Intergovernmental Oceanographic Commission

Workshop Report No. 126

IOC-PERSGA-ACOPS Workshop on Oceanographic Input to Integrated Coastal Zone Management in the Red Sea and Gulf of Aden

Jeddah, Saudi Arabia
8 October 1995

Edited by Y. Halim and S. Morcos, co-convenors

SC-98/WS/27

UNESCO

The Workshop on Oceanographic Input to Integrated Coastal Zone Management in the Red Sea and Gulf of Aden was convened in Jeddah on 8 October 1995. The workshop was planned as a preparatory technical meeting preceeding the **PERSGA-ROPME-UNEP-ACOPS Sea to Sea Regional Conference on Sustainable Use of the Marine Environment** which met in Jeddah, Saudi Arabia from 9 to 12 October 1995.

The scientific contributions to the one day Workshop consist in invited papers prepared by experts from the Region.

The present document comprises two parts:

Part I: Report and Recommendations of the Workshop.
Part II: Scientific contributions to the Workshop.

Foreword

Accounts by travellers from the nineteenth century and earlier writers describe a sparsely inhabited Red Sea, with long expanses of desolate shores. The changes were very slow throughout the centuries unitl the opening of the Suez Canal in 1869 that led to increased shipping and commercial activities associated with growth of population in cities such as Suez, Jeddah, Suakin (Port- Sudan) and Aden. The changes accelerated after the second world war as a result of the fast expansion in the development of oil reserves in the region extending from Sea to Sea and the associated economic activities. Jeddah stands as the most dramatic example. From a walled city, one square kilometer in area, and 35000 inhabitants in 1945, Jeddah grew in the years after the second World War at an unprecedented rate, the annual growth rate exceeding 10% at times.

Those among us who participated in the Jeddah (1974) and Jeddah II (1976) meetings that created PERSGA twenty years ago realize the importance of managing the Red Sea environment. Today we witness the convincing evidence for the need for coastal management: the spectacular growth of Jeddah from a city of half a million at the time we met in 1974 to the present- day Jeddah of over 2 million inhabitants, a quadrupling of the population at a rate of 7.4%, between 1974 and 1992. This rate is expected to slow down to an estimated 3.5% by the year 2015. The city of Suez grew from 100000inhabitants in 1960 to 417000 in 1994. Its population is excpected to double by the year 2000 as a result of large scale internal immigration. The population growth is associated with its impact on the resources, mainly freshwater and food, and the supporting infrasturacture, as well as the quality of life, including air, water quality and recreation.

On the other hand, the growth in population is indicative of the growth in economic sectors particularly in the industry and associated activities. Tourism became recently a major activity in the northern Red Sea. Extensive development of tourism is taking place along the coasts of Egypt which will soon increase the capacity of hotels and resorts to 38000 beds from the present 21000 beds It should be noted that most of the development of tourism was achieved in the 1980s and that the trend is expected to continue under the present climate of permissiveness and active free enterprise.

The growth in population and economic activities in the coastal zone of the Red Sea is not evenly distributed, and the annual growth rate differs considerably from one area to another. Certain areas in the Red Sea have exceeded their carrying capacity, but it is fair to recognize that the open Red Sea waters are much less impacted. It is equally important to realize that the magnitude of man's impact on the coastal zone of this sea was greater during the last twenty years than during the entire history of this basin. This impact is particularly severe in the Gulf of Suez where the state of pollution by oil exceeds the accepted levels for the world oceans.

We realize these facts twenty years after the inception of PERSGA in 1974, a testimony for the wisdom and foresight of those who initiated the Programme, the concept of Protection of the Red Sea and Gulf of Aden, and the public awareness which accommmpanied the creation of PERSGA.

Looking forward to the coming twenty years, our Workshop should learn from the past, assess the present conditions and make a realistic projection as possible of the future trends,. This is a daunting task because of our still imperfect knowledge of the coastal zone in the Red Sea.

When discussing integrated management of the coastal zone, many diverse factors have to be taken in consideration, and proposals either for research, monitoring or management will necessarily touch on issues and areas of competence covered by different governmental and non- governmental departments and different international organizations. Although the present Workshop and the proposals put forward are primarily concerned with the contribution that marine sciences can make towards a sound integrated coastal zone management, the authors were lead in many instances to deal with subjects that cover broader issues, outside the classical domain of marine sciences.

TABLE OF CONTENTS

PART I
REPORT AND RECOMMENDATIONS OF THE WORKSHOP

PART II
SCIENTIFIC CONTRIBUTIONS

In Arabic

PART I

MEETING REPORT AND RECOMMENDATIONS

1. BACKGROUND

During the early consultations among the co-sponsors and organizers of the "Sea to Sea Regional conference on Sustainable Use of the Marine Environment " it was concluded that the Conference should be based on solid scientific background information and on international experience in handling co- operative programmes in observing and managing the marine environment.

The Intergovernmental Ocenographic Commission (IOC) was invited to take the lead in convening a one-day workshop immediately before the Conference. It was understood that the scientific material for the workshop would be prepared during the months leading to the Conference, and that draft recommendations and proposals be elaborated by communication among the contributers before submitting for final discussion in the one-day workshop.

The following organizations joined the IOC in co-sponsoring the workshop:

PERSGA: Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden.

ACOPS: Advisory Committee on Protection of the Sea

In October 1994, the Executive Secretary of IOC, Dr. Gunnar Kullenberg, invited Professor Youssef Halim and Professor Selim Morcos to act as Co-conveners of the workshop and assume the responsibility of co-ordinating the various studies, integrating them into a coherent document, and submitting the relevant recommendations and proposals to the "Sea to Sea Regional conference".

The following issues were considered of prime importance when considering oceanographic input to integrated coastal zone management in the Red Sea and Gulf of Aden:

Urban Development.
Tourism
Oil Industry

Certain guidelines and criteria were recommended to the authors by the co-conveners (in consultation with IOC Secretariat).

The main focus of the Workshop is the Land- Based Activities and Sources of marine pollution. Particular attention was given to oil, sewage, nutrients, phosphate dust spills, tourism, coastal alterations and coastal development.

Agenda 21, Chapter 17, of the United Nations Conference on the Environment and Development (UNCED, Rio de Janeiro, 1992) will be taken in consideration when developing the contributions and the conclusions of the document.

Whenever possible, attention is given to proposals on monitoring and protection of the coastal environment suitable for application at the local authorities level.

Regional co-operation is essential. Proposals for co-ordination, inter-calibration, exchange of information, training opportunities are of particular importance.

2. OBJECTIVES

It was agreed that the workshop document will be concluded by:

2.1 An overview of integrated coastal zone management and it's implications in the Red Sea and Gulf of Aden.

2.2 A proposed plan for research and observation of land- based sources of marine pollution.

2.3 Draft recommendations to be presented by the workshop to the " Sea to Sea Regional Conference".

The Worksohp therefore had two main objectives:

- To address some of the major issues relevant to integrated coastal zone management in the Red Sea and Gulf of Aden;

- To develop proposals for management - related research and monitoring in the Red Sea and Gulf of Aden.

3. OPENING SESSION

The opening session of the workshop took place at 10 o'clock in the morning of 8 October 1995. The Opening Session was chaired by Dr. Nizar Ibrahim Tawfiq, Secretary -General of the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden, PERSGA. In what is considered as the first official activity of PERSGA after it's establishment as an autonomous organization, following the Cairo Declaration of 26 September 1995 issued by the first meeting of its Council, Dr. Nizar I. Tawfiq welcomed the participants to the workshop. He assured the meeting that PERSGA and the forthcoming " Sea to Sea

Regional conference" are looking forward to the outcome of the Workshop to enhance the ability of PERSGA to establish its future action plan and programmes on solid scientific grounds. Dr Tawfiq then invited the representatives of the sponsoring organizations to address the meeting. Dr. Amin Meshal (IOC), Dr. Makram A. Gerges (UNEP), Dr. Victor Sebek (ACOPS) and Dr. Francis Parakatil (IUCN) took the floor. They greeted the participants and briefed the meeting on the activities of their respective organizations, relevant to the objectives of the Workshop. They assured the participants of the continued interest and support of their organizations to the conservation of the environment of the Red Sea and Gulf of Aden.

The chairman of the opening session Dr. Nizar I. Tawfiq, then referred to the Agenda of the meeting (Annex I) and welcomed the chairmen of the following sessions: Dr. Othman Abdu Hashem, Dr. Selim Morcos, and Dr. Youssef Halim. The meeting then designated Dr. William Gladstone as Rapporteur of the meeting.

The meeting was attended by 37 participants of whom 23 participated to the Round Table discussion that took place in the afternoon of 8 October 1995. The participants included the authors of the papers presented, the representatives of the sponsoring organizations as well as UNDP in New York, and scientists who attended the meeting in their personal capacity. The list of participants is attached as Annex II.

In a keynote address to the meeting Dr. Selim Morcos highlighted the immense change that took place in the Red Sea in the last twenty years as illustrated by the quadrupling of the populations of Jeddah and Suez. Although certain areas have exceeded their carrying capacity, the open Red Sea waters are much less affected. It is equally important to realize that the magnitude of man's impact due to oil industry and urbanization on the coastal zone of the Red Sea was greater during the last twenty years than during the entire history of this basin.

Reflecting on the interdisciplinary nature of coastal zone managemeent , the speaker mentioned that proposals either for research, monitoring or management will necessarily touch on issues and areas of competence of different governmental departments, UN bodies, regional and international organizations.

Dr Morcos went on to remind the participants of the Jeddah I meeting in 1974 that started PERSGA, and paid tribute to those who, at this early time, called for the protection of the marine environment of the Red Sea and Gulf Aden. He followed by a comparison between the 1974 UNESCO Workshop in Bremerhaven on Marine Science Programme for the Red Sea that produced the working document for Jeddah I and the present IOC workshop on Oceanographic Input to Integrated Coastal Zone Management which precedes the "Sea to Sea Regional Conference".

4. WORKING SESSIONS

The two morning sessions, chaired respectively by. Dr. Othman Abdu Hashem and Dr. Selim Morcos, were devoted to the presentation of scientific papers. The topics were selected to cover the main issues proposed by the organizers of the Sea to Sea Regional Conference.

The papers included two case studies from Jeddah and Suez, as the most prominent examples of the effects of rapid urban development, and a paper on Tourism development of the Red Sea Coast. A paper on oil pollution in the Red Sea highligthed the state of the environment in this basin. Phosphate pollution in the northern Gulf of Aqaba was the topic of a paper illustrating the effects of phosphate dust spills during loading operations in the port of Aqaba. This was followed by a paper on the role of marine Parks and Reserves as a mechanism for large scale management of coastal resources in the Red Sea.

The above presentations were an introduction to a paper on "Proposals for a Research and Monitoring Programme for the Red Sea and Gulf of Aden". The paper included elements of recommendations and a work plan that were discussed by the Round Table during session III, chaired by Dr. Youssef Halim.

About twenty three participants contributed to the Round Table discussions on their personal capacity. Among them were experts from Red Sea countries (Egypt, Jordan, Saudi Arabia, Sudan and Yemen) as well as from international organizations (IOC, UNEP, UNDP, ACOPS and IUCN).

The Round Table was centered on the working paper entitled " Proposals for a research and monitoring programme for the Red Sea and Gulf of Aden". The objectives, the principles, the institutional requirements were discussed at length and partly emended. The participants to the Round Table agreed on several recommendations and on the proposed programme. The recommendations and programme adopted are given in Annex III.

ANNEX 1

AGENDA AND TIME TABLE

8.30-9.00 Registration

9.00-10.00 Opening session
Chair: Dr Nizar I. Tawfiq, Secretary General PERSGA
Welcoming address: Dr Nizar I. Tawfiq
Introductory remarks by representatives of:
IOC, UNEP, ACOPS, IUCN.
Key-note: Dr Selim Morcos

10.00-11.30 **FIRST SESSION**
Chair: Dr Othman Abdu Hashem, Dean,
Faculty of Marine Sciences, Jeddah

1. *Managing Municipal Growth in the Coastal Zone: Jeddah,Kingdom of Saudi Arabia.*
   D. Olsen, M. J. Abdulrazzak, A. Khan, S. Al-Gowhary and S. Al-Kouli

2. *Impact of Urbanization on the Coastal Zone of the Red Sea.*
   The case of Suez Bay.
   M. El-Samra and A.A. Moussa

3. *Tourism Development of the Red Sea coasts.*
   Mostafa A. Saleh

4. *Phosphate pollution in the northern Gulf of Aqaba.*
   Ahmad Abu-Hilal

11.30-12.00 Coffee break

12.00-13.30 **SECOND SESSION**
Chair: Dr Selim Morcos

5. *Oil Pollution in the Red Sea. State of the art.*
   Hassan E. Awad

6. *The role of Marine Parks and Reserves as a mechanism for large scale management of coastal resources*
Michael P. Pearson

7. *Proposals for a Research and Monitoring programme for the Red Sea and Gulf of Aden.*
Youssef Halim and Selim Morcos

13.30-14.30 Lunch break

14.30-16.00 **THIRD SESSION**
Chair: Dr Youssef Halim

Round Table discussion on the Proposals for a Research and Monitoring programme.

16.00-16.30 Coffee break

16.30-18.00 **THIRD SESSION (cont.)**

- Conclusions
- Recommendations
- Adoption of a Proposed Programme for Research and Monitoring in the Red Sea and Gulf of Aden.

ANNEX II

LIST OF PARTICIPANTS

1. **Dr Mohammed Mahdi A. ABUBAKR**
Institution: Sana'a University
Address: Oceanography Department,
Faculty of Science, Sana'a University
P.O. Box 12092
Sana'a, Yemen
Telephone: (9671) 200522/214329 (Home)
Fax: (9671) 278361
email:

2. **Dr Ahmad Hamed ABU-HILAL**
Institution: Marine Science Station, Director
Address: P.O. Box 195
Aqaba, Jordan
Telephone: (962) 3315144
Fax: (962) 3313674

3. **Dr Abdullah D. AL-FAWAZ**
Institution: Meteorology and Environment Protection Agency (MEPA), Saudi Arabia
Address: P.O. Box 14625
Jeddah 21434, Saudi Arabia
Telephone: (2) 651 2312 ext. 2663
Fax: (2) 651 7832

4. **Abdullah Hamoud Aba AL-FOTOUH**
Institution: Envrionment Protection Council (EPC), Yemen
Address: P.O. Box 18280
Sana'a, Yemen
Telephone: (9671) 215617
Fax: (9671) 215604

5. **Dr Salah Al-GAWHARI**
Institution: MEPA, Saudi Arabia
Address: P.O. Box 1358,
Jeddah 21314, Saudi Arabia
Telephone: (9662) 651 9868
Fax: (9662) 651 9868

6. **Eng. Bamaileh Jamal ALI**
Institution: MEPA, Saudi Arabia
Address: P.O. Box 1358,
Jeddah 21314, Saudi Arabia
Telephone: 651 3640

7. **Dr Saleh A. AL-SHARE**
Institution: Department of the Environment, Jordan
Address: Ministry of Municipal and Rural Affairs and the Environment,
P.O. Box 35206,
Amada, Jordan
Telephone: 673149
Fax: 695627

8. **Inger ANDERSEN**
Institution: United Nations Development Programme (UNDP) - Regional Bureau of Arab States (RBAS)
Address: 1, UN Plaza
New York
N.Y. 10017, United States
Telephone: (212) 906 6199
Fax: (212) 906 5487
email: inger.andersen@undp.org

9. **Dr Hassan AWAD**
Institution: Department of Oceanograhy, University of Alexandria
Address: Department of Oceanography
Faculty of Science,
University of Alexandria,
21511 Meharam Bek,
Alexandria, Egypt
Telephone: 4922918/19 (office) or 4223126 (home):

10. **Dr Hussein Kamel Amin BADAWI**
Institution: National Institute of Oceanography and Fisheries, Egypt
Address: National Institute of Oceanography and Fisheries,
101, Kasr El-Eing,
Cairo, Egypt
Telephone: 3551381/3556785
Fax: 3551381

11. **Pui Shan Catherine CHEUNG**
Institution: UNDP - Regional Bureau for Arab States (RBAS)
Address: 1, United Nations Plaza, 2240
New York
N.Y. 10017 , United States
Telephone: (1212) 906 5456
Fax: (1212) 906 5487
email: catherine.cheung@undp.org

12. **Ziad M. DAGHISTANI**
Institution: MEPA, Saudi Arabia
Address: P.O. Box 1358
Jeddah 21471, Saudi Arabia
Telephone: 6512312 ext. 2202/6970164
Fax: 651 3640

13. **Dr Bashir EISAWY**
Institution: King Saud University
Address: P.O. Box 87902
Riyadh 11652, Saudi Arabia

14. **Dr Danny ELDER**
Institution: Adviser to the IUCN
Address: Marchissy 1261
Gland, Switzerland
Telephone: (4122) 368 2103
Fax: (4122) 368 2104

15. **Mohamed Abd El Aziz EL-GINDY**
Institution: Egyptian Environmental Affairs Agency (EEAA), Egypt
Address: 8, St. Ahmed El Adham ,
San Stefano,
Alexandria, Egypt
Telephone: (03) 5871877 - 5877539
Fax: (03) 4930079

16. **Ahmed Ismail Ibrahim EL-IBIARY**
Institution: National Institute for Oceanography, Egypt
Address: Kasr El-Einy Str.,
Cairo, Egypt
Telephone: 356 3956/355 1381
Fax: 355 1381

17. **Rawya Amin EL-SAADANY**
Institution: National Institute for Oceanography, Egypt
Address: 101, Kasr El-einy Str.
Cairo, Egypt
Telephone: 356 3956
Fax: 355 1381

18. **Dr Mohammed I. EL SAMRA**
Institution: National Institute of Oceanography and Fisheries, Egypt
Address: National Institute of Oceanography and Fisheries,
P.O. Box 182, Suez, Egypt
Telephone: (2062) 360015
Fax: (2062) 360016

19. **Dr Mohamed A. FAWZI**
Institution: EEAA, Egypt
Address: 17, Tieba Str.,
Mohandseen,
Cairo, Egypt
Telephone: 360 4364
Fax: 361 0764

20 **Dr Makram A. GERGES**
Institution: United Nations Environment Programme (UNEP)
Address: Regional Office for West Asia (ROWA)
P.O. Box 10880
Manama, State of Bahrain
Telephone: (973) 276072/73
Fax: (973) 276075
email: mgunrowa@batelco.com.bh

21. **Dr Sameer Jameel GHAZI**
Institution: MEPA, Saudi Arabia
Address: P.O. Box 1358,
Jeddah 21341, Saudi Arabia
Telephone: 651 7832 or 651 2312/2259

22. **Dr William GLADSTONE**
Institution: Programme for the Environment of the Red Sea and the Gulf of Aden (PERSGA),
Address: P.O. Box 1358
Jeddah 21314, Saudi Arabia
Telephone: (9662) 651 4472
Fax: (9662) 651 9868
email: william.gladstone@saudibbs.com

23. **Dr Salah Al-GOWHARY**
Institution: WMO/MEPA/PERSGA
Address: UN Office,
P.O. Box 558
Riyadh 11421, Saudi Arabia
Telephone: (9662) 651 4075
Fax: (9662) 651 9868

24. **Dr Youssef HALIM**
Institution: University of Alexandria, Department of Oceanography
Address: Faculty of Science,
University of Alexandria
Alexandria, 21511 Egypt
Telephone: (203) 5869661
Fax: (203) 545 7611

25. **Dr Othman Abdu HASHIM**
Institution: King Abdulaziz University
Address: Faculty of Marine Science
King Abdulazia University
P.O. Box 1540
21441 Jeddah, Saudi Arabia
Telephone: 695 2043
Fax: 640 1747

26. **Dr Ahmed KHAFAGY**
Institution: EEAA, Egypt
Address: 17, Tieba St.,
Mohandeseen
Cairo, Egypt
Telephone: (02) 360 1191/ (03) 482 1208
Fax: (02) 361 0764/(03) 482 9582

27. **Dr Ahsanullah KHAN**
Institution: Pollution Control Directorate, MEPA, Saudi Arabia
Address: P.O. Box 1358
Jeddah 21431, Saudi Arabia
Telephone: 651 2312 ext. 2602
Fax: 651 7832

28. **Dr Samir MAHMOUD**
Institution: King Saud University
Address: Riyadh, Saudi Arabia
Telephone: (9661) 467 5120
Fax: (9661) 468 2476

29. **Dr Amin Hamed MESHAL**
Institution: IOC of UNESCO
Address: UNESCO Regional Office for the Arab States of the Gulf
P.O. Box 3945,
Doha, Qatar
Telephone: (0974) 867707
Fax: (0974) 867644
email: *UHMES UNESCO ORG*

30. **Dr Selim MORCOS**
Institution: IOC of UNESCO
Address: UNESCO
75015 Paris
or 28204 Kenton Lane,
Santa Clarita,
CA 91350, United States
Telephone: (1805) 296 1034
Fax: (1805) 263 8236 & (1805) 2961034
Email: smorcos@theonramp.net

31. **Dr Dirar H. Nasr**
Institution: MEPA
Address: P.O. Box 1358,
Jeddah, Saudi Arabia
Telephone: (9662) 2312
Fax: (9662) 651 9868

32. **Dr David A. OLSEN**
Institution: PERSGA
Address: Jecor,
Unit 62103
APO AE 09811-2103,
United States
Telephone: (9662) 651 4075
Fax: (9662) 651 9868

33. **Dr Francis PARAKATIL**
Institution: IUCN - The World Convservation Union
Address: 1196 Gland, Switzerland
Telephone: (4122) 999 0204
Fax: (4122) 999 0020

34. **Eng. Rashdan Ali RASHDAN**
Institution: Ministry of Municipal and Rural Affairs and the Environment, Jordan
Address: P.O. Box 1799, Jordan
Telephone: 619934
Fax: 640404

35. **Mostafa A. SALEH**
Institution: Al Azhar University, Cairo, Egypt
Address: Faculty of Science,
Al Azhar University,
Nasr City,
Cairo, Egypt
Telephone: 570 3492/8
Fax: 570 3491

36. **M. M. EL SAMMAN**
Institution: EEAA Egypt
Address: 17, Teiba Str.
Mohandseen,
Cairo, Egypt
Telephone: 360 1191
Fax: 361 0764

37. **Dr Viktor SEBEK**
Institution: Advisory Committee on Protection of the Sea (ACOPS)
Address: 11, Dartmouth Street,
London, SW1H 9BN, United Kingdom
Telephone: (44171) 799 3033
Fax: (44171) 799 2933

38. **Dr Jamil Yahya SOFI**
Institution: United Nations Development Programme (UNDP)
Address: P.O. Box 588,
Riyadh 11421, Saudi Arabia
Telephone: 465 2500
Fax: 465 2087

39. **Dr Nizar TAWFIQ,**
Executive Secretary
Institution: PERSGA
Address: P.O. Box 1358,
Jeddah, Saudi Arabia
Telephone: (9662) 651 9868
Fax: (9662) 651 9868

40. **Osama Amin WALI**
Institution: MEPA, Saudi Arabia
Address: P.O. Box 10751
Jeddah 21443
Saudi Arabia
Telephone: 651 7832
Fax: 651 7832

ANNEX III

RECOMMENDATIONS

1. International Agreements

Noting that not all countries of the PERSGA region have ratified the relevant International and Regional Agreements;
Recommends that countries of the region, as appropriate, ratify the relevant International and Regional Agreements concerned with conservation of biodiversity, and the protection of the marine environment particularly from Land- Based Activities.

2. Preparation and Adoption of a Protocol on the Protection of the Red Sea and Gulf of Aden from Land- Based Activities:

Noting the obvious need for the countries of the Region to agree on a legally binding instrument or a protocol to the Red Sea and Gulf of Aden Convention with a view to eliminating, reducing or controlling marine environmental degradation resulting from land- based activities.

Being aware of the Intergovernmental Conference to adopt a Global Programme of Action for the Protection of the Marine Environment from Land- Based Activities, to be held in Washington DC from 23 October to 3 November 1995;
Recommends that PERSGA, with the assistance of relevant international organizations as appropriate, should take the lead in the preparation and adoption of a regional protocol on land- based activities, taking into consideration the outcome of the Washington conference.

3. Priority Actions: A Research and Monitoring Programme to Support the Protocol on Land- Based Activities, and Integrated Coastal Zone Management

Recognizing that the development and full implementation of a regional research and monitoring programme is a prerequisite for the integrated management of marine and coastal areas and for the sustainable development of their resources; Building upon the past research activities, and the ongoing initiatives and programmes; Recommends that a management- related research and monitoring programme, which will incorporate an inventory of land-based activities and a review of coastal socio-economic activities, be developed by PERSGA, in consultation with and assisted by the relevant international organizations as appropriate, taking into account the regional priorities and needs, and considering the appended proposal as a possible framework to be further elaborated as deemed necessary, and adopted by PERSGA Council.

Proposals for a Research and Monitiring Programme for the Red Sea and Gulf of Adem Adopted by the Workshop.

Objectives:

The overall objective of the research and monitoring programme is to provide the Contracting parties to the Red Sea and Gulf of Aden Convention with an adequate scientific marine data base for the integrated management of the coastal and marine environment and the sustainable development of their resources. The proposed programme therefore is action oriented

The specific objectives of the programme are:

1. To design and conduct a long study of the basic Oceanographic processes in the coastal and marine environment in the Red Sea and Gulf of Aden

2. To establish a qualitative and quantitative inventory of all contaminant inputs from Land- Based Sources and of human activities susceptible to adversely affect the marine environment.

3. To assess periodically the levels and trends of pollution in the coastal and marine environment against the background of natural variations, together with the impacts of pollution on human health and on the ecosystem.

4. To assess the effectiveness of management and control policies adopted and implemented by the countries of the Region and to provide advice for improvements or for the adoption of new measures and policies.

5. To strengthen the capabilities and promote the level of expertise of the national institutions for carrying out research, monitoring and management of the coastal and marine environments in the Red Sea and Gulf of Aden Region.

Principles

1. Levels. It is proposed that the programme be carried out at two levels, the level of governmental institutions and that of NGO volunteers. At the NGO level, volunteers recruited from various sectors of the indigenous population will be trained in "Red Sea Campuses" to carry out simple observational activities and to collect and preserve samples for subsequent analysis. Involvement of the community will help to achieve two objectives, greater public awareness and a wider geographical coverage of the sampling programme.

   On the other hand, it is important that governmental institutions be involved in the scientific aspects of the programme to ensure continuity in its implementation and a greater reliability of the data.

2. Focus.The monitoring programme will be conceived in a cost effective way. Efforts will be focused on pollutants suspected to be of concern for human health and the quality of the environment in the Region. Priority will be given to the sites and habitats requiring more urgent attention.

3. Baseline Coastal Oceanography. Knowledge about coastal oceanographic processes, including meteorological, physico-chemical and biological processes, is essential for defining the background natural conditions and for understanding the fate and impact of contaminants. The programme therefore will encompass a coastal oceanographic component.

4. Quality and comparability. The programme will include a procedure for quality control of the data, ensuring their reliability and comparability. Achievement of this aim will require an intensive Capacity Building programme for the institutions and the personnel, and periodical intercomparison exercises. The adoption of common sampling and analytical methods, of data quality control procedures and of a common data reporting format should be mandatory.

Institutional requirements

The research and monitoring programme is conceived as a cooperative Regional effort. A mechanism for the active involvement and cooperation of all the countries of the Region, in both the early planning stages and the conduct of the programme, should be set up.The implementation of the programme, however, is the responsibility of the respective countries with the technical assistance of the relevant International Organizations such as the IOC with its subsidiary bodies, UNEP, IUCN and IMO. Due consideration must be given to the disparity in the respective economic potential and technical capability of the countries of the Region.

It is proposed that, at the Regional level, a standing **Technical Steering Committee** be set up by PERSGA/ UNEP/ IOC/IUCN/IMO in consultation with the countries of the Region. Membership will be drawn from experts from the Region, but the assistance of experts from outside the Region might be required, at least in the initial stages. The technical secretariat and the funding will be provided by PERSGA. UNEP, building upon its long involvement with the Region through its Regional Seas programme, would be requested to contributed to funding the activities of the committee together with other international organizations.

The main tasks of the Steering Committee are:

a. to design the operational details for the research and monitoring programme, including the priority contaminants to be assessed, the oceanographic processes to be monitored, the habitats to be investigated, the methodologies, the detailed sampling strategy, the time frame.

b. to follow up the cooperative implementation of the programme and to provide technical assistance to the countries, when needed.

c. to identify the needs of the Region in terms of logistics, training and capacity building in the framework of the programme.

d. to provide linkage and harmonization with the relevant ongoing national and international activities in the Region, including the Development Programmes supported by GEF.

At the national level,one or more **governmental departments** will be designated for the implementation of the research and monitoring programme and for compiling the information required for the Land- Based Sources inventory. A **national coordinator** will be designated by each country to coordinate and follow up the activities and to provide linking with the Regional Steering Committee.

PROPOSED RESEARCH AND MONITORING ACTIVITIES

1. Inventory of Land- Based Sources and a review of socio- economic activities.

An inventory of all Land-Based Sources of pollution and a socio- economic review of present and emerging human activities susceptible to adversely affect the coastal and marine environments will be carried out by in situ consultants with the full cooperation of the national authorities. The review will also account for the current management practices.

All data and information will be communicated to the Steering Committee and stored in a data base. Some guidelines are proposed in Appendix 1.

2. Pilot Projects

On the basis of the workshop deliberation, a phased approach is proposed. The workshop identified a series of priorities for each phases as defined in the following:

PHASE I:

The Pilot Projects proposed for Phase I require a low level training in "Red Sea Campuses" and limited sampling equipment.
During this Phase, the Institutional arrangements will be finalized and become operational, including the Steering Committee, the national coordinators and the national institutions.

Phase I will also initiate an intensive Capacity Building programme in preparation for the activities of Phase II.

Pilot Project 1. Visual monitoring by NGO volunteers.

This project will be concerned with the monitoring of floating tar balls, tar balls and litter on beaches, with visual observations of oil slicks, sea water discolouration, fish kills and any other environmentally significant observations.

The project could be carried out by trained NGO volunteers recruited from various sectors of the indigenous population, such as fishermen, school children and others.

The volunteers will also be trained to collect and preserve certain sample for subsequent analysis.

Pilot Project 2. Baseline coastal waters characteristics.

This Project consists of an introductory activity to the full coastal oceanographic project which will be initiated in the following phase. It will be concerned with the preliminary data collection of some basic oceanographic parameters from the coastal zone: salinity, temperature, dissolved oxygen, turbidity, suspended solids.

Such measurements could be carried out by trained technical assistants and junior scientists.

PHASE II

Pilot Project 3. Coastal Oceanographic processes.

Guidelines for this project are given in Appendix 2 II. The strategy and the operational details for the conduct of this project will designed by the Steering Committee.

Pilot Project 4. Biomonitoring of the coastal ecosystems and of biodiversity in the Red Sea and Gulf of Aden.

The objective is to inventoriate the major ecosystems, coral reefs, mangroves, eel- grass, creeks (khor) and others along all Red Sea coasts, including the islands, and record the biological characteristics indicative of their health condition and of potential human impacts. Several earlier reports on the coastal ecosystems are available and should be referred to.

The survey will benefit from the use of GIS techniques. Ground observations will deal with more than one aspect and should provide an ecological inventory of the species and the habitats which should be as comprehensive as possible. It should determine the processes which drive, sustain or effect productivity and diversity in the system. It will describe the representative communities, the dominant species, the trophic relations. It should also identify the exploited populations (fish, shellfish, crustaceans) and investigate their population dynamics in relation to fishing pressure, their spawning sites and seasons, their nursery grounds, their feeding habits.

The survey should aim at covering all Red Sea Coasts, but priority should be given to two types of area: he areas threatened by foreseen intensive developments such as the Gulf of Aqaba, and the less well known area of the southern Red Sea and the islands.

Pilot Project 5. Assessment and surveillance of oil pollution in the Red Sea and Gulf of Aden

The objective for this project is to assess the level of contamination by oil hydrocarbons in the Red Sea and Gulf of Aden in relation to marine and land based sources and to follow their trends of variation.

Oil hydrocarbons, including Polyaromatic Hydrocarbons, will be analyzed in water, sediments and in tissues from selected organisms. Tar balls, both floating and stranded on beaches will be monitored and their characteristics recorded.

Supporting data on coastal oceanographic processes and on the grain size and nature of the sediment samples will be needed. The sampling sites will be chosen so as to cover the Red Sea as much as possible, although the project can focus, in a first stage, on some hot spots such as the Gulf of Suez and the area of Jeddah.

Pilot Project 6. Assessment of hazardous substances in the Red Sea and Gulf of Aden

This project will consist in a survey of the level of the heavy metals and synthetic substances expected to be of concern for the Region. It will provide baseline data for both contaminated areas off large coastal cities and harbours and relatively uncontaminated reference areas. Periodical surveys will allow long term trends to be discerned. The substances will be analysis in the water column, in appropriate tissues of edible marine organisms, in different tropic levels of the food web and in relevant grain size sediment fractions. The type of sample, the metals and the synthetic organic compounds to be measured in priority will be decided upon by the Steering Committee.

Pilot Project 7. Microbiological contamination

The level of contamination of bathing waters and of Sea food by microorganism (bacteria and viruses) downstream from large coastal cities and all human settlements is to be monitored on a regular basis.

Appendix 1:

Elements of a Land- Based Sources Inventory and a socio- economic review in the Red Sea and Gulf of Aden.

1. **Demography.**
   Population density and rate of growth
   Health statistics of coastal dwellers
   Significant variations from the rest of the population

2. **Municipal sources of Pollution.**
   Urban centers, tourist resorts
   Type of source
   Sewerage system
   Treatment facilities
   Effluent characteristics: Site, length, depth, flux
   Coastal engineering: coastline modifications, building activities along coastal strip

3. **Industrial sources of pollution.**
   Type of industry, e.g. oil refinery, cement factory, desalination plant, power station, others
   Production size
   Freshwater consumption
   Effluent characteristics
   Type and amount of waste: liquid, solid, atmospheric.
   Treatment facilities

4. **Ports, oil terminals, offshore oil activities.**
   Port development
   Navigational dredging
   Size of loading-delooading activities
   Spill records: crude oil, refined oil products, phosphate ore, others
   Offshore oil production and prospection: lubricants, production wastes

5. **Fisheries.**
   Commercial, artisanal, subsistence fisheries
   Statistical trends
   Catch analysis
   Aquaculture

Appendix 2

Proposed guidelines for the long term monitoring of coastal oceanographic processes.

Meteorology

Precipitation
Winds
Storms & Surges

Hydrography

Sea- level
Water circulation
Inshore- offshore exchange
Flushing rate
Vertical stratification
Parameters to be measured: Salinity, temperature, density, current measurements

Suspended particulate material

Turbidity
Flux, sources, transport and fate
(Through runoff, coastal erosion, sedimentation, resuspension)
Effects on productivity, coral reefs, contaminant transport and accumulation

Chemistry

Dissolved oxygen and percent relative saturation
Biological oxygen demand (BOD)
Biogenic compounds: fluxes, distribution and time variability of ammonia, nitrate, phosphate and silicate

PART II

SCIENTIFIC CONTRIBUTIONS

PROPOSALS FOR A RESEARCH AND MONITORING PROGRAMME

Y.Halim* and S. A. Morcos**

* Department of Oceanography, Faculty of Science, Alexandria
** UNESCO consultant

Contents

Executive Summary

In the Red Sea, as well as in all regional seas, more than two thirds of the pollutants reaching the marine environment derive from Land-Based Sources. The situation in the Red Sea is of growing concern in areas surrounding urban, touristic and industrial centers. There is a pressing need for control strategies based on a sound scientific data base.

International obligations. The UN Convention of the Law of the Sea, now in force since November 1994, established a comprehensive legal framework of obligations for coastal states. In accordance with the Convention, while all states have the sovereign right to exploit their natural resources, the enjoyment of such right shall be in accordance with heir fundamental duty to protect the environment. Chapter 17 from Agenda 21 (UNCED, Rio, 1992) reaffirms this obligation and calls, among other things, for measures to maintain biological diversity of species and habitats and for the establishment and management of protected areas.

The Land-Based Sources of Pollution. Although there are internationally agreed guidelines, there is currently no global scheme for the control of pollution from Land- Based Sources. An Intergovernmental Conference is due to convene in Washington (USA) in October-November 1995 to deal with this issue on a global basis.

The case of the Red Sea and Gulf of Aden. A regional Convention for the Conservation of the Environment of the Red Sea and Gulf of Aden and a draft

Protocol concerning cooperation in combating Pollution by Oil and other harmful substances in cases of emergencies were adopted by the Jeddah Conference of 1982. The Conference also adopted an Action Plan and created an interim secretariat for PERSGA, now hosted by Saudi Arabia in Jeddah.In September 1995, the Council for the" Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden" issued the "Cairo declaration" announcing the establishment of the Regional Organization as an autonomous body.

The Red Sea is comparatively more vulnerable to pollution than other sea basins. Man made physical destruction of coastal marine habitats appears to be of greater concern in this sea than chemical pollution, oil excepted. The diversity of its characteristic habitats, coral reefs, mangroves, mudflats, seagrass beds and others, represents a natural heritage of worldwide significance but also an economic resource of importance to tourism and to fisheries. Such habitats are threatened by pervasive oil pollution and by the impacts of uncontrolled coastal development.

Suggested strategic steps. Three steps are recommended:

- Ratification of the relevant regional and international agreements by the Red Sea countries which have not done so as yet.
- Preparation and adoption of a Protocol to the Red Sea Convention on the Protection of this Sea from Land- Based Sources.
- Adoption and implementation of a management-related Research and Monitoring programme. Proposals for this Programme are included.

Proposed Research and Monitoring Programme. Its overall objective is to provide the Contracting Parties with an adequate scientific data base for the integrated development of the coastal zone. The programme is action oriented and should also aim at strengthening the capabilities of national institutions. It will establish a qualitative and quantitative inventory of all Land- Based Sources of pollution, in support of the Protocol on Land-Based Sources. A phased approach is proposed.

Phase I. During this phase the necessary institutional arrangements will be finalized and become operational, including the nomination of a standing Technical Steering Committee at the Regional level, the designation of the participating national institutes and of the national coordinators. Simple monitoring activities and the collection of samples for subsequent analysis will be carried out by trained NGO volunteers.

Phase II. Five Pilot Projects will be conducted during Phase II:

1- Coastal oceanographic processes.
2- Biological monitoring of coastal ecosystems and of biodivesity.
3- Assessment and surveillance of oil pollution.
4- Assessment of hazardous substances.
5- Assessment of microbiological pollution.

It is recommended that :

- an expert Working Group be set up to draft the Protocol for the prevention of pollution from Land-Based Sources and its financial implications before submission to the Contracting Parties. The Working Group will also propose the modalities for the land- based sources inventory.
- a standing Technical Steering Committe be nominated for the conduct and follow up of the Research and Monitoring Programme, for designing its operational details and for coordination with other national and international activities in the Red Sea.

Introduction

In the Red Sea , as well as in all regional seas, human activities in the coastal zone and further inland are the major contributor to the degradation of the marine environment. It is estimated that more than 70% of the marine pollution derives from Land Based Sources including atmospheric pollution (GESAMP, 1990). In the Red Sea, the situation is of particular concern in the areas surrounding growing urban and industrial centers. If unchecked, the trend will lead to more and more widespread deterioration and irreversible loss of habitats and of natural resources.

The basic concept in developing control strategies for pollution from Land Based Sources is that of Sustainable Development. Underlying this concept is the principle that technological and economical development should be consistent with the needs of future as well as present generations. The unrestricted use or misuse of environmental resources is not compatible with the principle of Sustainable Development and is no longer acceptable. Action is needed to make economic growth in the coastal zone and inland compatible with a healthy environment and with the conservation of its resources . This is a policy issue which is not meant to veto all development proposals but to find the best way to achieve development objectives while reducing the environmental damage.

The present workshop is convened by IOC in response to the need of the countries of the Region to generate a scientific marine data base as a prerequisite for a cooperative programme for the integration of environmental protection measures to economic development plans in the coastal zone, in the framework of pre-existing Regional agreements and of International guidelines and recommendations set up by the United Nations Convention on the Law of the Sea (UNCLOS) and the United Nations Conference on Environment and Development (UNCED, Rio, 1992).

International obligations

The United Nations Convention on the Law of the Sea (UNCLOS) came into force in November 1994. The Law of the Sea established a comprehensive legal framework of obligations , on which basis further international agreements and national measures shall be adopted.

In accordance with the Convention, all States have a fundamental duty, to protect and preserve the marine environment. While States have the sovereign right to exploit their natural resources, the enjoyment of such right shall be in accordance with their duty to protect the environment. Several obligations follow.

States are obliged to take all necessary measures to prevent, reduce and control pollution of the marine environment from any source. The measures taken shall include measures necessary to protect rare and fragile ecosystems and habitats of threatened or endangered forms of marine life .

They are required to adopt and enforce national laws and regulations to prevent, reduce and control pollution of the marine environment from Land-Based Sources, taking into account internationally agreed rules and standards.

With respect to monitoring and environmental assessment, States are under obligation to monitor the effects of pollution of the marine environment by recognized scientific methods, to keep under surveillance the effects of any activities likely to pollute the marine environment, and to publish the results of monitoring.

In accordance with the Convention, States are obliged to cooperate in developing the scientific and technological capacity of developing States and to provide them with assistance. They shall also assist them in the preparation of Environmental Impact Assessments.

Chapter 17 of Agenda 21, adopted at the Rio Conference in 1992, recognizes that the UN Convention on the Law of the Sea provides the international legal basis upon which the protection and sustainable development of the marine environment are to be pursued. Chapter 17 reiterates the major obligation of coastal States in accordance with the Law of the Sea and sets forth general objectives which incorporate the essential provisions of UNCLOS.

The concept of marine pollution is broadened in Chapter 17 to incorporate impacts from diverse land-based activities. This approach reflects the conviction that the issue of land-based pollution is linked to the management of all human activities in coastal areas .

Coastal States, with the support of United Nations Organizations upon request, should undertake measures to maintain biological diversity and productivity of marine species and habitats, including inventories of endangered species and critical coastal habitats, the establishment and management of protected areas .

States are further called upon , *inter alia*, to:

a) strengthen existing Regional agreements or initiate the development of new Regional agreements, where appropriate, to prevent, reduce and control marine pollution from Land- Based Sources and activities.

b) prepare and implement integrated coastal management and sustainable IOC development plans.

c) prepare coastal profiles identifying critical areas

d) carry an environmental impact assessment prior to the authorization of any major project and to follow up the impacts.

e) improve coastal human settlements, especially housing, drinking water , treatment and disposal of sewage and industrial effluents.

f) cooperate with developing countries through financial and technological support.

The Land -Based Sources of Marine Pollution.

There is currently no global scheme for the control of land-based sources of marine pollution. UNEP, recognizing that legally binding instruments are needed for the prevention of pollution from land, prepared guidelines to be taken into account when developing national strategies and control mechanisms, the Montreal Guidelines of 1985. In response to a request by the Rio Conference in 1992, an intergovernmental Conference on Land Based Activities has been convened in Washington by UNEP in October-November 1995 to deal with this issue..

Only three of UNEP Regional Seas Conventions are supplemented by protocols on the prevention of marine pollution from these sources. These are the Barcelona Convention for the Mediterranean, the Quito Protocol to the Lima Convention for the South East Pacific and the ROPME sea region. The reluctance to develop and adopt legally binding national and global instruments for the prevention of pollution from land can be understood in the light of the expected costs they would impose on industries and municipalities.

The case of the Red Sea and Gulf of Aden.

In 1974, the General Conference of the Arab League Educational, Scientific and Cultural Organization (ALECSO),approved a recommendation calling for the preparation of a cooperative regional programme for the environmental study of the marine area of the Red Sea and Gulf of Aden. In October 1974, UNESCO convened, upon the request of ALECSO, a workshop in Bremerhavn, Germany, on a "Marine Science Programme on the Red Sea " (UNESCO, 1976) . The report of the workshop served as a working document for the First Expert meeting on a Regional Programme for the Environmental Studies of the Red Sea and Gulf of Aden in Jeddah in December 1974 (Jeddah I). The Plan of Action for 1975 required a number of preparatory studies by IOC,UNEP and UNESCO which provided the basis for discussion at the Jeddah Conference on the Protection of the Red Sea and Gulf of Aden Environment (Jeddah II), convened by ALECSO in January 1976. The interim Secretariat for PERSGA was created within ALECSO. In February 1982, a Regional Conference of Plenipotentiaries convened in Jeddah, adopted the Regional Convention for the Conservation of the Red Sea and Gulf of Aden. At present, PERSGA secretariat is hosted by the government of Saudi Arabia in Jeddah, and performs in consultation with the member states, with advice and support from UNEP and technical assistance from UNESCO, IOC, IUCN and IMO The Jeddah Conference which adopted the Red Sea and Gulf of Aden Convention also adopted a draft Protocol concerning cooperation in combating Pollution by oil and other harmful substances in cases of emergencies (UNEP, 1983) and an Action Plan (UNEP, 1986).

Shortly before the present workshop, the Council of the "Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA)" issued the Cairo declaration in 26September 1995. In this declaration the Council announced the establishment of the Regional Organization as an autonomous body with a Secretariat in Jeddah headed by a Secretary-General to carry out it responsibilities in implementing the Regional Convention, its Protocol and Action Plan.

Several national projects, training courses and expert meetings have been carried out in the framework of PERSGA, in cooperation with UNEP, UNESCO and IUCN, since the adoption of the programme . Of particular relevance are several reports and studies :on "Management and Conservation of renewable marine resources in the Red Sea and the Gulf of Aden region" (IUCN/UNEP,1985), a regional review on " The State of the Marine Environment in the Red Sea and Gulf of Aden " (Halim *et al,* draft),a" Bibliograhy on Oceanographic and Marine Environmental Research of the Red Sea , Gulf of Aden and Suez Canal", (Morcos and Varley, eds, 1990), a review on the geology of coral reefs in the Red Sea published by UNEP (Behairy et al ,1992).

Knowledge about the Red Sea coastal zone is geographically very uneven. For management purposes, two types of surveys are urgently needed : an inventory of all land based sources and coastal activities likely to adversely affect the marine environment and a survey of the status of critical habitats.

The narrow configuration of the Red Sea basin and its semi-isolation render it more vulnerable to the impacts of pollution. On the long run, pollutants released in this basin are more likely to accumulate rather than be dispersed and diluted as would happen in the open ocean. Environmental stress in this region , however, results from both the direct introduction of pollutants and from a variety of coastal and marine uses (El Samra and Moussa, Olsen et al, Saleh, in this workshop). The physical destruction of the coastal marine habitats by human activities is a major problem, possibly of greater significance in this region than chemical pollution, oil excepted. Irreversible loss of habitats has occurred in association with coastal development in the major coastal towns of the Red Sea and Gulf of Aden. Infilling has taken place principally around tourist resorts such as Ghardaqa and industrial centers such as Jeddah, Yanbu, Rabigh and Jizan. The infilling material is often eroded by wave action and the reefs become smothered by increased sedimentation. As the discharge of untreated domestic waste water to the coastal zone is restricted to urban centers, the overall environment of the Red Sea and Gulf of Aden is still in a relatively good condition with respect to sewage pollution. Sewage outfalls, however, are expected to increase with urban settlements and touristic developments and the accompanying increase in desalination plants in the region.

Oil is the major environmental concern in the Red Sea. Spills derive from production, handling at terminals , from accidental as well as deliberate discharge from ships. Local but chronic oil pollution affects several areas along the Saudi Arabian coast, the Gulf of Suez and the port of Eilat. There is evidence that tank cleaning occurs deliberately in the open Red Sea and the Gulf of Aden, in areas where surveillance is poor (Awad, this workshop).

Coral reefs, with their associated fish and other marine animals represent certainly the most critical marine resource of the Red Sea, both economically and as a natural heritage of worldwide value .Their significance to tourism needs not to be stressed, but their significance to fisheries is less obvious to the public at large. Reef life is extremely dense and varied in the Red Sea. The fish crop on the Red Sea reefs exceeds by far the crop of the most productive parts of the world oceans. This high productivity is due to the activity of the corals themselves as well as to their associated vegetation, the "algal turf" or lawn.. Numerous kinds of fish are attracted to this lawn and graze on it intensively. Larger carnivorous fish are attracted to the reefs to predate upon these.

In addition, the outstanding diversity of the reef organisms represents a large genetic pool and many reef animals are of great potential medical value and may lead to considerable advances in medical research.

Adequate knowledge about the coral reef communities in the Red Sea is limited to particular sites in the Gulf of Aqaba, the vicinity of Ghardaqa , the Saudi Arabian coast and Port-Sudan. Information is otherwise lacking or fragmentary for the whole African coast down to Djibouti, as well as for the coast of Yemen and for the islands, with the exception of Dahlak to a limited extent. The health condition of the coral communities on both sides of the Red Sea needs to be systematically assessed on a periodical basis together with the natural or anthropogenic stresses they may be subjected to. A survey along these lines has been carried out along the Saudi Arabian coast in 1988 (Awad,in this workshop) and several coral diseases have been documented. Oil pollution around Yambu and Jeddah is suspected to be the cause. Incidence of such diseases elsewhere, however, has not been systematically looked for in the Red Sea.

It is in the vicinity of major touristic centers (Saleh, in this workshop) and of large industrial harbours that coral communities are under stress. Reef fish become almost depleted in places by overfishing to meet the increased demand of the tourist population. Perhaps more devastating is the uncontrolled business of collecting reef fish for export to aquaria. Where coastal development and building is carried out near the shore-line, the coral reefs become damaged by increased sedimentation.

Mangroves are able to grow in the intertidal environment because of their specially developed salt secretion glands. They are therefore particularly sensitive to coating by oil. The Red Sea is geographically the northenrmost sea where mangroves can be found. Historical evidence suggests that they were much more abundant on both sides of the Red Sea than they are at present. Mangrove communities have important functions in the coastal ecosystem and represent a valuable and significant natural habitat. They are at the base of important fish and shrimp fisheries. Their roots provide a habitat and a shelter for juvenile fish and shrimps and help to protect the shoreline from erosion .The trees provide wood for various uses and fodder for feeding cattle.

The major impact on mangroves in the Red Sea derives from direct exploitation and from alterations of the coastline. The level of exploitation of mangroves and the rate of alterations of the coastline appear to be on the increase. Along the Red Sea coast of Egypt, mangroves have been severely impacted by oil at several locations.

It is suggested that some selected Red Sea mangrove stands be conserved as park areas (UNEP,1985).The Egyptian experiment and its replicability is discussed by Pearson (in this Workshop).

Suggested Strategic steps

National strategies will be based on the needs and priorities of each state. However, because of the common concern and mutual interest in safeguarding their shared marine and coastal environment, member states will endeavour to develop their national strategies, taking in consideration the pre-existing regional agreements and international guidelines, in consultation, when necessary, with neighbouring states and relevant UN organizations
The elements of a strategy are proposed by the Workshop in the following.

1. International agreements.

It is highly recommended that all countries of the region - as appropriate- ratify the relevant Regional and International Agreements on the protection of the marine environment from all sources of pollution including Land-Based Sources. Ratification of such agreements represents a commitment to develop and enforce the corresponding national legislation and the supporting institutions.

2. Preparation and Adoption of a Protocol on the Protection of the Red Sea and Gulf of Aden from Land-Based Sources of Pollution.

There is an obvious need for the countries of the Region to agree on a legally binding instrument or a Protocol to the Red Sea Gulf of Aden Convention with a view to eliminate, reduce or control emissions from Land -Based Sources. The Mediterranean experience can serve as a model to be tailord to the specific needs of the Region.

The Protocol will encompass guidelines, measures and procedures to be adopted and progressively implemented by the countries of the Region. It will clearly state *inter alia,* the obligation for all countries of the Region to carry an Environmental Impact Assessment prior to authorization for any major coastal development project.

It is recommended that an *ad hoc* technical Working Group be set up by PERSGA in cooperation with UNEP/IOC/IMO/WMO to deal with the following tasks:

a-Drafting the Protocol and its financial implications

b-Submitting a proposal for an Inventory of Land-Based Sources in the Red Sea and Gulf of Aden and for the modalities of its implementation .

The *ad hoc* Working Group will take in consideration the outcome of the Intergovernmental Conference on Land-Based Sources due to meet in Washington, USA, in October- November 1995. After its report has been circulated to member states and relevant international organizations, and after due consultation, an Intergovernmental Conference will be invited by PERSGA to adopt the Protocol.

3. Priority Actions: Research and Monitoring Programme.

The Workshop recognizes that strategically, a prerequisite to the development of a sound Management policy for the marine and coastal environment in the Region consists in the full implementation of a Research and Monitoring programme in the Red Sea and Gulf of Aden. The following proposals are drafted in the framework of the Action Plan of PERSGA, although certain elements of the Plan are given higher priority.

PROPOSALS

Objectives:

The overall objective of the Research and Monitoring programme is to provide the Contracting Parties to the Red Sea and Gulf of Aden Convention with an adequate scientific marine data base for the integrated management of the coastal and marine environment and the sustainable developnment of their resources.
The proposed programme therefore is action oriented.

The specific objectives of the programme are:

1-To design and conduct a long term study of the basic Oceanographic processes in the coastal and marine environment in the Red Sea and Gulf of Aden

2-To establish a qualitative and quantitative inventory of all contaminant inputs from Land- Based Sources and of human activities susceptible to adversely affect the marine environment.

3-To assess periodically the levels and trends of pollution in the coastal and marine environment against the background of natural variations, together with the impacts of pollution on human health and on the ecosystem.

4-To assess the effectiveness of management and control policies adopted and implemented by the countries of the Region and to provide advice for their improvement or for the adoption of new measures and policies.

5-To strenghthen the capabilities and promote the level of expertise of the national institutions for carrying out research, monitoring and management of the coastal and marine environments in the Red Sea and Gulf of Aden Region.

Principles.

1- Levels. It is proposed that the programme be carried out at two levels, the level of governmental institutions and that of NGO volunteers. At the NGO level, volunteers recruited from various sectors of the indigenous population will be trained in "Red Sea Campusses" to carry out simple observational activities and to collect and preserve samples for subsequent analysis. Involvement of the community will help to achieve two objectives, greater public awareness and a wider geographical coverage of the sampling programme.
On the other hand,it is important that governmental institutions be involved in the scientific aspects of the programme to ensure continuity in its implementation and a greater reliability of the data.

2- Focus.The monitoring programme will be conceived in a cost effective way. Efforts will be focused on pollutants suspected to be of concern for human health and the quality of the environment in the Region. Priority will be given to the sites and habitats requiring more urgent attention.

3- Baseline Coastal Oceanography. Knowledge about coastal oceanographic processes, including meteorological, physico-chemical and biological processes, is essential for defining the background natural conditions and for understanding the fate and impact of contaminants. The programme therefore will encompass a coastal oceanographic component.

4- Quality and comparability. The programme will include a procedure for quality control of the data, ensuring their reliability and comparability. Achievement of this aim will require an intensive Capacity Building programme for the institutions and the personel, and periodical intercomparison exercises. The adoption of common sampling and analytical methods, of data quality control procedures and of a common data reporting format should be mandatory.

Institutional requirements:

The research and monitoring programme is conceived as a cooperative Regional effort. A mechanism for the active envolvement and cooperation of all the countries of the Region, in both the early planning stages and the conduct of the programme, should be set up.The implementation of the programme, however, is the responsibility of the respective countries with the technical assistance of the relevant International Organizations such as the IOC with its subsidiary bodies, together with UNEP, IUCN and IMO. Due consideration must be given to the disparity in the respective economic potential and technical capability of the countries of the Region.

It is proposed that:

- at the Regional level, a standing **Technical Steering Committee** be set up by PERSGA in consultation with UNEP/IOC/IUCN/IMO and with the countries of the Region. Membership will be drawn from experts from the Region, but the assistance of experts from outside the Region might be required, at least in the initial stages. The technical secretariat and the funding will be provided by PERSGA .UNEP, building upon its long envolvement with the Region through its Regional Seas Programme, would be requested to contribute to funding the activities of the Committee

The main tasks of the Steering Committee would be :

a. to design the operational details for the Research and Monitoring programme, including the priority contaminants to be assessed, the oceanographic processes to be monitored, the habitats to be investigated, the methodologies, the detailed sampling strategy, the time frame.

b. to follow up the cooperative implementation of the programme and to provide technical assistance to the countries, when needed.

c. to identify the needs of the Region in terms of logistics, training and capacity building in the framework of the programme.

d. to provide linkage and harmonization with the relevant ongoing national and international activities in the Region, including the Development Programmes supported by the World Bank and by the Global Environmental Facility,

At the national level, one or more **governmental departments** will be designated for the implementation of the research and monitoring programme and for compiling the information required for the Land- Based Sources inventory. A **national coordinator** will be designated by each country to coordinate and follow up the activities and to provide a link with the standing Steering Committee.

Proposed Research and Monitoring activities.

The activities will proceed along two parallel and complementary lines of action.

1- Inventory of Land-Based Sources and a review of socio- economic activities.

An inventory of all Land-Based Sources of pollution and a socio- economic review of present and emerging human activities susceptible to adversely affect the coastal and marine environments will be carried out by *in situ* consultants with the full cooperation of the national authorities. The review will also account for the current management practices of the respective countries. All data and information will be communicated to the Steering Committee and stored in a data base. Some guidelines are proposed in Annex 1.

2- Pilot Projects.

On the basis of the workshop deliberations, a phased approach is proposed. for the implementation of the programme and a series of priorities identified for each phase .

PHASE I:

The Pilot Projects proposed for Phase I require basic training in "Red Sea Campuses" and limited sampling equipment.
It is assumed that during this Phase, the institutional arrangements will be finalised and become operational, including the Steering Committee, the national coordinators and the assigned national institutions.

An intensive Capacity Building programme will be initiated during Phase I, in preparation for the activities of Phase II., with the assistance of IOC/UNEP.

Pilot Project 1. Visual monitoring by NGO volunteers.

This project will be concerned with the monitoring of floating tar balls, tar balls and litter on beaches (plastic materials in particular), with visual observations of oil slicks, sea water discolouration, fish kills and any other environmentally significant observations.

The project could be carried out by trained NGO volunteers recruited from various sectors of the indigenous population, such as fishermen, school children and others. The volunteers will also be trained to collect and preserve certain samples for subsequent analysis.

Pilot Project 2. Baseline coastal waters characteristics.

This Project consists in an introductory activity to the full coastal oceanographic project which will be initiated in the following phase. It will be concerned with the preliminary data collection of some basic oceanographic variables from the coastal zone: salinity, temperature, dissolved oxygen, turbidity, suspended solids. Such measurements could be carried out by trained technical assistants and junior scientists.

PHASE II

Pilot Project 3. Coastal Oceanographic processes.

Guidelines for this project are given in Annex II. The strategy and the operational details for the conduct of this project will be designed by the standing Steering Committee, in cooperation with IOC when necessary.

Pilot Project 4. Biomonitoring of the coastal ecosystems and of biological diversity in the Red Sea and Gulf of Aden.

The objective is to inventoriate the major ecosystems, coral reefs, mangroves, eel-grass, creeks (khor) and others along all Red Sea coasts, including the islands, and record the biological characteristics indicative of their health condition and of potential human impacts. Several earlier reports by institutions of the Region and by international organizations on the coastal ecosystems are available and should be referred to.

The survey will make use of the Geographical Information System techniques for the monitoring of coral reefs and mangrove stands. Ground observations will deal with more than one aspect and should provide an ecological inventory of the species and the habitats which should be as comprehensive as possible. It should determine the processes which drive, sustain or affect productivity and diversity in the system. It will describe the representative communities, the dominant species, the trophic relations. It should also monitor the exploited populations (fish, cephalopods, shellfish, crustaceans) and investigate their population dynamics in relation to fishing pressure, their spawning sites and seasons, their nursery grounds, their feeding habits.

The survey should aim at covering all Red Sea Coasts, but priority should be given to two types of areas:the areas threatened by foreseen intensive developments such as the Gulf of Aqaba, and the less well known areas of the southern Red Sea and the islands. The biomonitoring project will benefit from the expertise of the IUCN in this field.

Pilot Project 5. Assessment and surveillance of oil pollution in the Red Sea and Gulf of Aden.

The objective of this project is to assess the level of contamination by oil hydrocarbons and PAHs in the Red Sea anf Gulf of Aden in relation to marine and land based sources and to follow their trends of variation.

Oil hydrocarbons, including Polyaromatic Hydrocarbons, will be analysed in water, sediments and in tissues from selected organisms. Tar balls, both floating and stranded on beaches will be monitored and their characteristics recorded.

Supporting data on coastal oceanographic processes and on the grain size and nature of the sediment samples will be needed. The sampling sites will be chosen so as to cover the Red Sea as much as possible, although the project can focus, in a first stage, on some hot spots such as the Gulf of Suez , the area of Jeedah and the Strait of Bab El Mandab.

Pilot Project 6. Assessment of hazardous substances in the Red Sea and Gulf of Aden.

This project will consist in a survey of the level of heavy metals and synthetic substances expected to be of concern for the Region. It will provide baseline data for both contaminated areas off large coastal cities and harbours and relatively uncontaminated reference areas. Periodical surveys will allow long term trends to be discerned. The substances will be analysed in the water column, in appropriate tissues of edible marine organisms, in different trophic levels of the food web and in relevant grain size sediment fractions. The type of sample, the metals and the synthetic organic compounds to be measured in priority will be decided upon by the standing Steering Committee.

The assessment of hazardous substances in the Red Sea and Gulf of Aden will benefit form the technical assistance of GIPME of IOC, the Global Investigation of Pollution in the Marine environment.

Pilot Project 7. Microbiological contamination.

The level of contamination of bathing waters and of sea food by microorganisms (bacteria and viruses) downstream from large coastal cities and of all human settlements is to be monitored on a regular basis.

Annex I

Elements of a Land-Based Sources Inventory and of a Socio-Economic review in the Red Sea and Gulf of Aden.

1. Demography.

Population density and rate of growth
Health statistics of coastal dwellers.
Significant variations from the rest of the population

2. Municipal sources of Pollution.

Urban centers, tourist resorts.
Type of source
Sewerage system
Treatment facilities
Effluent characteristics: Site, length, depth, flux
Coastal engineering: cooastline modifications, building activities along the coastal strip

3. Industrial sources of pollution.

Type of industry, e.g. oil refinery, cement factory, desalination plant power station, others.
Production size of the industrial plants
Mines, type of ore, production size.
Freshwater consumption
Effluent characteristics
Type and amount of waste: liquid, solid, atmospheric.
Treatment facilities.

4. Ports, oil terminals, offshore oil activities.

Reception facilities
Port development
Navigational dredging
Size of loading- deloading activities
Spill records: crude oil, refined oil products, phosphate ore, others
Offshore oil production and prospection: lubricants, production wastes.

5. Fisheries.

Commercial, artisanal, subsistence fisheries
Statistical trends
Catch composition
Aquaculture

Annex II

Proposed guidelines for the long term monitoring of coastal oceanographic processes.

Meteorology

- Precipitation
- Winds, storms and surges
- Temperature

Hydrography

- Water circulation
- Inshore- offshore exchange
- Flushing rate
- Vertical stratification
- Measurements needed: Salinity, temperature, density, current measurements.

Suspended particulate material

- Turbidity
- Flux, sources, transport and fate.
- (Through runoff, coastal erosion, sedimentation, resuspension).
- Effects on productivity, coral reefs, contaminant transport and accumulation.

Chemistry

- Dissolved oxygen and percent relative saturation
- Biological oxygen demand (BOD)
- Biogenic compounds: fluxes, distribution and time variability of ammonia, nitrate, phosphate and silicate.

References

Awad, H.E. Oil Pollution in the Red Sea.State of the art. In this workshop. *IOC Workshop Report No.126*

Behairy, AKA, CRC Sheppard and MK El Sayed, 1992. A Review of the Geology of Coral Reefs in the Red Sea. *UNEP Regional Seas Reports and Studies No. 152,* UNEP 1992.

El-Samra ,M. and A.A.Moussa. Impact of Urbanization on the Coastal Zone of the Red Sea. The case of Suez Bay. In this Workshop. *IOC Workshop Report No. 126.*

GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP) Joint Group of Experts on the Scientific Aspects Marine Pollution,1990. The State of the marine environment. *UNEP Regional Seas Reports and Studies No. 115,* UNEP 1990.

Halim Y. et al. Regional Review on the State of the Marine Environment in the Red Sea and Gulf of Aden, UNEP (draft).

IUCN/UNEP, 1985. *Management and conservation of renewable marine resources in the Red Sea and Gulf of Aden Region*. UNEP, 1985.

Morcos SA and A Varley (eds), 1990. *Red Sea, Gulf of Aden and Suez Canal. A bibliography on Oceanography and Marine Environmental Research*. UNESCO/ ALECSO, Paris.

Olsen, D., M.J.Abdulrazzak, A.Khan, S.Al-Gowhary and S.Al-Kouli. Managing Municipal Growth in the Coastal Zone: Jeddah, Kingdom of Saudi Arabia. In this Workshop, *IOC Workshop Report No. 126*

Pearson, M.P. The role of Marine Parks and Reserves as a mechanism for large scale management of coastal resources. In this Workshop, *IOC Workshop Report No. 126*

Saleh, M.A. Tourism development of the Red Sea coasts. In this Workshop. *IOC Workshop Report No. 126*

UNEP, 1983. *Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment; Protocol concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency*, UNEP, 1983.

UNEP, 1986. Action Plan for the conservation of the marine environment and coastalareas of the Red Sea and Gulf of Aden. *UNEP Regional Seas Reports and Studies No 81*, UNEP 1986.

UNESCO, 1976. Marine Science Programme for the Red Sea . Recommendations of a Workshop held in Bremerhaven, F.R.Germany, October 1974, *UNESCO Technical papers in Marine Sciences No.25, 21 pp*,UNESCO, Paris, 1976.

Managing Municipal Growth in the Coastal Zone: Jeddah, Kingdom of Saudi Arabia

by

David A. Olsen
Mohammed Jameel Abdulrazzak
Ahsanullah Khan
Salah Al-Gowhary
Sayed Al-Kouli

Meteorology and Environmental Protection Administration
Kingdom of Saudi Arabia

Introduction

Jeddah, the "Bride of the Red Sea: is a coastal city of ancient lineage. Indeed, the derivations of its name stem from its position on the shoreline as noted in the 10th century by the Arab Geographer al-Bakri who wrote "Juddah is a coastal town and its name is derived from its position in relation to the sea" (Pesce, 1974). This appears to predate the currently held view now holds that the name is derived from the Egyptian word "Jaddah", or "grandmother" reflecting the belief that Eve, whose tomb was to be found just outside the old town until 1928, was buried there (figure 1).

Jeddah's geographical location offers a number of desirable attributes which have, over the years, enhanced its importance as a major coastal port. Among these are access to the Holy Cities of Makkah and Madina as well as the central portion of the Arabian Shield over the steep western escarpment by means of Wadi Fattima and the fact that its location offers one of the first major breaks in the line of offshore reefs which line the Red Sea Coast (figure 2).

This access meant that European ships could ride the winter monsoon down wind from the orient until south of Jeddah where they began to encounter the prevailing NNW winds which forced them to sail to windward, an inefficient point of sail for square rigged vessels of that time. Jeddah, then became a port where these vessels would offload their cargo into the smaller and more efficient (in sailing to windward) dhows of the Arabs who would transport their cargoes northward against the wind towards Europe.

Historical Growth

Early evidence suggests that Jeddah may have been the site of a fishing village as early as 350 BC (Pesce, 1974). Indeed, the maps of Ptolemy from the second century AD show a settlement in the position of Jeddah. Fishermen were perhaps attracted by the fact that there is a break in the continuous line of reefs that can be navigated by knowledgeable mariners but which pose a hazard to those unfamiliar with the area. Accounts from mariners throughout the city's history describe the protection provided by the outlying reefs which in 1517 provided sufficient deterrent to prevent a Portuguese landing (op. cit., figure 3a). Jeddah's importance as a transshipment port in the trade for spices and luxury items between Europe and the Far East and as a center of commerce in incense and the spices of the Arabian peninsula is well documented and was confirmed as early as 1050 AD by the Persian Poet, Naser Khusrow who reported that, "Jeddah is a great city surrounded by a strong wall, with a population of some five thousand males. The bazaars are fine. There are no trees or any vegetation at all, but all that is necessary for life is brought in from surrounding villages" (Buchon, 1981).

With the coming of Islam, the city became the port of entry for pilgrims coming on the Haj when the port of Shuaibah was abandoned in the 26th year of the Muslim era (646-7 AD, Buchon, 1991) in favor of Jeddah due to the vulnerability of Shuaibah to attacks by pirates (op. cit.) Since that time servicing the needs of the millions of religious visitors who annually pass through Jeddah has been an important element of the Jeddah economy.

By 1517 (figure 3b) the city appears to have fully developed as a walled town and center of trade following final construction of the wall by Husayn al Kurdi in 1514-15 (Pesce, 1974) which stood until the period following the second world war. Throughout much of the second millennia of its history, Jeddah remained much as seen by Khusrow. Plans and drawings from the period (figures 1 & 3) reveal a city within the town walls which slowly grew from "five thousand males" (or a population of around 10,000) to 20,000 to 30,000 in 1845 and 30,000 to 40,000 in 1945 (Table 1).

The opening of the Suez canal in 1869 led to increased commercial activity in Jeddah as the volume of trade between Europe, Arabia, Africa and the Far East expanded greatly, creating wealth for Jeddah's merchant families. Jeddah's fortunes began to decline with the advent of steam powered shipping which reduced the need for cargo to be shifted from inefficient square rigged European sail vessels to the more efficient (with regards to the prevailing NNW winds) Arab dhows. A century later in 1987, the Egyptians constructed the SUMED pipeline between Ain Sukhna in the Gulf of Suez and Sidi Kerir in the Mediterranean to allow annual transshipment of over 80 million tons of oil from 300 tankers which are too large to transit the canal.

Perhaps the seminal event in the city's history came in 1925 when the besieged city fell to the Al-Sauds and it was consolidated into the modern Kingdom of Saudi Arabia as the primary port of entry for trade with the outside world in a subsequent economic expansion which is probably unprecedented in human history. That growth, fueled first by development of the Kingdom's vast oil reserves which followed the Saudi Arabia/Standard Oil agreement in 1933 and the resultant flow of capital into the economy during the 1950s and 60s and later by a quadrupling of oil prices during the 1970s; led to an expansion of Jeddah from a walled desert city, one square kilometer in area and 35,000 inhabitants in 1945 area to a thriving modern city covering over 1200 square kilometers with over 2,000,000 inhabitants in 1992 (figure 4).

In 1973 the Jeddah Municipality published a plan for a modern graceful city of modern infrastructure, wide streets, monuments and open spaces for recreation with a planned 1990 population of between 800,000 and 1.65 million inhabitants (Sert Jackson, 1979). In subsequent years massive investment led to construction of much (but not all) of the necessary infrastructure to handle the anticipated population.

The present report is a discussion of the significance and consequences of this remarkable expansion upon the environment and people of Jeddah. In addition, statistical analysis of available time series data has been used to project future growth of population, consequent demand for services and infrastructure and resulting requirements for investment. Wherever possible, available planning documents, or suggested response activities have been analyzed and statements made regarding their adequacy to meet the needs for anticipated growth.

Environmental Setting

Jeddah lies in an arid climate with an annual rainfall of slightly over 64 mm/year (figure 5) and an annual average temperature of 28°C (figure 6). When the rain does come, it tends to come in torrential downpours, leading to flooding and rapid runoff of approximately 30% of the incident rainfall (Abdulrazzak, et al., 1989). This can be seen in figure 7 where the extreme monthly rainfall and the extreme daily rainfall are shown. Many of the extreme month's rainfall came in a single day.

The prevailing wind blows consistently from the NNW direction (figure 8) in the Jeddah areas although the southern portion of the Red Sea receives winds from the SSE during the winter months. The winter winds converge to the south of Jeddah, resulting in a net inflow of surface waters during the winter month and a rise in sea level of 0.5 M in the winter relative to the summer. (Sheppard, et al, 1993).

Tides in the Red Sea are complex and are a composite of both diurnal and semidiurnal tidal patterns. There is a well known oscillatory pattern (Morcos, 1970; Edwards, 1987) with the average tidal ranges about 0.6 m in the north and 0.9 m in the south and with almost no daily tidal fluctuation at Jeddah (figure 8). The extreme tide at Jeddah is around 0.2 m and tidal water movement provides insignificant flushing of inshore bays and empondments. Inshore currents are poorly studied in the Red Sea although divers report an occasional strong drift to the south.

Population

As can be seen in Table 1, the human population in Jeddah increased by nearly a factor of four between the 1974 and 1992 censuses. The annual rate of growth, 7.47% is 3.24% higher than the figure for the Kingdom as a whole, reflecting the process of urbanization in addition to a rapid population growth. If this rate of growth were to continue until over the next 20 years, Jeddah would have a population of nearly 12 million in the year 2015 (figure 9).

Jeddah's population increase is a combination of birth rate (2.3%/year, MOFNE. 1970-92); internal migration to urban centers and "immigration" from expatriate workers and overstayers from the Pilgrimage. Evidence for "net immigration" can be found in the MOFNE statistics for Foreigners entering and leaving the Kingdom as well as the number of airline passengers arriving and leaving. Net "immigration" to the Kingdom has been over 200,000 persons annually over much of the past decade.

There are, however, indications that this rapid rate of growth is slowing. These are based on a combination of the two official census figures from 1974 and 1992 and unofficial figures which have appeared in the literature (Table 1). When these intervals are fit to a curve (figure 10), they suggest that the growth rate is decreasing to approximately a 3.3% annual figure by the year 2015. If this analysis is correct, then the population of Jeddah in the year 2015 would be approximately 5.5 million inhabitants. In the present analysis, subsequent demand for services utilizes this lower projection.

Sources of this growth are various. The 1992 census indicated that Jeddah is inhabited by approximately 51% non-Saudis so the growth in population must consider reasons for "in-migration" as well as the increases in the Saudi population which has come about urban migration to Jeddah and through improved medical services and increased life expectancy.

Increases in the non-Saudi population are largely tied to the Kingdom's economic expansion as foreign workers have been employed to build the infrastructure, operate industries and participate in service and commercial sectors. Lately, the process of "Saudiization" has reached the state where many of the skilled and managerial positions are now being filled with Saudis and their expatriate counterparts are leaving the Kingdom. However, in order for Saudiization to effect a significant demographic change, Saudis will need to be employed in the more numerous worker and service positions1.

Admittedly, employment of non-Saudi's is a policy matter and the Kingdom has, in the past, exported nearly 1.2 million non-Saudi's in 1981/82 following construction of the massive infrastructure projects, a reported 250,000 Yemeni nationals during the 1990/91 Gulf War for security reasons and has (in 1994/5) deported over 135,000 illegal workers and Haj overstayers (Arab News, 1 May., 1995) in addition to instituting policies which make employment of additional expatriate labor both more costly and difficult.

Room for City Expansion

As can be seen in figures 4,11 & 12; recent municipal development has been linear in the coastal plain (or Tihama) between the rocky foothills preceding the escarpment and along the shoreline. Future expansion to the south most likely extend to the south towards Makkah or into the Wadi Fattima "flood plain". To the north, the municipality includes Dhaban. Recent expansion has concentrated to the north of the city and future city boundaries may well cover most of the coastal plain between Dhaban and Shuaibah.

Water

Water has always posed a problem for Jeddah. As early as the sixth century, the city's Persian rulers were obliged to dig three hundred wells and cisterns to meet the city's water needs (Buchon, 1991). In the tenth century al-Hamdani, a Yemeni geographer quoted a then current poem which stated that "al-Gugayyah of Huthariq and al-Qirsh (springs) have all dried up and Juddah is parched and shriveled." (Buchon, 1991). In 1330 Ibn Battuta reported described Jeddah's water system as consisting of "antique cisterns and in it are pits for water, bored in the solid rock and connected with each other in numbers beyond computation. This year (1330) was one of little rain, so the water was brought to Judda from the distance of a day's journey, and the pilgrims used to beg for water from the owners of the houses" (Pesce, 1974).

Between 1676 and 1683 Grand Vizier Kara Mustafa Pasha funded construction of a water duct which carried water from wells east of the city. This system was later reconstructed in 1934. Such descriptions of water scarcity in Jeddah were frequently repeated in the historical works of the following years. Poncet (in Pesce, 1974) reported that water cost 2 to 3 pence a liter in 1701.

The first small capacity boiler ("Kindasah") had been installed in 1909 and was producing around 300 M3/day by the 1940s. Already, Jeddah appears to have developed a dependency on sea water desalination for its survival. From 1947 until 1955 Jeddah's primary water supply came from 3200 cu. m/day which were transported from wells in the lower Wadi Fattima (Abu Rizaiza, 1993, page 135). After this period, the water authority developed wells in the Wadi Fattima and pumped three million gallons of water daily to Jeddah. The poet Mohamed Said Otaibi acclaimed that the pipeline would "Save us from the clamor of the Kindasah" (Buchon, 1991). Wadi Fattima supplied 16 million M3/yr in 1978; 8.5 million M3/yr in 1982 (Altimbilek, 1984) and presently about 5.3 million M3/yr (including water from Wadi Khulays, Ministry of Planning, personal communication) as the major portion of the aquifer's production is used by the villages located in the water table.

When the economic situation improved in the Kingdom, it stood to reason that development of a reliable water supply would be one of Jeddah's highest priorities because rainfall is low and unpredictable, and groundwater resources had become insufficient to meet the demands of a rapidly expanding population. Massive sea water desalination appeared to be the primary water option available to meet the city's demand for water. The first major (18,333 M3/day) plant came on line in 1970 (Abu-Rizaiza, 1993). In 1992 the city utilized 138 million M3 of desalinated water.

Desalinated water continues to be supplemented by the Wadi Fattima and Wadi Khulays aquifers which provide approximately 5.3 million M3 annually (Ministry of

Planning, personal communication); approximately 13.1% of treated wastewater (Al-Hoisney, 1990) which is utilized for horticultural irrigation. In addition, significant amounts of bottled drinking water are used by the populace. In all, as shown in Table 2, the total amount of water utilized in Jeddah in 1995 is probably approaching 80 M3/person/year. By 1992 there were indications that Jeddah was entering into a period of under supply.

The reason for this massive water use originates from rising per capita consumption (figure 13). Figure 14 would seem to indicate that Jeddah's inhabitants will consume as much water as can be produced as analysis of available supply (figure 14) and per capita demand show a highly significant correlation. There is no current evidence for any leveling off of demand. Indeed, the rate of per capita demand (figure 13) is increasing at a rate faster than that of the Kingdom as a whole. In fact, recent information (Arab News, Arpil 5, 1995; World Bank, 1996; Awadalla, et al., 1996) indicates that there is massive leakage (as much as 50% of the produced water) from the distribution system which may well account for much of the increasing per capita "demand" for water. What ever the reasons, if such growth in demand continues unabated, by 2015 the city would require over 800 million cubic meters of desalinated water annually which would necessitate additional investment of over one billion dollars (SR 4 billion). In addition, the government would have to support the operating costs of nearly 3.6 times the currently installed desalination capacity.

Much of this water use stems from excessive personal water use and it seems clear that some intervention will be required if the city is going to continue to expand. Analysis of possible interventions has been undertaken (Abdul-Razaq, et al., 1993). Their modeling results indicate (figure 12) that if a pervasive system of public education, plumbing codes, leak detection and pricing were instituted in 1995, currently installed desalination capacity (including Jeddah V which should come on-line in 1998) would be sufficient to supply water to the projected population increase for the foreseeable future and total demand could be reduced to 70% of current levels despite the projected population increase.

Sewage Treatment

The current system only services one-third of the area of Jeddah (Taylor and Ghazi, 1994). There are a total of eight sewage treatment plants which have a combined capacity of 176,000 M3/day and they are currently operating at 141% of their capacity of 43.8 million M3/year (figure 15).

It is reported by the Sewage Authority that, although only one-third of the municipal area is connected to the sewage system (figure 16), it contains some of the more densely populated districts in the city and serves two-thirds of the population. They report that the actual per capita generation of sewage is 55 M3/person/year which provided a 1995 estimate of approximately 130 million cubic meters of sewage generated annually, which is almost 3 times the rated capacity of Jeddah's sewage treatment plants. Sewage generation is expected to rise to over 302,000,000 M3/year by the year 2015 (figure 17).

In 1994, MEPA analyzed samples from of several plants and found that in flow and out flow had similar BOD content, indicating that very little sewage treatment is taking place in the overloaded plants. There is also some evidence that the existing municipal sewage system is only serving 600,000 people (Abu-Rizaiza, et al., 1991) and that the per capita sewage generation is nearly three times as great as that reported by the Sewage Authority.

Insufficiency of the sewage system resulted in construction of nearly 30 unregulated "private" sewage outfalls along Jeddah's coastline (figure 16). Most of these were concentrated along the Kornisch road where much of the city's recreational activities take place and even up current from the desalination plants. Recent efforts to reduce this problem have had some success.

Over 13% of the treated water which is reused for irrigation of the city's many parks and planted areas (Al-Hoisney, 1990) and another 36.5 million cubic meters which are disposed of in individual septic systems which are dumped at disposal sites in the north east of Jeddah (Taylor and Ghazi, 1994).

Ground Water

Excessive water use has led to another major problem facing the municipality today, a ground water table is rising at the rate of 0.5 m/yr (Abu-Rizaiza et al., 1985) and large areas of the city face threat from inundation of low-lying areas, flooding of basements, deterioration of roads and building foundations, offensive smells, breeding of mosquitoes, and other health hazards (figure 18).

A "ground water budget" (Tables 2 and 3) were constructed from available information. When the total ground water per square meter (0.09 M3/M2) is divided by the figure for the average porosity of Jeddah's sediments (0.2), the annual ground water rise (0.45 M3/Year) is extremely close to the figures provided in the literature (0.5 M3/Year).

The results also show that over 80% of the contribution to the ground water originates with disposal of sewage. Thus, expansion of the sewage system and disposal at sea will not only address the problem of sewage but also clearly contribute significantly towards alleviation of the problem of ground water rise. Failing this, the groundwater problem will most likely have to be addressed by an extensive drainage and sea disposal scheme.

The problem of rising groundwater levels has also occurred in Riyadh where the Arriyadh Development Authority has thus far spent SR 340 million on a system of collection and has requested another SR 200 million for disposal infrastructure (ADA, personal communication).

Resolution of the Jeddah groundwater problem has been extensively investigated by Abu-Rizaiza and his co-workers (1987) who have found that although contamination by fecal coliforms is very low, high salinity and hardness preclude its use for irrigation purposes. They recommend that sea disposal could be effected within MEPA's guidelines (MEPA, 1989) once the necessary infrastructure for its collection was developed.

Air Quality

In addition to its contribution to the sewage and groundwater problems, heavy dependence on desalinated water adds to a growing air pollution problem. As can be seen in Table 4, desalination contributes a major portion of the SO2 and NOx emissions from fixed sources. In addition, the location of the plume from the Jeddah desalination plant lies directly over several important government facilities, including a hospital (figure 19). Jeddah's industrial city contributes significant amounts of air borne pollutants as well as the Jeddah Refinery as well and the KAIA airport.

Presently, Jeddah's meteorology and consistent sea breezes dissipate much of the air pollution, although MEPA has received complaints from areas that are down wind from the Jeddah refinery, south of the town. would seem to be sufficient to relieve Jeddah of any significant buildup of airborne pollutants. The major source of air pollution in Jeddah originates from the transport sector (discussed later).

Electricity

Consumption of electricity increased rapidly during the 1970 to 1986 period but has shown signs of leveling off to an asymptotic level of approximately 3.4 MW/Person/Year (figure 20). Total consumption will continue to increase unless the sort of conservation program suggested for water consumption is instituted (figure 21). In 1995, the Kingdom of Saudi Arabia revised (upwards) the price for water and electricity to levels which could result in some market-driven reduction in consumption. At the same time programs are being developed to encourage energy efficiency through the use of variable-speed electric motors, building insulation and improved air-conditioning and refrigeration (Arab News, April 6, 1995).

In order to assess the effectiveness of such a program, a linear model which included elements of pricing and conservation was introduced to the expected pattern of electrical demand. The results indicated that if such a program were to commence in 1995, demand for electricity in Jeddah might be limited to 14 million MW/year in 2015 (compared to 24 million MW/yr if no conservation was introduced) or 139% of current demand.

Expansion of Jeddah (and the Western Province) electricity system will require substantial investment. Currently (figure 22), peak demand is in excess of currently installed (and projected) capacity, resulting in increasingly frequent brown outs and power outages during peak load periods. This problem may well double during the next two decades unless either production capacity is expanded or conservation programs achieve expected successes.

Transportation

Saudi Arabia does not require annual registration of vehicles and the vehicle fleet must, therefore be estimated as the official statistic provides only the cumulative number of vehicles registered. The Ministerial Committee for Environment (MCE, 1992) suggests that approximately 62% of the cumulative fleet remain on the road. This assumption has been used throughout the present analysis.

The Jeddah vehicular fleet was calculated by multiplying the population by the (national) per capita vehicle ownership rate (figure 23). This, in conjunction with statistics for the division of the fleet into private cars, light and heavy trucks, taxis, buses and motorcycles (MOFNE, 1970-92) was used to project the fleet. The results indicate that there are approximately 1 million vehicles in Jeddah at present and that the fleet may increase to 4.5 million vehicles by the year 2015 (figure 24).

Vehicular traffic in Jeddah is becoming increasingly congested in certain areas at certain busy periods. Despite this, it would appear that the road system could handle more traffic (figure 23). However, it would not be expected that the existing system could accept the quadrupling of the vehicle fleet that is expected by 2015 (figure 24).

The vehicle fleet is already a cause for health concern. Automobile accidents are currently the major source of mortality in the Kingdom with nearly 125,000 accidents annually creating an economic drain on the population in terms of lost work days, importation of vehicles and medical expenses.

In addition, automobile emissions are the major source of air pollution in Jeddah (Table 4). A MEPA and Ministry of Health study in 1985 (when the vehicle fleet was less than one-third of the 1995 size) of lead in the blood of school children found that the average level was 11mg/100 ml. This level was at the lower level of concern for health impacts and roughly equivalent to that found in large European cities. Since that time, the vehicle fleet has tripled (although the level of led in gasoline has been cut in half) and, even though no further studies have been undertaken, it would be expected that the level of lead in the blood the Jeddah's school children has also increased, perhaps to levels which warrant public health concerns. In addition, a recent study of lead in the breast milk of mothers from Riyadh, high levels were reported and attributed to environmental pollution and vehicular traffic.

Certainly, unless mass transit or alternative transportation and parking systems are put into place during the next 20 years, Jeddah will become a difficult city to move through and, expected levels of pollutants could lead to an increase in respiratory and other pollution related diseases.

Shipping

Throughout its history Jeddah has been a primary center for maritime activities, first as a fishing village, as the port of entry for pilgrims, as a major transshipment port for the trade between Europe and the Far East and currently as a major port of disembarkation for much of the Kingdom's material goods. The development of the Jeddah Islamic Port during the mid 1970's led to an increase in the amount of goods being unload from less than 1 million tonnes in 1965 to a high of 18 million tonnes in 1980 (figure 25).

Accompanying this increase in traffic has been a steady series of oil spills and other marine pollution incidents (figure 26) which threaten coastal resources and recreational facilities. The primary agency with responsibility for coordinating marine pollution response is MEPA which operates under the 1991 National Contingency Plan for Combating Marine Pollution in Emergency Cases.

Marine Pollution

Marine pollution sources originate from both land and sea-based emissions as well as the considerable amount of shipping which passes through the Jeddah Islamic port (figure 25) and offshore. Currently 100 million tons of oil transit the Red Sea although half of that passes through the northern Red Sea from the terminus of the trans-Arabian pipeline through the Arabian Gulf to the SUMED pipeline which has been operating over its 80 million ton capacity in recent years. Future plans to widen the Suez canal in order to provide passage for VLCC tankers in excess of 250,000 tonnes should increase this flow of oil through the Red Sea with a consequent increase in the frequency and volume of oil spills (World Bank, 1995).

The main land-based sources of pollution originate from heated brine from he desalination plant, the overloaded sewage treatment plants and the refinery, heated effluent from power plants and particulate emissions and sewage (25 million M3 of sewage are input from Jeddah's sewage treatment plants), and from coastal development where frequent use of dredge and drag lines are carried out without us of sediment reduction control or reduction of particulate levels in the mixing areas.

Solid and Hazardous Waste

Jeddah's citizens generate between 0.8523 and 1.4 kg of solid waste daily which created a low estimate of the total waste at total of 132 million tonnes of private/commercial solid waste in 1995. In addition, industry generated a total of 1,268,305 tonnes of solid waste which is expected to increase by an average of 3% annually. Thus, expected increases in population and continued industrial expansion are likely to result in a total of 4.4 million tonnes of waste in 2015 (figure 27).

The Jeddah land fill site is approximately 4 km2 in area and has approximately 5 more years of useful life (MEPA, 1994). The landfill operators estimate that approximately 12% of the waste could be recycled. The MEPA investigations also revealed that uncontrolled dumping of liquid wastes (some which are potentially hazardous) is occurring both at the landfill site as well as in several other locations around Jeddah, some of which are in Wadi beds. This practice poses obvious risks both to public use of the areas as well as to underlying aquifers.

Almost 30% of the waste is comprised of organic material (figure 28) which is breaking down into methane, a greenhouse gas, which could be utilized as a fuel for desalination or power generation. Over 45% of the solid waste is made up of materials which might profitably be recycled. Recycling is a relatively new phenomenon in Saudi Arabia although some recycling of aluminum has been going on during the past few years. In 1994, however, a major contract was let which may lead to development of a recycling industry utilizing much of the municipal waste throughout the Kingdom.

In addition to solid waste, Jeddah's industrial activities create 16 tonnes of spent caustic material, 274 tonnes of oil sludge and 180 tonnes of catalysts which are currently being disposed of either through the sewage system or in unregulated dumping in open pits near the city. Current studies are under way to assess the impacts of such dumping upon the city's ground water resources.

Recreation

Jeddah's coastline and offshore reefs has provided a spectacular recreational resource for its inhabitants. Development of 70 km of coastal Kornische facilities has been extremely successful in providing high quality coastal access for the city's inhabitants. As population expansion has continued, however, the Kornisch has become increasingly crowded. Outside of this Kornische facility nearly the entire shoreline from 40km south of the city to north of Khor Salman has become fully occupied by residential, industrial and security facilities, reducing access for the public to traditional fishing, swimming and boating activities which are shown in figure 29.

In addition to problems of access, a number of recreational and environmental resources have become degraded from sewage emissions. Most notable of these is the main sewage outfall south of the city (figure 16) which has heavily polluted the environmentally sensitive area at the Jeddah Salt Marsh waters and adjacent shoreline areas which are heavily utilized for recreation (figure 29).

Another example is the major recreational facility, the King Fahd Recreational City, which was constructed on the shores of an inland lagoon created by land filling. A major sewage treatment plant released its waste at the head of the lagoon, polluting the waters and filling the bottom with sewage sludge. Failing to realize that the absence of tidal flushing would lead to concentration of the effluent made water sports unavailable and created a potential health hazard instead of a recreational resource. The outfall was later moved outside of the lagoon (and into a location where the effluent might affect amenity beaches along the Kornische) but a major investment will have to be made in order to remove the sludge and restore the recreational potential of the lagoon.

Another example of the same sort of problem occurs in Arabian lagoon (Taylor and Ghazi, 1994) where 12 unregulated sewage outfalls empty into a lagoon that, once again, has been altered through landfill activities. The lagoon has become highly eutrophicated, generating unpleasant smells and posing a health hazard to children who play in the Such use conflicts will need to be resolved if Jeddah's inhabitants are to enjoy recreational and natural resources in the future.

Growth in Demand for Services (1995-2015)

The preceding analyses indicate that, over the coming 20 years, rising population and increases in the rate of consumption of services will create substantial increases in the requirements for infrastructural expansion. As can be seen in Table 6, meeting increased demand during the coming decades will require substantial expansion of the existing infrastructure. As was shown in the analysis of water demand (figures 13 & 14) substantial savings can be realized which can extend the period during which currently installed water, electricity and other services may be sufficient to meet the needs of the expanding population.

Required Investments

If Jeddah does not institute programs of conservation and efficiency, substantial investments will be required in order to maintain the quality of life in Jeddah. Estimates of some of these are shown in Table 7.

This very preliminary analysis suggests that approximately one billion dollars (SR 3.75 billion) may well need to be invested annually in order to keep pace with expected growth.

During the period between 1992-1994 The Kingdom's budget for Municipalities and Water averaged SR 6.26 billion and SR 2.27 billion for infrastructure development. Thus, the amount required by Jeddah amounts to 44% of the total amount budgeted Table (8).

As can be seen from this cursory analysis, the cost of resolution of environmental problems and providing services will require a major commitment of funds unless programs of efficiency, market control and conservation can lead to reduced demand as shown in the analysis of conservation on water demand.

Institutional Basis for Environmental Management

Key to any efforts to manage economic and population expansion in Jeddah over the next two decades will be establishment of the necessary institutional basis for coordination and implementation of the necessary economic expansion in a sustainable manner. A current analysis of environmental institutions in Saudi Arabia by the World Bank (MEPA/MOFNE/World Bank, 1994) has concentrated on minor alterations of the existing environmental infrastructure and suggested incremental increases in the Kingdom's resources for environmental management.

The Meteorology and Environmental Protection Administration (MEPA) is the central environmental agency in the Kingdom of Saudi Arabia. It has not, however, been given the extensive enforcement and regulatory authorities which is found in developed nations environmental agencies. Instead, the Kingdom of Saudi Arabia has chosen to distinguish between the setting of environmental criteria and actual operational management. Thus operational agencies such as the Ministry of Petroleum, Ministry of Agriculture and Ministry of Industry and Electricity retain actual regulatory control over activities carried out under their respective mandates.

MEPA has entered into a specific memorandum of understanding with the Royal Commission for Jubail and Yanbu (RCJY) in which the commission has been delegated authority for managing environmental activities in the industrial cities. The arrangement has been so successful that, in 1987 the RCJY was awarded the United Nations Sasakawa award for its environmental achievement. A recent analysis of environmental management in the Kingdom (World Bank, MOFNE, MEPA. 1994) has suggested that this approach should be employed on a broader basis.

As regards coastal zone management, MEPA has been consistently identified as the Kingdoms central environmental agency and the coastal zone management lead agency, institutionalization of authority for centralized coastal zone management has not been achieved. Instead, each individual agency operates under its own specific mandate and numerous overlaps and potential conflicts abound (Table 9). Currently, the only recourse for resolving such conflicts and establishing national environmental policy is the Ministerial Committee for Environment. Day-to-day coordinative mechanisms and central planning authority specific to the coastal zone are lacking.

The benefits of central planning and coordination have clearly been demonstrated by the successes of the Ministry of Planning's development plans and, on a municipal level, by the Arriyadh Development Authority (ADA) which has had notable success in dealing with a level of expansion which exceeds that in Jeddah.

There appears to be a growing recognition that the costs of catching up to and keeping pace with growth in the Kingdom's large cities may well warrant consideration of alternative planning strategies. One possible approach involves establishment of new "satellite" townships which encourage population movement away from the major cities.

Conclusions

Jeddah has been an important commercial center for much of the past millennium. It has expanded from a stable coastal city to a modern urban center of over 2 million inhabitants in 1992. Much of this growth has taken place during the past two decades under a plan for municipal development which was successful in anticipating much (but not all) of the requirements for such growth.

Future growth (based on a near doubling of the population during the next two decades) will require considerable expansion of infrastructure if the city is to maintain the quality of life for its inhabitants. Much of this expansion will require careful planning of the environmental consequences of development activities upon the coastal zone.

If such future planning is to take place, first attention must address the need for increased coordination between the many agencies whose mandates overlap and create potential conflicts within the coastal zone. It would also seem most appropriate that a centralized municipal planning entity, based upon the highly successful model of the Arriyadh Development Authority, be established in order to plan municipal expansion and mediate the potential conflicts between development and environment.

References Cited

Abdul-Razaq, M.J, M. Noori and A. Allehebi. 1993. Water Conservation Strategy for Saudi Arabia. Buchon, J. 1991. *Jeddah: Old and New*. Stacey International, London. 145 pp.

Abu-Rizaiza, O.S., H.Z. Sarikaya and Z.A. Khan. 1985. Urban ground water rise control: Case study. *J. Irrigation and Drainage Engineering*. Vol. 115(4):588-607.

Abu-Rizaiza, O.S. 1985. *Study of groundwater in north and south Jeddah*. Final Reports. Water and Sewerage Dept. Western Region, Jeddah, Saudi Arabia.

Abu-Rizaiza, O.W. and H.Z. Sarikaya. 1993. Drainage water disposal, Jeddah. Saudi Arabia. *J. Water Resources Planning and Management*. Vol. 119(6):707-710.

Abu-Rizaiza, O.W. and H.Z. Sarikaya. 1991. *Drainage water reuse or disposal*. Jeddah, Saudi Arabia. Vol. (5):357-367.

Al-Hoisny, A.T. 1990. *Cost of Waste Water Treatment*. Bsc. Thesis, King Abdul Aziz University, Jeddah. 152 pp.

Altimbilek, H.D. 1984. *Input-Output model for Jeddah water supply system*. King Abdulaziz University College of Engineering. Grant Report No. 02-109. 80pp.

Awadalla, S.; Allehaibi and M. Razzak. 1996. Conservation of domestic water use for Jeddah city using a simulation model. *Water and Arab Gulf Development Symposium*. University of Exeter, 10-12 September, 1996.

Becht, H.Y. and J.P. van Soest. 1989. Energy conservation for a long-term sustainable energy policy. in Okken, P.A., R.J. Swart and S. Zwenner (ed.). *Climate and Energy*. Kluwer Academic Pub. London.

Edwards, F.J. 1987. *Climate and Oceanography in Red Sea* (Edwards A.J. and Head, S.M. ed), Pergamon Press, Oxford 441 pp.

ESCWA. 1993. Water Desalination: The Experience of the GCC Countries. *ESCWA Document* 93-0872. 64pp.

Fisher, D. 1990. Options for reducing greenhouse gas emissions. *The Stockholm Environmental Institute.*

Manaa, A.J.I. 1995 Environmental impacts of dual purpose plants. *Desalination and Water Reuse*. Vol. 4(1):46-49.

MCE, 1992. *Report of the Kingdom of Saudi Arabia to the United Nations Conference on Environment and Development.*

MCE. 1993. *Agenda 21 Report.*

MEED (*Middle East Economic Digest*). 1995. Saudi Arabia rises to the power challenge. Vol.39, No.36, pp. 2-3.

MOFNE (Ministry of Finance and the National Economy). 1970-1992. *Statistical Yearbook for the Kingdom of Saudi Arabia*. MOFNE press.

MEPA. 1985. A Study of the level of lead in the air and blood. *MEPA Document*

MEPA. 1989. Environmental Protection Standards. *MEPA Document* 1409-01.

MEPA/MOFNE/World Bank. 1994. *Analysis of Saudi Arabia's Institutional basis for environmental management*. 60 pp.

MEPA. 1994. A study and assessment of the management of toxic chemicals and hazardous waste in the Kingdom of Saudi Arabia. *MEPA Documents* No. 08-18-94. 230pp.

MEPA/MOFNE/World Bank. 1995. *Pollution load of the Kingdom of Saudi Arabia.*

Morcos, S.E. 1970. Physical and chemical oceanography of the Red Sea. *Oceanographic and Marine Biology , Annual Review* 8:73-202.

NRDC. 1989. *Cooling the Greenhouse*. Natural Resources Defense Council, Washington D.C.

Sert Jackson Int. 1979. *Old and New Jeddah*. Published by Sert Jackson International. 40 pp.

Sheppard C., A. Price and C. Roberts. 1992. *Marine Ecology of the Arabian Region*. Academic Press Ltd. San Diego, CA. 358 pp.

SWCC (Saline Water Conversion Commission). *1992 Annual Report.*

Taylor, C. and S. Ghazi. 1994. Jeddah Environmental Study. *MEPA Report* No. 59pp.

World Bank. 1995. The experience of the World Bank in the legal, institutional and financial aspects of Regional Environmental Programs: Potential applications of the lessons learned for the ROPME and PERSGA Regions. Paper prepared for the *"Sea to Sea Conference"*, in Jeddah, October 9 to 13, 1995. 33 pp. and 2 figures.

World Bank. 1996. *The water use cycle in Jeddah*: Toward a full social cost accounting. 54pp.

Table 1. Available population estimates (and calculated annual growth rates) for Jeddah throughout its history.

Period	Population	Annual Growth Rate Jeddah	Saudi Arabia	Source
1050	5,000 Males			(Buchon, 1981)
		0.10%		
1831	22,000			Ruppel (in Pesce, 1974)
		-3.53%		
1839	15-18,000			d'Hericourt (in Pesce, 1974)
		0.48%		
1926	25,000			Altimbilek (1984)
		2.60%		
1945	30-40,000			(Buchon, 1981)
		4.56%		
1953	50,000			Altimbilek (1984
		12.69%		
1970	381,000			(Pesce, 1974)
		10.03%		
1974	558,528			Min. Planning, Census
		10.19%		
1980	1,000,000			(Buchon, 1986)
		6.13%		
	1,300,000			Altimbilek (1984
		6.67%		
1992	2,042,526			Min. Planning, Census
1974-1992		7.47%	4.23%	Min. Planning, Census

Table 2. Estimated ground water budget for Jeddah[5] based on 1992 data)

Groundwater Source	Amount (M^3/Yr)
Sources of Input	
Rainfall[6]	76,800,000
Wadi Water[7]	5,300,000
SWCC Desalination[8]	137,876,000
KAAI Airport Desalination	8,760,000
Saudia City Desalination	2,920,000
Bottled Water	Unknown
Total	231,656,000
Water Loss	
STP Sea Disposal[9]	24,750,000
Evaporation	53,760,000
Green Belt Transpiration[10]	365,000
Domestic Horticulture [11] (Transpiration)	6,153,000
KAIA Airport Horticulture (Transpiration)	1,217,000
Saudia City Horticulture (Transpiration)	2,628,000
Rain Runoff[12]	23,040,000
Total	111,913,000
Ground Water Inputs	
Domestic Horticulture	6,153,000
KAIA Airport Water Use	1,460,000
KAIA Airport Horticulture	3,650,000
Saudia City Water Use	1,168,000
Saudia City Horticulture	876,000
Land Disposal of Wastewater	40,865,000
Reuse of Wastewater[13]	9,385,000
Leakage from Distribution System[14]	32,840,000
Infiltration from Cesspools[15]	18,500,000
Land Disposal from Cesspools	18,500,000
Total	133,397,000

Table 3. Summary ground water budget for Jeddah and calculation of annual rise.

Total Groundwater Input (M^3)		133,397,000
Horticulture	10,690,000 (8%)	
Sewage	89,878,000 (67%)	
Leakage from Distribution system	32,840,000 (25%)	
Area of Jeddah (M^2)		1,200,000,000
Ground Water (M^2/Yr)		0.1111
Sediment Porosity		0.2000
Ground Water Rise (M/Yr)		0.556

Table 4. Sources of air pollution in Jeddah [16].

Pollutant	Refinery	Industrial City	Desalination	Vehicles*	Power	Total
CO	-	40	-	854000	-	854,040
VOC	3,700	-	-	-	-	3,700
HC	-	-	-	66,000	-	66,000
NOx	1,400	3,000	29,000	21,700	14,300	69,400
SO2	40,000	2,200	180,000	2,300	19,200	243,700
Particulates	530	58,000	6,800	-	1,010	66,340
Vanadium	-	-	50	-	9.1	59
Nickle	-	-	17	-	1.1	18
Lead	-	-	1.2	610	0.9	612

* Only gasoline powered vehicles

Table 5. Sources of marine pollution in Jeddah [21].

Pollutant (tonnes/yr)	Refinery	Industrial City	Desalination	Sewage	Shipping	Total
Oil	600	-	-	-	50	650
Phenol	22	-	-	-	-	22
Sulfide	22	-	-	-	-	22
Chloride	18	-	350	-	-	368
Phosphorus	-	2	1.5	2,200	-	2,204
Nitrogen	-	14	-	8,000	-	8,014
TSS	416	80	-	-	-	496
BOD	416	120	-	37,000	-	37,536
COD	1,250	210	-	92,000	-	93,460
Brine (M^3)[22]	0	0	1.73E+09	-	-	1.73E+09

Table 6. Increased demand for services between 1995 and 2015 if anticipated increases in population and rates of demand proceed as expected.

Service	1995	2015	% of 1995 Level
Population	2,350,513	5,513,410	235%
Desalination (M^3)			
W/O Conservation	222,343,219	808,373,358	364%
W/Conservation	222,343,219	127,078,251	57%
Electricity (MW/Yr)			
W/O Conservation	10,170,792[26]	23,900,000	235%[27]
W/Conservation	10,170,792	14,159,000	139%
Sewage (M^3)			
Current Capacity	43,800,000	301,859,175	689%
Current Generation	128,690,568	301,859,175	235%
Solid Waste (Tonnes)	2,180,000	5,396,000	248%
New Landfill Site			
Vehicles	1,030,678	4,535,053	440%

Table 7. Some investments which will be required in order to meet demand for services and resolve environmental problems associated with projected growth of Jeddah between 1995 and 2015.

ISSUE	COST $ (SR)
Rising Ground Water[28]	$144,000,000 (SR 540,000,000)
Additional Sewage Treatment Plants[5,29]	.
Capital Costs	$453,052,930 (SR 1,698,948,486)
Additional Operation & Maintenance Costs	$7,635,723 (SR 28,633,963)
Expansion of Sewage Collection System	Not Available
Additional Desalination Plants	
Without Conservation	$1,076,368,781 (SR4,036,382,929)
With Conservation	Demand reduced to 72% of Current levels and 20% of projected demand
Additional Electrical Generation [30, 31]	
W/O Conservation	$18,122,554,560
W/Conservation	$5,264,434,560
Landfills & Solid Waste Services	
Development of New Landfill Site	Not Available
Additional Garbage Collection (annual cost in 1995) [32]	$80,000,000 (SR 300,570,000)
Transportation	
Pollution Control	Not Available
Additional Roads and Parking	Not Available

Table 8. Saudi Arabia Budgetary Expenditures (Billion Saudi Riyals) Source: Gulf Economy (53, July-August), 1993. pp. 35

	Year		
Sector	1992	1993	1994
Human Resources	26.00	31.10	34.09
Transportation & Commerce	8.00	8.20	9.08
Economic Resources	4.70	8.00	8.94
Social & Health	11.00	12.20	14.09
Defence	48.70	54.30	61.64
Public Administration	29.00	29.80	31.29
Public Loan Institutions		4.60	8.00
Subsidies	7.00	7.10	9.17
Others		17.10	11.57
Infrastructure	2.60	2.10	2.10
Water & Municipalities	5.50	6.30	6.98

Table 9. Some unresolved interagency jurisdictional issues within the coastal zone.

MARINE ACTIVITIES
Saudi Coast Guard has jurisdiction between the border of the Territorial Sea (12 miles offshore) and 10 km inland (Royal Decree No. 33, dated 27/7/1377).
MEPA has jurisdiction for prevention of Pollution in the Territorial Sea (Council of Ministers decision No. 157, Dated 20/11/1411 and Royal Decree No. 7/505M, dated 28/3/1406..
Ministry of Agriculture (SWCC), Ministry of Petroleum (Saudi Aramco, oil companies), Ministry of Municipalities and Rural Affairs (Sewage Authority), Ministry of Industry and Electricity (SCECO and industrial cities) and RCJY all control activities which emit pollutants into the Territorial Sea.
MEPA has jurisdiction for oil spill response (coordination mechanism established under Royal Decree 7/B/13307, dated 22/7/1411).
Ministry of Transport has responsibility for Marine Navigation in Territorial Sea
Sea Ports Authority has responsibility for ports (Royal Decree No. 7/505M, dated 28/3/1406).
Ministry of Agriculture has jurisdiction for fishery activities (Royal Decree No. 7/505M, dated 28/3/1406).
Ministry of Petroleum has jurisdiction over oil production and marine mineral extraction activities in Territorial Sea.
Ministry of Defense has jurisdiction of military activities within the Territorial Sea.
Saudi Arabia is signatory to Regional and International agreements which place obligations upon it for prevention of pollution and protection of resources. (Notable among these is the Kuwait Regional Convention on the protection and development of the marine environment from pollution (1978); The protocol concerning Regional cooperation in combating pollution by oil and other harmful substances in cases of emergency (1978); The Regional convention for the conservation of the Red Sea and Gulf of Aden against pollution from land-based sources (1982); Protocol on marine pollution resulting from oil exploration activities in the Arabian Gulf Region (1989) and the ROPME protocol for protection of pollution of the sea from land-based sources (1990).
SUBMERGED LANDS
Sea Ports Authority has responsibility for ports (Royal Decree No. 7/505M, dated 28/3/1406).
Coast Guard has jurisdiction between edge of Territorial Sea and 10 Km inland (Royal Decree No. 33, dated 27/7/1377).
MEPA has jurisdiction for prevention of pollution including effluent from land fill ports (Royal Decree No. 7/505M, dated 28/3/1406).
Ministry of Petroleum has jurisdiction over oil production and marine mineral extraction activities in territorial sea.
Ministry of Agriculture and have been directed by Royal Decrees to enforce a moratorium on land fill ports (Royal Decree No. M/9, dated 27/3/1408).
Permits for extensive filling of submerged lands have been granted in the Eastern Province.
Ownership of submerged lands is unclear. Control resides primarily with National Government, but Municipalities and upland title holders have some independent control.

Table 9. (Continued)

RESOURCE CONSERVATION
Ministry of Agriculture is responsible for fishery management (Royal Decree No. 7/505M, dated 28/3/1406; Royal Decree No. M/9, dated 27/3/1408).
NCWCD is responsible for management of protected areas (Royal Decree No. M/22, dated 12/9/1406).
Ministry of Agriculture is responsible for management of national parks.
COASTAL DEVELOPMENT
Ministry of Municipal and Rural Affairs is responsible for Municipal development, flood water management and disposal of waste.
Ministry of Industry and Electricity is responsible for industrial development and electricity generation..
Ministry of Agriculture is responsible for agricultural development, development of groundwater resources and sea water distillation.
MEPA is responsible for setting standards for the environment (Royal Decree No. 7/M/8903, dated 2/14/1401) and for carrying a program of environmental impact assessment. They are also the designated coastal zone management agency.
Royal Commission for Jubail and Yanbu is responsible for industrial development within the two industrial cities. They are also responsible (under a MOU with MEPA) for environmental management within the two industrial cities

Table 10. See End Note 4

Reduction				Coverage		
Measure	1995	2000	2010	1995	2000	2010
Pub. Educ.	0.09	0.05	0.05	0.75	0.80	0.85
Adv. Plumbing Code	0.26	0.13	0.13	0.15	0.20	0.25
Leak Detetction	0.10	0.05	0.05	0.30	0.35	0.40
Pricing Policy	0.27	0.14	0.14	1	1	1

Figure 1. **City plans of Jeddah from Pesce, 1974.. (a) From the 13th century showing the basic layout of the city and Eve's Tomb. (b). From the 1762. (c) From 1938.**

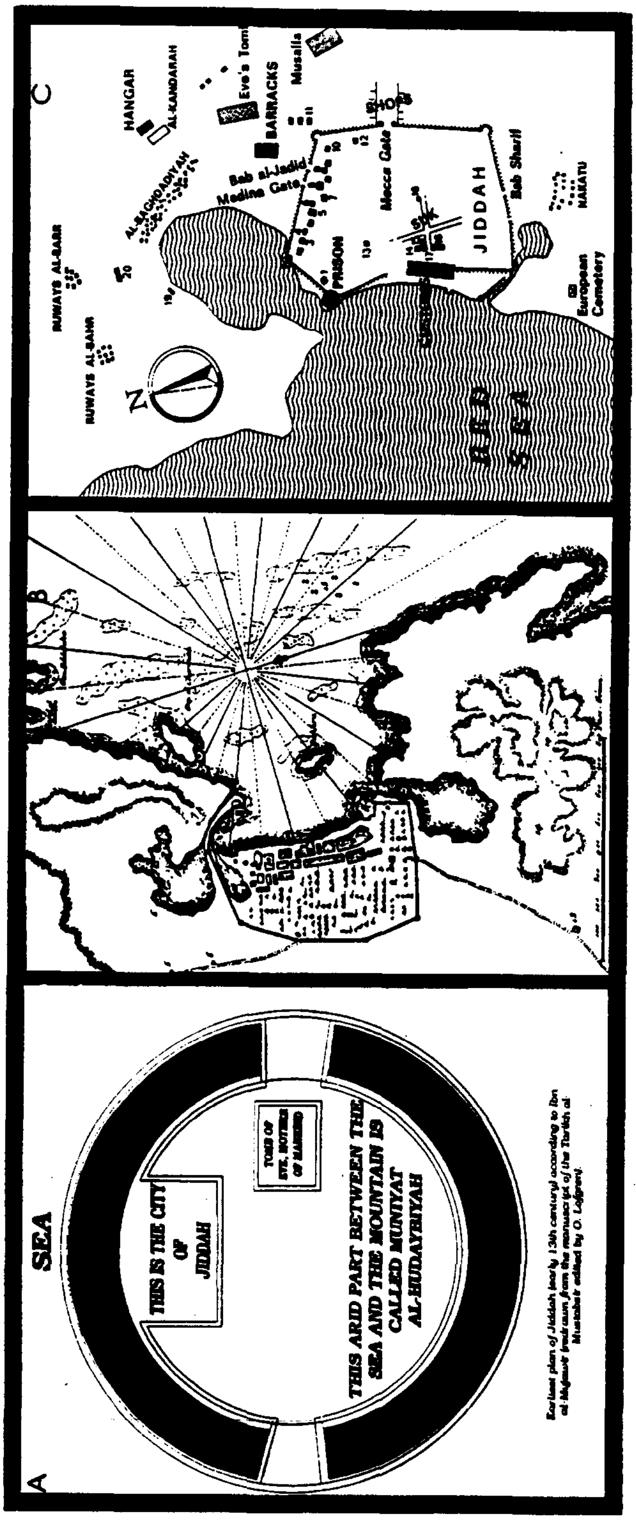


Figure 2. **Ptolmaic map of the Arabian Peninsula showing reef lined shoreline and break in reefs at Jeddah. The NNW/SSE orientation of the Red Sea also meant that European vessels returning downwind on the winter monsoon from the orient would encounter headwinds from Jeddah onwards, enchancing Jeddah's attractiveness as a transshipment port.**

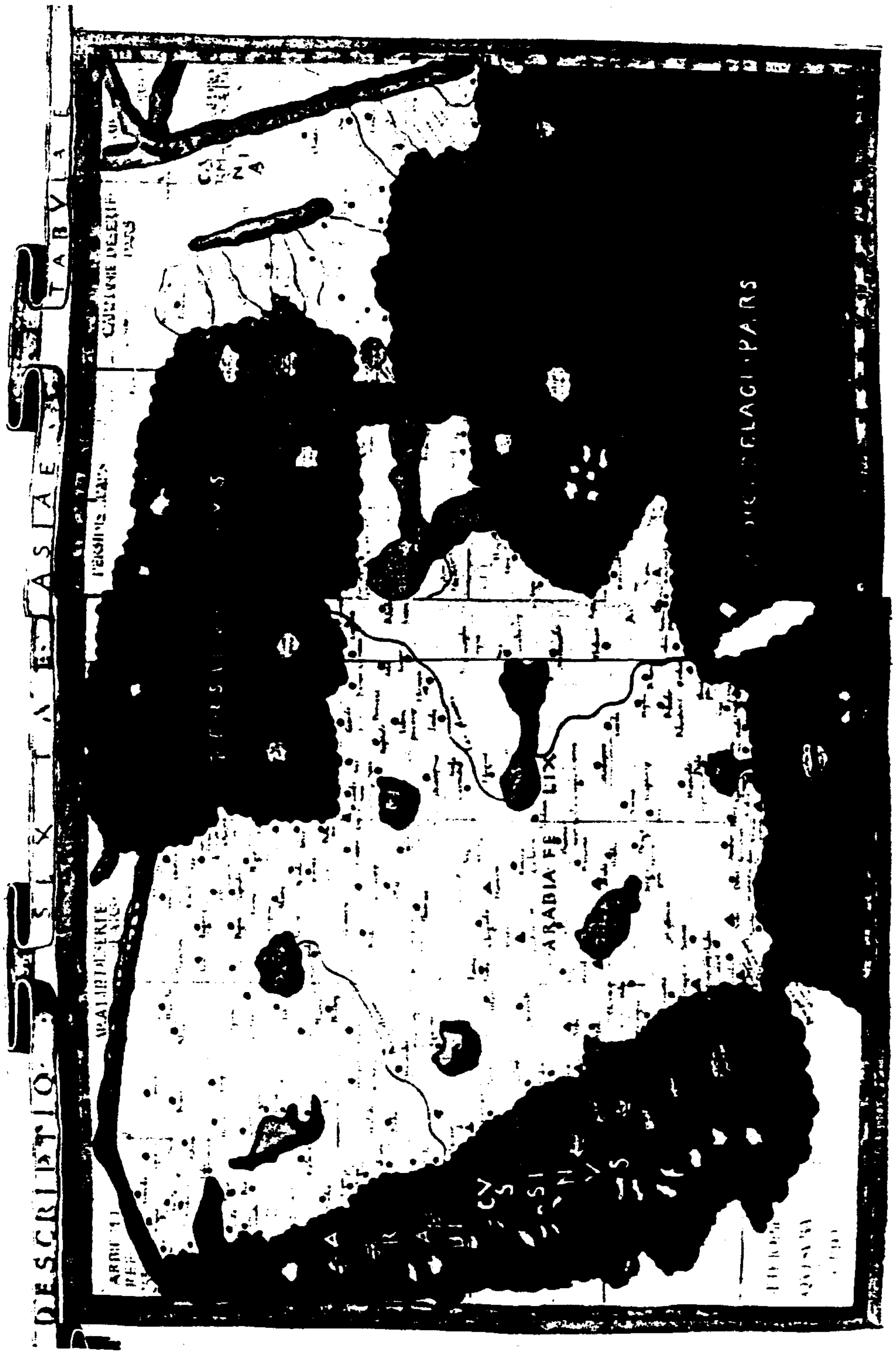


Figure. 3. Illustrations of Jeddah from Pesce, 1974. (a) From 1517 showing the Portuguese fleet attacking the city (it did not but were put off by the offshore reefs and weather). (b) From 1764 showing a developed walled city and much commerce. (c) From the late 19th century showing the city much as it had been throughout its history.

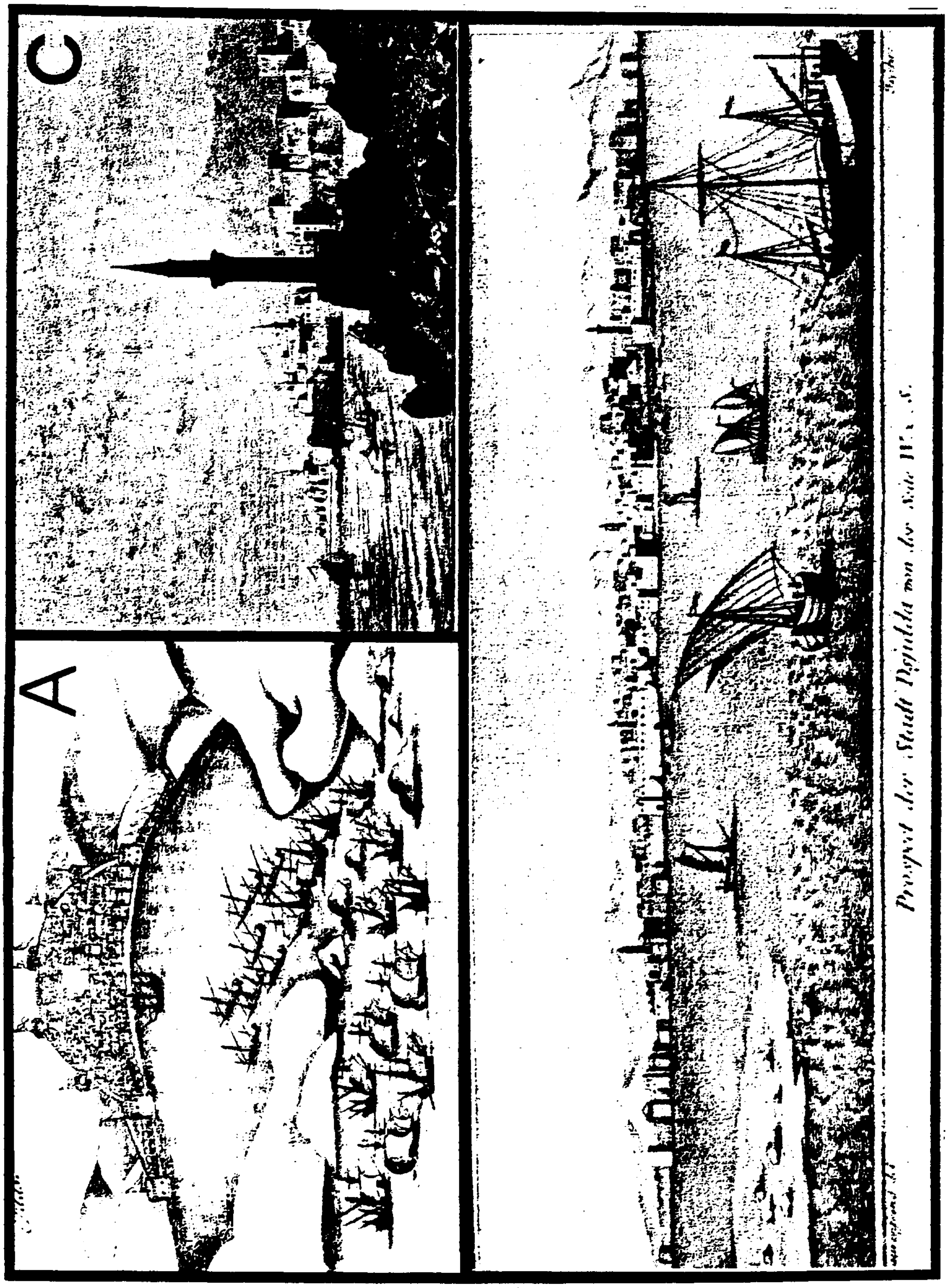


Figure 4. Historical boundaries of the City from 350 BC to present.

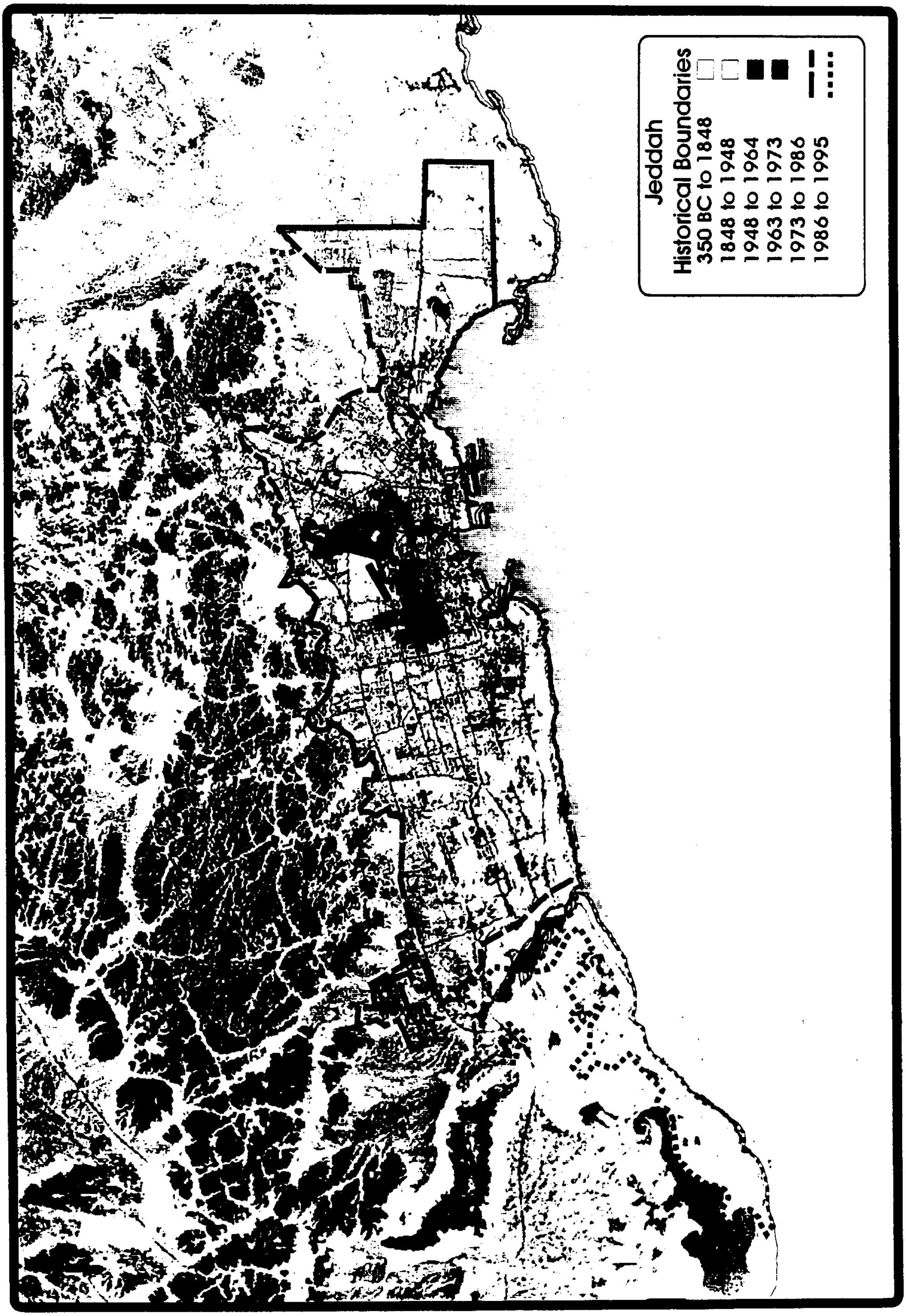


Figure 5. Average rainfall in Jeddah

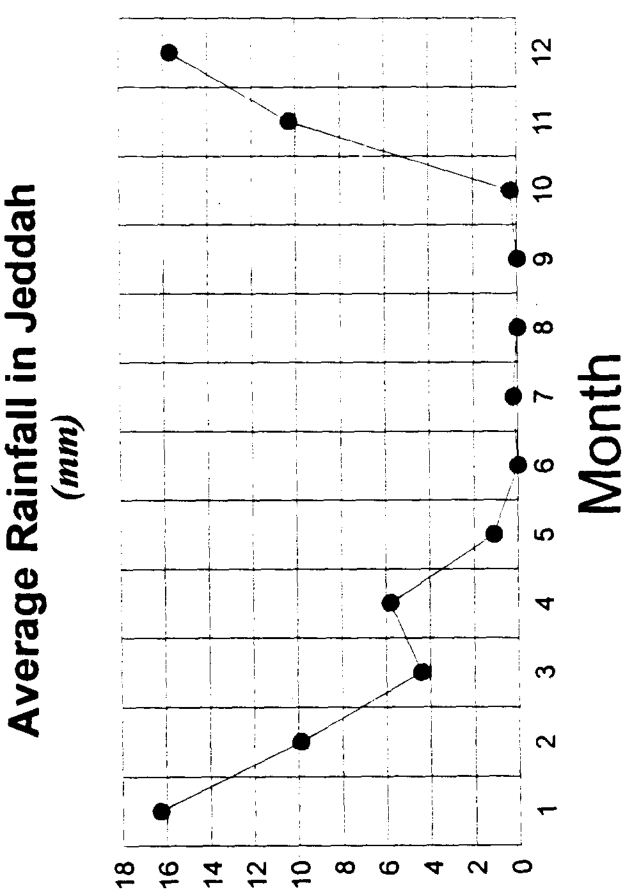


Figure 6. Annual temperature in Jeddah.

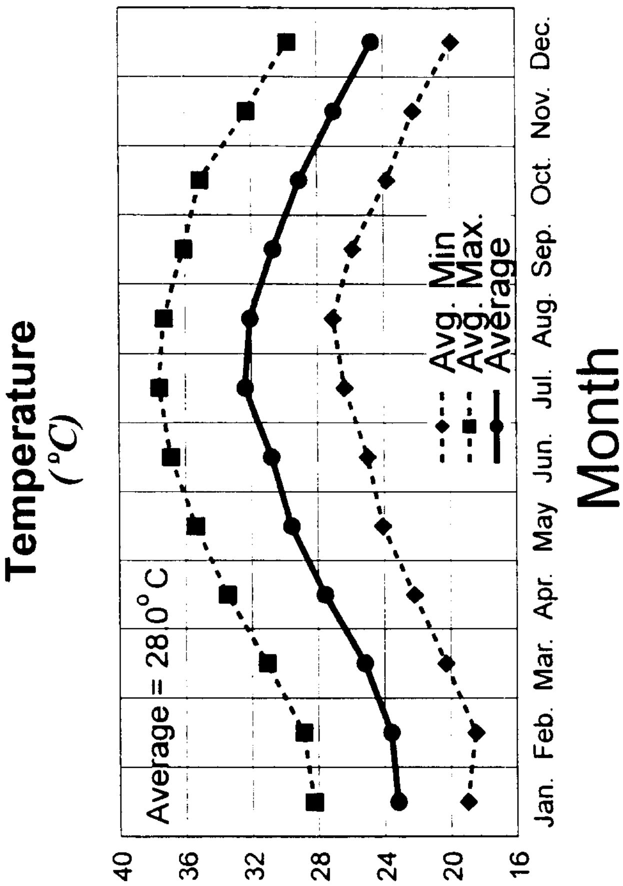


Figure 7. **Extreme daily and monthly rainfall in Jeddah showing that extreme rainfall tends to arrive in a single day.**

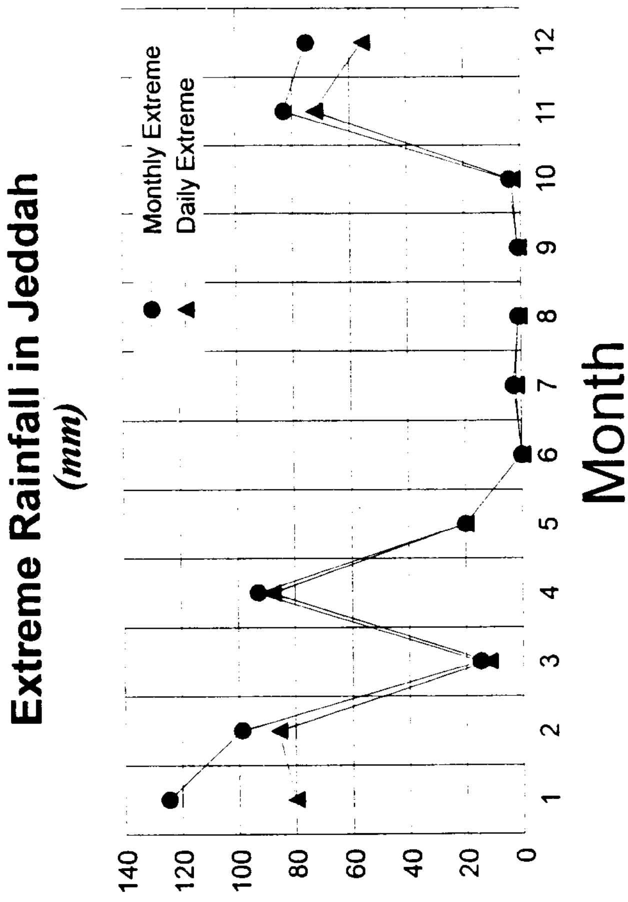


Figure 8. **Meteorology and oceanography of the Red Sea showing seasonal monsoonal changes in wind direction and net flow into the Red Sea and differences in tidal magnitude throughout the length of the Red Sea.**

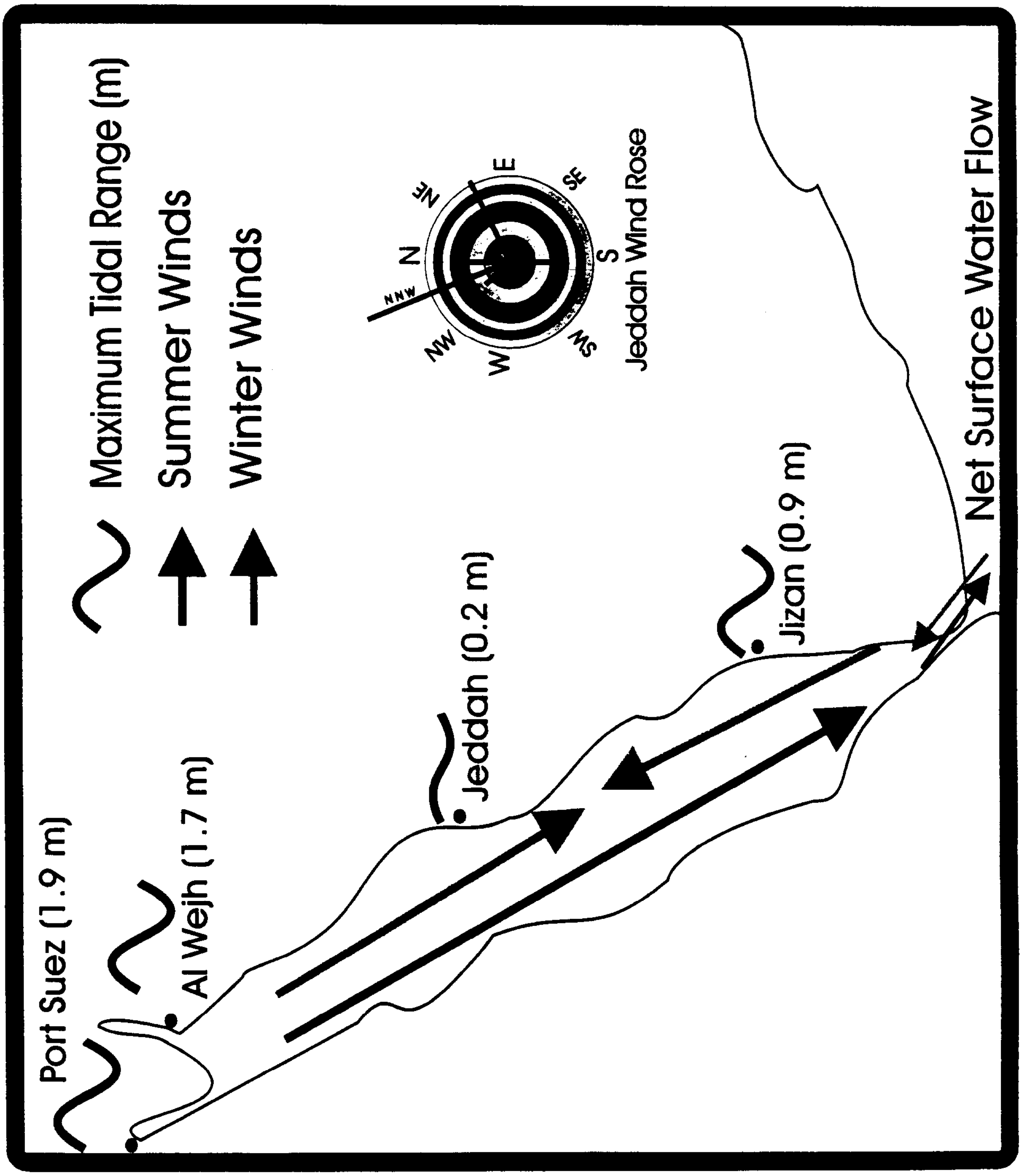
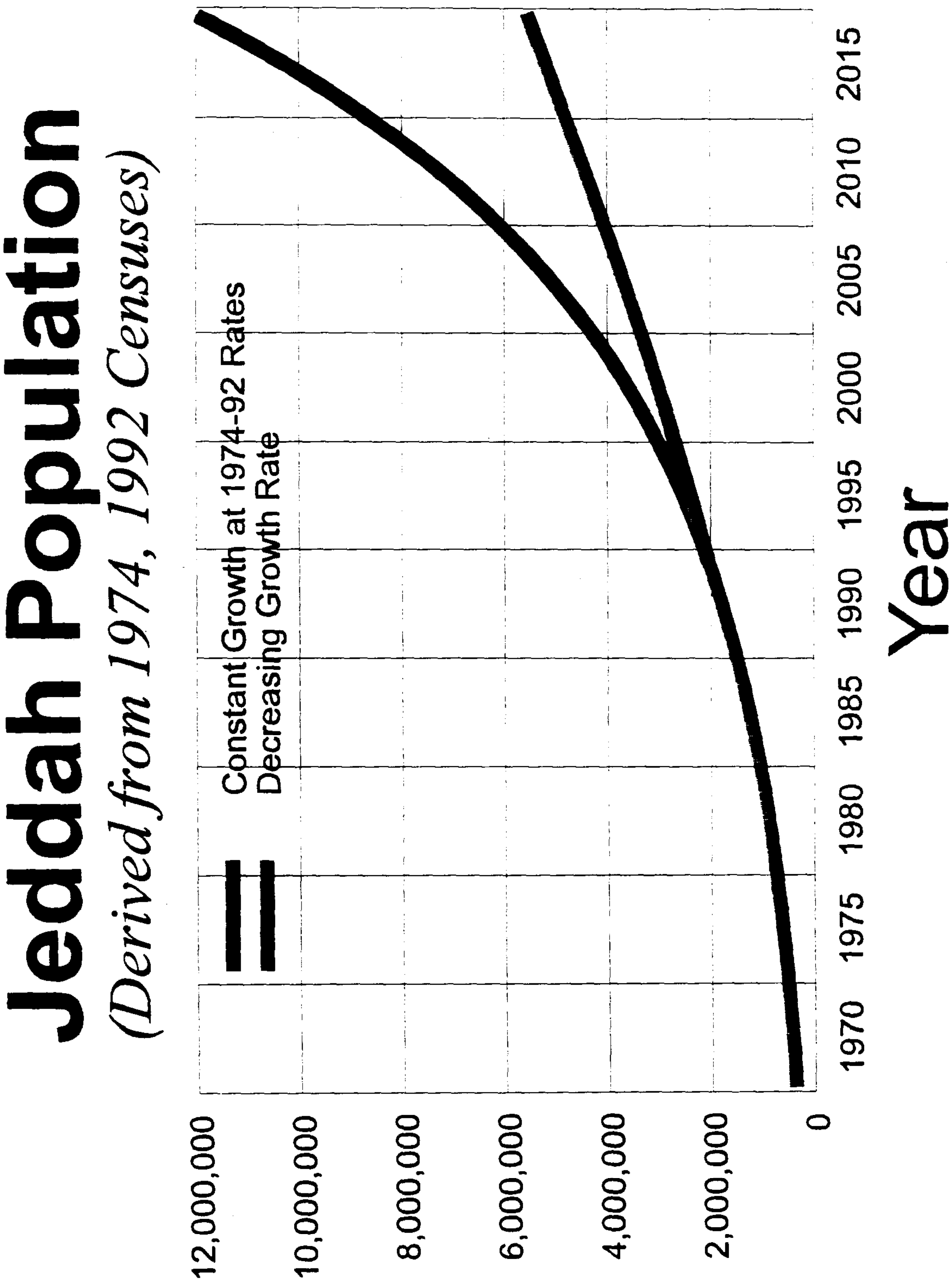


Figure 9. **Projected population in Jeddah showing expected population if the 1974-1992 growth rate continues and if an anticipated slowing in growth rate occurs (figure 10).**



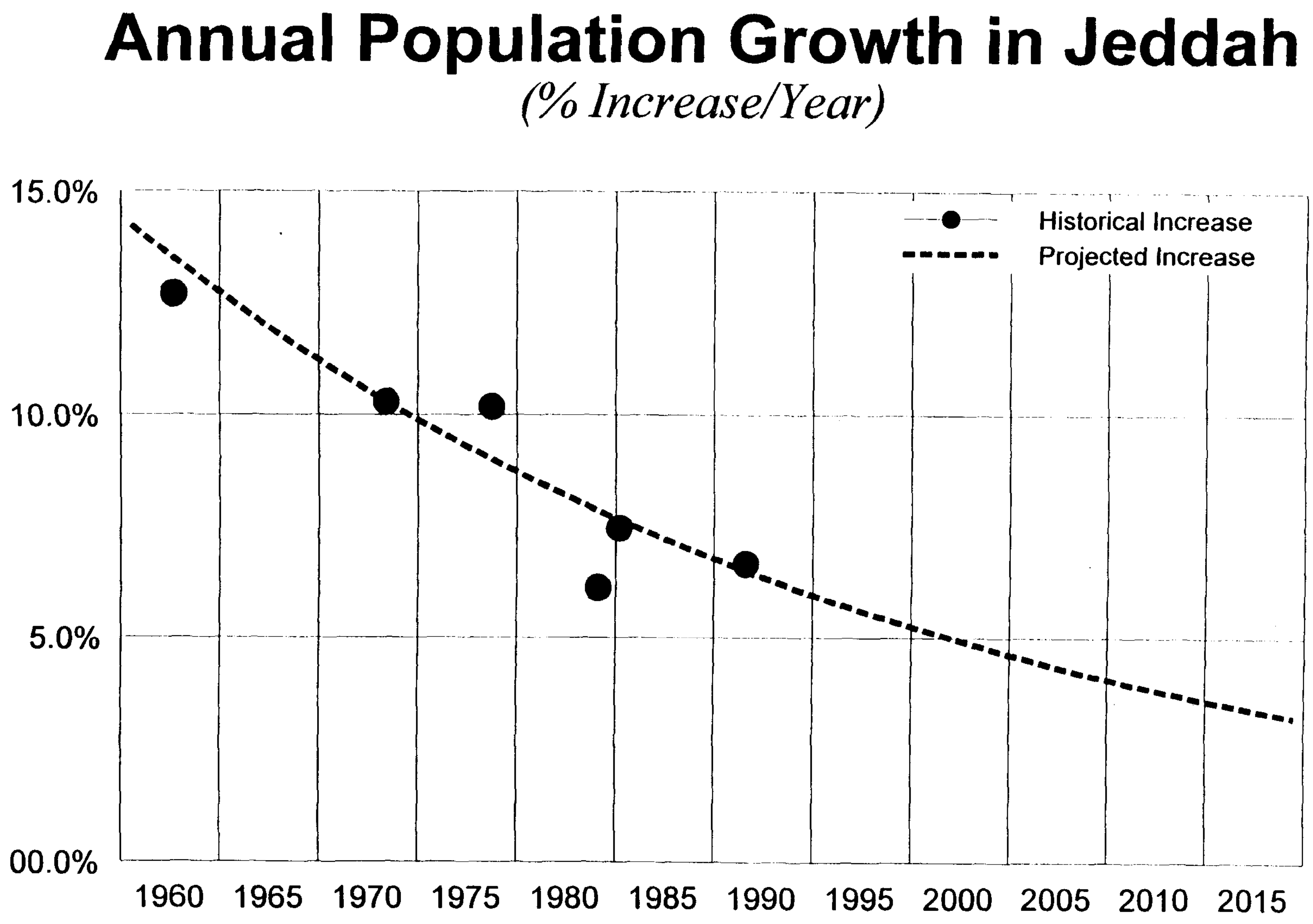


Figure 10. Statistical analysis of observed (inter census) and reported (Table 1) growth rates used in calculating projected population for demand analysis.

Figure 11. Aerial photographs of Jeddah from 1936 (a); 1940 (b); 1952 (c) and 1948(d).

Figure 12. **Composite aerial photograph of Jeddah from 1962 (a) and Landsat image from 1986 (b).**

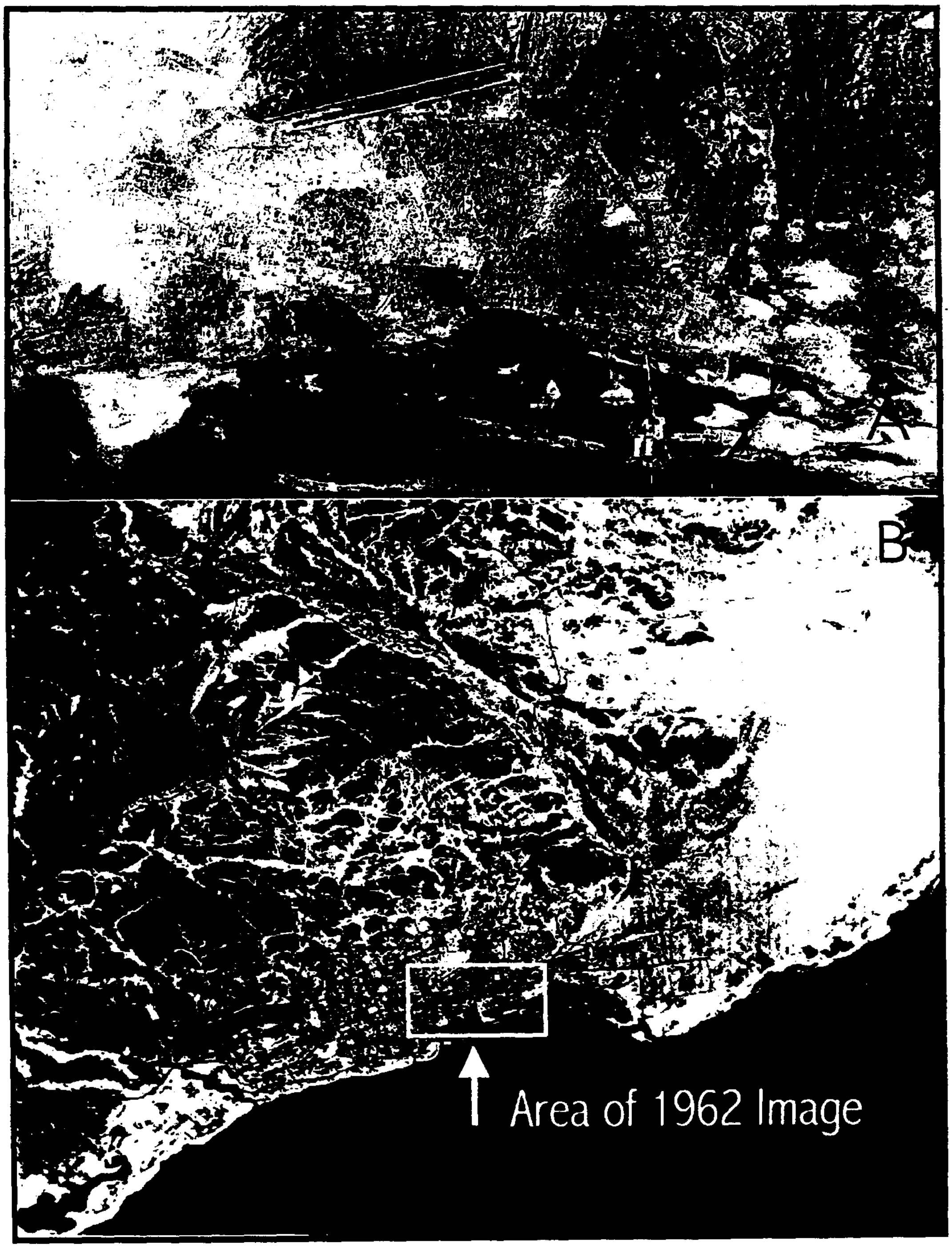


Figure 13. Observed and projected per capita demand for desalinated water, from 1970 to 2015. Projection show "business as usual" demand and demand if a program of conservation is initiated

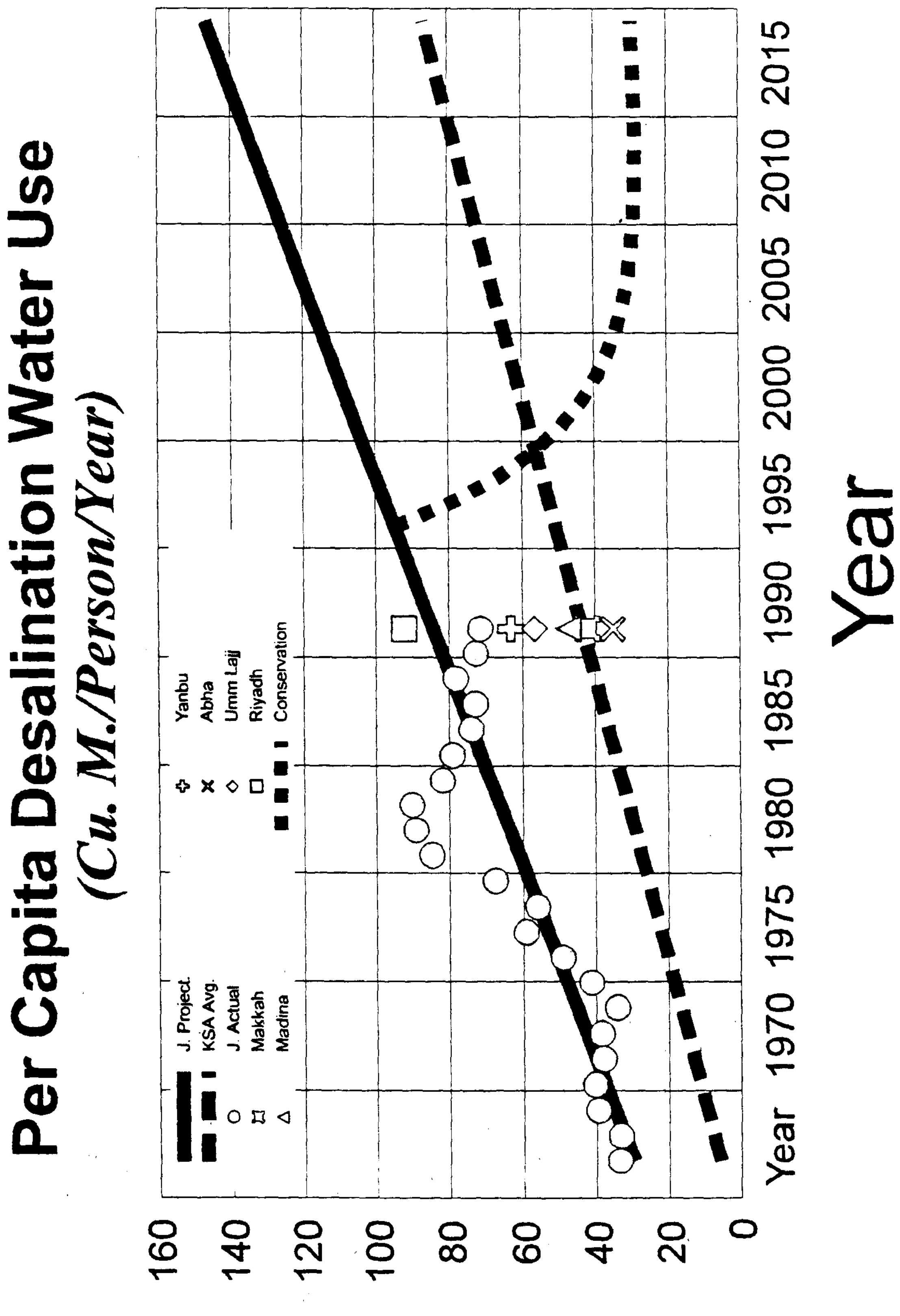
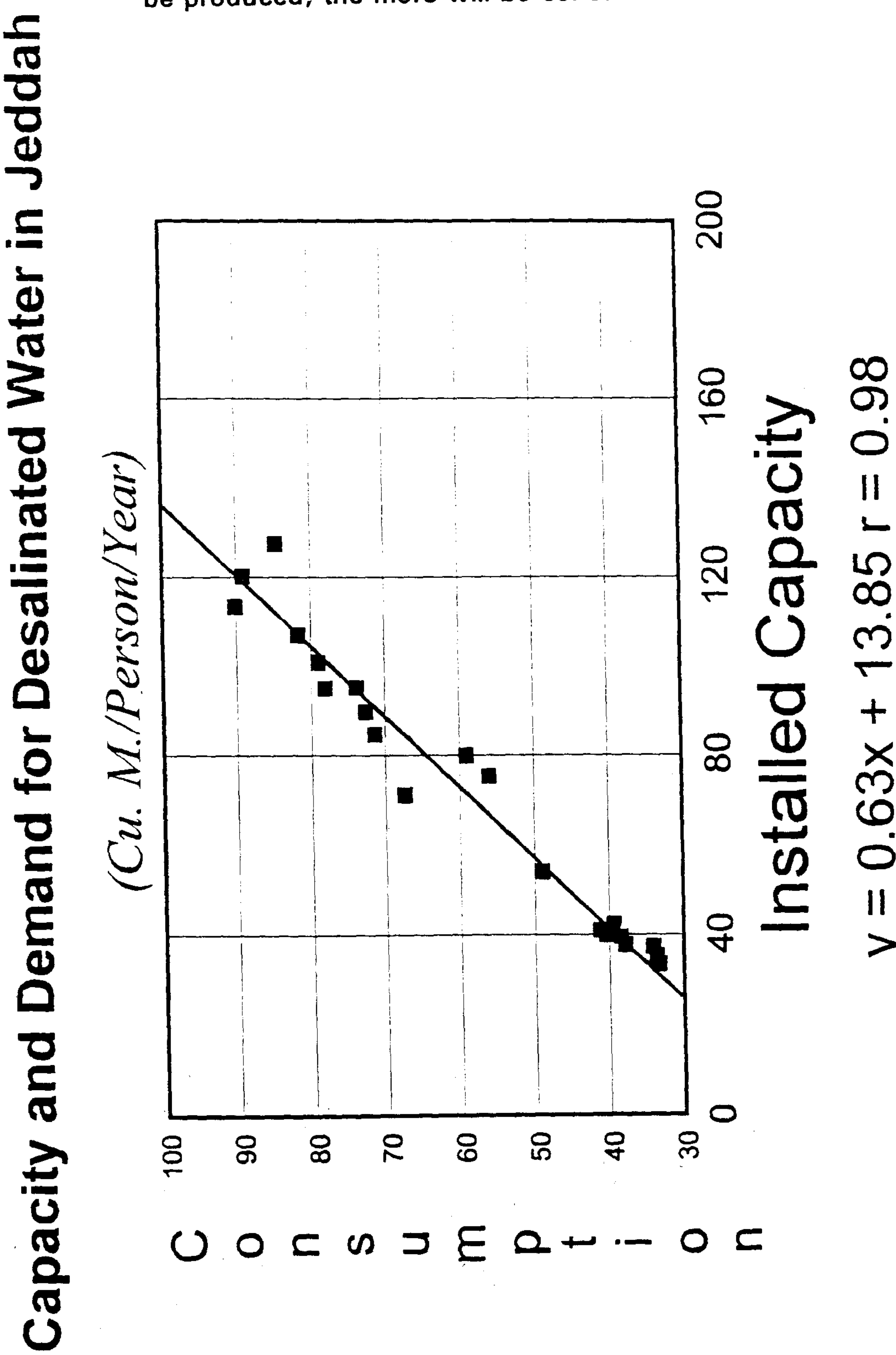


Figure 14. Correlatio of per capita capacity (M3 desalination capacity/person/year) against per capita consumption (M3 consumption of desalinated water/person/year). The results indicate that the more water that can be produced, the more will be consumed.



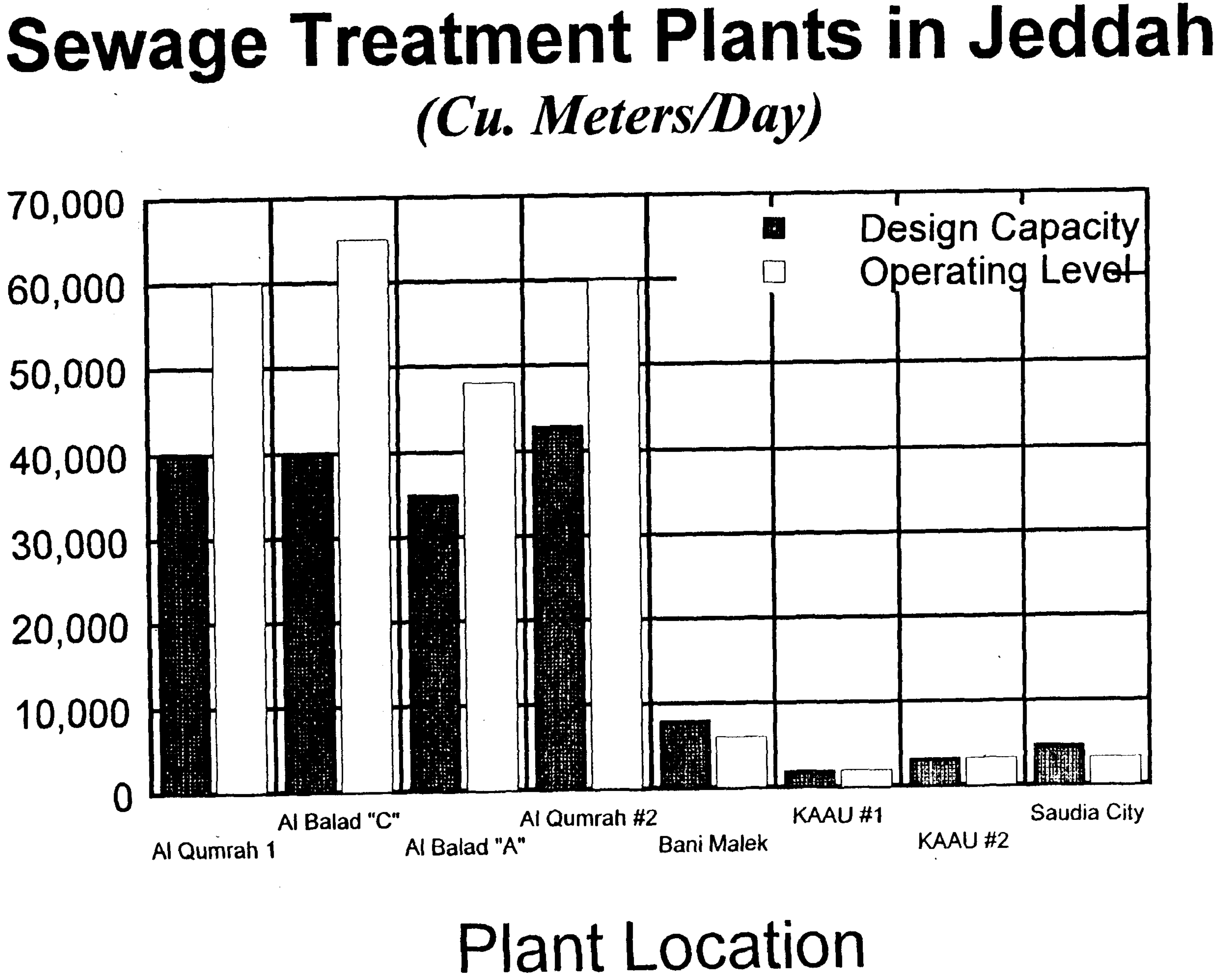


Figure 15. Capacity and actual throughput of Jeddah's sewage treatment plants in 1990.

Figure 16. **Area covered by Jeddah's sewage system and location of STP plants and outfalls.**

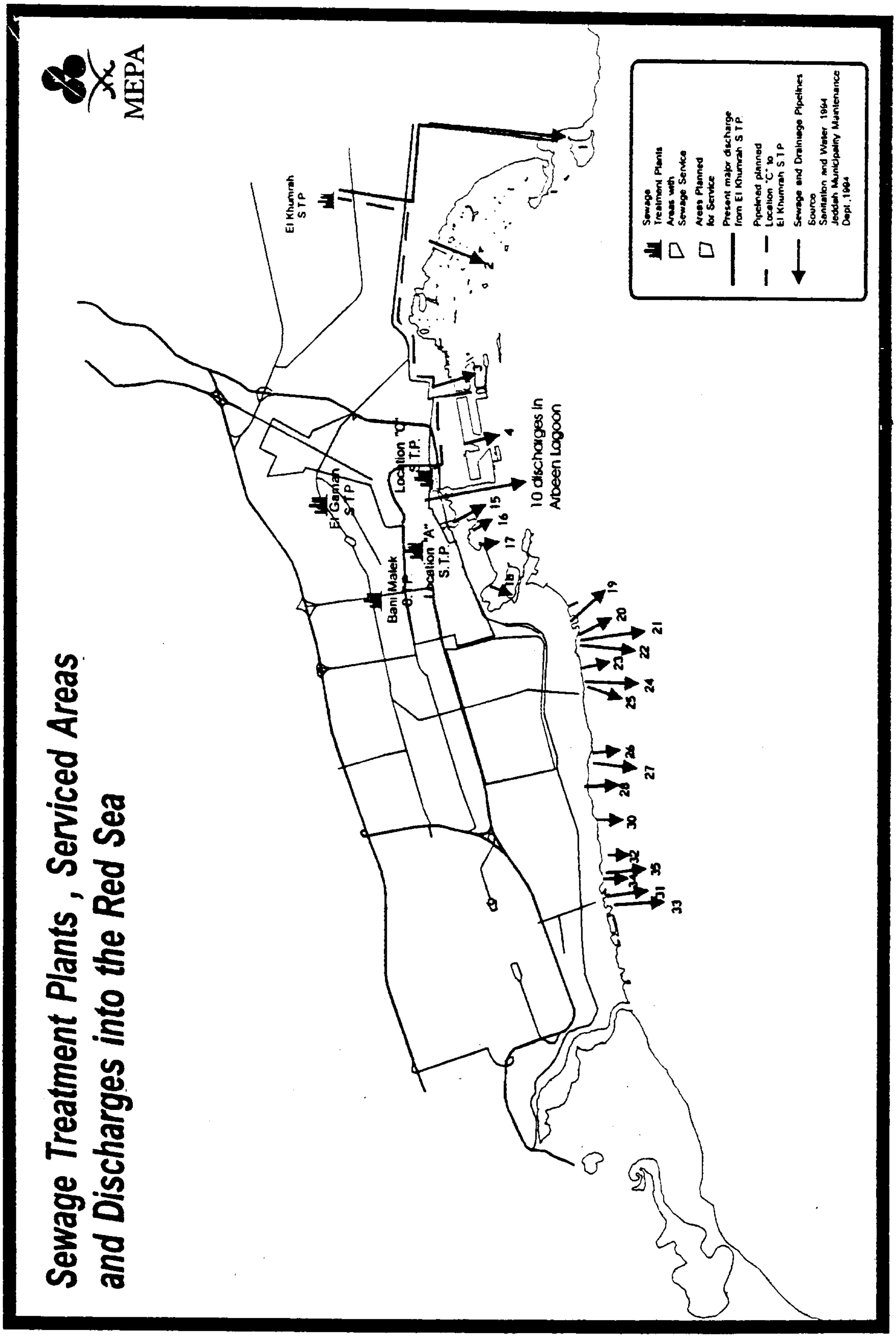


Figure 17. Total sewage production in Jeddah from 1970 to 2015.

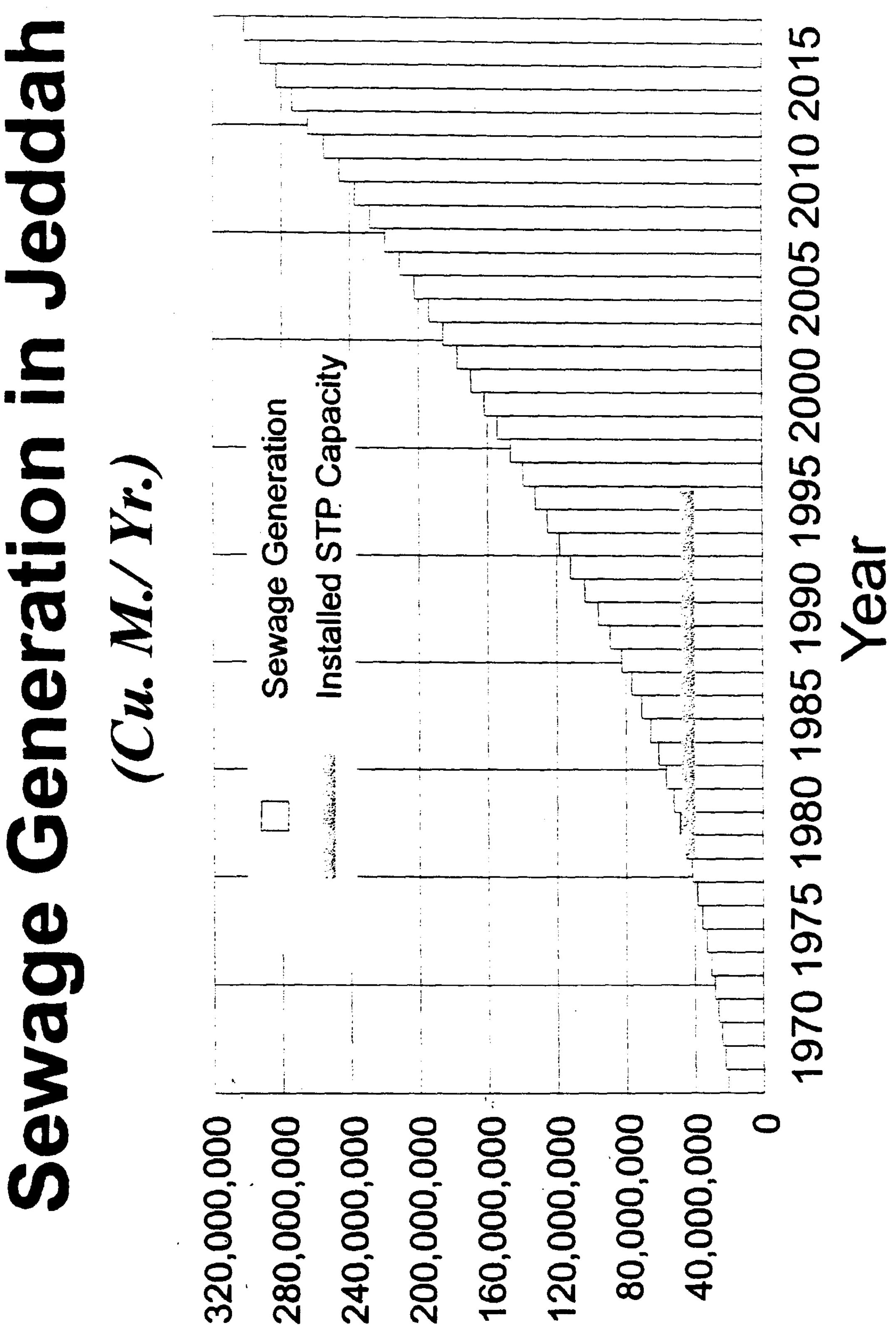
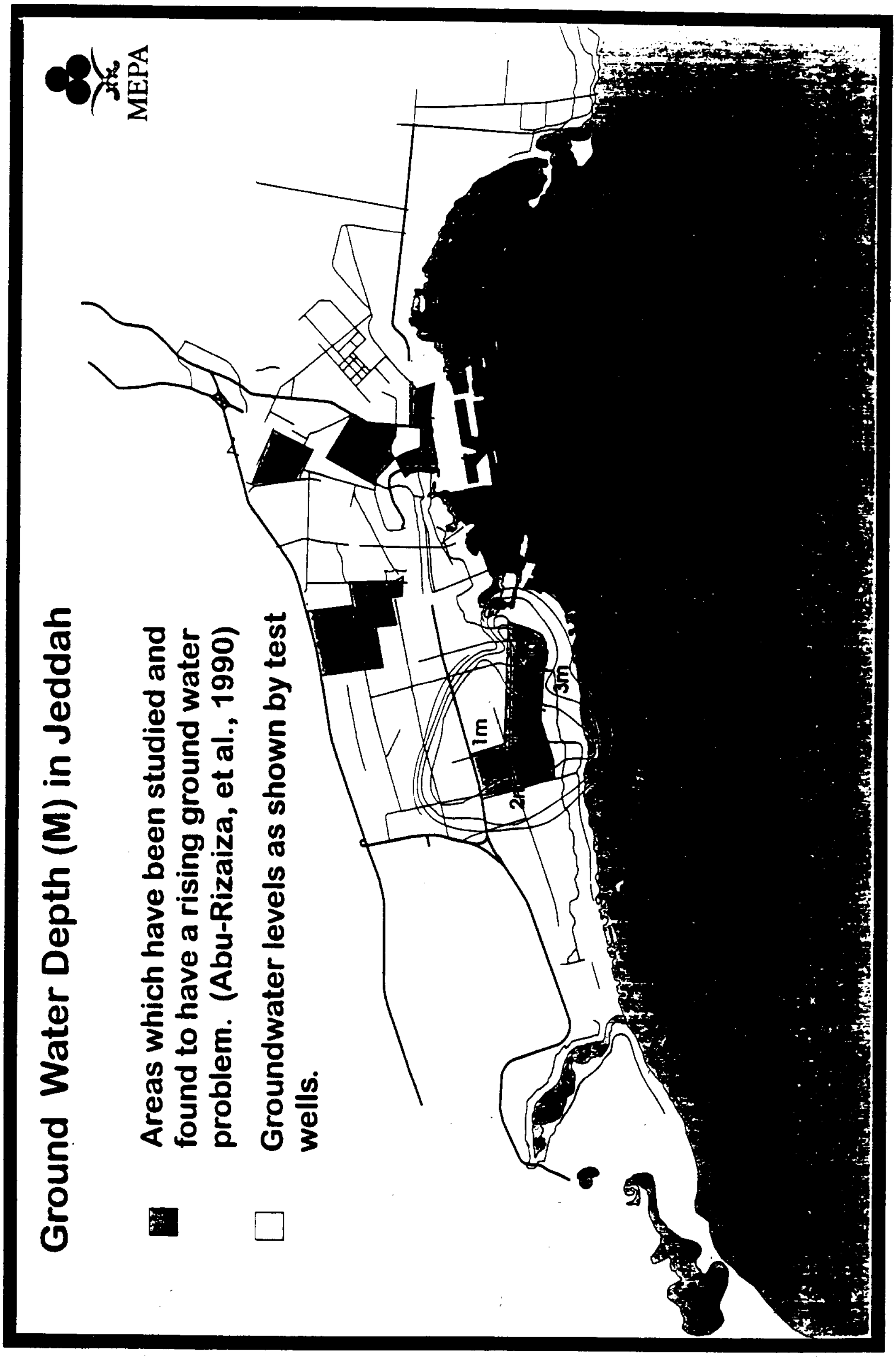


Figure 18. **Ground water in Jeddah showing areas where ground water problems have been reported and depth of the ground water lens.**



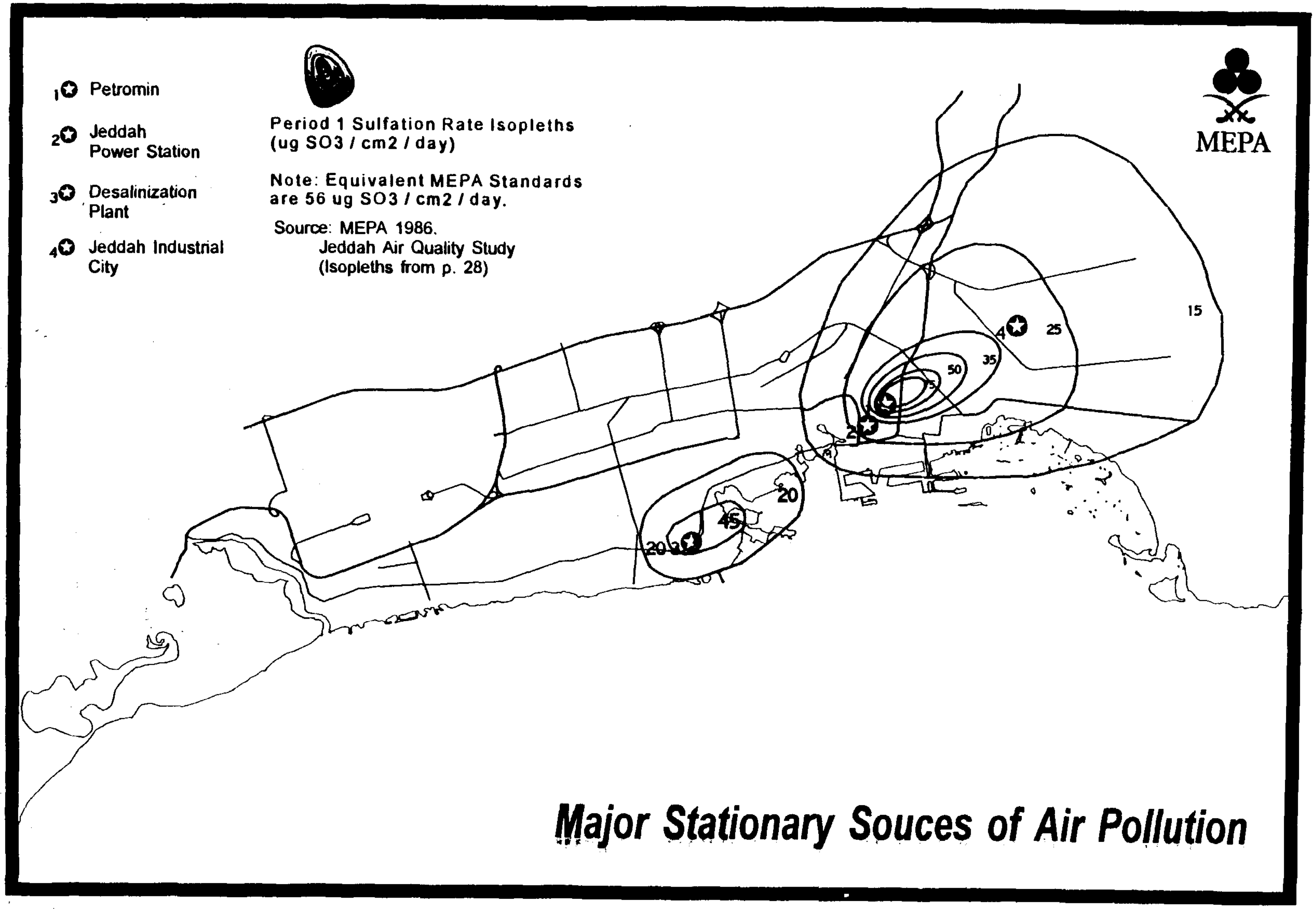
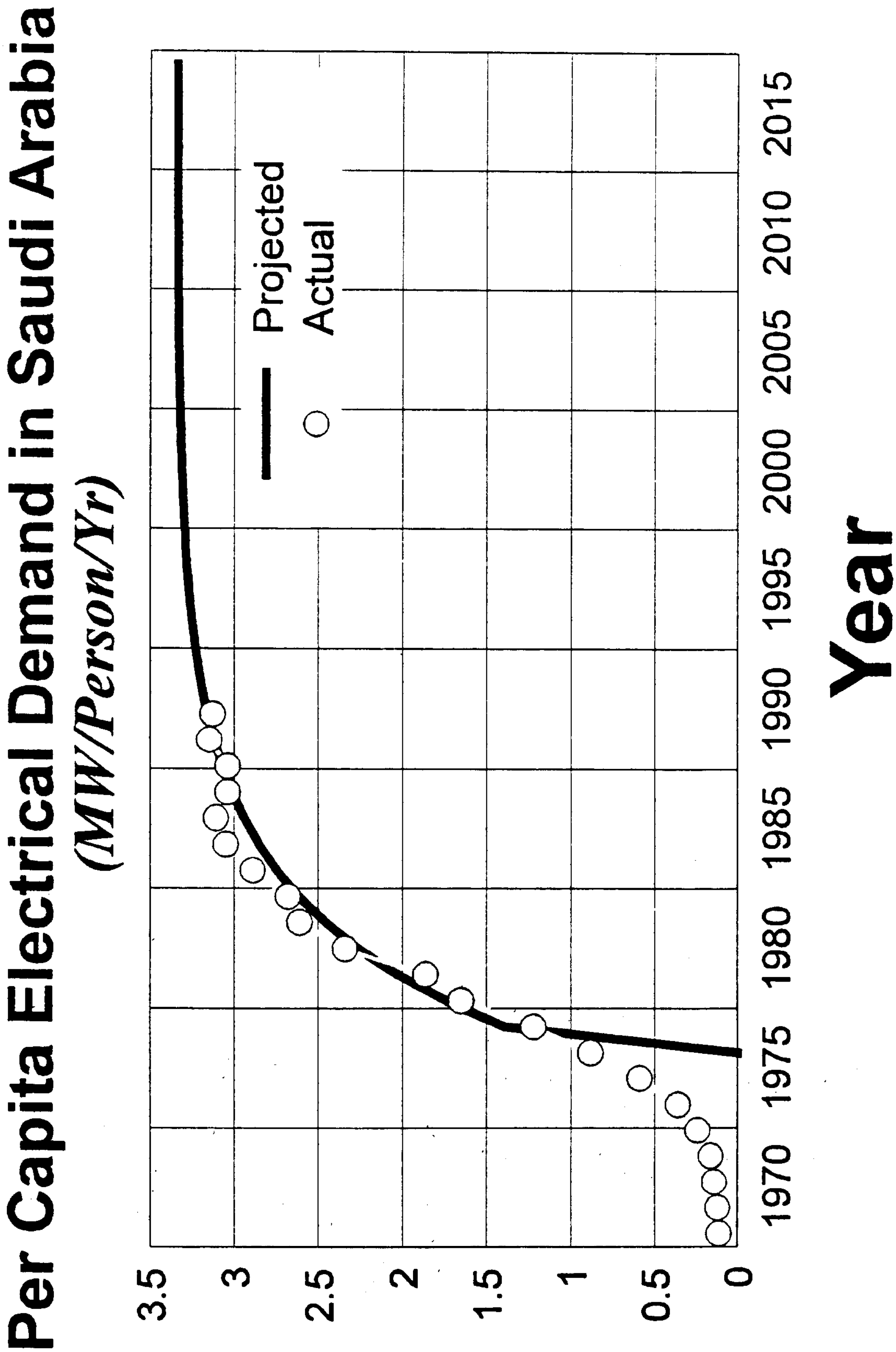


Figure 19. Air quality in Jeddah.

Figure 20. Per capita electrical demand in Saudi Arabia from 1970 to 2015.



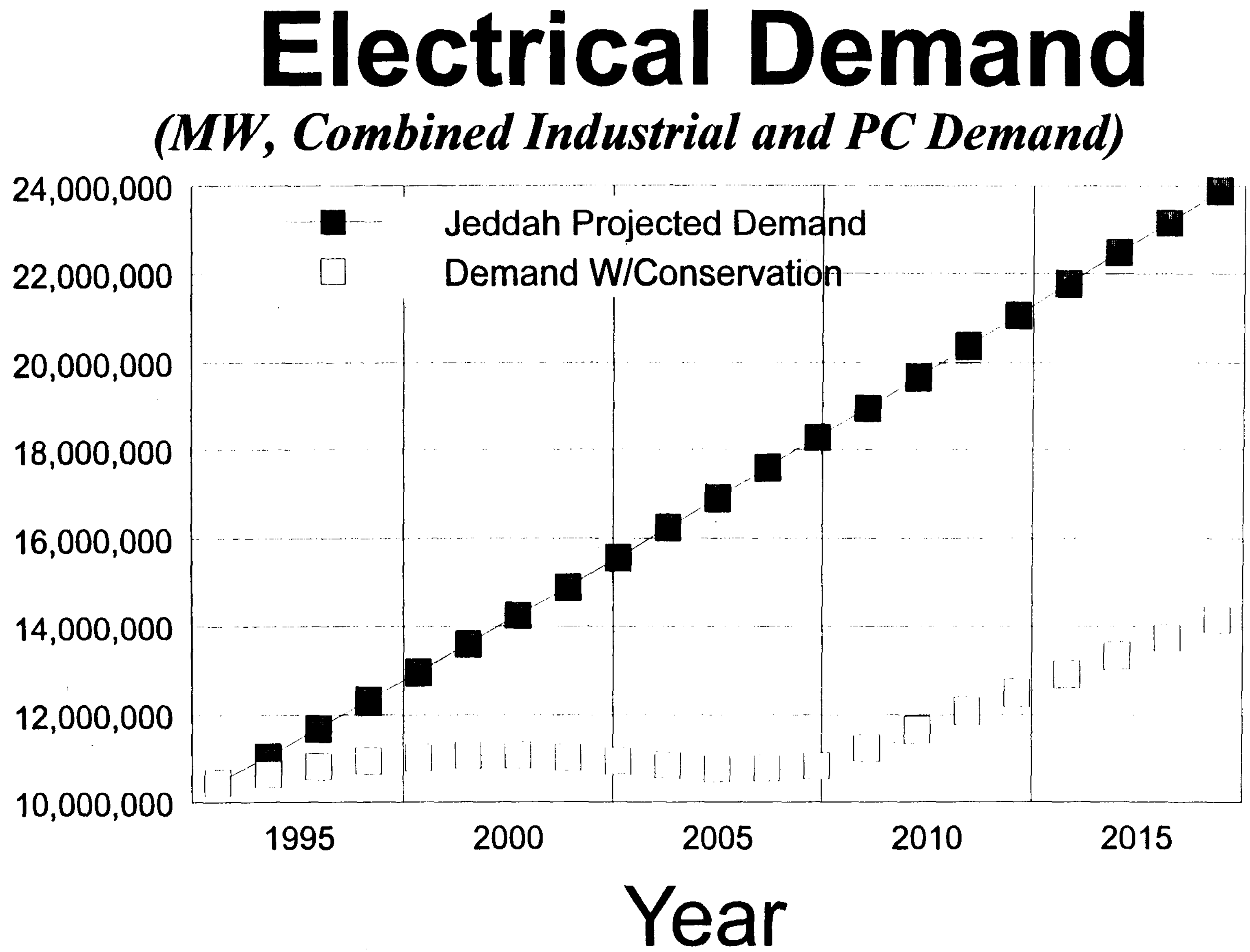


Figure 21. Electrical demand in Jeddah 1970 to 2015.

Figure 22. Total electrical demand in the Western Province showing total electricity sold, peak load and installed capacity.

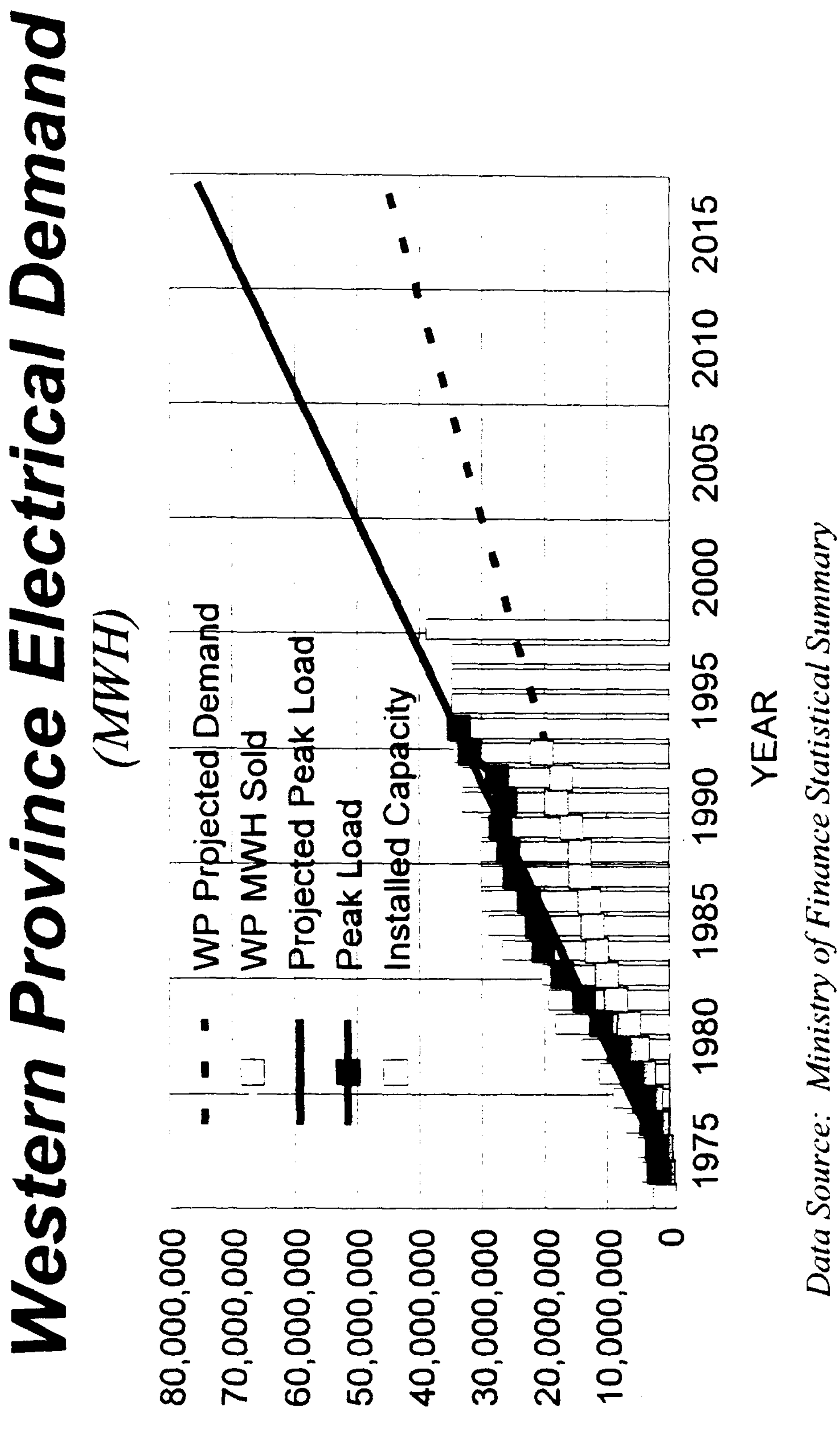
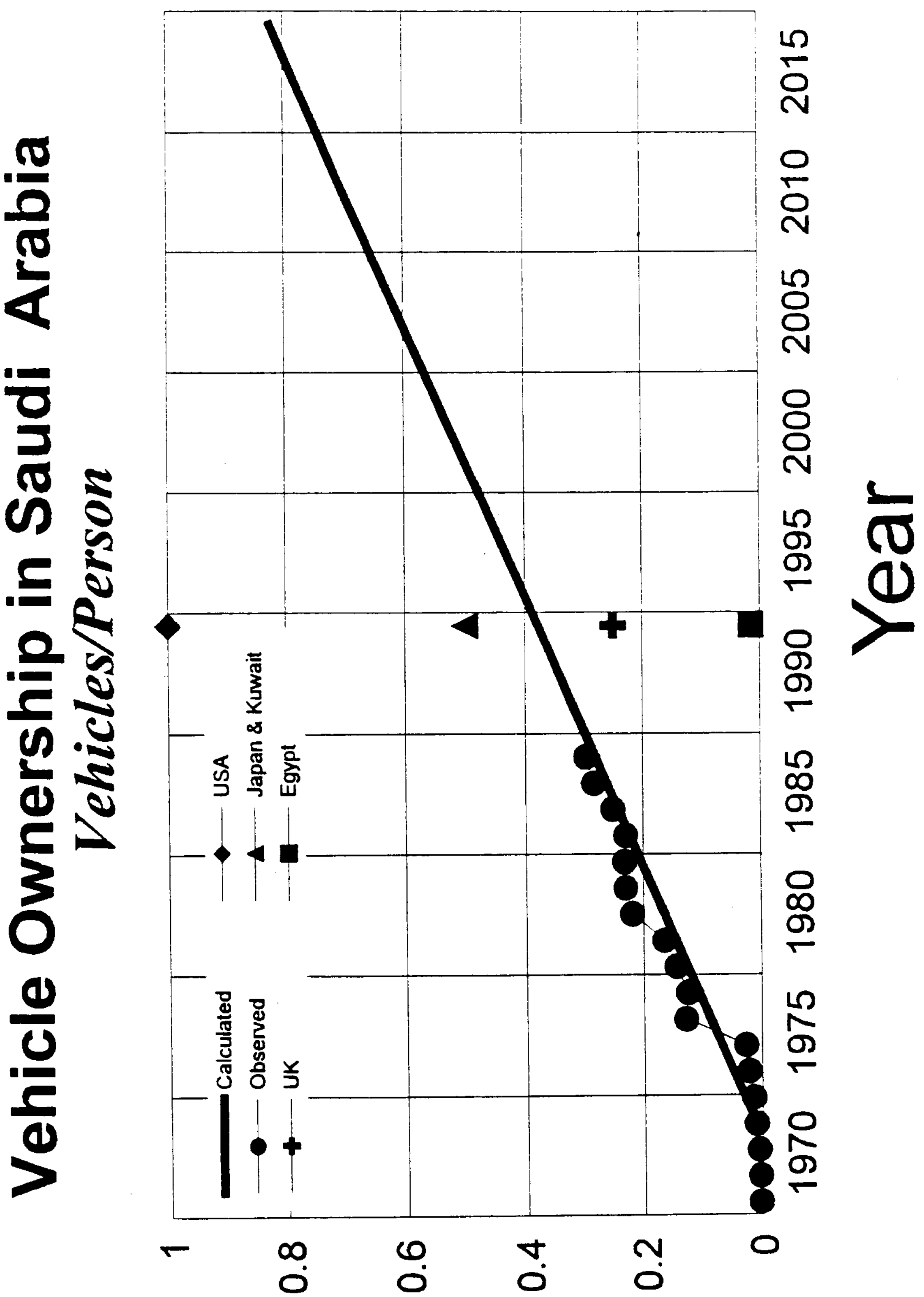


Figure 23. Per capita vehicle ownership in Saudi Arabia from 1970 to 2015.



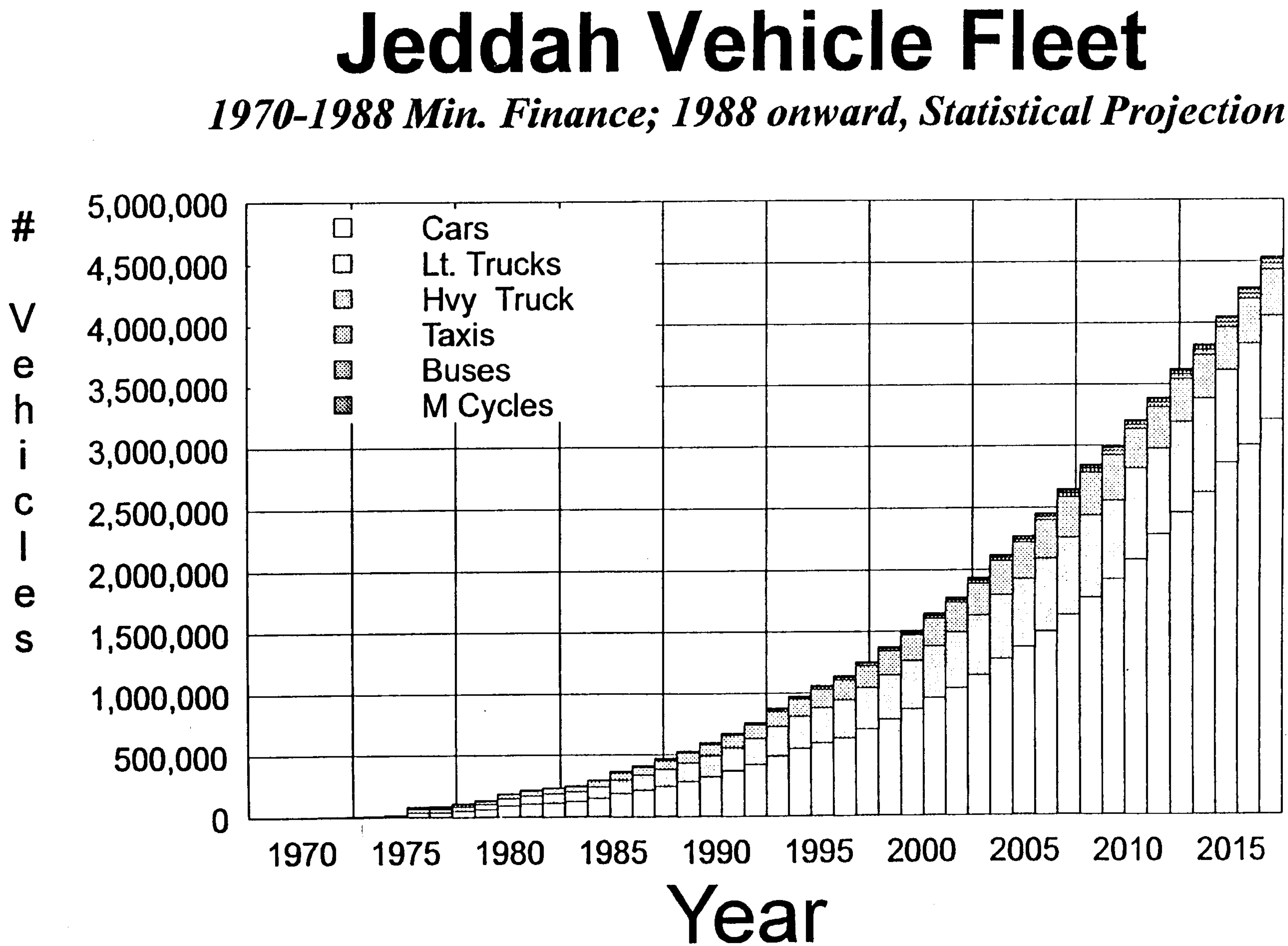


Figure 24. Total vehicle fleet in Jeddah from 1970 to 2015.

Figure 25. Shipping unloaded through the Jeddah Islamic Port from 1965 to 1990.

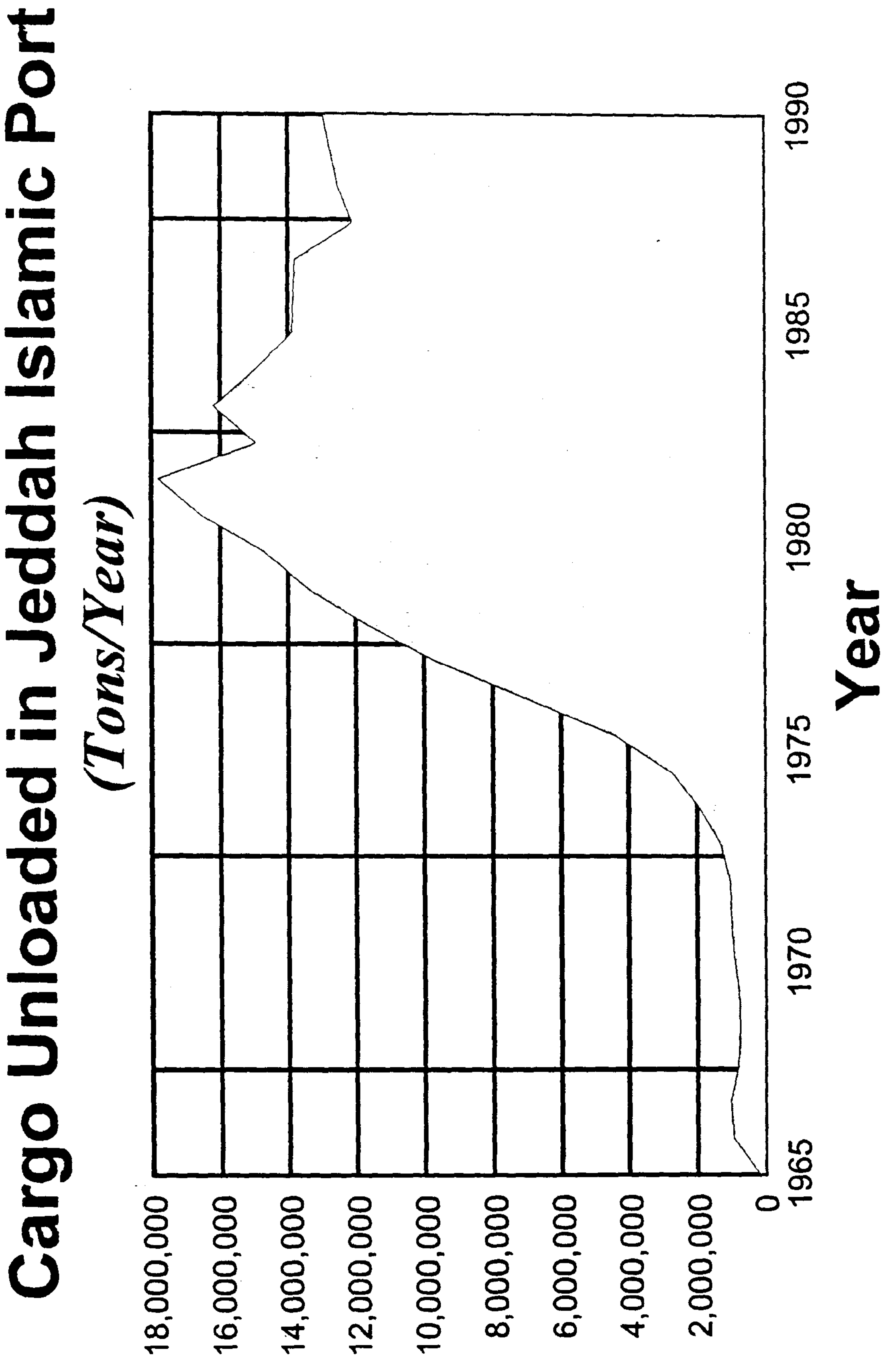


Figure 26. Location of marine pollution incidents in 1992-93.

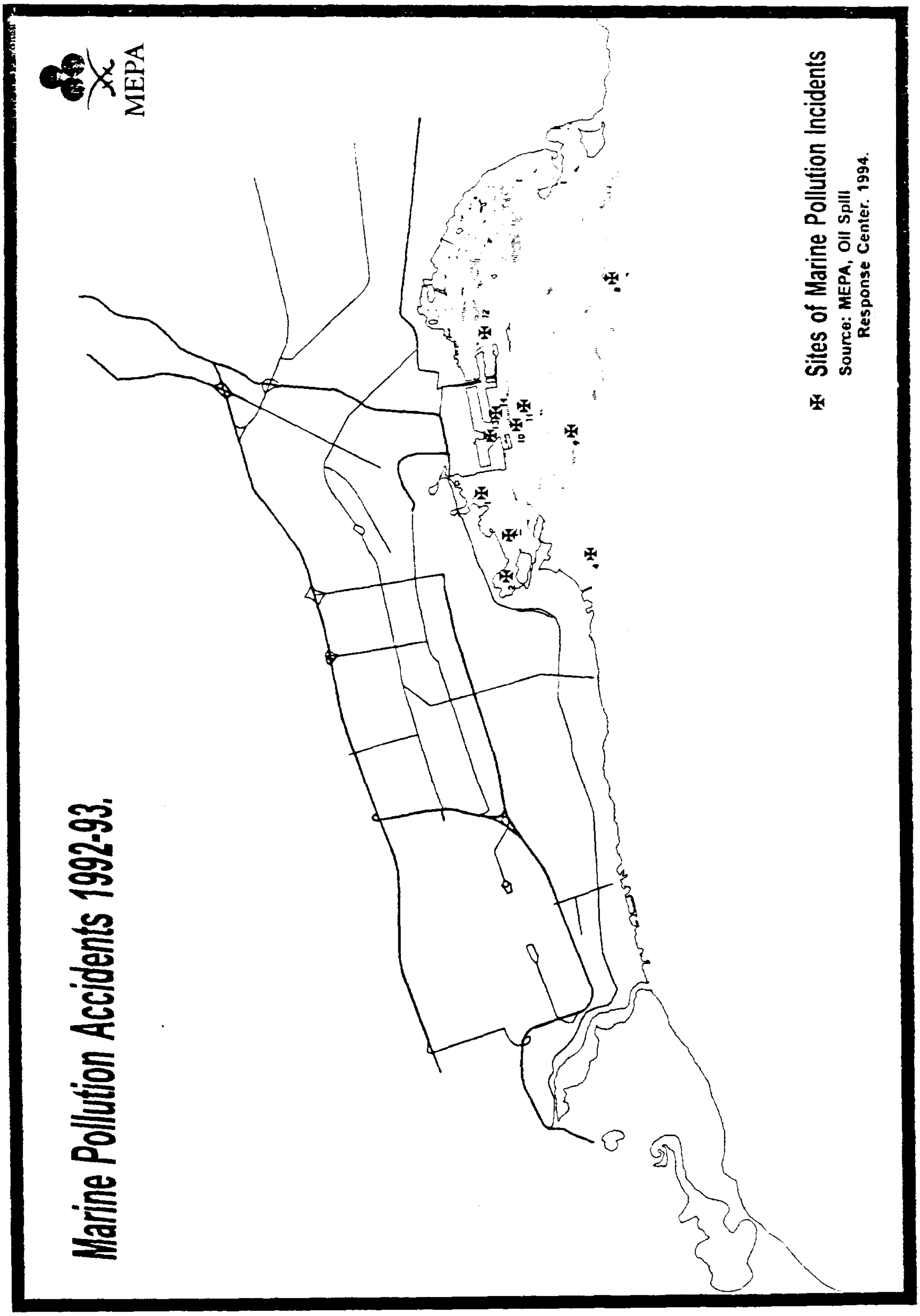
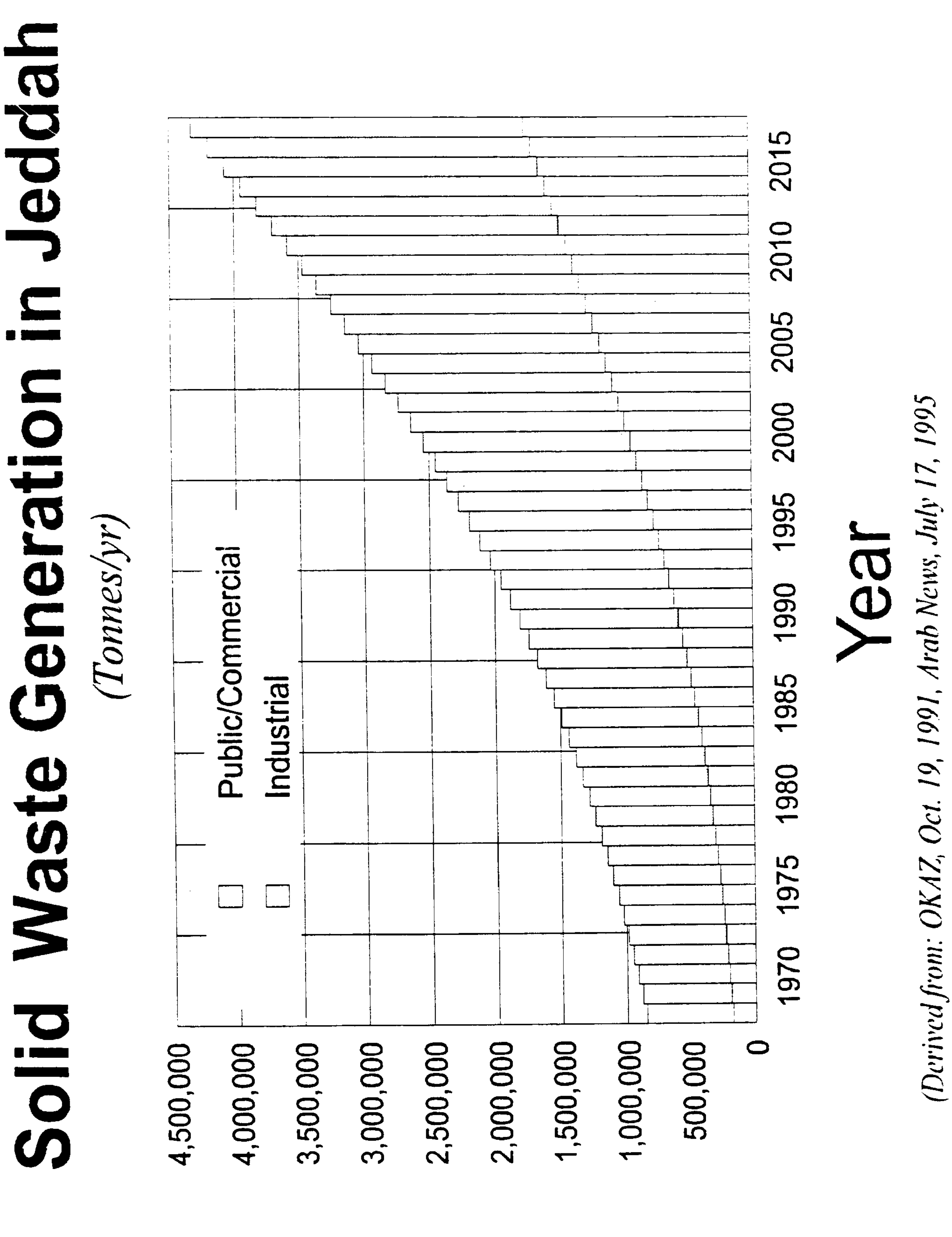
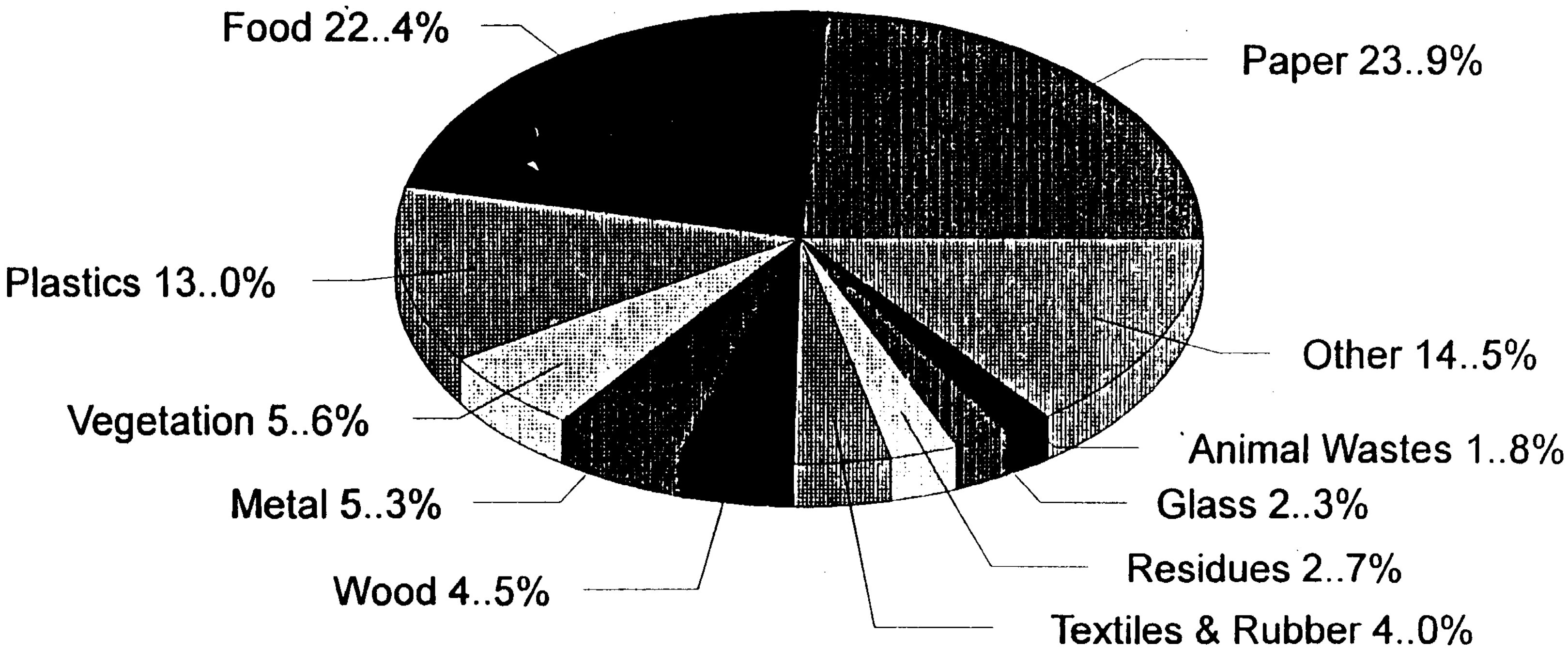


Figure 27. Total solid waste in Jeddah from 1970 to 2015.



Solid Waste in Jeddah Landfills (%)

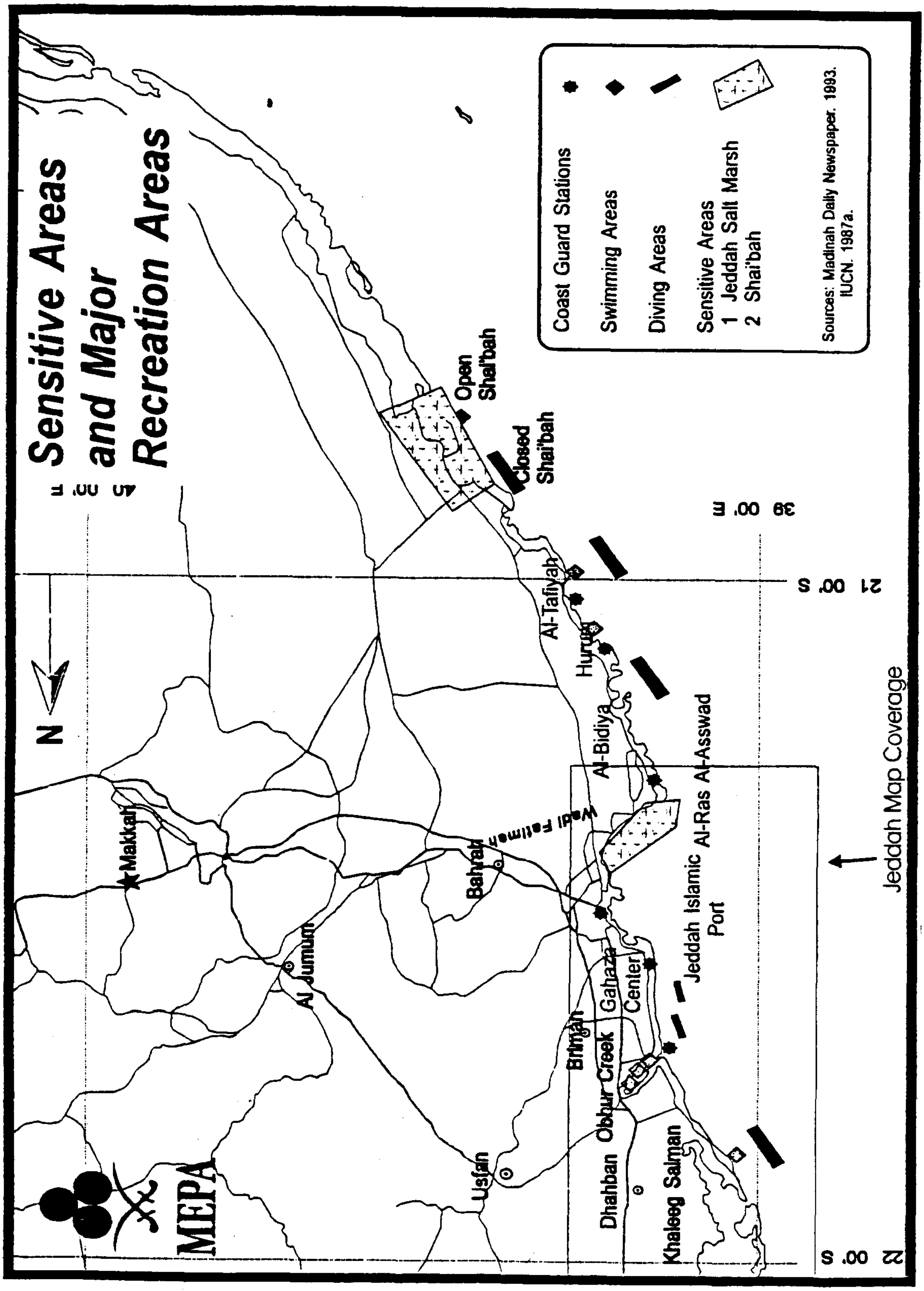
(Source OKAZ, Oct 19, 1991)



Jeddah Waste Generation is 1.4 kg/Person/Day

Figure 28. Composition of solid waste in Jeddah's landfills.

Figure 29. Regional figure showing location of recreational and environmental resources, coastal towns and Coast Guard stations.



Endnotes

1 An example of this can be found in MEPA (1994) where there was one manager at the Jeddah landfill and 3800 workers.

2 In this same article the Minister of Interior mentioned that an average of 300,000 "overstayers have been deported during recent years although in prior years (and possibly in the future) such individuals as had valid passports were given visas and allowed to work in the Kingdom. This information is presented as an example of the relationship between policy and significant components of the demographic equation.

3 Average capital cost/M3/day of desalination capacity in Jeddah is $2514 (ESCWA, 1990).

4 Abdul Razaq's model was based on the assumptions of specific actions which affected (covered) a certain proportion of the population in the model periods (see Table 10).

5 Based on Altinbilek (1984), Al-Hoisney (1990), Fogel (personal communication) and Abdulrazzak (personal communication).

6 Rainfall volume is given as 1200 km2 x 64 mm/year.

7 Ministry of Planning, personal communication.

8 MOFNE, Statistical Summary (1972-1992).

9 (1992 Population x 55 M3/year) x 2/3

10 The Jeddah Municipality has undertaken a major effort in tree planting which, at the end of 1993, resulted in over 500,000 M2 of "Green Belt" (Arab News, April 3, 1993)

11 The Jeddah Municipality has undertaken a major effort in tree planting which, at the end of 1993, resulted in over 500,000 M2 of "Green Belt" (Arab News, April 3, 1993)

12 Abdulrazzak, et al., 1989 report that 70% of incident rainfall recharges groundwater and 30% runs off.

13 Al-Hoisney, 1990. Jeddah's sewage plants cost SR 2403/M3/Day of capacity in capital costs and SR 40.5 /M3/Day of capacity in operating and maintenance costs. He also reports that 13% of the water in the sewage treatment plants is reused for irrigation.

14 Leakage from the water distribution system was reported at 14% in 1984 (Altimbilek, 1984). A recent SWCC study (Arab News, April 5, 1997) by Japanese experts states that the current leakage level is 40% of water carried in the distribution system. This figure is used in the current analysis.

15 Difference between annual total sewage generation and amount handled by Sewage Treatment Plants.

16 MEPA/MOFNE/World Bank. 1995. Pollution Inventory for the Kingdom of Saudi Arabia.

17 SCECO (Personal Communication) reports that the cost of electrical generation (including both capital and operating costs) is $1.32/Kw/Hr ($1,320/MW/Hr) at domestic fuel prices. At International fuel prices, the cost rises to $5.23/Kw/Hr.

18 This figure was arrived at by introducing a conservation model into the electrical demand in which per cent savings were calculated as a linear amount over a fixed time period. The components of the model for industrial energy demand were introduction of All savings were calculated linearly over the 20 year period. References for these figures are Fisher (1990), Becht and van Soest (1989) and NRDC (1989) (see Table 11).

19 The Arab News (March 21, 1995) reports a 47% increase in automobile accidents between 1993 and 1994. Traffic accidents led to 4077 deaths and 30,600 injuries during this period.

20 The study took place in Riyadh and was reported in the Arab News (July 3, 1995). It found higher levels in breast milk of young mothers than older mothers and attributed this difference to the fact that "young mothers have been exposed to less environmental pollution than older mothers". The study also found high levels of lead in the breast milk of mothers who lived in high traffic areas. In Saudi Arabia, the primary source of environmental lead comes from vehicular sources.

21 MEPA/MOFNE/World Bank. 1995. Pollution Inventory for the Kingdom of Saudi Arabia.

22 The Jeddah desalination plant(s) generate brine which at 51 ppm. is over 1.3 times the ambient salinity of the Red Sea (42 ppm) at a temperature of 41oC which is around 9oC over theaverage ambient Red Sea temperature.

23 The mayor of Jeddah reported in the July 18, 1995 Arab News that the city collects 2,100 tons of garbage daily. When divided by the 2.5 million estimated population this gives 0.85 kg/day. Collection is carried out under three main contracts: one for SR17.5 (3 years); SR570 million (5 years) and SR 35.5 million (3 years). Thus, the cost per year for garbage pickup in Jeddah in 1995 is SR131.26 or SR 53/person/year. (Derived from: OKAZ, Oct. 19, 1991.

24 OKAZ, Oct. 19, 1991.

25 MEPA, 1994 report that the Jeddah land fill recieves 4000 tonnes daily (1,460,000 tonnes/year) which is below the figure quoted by Okaz (around 2 million tonnes/year) yet higher than the figure reported in the Arab News (2100 tonnes/day).

26 1994/95 Production for SCECO West was reported at 11,300 million kWh with an installed capacity of 5,530 MW (MEED, 1995).

27 The increase in electricity is less than expected since the Ministry of Industry and Electricity report (Arab News, April 27, 1995) that electrical demand is expected to increase by 273%.

28 Arriyadh Development Authority (personal communication) reports that they have spent SR 340,000,000 ($91 million) thus far on the ground water problem and are requesting another SR 200,000,000 ($53 million) for the purposes of disposal. Jeddah's ground water quality is unsuitable for irrigation and requires disposal at sea (Abu-Rizaiza et al., 1993).

29 Fahd al Suleiman of the Jeddah Water and Sewage Authority detailed additional investments of SR 1.08 billion including one additional sewage treatment plant and expansion of the sewage network. (Arab News, Sept. 27, 1995)

30 SCECO (Personal Communication) report that the cost of electricity in Saudi Arabia is $1.32/kw/hr ($1,320/mw/hr) at local fuel prices. At international fuel prices, the cost would be $5,230/mw/hr. This figure includes both capital and operating costs. The figures provided in Table 7 therefore represent an underestimate of the actual costs in that they include both the one-time capital cost and only a single year's operating costs. The actual cost of keeping up with electrical demand would include both the capital costs as well as the cumulative additional operating costs. A recent article in Middle East Economic Digest (September, 1995) reports that planned expansions of the Kingdom's electrical network will cost approximately $2,000/MW of installed capacity. The same article reported that the Kingdom's electrical companies lost nearly $3 billion in 1993/4 and 1992/3 and that the company is required to provide shareholders with a 15% annual dividend. Thus, the figures provided in the current analysis may well constitute a major underestimate of the costs of keeping up with growth in that they underestimate actual capital costs, do not fully include the costs of financing, and do not adequately include annual operating costs.

31 In a 25 July Arab News article which emphasized the need for conservation by all of the Kingdom's electricity users, Dr. Bakr Kheshaim, Director General of SCECO summarized current plans for expansion of the Western Province electrical system. In the case of Jeddah, these included SR 191.5 million for expansion and consolidation of the distribution network and SR 1.47 billion for 520 MW (190,000 MW/Year) of power generation. This additional capacity is substantially less than that reequired to meet the calculated additional demand over the next twenty years and the SR 2.5 billion investment is significantly lower than the calculated amount required to meet growth in demand for electricity over the coming decades.

32 The cumulative additional costs for garbage collection between 1995 and 2015 are calculated to be SR 4.35 billion ($1.15 billion).

33 H.E. the Minister of Municipalities and rural affairs, Dr. Muhammad Al-Jarallah, announced finalization of plans to devleop new townships outside of major cities with the intention of attracting settlement outside of major municipalities. Saudi Gazette, 21 January, 1996.

IMPACTS OF URBANIZATION ON THE COASTAL ZONE ENVIRONMENT OF THE RED SEA
THE CASE OF SUEZ BAY

by

M. I. El Samra and A. A. Moussa

IMPACTS OF URBANIZATION ON THE COASTAL ZONE ENVIRONMENT OF THE RED SEA THE CASE OF SUEZ BAY

by

M. I. El Samra and A. A. Moussa

National Institute of Oceanography and Fisheres, Suez and Alexandria, Egypt

Introduction

The city of Suez, located at the northernmost part of the Suez Gulf (Fig., 1) is experiencing rapid industrial and demographic development. In a short period (about 20 years), it has undergone industrial diversification to such an extent that it became one of the major industrial centers of Egypt.

Development was interrupted by the 1967 and 1973 hostilities, when the Suez Canal was closed and the city evacuated. The return to normal after 1973 led to massive reconstruction of the whole city. The master plan for the development of the city showed that Suez area could be enlarged to reduce the population pressure on Cairo and Alexandria, without encroaching on agricultural land.

Suez Bay, at the head of the Suez Gulf is a relatively small (~ 100 km^2) and shallow water body. Its water depth barely exceeds 16m compared to 50-70m depth in the Gulf of Suez proper. The coast of the Suez Bay is bordered by 200-400 m wide tidal flats merging seaward with a wide zone (500 - 1500 m) 0-5 m in depth (Moussa, 1993).

Historical Background

Remains of ancient Suez or El Qalzam, dating from the 5th and 6th dynasties of the Old Kingdom of Egypt, (2563 - 2300 B.C.) were discovered during the excavations conducted by the French archaeologist Bernard Bruyere during three field campaigns from 1930 to 1932 (Bruyere, 1966). During World War II a great part of the collections he had made was lost. His monograph was published 34 years later. The southern section of the Bruyere excavations, (Fig. 2) consists of an ancient fort which was partly destroyed in 1923 by constructions for the Company of Peninsular Navigation. North and east of the fort stood the remnants of a villa of relatively recent origin built for the Khedive Ismail. The northern part consisted of the remains of ancient port facilities. The fort, houses and streets within its enclosure indicate that they were built in the Ptolemaic period of (330 - 30 B.C.). However, the remnants of the outer enclosing wall of the fort show it to have been different in construction technique and plan. It was of a pattern similar to that of a large rampart in the upper Nile valley. The archaeological evidence suggests that an earlier fort had existed on the site, but that it was rebuilt under the Ptolemies on a more rigidly geometric plan.

The marina settlement was first established in Hellenic times in connection with the completion of the sweet water canal in 270 B.C. under Ptolemy Philadelphos. Different kinds of installations such as grain mills, glass-making kilns and a fishing station reflect a diversity of activities of a civilian rather than a military character. There was abundant refuse of the Turkish rule superimposed over the old constructions.

Historic accounts cited by Bruyere relate that during periods of warfare and marauding, commerce was abandoned in all the Red Sea ports except Qalzam, which was the only one protected by a solid fort. Bruyere found also indications of Koranic schools inside the fort.

Suez Harbour and Urbanization

The Suez harbour has always been an important Egyptian gate on the Red Sea since historical times. The growing activity of this harbour has led to an increasing rate of urbanization in the whole region. Taking advantage of the site location, several industries have been established all of them along the western coastal stretch of the Suez Bay down to El-Adabiya in the south (Fig. 3). The growing industrial activities coupled with the fact that Suez represents the southern entrance of the Suez Canal have resulted in the transformation of the whole Suez Bay into a large harbour. More than 100 ships and tankers are waiting daily to cross the canal to the Mediterranean.

Suez area and Suez Bay comprise almost all types of land based sources of pollution. The Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources describes the sources to which it applies as follows: polluting discharges reaching the Protocol area from land-based sources , in particular, directly, from outfalls discharging into the sea or through coastal disposal, indirectly, through rivers, canals or other water courses or through run-off, and pollution from Land-Based Sources transported by the atmosphere. The Protocol also applies to polluting discharges from man-offshore structures (UNEP, 1992).

Socio- Economic Activities

Population

The population of Suez city in the 1960's was of about 100,000. With the active development of Suez city after the 1973 conflict the population showed an increasing rate of growth. The 1976 census of Suez Governorate showed a total population of 194,000 while in 1997, the estimated population was of 207,000. Recent statistics showed that the population reached 370,000 and, in 1994 it was of 417,000. The annual growth rate in the 1990s was estimated to be of 2.85% . A target population of 1,000,000 however is foreseen for the year 2000, based on large-scale immigration from other parts of Egypt.

In order to meet this target , a timely and fortuitous combination of housing construction and industrial expansion must occur together with the development of necessary utilities and urban services. Fig.4 reproduced from Suez master plan shows the planned distribution of population and employment for the year 2000.

Domestic waste water.

The first elements of a municipal waste water collection and disposal system for Suez were installed during the mid-1920s. The system was expanded and modified during subsequent years, providing service to the Port Tewfik area and to about 70 percent of the urbanized area of Suez at the time hostilities broke out in 1967. During that conflict, a considerable amount of damage was done to the system. Additionally, the city was evacuated and not reoccupied until 1974. During this period further deterioration occurred through disuse and lack of maintenance. Since 1974 and concurrent with general reconstruction efforts, work has proceeded to rehabilitate and to expand the existing sewerage system.

Until August 1995, the treatment plant was primitive and of limited efficiency. It included primary treatment ponds of 5 Acres. The waste water was then discharged into the bay through El-Kabanon drain, an open drain, 6 km south of Suez. The sewerage system was constructed to serve 98 % of the residential and commercial waste water, while 2 % were discharged directly to the sea. The discharge amounted to 75,000 m^{3-1}day in winter, increasing to 85,000 m^{3-1} day in summer.

A new waste water treatment plant has been constructed, and is presently fully operational. It provides treatment capable of meeting the legal effluent standard for BOD (Biological oxygen demand) and TSS (Total suspended solids). The planned system of treatment includes 4 aerated oxidation ponds and 2 basins for mechanical separation of settellable solids. The precipitated sludge will be dredged every 6-12 month (depending on the amount of solid material), transported to drying lagoons and then stockpiled for possible use for agriculture purposes. The plant is designed to treat 260,000 m^3/day.

The National Institute of Oceanography and Fisheries has been charged by the Governorate of Suez city to conduct a three phase monitoring programme. Water quality will be assessed to monitor the impact of the new effluent discharge on Suez Bay. Four parameters namely, total coliform, fecal coliform, fecal streptococci and settleable solids will be assessed at 20 locations (Fig. 5). The total sampling area is of 1.9 km^2 corresponding to a the shoreline length of about 2500 m. Additional oceanographic parameters are recommended in order to evaluate in detail the effects of the disposal of waste water on Suez Bay.

Industry and other Infrastructures

The development of Suez is seen as centering on a mix of labor - and capital- intensive industries, developed on the existing base of petroleum and petro-chemical plants. A UNEP report (1978), lists the present industries in Suez. The study has also proposed other new industries for Suez several of which are functional at present:

Fiberglass boat building plant.
Machine shop and assembly plant.
Merchant steel mill.
Ship scrapping yard.
General engineering foundry.
Ceramic tiles plant.
Denim plant.

1- Oil refineries, marketing, storage and piping.

Beside the super tanker traffic to and from oil terminals, there are two major refineries in Suez; El-Nasr Petroleum Co. and Suez Petroleum Co. They are located in Zeitia area about 3-5 km S of Suez city.

Atmospheric pollution, mainly sulfur oxides, hydrocarbons, nitrogen oxides and carbon monoxide are released during burning gases. The refineries in Suez have old burners and the combustion of released gases is not complete. This causes high emission factor for gases. For example, the SO^2 emission factor is above 32 g $l^{-1}$of oil burned. Emission of elements such as As, Cd, Co, V, Ni and Cu is also included.

The discharged waste water from El-Nasr Petroleum Co. amounts to $144x10^3$ m^3/day.

2- Fertilizer and chemical industry.

This company produces 1000 ton/day ammonium nitrate, 500 ton/day calcium nitrate and 50 ton/day ammonium sulfate. Besides, aqua-ammonia, sulfuric acid and nitric acid as byproducts (Anon, 1994). The company is located 2 km inland at about 8 km SW of Suez city. The factory uses freshwater for cooling and the effluent discharge amounts to $14x10^3$ m^3/day of low saline water (2.5 %.). As expected this water is loaded with ammonia, phosphate and nitrate in addition to certain metals e.g. Cu, Zn and Pb.

3- Power station.

The thermal power station at Ataqa (8 km S of Suez) is one of the largest in Egypt designed to generate 950 mega watt of electric power. Cooling water is taken from the Suez bay via an open canal extending over a half kilometer into the sea. A water temperature rise of about 1°C due to the thermal effect of the effluent is recorded in the near shore waters.

4- Harbour activities (Anon, 1994).

Activities of Suez and Adabiya ports include $900x10^3$ ton crops, $300x10^3$ ton ores and cement, $65x10^3$ ton fertilizer and $5x10^6$ ton oil and other liquids. The total number of trading ships is about 1200 in addition to 1027 passenger ships. The port handles huge amounts of hazardous materials such as cement, oil, chemicals.... etc. The port has no facilities for ballast water reception, no records of spills due to accidents or daily operations are available however.

5- Cement industry.

Suez cement factory lies 40 km south of Suez city. Manufacture of cement is a high temperature process, converting more than 30 raw materials to a fine gray cement powder. The process is energy consuming and results in atmospheric discharge of several pollutants. It was estimated that more than 10 g Pb and 600 mg Cd per ton cement produced could be released into the atmosphere. This indicates how huge are the amounts of trace elements which could be added to the atmosphere through cement production.

The factory lies on the coastal strip of the Gulf of Suez (5 km inland). Its location and the prevailing NW wind heighten the budget of heavy metals and dust contributed by the factory to the marine ecosystem (no available data). The deleterious effect of the atmospheric fallout represents a threat to coral reefs at Ain El-Sukhna (50 km south of Suez city).

6- Offshore and inshore oil production.

Extensive oil production operations are taking place in the Gulf of Suez region, both inshore and offshore. The number of producing oil fields in the gulf is 32 (1993 data), most of them lying offshore. Numerous fields are large, and the proven recoverable reserves amount to 125-250 million barrels. The cumulative production from the gulf oil fields amounts to over 2500 million barrels (Schlumberger, 1984).

The spills from oil rigs and ships have severely affected the intertidal zone in the central and southern parts of the Gulf. Dicks (1987) reported that many rocky shores are blanketed with oil pavements. He also found that in some beach areas oil is found buried beneath a thin veneer of wind blown sand. Not only the direct effects of spills are important, but also of much concern are the drilling operation themselves. The discharge of drill mud and rock cuttings during operations results in high turbidity of water column probably extending for few kilometers. According to Thompson and Bright (1977) the sediment loading from drilling operations has killed hermatypic corals.

The Ecosystem

The physicochemical characteristics of water

The tidal range in Suez Bay varies between 0.8 m and 1.4 m. Tidal currents are the dominant influence on circulation in Suez Bay. Tidal forces induce an alternating N-S trend to the current. wind-driven current and seasonal circulation patterns due to differences in sea level between Suez and Mediterranean are other factors of importance. In general, the residual current in Suez Bay runs anticlockwise.

Water quality of Suez Bay is rather unique compared to any other part of the Red Sea due to its small area, the nature of the surrounding land and the highly active urbanization along its coast.

Offshore waters retain the general characteristics of the northern part of the Gulf of Suez.Salinity is higher, about 41%, nutrients low and oxygen content normal (~ 5 mg O2/l). Inshore waters are affected by runoff effluents from land based sources. Salinity is lower, less than 40, nutrients content higher, particularly in front of the sewage and of the fertilizer company effluents (Ammonia 20g at Nl^{-1}, phosphorus 7g at^{1} Pl), high turbidity (suspended matter amounts to 2000mg/l), low oxygen content less than 2 O_2l^{-1}, high organic content (~ 8mg O2 /l). This reflects the adverse impact of land based sources on the natural marine environment. The immediate effect of effluents is more obvious in the immediate vicinity of the discharge sites resulting in the formation of a well characterized water type. In addition to the input of pollutants, thermal pollution from the power station results in higher temperature, lower oxygen and higher salinity.

The western coast of Suez Bay, where several outfalls are located, increases very slowly in depth to about 15 m within four kilometers from the shore. Such a small depth gradient severely limits the initial dilution which otherwise may have occurred.

In general, the extension of inshore water within the bay depends on the wind regime, water circulation and the residence time of water in the bay. The prevailing wind is N-NW causing sea water extension toward the offshore. Occasional E wind during winter confine the waste-waters near to the west coast. This is emphasized by bacterial counts made by the National Institute of Oceanography and Fisheries during 1994. In general, the pathogenic bacterial counts were less than 100 cell/100 ml, but during east winds a significant increase of fecal coliforms up to 2400 cell/100 ml was recorded.

Impact on marine life and beach zone

In addition to contamination from the aforementioned sources, the Suez Bay is suffering from increased sedimentation. This area is subjected to a high rate of sediment input, mainly fine aerosol materials and wind blown sands and silts. Meanwhile, the repeated dredging of the harbours and the Suez Canal contributes to the high turbidity of the water column. All these factors have adverse impacts on the biological communities in the Suez Bay. The reduction in light penetration and smothering of organisms have resulted in severe degradation of benthic life. The effects of siltation and contamination of the Suez Bay are exemplified by the dead coral reef fringe and dead coral island in Suez Bay. Even in the intertidal zone, the plant and animal life appear to be in a deteriorating stage.

The contamination of the Suez Bay coastal zone has also resulted in the loss of amenable beaches with adverse impacts on tourism. The discharge of domestic water has severely impacted the quality of important beach areas. El-Kabanon beach is a notorious example. One of the important and attractive beaches in Suez until the 1960s,it is now almost deserted. The threat to marine life in future may extend beyond Suez Bay. At Ain El- Sukhna, just south of the bay, the species diversity is found to be very low compared to areas like Ras Mohammed.

Conclusions:

Suez city and Suez Bay represent a clear case of the impacts of rapid and unregulated urbanization on the coastal zone environment of the Red Sea.

The impact of urban and industrial pollution on Suez Bay ecosystem affects human health, tourism and beach amenities, commercial and industrial investments,and the fisheries of Suez Gulf. Bio- diversity and density of the marine fauna and flora are severely decreased.

The deteriorating conditions in Suez Bay threaten to extend more and more to the south, as already shown by the conditions at Ain Sukhna.

A large number of new projects are to be developed along the northern coast of the Gulf of Suez: marinas, gas pipeline, steel factory, aquaculture, hotels, power station and others. It is imperative that these projects be preceded by an Environmental Impact Assessment and their waste discharges be put under strict control.

Recommendations:

1- Modeling of the Assimilation Capacity of Suez Bay- and of similar semi- closed water bodies downstream from large Red Sea cities is urgently needed in order to control the quality and quality of additional effluents into the Bay. Major factors are climatic conditions, the current system, and the residence time of water in the bay.

2- Urgent steps have to be taken to enforce safe effluent standards, taking into account internationally agreed guidelines.

3- Environmental protection should necessarily be included in all development strategies.

4- A monitoring and assessment programme for the Red Sea countries has to be designed and implemented to provide base - line data on the marine environment in this Sea. The programme should deal with two major aspects:

a) coastal oceanographic processes
b) assessment of the coastal ecosystems in the Red Sea, their biodiversity, their producitivity.

References:

Dicks,B., 1987. Oil Pollution. In : *Key Environments.The Red Sea*, A.J. Edward and S.M. Head (eds.), Pergamon, pp 383- 404

Moussa, A.A, 1993. Vulnerability assessment of the Suez Bay coastal zone to climate change and sea level rise, A case study proposal to UNEP, 21 p.

Schlumberger, 1984. *Well Evaluation Conference*, Produced by Editions Galilee, Imprimerie Moderne du Lion, Paris.

Thompson, J.H. and T.J. Bright, 1977. Effect of drill mud on sediment clearing rates of certain hermatypic corals, In: *Proc. of Oil Spill Conference*, 8-10 March, 1977, New Orleans, Lousiana, U.S.A., EPA / API / USCG, PP. 495- 498.

UNEP, 1992. *Mediterranean Action Plan and Convention for the Protection of the Mediterranean Sea against Pollution and its related Protocols* . UNEP, Athens 1992.

Fig.1: Location of Suez City

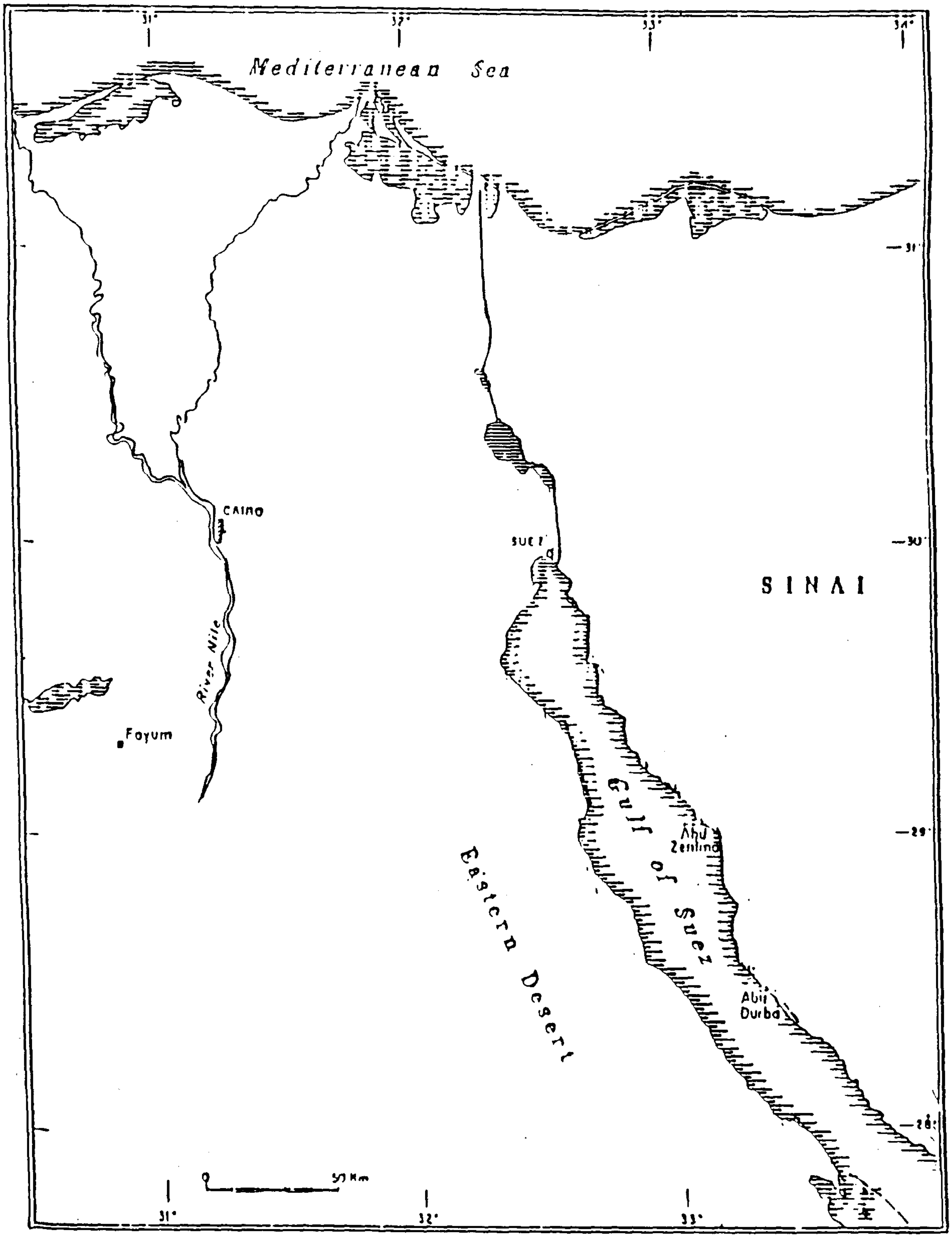
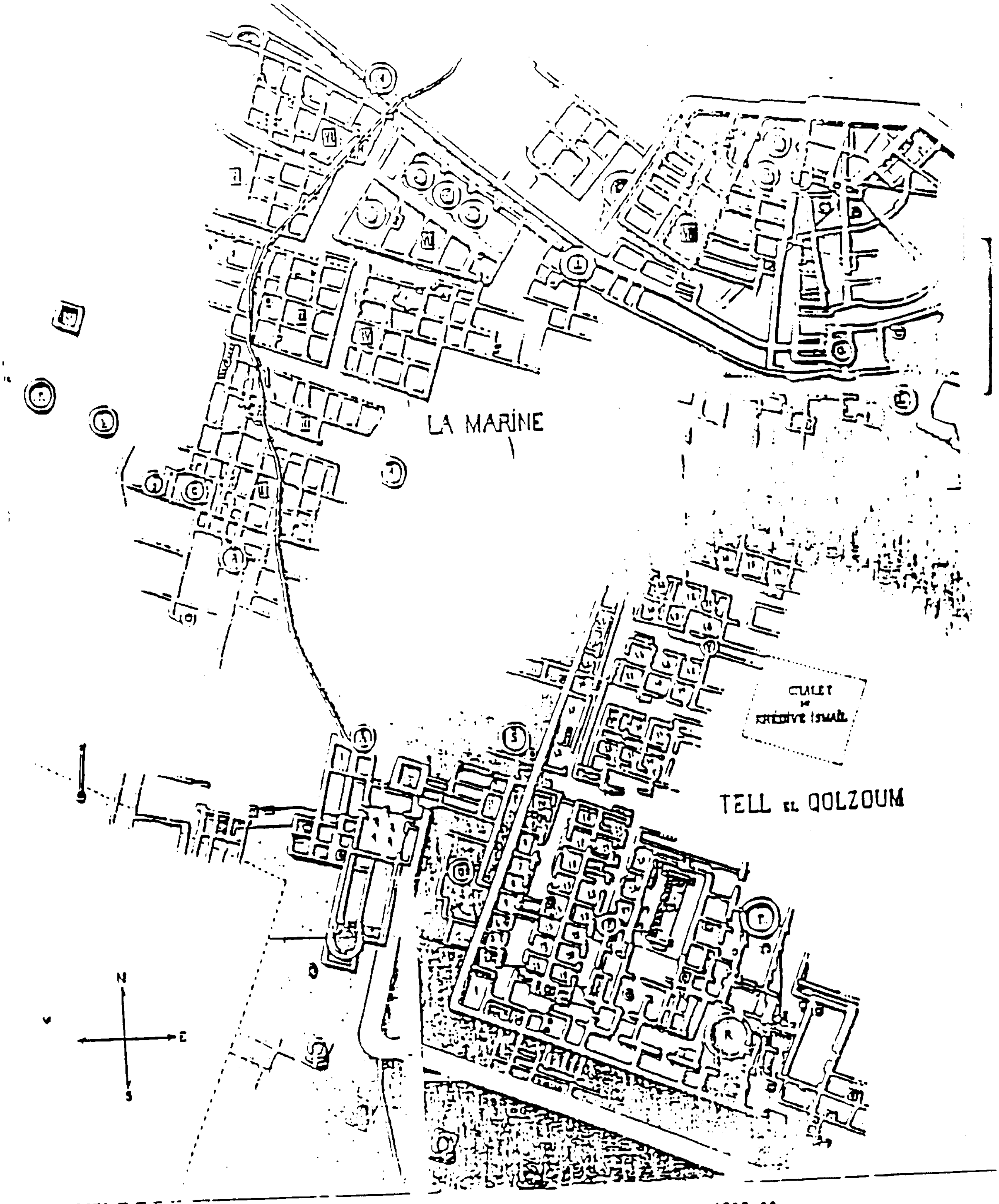


Fig.2: **Ancient city of Suez or El Qalzam**



REPRODUCED FROM: Bruyere; 1966, Fouilles de Clysma - Qolzoum, 1930-32, Institut Francais D'Archeologie Orientale du Caire

Fig.3: Land based sources of pollution to Suez Bay

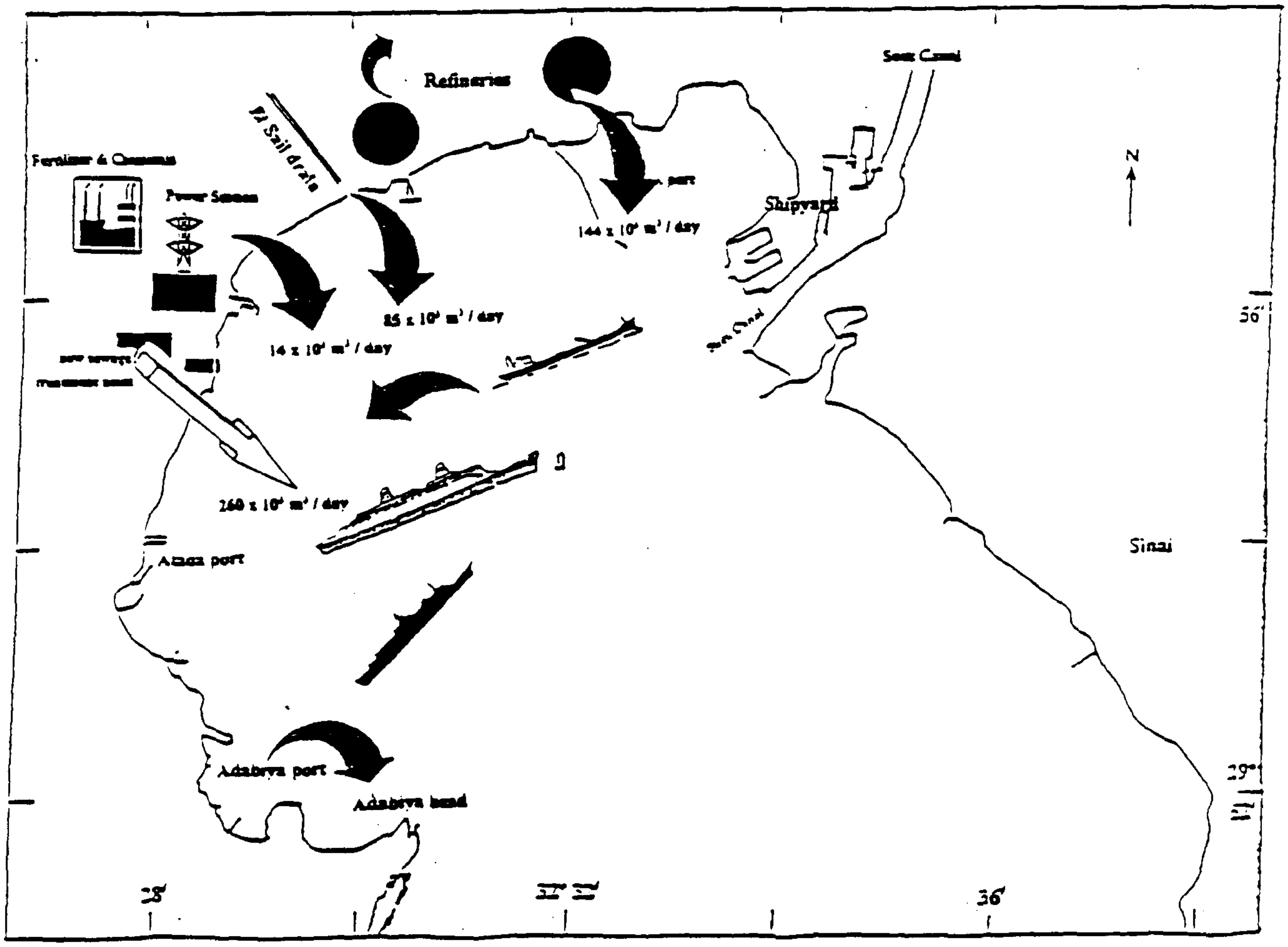


Fig.4: Distribution of population and employment for Suez City in the year 2000

Zone	Population	Workforce	Employment
1	.	.	37.100
2	80.000	32.000	14.280
3	5.000	2.000	8.925
4	80.000	32.000	14.280
5	.	.	4.000
6	.	.	14.294
7	80.000	32.000	14.280
8	5.000	2.000	8.925
9	80.000	32.000	14.280
10	.	.	14.500
11	.	.	14.290
12	80.000	32.000	14.280
13	20.000	8.000	22.000
14	60.000	24.000	10.708
15	187.250	74.900	32.484
16	.	.	10.570
17	.	.	21.700
18	.	.	14.257
19	80.000	32.000	14.280
20	5.000	2.000	8.925
21	80.000	32.000	14.280
22	.	.	14.250
23	.	.	12.150
24	80.000	32.000	14.380
25	5.000	2.000	8.925
26	60.000	24.290	10.868
27			12.159
TOTAL	988.150	395.290	395.290

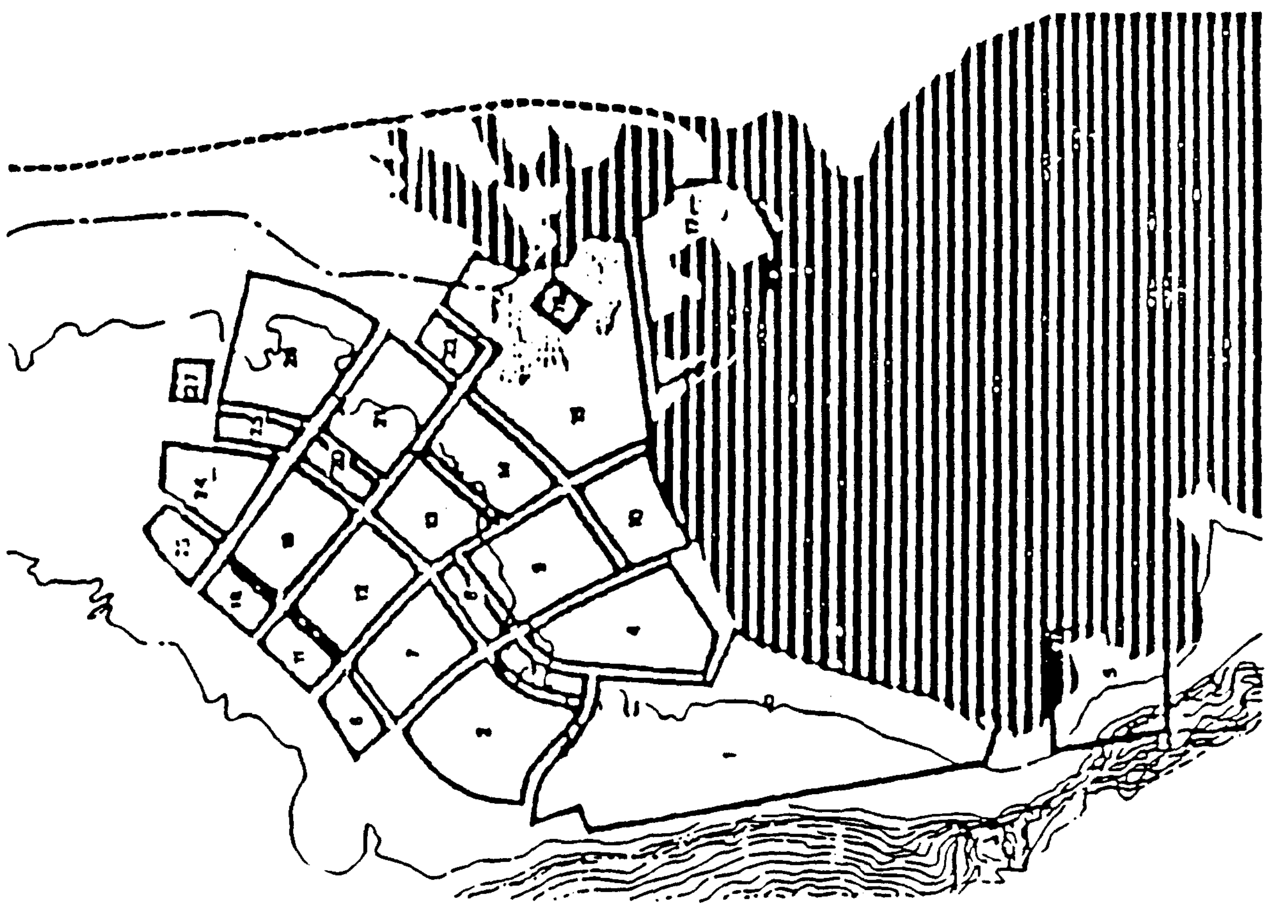
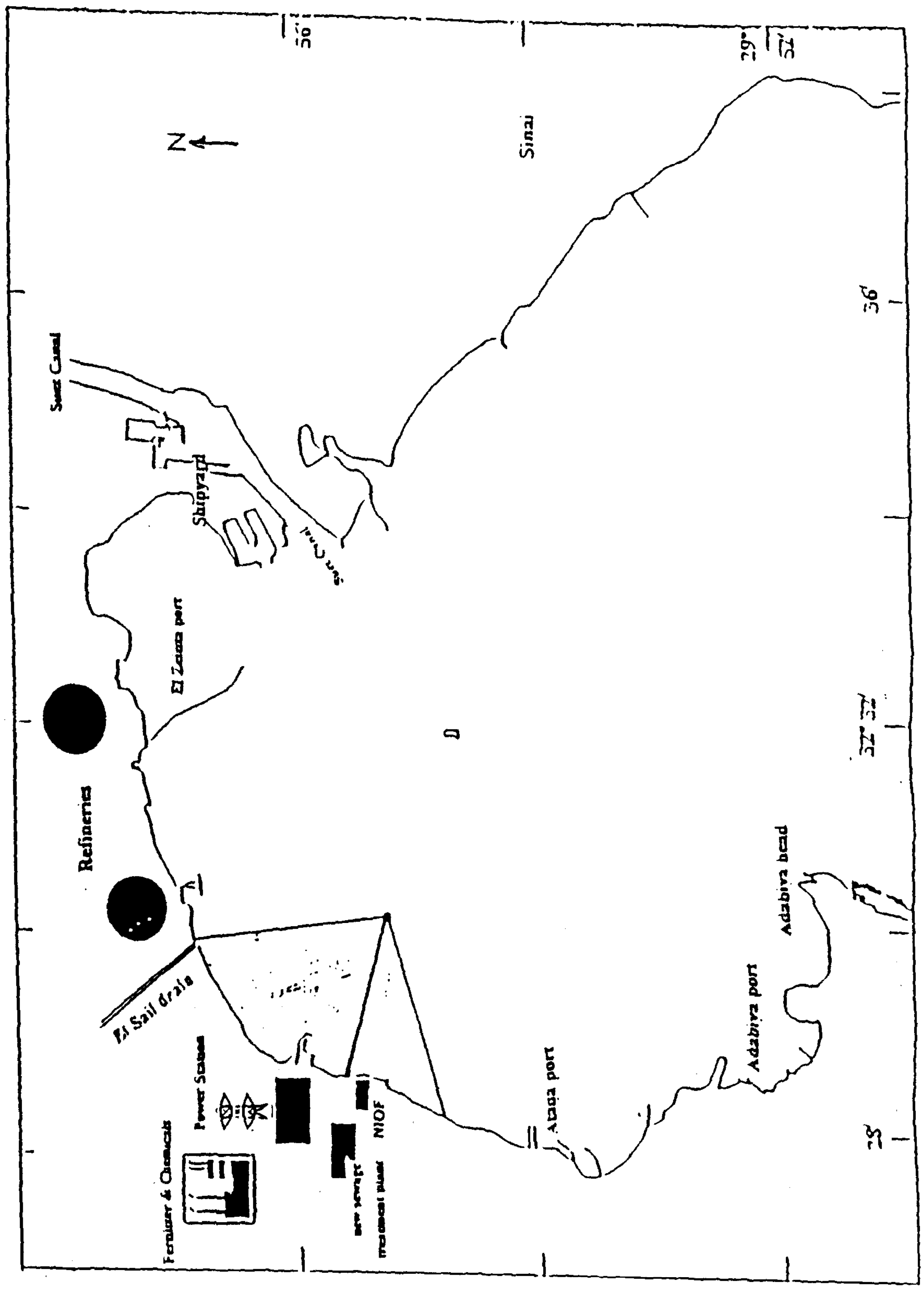


Fig.5: **Sampling area for pathogenic bacteria survey in Suez Bay**



TOURISM DEVELOPMENT OF THE RED SEA COASTS

by

Mostafa A. Saleh

Department of Zoology, Faculty of Science,
Al Azhar University, Nasr City, Cairo, Egypt

Introduction:

Today, tourism is the second largest industry in the world, comprising a major portion of the global trade in goods and services. By the year 2000, it is projected that tourism will become established as the world's leading industry (WTO, 1989). For many countries, both developing and developed, tourism is a major and an indispensable contributor to national economy.

Nature may play a primary role in attracting tourists to specific destinations the world over (Valentine, 1992). This has been widely exploited in recent years, and nature-based tourism, often called eco-tourism, has become one of the fastest growing types of tourism in the world.

Eco-tourism is usually labor intensive and can contribute socially and economically to the nation (Lucas, 1984). The idea of a symbiotic relationship between conservation and tourism has been frequently advocated (e.g. Budowski, 1976) on the basis of the principal of "wildlife pays so wildlife stays" (Kutay, 1989). According to Whelan (1991), ecotourism, done well, can be a sustainable and relatively simple economic alternative to the more consumptive exploitation of the environment. While creating economic benefit, it allows the continued existence of the natural resource base. In fact, it cannot survive without the survival of the resource on which it is based. In sum, ecotourism has the potential to maximize economic benefits and minimizing environmental costs (Whelan, 1991).

Ecotourism, however, does not, on its own, provide the perfect solution for the potential conflict between conservation and development. In fact, unless it is carefully planned as a tool for sustainable development, ecotourism may actually harm or even destroy its environmental resource base.

Coastal areas attract large numbers of ecotourists throughout the world. Snorkeling and scuba diving are now among the most popular activities for tourists travelling to the tropics and subtropics (Tabata, 1992). One of the most attractive areas for dive tourists in the world is the Red Sea.

Tourism in the Red Sea:

Tabata (1992) listed 12 factors that affect the desirability of diving sites. Among these, the three most important attributes were the outstanding marine life, good underwater visibility and the good underwater photographic opportunities. Accordingly, the Red Sea would provide some of the most attractive dive sites in the world.

A fast growing eco-tourism industry has evolved on the coasts of the Red Sea, the Gulf of Aqaba and the Gulf of Suez, based on the attractive marine life and the favorable climate of these areas. The tourist is offered a variety of nature-based activities including snorkeling, scuba diving, swimming and other water sports, in addition to the beautiful scenery and pleasant climate.

The most extensive tourism development of the Red Sea coastal land has taken place in Egypt. Large sectors of the Egyptian coasts of the Red Sea, the Gulf of Aqaba and the Gulf of Suez have been developed into beach resorts. The most intensively developed areas are the Hurghada and Sharm El Sheikh. Significant tourism development has also taken place at Dahab, Nuweiba and Taba on the Gulf of Aqaba coast as well as Safaga and Quosier on the Red Sea coast, and the northern sector of the Gulf of Suez. At the present time, the Egyptian Red Sea coastal resorts include 23 hotels and 20 tourist villages with a total capacity of 11,307 beds. In 1993 these resorts received a total of 879,000 tourists. The Egyptian Gulf of Aqaba resorts include 18 hotels and 29 tourist villages providing a total of 9474 beds and have received 411,000 tourists in 1993. An additional hotel and tourist village capacity of 11,180 and 5,658 beds are now under construction at the Red Sea and Gulf of Aqaba coasts of Egypt respectively.

Israel has a large tourism industry in Eilat at the northern tip of the Gulf of Aqaba. The 14 km of coastline of Eilat have been intensively developed. In 1992, Eilat had 33 hotel with a total capacity of 10,000 to 12,000 beds (ISPAN, 1992). In addition to several industrial facilities, Eilat has several tourism-related facilities including an underwater aquarium, a dolphin entertainment park, a marine reserve, and several diving facilities. Plans are underway to expand the Eilat tourism industry a great deal.

Jordan has only 27 km stretch of the Gulf of Aqaba coastline, much of which is occupied by essential industrial development. Limited tourism development has taken place there mostly serving domestic tourism. In 1992, Aqaba had 30 hotels with about 1300 rooms. The Jordanian government, however, has ambitious plans for developing mass international tourism, including ecotourism on the Jordanian Gulf of Aqaba coastal strip. A tourist development area near Aqaba is expected to have 4,000 beds by the year 2000.

In Saudi Arabia, international tourism is not permitted. However, massive development of coastal areas around major towns of the Red Sea coastal lands has taken place. Many of the developments are related to domestic tourism, particularly the building of summer homes (ISPAN, 1992). Sudan has an enormous potential for dive tourism, possessing in the Port Sudan area some of the most spectacular reefs of the whole Red Sea. Tourism is so far rather limited (Ormond, 1987). In Yemen, marine activities there still tend to be rather incidental and there is no significant tourism industry (Ormond, 1987). In Eritrea civil conflicts have closed the coasts to outsiders and at the present time there is potential tourism in the Red Sea coastal areas of Eritrea.

Planning Tourism Development:

Masterplanning and guidelines for tourism development are either now in existence, or nearly completed for Egypt, Jordan and Israel; the three countries with active tourism industries. However, extensive, and more or less haphazard tourism development of the coasts of these countries had already taken place several years earlier, with only limited or no environmental regulations. This has resulted in widespread degradation of the touristic resources of large sectors of the coastline. In Egypt, for instance, coastal and other resorts were often designed, built and operated on the initiative of individual investors, often with absolutely no consideration for their potential impacts on the natural environment. Very intensive tourism development took place, particularly in the areas of Hurghada on the Red Sea coast, and Sharm El Sheikh, on the Gulf of Aqaba coast since the late seventies and early eighties with little regard to the environmental or social carrying capacity or the sustainability of tourism. This haphazard development has resulted in extensive environmental degradation that now threatens the very resource on which the entire industry is based. The development of coastal tourism in Jordan and Israel followed similar pattern.

In Egypt, a "Priority Action Plan for Egyptian Tourism Development" was prepared in 1990. The plan was based on a hierarchial planning approach which requires that all lower-level planning decisions recognize national objectives and policies, as well as the country's social and economic conditions (Sultan, 1993). The plan identified a number of priority "Tourism Development Zones" which included the Gulf of Aqaba and the Red Sea coasts (Sultan, 1993). Detailed land use plans have already been prepared for the Gulf of Aqaba coast and a number of sectors of the Red Sea coastline. A set of environmental guidelines, rules and regulations for development was prepared and have been effective since 1990.

In Israel a "National Masterplan for the Coasts" has been prepared for some of the Israeli coastal areas. The plan for the Israeli Gulf of Aqaba coast, however, was under preparation in 1993 (Brachya & Marinov, 1993). In Jordan, there has been extensive management and planning for development of the Gulf of Aqaba coast (ISPAN, 1992). A master plan for Aqaba town, a proposed tourism development area, and the industrial area have been developed (ISPAN, 1992). The plan specifies the land use and required infrastructure and provides guidelines for development.

Environmental Problems:

Ecotourism development on the coasts of the Red Sea and its two gulfs has resulted in a number of environmental problems that threaten not only the unique and invaluable marine environment, but also the viability and sustainability of the tourism industry itself. Most of these problems are the result of the lack of environmental basis for planning or the ineffective enforcement of environmental regulations.

1. Over-development:

The sustainability of ecotourism in an area is closely linked to the keeping of the exploitation level below ecological carrying capacity. The ecological carrying capacity is reached when the number of visitors and characteristics of visitor use start to negatively affect the environment and degrade the ecosystem (Whelan, 1991). Preventing environmental degradation resulting from the development and operation of tourism in ecologically sensitive areas, such as the coasts of the Red Sea, is rather difficult or even impossible. Sound planning and effective enforcement of environmental regulations will certainly help. The so-called "acceptable" level of environmental degradation is rather difficult to identify. Consequently, answering questions such as how many tourists can visit an area without destroying it?, how much damage can the environment take? and how much environmental degradation will the "desirable tourist" accept? would be extremely necessary if sound planning is to be achieved.

The development of nature-based tourism is usually constrained by a characteristically low social carrying capacity (Wilson & Laarman, 1987). The social carrying capacity of an area is reached when the tourist encounters so many other tourists, or sees the impacts of other visitors, that his enjoyment of the site is marred (Whelan, 1991, Valentine, 1992). The nature-oriented tourist tends to perceive crowding as a major problem. To that tourist, the view of too many other tourists in a supposedly wild and pristine area certainly degrades its value. As a result, nature-based tourism must be low volume and will have limited prospects for growth.

Current tourism marketing of the Red Sea is mostly based on its attractive marine life, and essentially targets ecotourist, specially divers and snorkellers. These tourists are known to place more importance on good water quality, diversity of marine life and underwater scenery, than they do on low dive trip costs, boat facilities and other services. It is generally known now that as the environment becomes damaged or use level and type changes, some tourists are displaced (Valentine, 1992). The loss of these tourists will greatly affect the industry which is essentially geared for this type of tourism.

Areas such as Hurghada and Sharm El Sheikh, which appear to have been developed and exploited way beyond their ecological and social carrying capacities (Hashim, 1994) are already showing signs of environmental degradation which will almost certainly adversely affect their market competitiveness for quality tourism. The issues of environmental sensitivity, as well as the ecological and social carrying capacities require careful and site specific research, if nature-based tourism is to be sustainable.

Evidence of reef degradation due to tourism and other activities is clear even in protected areas such as the Ras Mohammad National Park in Egypt (Hashim, 1994), in the Eilat Coral Reserve, and the Aqaba Marine Reserve (ISPAN, 1992).

2. Coastline Alteration:

Throughout the coastline of the Red Sea, the Gulf of Aqaba and the Gulf of Suez, sandy beaches which are a highly desirable element in coastal tourism, are rare. If they are found, these sandy beaches often front extremely wide and shallow intertidal and subtidal areas which make access to deeper water suitable for swimming and other water sports rather difficult.

For several years prior to the formulation of the Egyptian masterplan for tourism development, allocation of coastal lands for tourism development projects on the Egyptian Red Sea coast was carried out in a total absence of environmental criteria for its suitability for that purpose. Areas with rocky beaches or very shallow and wide intertidal zone were allocated to tourism projects. Developers accepted the allocated land with the assumption that they will be able to alter the coastline features by land filling or dredging in order to create what they considered attractive sandy beaches. Massive coastline modifications, ranging from in-filling or dredging of shallow areas, to excavating artificial lagoons or building huge marine structures, were carried out, completely changing the coastline morphology. Extensive coastline modifications went on at an incredible scale in Hurghada and other areas, totally unchecked. At the present time, the original coastline of Hurghada has been completely obliterated by in-filling and other modifications.

In Aqaba, Jordan, it has been estimated that at least 30% of the natural coastline has been modified by coastal construction (ISPAN, 1992). In Eilat, construction of hotels, marinas, and tourist amenities and attractions has resulted in considerable alteration of the shoreline, filling of beach areas, and probably accelerated changes in longshore transport of littoral sediments (ISPAN, 1992).

In February 1994, a new law was issued in Egypt prohibiting modification of all coastlines. The enforcement of the law became effective immediately thereafter and the common practice of infilling and dredging of the Red Sea shore areas was finally stopped. Considerable damage had been done however, particularly around the Hurghada area. Vast areas of shallow water habitats, including coral communities, seagrass beds, mangrove stands, mudflats, halophyte vegetation or other natural habitats were severely affected.

Coastal shallows including sand- and mudflats are also feeding habitats of great importance for hundreds of thousands of palearctic migratory waders. These birds follow the Red Sea coastline during there spring and autumn migrations, stopping over to rest and feed at these shallow areas. The widespread loss of these important habitats may adversely affect the prospects of survival of these birds during their lengthy migration flights.

In addition to the direct destruction of marine life by dredging, filling and other coastal construction and modification operations, suspended fine sediments resulting from theses activities can inflict widespread damage to marine biotic communities. These suspended sediments can travel great distances driven by the prevailing water currents spreading death and destruction to the coral reefs, seagrass beds, mangroves and other marine life, tens of kilometers away. Layers of these fine sediments settled on the bottom in shallow areas, can easily become resuspended with the least amount of water agitation creating a continues source of pollution.

Siltation and sedimentation have caused mass coral mortalities in some areas. In Hurghada on the Egyptian Red Sea coast, for instance, sediments from coastal alteration activities spread to extensive fringing reefs, down the coastline and to the adjacent islands and offshore reefs. The once flourishing and attractive corals are now covered with a thick veneer of fine sediments and are mostly dead. The resulting widespread destruction of the Hurghada coral reefs and their associated marine life, is a gruesome and shameful witness of how haphazard and ill conceived tourism development can destroy the very source that created the tourist demand in the first place. Coral mortality caused by suspended sediments resulting from coastal construction, has also been reported in Aqaba and Eilat (ISPAN, 1992) and in Saudi Arabia (IUCN 1984).

Mangroves are found throughout the coasts of the Red Sea and to a lesser extent the Gulfs of Aqaba and Suez. They are extremely sensitive to excessive siltation or sedimentation, cessation of flushing and surface-water impoundment, all of which may result from coastline alteration activities. In Egypt, although all mangrove stands are protected by law, a small stand located at about 25 km north of Hurghada has been badly damaged by a tourism project. A larger stand on the Abu Minqar island, off Hurghada shows signs of stress which may have been caused by tourism related activities in the Hurghada area. With the rapid development of the coastline, it is feared that future tourism development, if not well regulated may result in mangrove destruction. Tourism development in Jordan and Israel, does not appear to have much affected the mangrove.

Segrasses are among key ecosystems of the Red Sea. As a benthic plant community, seagrass beds are extremely productive and are associated with an abundance and variety of small fishes and invertebrates, as well as turtles and dugongs. They also trap and bind sediments, considerably reducing the erosion and suspension of shallow sediments (Thayer, *et al,* 1975). Seagrasses, however, are extremely sensitive to excessive siltation which may result from coastal construction and shoreline modification activities. For reasons that are not clearly established, seagrasses only slowly, if at all, revegetate areas that have been dredged (Snedaker & Getter, 1985). Vast areas of seagrass have been destroyed as a result of dredging and filling activities, particularly in Hurghada, Egypt and other tourism centers in Eilat and Aqaba.

Beaches are temporary landforms that are particularly sensitive to factors which alter their sediment sources, nearshore currents, and wave regime (Snedaker & Getter, 1985). In addition to widespread modification of the coastline morphology, coastal construction work related to tourism development of the Red Sea coast has included the construction of harbors, jetties, and even hotels and residential or industrial facilities on the intertidal or immediate supratidal zone. Some of these structures extend for hundreds of meters into the sea.

The widespread coastline modification in Hurghada and other areas, were carried out in a totally haphazard and piecemeal fashion. Each investor was simply allowed to carry out any type of coastal modification he likes as long as he pays the local government for any new land created in the process. The resulting changes in the coastline morphology, therefore, resulted in considerable modifications in the current regimes, which, in tern, has created a plethora of erosion and sedimentation problems affecting the entire area. Excessive erosion, garbage trapping and unsightly man-made marine structures, have severely impacted the tourism marketability and competitiveness of the area. Legal conflicts related to the impact of coastal modifications of one project on others such as beach loss by erosion, accumulation of floating garbage in stagnation areas or obstruction of sea view by marine structures, became a commonplace among owners of tourism projects in these areas of haphazard tourism development. The untangling of these conflicts is coasting valuable time and money.

3. Pollution:

Degraded water quality resulting from the introduction of different pollutants, can adversely affect not only marine life, but also the general appeal of the area for tourists. One of the main and most dangerous sources of pollution in coastal areas in the Red Sea is the treated or untreated sewage effluents which may be discharged into the sea. Quite apart from the health risk, this type of pollution carries with it the risk of producing environmental changes directly detrimental to the enjoyment of visitors. Partially treated sewage effluents stimulate algal growth to such an extent that it overgrows and kills large sections of the reef.

At least up to the year 1992, nutrient-rich primary treated sewage water from the town of Eilat was discharged directly into the Gulf of Aqaba causing excessive damage to marine ecosystems (ISPAN, 1992). In Aqaba, Jordan a policy of zero discharge has been recently adopted, and all the municipal wastewater, after receiving proper treatment is used for irrigation (ISPAN, 1992).

In Egypt the discharge of partly treated sewage into the sea has always been widespread in most of the Red Sea coastal towns. A plan of building a series of treatment plants for these towns is being implemented and will eventually lead to a zero discharge.

In Egyptian Red Sea tourism areas outside city limits, however, all new establishments are required by law to provide their own sewage treatment facilities. Direct discharge of treated or untreated effluent is prohibited and violators risk the withdrawal of their operation permits. Many of these tourism establishments use compact treatment units. Proper operation of these units, particularly under widely fluctuating occupancy rates is difficult and the treatment efficiency of some of these units is doubtful. Discharge from overflow pipes into the sea occasionally occurs. Pollution due to sewage discharge from tourism facilities, and the consequent damage to marine life are evident in Taba, Nuweiba and Sharm El Sheikh on the Egyptian Gulf of Aqaba coast, and at several localities on the Egyptian Red Sea coasts.

Another source of pollution is the brine discharge of desalination plants. If discharged into the sea, this dense, hypersaline and copper-contaminated effluent, spreads on the bottom causing serious damage to benthic organisms before becoming diluted.

In Egypt, most tourism areas on the coasts of the Red Sea and Gulf of Aqaba obtain their fresh water requirements by desalination of sea water or brackish ground water. In addition, most of the Egyptian Red Sea coastal towns have their own desalination plants. These government owned desalination plants discharge their brine effluent into the sea, which most likely have resulted in considerable local damage to marine life. Tourist facilities outside these towns have their own desalination, usually reveres osmosis units. Currents regulations prohibiting the direct discharge of desalination brine into the sea appear to be adequately enforced.

In Israel, water requirements for the town of Eilat and its tourism facilities are supplied from the desalination of brackish ground water. The desalination plant produces a dilute effluent which is directly released into the Gulf of Aqaba (ISPAN, 1992). The effect of this discharge on marine life is not known.

4. Visitor Impact:

While recreation and tourism present major reasons for protecting the coastal and marine environment, uncontrolled use by visitors can itself result in serious impacts. Extensive collection of corals, shells and other reef animals, spearfishing, damage to corals by swimmers and boat anchors, destruction of coastal vegetation by trampling and vehicles, and proliferation of waste and garbage, are the types that of damage that may be caused by visitors and tourists. Corals, shells, and other souvenirs are often commercially collected by local fishermen and merchants for sale in shops and stalls to tourists. In Eilat, Israel, a recent report (ISPAN, 1992) describes the widespread damage to coral reefs caused by tourism and related activities. Coral breakage resulting from anchoring of pleasure and dive boats, using of fishing nets and basket traps, explosions, action by uneducated and inexperienced divers, and illegal collection for souvenirs and for resale were reported (ISPAN, 1992).

In Egypt, damage to coral reefs caused by tourists' activities is widespread. Mooring buoys for dive and pleasure boat are available only at very few of the favorite diving sites. Some of these sites are visited by up to 20 dive boats every day. As a result, the anchoring of thousands of boats visiting each site every year, directly to the reef has resulted in a very massive reef damage. Some of these dive sites have suffered so much damage that they ceased to attract tourists. Except for diving sites within National Parks and Protected Areas, the Egyptian authorities is exerting absolutely no control on the number of divers visiting diving spots or their activities. Damage to reef as a result of deliberate or accidental breakage of corals by divers is extensive in many areas. At the present time, the control of the tourist use of the coral reefs and other marine life is entirely left to tour operators and individual divers.

The collection of coral, shells, and other souvenirs by tourists is known to occur on the Egyptian coasts of the Red Sea. Several shops in Hurghada, Safaga and other Red Sea coastal towns, openly offer for sale to tourists corals, shells, dried fishes and turtle shell. The Egyptian government has made little effort to stop this drain on the Red Sea resources.

Conclusions and Recommendations:

The Red Sea, a globally important center of biological diversity, is currently subjected to a sweeping rate of tourism, industrial and urban development. Ill-planned and consumptive attitude in development is putting enormous pressure on the unique and highly fragile marine habitats of the Red Sea. The preservation of the unique and wondrous biological diversity of the Red Sea, and their wise and sustainable exploitation as an asset for an eco-tourism industry, requires not only careful planning and management, but also the cooperation of all its riparian nations.

- Red Sea coastal tourism development should be conceived within the framework of national, regional, and local development plans which assure proper integration of environmental objectives in development strategies. In particular, coastal tourism development should be approached within national strategy for coastal zone management plan, which identifies the zones most suitable for tourism.

- Tourism development planning should have, as a primary objective, the preservation the environmental assets of the area if sustainability of the industry is to be achieved. Limited tourism growth and careful management are, therefore, essential for eco-tourism to be sustainable. As the economic potential of nature-tourism may be extremely high, some kind of exclusiveness strategy should be adopted to keep the tourism flow below the social and ecological carrying capacities, at least in some areas. In that context, ecotourism can be viewed as an example of "low volume - high value" tourism.

- The issues of environmental sensitivity, as well as the ecological and social carrying capacities require careful and site specific research, if nature-based tourism is to be sustainable.

- The ecotourist can play a key role in the success or failure of sustainable ecotourism. Ecotour operator must instill a conservation ethic for environmentally sensitive travel in their clients if they are to continue bringing visitors to fragile sites.

References

Brachya, V, and Marinov, U., 1993. Coastal Zone Management in Israel and Prospects for Regional Cooperation. In Sandler, D., Adly E., Al-Khoshman, M., Warburg, P. and Bernstein, T. (eds.) *Protecting the Gulf of Aqaba, a Regional Environmental Challenge*, Washington, D.C.

Budowski, G. 1976. Tourism and conservation: conflict, coexistence or symbiosis. *Environmental Conservation*, 3(1): 27-31.

Hashim, M., 1994. Environmental Impact Assessment of Human Activities at Ras Muhammad National Park. Unpublished M. Sc. thesis, Environmental Studies and Research Institute, Ain Shams University.

ISPAN, 1992. Gulf of Aqaba Environmental Data Survey.

IUCN, 1984. *Management of the Red Sea coastal Resources: Recommendations for protected areas.* Saudi Arabia Marine Conservation Program, Meteorology and Environmental Protection Administration, Jidda.

Kutay, K. 1989. The new ethic in adventure travel, *Buzzworm: The Environmental Journal,* 1(4): 31-36.

Lucas, P.H., 1984. How protected areas can help meet society's evolving needs, 72-77 in McNeely, J. A., and Miller. K. R. (eds.), *National Parks, Conservation, and Development,* Smithsonian Institute Press, Washington, D. C.

Ormond, R., 1987. Conservation and management, 405-423. In Edwards, A. & Head, S. (eds.) *Red Sea (Key Environments),* Pergamon Press, Oxford, England.

Snedaker, S. C. and Getter, C. D., 1985. *Coastal Resources Management Guidelines,* Renewable Resources Information Series, Coastal Management Publication, No. 2.

Sultan, F., 1993. Tourism Development Along the Gulf of Aqaba Coast: An Egyptian Perspective. In Sandler, D., Adly, E., Al-Khoshman, M., Warburg, P. and Bernstein, T. (eds.) *Protecting the Gulf of Aqaba, a Regional Environmental Challenge*, Washington, D.C.

Tabata, R. S., 1992. Case Study, Scuba Diving Holidays, 171-184, in Weiler, B. and Hall, C. M. (eds.), *Special Interest Tourism,* Belhaven Press, London.

Thayer, G. W., Wolfe, D. A., and Williams, R. B., 1975. The impact of man on seagrass systems. *Am. Sci.,* 63: 288-296.

Valentine, P. S., 1992. Nature-based Tourism, 105-127, in Weiler, B. and Hall, C. M. (eds.), *Special Interest Tourism*, Belhaven Press, London.

Whelan, T., 1991. Ecotourism and its role in sustainable development 3-22, in Whelan T. (ed.) *Nature Tourism: Managing for the environment.* Island Press, Washington, D.C.

Wilson, M. A. & Laarman, J. G., 1987. Nature tourism and enterprise in Ecuador, *Forestry private enterprise initiative working paper no 27,* Southeastern Center for Forest Economics, Research Triangle Park, North Carolina.

World Tourism Organization (WTO). *Policy and Activities for Tourism and the Environment.* Madrid: WTO.

Oil Pollution in the Red Sea - State of the art

by

Hassan Awad

Department of Oceanography, Faculty of Science
Alexandria, Egypt

Oil pollution in the Red Sea and Gulf of Aden has been reviewed earlier shown to be the major pollution problem in this region (UNEP Report on the State of the Marine Environment in the Red Sea and Gulf of Aden, draft). Since then, additional information became available.

The present review will recall the main conclusions of the earlier report and focus on the results of a two- years project (1987- 1988) devoted to an investigation of the possible cause-effect relationship between oil pollution and coral reef health conditions along the Saudi Arabian Red Sea coast.

I- Main Chronic Sources, Inputs and Profile of Oil Pollution in the Red Sea.

Oil inputs from different sources were estimated for the Red Sea and compared with the world oceans (Awad, 1989a). The distribution of these sources is given in Fig.1 and estimates of their respective contributions to the total input are given in table 1. Using the figures of 3.2 Mt yr^{-1} (million ton per year) for the global annual inputs to the world oceans (IMCO, 1981) and of about 6800 t for the Red Sea , it is concluded that each km^2 in the Red Sea receives about 1.5 times oil than the world oceans (14.61 and 9.17/kg km^2 respectively). It is also estimated that while each km^2 of the world oceans receives 0.56 kg yr^{-1} from refining activities only each km^{-2} in the Red Sea receives 6.6/ kg yr^{-1} from the same type of source. While the estimated inputs of oil to the world ocean from marine transportation activities in 1989 dropped to one third of that estimated for 1981 (IMO, 1993), the trend seems to be reversed for the Red Sea, due to the intensification of oil transportation across this Sea especially after the re-opening of the Suez Canal in 1975 and more so during the Iraq- Iran war in 1982. Fig. 2 shows the actual routes of oil and refined products along the Red Sea. Due to stategic and economic reasons, there is an increasing tendency to transport oil through pipelines rather than through Hormuz strait. Risks from oil transportation are therefore increased.

Fig.3 represents the foreseen development of the pipeline network in the region (Awad, 1990a).

An oil pollution profiles is constructed and proposed in Fig 4 (Awad, 1989). It is based on the analysis of the available data (Wennink and Nelson-Smith, 1977, 1979a,b : Awad, 1984, 1985, 1988a: Awad *et al* 1983; Dicks, 1984, Hanna, 1983, Dixon and Dixon, 1975; Loya, 1975), on periodical visits to various centers of petroleum activities along the coasts of Egypt and Saudi Arabia during 1986-1988 and on information gathered through personal communications regarding coasts of difficult access.

It is evident from this profile that the Gulf of Suez is the area most affected. It is not infrequent to see weathered oil pavements, several centimeter thick, blanketting sandy beachs, rocky promontories, and in some locations the aerial roots of mangrove trees, and tar balls stuck to coral reefs. Outside the Gulf of Suez, oil pollution is a problem and a risk around oil-handling ports such as Jeddah, Yanbu, Rabigh, Eilat and Aqaba and along tankers routes.

II- Accidents and Episodic Events.

Potential of both accidental and deliberate oil spills in the Red Sea normally reflect the intense petroleum activities and oil transportation. In fact, there is almost a total absence of data for the rate of accidental oil spill in the Red Sea and Gulf of Aden. The cases included in table 2, provided by ITOPF (International Tanker Owner Pollution Federation LTD, London) are the only information which could be obtained for the period 1974- 1986. The author's efforts for gathering information related to this subject remained without response. There is an obvious reluctance on the part of the local authorities and the oil industry to record such oil spills, often ignoring them, a situation which requires new policy guidelines and strict enforcement.

Comparing the recorded accidental oil spills in the Red Sea (Table 2) with those in the Mediterranean (8 times greater in surface area, 330 x 103 tons of oil crossing annually), 45 accidents in the Red Sea were recorded during 12 years spilling about 25000 tons of oil yearly against 44 in the Mediterranean during the 3 years, 1983-1985 (UNEP, 1990).

The modest number of oil accidents in the Red Sea which transports about 650mt yr^{-1} of oil (Wennink and Nelson- Smith, 1979a) is obviously an unreal figure and it can be assumed that many other spills went unrecorded. Unless a well developed regional contingency plan for preventing and combating accidental oil pollution in the Red Sea is established, risks and potential accidents will remain on the increase especially after the progressive modification in the transportation routes for crude oil and refined products.

While most crude oils produced in the region are transported across high capacity pipelines, no reliable information is available about the operational oil spill around the terminals in the Red Sea. The functioning oil terminals at present are:

Petroline loading terminal, from the Arabian Gulf to the Red Sea at Yanbu in Saudi Arabia (180mt yr^{-1}).

Hodeida loading terminal, from N. Yemen oil fields to Red Sea at Hodida (10mt yr^{-1}).

SUMED deloading terminal, at Ras Shokeir in the Gulf of Suez to the Mediterranean Sea (117mt yr^{-1}).

Eilat deloading terminal, at Eilat in Gulf of Aqaba (25mt yr^{-1}).

The only available estimate of accidental oil spill is for the terminal of Eilat-Mediterranean pipeline in the Gulf of Aqaba. In this area, 92 accidental oil spills have occurred during 3 years (1969- 1973) spilling about 100 tons of oil annually (Dixon and Dixon, 1975). However, a rough estimate of oil spillage potential around the area of other pipeline terminals in the Red Sea could be predicted by comparing the capacity of Eilat's terminal with the others.

Based on the analysis of frequencies, inputs, locations and causes of the accidents grouped in tables 2 and 3 and on their geographic distribution (Figure 5) the following conclusions should be considered in any suggested regional contingency plan:

1- Frequency of accidental oil spill near the eastern coast of the Red Sea (in proximity of the navigation route) is much higher than near the western coast. The highest dissolved oil concentrations in the Red Sea surface water were in fact found along the eastern coast, especially off the desert area of the Saudi Arabian coast (Awad, 1988a).

2- The coastal waters of the Gulf of Aden are subjected to the same number of accidental oil spills as the eastern coast of the Red Sea but the spilled amounts are relatively lower.

3- In spite of the limited number of spills recorded along the northern Egyptian Red Sea coasts, the amounts spilled are relatively larger in this area.
4- Equipment failures followed by human errors are the main causes of accidental oil spills in the Red Sea and Gulf of Aden.
5- Accidental oil spills frequently occur during oil loading and tanker deballasting operations.

III- Assessement of Oil Pollution Levels.

While the petroleum activities in and around the Red Sea and Gulf of Aden are continuously and rapidly increasing, the data available on the levels of different hydrocarbon forms in various environmental compartments (water, sediment and biota) are still scant.

a) Stranded tar balls on beach.

Recently, a limited monitoring of tar balls on beach was conducted in the region south of Yanbu city (Fig. 6) where almost all types of petroleum activities are concentrated. Within the monitored area, tar balls were periodically collected from three sites covering 50km of coast line. They presented a mixture of all shapes, weights and ages. They ranged from 0.2 to 5cm, from very soft fresh to hard, from nearly free to entirely coated with sand, individual tar balls exceeding sometimes 50g each in weight. Details of this survey are included in Table 4.

This variability in tar analysis parameters shows clearly that the marine environment off this area faces continuous and intensive oil pollution. This statement is confirmed by table 4. The results show that the calculated average daily tar ball arrival to the zone studied ranges from 126.48 to 634.18mg/m^2 and represents a heavy oil pollution situation in the area. This value is higher than the monthly average estimates for the beaches of Japan (> 100mg/m^2/d), a country characterized by the heavy oil pollution of its beaches (IOC/ WHO, 1981).

In fact, the situation in the investigated area is to a large extent visually similar to that around the Red Sea - Miditerranean pipeline (SUMED) at Ras Shukier on the western of the Red Sea where tar balls, lumps and aggreyates are dominant on the beach (Awad et al 1983).

b) Total and polyaromatic hydrocarbons in surface water.

Levels of oil pollution along the Red Sea Saudi Arabian coast were intensively monitored in the framework of two long- term research projects. The first survey

(1982-1986) covered about 1000km of coast-line between Yanbu, north, to the area of Jizan, south, to the western side of Farassan island. It was re-investigated in parallel with another project directed at the investigation of a possible correlation between oil pollution and coral reef health condition (1987-1988).

In both projects the procedure of MAPMOPP (IOC/ WMO, 1976) was followed. One of the two dominant Arabian oils (light or heavy), or both, the most probable types of oil to be found all over the Saudi Arabian Red Sea territorial waters, were considered as regional reference for expressing oil residue concentration in water, beside the international reference, Chrysene Units Equivalent (CUE) recommended by MAPMOPP. The latter reference enables us to compare oil pollution situation in the region with that elsewhere.

The relative concentration of five of the most persistent polyaromatic hydrocarbons and their concentration relative to the total hydrocarbon content were measured. The results of the first survey clearly demonstrated the relation between levels of dissolved/ dispersed oil residues and the intensity of shipping and coastal petroleum activities in all investigated areas. The highest values were found along the main shipping route. In areas C and E (Fig. 7), the mean dissolved/ dispersed oil residues exceed 500 Fg l^{-1}, a value unrecorded from any of the regions reported on by MAPMOPP (IOC/WHO, 1981).

Although no direct source of oil pollution exists in area C, its waters contain more oil than in the Egyptian waters (area A) where all sources of oil pollution exist (Fig. 1). This result supports the assumption that much of the oil discharged in the Red Sea, even on the African side, is transported towards the eastern coast following the prevailing wind pattern (Wennink and Nelson-Smith, 1977).

In the final report of MAPMOPP (IOC/WHO, 1981) on the global assessment of oil pollution in the oceans, 85 Fg l^{-1} of dissolved/dispersed oil concentration was given as the highest mean value (measured in the west coast of India) for the world oceans. During the second survey, double this value was measured in the near-shore waters of both Yanbu and Jeddah (Table 6, Fig. 8) during both first and second trips.

Water samples collected from Yanbu included two groups: the stations off the industrial zone and those off the the region of Al-Baridi, 70 km north of Yanbu city. Comparing the mean results from the two areas, the relatively heavy oil pollution off Yanbu becomes clear: 192 Fgl^{-1} against 17 Fg l^{-1} as mean CUE for the waters off the industrial zone and off Al-Baridi respectively.

Jeddah waters had a mean concentration of 165 Fg l^{-1} CUE in the near-shore. The highest concentrations of dissolved/dispersed petroleum residues characterize the waters surrounding the tankerage area. In this station. a value of more than 500 Fg l^{-1} CUE was measured. Illegal spillage of tanker washings and bilges are most probably of frequent occurrence in this area (Fig. 5).

The other sites yielded lower concentrations of dissolved/dispersed oil residues, but were still above 50 Fg l^{-1} CUE, a value which corresponds to ocean areas characterized by heavy pollution. Near-shore waters off Al-Wedjh showed the lowest concentrations, ranging between 7 and 21 Fg l^{-1} as CUE with a mean value of 17 Fg l^{-1}. This area could be proposed as a reference area for future studies along the Saudi Red Sea coast.

Some persistent polyaromatic hydrocarbons (PAH) were measured in surface waters: Phenanthrene (PH), Chrysene (Ch), Perylene (P), Benzo-3,4 Pyrene (Bap) and Benzo- ghi- Perylene (Bghip). The detection of PAHs in water represents a good indication of the source of oil pollution in water. For example, compounds such as fluoranthene, anthracene, perylene, chrysene...etc..., which are not abundant in petroleum, are produced when oil and other organic materials are subjected to high temperature in internal combustion engines, to industrial and domestic heating, to forest fires, etc. Indeed there are no indications of naturally occurring aromatic compounds of recent biological origin. The mean values determined for total hydrocarbon content during the second trip confirm the above situation (Table 7).

The importance of PAH measurements in defining the source of oil pollution in any area can be clearly seen from the results in table 7, giving the mean values of total PAH in each site. While the near-shore waters off Yanbu and off Al-Wedjh contained the highest and lowest total oil residues respectively, the two sites have the lowest and highest values of total PAH contents, in the opposite order. These results indicate that, while the source of oil pollution at Yanbu is mainly from spillage of crude oils, tanker washings and ballast waters, the source of oil in Al-Wedjh water is mainly from spillage of bilges and pyrolized oils from tankers and ships. The results for the other sites surveyed are similar to those from Al-Wedjh, especially in their general high content of perylene and chrysene.

During the first survey, perylene was found to be the dominant constituant, representing more than 50% in all water samples. Concentrations above 3000 $ng1^{-1}$ were detected in some cases (Awad, 1990b). The second survey confirmed these results (Tab. 7 and 8 Fig. 9and 10). More details can be found in Awad et al (1983), Awad (1983, 1985, 1987, 1990b), and KACST report (1988).

c) Petroleum Hydrocarbons in Sediments.

Total Hydrocarbon content (THC) and total polyaromatic Hydrocarbon content (PAH) and the five individual polyaromatic compounds measured in water were also measured in the sediments (Table 8, Fig.10) . The highest values were found in the sediments off Jeddah followed by those of Yanbu (413.9 and 112.4 Fg/g dry weight as chrysene equivalent units respectively), while the absolute minimal value was found in the area off Al Baridi, North of Yanbu (8.11 Fg/g). The same distribution pattern was found for the polyaromatic content (Table 10, Fig.10). As was the case for the water content, perylene and to some extent chrysene were the dominant compounds detected in sediments.

It can be concluded on this bases that most of the Saudi Arabian Red Sea coast suffers from illegal discharge of bilges (IOC/WHO, 1981). In addition, crude oil wastes and refined oil products might be the main contributors to the levels of total hydrocarbon content in the sites off Jeddah and Yanbu.

Data from areas other than the Saudi Arabian coastal waters are given in Table 9. The highest content in THC is in the Gulf of Suez sediments (Dicks, 1984, and Awad, 1987) where it is of the order of tens of g kg^{-1}. The intertidal sediments are the most contaminated as a result of continuous accumulation (Dicks, 1984). In general, sediments collected from the Saudi Arabian coasts showed lower levels of both THC and PAH.

d) Oil Hydrocarbons in Biota.

Several types of Red Sea organisms from the coastal waters were analyzed for their petroleum hydrocarbon content (Tab. 11). While coastal Red Sea organisms contained THC of the order of mg Kg^{-1} (dry weight), Anderson *et al* (1974) report that organisms suffering from either chronic or acute oil pollution contained, in most cases, hydrocarbons of the order of ug kg^{-1}. This type of comparison, however, is not quite acceptable given the variability of the analytical techniques and of the references.

Conclusions:

The Red Sea marine environment is characterised by high potential risks of oil pollution, particularly in the coastal waters.

Surveys of the sources of oil pollution in the Red Sea and their quantification, (Awad 1989) largely support the above statement.

The frequency of accidental oil spills (Awad, 1988b) is highest in the area between Yanbu and Jeddah as well as in the Gulf of Suez.

The data in this report show that some of the areas studied suffer from chronic oil pollution. In Yanbu and Jeddah, values of dissolved/dispersed oil close to 200 Fg l^{-1} in surface waters have been measured. Values twice as high have been found in front of the Islamic Harbour in Jeddah. These values are about twice the level declared by MAPMOPP (IOC/WHO, 1981) as the highest for the world oceans (85 Fg l^{-1}). The magnitude of the stress in the two areas is obvious. The results for the sediment content confirm those of the water content.

In the other sites, measurable amounts of polyaromatic hydrocarbons (PAH) are found, especially perylene and chrysene, which indicates that for some ares in which observable pollution by crude oil is not frequent, other sources of oil hydrocarbons exist (bilges, washes, ballast water, etc....) Moreover, the limited survey for tarballs on beaches at Yanbu (table 4) indicates the importance of oil accumulation in the area.

In our opinion, priority should be given to oil pollution when an assessment of the impact of human activity (including the impact on coral reefs) is to be conducted in the Red Sea environment.

There are some evidence pointing to the role of oil contamination as the causing factor for certain coral reef diseases, namely the white and black band diseases. The preliminary conclusions of the investigation points to a correlation between the frequency of detection of white and black types of diseases in coral with the level of oil hydrocarbon content in water and sediment in the regions of Yanbu and Jeddah (Antonios, in KACST, 1988).

Proposed Strategy:-

Since the declaration of the Red Sea as a "Special area" by MARPOL (1973-1987), restricting and even forbidding oil discharges, the Jeddah Regionl Contingency Protocol was signed (1982) and an Action Plan for the Conservation of the Red Sea and Gulf of Aden adopted (1986). Numerous meeting have been held since that time for the same purpose and numerous recommendations adopted, but, with few exceptions, most of them have not been followed by concrete action.

Reiterating earlier recommendations or adding new ones becomes meaningless, unless a pragmatic, practically feasible, plan of work, acceptable to all, is adopted and implemented.

In this Action Plan, contribution of all partners is imperative. Since "the Red Sea is for all, all should be for a healthy environment in the Red Sea". The historical heritage, the cultural characteristics as well as the economic capacity of each of the Red Sea countries should be taken in consideration and respected in any proposed Action Plan.

Concerning oil pollution, which is obviously a problem common to all countries bordering the Red Sea, an action programme for control, mitigation and management of various oil pollution aspects in the area can be proposed taking in consideration the following facts:

1- There is strong evidence that the Red Sea environment is increasingly under stress from intensive oil activities as a result of:

a) Oil maritime transportation;
b) Increase in length and capacity of sea to sea giant pipelines;
c) Continuous increase in number and capacity of coastal oil refineries;
d) Intensive offshore and onshore exploration and exploitation of oil in some areas, especially in the Gulf of Suez.

2) During the last 25 years, the rapid evolution in petroleum activities along the Red Sea basin became synchronized with a significant damage and degradation of the living resources in the Red Sea in certain areas, especially the unrecoverable fringing coral reefs and mangroves. Undoubtedly, oil as a contaminant is not the only cause for this degradation but it should be considered as one of the major causes of stress.

Although the final Act of Jeddah Plenipotentiary Regional Conferencce on the Conservation of the Marine Evvironment and Coastal Areas in the Red Sea and Gulf of Aden (1982) includes the main elements for a successful action plan for monitoring and combating oil pollution in the area, we would like to put forward the following proposals which could help putting the action plan into motion.
Monitoring and assessment of oil pollution in the area should be conducted at two levels.

a) -Non- governmental level, through the creation of a "Red Sea Campus" an NGO. Membership of this campus would be open to non- professional volunteers and guided be especialists in oil pollution aspects. The participants from each country will be responsible for recording oil spills, for monitoring stranded tarballs on beaches, and the collection of water samples, nearshore sediments and biota. They will be trained to apply simple techniques to keep and store the samples in a satisfactory condition for later analysis in one of the designated reference laboratories in the area.

Funding of these activities, which will be normally modest, could be supplied through oil companies working in the area. IMO and local authorities should be approached to contribute to the funding.Training of the volunteers could proceed either in a designated laboratory in the area or preferably through short term on-site training by qualified experts and technicians from the region.

b) Governmental level. It is evident that the main obstacle to the implementation of the monitoring programme adopted earlier for oil pollution in the region does not reside in its scientific approach or in its technical components but is mainly due to the lack of practical coordination and political will between the Red Sea partners. We have to avoid the obstacles which have hindered PERSGA from implementing its earlier plans in any forthcoming cooperative research and monitoring.

In our opinion, the best approach for coordinating efforts to study oil pollution in the area is to share responsibilities between all the Red Sea and Gulf of Aden countries.

Our proposal could be summarized in the following points for both a short and a long term monitoring research programme. While all partners in the "PERSGA" programme should participate in the sampling programme, certain laboratories should be designated to take the responsibility for the analysis of one sort of samples.

The implementation of the monitoring programme requires the selection of few capable laboratories. Selection of the laboratories should be based on the availability of specialized personel and of equipment. The laboratories would be responsible for carrying out one or more of the following tasks:

a) analysis of hydrocarbons in water.
b) analysis of hydrocarbons in sediment.

c) analysis of hydrocarbons in biota.
d) ecotoxicological research on crude oils, refined products and petroleum wastes.
e) test laboratory for the efficiency of chemical dispersants in relation to the variety of oil existing in the region, and assessment of their ecological impacts.

There is need for supporting Oceanographic data. The responsibility for oceanographic surveys should be shared and co-ordinated.

The author believes that with this approach, we can be fairly sure that each monitoring parameter could be studied throughout the Red Sea region without overlapping and without geographic gap.

Finally, a coordination unit is urgently needed in the region, similar to that in the Mediterranean Sea. Through this unit, a group of experts or a Technical Steering Committee from the region and from outside the region when needed, should be formed to support the local expertise in the region for following up technically and scientifically the progress as well as the operational problems in each of the proposed laboratories.

Concerning the adoption of a regional oil spill contingency plan, the Action Plan of "PERSGA". should be supported and implemented. It should be stated, however, that the few local or national contingency plans need to be linked into a regional one through the proposed coordination unit.

References

ALECSO, 1982. *Final Act of Jeddah Plenipotentiary Regional Conference on the Conservation of the Marine Environment and Coastal Areas in the Red Sea and Gulf of Aden.* Jeddah, S.A, 13- 15 Feb, 1982. 82p.

Anderson, R. W; R.C. Clark and J. J Stegman, 1974. Contamination of marine organisms by petroleum hydrocarbons. *Proceedings of a workshop on Marine Bioassay.* G.Cox (ed). Marine Technology Society. p.p. 63- 75, Washington D.C..

Awad , H, 1984. Petroleum hydrocarbons in surface water and some fishes in the Red Sea coastal area between Jeddah and Yanbu, Saudi Arabia. In: *The Environment and Fisheries in the coastal area between Jeddah and Yanbu.* Report Fac. Sci., KAU Jeddah, pp. 195- 205 (in Arabic).

Awad, H. 1985. Role of Petromin Refinery in adding crude oils to Jeddah coastal waters. *J. Fac. Sc., KAU Jeddah*, 4: pp. 131- 144.

Awad, H., 1987. Aromatic hydrocarbons in some organisms of coastal Red Sea. *Indian Journal of Marine Science*, 6: 114- 116.

Awad, H., 1988a. Oil in Saudi Red Sea territorial waters. *Mar. Pollut. Bull.*, 19, (6) 287- 29.

Awad, H., 1988b. Potential and causes of accidental oil spills in Red Sea and Gulf of Aden: 1974- 1986 (A review). *Bull. Inst. Oceanogr and Fish.*, Alex., Vol. 15.p. 293- 296.

Awad, H., 1989. Oil Contamination in the Red sea Environment. *Water, Air and Soil Pollution*, vol, 45 (3-4) 235- 242.

Awad,H., 1990a. One of Iran- Iraq war consequences: more oil pollution in Persarabian Gulf and Red Sea. *Proceedings, First Conference on Environmental Science,* Sabha, Lybia, 27-31 Jan. 1990

Awad, H., 1990b. Survey of some persistent polyaromatic hydrocarbons in Saudian Red Sea coastal waters. *Bull. Inst. Oceanogr. and Fish.,* Vol. 16, pp 41- 50.

Awad, H., 1990c. Hydrocarbon content in Red Sea surface waters and fishes in the region between Jeddah and Yanbu, S.A., *Proceedings, First Conference on*

Environmental Sciences. Sabha, Libya, 27- 31 Jan. 1990 (Arabic with English abstract).

Awad, H., P. Michel and A. El Shazly, 1983. Actual Situation of Oil Pollution in the ecosystem along the Egyptian Red Sea coast. *Bull. Inst. Oceanogr. and Fish.*, Vol. pp 102- 108.

Awad, H., and S. Bakhazlak 1991. Monitoring of oily refinery effluent in the marine environment: a case study. *Proceedings, Regional Symposium on Environmental Studies*, IGSR, UNESCO and Goethe Institute, Alexandria, Egypt, 15- 17 May 1990.

Bakhazlak, S, 1988. Evaluation of petroleum wastes in the Petromin Refinery of Jeddah and their effects on marine phytoplankton. M.Sc. Thesis, Fac. Mar. Sc., UKA, Jeddah (Unpubl.).

De Kok, F. and Marson, H.W, 1978. Tanker ballast water treating plant meets tough specs. *The Oil and Gas J.*, vol 76. P 92- 96.

Dicks B., 1984 Oil pollution in the Red Sea. Environmental Monitoring of an oil field in a coral area, Gulf of Suez. *Deep Sea Research*, Vol. 31, (6- 8A): 833- 854.

Dixon, T. and T. Dixon, 1975. Oil Pollution on Israeli Coasts. *Mar. Pollut.* 6 (5): 70- 72.

El Samra, M.I., K.Z. El Deeb and Y. Halim, 1982. Transport of pollutants along the Suez Canal and its effects on the South-East Mediterranean. In. *Proceedings of VI es Journees Etudes des Pollutions.* Cannes, CIESM. (1982), pp. 227-9.

Hanna, R.G.M. 1983. Oil Pollution on the Egyptian Red Sea Coast. *Mar. Pollut. Bull.* 14 (7): 226- 271.

IMO, 1986. *The international convention for the prevention of pollution from ships, 1973, as modified by the protocol of 1978* (Marpol 73/ 78).

IMO, 1993. Impact of oil and related chemicals and wastes on the environment. *GESAMP Reports and Studies* No 50.

IMCO, 1981. *Petroleum in the marine environment. Inputs of hydrocarbons in the Ocean due to marine transportaion activities.* Intergovernmental Maritime Consultative Organization, London.

IOC/WHO, 1976. Global Oil Pollution , Results of MAPMOPP, the IGOSS pilot project on marine pollution (petroleum) monitoring . *IOC Manual and Guide* No 7, 150 pp.

IOC/WHO, 1981. Global Oil Pollution, Results of MAPMOPP, the IGOSS pilot project on marine pollution (petroleum) monitoring. IOC, UNESCO, 34p.

KACST, 1988. Man's impact on coral reef health in the Red Sea. Final report. 240p. Project sponsored by King Abd El Aziz City for Science and Technology (1986- 1988).

Loya, Y, 1975. Possible effects of water pollution on the community structure of Red Sea corals. *Mar. Biol.* 29: 177- 185.

UNEP, 1987. State of the Marine Environment in the Red Sea and Gulf of Aden Region. *UNEP Regional Seas Reports and Studies (draft).*

UNEP, 1990. State of the Marine Environment in the Mediterranean Region. L. Jeftic et al (eds). *MAP Technical Report Series.*

Wennink, C. J and A. Nelson- Smith, 1977. *Coastal oil pollution evaluation study for the Gulf of Suez and the Red Sea Coast of the Republic of Egypt, IMCO,* London.

Wennink, C. J and A. Nelson- Smith, 1979a. *Coastal oil pollution evaluation study for the Gulf of Aqaba Coast of the Hashemite Kingdom of Jordan,* IMCO, London.

Wennink, C. J and A. Nelson- Smith, 1979b. *Coastal oil pollution evaluation study for the Kingdom of Saudi Arabia.* Vol 1, Red Sea Coast, IMCO, London.

Table 1: Estimate for possible annual inputs of oil in the Red Sea from some sources

SOURCE	Location	oil capacity mt/yr	Water effluent mt/yr	assumed oil conc. in water pm	released oil amount ton/yr	Notes	Ref.
EASTERN COAST							
-Refinery effluent	Jeedah	0.25	6.5	10	13	one lubricating oils refinery	Awad, 1985
	"	5.0	131.5	10	260	one refinery for local consumption.	Awad, 1989
	yanbu	21.3	560[a]	2[b]	1120	two refineries: for local consumption and exportation.	"
	Rabigh	17.5	450[a]	2[b]	900	ready to start processing for exportation.	
- Petroline Terminal (clean tanker ballast water)	Yanbu	160.0	52[c]	10[d]	345	two terminals: one for exporting Iraqi oil (capacity: 0.5m b/d), the other for Saudi oil (cap. 2.6m b/d) for supplying saudian refineries and exporting the rest (about 115 m t/a)	"
-Yemeni Oil Terminal (clean tanker ballast water)	Sana'a	10	3[c]	15	150	press declaration: the Yemen starts to export its recently discovered oil at rate of 0.2 m b/d.	"
Gulf of Aquba							De Kok & Marson, 1978
- Oil Terminal (clean tanker ballast water)	Eilat	25	7.5[c]	6	45	supposing that at Eilat, there are the same deballastation facilities as for the other Red Sea Maditerranean Sea pipeline (SUMED) in Egypt	Dixon, 1975
- terminal spills	"					annual accidental spillage rate during oil deloading	
Gulf of Susz							
- Refinery effluents	Suez bay	3	70	2 and 100	826	two refineries dischrges at 2 ppm for cooling waters and process waters at 100 ppm.	Wennink& Nelson-Smith 1979a
- oil production waters	offshore waters	24.3	0.243	100	972	assuming that production water amount respresent 10% of produced oil (1 m b/a)	
- Tanker ballast water	coastal waters	24.3	7.3[c]	15	218		
SUEZ CANAL			1680[e]	$115X10^{-5}$	1902	estimated annual amount of dissolved/ dispersed hydrocarbon to the Red Sea	El Samra et al, 1982
	Total				6851		

Table 2: **Oil spills in the Red Sea and Gulf of Aden area (1974-1986) after International Tanker Owners Pollution Federation Ltd, London, May 1987.**

Date	Country	oil type	oil amount bls	operate	cause	Date	Country	oil type	oil amount bls	operate	cause
1974	S.Arabia	A	B	?	D	1980	S.Arabia	?	?	?	?
"	S.Yamen	E	A	D	?	"	"	B	?	B	C
"	"	?	?	?	E	"	"	A	E(70)	C	?
"	"	G	C	A	C	"	S.Yamen	?	?	?	?
"	"	?	?	?	E	1981	Sudan	E	C(50)	G	B
"	"	A	?	A	B	"	Egypt	A	D(6)	A	B
"	S.Arabia	D	E(2250)	?	?	"	"	A	C(1)	D	A
"	Sudan	A	A	E	C	1982	S.Arabia	B	?	A	?
"	S.Yamen	E	D	?	?	"	"	A	C(2)	C	B
"	Sudan	E	A	D	B	"	"	A	D(40)	C	B
"	S.Yamen	E	B	C	C	"	"	A	D(10)	A	B
"	"	E	C	A	C	"	Somal	A	?	D	. B
1975	"	?	?	?	?	"	Egypt	A	E(2000)	K	?
"	"	B	C	B	A	1983	"	A	F(11700)	J	?
"	"	E	C	A	C	"	S.Arabia	E	?	C	?
"	"	?	?	?	E	"	"	H	?	J	A
1976	S.Arabia	A	B	A	B	"	"	?	?	?	?
1978	S.Yamen	D	?	J	?	1984	N.Yamen	B	?	J	?
"	S.Arabia	C	A	C	D	1985	S.Arabia	?	?	C	?
"	N.Yamen	B	?	F	B	"	"	?	?	?	?
1979	Egypt	?	?	?	?	"	"	A	?	A	?
"	S.Yamen	F	B	C	?	1986	"	A	D	C	B
1980	"	?	?	?	?						

LEGEND FOR TABLE 2

SPILTYPE(type of oil)

A crude
B bunker
C bilges
D fuel (cargo)
E white prod.
F tank washing
G lube oil
H bitumen

SPLIOPER (operation in progress)

A loading
B bunkering
C deballasting
D discharging
E ballasting
F bilge pumping
G tannk cleaning
H intern trans
J strand/ grndg
K collision
U unknown

SPILCUSE (CAUSE OF SPILL)

A hull failure
B equip. failure
C human error
E fire/ explos
U unknown

Table 3: Oil pollution sources and risks in the Red Sea (Awad, 1988b)

Source	Gulf of Suez	Gulf of Aqaba	Red Sea W. coast	Red Sea E. coast	Chronic Risk
OILY WATER DISCHARGES:					
- Refinery	+		+	+	+
- Ballast water	+	+		+	+
- Offshore oil production water	+			+	+
- Onshore oil production water	+				+
- Oil farm drainage water	+	+	+	+	+
- Dry docking	+	+	+	+	+
- Bilges and bunkering	+	+	+	+	+
ACCIDENTS CAUSING OIL SPILLS					
- Monr spills	+	+		+	+
-Major spills	+				
- Production operations	+				
- Terminal operations	+	+	+	+	
- Offsgore- onshore connection	+	+	+	+	
- Tanker grounding	+	+	+	+	
- Tanker- tanker	+				
- Non- tanker accident	+	+	+	+	
- Inter- seas pipelines	+	+		+	

Table 4: Stranded tar balls concentration along southern shore of Yanbu, Saudi Arabia.

Date	Site.	Tar ball conc. in g/m²	Time interval in days	rate of Tar ball Arrival in mg/m²/d
19.11.1987	I	13.33		
	II	2.75	0	-------------------
	III	16.63		
24.12.1987	I	7.34		212.3
	II	3.76	35	107.4
	III	49.50		1414.3
28.1.1987	I	3.78		108
	II	1.40	35	40
	III	15.31		437.4
3.3.1988	I	2.64		75.5
	II	2.25	35	64.0
	III	5.52		157.8
31.3.1988	I	3.08		110.1
	II	1.32	28	47.1
	III	5.52		527.2
Mean for the whole Period (133d)	I	6.01		126.84
	II	2.30		64.63
	III	20.35		634.18
Grand mean for the whole area		9.56		275.10

St. I : 3 km S. Yanbu Industrial zone
St. II : 25 kms S. Yanbu Industrial zone
St. III : 50 kms S. Yanbu Industrial zone

Table 5: Average dissolved/dispersed oil residues distribution in Red Sea Waters (Awad, 1988a)

Area	coordinates		date	number of stations	number of samples	Dissolved/ dispersed petroleum residues conc. as					
						chrysene equivalent units (CEU)			Arabian light oil ($\mu g\ l^{-1}$)		
	long. E	Lat. H				range	mean	S.D.	range	mean	S.D.
B	37° 24'- 39 04'	21°35'- 24° 03'	1982-1983	34	58	35 - 612	174	132	25 - 490	138	105
C	38° 53'- 40° 01'	18°43'- 21° 33'	1987	6	6	314 - 1393	757	424	273 - 1114	609	335
D	41° 52'- 42° 38'	16°40'- 17° 21'	1985-1986	28	74	6 - 1874	63	55	5 - 1500	50	46
E	41° 00'- 41° 35'	16°30'- 17° 00'	1987	6	6	97 - 1994	809	737	120 - 1356	627	536

Table 6: Concentration of dissolved/dispersed petroleum residues in nearshore surface waters along the Saudi Arabian coast during 1987-1988 (Awad, in KACST, 1988)

Area	Coordinates		Dissolved/ Dispersed conc.in ug l^{-1} as :								Chrysene equivalent units			Date
	Long E	Lat. N	St.	Arabian light			Arabian heavy						
				Rang	Mean	SD	Rang	Mean	SD	Rang	Mean	SD	
Haql	34°52'-	19° 14'-		28-63	42	63.9	23- 49	32	51.3	31.72	54	37	Oct. 87
	34° 57'	19° 22'	8	6- 54	31	42.3	4- 42	38	40.1	9.64	58	67.1	Apr. 88
Wajh	36° 37'-	27° 07'-		5- 18	12	21.2	3-14	9	18.3	7.21	12	20.1	Oct. 87
	36° 46'	26° 18'	8	4- 12	17	18.0	3-8	6	5.4	5.18	15	16.1	Apr. 88
Yanbu a	37° 29'-	23° 51'-		11-17	14	-	8- 14	12	-	15- 19	17	-	Nov. 87
			3	4- 10	6	-	3- 7	5	-	5- 8	7	-	Mar. 88
b	38° 05'	24° 17'	12	112- 271	198	79.8	86- 174	178	105.4	137- 229	192	123.4	Nov. 87
			15	96- 159	123	69.1	82- 132	102	96	112- 189	201	196.2	Mar. 88
Jeddah	39° 04'-	21° 23'-		92- 183	146	87	73- 154	134	99.2	101-205	165	117.3	Apr. 87
	39° 10'	21° 43'	5										
Qunfidhah	41° 04'-	18° 57'-	4	36- 102	51	-	31- 83	-	137	39- 108	63	-	Dec. 87
	41° 13'	19° 05'	5	23- 36	29	33.9	20- 32	26	31.0	28- 44	36	40.3	Mar 88
Jizan	42° 31'-	16° 52'-		8- 129	44	44.7	6- 103	35	62.1	9- 161	56	55.1	Jun 87
	42° 33'	16° 56'	8	12- 89	53	56.8	10- 69	51	61.9	15- 100	66	52.8	Mar 88

a- Yanbu industrial city
b- Al- Baridi

Table 7: **Relative predominance of the five polyaromatic hydrocarbon compounds considered (%:percentage concentration to the total PAH), AWAD, 1990b**

Zone	Concentration of individual PAH compounds in ng l^{-1}																			
	phenanthrene				chrysene				perylene				benzo-3, 4 pyrene				benzo- 8,9 perylene			
	range	mean	S.D.	%	range	mean	S.D.	%	range	mean	S.D.	%	range	mean	S.D.	%	range	mean	S.D.	%
A_1	68-185	109	65.9	43.3	0	0	0	0	0-428	142.7	247.1	56.7	0	0	0	0	0	0	0	0
A_2	5-56	19.4	23.7	9.5	41-201	108.8	59.9	53.0	0-267	77	102.4	37.5	0	0	0	0	0	0	0	0
A_3	0-504	155 9	193.5	22.1	87-304	135.4	70.3	19.2	0-1107	414.9	407	58.7	0	0	0	0	0	0	0	0
A_4	0-83	23.4	36.2	19.4	19-201	46.3	62.6	38.4	0.233	51	89.5	42.2	0	0	0	0	0	0	0	0
A_5	0-38	15.4	15.7	3.1	17-433	139.6	159.3	28.5	102-666	335.6	210.2	68.4	0	0	0	0	0	0	0	0
Total / average	0-504	66.3	119.5	16.1	0 433	97.2	99.9	24.8	0-1107	228.3	283.7	58.3	0	0	0	0	0	0	0	0
B	67-433	245	167	6.4	167-1500	707	625	17.5	470-5750	3083	2106	76.4	0	0	0	0	0	0	0	0
C_1	0-233	34	70.5	12.5	0-218	39	60.6	14.4	0-1062	190	321.3	70.1	0-52	7	14.9	2.6	0- 5	1.2	1.8	0.4
C_2	0-270	41.9	79.7	23.8	0-140	36.4	42.9	20.7	0-513	84	151.1	47.8	0-58	9.2	16.7	5.2	0- 15	4.3	5.6	2.5
C_3	0-573	13.5	25.6	3.9	0-1424	29.5	43.3	8.6	0-1541	293.7	466	85.7	0-150	4.6	9.4	1.3	0- 10	1.6	3.1	0.5
C_4	0-132	22.7	40.7	15.5	0 204	34.6	65.5	23.7	0-493	80.4	146.8	55	0-42	5.7	11.4	3.9	0-13	2.7	4.2	1.9
C_5	0-340	53.2	94.8	13.8	0-467	66.5	130.8	17.3	0-2376	262.4	672.8	67.9	0-10	2.3	3.6	0.6	0-9.5	1.7	3.3	0.4
Total / average	0-573	29.3	60.8	10.8	0-1424	41.3	72.7	14.2	0-2376	200.2	411.3	72	0-150	5.6	11.4	2.2	0-15	2.2	3.7	0.8
D	43-1118	407	393	9.2	124-1234	550	448	12.4	0-7704	3470	3389	78.4	0	0	0	0	0	0	0	0

Table 8: Mean concentrations of persistent polyaromatic hydrocarbons (PAH) in nearshore surface water along the Saudi Arabian coast during 1987-1988 (AWAD, in KACST, 1988)

Area	coordinates		St.	polyaromatic hydrocarbons conc ngl^{-1}					Total PAH ngl^{-1}	% of T. PAH in THC (as CEU)	Date
	Long E	Lat. N		Ph	Ch	P	Bap	Bghip			
Haql	34° 52'-	19° 14'-	8	4	44	35	0	0	83	0.15	Oct. 87
	34° 57'	19°22'		6	31	61	0	0	98	0.17	Apr. 88
Wajh	36° 37'-	27° 07'-	8	8	57	118	0	0	183	1.41	Oct. 87
	36° 46'	26°18		15	49	96	0	0	160	1.07	Apr. 88
Yanbu	37° 29'-	25° 51'-	3	7	18	72	0	0	97	0.57	Nov. 87
				22	12	36	0	0	70	1.00	Mar. 88
	38° 05'	24° 17'	12	13	127	233	5	2	380	0.19	Nov. 87
				21	29	112	3	15	180	0.09	Mar. 88
Jeddah	39° 04'- 39° 10	21° 23'- 21° 43'	5	32	89	362	7	3	493	0.30	Apr. 87
Qunfidhah	41° 04'-	18° 57'-	4	71	69	206	0	0	346	0.55	Dec. 87
	41° 13'	19° 05'	5	42	63	109	5	27	246	0.68	Mar 88
Jizan	42° 31'-	16° 52'-	8	3	17	111	2	0	133	0.24	Jun 87
	42° 33'	16° 56'		5	31	82	2	18	138	0.21	Mar 88

Ph : phenanthrene
Ch : chrysene
p. : perylene
Bap : Benzo- a- pyrene.
Bghip : Benzo- ghi- perylene

Table 9: Measured hydrocarbons in Red Sea sediments

Area	*site*	*sediments*	*year*	*THC mg kg⁻¹ wet wt.*	*PAH mg kg⁻¹ wet wt.*	*Analysis*	*Reference*
A	Ras Budran	Intertidal	1980	10-463	<1- 183	GC- MS	Dicks, 1984
	"	"	1983	38-98,950	4-44,150		
	"	Lagoon	1980	13- 139	<1- 183		
	"	"	1983	45-68,500	4-44,150		
	"	Reef and nearshore	1980	3- 87	<1-183		
	"	"	1983	43- 54	4-44,150		
	"	offshore	1980	43-68,500	<1-183		
	"	"	1983	82-1440	4-44,150		
	Suez	Intertidal	1981	488.5*	9.1*	GC and HPLC- UV	Awad,1987
B**	N. Jeddah	Back-reef (lagoon)	1983	65	28	HPLC-UV	Awad, 1984
	"	"	1986	132	143	UV fluores-cence	Bakhazlag, 1988
	"	Fore- reef	1983	62	25	HPLC-UV	Awad, 1984
	Jeddah	nearshore	1986	365	448	UV fluores-cence	Bakhazlag, 1988

* concentration as mg kg^{-1} dry wt.

** Total hydrocarbon content (THC) in area B is expressed as light arabian crude while Polyaromatic content (PAH) as chrysene equivalents (MAPMOPP) in µg kg^{-1} dry wt.

Table 10: Total and aromatic hydrocarbon content in surface sediments in the area of investigation during 1987-1988 monitoring. (AWAD, in KACST, 1988)

Area	THC in ug/g (dry wt)			PAH conc in ng/ g (dry wt)					T. PAH ng/g	% T. PAH IN THC
	LSACO	HSACO	CH.E.U.	PH	CH	P	B-3,4-P	B-8,9-P	PAH	(As CEU)
Haql	64.30	49.10	93.00	35.00	22.00	31.90	.00	.00	88.90	0.10
Wedjh	52.90	38.80	71.20	5.50	10.20	44.10	.00	.00	59.80	0.08
Yanbu a	10.20	8.40	12.50	.00	8.10	15.00	.00	.00	23.10	0.19
b	101.00	89.60	112.10	.00	38.00	105.10	5.00	.00	148.10	0.13
Jeedah	354.60	291.00	413.90	24.70	113.60	202.00	7.00	2.00	349.30	0.08
Qunfidah	31.40	28.00	41.20	12.40	25.70	133.80	.00	.00	171.90	0.42
Jizan	16.40	11.10	18.00	8.10	8.90	21.80	.00	.00	38.80	0.22

Ph, Ch, P, B-3, 4- P and B-8, 9-P.......see text
Ref : LSACO- Light Saudi Arabian Crude Oil
HSACO- Heavy Saudi Arabian Crude Oil
CEU- Chrysene Equivalent Units
a- Yanbu industrial city
b- Al- Baridi

Table 11: Levels of petroleum hydrocarbons in some Red Sea fishes

Area	*Species*	*date*	*organ*	*THC ug kg-1 (dry wt.)*	*PAH ug kg-1 (dry wt.)*	*Analysis*	*Reference*
	Sardinella melanura		flesh	1877	235		
	Lethrinus minimatus		"	1039	279		
A	Sparus nokt		"	151	6	GC for THC	
	Parapeneus barberinus	1981	"	125	4	HPLC for PAH	Awad (1987)
	Theraponidae ap.		"	133	0.3		
	Chanidea sp.		"	620	32		
B	Sphyraena sp.		flesh	375	51		
	Decapterus sactae		"	5188	98		
	Sardinella sp.	1983	"	250	34	HPLC for THC	
	Holocentrus spinifer		"	438	14	U.Vfluoresce-nce for PAH	Awad (1984)
	Lethrinus ientjan		"	625	1067		
	Mugil cephalus (3)		"	6214	10628		
D	Epinephelus spp (6)		flesh	281	333		
	"(2)		liver	214	257		
	Cephalopholis rogoa		flesh	330	277		
	Varida lauti		"	139	563		
	Chanos chanos	1984	"	61	27	U.V fluorescence	Awad (1990) c
	Plectorhychus schotaf		"	250	1300		
	Lutianus spp. (4)		"	257	532		
	"		liver	174	638		
	Siganus rivulatus		flesh	101	252		
	Lethrinus spp.		"	153	142		
	Labridae spp. (3)		"	157	168		
	Scomberoid commersonianus		"	214	176		
	Caranx sexfasciatus		"	150	0	U.V fluorescence	Awad (1990) c
	Holocentrus spinifer		"	84	0		
	"		liver	101	66		
	Scarus harid		"	225	0		
	Gerres ogina		"	242	241		
	Mugil cephalus		"	351	192		

Concentration of total hydrocarbon contents in areas B and D expressed by referance to a standard light arabian crude oil solution using 310 nm ex., 371nm em.
- Aromatic hydrocarbon concentrations expressed as the sum of 5 PAH concentrations (phenanthrene, chrysene, perylene, benzo- 8,9 perylene and benzo-3,4- pyrene) measured according to SAWICKS et al, 1960.
- between parenthesis:number of samples.

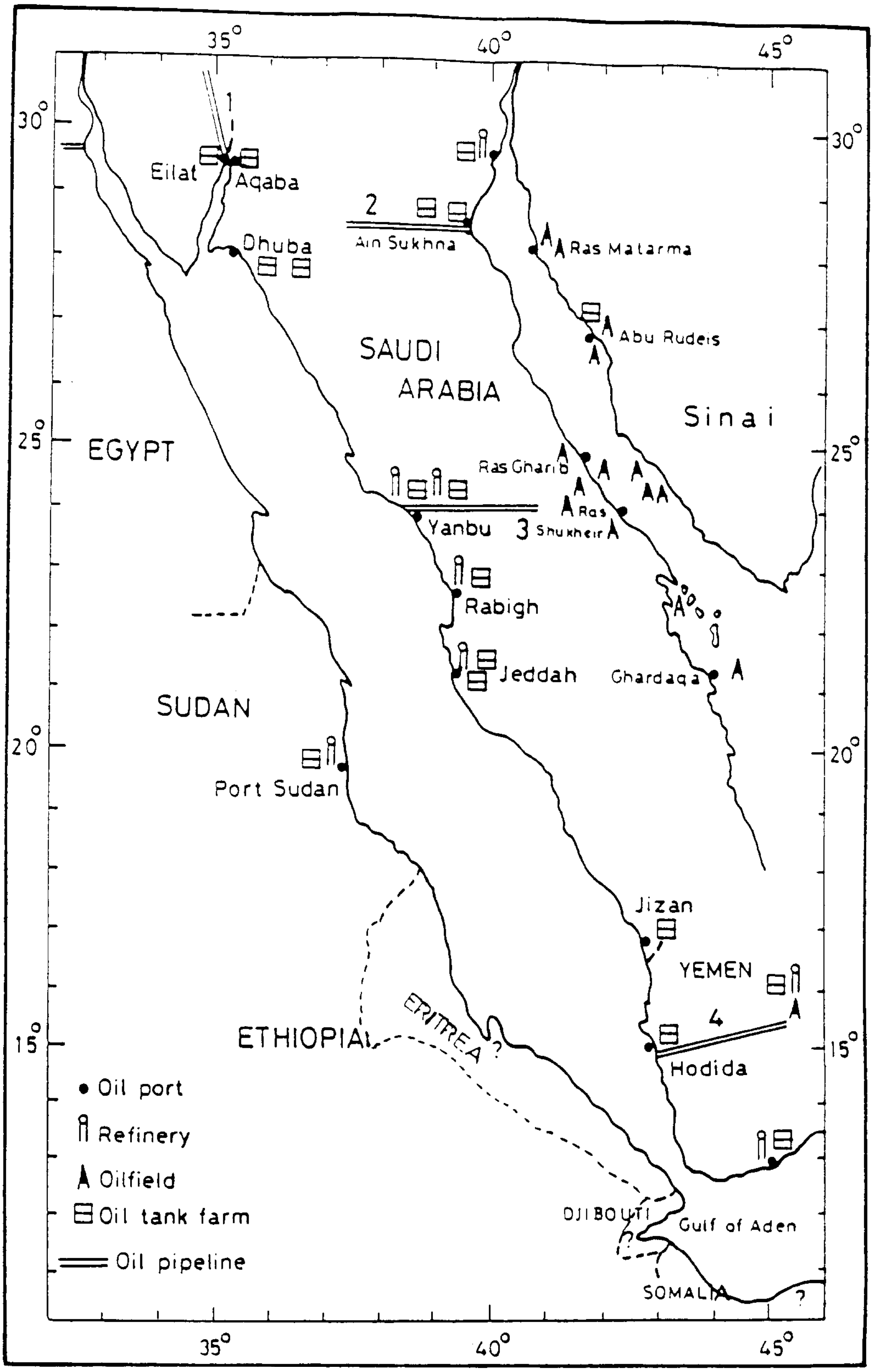


Fig. 1 - Main oil activities in and around the Red Sea (Awad, 1989a)

1-Eilat to Mediterranean Sea (25 mta) 3-PETROLINE from Arabian Gulf (160 m

2-SUMED to " " (80 mta) 4-from Yemen oilfield (10 mta)

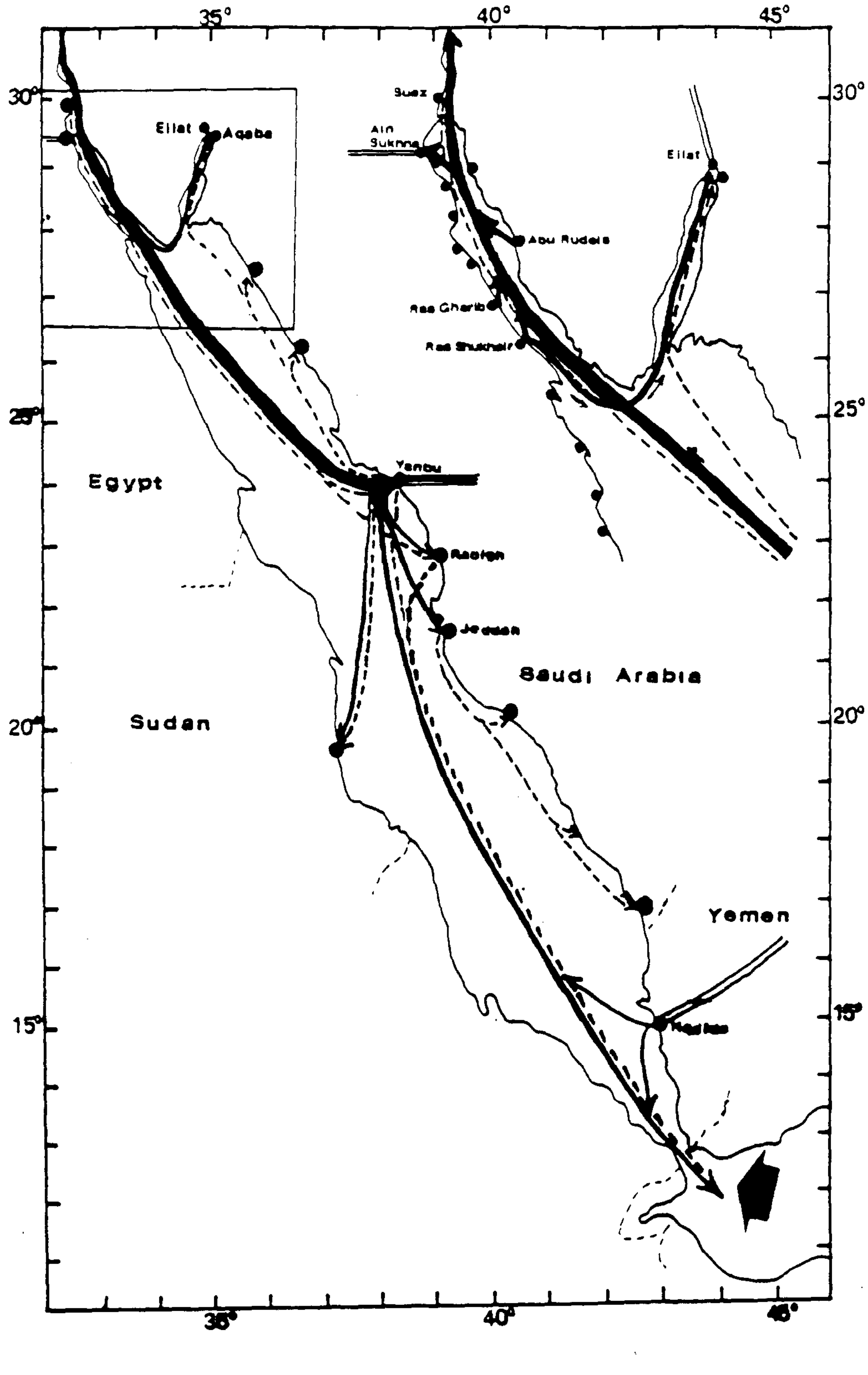


Fig. 2-Routes of oil (——) and refined products (---) in the Red Sea (Awad, 1989a)

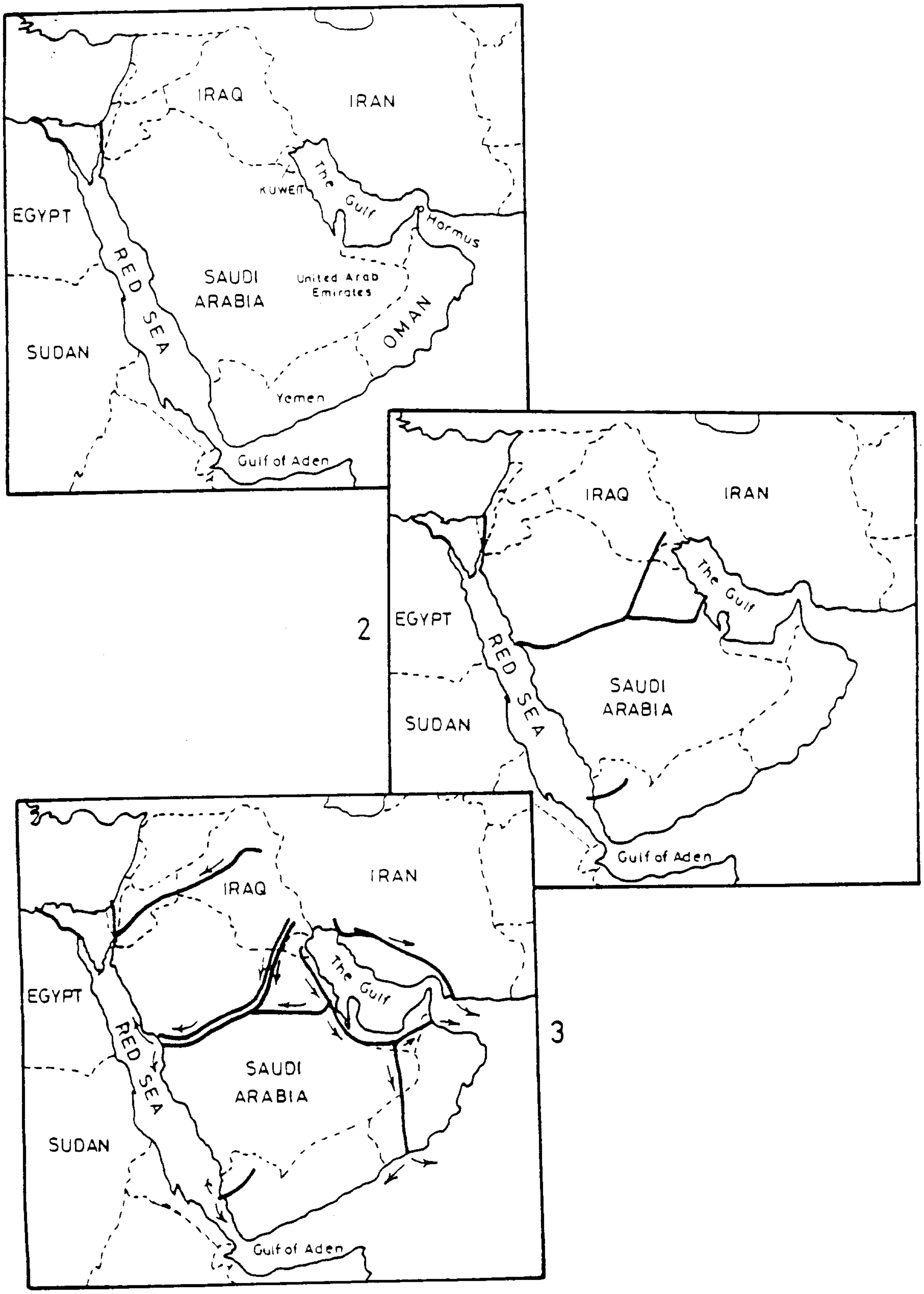


Fig. 3-Development of oil transportation by pipelines in the Middle East

1-before 1980 2-present 3-in future

(AWAD 1990a - modified from Le Monde, 20 Aug 1987)

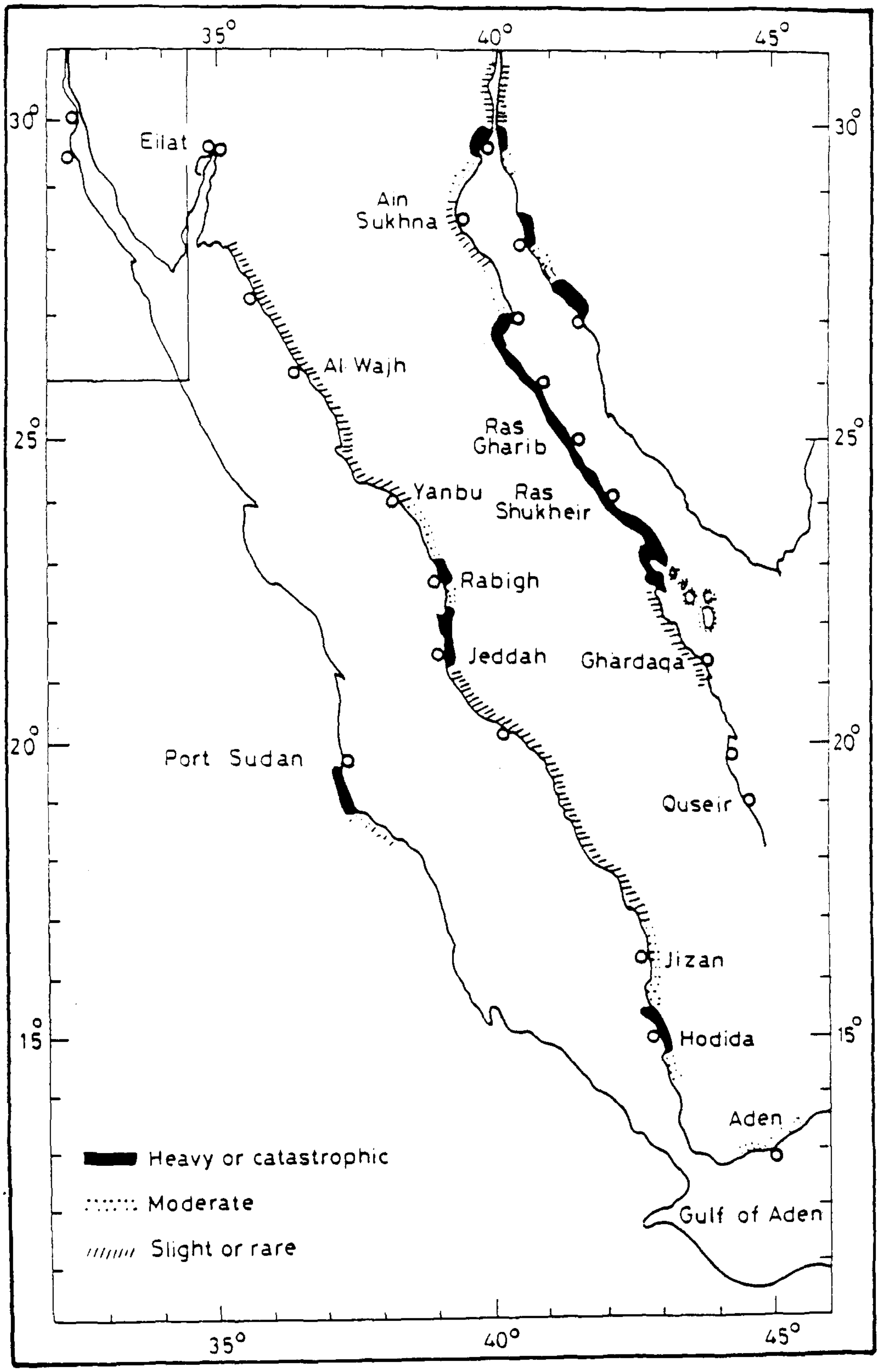


Fig. 4-Oil pollution profile along the Red Sea coasts (Awad, 1989a)

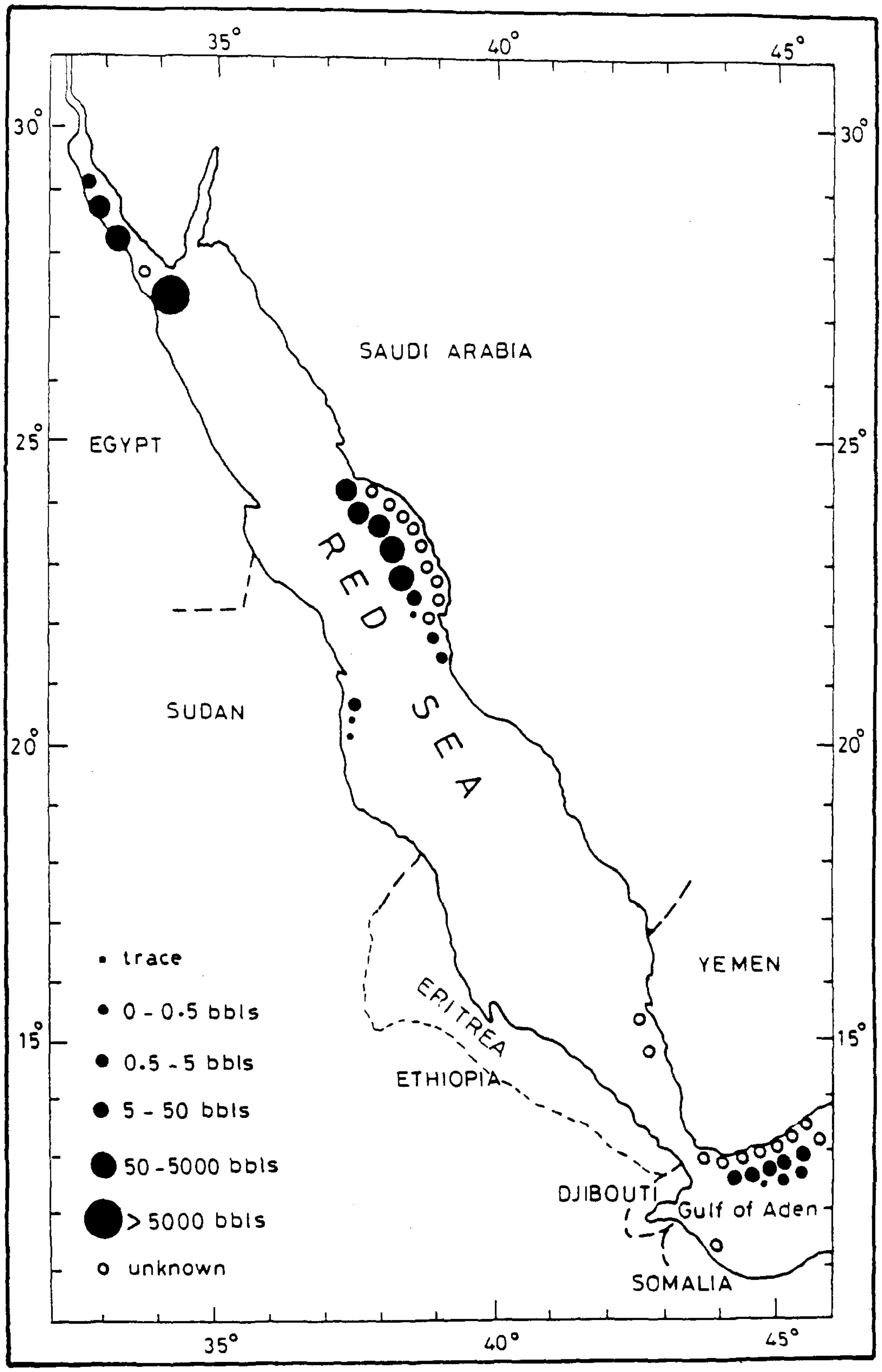


Fig. 5 - Distribution of accidental oil spills along the Red Sea and Gulf of Aden coasts (1974 - 1986) (AWAD 1988 b)

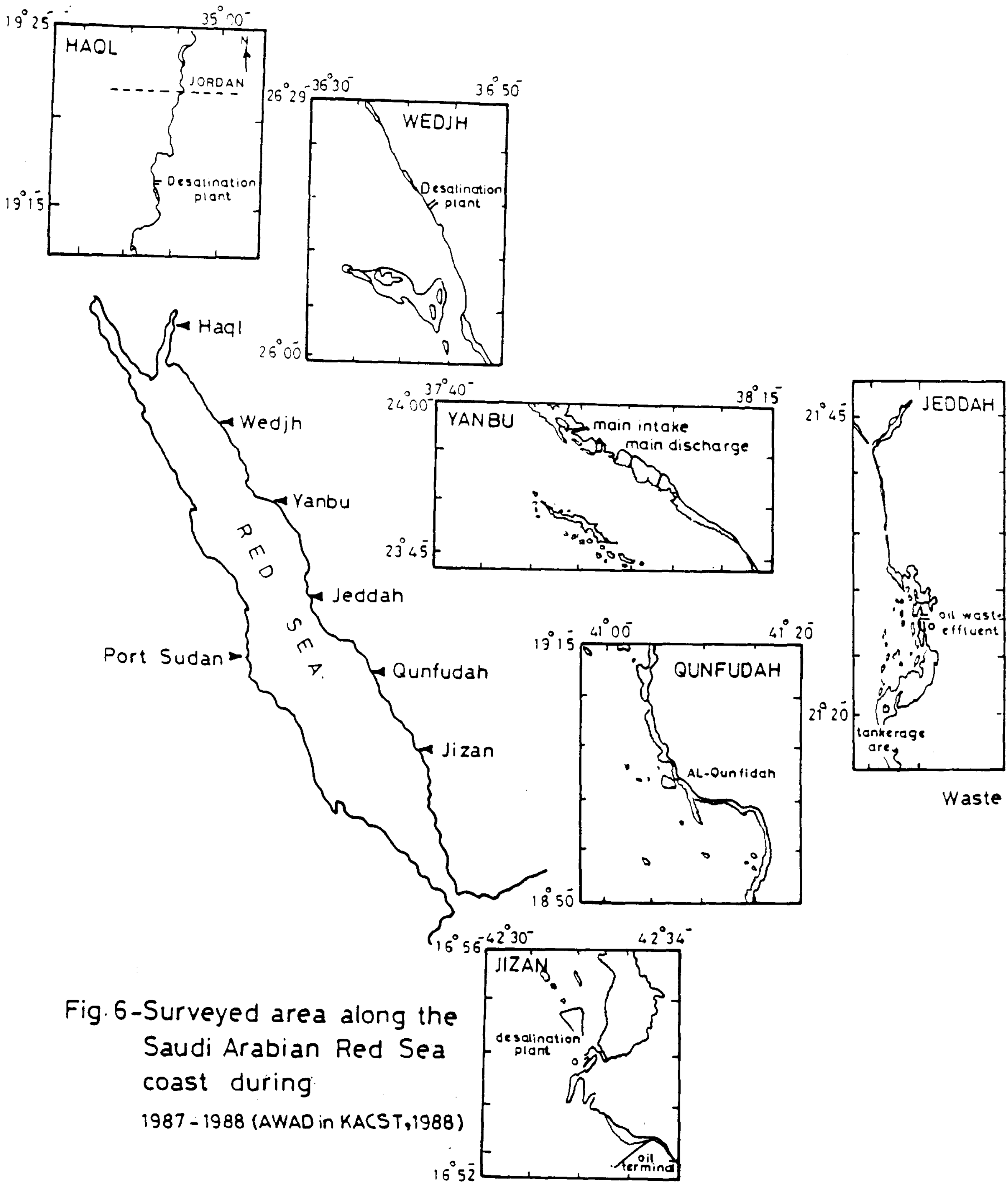


Fig. 6-Surveyed area along the Saudi Arabian Red Sea coast during 1987-1988 (AWAD in KACST, 1988)

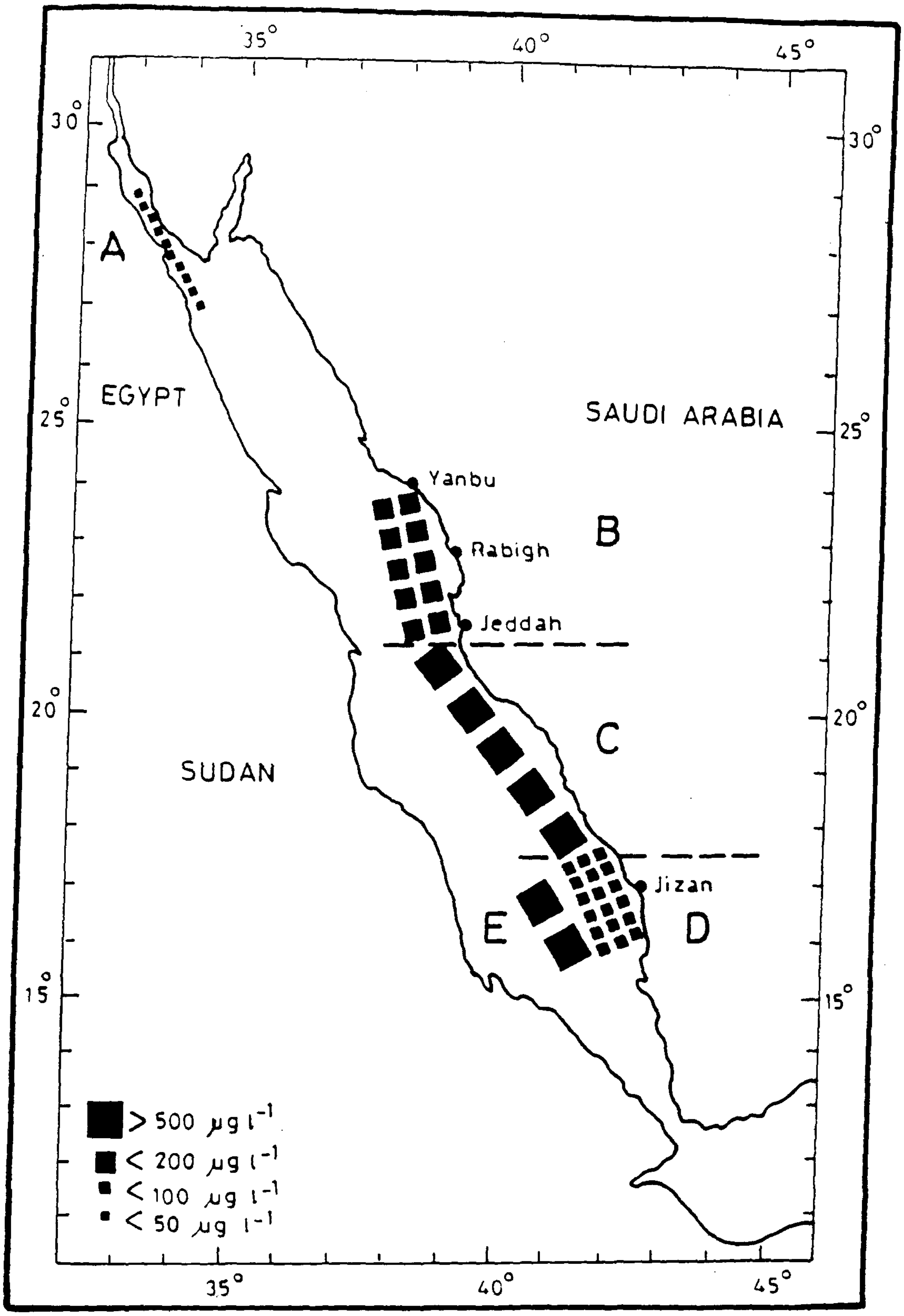


Fig.7 - Geographical distribution of dissolved/dispersed petroleum residues concentrations (as chrysene equivalents) in Red Sea waters (Awad, 1988a)

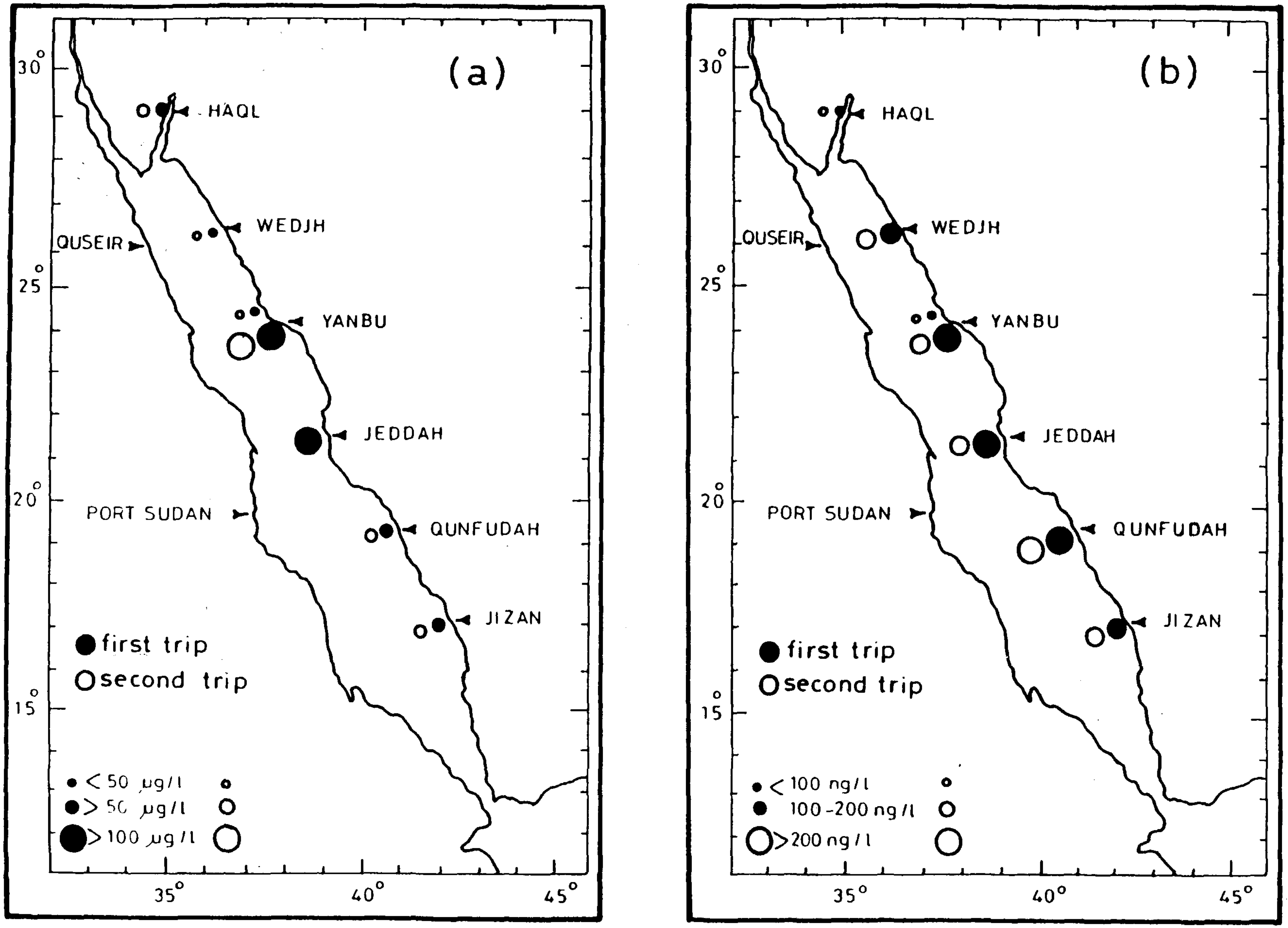


Fig 8-Distribution of dissolved / dispersed petroleum hydrocarbons (a) and total polyaromatic hydrocarbons in near shore waters along saudian coast during 1987-1988. (AWAD in KACST, 1988)

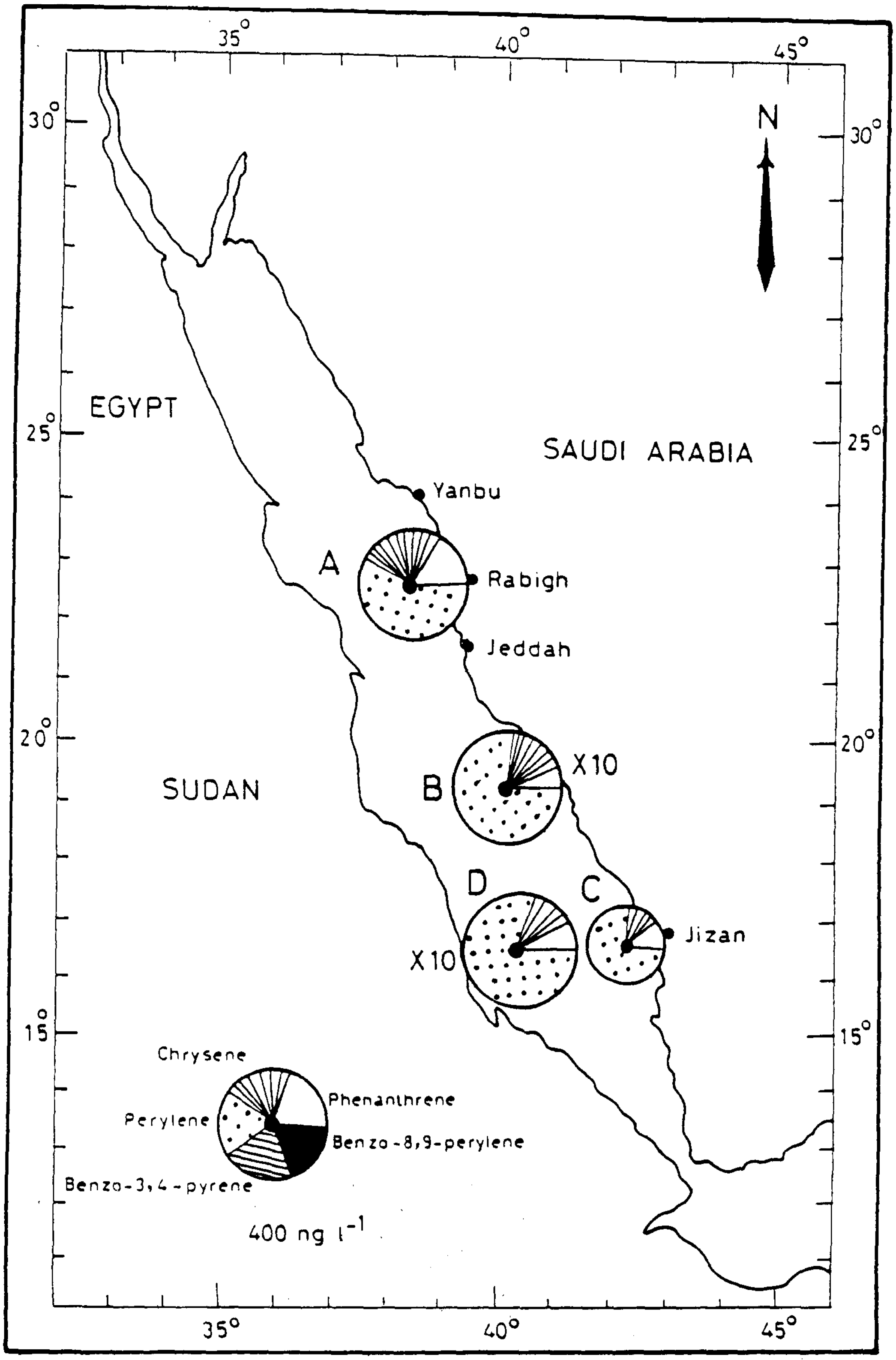


Fig. 9 - Relative contribution of individual polyaromatic hydrocarbon compounds in soudian surface nearshore waters (AWAD, 1990 c)

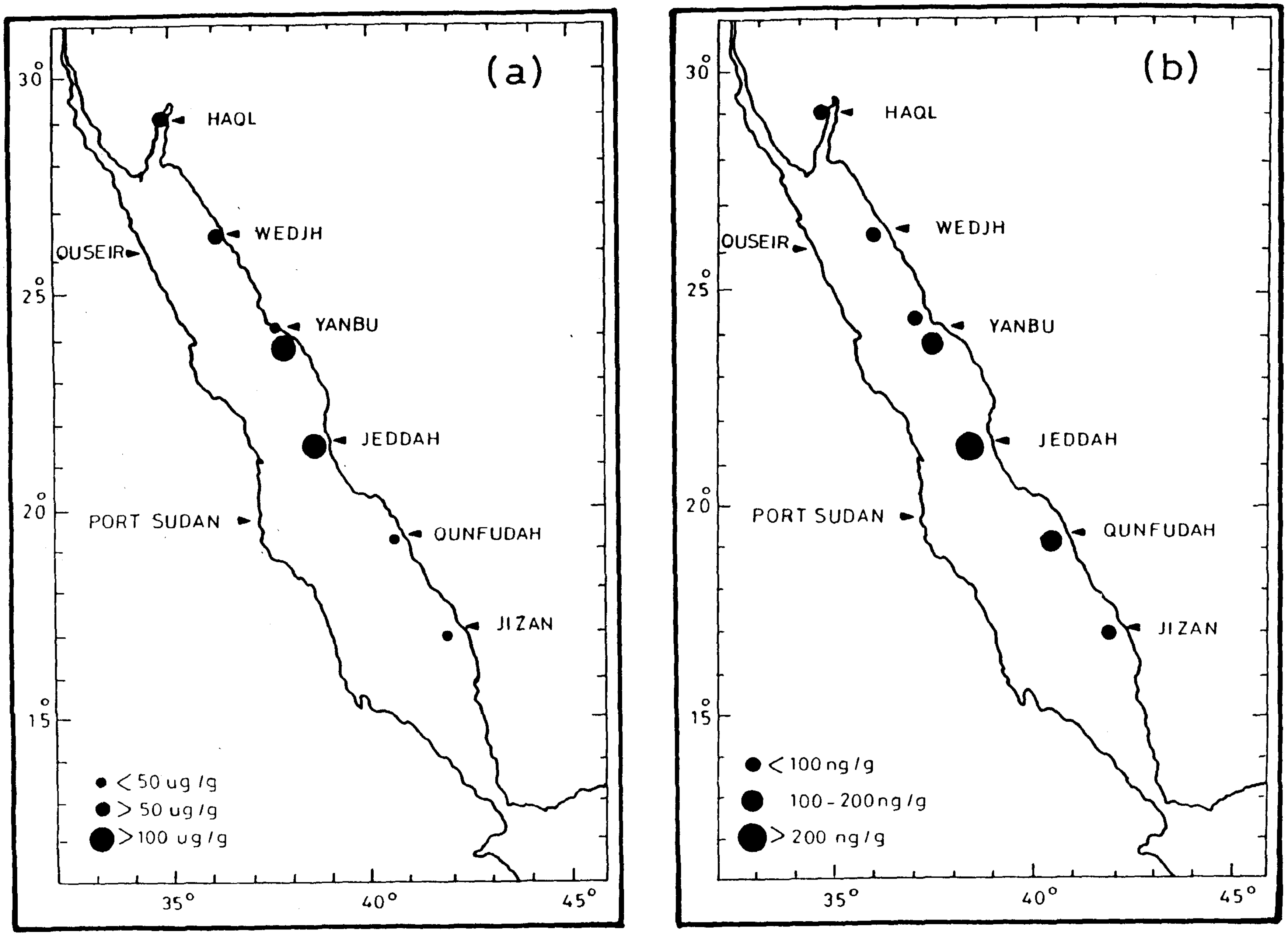


Fig. 10 - Distribution of petroleum (a) and polyaromatic hydrocarbon contents (b) in surface marine sediments along the saudian Red Sea coast during 1987-1988 (AWAD in KACST, 1988)

The Problem of Phosphate Pollution in the Northern Gulf of Aqaba

by

Ahmad Abu-Hilal

Department of Earth and Environmental Sciences
Faculty of Science - Yarmouk University
Irbid - Jordan

Abstract

This paper deals with the phosphate pollution and related problems in the unique and very sensitive coral reef area in the northern portion of the Gulf of Aqaba. The sources and magnitude of pollution are pointed out. The levels and distribution of phosphate and other pollutants are reviewed taking in consideration the effects of the phosphate dust spills during loading operations in Aqaba port. Human activities, stresses and environmental impacts resulting from these activities and from pollutants are reported. Results of previous scientific reports that appeared during the last two decades are reviewed and discussed.

Introduction

The occurrence of excessive phosphate concentrations in nutrient-enriched waters has lead observers to label phosphates as the key factor controlling the eutrophication process. This pollutant can reach the marine environment from many sources and in a variety of ways. Natural sources include rainfall, aquatic plants, waterfowl, fish, bottom fauna, muds, and runoff from land. Man-generated sources include domestic and industrial wastewater. Runoff from urban centers, fertilized and unfertilized cultivated land are considered as important sources of phosphates in many regions of the world. While there appears to be a fairly general agreement that wastewater treatment plants contribute the largest annual amount of phosphate, other sources can be large contributors. A potential source of phosphorus is bottom sediments which have phosphorus reserves that have built up over the years. Evidence is developing that even the most insoluble forms of phoshorus which can be present in these sediments as calcium hydroxyapatite are available as a nutrient for algal growth, and that this occurs under both aerobic and anaerobic conditions (Weaver, 1969). Factors affecting or controlling phosphate solubility in sea water are numerous. Among them are the effective surface area of phosphate particles, phosphate type, temperature and pH of seawater, oxygenation state of the system and the interaction amongst different sediment types in any localility.

In this report the problem of phosphate pollution in the northern portion of the Gulf of Aqaba particularly within the Jordanian waters is reviewed and discussed, based on previous scientific reports which appeared during the last two decades.

The Northern Gulf of Aqaba. Jordanian Coast

The Gulf of Aqaba is characterized by warm, clear and very deep water, low productivity, long water residence time, and fringing coral reefs with large biological diversity and very high productivity. It embraces also exceptionally productive seagrass meadows which yield oxygen and host many associated species of flora and fauna. These ecosystems are recognized to be of particular importance as nursery areas for certain species of fish, and a source of food for turtles, fish and numerous invertebrates. Appropriate shallow water habitats with at least three kinds of seagrass occur in many places along the entire Gulf shoreline.

Coral reefs in the Gulf Aqaba, among the most spectacular in the world for sheer beauty and biological diversity, represent the nothernmost limit for reef corals in the Western Indo-Pacific region. As many as 140 species of corals contribute to the construction of reefs in the Gulf. However, hundreds of other organisms, plants and animals are vital to the survival and development of these ecosystems.

The Jordanian coastline on the Gulf of Aqaba extends for 26.5 Km (Fig.1) Developments along the nothern portion of the coast include the construction of a modern town of many housing areas, roads, hotels, sewage treatment plant and international airport.

The northern most tip of the Jordanian coastline is known as the hotels area. This area is characterized by its soft sandy beaches, the presence of scattered seagrass meadows and the absence of reef building corals.

The area between the Royal Yacht Marina and the main Port is shallow and represents the remainings of the northernmost coral community in the Gulf of Aqaba. The area which is partly used as a "marina" for fishing and glass boats has a significant natural and tourisitic value due to its richness and close vicinity to the town.

The north-eastern part of the Jordanian coastline, south of the glass boat"marina" is known as the ports area and includes the main port, the phosphate berth, the rice, cement and clinker port (Al-Mushtarak port), containers port, as well as the ferry (passengers) port.

South of the ports area and along the middle part of the eastern coast (Middle or Tourist Development Zone) extends a semi-continuous, actively growing and exceptionally productive coral reef of the fringing type. The Marine Science Station Nature Reserve constitutes the northern boundary of this zone. Mountains in this zone are set back further from the shore and regularly arranged fringing reefs related to the series of small embayments are situated where one or more Wadis (small valleys) occur in the sides of the coastal mountains. The fringing reefs are best developed on the headlines between these embayments, while the occasional floodings from the Wadis with their load of fresh water and sediments tend to prevent coral growth in the back of these embayments. This Tourism Development Zone extends for about 6.5 km southwards to the Royal Navy Port and includes the proposed Aqaba Marine Park.

The south coast which extends for about 5 km from the Royal Navy Port to the Saoudi Arabian border accommodates many important industrial enterprises which include, in addition to the oil terminal, Aqaba Thermal Power Plant (ATTP), Fertilizers Plant of Jordan Phosphate Mining Company Ltd (JPMC) and Arab Potash Industry (API) storage and loading facilities.

Climate of the Area

The climate in the area is hot and dry. June,July and August are the hottest months. In the period 1959-1987 the average air temperature during these summer months ranged between 30.6 and 32.1 °C compared to 14.9 to 17.6 °C during winter months of December, January and February (Jordan Climatolgical Data Handbook, Meteorological Department, 1988).

The relatively high temperatures throughout the year are coupled with low relative humidity. The mean relative humidity averaged 29% in the period 1960-1987. The average yearly rainfall as recorded by the Aqaba Station in the period

1959-1987 was very low and ranged between 30.6 t0 32.1 mm (Jordan Climatological Data Handbook, Meteorological Department, 1988).

Wind in the area blows from the north 85% of the time (Hulings, 1989). Southerly wind occurs during 9% of the time.

Physical, Chemical and Biological Characteristics of the Area

Tides in the area are semidiurnal. However, a distinct diurnal inequality in the high and low tides has been reported by Hulings (1989), who preferred to describe them as "mixed " rather than semidiurnal. He reported a spring range of 90 to 100 cm and a neap range of 25 to 50 cm.

Currents follow a clockwise direction (Hulings, 1979). However, reversal in direction occurs with changes in wind direction, especially with prolonged southerly winds (Hulings, 1989). The currents run parallel to the eastern shoreline at a depth range of 20-60 m, with a velocity of 5-10 $cm.s^{-1}$. Closer to the coast, the speed is only of 2.8 cms^{-1}.

Water temperature from the surface down to 200 m ranged between 20.7 in early March to 26.0C in early August. But temperatures of about 30C may occur in shallow coastal areas during the warmer months (Hulings, 1979).

Salinity of sea water in the area is relatively high and ranges between 40.0 to 40.5. Vertical salinity differences are very small between 50 and 150m (Klinker et al ., 1976). It is 40.6 for the 0.0 -300 m water column which indicates that the water of the Gulf is well mixed and lacks any stratification within this layer.

The surface water of the Gulf is well oxygenated, values between 6 $mg.l^{-1}$ have been recorded during the last two decades by the Marine Science Station and by visiting scientists (Klinker et al.,1976 Seguin, 1978). Surface water saturation levels are always between 98 and 103%.

The Gulf waters are exceptionally clear. Their high transparency is partly related to the absence of rivers or major streams flowing into the sea. Occasional storm generated floods transport nutrient-bearing sediment debris from the surrounding wadis into the Gulf, via alluvial fans. Wind-borne sediments account for some input of suspended matter, nutrients and metals . In recent years many pollutants, including suspended matter, have come from ships, land-based human activities and from population centres. These sources of pollution, in addition to the phosphate berth as a source for phosphate dust particles, are responsible for the deterioration of the water clarity in the area.

Sources of Pollution in the Northern Gulf of Aqaba and their Environmental Impacts

The natural, background, loadings with pollutants in the northern Gulf of Aqaba are very small. Therefore, small discharges to the Gulf water may significantly increase the concentration of pollutants in this sensitive coral reef environment, and lead to change in its plant and animal communities. Generally speaking, coastal development and port activities usually have a large impact on the marine environment. In the northern Gulf of Aqaba, Port activities urban and tourist development of the coast are at present concentrated primarily at the northern tip of the Gulf and are expected to increase. The port cities of Eilat and Aqaba are the major centres of development along the Gulf coast. In addition, there are several towns and tourist villages existing or under construction along the Egyptian coast. Residential, commercial, port, shipping and tourism activities are associated with these cities and are expected to increase in the future. In contrast, there is very little development , existing or planned, on the Saoudi Arabian coast.

The principal industrial activity in the Gulf is shipping. Major shipping activity is conducted by Jordan and Israel. In Israel, the town of Eilat (population of about 35,000) occupies 14-kilometers of the Gulf coast. The port facilities accommodate a container port, two oil terminals, a naval port, Ro-Ro (roll on-roll off) port and an old port. For Jordan, Aqaba (population 63,000) is the only point of maritime access and has a major role in import- export. The total movement of goods through the Aqaba main port, including phosphate, container and industrial ports in 1994 exceeded 2485 ship loads. Import totalled more than 3.92 million tonnes while exports totalled 10.57 million tonnes, including about 4.0 million tonnes of raw phosphate, about 517,788 tonnes of chemical fertilizer and large quantities of potash and cement clinker (Table 1). The present uses of the coast of the northern Gulf of Aqaba are diverse, expanding and interrelated. The sources of pollution from human activities are numerous and include: tourism, fishing, maritime activities in ports and oil terminals, wastewater disposal from the sewage treatment plant, mariculture and fish farming projects, desalination plants (Eilat), power plants (Eilat and Aqaba), boat repair facilities, and major industries (Aqaba). The environmental impacts resulting from the above mentioned activies are related to stresses, pollutants, physical destruction and / or deterioration of physical and chemical properties of seawater.

Pollutants in the marine and coastal environment of the Gulf include: sewage and related nutrients; cooling water from major industries, (Fertilizer plant), power plants and desalination plants; oil and related hydrocarbons and other hazardous materials., heavy metal; organic substance; suspended matter which increase water turbidity; marine debris and litter; phosphate dust and related pollutants such as trace metals, fluoride, and uranium.

Physical impact on the quality of sea water and on the coastal enviroment is considered as a critical problem, particularly in sensitive coral reef areas. Construction along the coast, effluents dumped into the sea, cooling water systems, ship activities and anchoring, tourism and diving activities, posphate dust lost to the sea, man-made litter and fishing gear, usually result in serious physical damage to all marine communities, particularly to corals. These impacts result in the gradual degradation of coastal and marine resources. The cumulative damage to the environment is of significant concern.

At present, there is a general concern for the condition of marine habitats along the Gulf of Aqaba coast. Marine communities across many habitats are showing signs of increasing stress . Degradation of the marine and coastal environment in the Gulf includes :

a-loss of coral areas due to coastal constructions of ports, power plants, desalination plants, industries, marinas and tourist facilities.

b-physical damage to corals by divers , beach users, boat anchors and souvenir collectors.

c-Reduced seagrass meadows compared with historical distribution.

d-Reduced fish catch and increased fish kills because of unregulated commercial and sport fishing.

e-Stress on or loss of marine life because of discharge of high salinity desalination residual water or high temperature cooling water.

f-Coral degradation and reef siltation from coastal development and accumulation of phosphate dust particles.

g-Physical damage to corals, fish and mammals from marine debris such as fish traps, lines, nets and litter accumulation.

Phoshate Pollution - the Magnitude of the Problem

Municipal sewage from Aqaba and Eilat towns was the major source of phoshate pollution. Now, there are no direct discharges of sewage to the Gulf from the Egyptian or Jordanian coasts . By comparison, the municipality of Eilat was discharging approximately 4 million cubic meters per year of primary treated wastewater. However, recent reports indicate that sewage dumping into the Gulf water from this city has been stopped. The effluent of the city's new treatment plant is to be applied to irrigation with no discharge to the Gulf other than on an emergency bypass basis.

Of all the bulk material loaded at the port of Aqaba, phosphate dust appears to represent the most significant problem during the last two decades. Phosphate rock in the form of fluorapatite is exported through Aqaba port in millions of tonnes annually. In 1994, 3,825,000 tonnes were exported. The total amount of phosphate exported during the last five years (1990-1994) was about 21 million tonnes (Table 2) (Aqaba Port Corporation, 1995). The phosphorus content of the rock , calculated as P2O5, ranges from 30.8 to 33.9% with the remainder consisting of calcium (50.37 - 52-20%) as CaO and fluoride (3.53 -3.99 %) (Abu-Hilal, 1985).The chemical analysis of the various grades of rock phosphate (Table 3) indicates that it contains substantial percentage of Fe, Al, Mn, Sr, Mn, Ti, F and organic matter. It contains also high levels of some trace metals such as U, V, Cr and As (Table 3).

It has been estimated that 0.1% of the exported phoshate is lost to the sea during loading operations (Abu-Hilal, 1987, Schuhmacher et al, 1982). Freemantle et al.(1978) gave relatively higher estimates (1%).

In 1985, the Jordan Phosphate Mines Company estimated the loss to be of 0.05 % of the amount handled (Abu-Hilal, 1985). However the percent loss must have been much lower during the last 4 years because of the installation, by the Port Corporation, of choke feeders. However, no estimate was made after the installation of these choke feeders. Yet some of the phoshate is still reaching the marine environment in the close vicinity of the phophate port and some fine phosphate dust is lost to the atmosphere in the same area. Because of their relatively high density, the fine sized (0.07-1.00 mm), sparingly soluble phosphate rock particles are mostly deposited near the phosphate loading berth (Abu-Hilal, 1985). After sedimentation, bacterial activity and other environmental conditions such as low pH and anaerobic sedimentary environment may enhance the solubility of the insoluble phosphate particles and increase the rate of release of the toxic elements present in these particles (e.g Cu, Cd, Zn, F and U) as well as the concentration of dissolved phosphate, to the surrounding marine environment.

Prior to the early 1970's, limited data were available on phosphate and nutrients in the Red Sea and even less for the Gulf of Aqaba (Morcos, 1970). Subsequently a number of investigations on nutrients have been conducted in the Gulf and results have been reported by Freemantle et al (1978), Klinker et al.(1978), Mulqi (1978), Levanon Spanier et al. (1979), and Hulings and Abu-Hilal (1983).

During the 1980's it was realised by scientists in the area that phosphate pollution problem in the northern portion of the Gulf of Aqaba needs more attention. The first investigation along the Jordanian coast was made by Mulqi (1978) who studied the effect of phosphate dust on the levels of dissolved phosphate, calcium and magnesium in sea water and sediments. Normal levels of calcium and phosphate were found in all water samples (0.4 ug - at P l^{-1}) except near the phosphate berth and the nearby Aqaba sewage outlet (closed since 1985) where the phosphate was relatively higher (0.7 μg - at l^{-1}) (Freemantle et al, 1978). In solubility studies for various types of phosphate dust, up to 20 μg -at P l^{-1} were found to dissolve in Aqaba seawater. It was concluded that the phosphate released by dissolution of phosphate dust particles is rapidly diluted and dissipated in the waters of the Gulf (Freemantle et al., 1978). The same year Klinker et al. (1978) reported phosphate in the Gulf ranging from about 0.03 to 0.99 μg - at l^{-1} over a depth range from the surface down to 600 m. However, they did not include in their report the episodic, extremely high phosphate content (> 2.5 μg-at l^{-1}) throughout the water column near the town of Eilat. They attributed this abnormally high phosphate value to air-transported particulate phosphate brought into the waters from the loading facilities in both Eilat and Aqaba ports. A year later another report on primary production in the Gulf of Aqaba was published by Levanon-Spanier et al (1979). The low phosphate values included in their report for the waters of the Gulf including the water of a station near Eilat were in the same range (0.03-0.90 μg-at l^{-1}) as reported previously by Klinker et al (1978), and they did not relate their findings to any source of pollution. Three reports appeared during 1982 by Hulings (1982), Walker and Ormond (1982) and Schuhmacher et al (1982). Hulings (1982) reported on the distribution of uranium in the surface sediments within the Jordanian sector of the Gulf. On the basis of the results obtained from the analysis of a limited number of coastal sediment samples, it was concluded that uranium concentrations were relatively high (up to 3.6 ppm). He indicated that a higher concentration of uranium was associated with phosphate dust pollution at a site located nearby the phosphate loading berth.

In view of the fact that many workers have shown that calcification in reef corals can be suppressed by a large increase in phosphate concentration in the surrounding waters (Simkiss, l964; Kinsey and Davies, 1979), Walker and Ormond (1982), conducted an intensive survey on the coral reef near the phosphate berth and other sites along the Jordanian coast. They related the increased algal growth and coral death near the phosphate berth to phosphate pollution from the loading berth. In 1983 Hulings and Abu-Hilal (1983) published the first report on the distribution of dissolved inorganic phosphate and other nutrients in the surface waters of the Jordan Gulf of Aqaba. They collected samples from six offshore stations and eight coastal stations including one station south of the phosphate berth and close to the sewage outlet (not used now). They reported an annual mean value of 0.27 and 0.24 μg - at l^{-1} in surface waters at the coastal and offshore stations respectively. The relatively high levels of phosphate (0.90 μg - atl^{-1}) they found at the latter station was attributed to the sewage effluent from the main sewage outlet and phosphate dust from the phosphate berth.

The use of sediment and suspended particulate matter for monitoring contamination in the marine environment is widely accepted by marine scientists. Sediments are considered a suitable reservoir for pollutants since many pollutants have strong affinities for sediments in receiving water. Therefore, the concentration and distribution of these pollutants in sediments can serve as an indication of time history and extent of pollution discharge in specific areas. Moreover, the study of the physical, chemical and biological characteristics of the sediments can be used as a useful monitoring tool. Knowing this fact, scientists in the area started to monitor the environment of the Gulf of Aqaba and the phosphate dust pollution problem by analysing sediment samples in addition to water and biological samples. Many reports appeared during the 1980's and 1990's that dealt with phosphate and other pollutants, their magnitude, distribution and effects on the environment the Gulf.

Abu-Hilal (1985) tried to assess the magnitude of the phosphate problem, the distribution of total phosphorus, fluoride, calcium and calcium carbonates and their association with each other. Sediment cores were used for this purpose. Abnormally high values of total phosphorus and fluoride were found near the phosphate loading berth (Table 4) which decreased with increasing distance from the berth. The results indicated that phosphate pollution is mainly localized in the vicinity of the berth although its influence was detected in other areas along the coast. The results also indicate that the levels of total phosphorus had increased at the berth area by at least an order of magnitude as compared with Mulqi (1978). As a followup to the problem, Abu-Hilal (1986) studied the distribution of fluoride in sediment and water samples collected from selected areas along the whole

Jordanian sector of the Gulf. Normal fluoride concentrations were found in the water samples, whereas abnormally high values of fluoride and total phosphorus were found in the phosphate-polluted sediments, particulary from the phosphate berth area (Table 4). According to Abu-Hilal (1985) it was not enough to measure the concentration of reactive phosphate in water or the total sedimentary phsphorus in sediments to assess the potential effects of phosphate pollution in the area. A detailed study was carried out therefore on the sedimentrary phosphorus in sediment cores collected from seven localities along the Jordanian sector of the Gulf (Abu-Hilal, 1987). It was found that the apatite fraction was the predominant form of phosphorus in polluted and unpolluted , calcareous and terrigenous sediments. The non-apatite inorganic phosphorus (NAIP) values were almost equal in all unpolluted sediments and much higher in polluted sediments. It was noted also that all forms of phosphorus except the (NAIP) are poorly or negatively correlated with organic matter concentration. It was concluded that all forms of phosphorus were more abundant near the phosphate berth and that the apatite fraction concentration was anomalously high in the same area, which reflects the effect of phosphate rock particles that reach the sediments during the loading operations. It was pointed out that the concentrations of all forms of phosphorus decrease down within the cores and with increasing distance from the phosphate berth.

In a continuing effort to make more data available on the magnitude of the pollution problems, the pollutants distribution and the contribution of the phosphate dust particles to these problems, the author studied the distribution of many trace metals and organic matter in sediments of the northern Gulf of Aqaba (Abu-Hilal, 1987; Abu-Hilal et al. 1988; Abu-Hilal and Badran, 1990). The effect of the sources of pollution on the levels and distribution was pointed out. The contribution of each source to selected sites was assessed on the basis of metal abundances, pattern of distribution, relative proportions of metals and other sediment parameters. High levels of Cd, Cu, Pb, Zn, Ni, Co, and organic matter was found in the sediments of the port area (Table 4).

This was attributed to the presence of major sources of pollution, including intensive ship and boat activities, domestic sewage discharge (discontinued) and phosphate dust particles reaching the sea from the phosphate berth. The high levels of Cd, Cu and Zn were attributed mainly to the heavy settleable phosphate dust particles from the phosphate berth, since these particles contain high levels of Zn (190-490 ppm), Cd (6-9 ppm) and Cu (19 -48 ppm) as reported by Abu-Hilal (1987). It was noted that the surface and vertical distributions of trace metals in this polluted site were similar to the distribution of total phosphate-phosphorus, Fluoride and organic carbon which confirms the association of these pollutants with the deposited phospate particles .

To have an impact on aquatic organisms, metals and other pollutants must be in a form that is biologically available to them. The bioavailability and recycling of trace metals in aquatic environments depends largely upon the geochemical fraction with which the metal is associated in that environment. Bearing this in mind, in addition to the fact that phosphate dust particles are sparingly soluble in sea water under the normal pH levels of Aqaba sea water (> 8.2) the author tried to determine the chemical forms in which the above mentioned trace metals are likely to occur in various sediment phases from the northeastern tip of the Gulf (Abu-Hilal , 1993). Previous findings by Abu-Hilal(1987) and Abu-Hilal and Badran (1993) were confirmed. Unusual and highest total concentrations of Cd, Cr, Cu, Ni, and Zn were present in the sediments of the phosphate berth area. The concentration of Cd is 1.8 - 3.5, Cr, 1.8 - 10.5, Cu, 2.2 - 3.6 and Zn, 5.5 - 8.2 times higher than their respective concentrations in other sites of the area. It was found that the non-lithogenous fractions of each element, which is made of the exchangeable, carbonate-bound, Fe-Mn oxides-bound and organic matter-bound fractions contribute high percentage (38 - 94.7) of the total element concentrations, which confirm the polluted nature of the sediment in the area. The investigation indicated that Fe- Mn oxides and hydroxides-bound fraction was the most important non-lithogenous phase for all metals in the area. It was concluded therefore that Fe and Mn seem to play a major role in scavenging the non-lithogenous metals in this fraction .

Because uranium is present in high concentrations (82 - 162 ppm) in the Jordanian raw phosphate exported through the Aqaba port, it was felt necessary to study its distribution and determine its levels in the marine environment of the northern portion of the Gulf. This was made by Hulings (1982) and Whitehead et al. (1987) who determined uranium concentration and distribution in sediment samples from selected sites within the area. It was concluded that uranium concentrations were relatively high (up to 3.6 ppm) near the phosphate berth area and that the accumulation of uranium was localized. Very recently, Abu-Hilal (1994) determined the levels of uranium and investigated the relationships between uranium concentrations in sediments, corals, algae and seagrass species common to the area in various depositional environments. It was intended to assess the effect of the large input of uranium-rich phosphate dust particles on uranium concentrations in selected organisms and in sediments of the Jordanian sector of the Gulf. The report highlighted very important results and conclusions. It was found that uranium contents were relatively high in all localities and ranged from 2.5 - 16.2 ppm. Unusually high values (5.0 - 16.2 ppm) were found in the port area near the phosphate berth(Table 4). The concentration of uranium was decreasing to the north and south with increasing distance from the berth . Significant vertical changes in uranium concentration were found within the upper 15 cm of individual cores at the phosphate berth area only. At this site the uranium content decreased from 16.2 ppm in the top 2 cm to 5 ppm in the lower section of the sediment core. It was noted that this decline was accompanied by a parallel decline in calcium and P2O5 content within the cores. Accordingly, it was also concluded that the deposited uranium-rich phosphate particles are the main source for this pollutant in the area. It was possible to conclude from the results of the same study (Abu-Hilal 1994) that the phosphate dust particles increased the element concentration in corals collected from the phosphate berth area (7.5 - 12.5 ppm) by a factor of 1.8 compared to corals (6.7 - 7.6 ppm) collected from other localities along the Jordanian sector of the Gulf of Aqaba. The relatively high uranium concentrations in the tissues of some algae and seagrass species collected from the phosphate berth area (7.5 - 12.5 ppm) compared to species from other localities (2.3 - 7.2 ppm) were attributed also to the phoshate dust particles.

The general conclusion that can be drawn from all the reports on the environment of the nothern Gulf of Aqaba, is that phosphate dust particles are a major source for total phosphate-phosphorus, Cd, Zn, Cu, F and U in sediments. Moreover, it is a potential source for these pollutants for benthic fauna and flora in the northern Gulf of Aqaba. The possible dissolution of the phosphate dust particles may increase the concentration of dissolved phosphate and metal species in sea water of the Gulf. Eutrophication is the most dangerous potential consequence, phosphate dust deposition on coral reefs and low calcification rate in corals (phosphate poisoning) are other important consequences (Simkis, 1964).

The effects of phosphate dust are not limited to the introduction of chemical species in the marine enviroment. It also increases the total load of suspended matter and the sedimentation rate in the affected areas, increasing water turbidity and thus adversely affecting marine life. The phosphate berth area is characterised by a relatively high load of suspended matter, high sedimentation rate and decreased water transparency (Table 5).

References

Abu-Hilal, A.H., 1985 Phosphate pollution in the Jordan Gulf of Aqaba. *Mar. Pollut. Bull.* 16:285-285.

Abu-Hilal, A.H, 1986. Fluoride distribution in the Jordanian Gulf of Aqaba (Red Sea). *Sci. Total Environ.* 49:227-234.

Abu-Hilal, A.H., 1987a. Distribution of trace elements in nearshore surface sediments from the Jordan Gulf of Aqaba (Red Sea). *Mar. Pollut. Bull.* 18:190-193.

Abu-Hilal,A.H.,1987b. Distribution and forms of phosphorus in a phosphate polluted coral reef area in the Jordan Gulf of Aqaba. *Dirasat.* 14:137150, Univ.Jordan, Amman-Jordan.

Abu-Hilal,A.H., 1993. Observation on heavy metal geochemical association in marine sediments of the Jordan Gulf of Aqaba *Mar. Pollut. Bull.* 26:85-90.

Abu-Hilal,A.H., 1994. Effect of depositional environment and pollution sources on uranium concentration in sediments,coral, algae and seagrass species from the Gulf of Aqaba(Red Sea) . *Mar. Pollut.Bull.* 28(2): 81- 88.

Abu-Hilal,A.H. and S.M. Al-Moghrabi, 1994. Marine survey on environmental conditions of the coastal waters offshore the Aqaba thermal power plant site in the Hashemite Kingdom of Jordan. Final report prepared for Jordan Electricity Authority, Amman, Jordan, by the Marine Science Station, Aqaba, Jordan.

Abu-Hilal, A.H. and S.M. Al-Moghrabi, 1995. Marine environmental survey of physical, geochemical and biological characteristics of coastal waters, nearshore sediments and coral reefs of the Gulf of Aqaba (Jordan). A final report prepared for Pacific Consultants International (Japan), Japan International Cooperation Agency (JICA) by the Marine Science Station, Aqaba- Jordan.

Abu-Hilal,A.H., M.I.Badran, J.Vaugelas,1988. Distribution of trace elements in Callichirus laurae burrows (Crustacea, Thalassinidae), Jordan Gulf of Aqaba (Red Sea). *Mar.Environ. Res.* 25:233-248.

Abu-Hilal,A.H.,M.I.Badran, 1990. Effect of pollution sources on metal concentration in sediment cores from the Gulf of Aqaba (Red Sea). *Mar Pollut. Bull.* 21:190-197.

Fishelson, L., 1973. Ecology of coral reefs in the Gulf of Aqaba (Red Sea) influenced by pollution. *Mar.Biol.* 12, 55-67.

Freemantle, M.H.,N.Hulings, M.Mulqi and E.C. Watton ,1978. Calcium and phosphate in the Jordan Gulf of Aqaba. *Mar.Pollut.Bull.* 9,79-80.

Hulings, N.C.1979. Currents in the Jordan Gulf of Aqaba. *Dirasat.* 6,21-33. Univ. Jordan, Amman-Jordan.

Hulings, N.C.1982. Uranium in the sediments of the Gulf of Aqaba. *Mar.Pollut.Bull.* 13, 47- 49.

Hulings,N.C.1989. A review of marine science research in the Gulf of Aqaba.Marine Science Station, Aqaba- Jordan.

Hulings, N.C. and A.H. Abu-Hilal, 1983. The temporal distribution of nutrients in the surface waters of the Jordan Gulf of Aqaba. *Dirasat.* 10, 91-105. Univ. Jordan-Amman, Jordan.

Jordan Phoshate Mines Company (1993). Report for 1993 " *50 Years of Experience in Phosphate Mining.* JPMC. P.O.Box 30 Amman, Jordan.

Kinsey, W.D. and P.I.Davies, 1979. Effect of elevated nitrogen and phosphorus on coral reefs growth. *Limnol. Oceanogr.* 24, 935-940.

Klinker,J., Z. Reiss, C. Kropach, I. Levanon, H. Harpaze, E. Halicz, 1976. ObservationS on the circulation pattern in the Gulf of Ellat (Aqaba), Red Sea. *Israel J. Earth Sci.* 25, 85-103.

Klinker, J., Z. Reiss, C. Kropach, I.. Levanon, H. Harpaz and Y.Shapiro, 1978. Nutrients and biomass distribution in the Gulf of Aqaba (Eilat), Red Sea. *Mar.Biol.* 45,53-64.

Levanon-Spanier, I., E. Padon, and Z.Reiss, 1979. Primary production in a desert enclosed sea- The Gulf of Eilat (Aqaba), Red Sea. *Deep Sea Res.*26,673-685.

Marine Science Station Monitoring programme, 1994. Marine Science Station. Aqaba- Jordan.

Morcos, S.A.1970.Physical and chemical oceangraphy of the Red Sea. *Mar. Biol.* Annual Rev. 8,73-202

Mulqi,M.W. 1978. The effect of phosphate rock dust on the calcium, magnesium and phosphate levels in the Jordan Gulf of Aqaba. Master in Science Thesis, Univ. of Jordan, Amman, Jordan .p. 84.

Schuhmacher, H., H. Koss and F. Brieda ,1982. Report on the environmental impact of industrial activities in the southern region. Environmental and Development studies for the southern region of Jordan. Ministry of Municipal and Rural Affairs (Jordan), and German Agency for Technial Cooperation (GTZ). PP. 1-135.

Seguin, G. 1978. Etude preliminaire du zooplankton des eaux Jordaniennes du Golfe d'Aqaba. Ann.Rep. Univ.Nice-Univ. Jordan Coop. Prog. pp 15.

Simkiss,K.,1964. Phosphate as crystal poisons. Biol.Rev.Cambridge.Phil. Soc. 39, 487-505.

Waldichuk,M.1985. Biologcal availability of metals to marine organisms. *Mar. Pollut.Bull.* 16, 7-11.

Walker, D.I. and R.F.G. Ormond, 1982. Coral death from sewage and phosphate pollution at Aqaba, Red Sea. *Mar. Pollut. Bull.* 13, 21 - 25.

Whitehead, N.E., J.Vaugelas de, P.Parsi, and M.C. Navarro, 1988. Preliminary study of uranium and thorium redistribution in Callichirus laurae burrows, Gulf of Aqaba (Red Sea). *Oceanologica Acta*, 11, 259 - 266.

Weaver,P.J., 1969. Phosphates in the surface waters and detergents. *J. Water Pollut. Control Fed.* 41, 1641 - 1653.

Table 1: Ship traffic and grand total exports and imports at Aqaba Ports during the last five years.

Year	Ships	Exports/ tonnes	Imports/ tonnes	Total/ tonnes
1990	2,222	8,871,857	6,164,599	15,036,456
1991	2,075	7,677,470	5,547,988	13,225,468
1992	2,430	7,361,798	6,021,703	13,383,501
1993	2,491	6,381,181	5,252,689	11,633,870
1994	2,485	6,648,377	3,923,903	10,572,280

Table 2: Grand total exports (tonnes) of phosphate fertilizer and other Industrial metrial through the Aqaba Ports during the last five years.

Year	Phosphate	Fertilizer	Potash	Cemment
1990	4,874,002	668,656	1,393,744	1,365,674
1991	3,564,960	663,263	1,265,294	1,268,429
1992	4,263,880	549,109	1,234,588	1,005,571
1993	3,564,960	412,245	1,452,063	694,453
1994	3,825,000	517,788	1,500,854	516,145

Table 3: **Some constituents of various grades of Jordanian rock phosphates (%).**

Constituent	Grade			
	El-Hassa	El-Abyad	Eshidiya	El-Hassa
P_2O_5	33.90	32.04-332.95	33.40-34.32	32.50
CaO	52.20	49.00-50.50	50.00-51.50	51.00
CO_2	4.20	4.00-5.00	3.00-4.00	4.00
SiO_2	3.15	4.50-6.50	3.00-5.50	5.00
Fe_2O_3	0.17	0.18-0.30	0.15-0.30	0.22
Al_2O_3	0.20	0.40-0.50	0.20-0.40	0.52
MgO	0.23	0.20-0.35	0.10-0.25	0.25
SrO	0.25	-	-	0.22
MnO	0.01	-	-	0.01
TiO_2	0.04	-	-	0.04
F	3.99	3.50-3.80	3.50-4.00	3.89
Organic matter	0.14	0.12-0.20	0.10-0.40	0.14
Trace metals (ppm):				
U	73			105
V	60			130
Cr	50			72
As	9			10
Cd	6			9
Cu	19			25
Mn	77			77
Zn	190			190

Table 4: **Concentration of total phosphate, fluoride, uranium, cadmium, copper, zinc and lead in sediments of the Gulf of Aqaba.**

Pollutant	Location (station)					Reference
	1	2	3	4	5	
Total Phosphate-P (% P_2O_5)	0.090 0.093 0.19	0.124 0.130 0.310	18.62 18.71 12.36	0.096 0.107 0.090	0.083 0.083 0.100	1 2 5
Fluoride %	0.014 0.014	0.103 0.10	2.64 2.65	0.013 0.012	0.014 0.013	2 1
Uranium (ppm)	-	5.0	16.2	3.94	-	4
Cd- Total (ppm) -non lithogenous	4.0 2.2	-	13.7 12.7	3.94 2.6	- -	3 3
Cu-total (ppm) - non-lithogenous	9.0 7.2	- -	25.6 23.6	115.5 7.2	- -	3 3
Zn-total (ppm) - non-lithogenous	35.2 15.2	- -	194.9 173	32.3 15	- -	3 3
Pb-total (ppm) - non-lithogenous	101.5 54	- -	168.3 139.5	96.3 62.5	- -	3 3

1. Abu- Hilal (1985) 2. Abu- Hilal (1986) 3. Abu- Hilal (1993)
4. Abu- Hilal (1994) 5. Abu- Hilal and Al-Moghrabi (1995)

Table 5: Secchi disc readings, suspended solids (TSS) and sedimenation rates recorded at the northern Gulf Aqaba (Jordan).

Station	Secchi disc reading (m)	TSS ($mg.1^{-1}$)	Sed. rate $mg.cm.day^{-1}$	Reference *
Hotels Area	21.0	2.09-3.08	-	(1)
Phosphate Berth	21.8 24-25	1.96-2.97 2.60-3.13	- 3.15	(1) (3)
Marine Sci. Station	27.0	1.60-1.80	0.77	(3)
Industrial Area -Fertilizer Industry	18.30 25.3 34.0	2.29-3.86 2.30-3.02 1.56-3.86	- 0.35-1.48 -	(1) (2) (3)
Thermal Power Plant	- 20	- 1.30-3.02	- 0.49-1.50 0.41- 073	(1) (2)

* (1) Abu- Hilal and Al-Moghrabi (1995)
(2) Abu- Hilal and Al-Moghrabi (1994)
(3)Marine Science Station Monitoring Programme (1994)

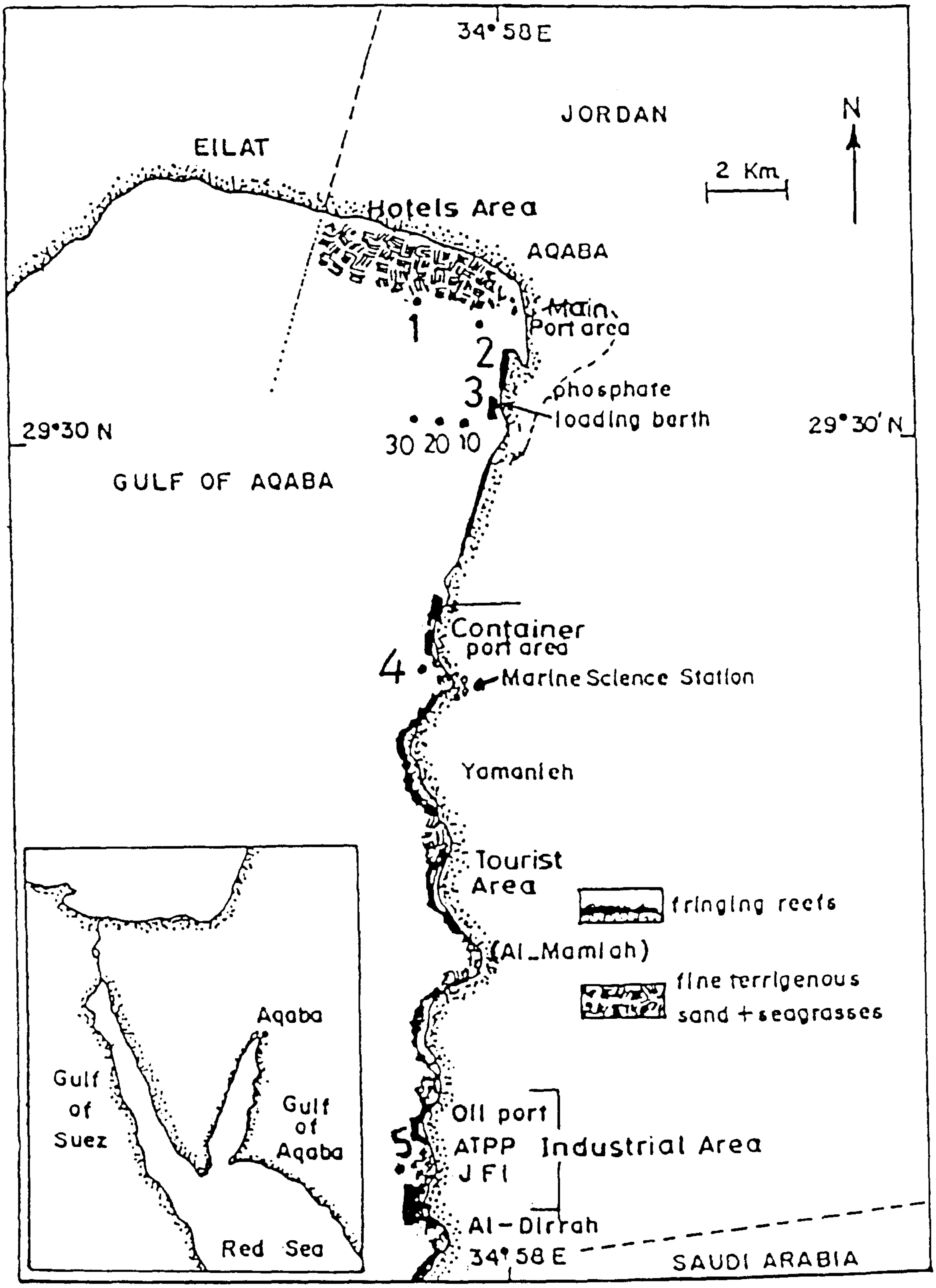


Fig.1 Detailed Map of the Jordanian Sector of the Gulf of Aqaba.

THE ROLE OF MARINE PARKS AND RESERVES AS A MECHANISM FOR LARGE SCALE MANAGEMENT OF COASTAL RESOURCES

by

M.P.Pearson

Ras Mohammed National Park Sector Development Project
Egyptian Environmental Affairs Agency

Abstract

Recognizing the close linkage between coral reefs, associated marine environments and tourism development objectives in Southern Sinai, the Government of the Arab Republic of Egypt developed, with assistance from the European Union, the Ras Mohammed National Park at the Southern extremity of the Sinai Peninsula. The National Park, now extended to cover 52% of the Egyptian Gulf of Aqaba littoral, has become the driving force behind a successful coastal zone management strategy that has achieved a balance between economic development activities and the conservation of critical marine resources.

Introduction

The purpose of this paper is to present, in the form of a case study, a model for integrated large scale management of coastal resources applied on the principles of coastal protected areas management. The case study will address the evaluation of Ras Mohammed Marine Protected Area (97 Km and 0.6% of the Egyptian littoral on the Gulf of Aqaba), Declared by Law 102 of 1983, into what is presently known as the Ras Mohammed National Park Management Sector. The Management Sector comprising the Ras Mohammed National Park .and the Managed Resource Protected Areas of Nabq and Abu Galum, together represent 2000 km of surface (marine, coastal and terrestrial) and 52% of the Egyptian littoral on the Gulf of Aqaba (fig-1).

The recognition that resource based tourism is limited by the condition and health of those resources that have engendered it is now well established. The Government of the Arab Republic of Egypt, conscious of this limitation, has charged its Environmental Affairs Agency with the task of ensuring that coral reefs and associated ecosystems are protected while permitting tourism development objectives to be reached. This mandate has become the basis for a successful coastal zone management plan that is establishing a balance between the development of coastal areas and the protection of their biodiversity and habitats.

Coastal Protected areas in South Sinai

At the request of the Government of Egypt a study was carried out (Pearson,1988) to determine the feasibility of and technical requirements for the development of the Ras Mohammed Marine Protected Area. The study proposed that the protection of coral reefs and associated environment in Ras Mohammed from rapidly encroaching tourism development could be achieved through; a) upgrading its status to that of National Park, b) re-definition of its boundaries and increasing its area to 210 km, c) establishment of strong management on the basis of the legal instruments pertaining to Protected Areas in Egypt, d) establishment of a monitoring programme to evaluate and modify management measures. This approach was meant to mitigate against rapid tourism development that would have seriously reduced the resource base in the time required to establish a resource inventory and apply traditional area management procedures.

Development of the Ras Mohammed National Park was initiated in 1989 with Technical Assistance and support from the European Union. The initial development phase lasting 30 months established the basis of an area management plan, provided essential equipment, initiated a public awareness campaign, recruited and trained staff and established a rudimentary, monitoring programme. The initial phase also demonstrated that resource management and strict protection measures did not imply a limitation to development activities.

It was shown that all development in Southern Sinai is resource based and that environmental degradation would lead to reduced economic potential and capital loss. The Government of Egypt reacted rapidly and declared all coastal area fronting the Sharm El Sheikh development zone as an integral part of the National Park. In so doing the government recognized the linkage between tourism development activities and coastal marine resources (coral reef and associated environments).

During 1992, following acceptance of the second phase of development for the National Park (Pearson 1991), the Government of Egypt declared the Nabq and Abu Galum Managed Resource Protected Areas. These areas including a Coastal Managed Area linking them (Fig-1) were added to the National Park to establish the Ras Mohammed National Park Management Sector.

Declaration of the above mentioned areas followed an extensive appraisal of planned development activities in Southern Sinai. Coastal environments were surveyed and classified according to uniqueness and sensitivity. Terrestrial environments were subject to similar appraisals given the linkages existing between marine and terrestrial environments. The studies led to the formulation of a plan that would establish Protected Areas adjacent to development zones on the Gulf of Aqaba. In so doing, development areas would be separated by large protected Areas that would provide space, undisturbed natural systems, economic opportunities in nature- based tourism and a mechanism to regulate development activities on an equitable basis firmly established on the principles of common property resources.

Environmental implications of rapid tourism development.

South Sinai's proximity to European tourism market and the economic requirement for foreign exchange due to tourism in Egypt have together resulted in rapid growth of tourism developments and associated infrastructure in South Sinai. Expansion and development of a tourism- based local economy (table-1) is reflected in the number of beds available in the area, 1030 in 1988 and an expected 12248 in 1995 (based on existing constructions due for completion in 1995). A development ceiling for the Sharm El Sheikh area has been set at 23,000 beds. Conservative estimates based on an average annual occupancy of 70% (National Park Surveys) imply that in 1995 approximately 520,000 visitors are expected to access the area.

The environmental consequences of tourism activities on fragile coastal ecosystems have been reported from numerous locations globally.In Egypt, the Red Sea resort complexes at Hurghada are a case in point. Unregulated tourism development has modified coastlines through infilling, coral reefs and associated environments have been severely damaged by siltation, anchor damage, fracture, abrasion, collection and waste water discharges.

Year	1988	1989	1990	1991	1992	1993	1994	1995
No. Hotels	5	7	8	15	18	27	36	40
No. Rooms	565	694	805	1492	1662	2578	4050	6124
No. Beds	1030	1276	1358	2906	3306	5190	8234	12248
Dive Centers	5	6	10	14	16	18	26	30
Shore Diving Sites	22	22	18	14	10	6	4	1
Dive Boats	23	25	47	60	89	120	200	240

Table.1: Tourism development trends. Sharm El Sheikh, Sinai, Egypt.

Unregulated tourism on coastlines adjacent to or fronted by coral reefs results in the rapid deterioration of coral reef resources to critically low levels. Species diversity on coral reefs is essential. Data on the dynamic of coral reefs is still insufficient to predict the consequences of reduced biodiversity or to even suggest at what point damage becomes critical and irreversible. It is therefore imperative to regulate development and tourism activities in coral reef or reef associated areas and to monitor impacts due to those activities on coral reefs. Continuous, targeted, monitoring programmes provide the means to assess the nature of damage and to propose mitigating measures to, where possible, redress the problem and permit coral reef areas and coastal ecosystems to recover.

In South Sinai, regardless of the rate of development, regulatory procedures established by the Egyptian Environmental Affairs Agency through its National Parks and Protected Areas Department have been in place since 1989. These procedures have effectively regulated tourism activities and related developments, and in so doing, have significantly limited direct and indirect damage to coral reefs and associated environments.

Waste water discharges from either urban or development areas are absent on the Egyptian littoral of the Gulf of Aqaba. All domestic sewage is treated either at municipal biological treatment facilities or by individual hotel operators using biological compact treatment units. All effluents are then used to irrigate gardens or small scale tree plantations. The treatment process is completed by root filtration. As a result, there has not been any impact due to discharges on marine ecosystems in general and coral reefs in particular on the Aqaba coastline. Brine concentrates from desalination plants are also regulated. Discharge of these into receiving coastal waters are not permitted without prior dilution to a standard 10% of ambient salinity (41-43PPT). Shorelines and coral reefs adjacent to discharge points are closely monitored by National Park staff. Any changes to coastal environments attributed to specific discharge point lead to immediate closure of that facility. Agreed modifications are then carried out by the owner, verified by the National Park, endorsed by the EEAA who then authorizes the facility to operate.

Divers currently represent 38% of the total number of visitors to Sharm El Sheikh, down from 85% in 1989 . Despite this significant reduction in relative resource use, the number of divers has increased since 1989. As a result, the number of Diving Centers and the number of diving vessels they operate in the area has increased from 6/25 respectively in 1988 to 26/200 in 1994 (Table-1). Damage to coral reef due to diving activities has occurred (Table-2, Ormond, 1993), but these have been minimized through the use of fixed mooring, a total ban on the use of anchors, a ban on fish feeding, diver education programmes (Table-3, Medio et al ,1994) and close cooperation with commercial operators in the area. The concept of community based management has been applied and this has now been extended to include procedures to identify abnormal events on reef areas (Crown of Thorns *Acanthaster planci*, Bleaching, White Band disease, human impacts, illegal practices, discharge of hydrocarbons, etc.) Staff of the National Park monitor these events and apply solutions to, where possible, reduce the resulting impact to coral reef resources. The Crown of Thorns problem is investigated in cooperation with the Great Barrier Reef Marine Park Authority (Lassig, 1994).

Reef section dived/ undived	Damage type. Abrasion	Damage type. Crushed	Damage type. Broken	Damage type. Knocked over	Damage type. Bleached
Mid reef flat. undived	0	0.01	0.16	0	0
Outer reef flat. undived	0	0.07	0.01	0	0
Upper reef face. undived	0	0	0.01	0.01	0
Lower reef face. undived	0	0	0.09	0.32	0
Mid reef flat. dived.	1.69	3.07	0.45	0.54	0
Outer reef flat. dived	3.08	0.75	5.33	0	2.23
Upper reef face. dived.	3.97	0.21	0.21	0.01	0.42
Lower reef face. dived	0.02	0.01	0.11	0.03	0.07

Table 2. Damage to reef section on dived and undived reefs. Values given as percentages of a square meter damage category. (Ormond, 1993).

<u>Monitoring Coastal Marine Resources in the Management Sector</u>.

The nature of coral reefs and associated marine environments in the Gulf of Aqaba have been described (Mergner, 1971, Sheppard et al, 1992), but regardless of the volume of data available and published on this area, few data or analyses are available to clearly define the nature, extent, complexity and linkages between coral reefs and associated marine environments represented in the Gulf. No data is yet available to determine the susceptibility of these systems to human induced impacts.

	Before briefing	After briefing	Control
Voluntary impact % of total impacts.	50	65	40
Involuntary impact % of total impacts.	50	35	60
Voluntary on dead substrate % voluntary	4	60	30
Voluntary on live corals % voluntary.	70	20	70

Table 3. **Changes in the number of impacts as a result of diver education (full ecological and management briefing) prior to diving on coral reef in the National Park. The values represent, as a percentage, the various contacts diver has with the reef during observation periods, before an ecological briefing, after the briefing and during control weeks where no briefings were given**

In order to assess the success of the management and regulatory measures applied by the EEAA through the protected Area programme, and to determine the impact of tourism and related development activities on the coastal ecosystems, the National Park has established a Monitoring Unit whose function is to assess the state of marine environments and to coordinate research activities of visiting scientists.

Monitoring activities are designed to respond to both long and short term objectives These can be categorized as follows:

resource inventories: baseline data and establishment of a comprehensive GIS (ERDAS, ENVI software, SPOT and LANDSAT- TM images).

long term monitoring: fixed transects, permanent photo monitoring station, physical parameters, dynamics and interactions of coral reefs, mangrove and sea grass systems.

short term monitoring: study and control of abnormal phenomena (crown of thorns, etc.), beach dynamics, flash floods, assessment of artisanal fisheries and their effect on reef areas.

evaluation of environmental impact assessments: verification of impacts and mitigation measures for all development activities adjacent to or fronting Protected Areas.

damage assessments and valuation of damage: shipping accidents and litigation.

co-ordination of research activities: visiting scientists and graduate students having research and field work programmes in the National Park and Coastal Protected Areas.

consultancy services: protection of coral reef resources adjacent to tourism development projects

laboratory facilities: operation and management of the laboratory facilities in the Ras Mohammed National Park.

The National Park and protected Areas development programme has provided an opportunity to address coastal zone management issues on a scientific basis. Resource inventories and baseline data gathering requirements have been met through the establishment of links with Egyptian Academic Institutions. Experts in relevant marine and terrestrial disciplines have been contracted to provide data to assess the nature of the resource base throughout the Protected Areas network in South Sinai and from specific fixed monitoring stations.

Staff of the National Park, faced with the task of evaluating the success of management decisions, have developed an effective technique to study changes on coral reef and associated environments. This technique, uses GIS software in macro mode to determine changes occurring at fixed photo monitoring station on accessible reefs and closed reference reefs. Images taken at intervals (with zero shift) are overlain and compared by the software which identifies all segments of the image where a change has occurred. Using this technique it is possible to determine: growth rates of sessile invertebrate fauna; damage to coral due to diver impact; ecological interactions; competition for space; settlement rates; changes due to natural events and any other parameter of interest to the reef scientist. The technique being two dimensional has obvious limitations, but given that up to 89%

of the biological material present is being recorded and given that images can be retained for future reference, the technique remains a powerful management tool.

Other techniques used to assess the health of coral reefs and associated environments are: in situ fish population estimations using visual census techniques; the incidence of coral mortality due to pathogenic diseases; and fixed belt transects at selected locations and on reference reefs (Medio et al, 1994).

The monitoring unit is called in any event resulting in damage to coral reef areas (ship grounding, illegal collection of marine fauna, etc.). In these cases the unit records the damage, assesses the implications of the damage and estimates a period for recovery of the damage site. The unit then sets a monetary value for the damage based on an economic valuation of the reef. . The economic valuation is based on the total capital investment in resource based tourism in development areas adjacent to the damage site and diving tourism revenues. Theoretical values of the valuation process (existence value, future value, etc.) have not been considered.

The national Park also offers a free consultancy service to both investors and local government authorities. In these cases, the monitoring unit will study the ecological implications of proposed development on coastal resources. The results are used by Park Management to either accept the proposal or suggest modifications that will mitigate or eliminate expected damage. This service has provided the National Park with the opportunity to establish partnership with individual developers. These partnerships are based on the principle that coral reef resources, though an integral part of the National Park ,are also critical to the economic sustainability of the tourism project. Through the partnership, the developer recognizes the existence of the National Park, guarantees not to alter or damage coastline, not to discharge any effluent without prior approval, to prevent all domestic waste water from reaching the sea and to make their guests aware of National Park Regulations. The National Park remains available to the developer, on request, to solve any problems.

Experience to date has shown that the above mentioned formula combining management, monitoring and community based management all provided by the National Park and EEAA are an effective means to achieve functional and equitable large scale coastal zone management objectives.

Replicability of the Egyptian Coastal Zone Management model

The Coastal Zone Management Programme implemented in South Sinai on the principles of protected Areas Management owes its success to increased awareness and commitment to preserve marine resources by the private sector; strong support for the programme by the government sector; and a solid legislative basis for the implementation of controls and regulatory measures.

Conditions for achieving coastal zone management objectives are not automatic, they are the result of considerable effort, argument, analysis and a slow erosion of conceptual barriers that have traditionally linked resource protection measures to development exclusion measures.

The result achieved in Southern Sinai are clear, the programme therefore lends itself to replication in any coastal state having economic development priorities where the resultant environmental implications of that development are recognized.

Data from the World Conservation Monitoring Center (Table-3) suggest that most countries having littoral on the Red Sea, also have Protected Areas declared on that littoral.

Country	No of Areas	Coral/Mangal	Surface (Ha)
Djibouti	2	yes	N.A
Egypt	4	yes	228.300
Eritrea	1	yes	200.000
Saudi Arabia	3	yes	510.200
Sudan	1	yes	26.000

The Egyptian model is transferable, the conditions for success are both simple, clear and applicable within the economic framework and legal structure of any of the above mentioned coastal states. The present climate of co-operation can lead to technology transfers, training opportunities, networking and co- ordination of monitoring programmes and the protection of marine and coastal ecosystems, all on a regional basis.

References

Kelleher, G. and Kenchington,1991. Guidelines for Establishing Marine Protected Areas. *A Marine Conservation and Development Report.* IUCN, Gland, Switzerland., 79pp.

Lassig, B., 1994. Crown of Thorns starfish surveys in the Ras Mohammed National Park, Egypt. Great Barrier Reef Marine Park Authority. *Consultancy report to the Egyptian Environmental Affairs Agency.*

Medio, D., M. Pearson and R.F.G. Ormond, 1994. The rates of damage to coral reefs by divers and the effectiveness of environmental awareness briefings. *Biol. Conserv.* (in press).

Mergner, H. 1971. Structure,ecology and zonation of Red Sea reefs (in comparison with South Indian and Jamaican reefs). In: *Regional variation in Indian Ocean reefs* . Symposium , Zool. Soc. London 28. Eds D.R.Stoddart and C.M.Yonge. Academic Press, London, pp. 141-161.

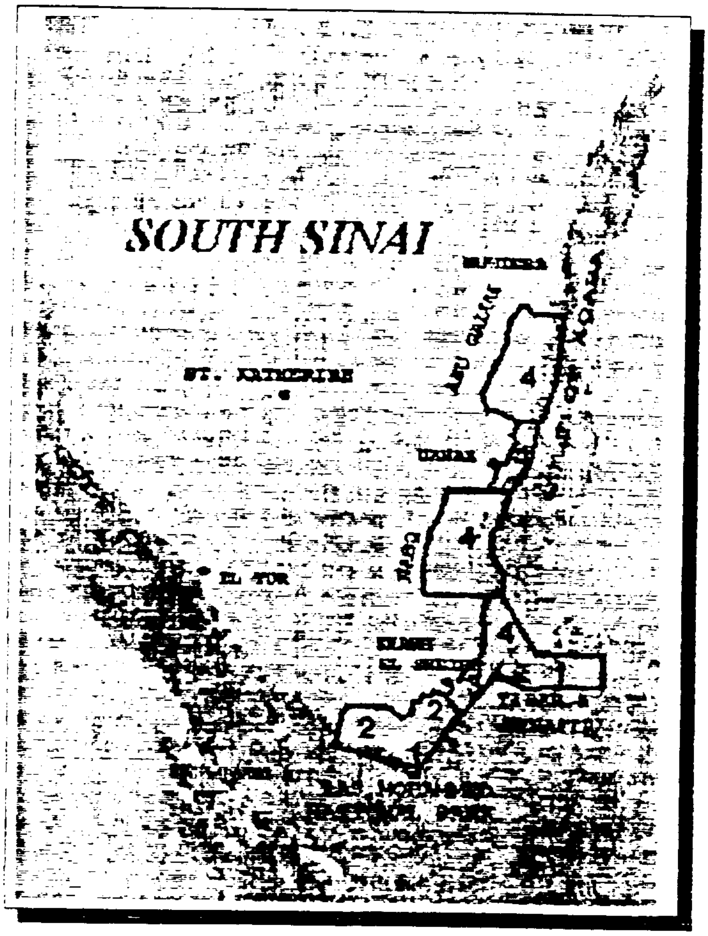
Ormond, R.F.G., 1993. Reef Fish and Fisheries and the Balance of Reef communities. *Int. Conf. Towards the Development of Sustainable Wildlife Conservation Strategy*, Sharm El Sheik, Egypt.

Pearson, M.P.,1988. Specification study for the development of the Ras Mohammed Marine Protected Area, Sinai, Egypt. Commission of the European Community, DG1.

Pearson, M.P.,1991. Specification study for the development of the Ras Mohammed National Park Sector, Phase II: Ras Mohammed National Park, Nabq Resource Protected Area, Abu Galum Resource Protected Area. Commission of the European Community, DG1.

Sheppard , C., A.Price and C. Roberts, 1992. *Marine Ecology of the Arabian Region. Patterns and processes in extreme tropical environment*. Academic Press, London.

RAS MOHAMMED NATIONAL PARK SECTOR: GROWTH AND DEVELOPMENT MILESTONES FROM 1983 TO 1994



LEGEND.

[1]- The Ras Mohammed Marine Protected Area is enacted by Law 102 of 1983. The original boundaries included the Ras Mohammed peninsula and the islands of Tiran and Senafir.

[2]- June 1989: The limits of the Marine Protected Area are extended. Its status is upgraded to that of a National Park prior to and as a consequence of the implementation of the Ras Mohammed National Park Management Project, a Technical Assistance from the European Communities to the Government of the Arab Republic of Egypt.

[3]- 1991. The two parts of the National Park are joined. The jurisdictional limits of the Park and the EEAA are defined as the highest equinox tide line in this link area that fronts land designated for tourism development.

[4] - 1992. The Protected Areas of Nabq and Abu Ghalum were declared by Prime Ministerial Decree 1511 of 1992. Both Protected Areas are classified as Multiple Use Management Areas and, together with territories contained in the Ras Mohammed National Park, now comprise the Ras Mohammed National Park Sector (South Sinai Sector).

ورشة عمل عن أسهام علوم البحار فى الإدارة المتكاملة للمنطقة الساحلية فى البحر الأحمر وخليج عدن.
IOC/ UNEP/ PERSGA/ ACOPS/ IUCN Workshop
جدة ٨ أكتوبر ١٩٩٥ ١٣ - جمادى الأولى ١٤١٦

مقترحات ببرنامج للبحوث والرصد

يوسف حليم و سليم مرقس

المحتويات:

مقدمة

تعتبر الأنشطة البشرية فى المنطقة الساحلية وفى الداخل العامل الرئيسى فى تدهور البيئة البحرية فى كافة البحار الأقليمية بما فى ذلك البحر الأحمر. ويقدر أن ما يزيد على ٧٠٪ من التلوث البحرى ناتج عن المصادر الواقعة على البر بما فى ذلك التلوث المنقول جوا. وفى البحر الأحمر يزداد حال البيئة خطورة حول المراكز الحضرية وكذلك المراكز الصناعية وما لم يتم التحكم فى هذا الحال يخشى أن يزداد تدهور البيئة مستقبلا بما قد يؤدى إلى تدمير المواطن الطبيعية للأحياء وكذلك الثروات الطبيعية تدميراً لا علاج له.

لقد دعت IOC اللجنه الدولية الحكومية للمحيطات إلى عقد ورشة العمل هذه تلبيةً لحاجة دول المنطقة لإتاحة قاعدة بيانات علمية عن البيئة البحرية بإعتبار ذلك كشرطا مسبقاً لوضع برنامجا تعاونيا يهدف إلى دمج تدابيرحمايه البيئة مع خطط التنمية الإقتصادية فى المنطقة الساحلية فى أطار الأتفاقيات الأقليمية القائمة والتوجيهات والتوصيات الدولية (أتفاقيه الأمم المتحدة لقانون البحار، مؤتمر الأمم المتحدة للبيئة والتنمية بريو).

الإلتزامات الدولية:

إن إتفاقية الأمم المتحدة لقانون البحار (UNCLOS) قد أصبحت سارية المفعول منذ (تشرين ثان) نوفمبر عام ١٩٩٤. ولقد وضع قانون البحار إطاراً قانونيا شاملا لإلتزامات الدول ينبثق منه المزيد من المواثيق الدولية والتدابير الوطنية ووفقا لهذا الأتفاقية فعلى جميع الدول أن تلتزم بواجب أساسى ألا وهو الحفاظ على البيئة البحرية وحمايتها. وإن كان للدول أن تتمتع بكافة حقوقها السيادية فى إستغلال مواردها الطبيعية إلا ان ممارسة هذا الحق ينبغى أن تتفقا مع واجبها نحو حماية البيئة البحرية . وعليه فهناك العديد من الإلتزامات. فعلى جميع الدول أتخاذ كافة التدابير اللازمة لمنع وتقليل تلوث البيئة البحرية من كافة المصادر. والتحكم فيها وتتضمن هذه التدابير الإجراءات اللازمة لحماية النظم البيئة النادرة والهشة وكذلك المواطن الطبيعية للأحياء المائية المهددة بالأنقراض.

وعلى تلك الدول أن تسن القوانين واللوائح التى من شأنها منع وتقليل تلوث البيئة البحرية من المصادر الواقعة على البر والتحكم فيها مع مراعاه القواعد والمعايير المتفق عليها دولياً.

وفيم يختص بعمليات الرصد والتقييم البيئى، فالدول ملزمة برصد عواقب التلوث على البيئة البحرية بالأساليب العلمية المعترف بها وبوضع الأنشطة التى يحتمل أن تحدث تلوث للبيئة البحرية تحت الملاحظة وبنشر نتائج عمليات الرصد.ووفقا للأتفاقية فالدول ملزمة أن تتعاون لتطوير القدرات العلمية والتكنولوجية للدول النامية وبامدادها بالمعونه كما أنها ملزمة بمعاونتها فى أجراء دراسات العواقب.

ويسلم الباب السابع عشر من جدول أعمال القرن الواحد والعشرين (Chapter ١٧, Agenda ٢١, UNCED ١٩٩٢) التى أعتمدها مؤتمر ريو عام ١٩٩٢ بأن أتفاقية الأمم المتحدة لقانون البحار يؤكد الأساس القانونى الدولى الذى تقوم عليه حماية البيئة البحرية والتنمية المتواصلة لها. ويؤكد الباب السابع

عشرمن جديد الألتزام الرئيسى للدول الساحليه بما يتفق مع قانون البحار كما يضع تندرج تحتها الأحكام الرئيسية لهذا القانون

ولقد أصبح مفهوم تلوث البحار أكثر شمولاً فى الباب السابع عشر بحيث أمتد إلى عواقب مختلف الأنشطة البرية. وهذا الأتجاه يعكس الأعتقاد فى أن قضية التلوث من المصادر الواقعة على البر مرتبطة بإدارة كافة الأنشطة البشرية فى المناطق الساحليه.

ينبغى على الدول الساحلية بتأييد منظمات الأمم المتحدة عند الطلب أن تضع الضوابط الكفيلة بالإبقاء على التنوع البيولوجى وأنتاجية الأحياء البحرية وعلى مواطنها وبما فى ذلك أجراء حصر للأنواع المهددة والمواطن الساحلية الحرجة وإنشاء والمناطق المحميه وإدارتها.

كما أن الدول مدعوة للقيام بالأتى:

أ) دعم الإتفاقيات الأقليمية القائمة أو العمل على وضع أتفاقيات أقليمية جديدة لدى الأقتضاء لمنع التلوث البحرى من المصادر والأنشطة البرية والأقلال منه والتحكم فيه.

ب) إعداد وتنفيذ الخطط اللازمة للإدارة المتكاملة للمنطقة الساحلية والتنمية المتواصلة لها.

جـ) تحديد المعالم الرئيسية للمنطقة الساحلية مع تحديد المواقع ذات الظروف الحرجة.

د) أجراء تقييم العواقب البيئية قبل تنفيذ أية مشروعات كبيرة ومتابعة عواقب هذه المشروعات.

هـ) النهوض بالمجتمعات البشرية الساحليه وخاصة فيما يتعلق بالإسكان ومياه الشرب ومعالجة مياه الصرف الصحى والمخلفات الصناعية والتخلص منها.

و) التعاون مع البلدان النامية ومن خلال الدعم المالى والتكنولوجى.

المصادر البرية لتلوث البحار.

لا يوجد فى الوقت الحاضر مخطط عالمى للتحكم فى المصادر البرية لتلوث البحار إلا أن برنامج الأمم المتحدة للبيئة أدراكا منه للحاجة إلى تشريع ملزم لمنع التلوث الصادر من البر قد أعد المبادئ الأرشادية التى ينبغى مراعاتها عند تطوير الإستراتيجيات الوطنية وآليات التحكم وهى المبادئ الأرشادية الصادرة فى"مونتريال" عام ١٩٨٥. وأستجابة لطلب مؤتمر ريو عام ١٩٩٢ سوف يعقد مؤتمر لممثلى حكومات الدول عن الأنشطة البرية بدعوة من برنامج الأمم المتحدة للبيئة عام ١٩٩٥.

أثنان فحسب من بين أتفاقيات البحار الإقليمية لبرنامج الأمم المتحدة للبيئة تتضمن بروتوكولات بشأن منع تلوث البحار من تلك المصادر: وهما أتفاقيه برشلونة بشأن البحر المتوسط والبرتوكول الملحق بإتفاقية ليما بشأن جنوب شرق المحيط الهادى. ومما لا شك فيه أن التردد فى تطوير وأقرار المواثيق الملزمة على الصعيدين الوطنى والدولى من أجل منع التلوث من البر يمكن أرجاع أسبابه إلى التكلفة المرتفعة المتوقع أن تتحملها الصناعات والبلديات المتوقعة.

وضع البحر الأحمر وخليج عدن.

وافق المؤتمر العام لمنظمة التربية والعلوم والثقافة التابعة لجامعة الدول العربية (الكسو) عام ١٩٧٤ على توصية تدعو إلى إعداد برنامج تعاونى أقليمى لدراسة البيئة البحرية للبحر الأحمر وخليج عدن. وفى أكتوبر تشرين أول عام ١٩٧٤ دعت اليونسكو بناء على طلب الكسو إلى عقد ورشة عمل فى برمرهافن بألمانيا حول "برنامج لعلوم البحار فى البحر الأحمر" (يونسكو ١٩٧٦) وقد أتخذ هذا التقرير كورقة عمل لإجتماع الخبراء الأول الخاص بالبرنامج الإقليمى للدراسات البيئية للبحر الأحمر وخليج عدن فى جدة فى ديسمبر كانون أول ١٩٧٤. وقد تطلبت خطة العمل لعام ١٩٧٥ عدداً من الدراسات التمهيدية من جانب اللجنة الدولية الحكومية للمحيطات IOC، وبرنامج الأمم المتحدة للبيئة UNEP واليونسكو UNESCOأوجدت قاعدة للمداولات فى مؤتمر جدة لحماية البحر الحمر وخليج عدن (جدة٢) الذى دعا إليه الكسو فى يناير كانون ثان عام ١٩٧٦. ثم شكلت السكرتارية المؤقته لبرنامج PERSGA فى أطار الكسو. وفى فبراير عام ١٩٨٢ أجتمع مؤتمر أقليمى لممثلى الحكومات فى جدة وأعتمد الأتفاقية الإقليمية لحماية بيئة البحر الأحمر وخليج عدن. وتستضيف المملكة العربية السعودية فى الوقت الحاضر سكرتارية البرنامج فى جدة وتؤدى هذه السكرتارية أعمالها بالتشاور مع الدول الأعضاء بدعم من برنامج الأمم المتحدة البيئية UNEP وكذلك بالمعاونة الفنية من اليونسكو واللجنة الدولية الحكومية للمحيطات IOC. والمنظمة الدولية للنقل البحرى IMO والأتحاد الدولى للحفاظ على الطبيعة IUCN.إن مؤتمر جدة الذى أعتمد أتفاقية البحر الأحمر وخليج عدن أعتمد أيضاً خطة عمل (UNEP ١٩٨٦) ومشروع بروتوكول للتعاون على مكافحة التلوث بالزيوت وغيرها من المواد الضارة فى حالات الطوارئ (UNEP ١٩٨٣).

لقد تم تنفيذ عدة مشروعات وطنية وعقد دورات تدريبية وأجتماعات خبراء فى نطاق برنامج البيئه للبحر الأحمر وخليج عدن بعد أعتماد الأتفاقية بالتعاون مع برنامج الأمم المتحدة للبيئة واليونسكو والأتحاد الدولى للحفاظ على الطبيعة وهناك بعض التقارير ذات الأهمية الخاصة للأقليم عن "أدارة وحماية الموارد البحرية المتجددة فى البحر الأحمر وخليج عدن" (UNEP ١٩٨٥) وعن "حال البيئة البحرية فى البحر الأحمر وخليج عدن" (Halim et al, draft).

إن المعرفة العلمية للمناطق الساحلية للبحر الأحمر غير متكافئة جغرافياً. ولذا يتعين أجراء دراستين بصفة عاجلة تلبيه لمتطلبات الأدارة البيئية: الأولى خاصة بعملية حصر لكافة مصادر التلوث من البر وللأنشطة البشرية الجارية على السواحل والتى قد تضر بالبيئة البحرية والأخرى مقصود بها المسح الشامل للنظم البيئية وللمواطن الطبيعية المهددة.

إن طبوغرافيا حوض البحر الأحمر من حيث أنه حوض ضيق وشبه معزول عن المحيط تجعله أكثر حساسية لعواقب التلوث إذ تتراكم به على المدى الطويل الملوثات التى تصرف إليه خلافاً لما يحدث من

٥

تشتيت وتخفيف للملوثات فى المحيطات المفتوحة. إلا إن الضغوط البيئية الواقعة على البيئة فى هذه المنطقة يسببها معا أمرين: الصرف المباشر للملوثات ثم العديد من الأعمال فى المناطق الساحلية والبحرية (أنظر السمرة وموسى، ثم أولسن وآخرين وصالح ضمن أعمال ورشة العمل هذه). ويشكل التدمير الحادث للمواطن الساحلية البحرية المتسبب عن الأنشطة البشرية مشكلة كبرى قد تفوق فى خطورتها فى هذا الأقليم عواقب التلوث الكيميائى فيما عدى الزيوت.

لقد حدث تدمير لا يمكن تعويضه لبعض المواطن الطبيعية نتيجة للتنمية الساحلية الجائرة فى المدن الساحلية الرئيسيةللبحر الأحمر وخليج عدن. لقد حدث ردم لبعض المواقع الساحلية خاصة حول بعض المراكز السياحية مثل الغردقة والمراكز الصناعية مثل جدة وينبع، ورابغ، وجيزان، وكثيراً ما يحدث تآكل لمواد الردم بفعل الأمواج يعقبه ردم الشعاب المرجانية بالمواد الرسوبية ولما كان صب مياة الصرف الصحى دون معالجة إلى المنطقة الساحلية يقتصر على المراكز الحضرية فى البحر الأحمر فلا تزال بيئة البحر الأحمر وخليج عدن فى مجملها فى حالة مرضيه نسبياً فيما يختص بالتلوث بالمجارى إلا أنه من المتوقع أن يتزايد صرف مياه المجارى مع تزايد المراكز السكانية والسياحية وما يصاحبها من تزايد وحدات تحلية المياه.

والتلوث بالنفط هو أكثر الأمور المقلقة بالنسبة لبيئة البحر الأحمر وهذا ناجمه عن عمليات الإنتاج والتحميل والتفريغ وعلى الحوادث وكذلك على الصرف المتعمد من السفن وهناك حالات من التلوث المزمن بالزيوت على سواحل المملكة العربية السعودية وخليج السويس بمصر وميناء إيلات وإن كانت محدودة الأنتشار وهناك شواهد تدل على حالات متعمدة من تنظيف خزانات ناقلات البترول من البحر الأحمر وخليج عدن فى المناطق التى تضعف فيها المراقبه (أنظر عوض فى أعمال ورشة العمل هذه).

وتمثل الشعاب المرجانية ومايرتبط بها من أسماك وغير ذلك من الأحياء البحرية أكثر موارد البحر الأحمر أهميه بلاجدال من حيث القيمة الأقتصادية وأيضا بصفتها تراثاً طبيعياً ذو قيمة عالمية، إن أهميتها بالنسبة للسياحة فى غنى عن التوضيح إنما أهميتها بالنسبة للمصايد أقل وضوحاً فى نظر الجمهور العادى. والأحياء القاطنة للأرصفه المرجانية شديدة التنوع وعالية الكثافة فى البحر الأحمر ولذا فالمحصول القائم من الأسماك المرتبطة بالأرصفة المرجانية فى البحر الأحمر يتجاوز كثيراً المحصول القائم فى أكثر محيطات العالم إنتاجية وهذه الأنتاجية المرتفعة ترجع إلى المرجانيات ذاتها بقدر ما تعود إلى الأحياء النباتية المرتبطة بها. ما يسمى بالكساء الطحلبى أو البساط الخضرى وهذا البساط الخضرى يجتذب العديد من أنواع الأسماك العشبية التى ترعى فيه بشراهة وما يتبعها من أسماك قناصة تتغذى عليها.

وعلاوة على ذلك فالتنوع البيولوجى الفريد للأحياء المرتبطة بالأرصفة المرجانية يشكل مخزوناً كبيراً للجينات كما أن الكثير من الأحياء المرتبطة بها ذات قيمة طبية عالية قد تؤدى إلى تقدم كبير فى البحوث العلاجية مستقبلاً.

تقتصر الدراسات العلمية للأرصفة المرجانية بتجمعاتها فى البحر الأحمر على مواقع بعينها فى: خليج العقبة وبجوار الغردقة، وسواحل المملكة العربية السعودية وبورسودان، وإلى حد محدود جزيرة دحلج. واما عدا ذلك فلا توجد معلومات– وإن وجدت فهى جزئية وناقصة– عن شواطىء السواحل الأفريقية الممتدة إلى جيبوتى وكذلك شواطىء اليمن وشواطىء الجزر بأستثناء دحلج نسبيا ولا شك أن حالة الأرصفة المرجانية على جانبى البحر الأحمر ينبغى أن تقييم بأنتظام بشكل دورى وكذلك ما تتأثر به من عوامل سواءً كانت طبيعية أو من عمل البشر. لقد أجرى مسح على أمتداد شواطىء المملكة العربية السعودية عام ١٩٨٨م وفقا لهذا المنظور (أنظر عوض فى أعمال ورشة العمل هذه) ورصدت عدة أمراض مرجانية مشتبه أن يكون المتسبب فيها التلوث بالزيوت حول جدة وينبع إلا إن مدى أنتشار مثل هذه الأمراض لم يبحث عنه فى أى مكان آخر فى البحر الأحمر.

إن الأرصفة المرجانية معرضة للضغط البيئى فى المناطق المجاورة للمراكز السياحية الكبرى (يرجع إلى صالح فى أعمال ورشة العمل هذه) وللمرافق الصناعية الرئيسية وتوشك أسماك الأرصفة المرجانية أن تنقرض فى بعض المواقع نتيجة للصيد الجائر تلبيه للطلب المتزايد للوفود السياحية وربما كان من أكثر الأمور إضراراً بها عمليات جمع أسماك المرجانيات بغير ضوابط لأغراض التصدير.إلى المعارض وإلى الهواه وحيثما تجرى أية أعمال تنموية وأنشاءات بالقرب من الشواطىء تضار الأرصفة المرجانية نتيجة لتزايد الترسيب.

لأشجار المنجروف القدرة على النمو فى البيئة الساحلية فى الشريط البينى بين المد والجزر بفضل غدد خاصة طاردة للأملاح ولذلك فهى شديدة الحساسية للتلوث بطبقة من الزيوت ويعتبر البحر الأحمر جغرافياً أقصى البحار شمالاً التى تتواجد فيها المنجروف وهناك دلائل تاريخية تشير إلى أنها كانت أوسع أنتشاراً بكثير على جانبى البحر الأحمر مما هى عليه الآن فى يومنا هذا ولتجمعات الأحياء المرتبطة بالمنجروف دور هام فى النظم البيئية الساحلية وهى تمثل بيئة طبيعية وذات أهمية بالغة وذات دور أساسى بالنسبة لمصايد الأسماك والجمبريات، وتوفر جذورها موطنا ومأوى لصغار الأسماك والجمبريات كما أنها تساهم فى حماية الشواطىء من التآكل وتوفر الأشجار أخشابا لمختلف الأستخدامات ومرعىللحيوانات العشبية الأليفة.

والضغط الرئيسى الواقع على المنجروف فى البحر الأحمر ناتج عن الإستغلال المباشر لها وكذلك عن التعديات على الشريط الساحلى ويبدو أن معدل الأستهلاك معدل متزايد وعلى الشواطىء المصرية للبحر الأحمر تعرضت المنجرف لأضرار شديده نتيجة للتلوث بالزيوت فى العديد من المواقع والمقترح أن يتم إختيار بعض مواقع المنجرف فى البحر الأحمر للحفاظ عليها كمحميات (برنامج الأمم المتحدة للبيئة سنة ١٩٨٥م). ويعرض بيرسون Pearson فى هذا الأجتماع وصفاً للتجربة المصرية ويناقش مدى قابليتها للتكرار فى غيرها من المناطق.(أنظر بيرسون فى أعمال ورشة العمل هذه).

تدابير أستراتيجية مقترحة:

تقوم الأستراتيجيات الوطنية على أساس أحتياجات وأولويات كل دولة. إلا أنه على الرغم من ذلك ونظراً لأن حماية البيئة البحرية والساحلية المشتركة أمر يعنيها جميعاً فإن الدول الأعضاء تشرع فى تنمية استراتيجياتها الوطنية واضعة فى الأعتبار الإتفاقيات الأقليمية القائمة والإرشادات الدولية بالتشاور عند اللزوم مع الدول المجاورة ومع منظمات الأمم المتحدة المختصة. وفيما يلى بعض عناصر استراتيجية مقترحة من ورشة العمل هذه:

١- الأتفاقيات الدولية:

يوصى بوجه خاص أن تصادق كافة بلدان المنطقة - ما لم تكن قد قامت بذلك من قبل- على الأتفاقيات الدولية الخاصة بحماية البيئة البحرية من جميع مصادر التلوث بما فى ذلك المصادر الواقعة على البر. وتعتبر المصادقة على الأتفاقيات الدولية إلتزاماً بتطوير التشريعات الوطنية المقابلة وضمان الألتزام بتنفيذها وما يتبعها من المؤسسات المساندة لذلك.

٢- أعتماد بروتكول بشأن حماية البحر الأحمر وخليج عدن من مصادر التلوث من البر:

من الواضح أن دول المنطقة فى حاجة للإتفاق على وثيقة ملزمة قانوناً أو بروتكول لإتفاقية البحر الأحمر وخليج عدن من أجل منع وأقلال الصرف من البر أو التحكم فيه. وربما أفادت تجربة البحر المتوسط كنموذج يمكن تطويره كى يتوائم مع الظروف الخاصة للمنطقة.

وسيتضمن البروتوكول أرشادات وتدابير واجراءات يتم تطبيقها تدريجياً من جانب دول المنطقة. ويضع هذا البرتوكول- ضمن ما يضع- إلتزام على جميع بلدان الأقليم بإجراء تقييم للعواقب البيئية لكبرى المشروعات النمويه على السواحل قبل التصريح بها.

Environmental Impact Assessment.

ويوصى لذلك بإعداد فريق عمل فنى محدد المهام يتولى تشكيله برنامج بيئة البحر الأحمر وخليج عدن مع برنامج الأمم المتحدة للبيئة واللجنة الدولية الحكومية للمحيطات والمنظمة الدولية للنقل البحرى والأتحاد الدولى للحفاظ على الطبيعة PERSGA/UNEP/IOC/IUCN/IMO

وذلك للإعداد للإجتماع المقترح على أن يكلف فريق العمل هذا بالمهام الآتية:

أ- صياغة البروتوكول وتضمناته الماليه.

ب- وضع أقتراح لحصر مصادر التلوث من البر فى البحر الأحمر وخليج عدن وللترتيبات اللازمة لتنفيذه.

وينبغى أن يراعى فريق العمل ما يصدر عن المؤتمر الدولى الخاص بمصادر التلوث من البر المزمع أنعقاده فى واشنطن بالولايات المتحدة خلال أكتوبر، نوفمبر ١٩٩٥. وعقب توزيع تقرير الفريق على

الدول الأعضاء وعلى المنظمات الدولية المختصة وبعد أستيفاء المشاورات اللازمه ستدعو برسحا PERSGA مؤتمراً لممثلى الحكومات لإعتماد البروتوكول.

٣- أولويات العمل: برنامج للبحوث والرصد:

يرى أجتماع مجموعة العمل أنه من الوجهة الأستراتيجية هناك شرط مسبق لوضع سياسة رشيدة لإدارة البيئة البحرية والساحلية للمنطقة وهو تنفيذ برنامج متكامل البحوث والرصد فى البحر الأحمر وخليج عدن. وقد وضعت المقترحات التاليه فى أطار خطة العمل السابقة لبرسحا PERSGA وإن كانت بعض عناصر الخطة قد أعتبرت ذات أولوية أعلى من غيرها.

برنامج البحوث والرصد المقترح للبحر الأحمر وخليج عدن:

الأهداف:

الهدف الشامل لبرنامج البحوث والرصد هو إمداد الأطراف المتعاقدة فى إتفاقية البحر الأحمر وخليج عدن بقاعدة البيانات العلمية البحرية المناسبة للأدارة المتكاملة للبيئة الساحلية والبحرية وللتنمية المتواصلة لمواردها وعلى ذلك فالبرنامج المقترح ذو توجه تطبيقى.

وللبرنامج اهداف محددة وهى:

١- وضع وتنفيذ دراسة بعيدة المدى للعمليات الأفيانوغرافية الأساسية فى البيئة الساحلية والبحرية فى البحر الأحمر وخليج عدن.

٢- أعداد حصر نوعى وكمى لكافة الملوثات المنصرفة من المصادر البرية وللانشطة البشرية التى يحتمل أن تضر بالبيئة البحرية.

٣- التقييم الدورى لتركيز الملوثات ولأنماط تغيراتها فى البيئة الساحلية والبحرية بالمقارنة بالخلفية الطبيعية وكذا عواقب التلوث على الصحة العامة وعلى النظم البيئية.

٤- تقييم فاعلية السياسات الإدارية والضوابط التى أعتمدتها وتطبقها بلدان المنطقة مع تقديم المشورة نحو تحسينها أو نحو الأخذ بإجراءات وسياسات مستحدثة.

٥- دعم قدرات المعاهد الوطنية ورفع مستوى الخبرة بها لإجراء البحوث وعمليات الرصد والإدارة للبيئة الساحلية والبحرية فى البحر الأحمر وخليج عدن.

المبادىء:

١- **مستويات الأداء**: يقترح تنفيذ برنامج الرصد على مستويين مستوى المؤسسات الحكومية ومستوى المتطوعين المنتمين إلى منظمات غير حكومية. ويتم أختيار متطوعين من مختلف قطاعات المجتمع للتدريب فى ما يسمى بمعسكرات البحر الأحمر.من أجل القيام باعمال الرصد المبسطة ولجمع وحفظ بعض العينات لحين تحليلها فيما بعد. وبإشراك قطاعات المجتمع يتحقق هدفان هما أزدياد الوعى لدى الرأى العام والتوسع الجغرافى فى برنامج جمع العينات.

ومن جانب آخر فمن الأهمية بمكان تكليف المعاهد العلمية الحكومية بالجوانب العلمية للبرنامج بما يكفل استمرارية تنفيذه وللحصول على نتائج موثوق بها.

٢- **الأولويات**: يوضع برنامج الرصد بحيث يكفل العائد الأمثل وعلى ذلك فيتم التركز على تلك الملوثات المشتبه فى تأثيرها على الصحة العامة وعلى نوعية البيئة فى المنطقة. كما تعطى أولوية للمواقع والمواطن التى تستلزم عناية عاجلة.

٣- **أساسيات أفيانوغرافيا المنطقة الساحلية**: أن التعرف على العمليات الأفيانوغرافية الساحلية بما فى ذلك الأرصاد الجوية والعمليات الفيزيائية والكيميائية والبيولوجيه أمر ضرورى لمعرفة ظروف الخلفية الطبيعية ولتفهم مصير الملوثات وعواقبها. لذلك فيتضمن البرنامج دراسات للأفيانوغرافيا الساحلية.

٤- **التثبت من دقة النتائج وتماثل المناهج**: سوف يتضمن البرنامج آلية للتثبت من جودة النتائج ودقتها ولضمان الوثوق بها وصلاحيتها للدراسة المقارنة والتوصل إلى هذا الغرض يستدعى إيجاد برنامجا مكثفا لرفع قدرات المعاهد والعاملين وكذا تدريب دورى لمضاهاة أساليب التحليل وينبغى التزام الجميع بإتباع أساليب موحده لجمع العينات ولاجراء التحليلات، ولتأكيد جودة النتائج واتباع نموذج موحد لتسجيل البيانات.

المتطلبات المؤسسية:

أعد برنامج الأبحاث والرصد بمفهوم تعاونىعلى مستوى أقليمى ولذلك فينبغى وضع التنظيمات الكفيلة بإشتراك وتعاون كافه بلدان المنطقة سواء فى مراحل التخطيط المبكرة أو فى تسيير البرنامج. الا أن مسئولية تنفيذ البرنامج تقع على عاتق البلدان ذاتها بالتعاون الفنى مع المنظمات الدولية المختصة مثل اللجنة الدولية الحكومية للمحيطات IOC واجهزتها الفرعية وبرنامج الأمم المتحدة للبيئة UNEP والإتحاد الدولى للحفاظ على الطبيعة IUCN والمنظمة الدولية للنقل البحرى IMO. ولا بد أن يوضع فى الأعتبار التباين بين دول المنطقة من حيث القدرات الفنية والقدرات الإقتصادية ويقترح الآتى:

على مستوى المنطقة: تشكل لجنة فنيه قيادية دائمة:

standing Technical Steering Committee يشارك فى تشكيلها برنامج بيئة البحر الأحمر وخليج عدن PERSGA وبرنامج الأمم المتحدة للبيئة UNEP واللجنه الدولية الحكومية للمحيطات IOC والأتحاد الدولى للحفاظ على الطبيعة IUCN والمنظمة الدولية للنقل البحرى IMO بالتشاور مع دول المنطقة. تشكل عضوية اللجنة أساساً من خبراء من المنطقة الا أن الأمر قد يستدعى أشتراك خبراء من خارج المنطقة اذا دعت الحاجة إلى ذلك. وتتولى برسجا PERSGA أعمال السكرتارية الفنية والإنفاق على أعمال اللجنه كما يقترح أن يقوم برنامج الأمم المتحدة للبيئة بماله من علاقة طويله المدى بالمنطقة من خلال برنامجه للبحار الإقليمية بالأسهام فى تمويل أعمال اللجنة علاوة على أسهام واللجنه الدولية الحكومية للمحيطات والمنظمة الدولية للنقل البحرى وغيرها

تحدد المهام الرئيسية للجنة الفنيه القيادية الدائمة على الوحة الآتى:

أ- وضع الخطط التفصيلية لبرنامج البحوث والرصد بما فى ذلك أختيار الملوثات ذات الأولوية للرصد والعمليات الأفيانوغرافية والمواطن الطبيعية ومناهج البحث واستراتيجية جمع العينات ثم الجدول الزمنى للبرنامج.

ب- متابعة التنفيذ التعاونى للبرنامج وامداد الدول بالمعونة الفنية عند اللزوم.

ج- التعرف على احتياجات المنطقة فيما يختص بالتجهيز والتدريب ورفع كفاءة الأداء وذلك فى أطار البرنامج.

د- ضمان إيجاد الترابط والتنسيق مع البرامج الحكومية والدولية القائمة فى المنطقة بما فى ذلك برامج أدارة التنمية البيئية التى يدعمها البنك الدولى.

على مستوى الدول الأعضاء:

يتم أختيار ادارة حكومية أوما يزيد لتنفيذ برنامج البحوث والرصد ولتجميع البيانات اللازمة لإعداد حصر للمصادر البرية للتلوث. كما تعين كل دوله منسق مسئول عن تنسيق الأعمال ومتابعتها وكذلك عن الأتصال باللجنة القيادية الدائمة.

الأنشطة المقترحة للبحوث والرصد:

تجرى الأعمال على التوازى بين مسارين متكاملين:

أولاً: حصر المصادر البرية للتلوث والأنشطة الإجتماعية والإقتصادية المعنيه:

يعد حصر لكافة مصادر التلوث من البر وكذلك للأنشطة الإجتماعية والإقتصادية الراهنه والمرتقبة التى من شأنها الأضرار بالبيئة الساحلية والبحرية وذلك بواسطة خبراء محليين بالتعاون الكامل مع السلطات الوطنية. كما يتضمن هذا الحصر بيانا للإجراءات الإدارية المتبعة من جانب الدولة. وتبلغ

جميع البيانات والمعلومات للجنة القيادية لتختزن فى قاعدة معلومات. ويتضمن الملحق رقم ١ بعض الإرشادات المقترحة.

ثانياً: المشروعات الرائدة:

وافقت ورشة العمل خلال مداولاتها على أقتراح بالتنفيذ المرحلى للبرنامج كما رأت أولويات لكل من مرحله كما هو وارد فيما يلى:

المرحلة الأولى:

لا تتطلب المرحله الأولى سوى تدريبا أساسياً يمكن أن يجرى فيما يسمى بمعسكرات البحر الأحمر ومعدات ومحدودة لجمع العينات. خلال هذه المرحلة يجرى أتمام الترتيبات التنظيمية وتوضع موضع التنبؤ فعلياً. بما فى ذلك اللجنة القيادية الدائمة والمنسقون الوطنيون والمؤسسات الوطنية المطلق بالأمر كما يتم خلال هذه المرحله تنفيذ برنامجا مكثفاً لرفع كفاءة الأداء تمهيداً لأعمال المرحلة الثانية. وذلك بالتعاون مع منظمات الأمم المتحدة المختصة. **المشروع الرائد الأول: الرصد العينى بواسطة متطوعين من المنظمات غير الحكومية:**

يتناول هذا المشروع رصد حبيبات القار الطافية وكذلك الحبيبات المترسبة على الشواطىء والقمامة بأنواعها وبوجة خاص مواد البلاستيك ورصد يقع الزيت وتغيرات لون مياه البحر ونفوق الأسماك وأية من الظواهر ذات المغزى البيئى ويمكن أن يعتمد لتنفيذ هذا المشروع على متطوعين مدربين ينتمون إلى منظمات غير حكومية يختارون من بين مختلف القطاعات الشعبية مثل صيادى الأسماك وتلاميذ المدارس وغيرهم وسيدرب المتطوعون أيضاً على جمع وحفظ بعض العينات للتحليل فيما بعد.

المشروع الرائد الثانى الخواص الأولية للمياه الساحلية:

يعتبر هذا المشروع تمهيداً للمشروع الأفيانوغرافى المتكامل المقترح للمرحلة الثانية. هو يهدف إلى رصد بعض البيانات الأولية لبعض المتغيرات الأفيانوغرافية الأساسية للمياه الساحلية: وهى الملوحة ودرجة الحرارة والأكسجين الذائب ودرجة التعكير والمواد العالقة ومن الممكن أن يقوم بهذه القياسات مساعدون فنيون أو المبتدئين من الأفراد العلميين بعد التدريب.

المرحلة الثانية:

المشروع الرائد الثالث: العمليات الأفيانوغرافية فى المياه الساحلية:

يرد بالملحق الثانى بعض الإرشادات عن هذا المشروع وعلى اللجنة القيادية الدائمة وضع تفاصيل أستراتيجية تنفيذ المشروع بالتعاون مع اللجنة الدولية الحكومية للمحيطات IOC عند اللزوم.

المشروع الرائد الرابع: الرصد البيولوجى للنظم البيئية وللتنوع البيولوجى فى المياه الساحلية للبحر الحمر وخليج عدن

يهدف هذا المشروع إلى اعداد حصر للنظم البيئية الرئيسية كالشعاب المرجانية والمنجروف وحقول النباتات الزهرية البحرية والأخوار والسهول الطينية وغير ذلك على أمتداد جميع شواطىء البحر الأحمر وخليج عدن بما فى ذلك شواطىء الجزر وتسجيل الخواص البيولوجيه التى تعتبر مؤشرات لحالتها الصحية وللعواقب المحتملة للانشطة البشرية وقد نشرت تقارير من قبل عن النظم البيئية الساحلية سواء من المعاهد العلمية بالمنطقة أو من المنظمات الدولية ينبغى الرجوع إليها

ويستخدم لأغراض هذا الحصر تكنولوجيات نظام البيانات الجغرافية GIS من أجل رصد الشعاب المرجانية ومواقع المنجروف وأما الدراسات الميدانية.فسوف تتناول أكثر من جانب وعليها أن تتوصل إلى حصر أيكولوجى للأنواع والمواطن الطبيعية متكاملاً بقدر الإمكان و عليها أن تحدد العمليات التى تتحكم فى الإنتاجية وفى التنوع البيولوجى والعوامل التى تؤثر فيها وسيقدم المشروع وصفاً للتجمعات البيولوجيه وللأنواع السائدة وعلاقات التغذى بينها كما يتيح التعرف ايضاً على المجموعات المستغلة مثل الأسماك والرأس قدميات والصدفيات والقشريات وكذلك الموارد الحيه غير المستغلة وبحث ديناميتها فى علاقتها بعمليات الصيد ومواطن ومواسم التوالد ومواطن التربى وسلوكيات التغذى.

ينبغى أن يغطى المسح كافة شواطىء البحر الأحمر الا أن هناك أسبقية بالنسبة لنوعين من المناطق تلك التى تهددها مشروعات مرتقبة للتنمية المكثفة مثل خليج العقبة والمناطق التى لايعرف عنها الا القليل وهى السواحل الجنوبية للبحر الحمر وسواحل الجزر. وسوف يفيد مشروع الرصد البيولوجى من خبرات الأتحاد الدولى للحفاظ على الطبيعة IUCN فى هذا المجال

المشروع الرائد الخامس: تقييم ومراقبة التلوث بالزيوت فى البحر الأحمر وخليج عدن :

يهدف هذا المشروع إلى قياس مدى التلوث بالهيدروكاربونات الزيتية فى البحر الأحمر وخليج عدن فى علاقته بالمصادر الواقعة بحراً أو براً ومتابعة أنماط تغيراتها.

سيجرى تحليل للهيدروكاربونات الزيتية بما فى ذلك الهيدروكاربونات عديدة النويات فى المياه والرواسب وفى أنسجة بعض الأحياء المختارة. سيتم رصد حبيبات القار سواء الطافية أو المترسية على الشواطىء وتسجيل خواصها. وسوف يحتاج المشروع لبيانات عن العمليات الأفيانوغرافية الساحلية وللتركيب الحجمى لحبيبات الرواسب وطبيعتها. وسيتم أختيار مواقع جمع العينات بحيث تغطى البحر الأحمر بقدر الإمكان وإن كان من الممكن أن يركز المشروع فى البداية على بعض المناطق الحرجة مثل خليج السويس ومنطقة جدة.

المشروع الرائد السادس: قياس تركيز المواد الضارة فى البحر الأحمر وخليج عدن.

يقصد بهذا المشروع أجراء مسح لتركيز الفلزات الثقيلة والمواد العضوية المخلقة المتوقع أن تكون ذات شأن فى الإقليم. وسوف يتيح المشروع قاعدة معلومات عن كل من المناطق الملوثة حول المدن الساحلية والموانى الرئيسية والمناطق غير الملوثة نسبياً بأعتبارها مناطق مرجعية. وبأجراء عمليات المسح

بصفة دورية يمكن أن نتبين أتجاهات التغيرات على المدى الطويل وسوف يجرى تحليل لهذه المواد فى طبقات المياه وفى أنسجة الأحياء البحرية القابلة للأستهلاك البشرى على مختلف مستويات الشبكة الغذائية وفى المكونات ذات الدلالة من الرواسب وعلى اللجنة القيادية الدائمة أن تحدد نوعيات العينات وماهية الفلزات والموادالعضوية المخلقة ذات الأولويةبالنسبة للتحليلات وسوف يدعم التعاون الفنى مع هيئة GIPME (بحوث تلوث البيئة البحرية فى محيطات العالم) عمليات البحث والتحليل.

المشروع الرائد السابع: التلوث بالجراثيم.

ينبغى رصد مدى تلوث مياه الأستحمام وتلوث الأغذية البحرية بالجراثيم (البكتيريا والفيروسات) فى المناطق المجاورة للمدن الساحلية الرئيسية ولكافة التجمعات السكانية وذلك بصفة منتظمة.

ملحق رقم (١)

عناصر عملية حصر مصادر التلوث من البر والمسح الأقتصادى الأجتماعى لسواحل البحر الأحمر وخليج عدن.

١- البيانات الديموغرافية.

تعداد السكان ومعدل النمو السكانى.

الأحصائيات الصحية لسكان السواحل.

الإختلافات ذات الدلاله عن باقى السكان.

٢- مصادر التلوث من بلديات المدن.

المراكز الحضارية والمنتجعات السياحية.

نوعية مصادر التلوث.

شبكة المجارى والصرف الصحى.

وحدات المعالجة

مواصفات المصبات: الموقع ، الطول، العمق، معدل الصرف

الأعمال الهندسية على السواحل: تعديل السواحل، أعمال البناء على الشريط الساحلى.

٣- مصادر التلوث من الصناعة.

نوع الصناعة مثل: معامل تكرير البترول، مصانع الأسمنت، وحدات تحلية المياه، محطات توليد الكهرباء وغيرها.

حجم الأنتاج.

المناجم: أنواع الخامات، حجم الأنتاج.

أستهلاك المياه العذبة

مواصفات المصبات:

نوع وحجم المخلفات: مخلفات صلبة أو سائلة أو غازية.

وحدات المعالجة

٤- الموانى ومواقع تحميل البترول وأعمال البترول فى عرض البحر.

معدل الإستقبال

إنشاءات الموانى

تعميق الممرات الملاحية

حجم عمليات التحميل والتفريغ

رصد حوادث تسرب الزيوت: زيوت خام، مواد بترولية مستخلصة،حوادث أنسكاب خام الفوسفات وغيرها.

عمليات أستكشاف وأستخراج البترول فى عرض البحر: زيوت التشحيم، ومخلفات الإنتاج.

٥- المصايد:

اعمال الصيد على النطاق التجارى وعلى نطاق الجهود المحدودة وعلى نطاق الجهود الفردية الدلالات الإحصائية.

تركيب المحصول المصيد

مزارع الأحياءالمائية.

ملحق رقم (٢)

أرشادات مقترحة لرصد العمليات الأفيانوغرافية الساحلية على المدى الطويل

الهيدروغرافيا.

التيارات المائية

التبادل بين المياه الساحليه ومياه أعالى البحار.

معدل تجدد المياه.

التسلسل الرأسى للطبقات المائية.

المتغيرات المطلوبة: الملوحة، درجات الحرارة، الكثافة، قياس التيارات.

الحبيبات العالقة:

العكارة

معدل الصرف، المصادر، الإنتقال، المصير.

(الصرف من البر وتأكل الشواطئ، الترسب، أعادة الأنبعاث)

العواقب على الأنتاجية، والأرصفة المرجانية، ونقل الملوثات، والتراكم.

الكيماويات

الأكسجين الذائب والنسبة المئوية للتشبع.

المواد اللازمة للأنتاج الأولى: معدل الوارد منهـا، التوزيـع، التغـيرات الزمنيـة لكـل مـن الأمونيـا والنـترات والفوسفات والسليكات.