

SWOT Analysis for Published Marine Scientific Research in the Kingdom of Bahrain from 1960s through to 2011

Khadija Zainal and Mohammed Al-Rumaidh

Department of Life Sciences, College of Science, University of Bahrain,
Sakair Campus, PO Box 32038, Kingdom of Bahrain

ABSTRACT

(1D# 2617)

Received 08/01/2012

Revised 27/05/2012

Corresponding Author:

Khadija Zainal

E-mail: kzainal@sci.uob.bh

kzainal@gmail.com

The study provides an analysis of the strengths; weaknesses; opportunities and threats (SWOT) of the scientific researches carried out in the field of marine environment and fisheries in the Kingdom of Bahrain from 1960s until 2011. Internationally recognized databases such as SCOPUS, E-village, Science Direct, Google were used and 82 articles were collected. A recent bibliography of fisheries issued by the Bahrain Centre for Studies and Research included 328 research titles but only 40 were published in refereed scientific journals and therefore were added. Overall, a total of 122 articles which were published in peer-reviewed journals covered a diverse topics and included Fisheries and Fisheries' Management (18 articles, 14.8%); Ecology of selected habitats (29 articles or 23.8%); Biology of fishes, oysters, crabs, sea urchins, mollusk and shrimps (20 articles or 16.4%); Mari-culture technology, management and fish feed (9 articles or 7.4%); Pollution monitoring in biota, sediment and water including bacteriological studies (45 articles, 36.9%) and Recreation as a management resource (1 article or 0.8%). Pollution received the highest proportion of research interests followed by Ecology and Fisheries. Despite the amount of efforts that were made, gaps in our knowledge of the marine environment and marine organisms of Bahrain remain wide. There is a need for more research in this field of studies. If more data gathered in a collaborated manner on a regular basis, it would be an invaluable management resource for both fisheries and the wellbeing of the marine environment in Bahrain.

KEYWORDS

Inventory, environment, fisheries, statistics, pollution

Introduction

The history of marine environment research in the Kingdom of Bahrain goes back to almost five decades. Since 1960s, the fisheries of Bahrain have witnessed several important events that have played a significant role in the appearance and continuation of special fisheries' publications. The huge shrimp catches had stimulated a joint venture project on the commercial exploitation of this resource, and hence, exports through the Bahrain Fishing Company which started its first exploitation of the shrimp resources in 1967. The commercial exploitation of shrimp resources also played a role in establishing the "Fisheries Resources Bureau" in 1968. This was the first government agency responsible for the management of the fisheries. Food and Agriculture

Organization (FAO) had conducted a Regional Fishery Survey and Development Project from 1976 to 1979 which had motivated local experience and strengthened the appearance of fishery reporting system.

Few institutions in Bahrain are involved in fisheries' research. The General Commission for the Protection of the Marine Resources, Environment and Wildlife (GCPMREW) through its Directorate of Fisheries is a major contributor. A significant part of the publications however, are the organization regular technical circulars. The first technical circular covered the statistics from April to June 1979 and the latest in this series covered up until 2005 statistics. Bahrain Center for Studies and Research (BCSR) had made significant contributions to Bahrain's fisheries' publications from the 1980's

through to 2010. This partnership was sustained and strengthened by the ongoing fisheries' studies. Both (GCPMRW), and the University of Bahrain (UOB) have made occasional contributions to these studies. The activities of these institutions yielded hundreds of scientific articles and reports dealing with the fisheries. In addition, a wide range of pollution related topics have also been covered.

This study provides an analysis of the strengths, weaknesses, opportunities and threats (SWOT) of the scientific researches that were carried out in the field of fisheries and the marine environment in the Kingdom of Bahrain over the last five decades.

Materials and Methods

Several articles (82) were investigated using internationally recognized databases such as SCOPUS, E-village, Science Direct and the Scholar-Google. A recent bibliography issued by the Bahrain Centre for Studies and Research on the research works from 1960 - 2005 (328 topics) but only (40) articles were used in the analysis since these were peer-reviewed and published in recognized scientific journals.

The articles were categorized according to subject and further subdivided within each category. Overall, 122 articles were subjected to the analysis. Other types of publications such as technical reports, internal circulars, etc., were not considered in the analysis.

Results

The Bahrain fisheries' bibliography (Abdulqader and Al-Rumaidh, 2005) included different types of publications some of which were peer-reviewed journal articles, conference papers, books, theses, locally produced annual reports and circulars. A large proportion of the bibliography was in fact related to local annual reporting.

In the current investigation, six major categories of subject areas were identified viz., fisheries of finfish, crustacean and mollusks; ecology of marine habitat; marine pollution; mari-culture, and recreation. The research on pollution (37%) stands out of overall research efforts made in the field of marine environment (Figure 1).

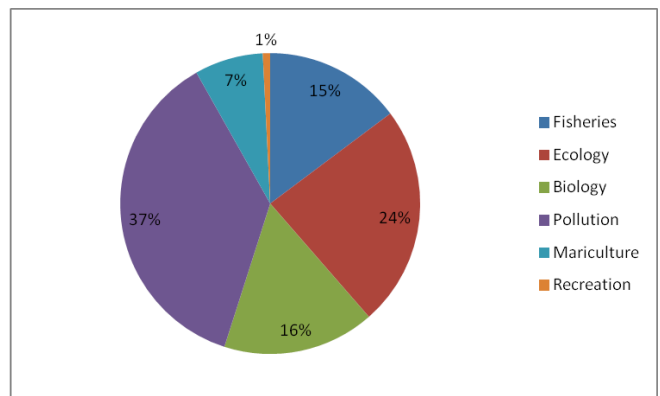


Figure 1. The proportion of the six major categories of research subject areas

The above categories were further sub grouped into specific sub-categories (Table 1). For example, the pollution category was sub-divided to show what type of pollution or impact on the marine environment had been discussed in the published work. These included topics such as oil pollution, solid waste disposal, heavy metals in sediment, in biota or in dredging spoils; land reclamation and water quality. The method of the research is highlighted to show if it was a survey or experimental. It was found that the majority of the researches was descriptive and presented survey results. The majority of the research was carried out during the 1990's and early 2000's.

Fisheries of Finfish and Shellfish

Out of the 122, the fisheries category comprised 14.8% articles and included fisheries of finfish, crustaceans such as shrimps and crabs, mollusks such as snails and clams (shellfish). Five major sub-categories were related to the fisheries of marine living resources of Bahrain, i.e. management, shrimps, finfish, pearl oyster and by-catch. Table 1 indicates that finfish research has dominated the efforts in the field of fisheries (38.9%) followed by pearl oysters and management (22.1%) and (16.7%) respectively. Limited amount of data was available since the early 1970,s. A system of collecting statistics on fish landings and marketing of fish has been recently developed by the Directorate of Fisheries in the form of Technical Circulars.

Table 1: The percentages of different categories of published marine research carried out around the coastal areas of Bahrain since 1960's. The type of research is indicated (*Surveys means ecological; experimental means specimens were subjected to laboratory experiments*).

No.	Categories	Sub-categories	No. of articles	Percentage	Type of research	
1	Fisheries (14.8%)	Management	3	16.7 %	Surveys	
		Shrimps	2	11.1 %	Surveys	
		Finfish	7	38.9 %	Surveys	
		Pearl Oysters	4	22.1 %	Surveys	
		By-Catch	2	11.1 %	Surveys	
		Sub-total	18			
2	Ecology (23.8%)	Macrobenthic animals	3	10.3 %	Surveys	
		Algae	6	20.7 %	Surveys	
		Dugong	1	3.4 %	Surveys	
		Dolphin	1	3.4 %	Surveys	
		Habitats	12	41.4 %	Surveys	
		Marine birds	2	6.9 %	Surveys	
		GIS/ Remote sensing	2	6.9 %	Surveys	
		Coral reefs	1	3.4 %	Surveys	
		EIA	1	3.4 %	Surveys	
Sub-total	29					
3	Biology (16.4%)	Pearl oyster (Mollusks)	5	25 %	Investigation/ Experimental	
		Shrimps (Crustaceans)	2	10 %	Investigation/ Experimental	
		Crabs (Crustaceans)	1	5 %	Investigation/ Experimental	
		Sea urchins (Echinoderms)	4	20 %	Investigation/ Experimental	
		(snails) Mollusks	3	15 %	Investigation/ Experimental	
		Mangroves	4	20 %	Investigation/ Experimental	
		Fish	1	5 %	Investigation/ Experimental	
		Sub-total	20			
				Dredging	1	2.22 %
		Desalination	1	2.22 %	Surveys	
		Heavy metals in algae	1	2.22%	Chemical analysis	

No.	Categories	Sub-categories	No. of articles	Percentage	Type of research
4	Pollution (36.9%)	Heavy metals in fish	4	8.88 %	Chemical analysis
		Heavy metals in pearl oysters	2	4.44 %	Chemical analysis
		Heavy metals in snails	2	4.44 %	Chemical analysis
		Heavy metals in marine sediment	4	8.88 %	Chemical analysis
		Heavy metals in sea water	8	17.77 %	Chemical analysis
		Parasites	2	4.44 %	Microscopic-investigation
		Bacteria in pearl oysters	5	11.11 %	Media-culture/ Microscopic-investigation
		Bacteria in water	6	13.33 %	Media-culture/ Microscopic-investigation
		Solid waste	1	2.22 %	Surveys
		Oil pollution	7	15.55 %	Chemical analysis
General/ Environment	1	2.22 %	Survey/ investigation		
		Sub-total	45		
5	Mariculture (7.4%)	Development	5	55.6 %	Investigations
		Fish feed	4	44.4 %	Experimental
		Sub-total	9		
6	Recreation (0.8%)	Fishing	1	100 %	
		Sub-total	1	100 %	
	100%	Grand Total	122		

Studies on the by-catch in shrimp trawl fishery, have established baselines from the management point of view, which enabled minimizing the damage on marine organisms that share with shrimp the same habitat. Studies such as bionomics and migration pattern of the green tiger prawn (Abdulqader & Nayler, 1995), and the role of Tubli Bay in the life cycle of the latter species (Abdulqader, 1994), have shed light on the biological aspects of the commercial shrimp fishery. Also, experimental work on gillnet selectivity for catching the Spanish Mackerel (Abdulqader, 2001a) and investigations on the GCC Spanish mackerel fisheries monitoring

program (Abdulqader, 2001b) established a management scheme for harvesting marine resources. Other studies included video technology applied to the management of marine resources and fish stock enhancement programmes. Such studies were useful in formulating management schemes for commercially important species (Uwate & Sham, 1996). The incidence of pearls of various sizes in the pearl oyster of Bahrain (Al-Rumaidh & Nayer, 1994); pearl fisheries of the Arabian Gulf (Bowen, 1985); Bahrain's pearling industry (Datta & Nugent, 1985) and others, have contributed to an understanding to the pearl fishery in the past,

forming bases to establish future pearl fishery. Musaiger, 1987; Zainal & Abdulqader, 2009; Abdulqader, 2010; and fish consumption patterns in the Bahrain community (Musaiger & Al-Rumaidh, 2005) have furnished a significant addition to our knowledge on Bahrain's fishery resources.

Ecology

The ecological aspects of Bahrain marine environment articles accounted to 29 articles (23.8%) (See table 1 and figure 1), nine of which major sub-categories were identified: macrobenthic organisms (Al-Sayed *et al.*, 2008; Naser, 2010 and Zainal *et al.*, 2007); macrobenthic fauna associated with seagrass beds (Alwedaei, 2008); algae (Basson, 1979, Basson *et al.*, 1989, Al-Sayed *et al.*, 1995); distribution and habitats of dugongs and dolphins (Preen, 2004), waders (marine) birds (Saleh & Mohamed, 1990; Mohamed, 1991; Saleh & Mohamed, 1993; Mohamed, 1998; Al-Sayed *et al.*, 2008); mapping the coastal marine habitats using various tools, e.g. geographical information system (GIS) (Vousden, 1986; Vousden, 1988; Zainal, 1993; Zainal *et al.*, 1992); environmental impact assessment (EIA) (Naser, 2007 & Naser, 2010), and coral reefs studies (Smith *et al.*, 1987). Abbas, 2002a; Abbas, 2002b; Abbas, 2002c; Abbas, 2005; Abbas, 2006 and AlMansoori *et al.*, 2009 a,b have provided a considerable amount of work on the geographical distribution, seasonal variation and physiological aspects of coastal vegetation around Bahrain islands. More recently, environmental and sustainable development indicators for the Kingdom of Bahrain were the focus of research on combined aspects of the environmental issues revealing gaps in the available data to further develop such indicators (Zainal, *et al.*, 2011).

The majority of research works in the field of ecology were carried out on various marine habitats (41.1 %) followed by research on algae and macrobenthic organisms (20.7 %) and (10.3 %) respectively. Other areas of ecological research such as the distribution of the dugongs and dolphins (3.4 % each), applying GIS on marine ecosystems around Bahrain, and waders (6.9 % each) as well as coral reef and EIA (3.4 % each) have received some concern.

In view of the unique nature of the marine environment with high annual temperatures and

hyper saline conditions adding to this is the threat of oil spills and degradation of the coastal areas due to land reclamation and dredging, there is a need to continue the ecological studies initiated by the Bahrain Marine Habitat Survey. This field of study is considered as critical to the well being of the marine environment and the fisheries.

Biology of Marine Organisms

Aspects of the biology of some marine organisms scored 16.4% of the total articles. This field included the biology of mollusks represented by the pearl oysters (25%) followed by the snails (20%); the echinoderms sea urchin (20%); mangroves (15%); shrimps (10%), crabs and other crustaceans (5%). Some of the work in this field have investigated changes in pearl oyster shell morphometrics in relation to environmental salinity changes (Al-Sayed *et al.*, 1997) and size at first maturity (Khamdan, 2001a) including the occurrence of parasites (Khamdan, 2001b) in the oysters. Other workers went a little deeper in their approach and carried out sophisticated experimental work coupling biological processes with the magnetic fields in the sea urchins (Sakhnini and Dairi, 2004, 2007). In addition, the reproduction biology of only few marine animals has been tackled. This included fish (Akatsu *et al.*, 1984); clams (Dairi *et al.*, 2008) and shrimps (Abdulqader, 1999). Aspects of the biology and physiology of the oysters, crabs and fishes are currently being investigated by (Zainal, unpublished data- not counted). The edible snail has also received some attention in terms of the biochemical and calorific contents impact on the reproductive activity of the animal (Freije and Al-Sayed, 2008). Apart from the topics listed in Table1, there is a clear limitation of data on the fish biology (5%) in support of stock analysis and management of fisheries. The available data on the biological aspects of the marine organisms is therefore considered far from complete. More research is required for example, on important fish species and on the population dynamics of important or endangered species of mammals such as the dugongs and their habitats.

Marine Pollution

The majority of articles (36.9 %) have covered some aspects of the marine pollution indicating the importance of this field of study. There are a wide range of point and non-point sources of pollution reaching the marine environment (Zainal, *et al.*,

2008; Sheppard et al., 2010). Many researchers have investigated pollutant levels in water, sediment and the biota such as fish and oysters. These included trace (or heavy) metals concentrations in the marine organisms (Al-Sayed et al., 1996; Al-Sayed and Mahasneh, 1992; Dairi et al., 1998; De Mora et al., 2003; Freije and Awad, 2009; Hasan, 1992; Madany et al., 1996; Mohammed, 2002). The whole of the Arabian Gulf has been exposed for decades to both acute and chronic oil pollution. Oil spills have been the subject of some research, for example, De Mora et al., 2003 Mohammed, 1988; Linden et al., 1989; Larsson et al., 1990; Mahasneh and Al-Sayed, 1994). Within the pollution category, heavy metals and oil pollution (hydrocarbons) if added together comprise more than half of these topics (62.2 %).

Land reclamation, dredging and infilling have also been a cause of concerns for many scientists. Cumulative impact of these activities is unpredictable. The research on pollution from land reclamation and dredging are extremely limited (2.2%). The law mandates a compulsory Environmental Impact Assessment (EIA) for all such projects and mitigation plans are included. Limited information (2.2 %) is also available on the marine debris and the contamination of the marine environment by solid waste disposal (Zainal et al., 2007 and 2008). Bacterial and microbiological contamination of marine environment has received a significant share of these studies (17.1%) (Qureshi et al., 1993; Mahasneh and Al-Sayed, 1997; Ghanem and Al-Sayed, 1998).

In addition, few researchers had lightly touched upon the impact of the desalination plants, which are widely spread across the Gulf, on the marine environment (Al-Madani et al., 1988; Zainal, et al., 2008). The work on pollution is therefore considerable but only few aspects of pollution problems have been tackled. More investigations on the impact and effects of different sources of pollution, not only on the marine animals but also on human health as the final receiver of the accumulated pollutants are required in order to build up an integrated view of the scale of this issue.

Mari-culture

Few publications, nine articles (7.4 %) have been issued in this field. They dealt with the development and management of the mari-culture in Bahrain (Akatsu et al., 1984; Kawahara et al., 1997;

Suen and Shiau, 1997; Suen et al., 1997; Suen and Alaradi, 1996, and 1996; Uwate and Shams, 1997). Egg and larval development of some commercial fishes such as Saffi, *Siganus oramin* had been described and their morphometrics carried out with the objectives of the hatchery development. Nayar and Al-Rumaidh, 1993 investigated the incidence of various sizes of pearls in the oysters. They have even attempted to culture oysters under controlled conditions. Responses of orange-spotted grouper *Epinephelus coiodes* eggs to various incubation temperatures and salinities were measured in terms of incubation period and hatchability by Kawahara et al., 1997. There has also been some focus on the developing fish feed and feed optimum composition requirement for the growth of fishes.

Shrimp aquaculture experiments were carried out as early as in the 1970's but poor results were obtained due to the lack of appropriate infrastructure facilities and expertise at that time. In recent years however, there had been a considerable improvement in the mari-culture. Some feasibility studies are currently underway to explore the potential of shrimp aquaculture in Bahrain (Aquaculture forum December, 2011 in the Kingdom of Bahrain).

Establishing infrastructures to support commercially produced fishes is the ultimate goal of any mari-culture development. Feasibility studies had been occasionally conducted. It appears that the industry requires more collaborated efforts. The shrimp, *Penaeus latisulcatus* for example, is a locally available species is a potential species for aquaculture in Bahrain similar to Australia and India. This shrimp can tolerate very high salinities and grow well under sandy pond conditions. Cage culture was one of the proposed ideas to grow shrimps and fish to the marketable size. The mari-culture activities once fully operational can help in food security in the Kingdom of Bahrain.

Recreation

Only one article (1 %) was published (Uwate and Almeshkhas, 1999) dealt with non-commercial activities in the sea such as sport diving. Nevertheless, the study had highlighted the role of volunteers as an invaluable resource for the management of the fisheries in Bahrain.

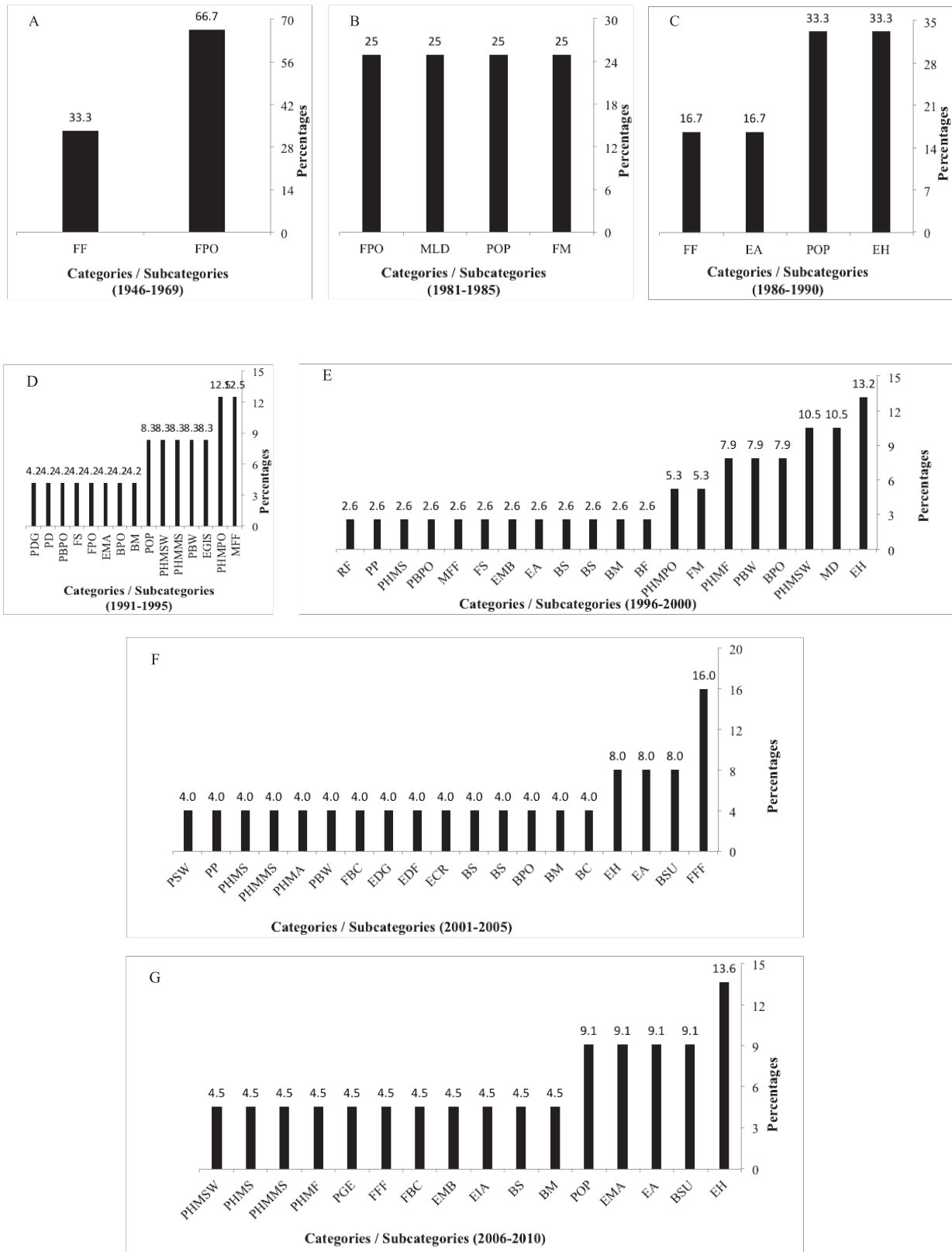


Figure 2: Classification by subject categories of the scientific published research in the field of marine biology since 1946 up until 2012 (A-G).

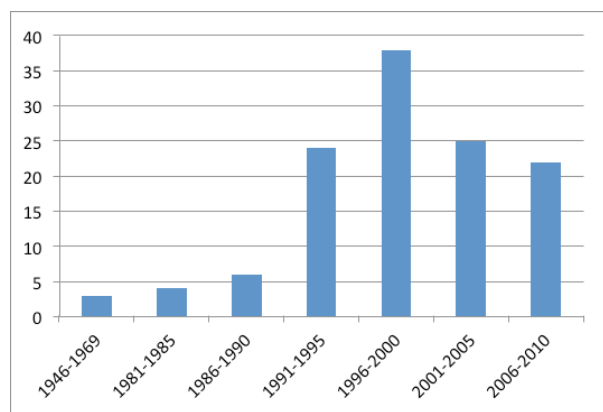


Figure 3: Total number of scientific research in marine biology since 1946-2010.

Past, Present and Future Trend

In terms of the total number of scientific research, overall, the pollution subject dominated (36.9%) followed by ecological studies (23.8%) (Table1). To find out which research topic dominated over time, the proportion of categories and subcategories during specified time intervals was plotted (Figure 2 A-G). These graphs indicate that during the earlier time intervals, prior to the eighties, the main research focus has been on the fisheries of pearl oysters (FPO) which was 66.7% of the publication during the period (1946-1969). The research on the FPO however declined down to 25% during the years (1981-1985) because other research topics had emerged and had equal share of interests. These included Pollution/Oil Pollution; Mari-culture Development and Fisheries Management (POP, MLD, FM) respectively (Fig. 2-B). Ecological studies and Oil Pollution (33.3% each) dominated the topics during (1986-1990) (Fig. 2-C), whereas, the main focus had shifted to Pollution/ Heavy Metals in Pearl Oysters (PHMPO) and (MFF) (12.5% each) during (1991-1995). In the period (1996-2000), Ecological/ Habitats (13.2%) were dominant. Fin Fish Fisheries (FFF) dominated (16%) during (2001-2005). Thereafter during (2006-2010), the (EH) covered the main research. The total number of all scientific research combined was higher during the years 1996-2000 (see Figure 3). Based on the above trend, one can predict that ecological and human impacts on the physical and biological environment would probably dominate the topics for future research. Adding to these would be research on fisheries and other marine resources.

SWOT Analysis, Discussion and Conclusion

The analysis used during the present investigation is one of strategic planning techniques whereby, key issues are revealed with the objectives of improving an existing practice. It is a summary of Strengths, Weakness, Opportunities and Threats of peer-reviewed scientific researches in the field of the marine environment and fisheries' enhancement. It was based on the evaluation of 122 published papers. The analysis can be seen as a tool aiming at helping organizations to assess if the organization is aligned with the outside world. This analysis is important if used correctly to make decisions about the future research priority. The overall process of the analysis gives an insight for planning future research. It must be emphasized however, that the points listed under the SWOT given hereafter, may not be comprehensive. Nevertheless it provides a basis for future analysis or further updating information.

The considerable amount of effort put forward in marine pollution subject (36.9 %) was likely to be due to the Gulf War event. The enormous pollution and damage caused by the hostility perhaps triggered these studies in Bahrain and the Gulf. Protecting the marine environment from offshore and land based sources of pollution have received many more recent topical discussions. Impact of dredging and land reclamation is also a growing area of concern not only in Bahrain but also around the Gulf sensitive coastal and marine areas. In terms of research priority indicator, marine pollution issues would still receive the priority concerns as people become more aware of the environment and human health.

The internal reports, which make the most of Bahrain's fisheries reporting, were found to be in most cases unpublished in scientific journals, and accordingly were restricted within the concerned institutions. A large proportion of the bibliography was in fact statistical circulars. These reports were omitted from the present analysis.

The present study emphasizes on the necessity for preserving and documenting all these reports and making them accessible to the scientific community. Marine biologists in collaboration with the fisheries directorate could have access to scientifically collected data which could be used in analyzing fish stock, fish yield and fisheries'

enhancement. The current work includes a list of refereed articles which can be considered a positive indicator showing the amount of efforts towards increasing our understanding of the marine environment and the biological systems.

The main questions which could be asked in any SWOT analysis could be summarized to show what advantages could be gained (Strength); what could be improved or avoided (Weakness); what opportunities can be spotted and what obstacles or competitors (Threats) are there? The key findings of the present study using SWOT analysis are summarized in: SWOT analysis for the published marine scientific research in the Kingdom of Bahrain from 1960s through to 2010.

Strengths

- Fairly a good amount of publications on the marine environment research containing the history of Bahrain's fisheries, pollution and other important issues.
- Highly qualified researchers.
- Expertise in a wide range of scientific knowledge.
- High quality library facilities in Bahrain.
- Recognition of UOB as a national scientific research institute.
- Basic and existing infrastructure and capabilities at the University of Bahrain and the Arabian Gulf University, Ras-Hayan Mari-culture and Environmental Affairs Directorates (GCPMRW) as research institutions.

Weaknesses

- Shortage in human resources involved in the field of marine environment research.
- Limited internal financial and technical supporting system.
- Unpublished internal reports are not accessible to the researchers.
- Underutilization of the available expertise.
- Research funding priorities may be imbalanced.
- Poor collaboration between the scientific community in Bahrain and with the Gulf States and beyond.
- Inadequate awareness of the quality research journals such as impact factor, citation, indices etc.
- Scientific publication not serving the national priority issues.
- Duplication of unnecessary research activities.
- Some scientist lack interest in the appropriate

scientific research with or without reasons.

- Lack of research assistants.
- Limited or lack of post graduate research programmes.
- Weak team working spirit and sometimes even personality clashes.
- Competing between researchers instead of working together.
- Lack of scientific accountability.
- Poor fundraising scheme or grant policy

Opportunities

- Existing published articles contain a considerable amount of topics including the history of Bahrain's fisheries forming the foundation for future research.
- An opportunity for regional and international recognitions.
- Research prioritization.
- Multidisciplinary approach in research to serve the community at large.

Threats

- Lack of moral and financial supports (government and higher education organizations should increase the budget for the research programmes).
- Shortage of training programmes for the human resources in the field of marine environment.
- Improper utilization and allocation of the available limited research budget.
- Poor national direction on focused marine research.
- Limited financial and technical supporting policy.
- Lack of research councils.
- Limited involvement of the private sector in supporting scientific research in the field of marine biology.

These findings help in answering the above questions.

In conclusion, there is a range of scientific publications serving the marine environment and fisheries in Bahrain. However, the issues tackled are far from complete. For example, at present, although fishes constitute more than 80% of the total fisheries' landing, there is a lack of comprehensive biological information on the commercially important species of either finfish or shellfish. Only scattered data is available on length, weight, gonad maturation and feeding habits of only one commercially important species of fish (King Mackerel). The impact of environmental stressors on their survivals is extremely limited. The present

data on shrimp landing statistics lack updating information on catch and effort from different fishing grounds and shrimp biological information is fragmentary. Given these information, it would be difficult to interpret data from the management point of view. There is a need for a better collaboration in this field. It can be concluded that the marine environment and the biology of finfish, shellfish, marine birds and mammal; fisheries' management and pollution impact and monitoring in Bahrain waters must be given priority. Some of these areas require immediate research funding in order to cover a wider range of the scientific research.

Strengths and opportunities are the positive sides of the SWOT analysis presented in this paper whilst, the weakness and threats are the negative sides of it. There are opportunities to achieve excellence in many research areas. However, external threats can impose a major factor in hindering valuable quality scientific research. Strengths and opportunities are also positive indicators for future improvement. The quality of the scientific research is extremely important in order to achieve recognition at national, regional and international levels. Similar to other countries in the region, the focus of research may be shifting over time as a reflection of the economic importance and research priorities.

References

- Abbas, JA** (2002a) Coastal Vegetation of Bahrain Island. *Arabian Gulf Journal of Scientific Research*, **20** (2): 87-91.
- Abbas, JA** (2002b) Plant Communities Bordering the Sabkhat of Bahrain Island. In: **Barth and Boer (eds.)** *Sabkhas Ecosystems, vol. 1*. Kluwer Academic Publishers, Netherlands. pp. 51-62.
- Abbas, JA** (2005) Seasonal Variations of Ash Content of the Halophyte *Zygophyllum qatarense* Hadidi from Saline and Non-Saline Habitats in Bahrain. *Pakistan Journal of Botany* **37**: 853-858.
- Abbas, JA** (2006) Seasonal Variations of Protein Content in Roots and Leaves of *Zygophyllum qatarense* Hadidi from saline and non-saline habitats in Bahrain. *Dirasat* **33**: (1) 13-20.
- Abdulqader, EAA and Al-Rumaidh, MJ** (2005) *Fisheries Publications of Bahrain: an Annotated Bibliography*. Bahrain Centre for Studies and Research, Kingdom of Bahrain. p. 175.
- Abdulqader, EAA, and Naylor, E** (1995) Bionomics and Migration Pattern of the Green Tiger Prawn, *Penaeus semisulcatus* De Haan, in Bahrain waters. *Fisheries Research*, **21**: 395-407.
- Abdulqader, EAA** (1994) Bionomics Patterns of the Green Tiger Shrimp, *Penaeus semisulcatus* De Haan, in Bahrain waters. In: *the Technical Consultation on Shrimp Management in the Arabian Gulf 6-8 Nov.1994, Al-Khobar*. Ministry of Agriculture and Water, Saudi Fisheries Company, KSA, Riyadh, pp. 20.
- Abdulqader, EAA** (1996) Development of Bahrain's Shrimp Fisheries Information System. In: **Ye, Y & Almatar, S (eds)**, *Proceedings of the Meetings of the Working Group on Shrimp and other Invertebrates and Working Group on Demersal Fishes and Marine Habitat*. 11-13 May 1996, Kuwait. pp. 111-121.
- Abdulqader, EAA** (2001a) Gillnet Selectivity Experiments in Bahrain Waters on the Spanish Mackerel, *Scomberomorus commerson* (Lacepede), fishery. *Arab Gulf Journal of Scientific Research*, **19**: 66-71.
- Abdulqader, EAA** (1999) The Role of Shallow Waters in the Life Cycle of the Bahrain Penaeid Shrimps. *Estuarine, Coastal and Shelf Sciences*, **49** (Suppl. A): 115-121.
- Abdulqader, EAA** (2001b) The GCC Spanish Mackerel Fisheries Monitoring Program. In: **Goddard S, Al-Oufi, HS, Mellwain, J, Clareboudt, M (eds.)**, *Proceedings of the First International Conference on Fisheries, Aquaculture and Environment in the Northwest Indian Ocean*. Sultan Qaboos University, Sultanate of Oman, Masqat, pp 49-50.
- Abdulqader, EAA** (2010) Turtle Capture in Shrimp Trawl Nets in Bahrain. *Aquatic Ecosystem Health & Management*, **13** (3): 307-318.
- Al-Mansoori, T, Buflasa, A, & Musselman, LJ** (2009a) Stable Isotope Ratios and Mineral Nutrient Composition of *Cynomorium coccineum* L. and its Halophytic Host *Zygophyllum qatarense* in Bahrain. In: *Proceedings of the 10th World Congress on Parasitic Plants (Abstract) 08-12 June 2009*. Kusadasi, Turkey.
- Al-Mansoori T, Thuraya A, Al-Sayed H** (2009b) Nitrogen and $\delta^{15}\text{N}$ composition of Black Mangrove (*Avicennia marina* L.) in the Kingdom of Bahrain. In: *International Conference on Plants & Environmental Pollution (Abstract) 6-11 July 2009*, Erciyes University, Kayseri, Turkey.

- Al-Rumaidh, MJ, Nayar, KN** (1994) Incidence of Pearls of Various Sizes in the Pearl Oyster of Bahrain. *Journal of Shellfish Research*, **13**: 325-354.
- Al-Sayed, H** (1996) Periodicity of Reproduction in Pearl Oyster *Pinctada radiata* in Bahrain. *Journal of Egypt General Society of Zoology*, **21**(D): 121-133.
- Al-Sayed, H, Al-Rumaidh, MJ, Nayar, KN** (1997) Spat Settlement and Growth of Yearling of the Pearl Oyster, *Pinctada radiata*, in Bahrain waters. *Arab Gulf Journal of Scientific Research*, **15** (2): 467-480.
- Al-Sayed, H, Al-Saad, J, Madany, IM, & Al-Hooti, D** (1996) Heavy Metals in the Grouper Fish, *Epinephelus coioides*, from the Coast of Bahrain: an Assessment of Monthly and Spatial Trends. *International journal of environmental studies*, **50** (3/4): 237-246.
- Al-Sayed, H, Ateef Qureshi and Jalal Al-Saad** (1992) Some Indicators of Chemical and Microbial Pollution in the Al-Lawzy hypersaline Pit, Bahrain. *Biomedical Letters*; **47**:239-245.
- Al-Sayed, H, Bu Ali, A, Raveendran, E, & Buflasa, A** (1995) Ecological Characteristics of the Littoral Fauna of Tubli Bay, Bahrain. *Qatar University Science Journal*, **15**: 231-238.
- Al-Sayed, H, Dairi, M** (2006) Metal Accumulation in the Edible Marine Snail *Turbo coronatus* (Gmelin) from different locations in Bahrain. *Arab Gulf journal of Scientific Research* **24** (2): 48-75.
- Al-Sayed, H, Gamal El-Din, A, Saleh, KM** (1997) Shell Morphometrics and some Biochemical Aspects of the Pearl Oyster, *Pinctada radiata* (Leach, 1814), in Relation to Different Salinity Levels around Bahrain. *Arab Gulf Journal of Scientific Research*, **15** (3): 767-782.
- Al-Sayed, H, Ghanem, E, and Saleh, K** (2005) Bacterial Community and Some Physico-Chemical Parameters of Subtropical Mangrove Environment in Bahrain. *Marine Pollution Bulletin*, **50** (2): 147-155.
- Al-Sayed, H, Mahasneh, AM, & Al-Saad, J** (1994) Variation of Trace Metal Concentrations in Seawater and Pearl Oyster *Pinctada radiata*, from Bahrain (Arabian Gulf) *Marine Pollution Bulletin*, **28** (6): 370-374.
- Al-Sayed, H, Naser, H, & Wedae, K** (2008) Observations on Macrobenthic Invertebrates and Wader Bird Assemblages in a Protected Mudflat in Bahrain. *Aquatic Ecosystem Health & Management*, **11**(4): 450-456.
- Al-Sayed, H, Zainal, K** (2005) The Occurrence of Anostracans- Fairy Shrimps *Branchipus Schaefferi* in Vernal Pools of Bahrain. *Journal of Arid Environment*. **61** (3): 447-460.
- Akatsu, S, El-Zahr, C, Al-Aradi, J** (1984) Egg and Larval Development of *Siganus oramin* (Bloch & Schneider) Obtained through Induced Spawning. *Kuwait Bulletin of Marine Science*, **5** (1): 1-10.
- Basson, PW** (1979) Marine Algae of the Arabian Gulf Coast of Saudi Arabia (first half). *Botanica Marina*, **22**: 47-64.
- Basson, PW** (1989) Notes on Economic Plants. *Economic Botany*. **34** (2): 271-278.
- Basson, PW, Mohammed, SA, & Arora, DK** (1989) Survey of the Benthic Marine Algae of Bahrain. *Botanica Marina*, **32** (1): 27-40.
- Datta, SK, Nugent, JB** (1985) Bahrain's Pearling Industry: How it was, why it was that Way and its Implications. In: **Nugent, JB, & Thomas, TH (eds)**, *Bahrain and the Gulf*. Croom Helm Ltd, Kent, UK, pp. 25-41.
- Dairi, M, Al-Alawi, SM, and Al Sayed, H** (1998) Study of Heavy Metals in the Gills of two Edible Clam Species *Marcia flammea* and *protapes* from Tubli Bay, Bahrain. In: *The Proceedings of Regional Conference on the Marine Environment of the Gulf*, 12-15 Dec. 1998, Doha, Qatar, pp. 12-15.
- Dairi, M, Sakhnini, L** (2008) Effects of Static and Extremely Low Frequency Electromagnetic Fields on Early Embryonic Development of the Sea Urchin *Echinometra mathei*. In: *The 16th International Conference on Medical Physics (ICMP)*, 14-16 April 2008, Dubai, UAE.
- De Mora, SJ, Fowler, SW, and Cassi, R** (2003) Assessment of Organ Tin Contamination in Marine Sediments and Biota from the Gulf and Adjacent Region. *Marine Pollution Bulletin*, **46** (4): 401-409.
- Freije, A, and Al-Sayed, H** (2008) Impact of Biochemical and Calorific Contents on the Reproductive Activity of the Marine Edible Snail *Turbo coronatus* Gmelin 1791. *J.of Arab Universities for basic and Applied Sciences*. **6** (1): 57-68.
- Freije, A and Awad, M** (2009) Total and Methylmercury Intake Associated with Fish Consumption in Bahrain. *Water and Environment*. **23** (2): 155-164.
- Ghanem, EH, and Al-Sayed, HA** (1998) Die – off of Potentially Pathogenic and Indicator Bacteria

- in Mangrove Channel in Bahrain. In: *The 2nd International Conference on Marine Pollution & Ecotoxicology 10- 14 June 1998*, City University of Hong Kong, Hong Kong, China.
- Hasan, MA** (1992) Assessment of Tributyltin (TBT) in the Amrine Environment of Baharain. *Marine pollution Bulletin*, **24** (8): 408-410.
- Kawahara, S, Shams, AJ, Al-Bosta, AA, Mansoor, MH, and Al-Baqaal, AA** (1997) Effects of Incubation and Spawning Water Temperature, and Salinity on Egg Developemnt of the Orange-Spotted Grouper (*Epinephelus coioides*, *Serranidae*). *Asian Fisheries Science*, **9**: 239-250.
- Khamdan, SAA** (2001a) Size at First Maturity of the Pearl Oyster, *Pinctada radiata* (Bahrain, Arabian Gulf), In: **Goddard, S, Al-Oufi, H, Mcllwain, J, and Claereboudt, M (eds.)** *Proceedings of First International Conference on Fisheries, Aquaculture and Environment in the NW Indian Ocean*. Sultan Qaboos University, Muscat, Sultanate of Oman, pp. 83-85.
- Khamdan, SAA** (2001b) Incidence of *Polydora*, *Cliona* and Natural Pearls in the Gulf Pearl Oyster, *Pinctada radiata* (leach) In: **Goddard, S, Al-Oufi, H, Mcllwain, J, and Claereboudt, M (eds.)** *Proceedings of First International Conference on Fisheries, Aquaculture and Environment in the NW Indian Ocean*. Sultan Qaboos University, Muscat, Sultanate of Oman, pp. 106-112.
- Larsson, U, Linden, O, Hagstron, A, Al-Alawi, ZS** (1990). Pelagic Bacterial and Phytoplankton Production in Subtropical Marine Environment Exposed to Chronic Oil Contamination. *Oil and Chemical pollution*, **7**: 129-142.
- Mahasneh, AM, Al-Sayed, H** (1994) Levels of Chlorinated Hydrocarbons, Total Polychlorinated Biphenyls and Total Hydrocarbons in the Pearl Oyster *Pinctada radiata* from Bahrain (Arabian Gulf) *Marine Research*, **3** (2): 15-25.
- Mahasneh, AM, Al-Sayed, HA** (1997) Seasonal Incidence of some Heterotrophic Aerobic Bacteria in Bahrain Pelagic and Near Shore Waters and Oyster. *International Journal of Environmental Studies*, **51**: 301-312.
- Madany, IM, Abdulwahab, AA, Al-Alawi, Z** (1996) Trace Metals Concentrations in Marine organisms from the coastal areas of Bahrain, Arabian Gulf. *Water, Air, and soil pollution*, **91**: 233-248.
- Mohamed, AYA** (2002) The Metal Concentration in Marine Algae, *Hormophysa triquetra*, Bahrain Coastline (Arabic Gulf) *Pollution Research*, **21** (4): 397-402.
- Mohamed, SA** (1998) Density and Distribution of Migratory Waders along the Shores of Bahrain Islands. *Arab Gulf Journal of Scientific Research* **16** (1): 145-157.
- Mohamed, SA** (1991) On the Movement and Distribution of the Greater Flamingo, *Phoenicopterus ruber* in Bahrain, Arabian Gulf. *Arab Gulf Journal of Scientific Research*, **9** (3): 133-142.
- Musaiger, AO, Al-Rumaidh, MJ** (2005) Fish Consumption Patterns in the Bahrain Community (Preliminary study) *Arab Journal of Food and Nutrition*, **6** (12): 31-47.
- Musaiger, AO** (1987) Marine Fisheries in Bahrain. *Marine Fisheries Review*, **49**: 96-99.
- Naser, H** (2010) Testing Taxonomic Resolution Levels for Detecting Environmental Impacts using Macro-benthic Assemblages in Tropical Waters. *Environ. Monit. Assess.*, **170** (1/4): 435- 444.
- Naser, H** (2007) Use of Macro-benthic Assemblages in Ecological Impact Assessment with Particular Emphasis on Environmental Impact Assessment (EIA) System in Bahrain. Ph.D. Thesis, Arabian Gulf University, (unpublished).
- Nayar, KN, Al-Rumaidh, MJ** (1993) The Rate of Growth of Spat and Yearlings of the Pearl Oyster *Pinctada radiata* (Leach) of Bahrain Waters. *Journal of the Marine Biological Association of India*, **35** (1/2): 1-14.
- Preen, A** (2004) Distribution, Abundance and Conservation Status of Dugongs and Dolphins in the Southern and Western Arabian Gulf. *Biological Conservation*, **118** (2): 205-218.
- Qureshi, AA, Mahasneh, A, Al-Sayed, H, Al-Buflasa, A, and Al-Shuaibi, M** (1993) Fecal Pollution of Pearl Oyster (*Pinctada radiata*) *Water Science Technology*, **27** (3/4): 35-39.
- Sakhnini, L, Dairi, M** (2004) Effects of Static Magnetic Fields on Early Development of the Sea Urchin *Echinometra methaei*. *IEEE :Transaction on Magnetic* **40** (4): 2979-2981.
- Sakhnini, L, Dairi, M** (2007) Orientation of Sea Urchin Sperms in Static Magnetic Fields Compared to Human Sperms. *Magnetism and Magnetic Materials* **310**e:1035-1037.
- Saleh, M, Mohamed, SA** (1993) The Migration of Coastal Waders in Bahrain, Arabian Gulf. *Fauna of Saudi Arabia*, **13**: 375-
- Saleh, MA, Mohamed, SA** (1990) The Western Reef

- Heron (*Egretta gularis* Hemprich & Ehrenberg, 1833) in Bahrain. *Funa of Saudi Arabia*, **11**: 305-317.
- Sheppard Charles, et al**, (2010) The Gulf: A Young Sea in Decline. *Marine Pollution Bulletin* **60** (1): 13-38.
- Smith, GB**, and **Saleh, MA** (1987) Abundance and Bathymetric Distribution of Bahrain (Arabian Gulf) Reef Ichthyofaunas. *Estuarine, Coastal and Shelf Science* **24** (3): 425-431.
- Suen, GS, Al-Aradi, JS** (1996) Optimal Dietary Level for Grouper (*Epinephelus suillus*) Reared in High Salinity Water in Bahrain. *Bulletin of International Technical Cooperations* (Taiwan, ROC), **3** (2): 87-96.
- Suen, GS, Al-Aradi, JS** (1994) Studies on Optimum Protein Requirement of Rabbit-fish. *Bulletin of International Technical Cooperations* (Taiwan, ROC), **1** (1): 39-47.
- Suen, GS, Al-Aradi, JS, Shiam, SY** (1997) Biology and Body Composition of Rabbit-fish (*Siganus canaliculatus*) in Bahrain. *China Fisheries Monthly*, **521** (1): 2-19.
- Suen, GS, Shiau, SY** (1997) Aquaculture Management of Rabbitfish. *China Fisheries Monthly*, **528** (1): 11-24.
- Uwate, KR, Almeshkhas, J** (1999) Volunteer Sports Divers: an Invaluable Resource in the Management of Bahrain's Fisheries. *NAGA, the ICLARM Quarterly* **22** (4): 17-19.
- Uwate, KR, Shams, AJ** (1997) Bahrain Fish Stock Enhancement: Lessons Learned and Prospects for the Future. *SPC Live Reef Fish Information Bulletin*, **3** (1): 09-13.
- Uwate, KR, Shams, AJ** (1996) Video Technology Applied to the Management of Bahrain's Marine Resources. *NAGA, the ICLARM Quarterly* **19**(2): 09-11.
- Vousden, DH** (1986) The Bahrain Marine Habitat Survey: A Study of the Marine Habitats in the Waters of Bahrain and their Relationship to Physical, Chemical, Biological and Anthropogenic Influences, vol 1. *Environmental Protection Secretariat, Bahrain*.
- Vousden, DH** (1988) The Bahrain Marine Habitat Survey : A Study of the Marine Habitats in the Waters of Bahrain and their Relationship to Physical, Chemical, Biological and Anthropogenic Influences, vol 2. *Environmental Protection Secretariat, Bahrain*.
- Zainal, AJ** (1993) New Technique for Enhancing the Detection and Classification of Shallow Marine Habitats. *Marine Technology Society Journal*, **28** (2): 68-77.
- Zainal, AJ, Dalby, DH & Robinson, IS** (1992) Marine Ecological Changes on the East Coast of Bahrain with Landsat TM. *Photogrammetric Engineering and Remote Sensing* **58** (2): 795-808.
- Zainal, AJ; Dalby, DH, & Robinson, IS** (1993) Monitoring Marine Ecological Changes on the East Coast of Bahrain with Landsat TM. *Photogrammetric Engineering and Remote Sensing*, **59** (3): 415-421.
- Zainal, K, & Abdelqader, A** (2009) *Fisheries*. In *Marine Atlas of Bahrain (1st ed.)*. Bahrain Centre for Studies and Research, K. of Bahrain. pp. 199-231.
- Zainal, K, Al-Madany, I, and Zainal, W** (2007) Quantities and Composition of Solid Waste at the Bottom of the Sea in the Kingdom of Bahrain, In: *Arabian Gulf 4th International Conference on Marine Pollution and Ecotoxicology 2007*, Hong Kong.
- Zainal, K, Al-Sayed, H, Ghanem E, Butti, E, & Naser, H** (2007) Baseline Ecological Survey of Huwar Islands, The Kingdom of Bahrain. *Aquatic Ecosystem Health and Management*, **10** (3): 290-300.
- Zainal, K, Al- Sayed, H, Al-Sayed, H, and Al-Madany, I** (2008) Coastal Pollution and its Management. In: **Abu-Zinada et al.,(eds)**, *Protecting the Gulf's Marine Ecosystems from Pollution* Birkhiuser, Switzerland, pp: 147-162.
- Zainal, K, Ghanem, E, and Buhammood, S** (2011) Selected Environmental and Sustainable Development Indicators for the Kingdom of Bahrain. In: *The State of the Gulf Ecosystem Functioning and Service, Environmental Sustainability, Gulf II: An International Conference, 7-9 Feb. 2011*, Kuwait.