر صيد الروبيان بمُدة زمنية ملائمة لإحاطة الصيادين	☐	☐	☐	☐	☐
R2	عدم تقيّد بعض الصيادين وهواة الصيد بقرار منع صيد الروبيان خلال فترة حظر الصيد	☐	☐	☐	☐	☐
R3	لايزال بعض الصيادين يستخدمون شباك الجر القاعية (الكراف) لصيد الروبيان	☐	☐	☐	☐	☐
R4	لايزال بعض الصيادين غير ملتزمين بتطبيق الأنظمة والقوانين المتعلقة بالصيد في مناطق يحظر فيها صيد الروبيان	☐	☐	☐	☐	☐
R5	يتم تنظيم ورش عمل لتوعية الصيادين وهواة الصيد بالتشريعات المعتمدة	☐	☐	☐	☐	☐
R6	يتم تنظيم ورش توعوية للصيادين قبل بدء موسم صيد الروبيان حول ممارسات الصيد المسموحة	☐	☐	☐	☐	☐
R7	يتم توعية الصيادين بالآثار السلبية لممارسة الصيد غير المصرح به	☐	☐	☐	☐	☐
R8	يتم شرح الوسائل المناسبة لصيد الروبيان البديلة عن شباك الجر القاعية (الكراف) للصيادين	☐	☐	☐	☐	☐
R9	تقوم الجهات المختصة بشؤون الثروة السمكية بابلاغ الصيادين بموسم صيد الروبيان سنويًا	☐	☐	☐	☐	☐
R10	توجد برامج رقابة لمنع الانتهاكات في مصائد الروبيان	☐	☐	☐	☐	☐
R11	تطبق العقوبات على مخالفي قوانين صيد الروبيان بصرامة	☐	☐	☐	☐	☐

R12	برأيك ما الإجراءات الأخرى التي تقترح اتخاذها للمساعدة في إستدامة مصائد الروبيان في مملكة البحرين؟	....

عزيزي الصياد لا مانع إن كانت لديك الرغبة بالإدلاء بمعلوماتك الشخصية أدناه:

الاسم: ..... رقم الهاتف: .....

مقابلة شخصية مع صيادي الروبيان

1- عرف بنفسك؟

مالك لقارب صيد الروبيان فقط ( )	مالك لقارب صيد الروبيان والأسماك ( )
صياد روبيان فقط ( )	صياد روبيان وأسماك ( )

2- هل تعود ملكية القارب

لك ( )	لشركة ( )	لجماعة ( )	أخرى ( )

3- ما افضل ثلاث مناطق لصيد الروبيان في البحرين؟ ولماذا؟

	اسم المنطقة	السبب
1		
2		
3		

4- ما هي أنواع الروبيان المتوافرة في مناطق صيد الروبيان؟

.....

5- أجب عن ما يلي (مع ذكر السبب رجاءً):

السؤال	نعم	لا	السبب
هل تستمر بالصيد في نفس المنطقة طوال الموسم؟			
هل يختلف نوع الروبيان من منطقة لأخرى؟			
هل يختلف حجم الروبيان من منطقة لأخرى؟			
هل تؤيد استخدام شباك صيد الروبيان الانتقائي؟			

6- ماهي الوسائل التي تستخدمها لصيد الروبيان؟

.....

.....

7- ما الكائنات البحرية المهمة اقتصادياً التي تُصاد بشكل عرضي أو جانبي أثناء صيد الروبيان.

(ضع دائرة حول تلك الكائنات البحرية)

السلاحف	الدلافين	بقر البحر	الصافي	الشعري	القبقب	الخثاق

أخرى (حددها رجاءً): .....

8- من خلال خبرتك، أجب عن ما يلي:

العبارة	الفترة الزمنية		السبب
	من شهر	إلى شهر	
أفضل فترة لصيد الروبيان في الموسم			
الفترة الزمنية التي تراها مناسبة لحظر صيد الروبيان			

9- ماهي المناطق البحرية التي يمنع فيها صيد الروبيان؟ وحدد أسباب المنع.

اسم المنطقة التي يمنع صيد الروبيان فيها	أسباب منع صيد الروبيان في المنطقة		
	بيئية	أمنية	أخرى (حدد رجاءً)

10- هل تأثرت المتغيرات التالية لصيد الروبيان بسبب جائحة كورونا؟

المتغير	لا	نعم	السبب
كمية الصيد			
عدد قوارب الصيد			
رخص صيد الروبيان			
فترات الصيد			
عدد الصيادين			
أسعار الروبيان			

11- ما الأنشطة التي يمارسها الصيادون وتؤثر سلباً على مصائد الروبيان؟

1) .....

2) .....

12- ما هي الإجراءات والتدابير التي تراها ضرورية لحماية وتنمية مخزون الروبيان وجعله أكثر إنتاجية؟

1) .....

2) .....

3) .....

13- حسب تقديرك، حدد التالي:

اجمالي عدد رحلات صيد الروبيان التي تقوم بها في الموسم الواحد	
كميات الروبيان التي تصطاد خلال رحلة الصيد الواحدة	
عدد أيام رحلة صيد الروبيان	

14- كم كيلو من الروبيان تصطاد في الموسم الواحد؟

قبل عشر سنوات	
قبل خمس سنوات	
الآن 2020	

15- ماهي المصروفات الشهرية (التشغيلية):

أوجه الصرف	شهرياً (بالدينار البحريني)
شراء معدات الصيد	
صيانة القارب	
وقود للقارب	
رواتب العمال لديك	
أخرى	

16- ما متوسط دخلك من موسم الروبيان في الأعوام الثلاث الأخيرة؟ ..... دينار

17- ما مصادر دخلك خلال أشهر حظر صيد الروبيان؟

.....

18- ما الدعم / المساعدة التي تقدمها الدولة لصيادي الروبيان؟

.....

19- هل يتم منحك قرض من الجهات الحكومية؟

نعم ( ) ومقداره ..... دينار من هي هذه الجهات الحكومية:.....	لا ( )

Appendix (3): Annual catch (kg), Catch per unit effort (CPUE) (kg/boats) during 1980/1981 to 2020

Year	Catch (kg)	Number of shrimp licenses (boats)	CPUE (kg/boats)
1980/1981	625,500	NA	-
1981/1982	543,500	68	7,993
1982/1983	685,400	NA	-
1983/1984	727,500	NA	-
1984/1985	778,100	NA	-
1985/1986	1,444,200	NA	-
1986/1987	1,313,200	NA	-
1987/1988	1,695,100	NA	-
1988/1989	1,072,600	NA	-
1989/1990	1,258,200	NA	-
1990/1991	1,150,800	324	3,552
1991/1992	620,400	266	2,332
1992/1993	806,700	210	3,841
1993/1994	2,079,300	203	10,243
1994/1995	1,115,500	244	4,572
1995/1996	1,666,000	245	6,800
1996/1997	3,799,800	259	14,671
1997/1998	2,247,000	288	7,802
1998/1999	NA	355	-
1999/2000	NA	403	-
2000/2001	NA	387	-
2001/2002	NA	394	-
2002/2003	NA	376	-
2003/2004	1,584,691	377	4,203
2004/2005	1,107,097	351	3,154
2005/2006	1,951,420	352	5,544
2006/2007	2,793,958	345	8,098
2007/2008	2,402,937	312	7,702
2008/2009	3,431,675	325	10,559
2010	4,666,968	352	13,258
2011	2,536,554	NA	-
2012	2,494,667	NA	-
2013	3,083,157	NA	-
2014	2,964,860	382	7,761
2015	3,544,857	374	9,478
2016	2,973,350	256	11,615

Year	Catch (kg)	Number of shrimp licenses (boats)	CPUE (kg/boats)
2017	4,277,944	263	16,266
2018	2,292,506	276	8,306
2019	1,315	271	5
2020	2,170	271	8

NA: Not Available

Source: MUN, 2022; MUN, 2011; Fisheries Directorate

Note: Number of boats licenses from 2010-2021 were collected from news archives published on the MUN website.

Appendix (4): A comparison of shrimp catches (MT) in the Kingdom Bahrain and Saudi Arabia

Year	Shrimp Catch in Bahrain (MT)	Shrimp Catch in Saudi Arabia (MT)*		
		Arabian Gulf	Red sea	Total
1990	1258	2381	521	2902
1991	1151	1084	1060	2144
1992	620	3096	547	3643
1993	807	2454	574	3028
1994	2079	2960	1281	4241
1995	1116	3830	2105	5935
1996	1666	5705	1717	7422
1997	3800	5207	1804	7011
1998	2247	6192	1515	7707
1999	NA	2370	1235	3605
2000	NA	4760	878	5638
2001	NA	3163	833	3996
2002	NA	6040	979	7019
2003	NA	4877	1060	5937
2004	NA	6618	660	7278
2005	1,107	7355	961	8316
2006	1,951	7701	922	8623
2007	2,794	8740	949	9689
2008	2,403	9003	977	9980
2009	3,432	8861	962	9823
2010	4,667	8527	926	9453
2011	2,537	6046	916	6962
2012	2,495	10670	935	11605
2013	3,083	6497	803	7300
2014	2,965	7712	602	8314
2015	3,545	7173	808	7981
2016	2,973	7367	669	8036
2017	4,278	7328	501	7829
2018	2,293	7339	535	7874
2019	1	6897	568	7465
2020	2	6586	668	7254

* Source: General Authority for statistics – Kingdom of Saudi Arabia (https://www.stats.gov.sa/en)

Appendix (5): Bahrain's population from 2000 to 2021

Year	Population (Total Number)	Yearly change (%)	Yearly change
2021	1,504,365	2.14	32,161
2020	1,472,204	-0.78	-11,552
2019	1,483,756	-1.30	-19,335
2018	1,503,091	0.13	1,975
2017	1,501,116	5.16	77,390
2016	1,423,726	3.75	53,404
2015	1,370,322	4.07	55,760
2014	1,314,562	4.67	61,371
2013	1,253,191	3.53	44,227
2012	1,208,964	1.15	13,944
2011	1,195,020	-2.81	-33,523
2010	1,228,543	4.08	50,128
2009	1,178,415	6.36	74,919
2008	1,103,496	5.82	64,200
2007	1,039,296	7.59	78,871
2006	960,425	7.46	71,601
2005	888,824	7.32	65,080
2004	823,744	7.19	59,225
2003	764,519	7.06	53,965
2002	710,554	6.93	49,237
2001	661,317	3.59	23,735
2000	637,582		

Source: IGA (2022)

Appendix (6): The increase in the land mass and the annual rate of increase

(Total Area of Bahrain is 8,269 km^2)

Period	Added area (km^2)	Land area (km^2)	Annual rate of increase (km^2/year)	Source
1963-1977	13	668	0.94	A
1977-1982	1	681	0.29	A
1982-1989	20	682	2.87	A
1989-1997	9	703	1.07	A
1997-2004	16	711	2.24	A
2004-2006	9	727	5.06	A
2005	5	736	0.20	B
2006	9	741	0.11	B
2007	8	750	0.13	B
2008	2	758	0.50	B
2009	2	760	0.50	B
2010	5	762	0.20	B
2011	3	767	0.33	B
2012	0	770	0.00	B
2013	4	770	0.25	B
2014	4	774	0.25	B
2015	1	778	1.00	B
2016	1	779	1.00	B
2017	0	780	0.00	B
2018	3	780	0.33	B
2019	2	783	0.50	B
2020	2	785	0.50	B
2021		787		B

Source: A: Zainal et al., (2012); B: IGA (2022)

المُستخلص

يعتبر روبيان النمر الأخضر (*Penaeus semisulcatus*) – من الناحية الاقتصادية والاجتماعية – أكثر أنواع الروبيان شيوعًا في مياه البحرين والخليج العربي. ويعد موسم صيد الروبيان أحد الأنشطة الحرفية التقليدية للصياد البحريني، حيث يقتصر صيد الروبيان على قطاع الصيد الحرفي والذي يعمل تحت إشراف وكالة الزراعة والثروة البحرية. أسهم النمو السكاني السريع إلى زيادة نصيب الفرد من استهلاك الأنواع البحرية التجارية المهمة من القشريات (مثل الروبيان وسرطان البحر)، والرخويات (كالمحار)، والأسماك الزعنفية، في حين تتعرض هذه المصائد لتهديد الأنشطة البشرية والناجمة عن ممارسات الصيد غير القانوني واستخدام أساليب الصيد المدمرة – من قِبل بعض الصيادين – والتي تؤثر سلبًا على إنتاجية هذه المصائد واستدامتها. ونتيجة لذلك فإن الجهود المبذولة لضمان استدامة مصائد الروبيان والمتمثلة في وضع التدابير والإجراءات الإدارية التنظيمية –وفق أسس بيولوجية وإيكولوجية– تتعرض لضغوط شديدة بسبب هذه الممارسات غير المستدامة؛ الأمر الذي ألقى بمزيد من الأعباء على إدارة مصائد الروبيان وأثر على عملها بشكل كبير. تهدف الدراسة الحالية إلى تقييم ديناميكية مصائد الروبيان في مملكة البحرين خلال الفترة من 1990 إلى 2020 باستخدام منهجية التقييم البيئي المتكامل القائم على نهج النظام الإيكولوجي والتي تجمع بين إطار DPSIR (القوى المحركة، الضغوط، الحالة، الآثار، الاستجابة) ونهج إدارة مصائد الروبيان القائمة على النظام الإيكولوجي (EBSM). ويشار إلى أن نهج إدارة مصائد الروبيان القائمة على النظام الإيكولوجي يسعى إلى الحفاظ على سلامة النظم البيئية الداعمة لنمو الروبيان والخدمات التي تقدمها من خلال المعالجة الشاملة للقضايا البيئية بطريقة تكيفية ومتكاملة مع تضمين الجوانب الاجتماعية، والمستندة على مبادئ التنمية المستدامة والقائمة على مشاركة فاعلة من أصحاب المصلحة المعنيين. وقد تناولت الدراسة إمكانية تطبيق منهجية التقييم البيئي المتكامل القائم على نهج النظام الإيكولوجي في إدارة مصائد الروبيان، ولهذا الغرض تم إعداد استبيانين، الأول لعينة من أصحاب القرار، والثاني لعينة من الصيادين وفقًا للمراحل الخمسة لنهج النظام الإيكولوجي، وتم تحليل النتائج إحصائياً باستخدام برنامج SPSS. كما تم جمع وفحص عينات من روبيان النمر الأخضر (*Penaeus semisulcatus*) ميدانياً، حيث فرزت وعزلت 1695 عينة (سليمة) في الفترة من أغسطس 2020 إلى يناير 2021، وتم قياس أطوال العينات بالطول الكلي بوحدة السنتيمتر ومعالجتها باستخدام برنامج FISAT II (عن طريق تطبيق طريقة Bhattacharya). كما تم دراسة تأثير جائحة كوفيد–19 على قطاع مصائد الروبيان. وقد بيّنت النتائج أن مصائد الروبيان قد تأثرت بارتفاع الطلب، مما أدى إلى زيادة جهد الصيد "الضغوط" استجابةً للعوامل الاقتصادية والاجتماعية "القوى المحركة". كما تناولت الدراسة المشاكل التي تتعرض لها مصائد الروبيان نتيجة الاستغلال المفرط لهذه الثروة المهمة، والآثار السلبية على "حالة" النظم البيئية البحرية القاعية، و"الآثار" الاقتصادية السلبية الناتجة عن انخفاض العوائد المادية للصيادين، والآثار الإجتماعية الناجمة عن ذلك، والحوكمة غير الفعالة لمصائد الروبيان. وقد أظهرت نتائج استطلاع رأي أصحاب القرار والصيادين التأثير السلبي لجائحة كوفيد–19 على أنشطة صيد الروبيان وخاصة كمية الصيد وعدد القوارب والصيادين. وقد أوصت الدراسة بضرورة بذل المزيد من الجهود لإدماج مبادئ نهج النظام الإيكولوجي في السياسات واللوائح والإجراءات البيئية الوطنية لتعزيز المساعي الرامية إلى الحفاظ على النظم البيئية في مملكة البحرين وما تضمه من موارد طبيعية وما تقدمه من خدمات جلية للمجتمع البحريني. بالإضافة إلى ذلك، تركز الدراسة على الجهود المستقبلية التي ترسم أجندة بحثية جديدة متعددة التخصصات لاستزراع الروبيان على نحو مستدام في مملكة البحرين. وقد ساهمت منهجية التقييم البيئي المتكامل القائم على نهج النظام الإيكولوجي في تحديد المكونات الرئيسية لتدهور مصائد الروبيان خلال العقد الماضي. كما وتقترح المنهجية عددًا من الاستراتيجيات للإدارة المستدامة للمصائد.

الكلمات المفتاحية: نهج النظام الإيكولوجي، النظم البيئية البحرية، إطار DPSIR، إدارة مصائد الروبيان، الاستغلال المفرط، التنمية المستدامة، مملكة البحرين

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿ وَهُوَ الَّذِي سَخَّرَ الْبَحْرَ لِتَأْكُلُواْ مِنْهُ لَحْمًا طَرِيًّا وَتَسْتَخْرِجُواْ مِنْهُ حِلْيَةً تَلْبَسُونَهَا وَتَرَى الْفُلْكَ مَوَاخِرَ فِيهِ وَلِتَبْتَغُواْ مِن فَضْلِهِ وَلَعَلَّكُمْ تَشْكُرُونَ (14) ﴾

سورة النحل، الآية: 14

جامعة البحرين

كلية العلوم

برنامج البيئة والتنمية المستدامة

تقييم مصائد الروبيان باستخدام منهجية التقييم البيئي المتكامل القائم على نهج النظام الإيكولوجي لإدارتها على نحو مستدام في مملكة البحرين

أطروحة مقدمة كجزء من متطلبات الحصول على درجة الدكتوراه في البيئة والتنمية المستدامة

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