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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NO. 2

METEOROLOGY AND ENVIRONMENTAL
PROTECTION ADMINISTRATION (MEPA)

THE STUDY ON
AN ENVIRONMENTAL ASSESSMENT AND MONITORING
OF ARABIAN GULF
IN THE KINGDOM OF SAUDI ARABIA

FINAL REPORT

January 2001

CHIYODA-DAMES & MOORE CO., LTD.

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PREFACE

In response to a request from the Government of Kingdom of Saudi Arabia (KSA), the Government of Japan decided to conduct a master plan study on Environmental Assessment and Monitoring of Arabian Gulf and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Yasuhiro Shimazu of Chiyoda-Dames & Moore (CDM) Co., Ltd. to KSA, five times between March 1999 and November 2000. In addition, JICA set up an advisory committee headed by Mr. Masahiro Ota, JICA Development Specialist between March 1999 and November 2000, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of KSA and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I with to express my sincere appreciation to the officials concerned of the Government of KSA for their close cooperation extended to the Team.

January 2001

Kunihiko Saito
President
Japan International Cooperation Agency

January 2001

Mr. Kunihiko SAITO
President
Japan International cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "The Study on an Environmental Assessment and Monitoring of Arabian Gulf in the Kingdom of Saudi Arabia". This report has been prepared by the Study Team in accordance with the contracts signed on February 19,1999, May 20 1999 and May 10, 2000 between the Japan International Cooperation Agency (JICA) and The Study Team organized by Chiyoda-Dames & Moore Co.

The report describes the study results of developing guidelines for the national water quality monitoring program for coastal areas in KSA and developing a specific coastal water quality monitoring plan for the Arabian Gulf area.

The report consists of the Main Report and Summary Report, Supporting Report and Data Book, and Technology Transfer Report in English.

The Main report presents: i) existing states of coastal environment and water quality monitoring, ii) planning policy for the coastal water quality monitoring, iii) the coastal water quality monitoring plan for the Arabian Gulf area. iv) the laboratory plan in the future, and v) the recommendation on the improvement of organization structure for Coastal Zone Management.
The summary Report presents these results concisely. The Supporting Report describes technical details concerning the methods of coastal water quality monitoring including field surveys, analysis of sea water quality, laboratory management, and data analysis. The Data Book contains the collected data in KSA and detailed results of monitoring surveys. The Technology Transfer Report describes the various on the job and off the job training activities carried out in the course of the Study, and their evaluations.

We with to express grateful acknowledgements to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Environment Agency, and Embassy of Japan in KSA. We also with to express sincere appreciation to our counterpart, the Meteorology and Environmental Protection Administration (MEPA) of KSA. We hope that the proposed plan and guidelines will contribute to the realization of sustainable development of coastal areas in KSA.

Yours faithfully,

Yasuhiro Shimazu
Team Leader

Y. Shimazu

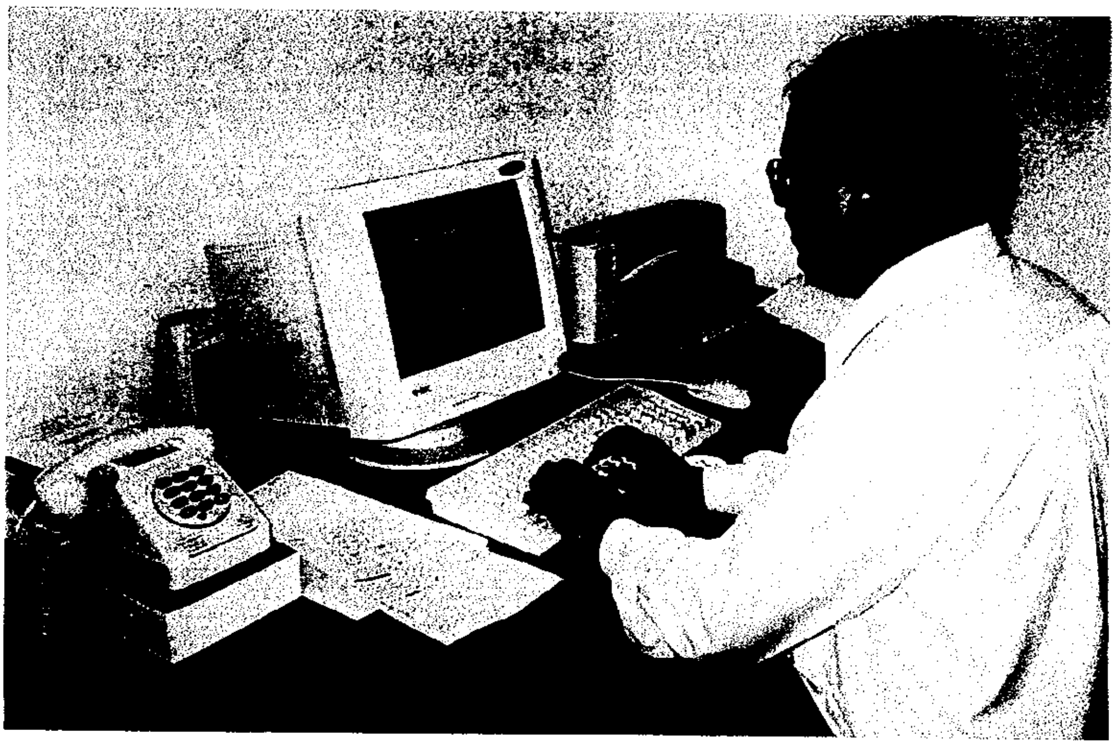
Monitoring Planning

Sampling Bottle Preparation

Field Sampling

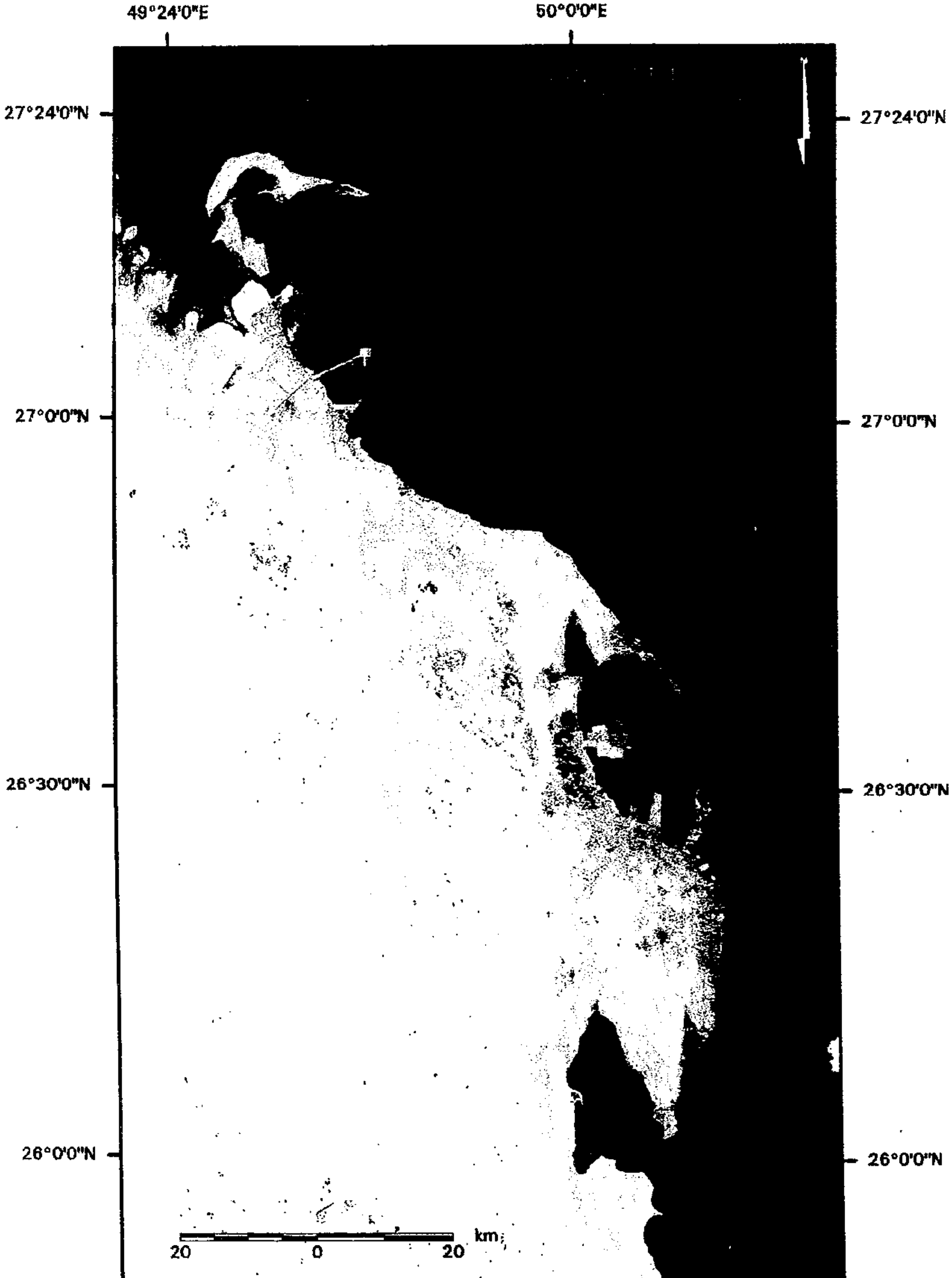
Field Sampling

Laboratory Analysis



Data Analysis

Intensive Study Area - Arabian Gulf, Saudi Arabia



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
METEOROLOGY AND ENVIRONMENTAL PROTECTION ADMINISTRATION (MEPA)

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List of Abbreviations /Acronyms

ACOPS	Advisory Commitee on Protecion of the Sea
ARAMCO	Arabian Oil Company
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
C/P	Counter Part
CZM	Coastal Zone Management
DO	Dissolved Oxygen
E.P.	Eastern Province
FL-ASS	Flameless Atrmic Absorption Spectrophotometer
GC-ECD	Gas Chromatography-Electron Capture Detector
GC-MS	Gas Chromatography-Mass Spectrometer
GDP	Gross Domestic Product
GSFMO	Grain Sils & Flour Mills Organization
HPLC	High Performance Liquid Chromatography
IC	Ion Chromatography
ICP-MS	Inductively Coupled Plasma-Mass Spectrometer
IOC	Intergovermental Oceanographic Commision
ISA	Intensive Study Area
IUCN	The World Conservation Union
ITCZ	Inter Tropical Convergence Zone
JICA	Japan International Coopeation Agency
KFUPM	King Fahad University Petronium and Minerals
KSA	Kingdom of Saudi Arabia
MAW	Ministry of Agriculture and Water
MEPA	Meteorology and Environmental Protection Administraton
NCWCD	National Commission for Wild Life conservation and Development
OJT	On the Job Training
ORP	Oxidation Reduction Potential
PERSUGA	Reional Organizaions of the Red Sea and Gulf of Aden
PETROMIN	General Petroleum and Minerals Organization
QA/QC	Quality Assurance /Quality Control
RCJY	Royal Commission for Jubail and Yanbu
ROPME	The Regional Organization for the Protection of the Marine Environment
SABIC	Saudi Basic Industries Corporation
SAFCO	Saudi Fartillizer Company
SCH	Saudi Consulting House
STP	Sewerage Treatement Plant
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
T-N	Total Nitrogen
T-P	Total Phosphorus
TOC	Total Organic Cargon
TSS	Total Suspended Solids
UNEP	United Nations Environment Program
VOC	Volatile Organic Carbon

Summary

Summary

1. INTORDUCTION

1.1 Background

In accordance with the agenda for mutual cooperation between the Government of Japan and the Government of Saudi Arabia agreed on November, 1997, Meteorology & Environmental Protection Administration (MEPA) and Japan International Cooperation Agency (JICA) have conducted a joint project entitled "The Study in an environmental Assessment and Monitoring of Arabian Gulf in the Kingdom of Saudi Arabia (the Study)" from 1999 to 2001.

The JICA study team (hereinafter referred to as the Team) and MEPA Eastern Province (hereinafter referred to as MEPA E. P.) worked on various activities including collection of existing data and information, field monitoring, laboratory work and visiting to other organizations for the progress of the Study in accordance with the planned program.

1.2 Objectives

The objectives of this project is addressed in, through implementation of actual sea water monitoring along the Arabian Gulf, the following three issues.

1) to examine seawater quality and to identify causes of water quality degradation along the Arabian Gulf;
2) to review the existing sea water quality monitoring activities conducted by MEPA and by other parties, and to help develop a more comprehensive, integrated and appropriate sea water quality monitoring system;
3) to strengthen MEPA 's capacity for managing environment particularly along the Arabian Gulf through technology transfer to counterpart personnel during the course of the Study.

1.3 Study Area

The study area was identified to be the sea and coastal areas along the Saudi Arabian Coast of the Arabian Gulf.
Following the preparative site inspection undertaken in accordance with MEPA's suggestions and subsequent discussion, the Team agreed to expand the proposed Intensive Study Area that in between north of Jazirat Abu Ali Area (North Point) and Ras Al Qurayyah Area (South Point).

2. MARINE POLLUTION INVESTIGATION

2.1 Collection and review of existing data/information

Data and information concerned with the natural environment, ecology, economical activities and pollution condition and environmental management of Arabian Gulf were collected and summarized.

Distribution of main pollution sources and important habitats are also clarified from collected information and MEPA's GIS Map. These information have been used for planning future marine monitoring programs and studies.

2.2 Marine Monitoring Survey

For the purpose of understanding the pollution condition of the intensive study area, two rounds of water quality monitoring in the pilot monitoring area (Intensive Study Area) were conducted in October-November, 1999 and June-July, 2000.
Technology transfer (equipment upgrades) and on the job training on field monitoring techniques and laboratory analyses were also conducted during the monitoring survey.

A total of 34 sampling sites were selected for the 1st marine monitoring survey. The locations of these sampling sites were determined based on the results of field studies by previous programs in the whole Arabian Gulf area, and a preliminary survey within the intensive study area which was conducted during the 2nd work stage in KSA.

The results of the monitoring can be summarized as follows.

- In Tarut Bay, Dammam Port and coastal area of Khobar, water pollution caused by influent water from land area was observed. Especially, water pollution at the area near from the outlets of sewage treatment plant, fertilizer factory and municipal sewage are serious. On the contrary, serious influences of power plant and desalination plant on water quality were not observed.
- Since serious water pollution was observed at fishing harbors in Tarut Bay including Darin Jetty, it can be said that fishing harbor is one of the major pollution sources.
- At the coastal area, water pollution by eutrophic substances such as nitrogen and phosphorus is serious. Contamination of metals in water is not so serious.
- Accumulation of metals in sediment was observed in some areas where

contamination of metals was not observed in water. High concentration of metals (Chromium, Cadmium, Copper, Mercury, Nickel, Lead, Vanadium, Zinc) and petroleum-hydrocarbon was observed.

- Contaminant concentrations in the offshore waters entering the Intensive Study Area in October 1999 and June 2000 were below national and many international Water Quality and Sediment Quality standards and guidelines, a finding also supported by the results of the Satellite Image Analysis.
- In offshore, deterioration of sediment caused by offshore oil production was observed. High concentration of pollutants including nickel peculiar to oil production was detected.
- A large seasonal variation was observed in plankton study. It is necessary to grasp the fluctuation in the numbers of plankton by conducting all year round monitoring.

In view of the above results, MEPA should pay attentions to following matters in developing future monitoring plan.

- As for water quality, concentrations of eutrophic substances should be monitored more precisely.
- As for sediment, metals and oil related substances should be monitored more precisely.
- As for coastal areas, effects of onshore pollution sources such as sewage treatment plants, factories and municipal sewage and fishing harbor should be investigated in detail.

2.3 Satellite Image Analysis

Satellite image data covering Arabian Gulf were analyzed. And then the following maps, indicating the condition of water pollution, were created.

-Suspended Solid Distribution map
-Chlorophyll Distribution map
-Oil Pollution Distribution map
-Temperature Distribution map
-Coastal Areas Distribution map

The apparent trend of temperature, SS and chlorophyll distribution estimated from the maps corresponded to the water monitoring survey results.
On the other hand, the oil distribution map did not seen to correspond to the survey results.

The analysis result showed the effectiveness of the satellite image data for providing a synoptic and quantitative overview of the water quality in the Intensive Study Area.

In the near future, MEPA is needed to have a couple of specialists with a background in satellite data analysis and its own well established image analysis system in combination with Geographic Information System (GIS). This will allow regional, real time and historic monitoring of activities such as continuing coastal developments and synoptic patterns of coastal, as well as disasters such as major oil spills in the coastal waters of the Arabian Gulf.

3. STUDY FOR THE RECOMMENDATION ON FUTURE MONITORING SYSTEM

3.1 Existing monitoring Systems

During the 2nd and 3rd work stages, existing monitoring systems were reviewed using collected data and information. Only one case of long term continuous marine monitoring occurs in the Arabian Gulf. This is conducted by the Royal Commission mainly in the Jubayl area. JICA Study Team requested through MEPA that the Royal Commission could cooperate with the marine monitoring survey by providing their monitoring data where comparisons would be beneficial to both MEPA and the Royal Commission.

3.2 Recommendation on the future monitoring Plan in the Arabian Gulf

Based on the monitoring result of this Study, a future monitoring system in the Gulf was discussed and developed.
The key is to have developed step-wise procedure in order for MEPA to be able to realize. Four steps are assumed as follows;

Phase I (Preparation and Planning Period)

Phase I is a preparation and planning phase and all preparation which includes the basic technology transfer for basic field monitoring survey, laboratory analyses and planning were already conducted in this Study.

Phase II (Consolidation Phase)

The objective of this phase is to consolidate the system developed in the previous phase, since MEPA must achieve the ability to undertake basic regional monitoring by itself.

Two kinds of monitoring activity named routine baseline monitoring and specific monitoring should be started in this phase. Baseline monitoring is the monitoring activities which investigate regional baseline water quality and its long-term trends . Specific monitoring focuses the affect of land-base sources. The results from these surveys will supply useful information to prevent water quality from degradation.

Phase III (Enhancement Phase)

The aim of Phase III is to further enhance and strengthen MEPA's field monitoring and laboratory analysis capabilities. During Phase III, recommended installation of additional laboratory equipment and further laboratory staff recruitment will allow MEPA to enhance its monitoring capabilities. Regional monitoring will be continued and the specific monitoring tasks commenced in Phase II should be completed.

At the end of Phase, all laboratory operations and monitoring results should be reviewed carefully. The purpose of the review is to confirm if progress in monitoring and laboratory skills has been satisfactory, and to identify an appropriate monitoring and laboratory analysis system that will allow MEPA to move into Phase IV.

Phase IV (Maturation and Focus Phase)

Phase IV represents the critical maturation phase when MEPA can reach its goal of operating a comprehensive water quality monitoring program under the umbrella of a coordinated Coastal Management Plan for the KSA Gulf coastal zone.

All these phases are planned to be completed for a period of two years.

The Study Team and MEPA understand that the intention of implementing MEPA's duty and the support of donors like will be highly required to realize the above plan.

Future marine monitoring programs by MEPA should be discussed based on the results of the proposed program and conditions in the Arabian Gulf. Both water quality variation and estimation of effects from discharges need to be taken into consideration when planning future marine monitoring program. In addition, data and information collection (to help further the understanding of existing conditions and the planning of future marine monitoring programs by MEPA E.P.) should be continued. Consideration of the future monitoring program will benefit from the results of the satellite image analyses implemented in the 2nd to the 4th work stages.

4. STRENGTHENING OF MEPA's MARINE MONITORING CAPABILITY

4.1 Operation of MEPA's laboratory

With the full cooperation of MEPA Eastern Province, the laboratory and field equipment were purchased in the Kingdom during the 2nd work stage, and all items were installed in the laboratory during the 3rd work stage.
Thereafter, preliminary technology transfer was started between counterparts from the JICA Team to MEPA personnel. The official inspection for the installed equipment was completed satisfactorily by JICA personnel from Riyadh on November 17, 1999.

The installed equipment was used for sampling and analyses of water and sediment during the 3rd and 4th work stages. Most of these equipment have enough capacity to analyze many sea water/effluent quality parameters, including nutrients and organic substances.
On the other hand, some of the equipment do not have enough capacity to analyze a few but important parameters which require very low reporting limits for the purpose of marine ecosystem protection. For such parameters, the reporting limit had to be set temporarily, at a higher level than the environmental standard. This was caused by the fact that the installed equipment was not totally matched to trace substance analysis but for efficient laboratory skill improvement. At the beginning stage of any laboratory operation, it is natural that the skill progress of technicians has to come before the purchase of very expensive, delicate and, in some cases, potentially dangerous high-class equipment. Once analysis skills are improved, then the high-class equipment can be safely installed and operated in an efficient manner..

In order to maintain and/or improve the capacity of the MEPA E.P. laboratory in the future, the following four issues will need to be resolved at the earliest opportunity:

(1) Personnel arrangement,
(2) Continuous improvement of analytical skill,
(3) Installation or upgrade to high-level equipment,

(4) Close collaboration with other organizations specialized in environmental chemical analyses at very low reporting limits.

4.2 Recommendation about organization and administration

Data collection and interview about organization structure, tasks and management of Environmental Division of MEPA were conducted during from the 2nd to the 4th work stages.

It is considered that MEPA E. P. needs to improve the following items to enhance its marine monitoring capability.

1) Clear Administrative and Operational Objectives of MEPA E. P.
   It is suggested that MEPA E. P. be given a clear leading positioning as a center for environmental management in the Eastern Province. It is also suggested that MEPA E. P. be provided an appropriate authority and responsibility as to environment protection management, with a clear definition of scope of work between Head office and Eastern Province.

2) Flexible Budgeting System of Eastern Province
   MEPA Eastern Province should have more flexible budgeting system which allows necessary budget expending with some autonomy at its criteria.

3) Collaboration and Integration for Environmental Protection Management
   MEPA E. P. should coordinate and integrate environment protection management with other government agencies in the eastern province, so that MEPA Eastern Province had better establish "Environment Protection Conference" with related agencies to discuss various topics related with environment and grasp the actual situation and cooperate each other for protection of the environment.

4) Development of Method for Environmental Protection Administration and Management
   MEPA Eastern Province should plan and develop environment protection management and administration system with third parties (to control factories with Ministry of Industry and Electricity, to control agricultural water and fishing with Ministry of Agriculture and Water, to control degraded environment affecting public health with Ministry of Health, to control oil spillage from ships with Ministry of Communication and /or Port Authority, etc.,)
   For this purpose, planning section with appropriate persons should be created in MEPA Eastern Province.

5) Office Administration and Personnel Management

For MEPA administration and personal management, the Team recommends:

i) Clarification of objectives and responsibility of department, section and staff members.

ii) Establishment of work-flow and procedure

iii) Establishment of career development plan and training

iv) Action Plan for long-term and short-term activities.

6) Establishment of Action Plan

MEPA establishes an action plan for a short term, yearly and long term which specifies the goal, schedule, person in charge, etc. Also, all staff members are expected to take actions in line with the plans under strategic objectives.

7) Cooperation with ROPME Countries

MEPA E. P. should make effort to establish the cooperative relationship with GCC countries and Oman (ROPME members) through the information and technical exchange.

MEPA E. P. is expected to become a core center for environment management of the Gulf water quality and leads the ROPME member countries in the future.

Chapter 1

Introduction

Chapter 1 Introduction

1.1 Background of the Study

Since the beginning of 1970, the area along the Arabian Gulf has been developed rapidly. Because of this rapid development, environmental deterioration from water pollution such as oil spills, wastewater discharges and run-off from both various industries and residential areas, dredging and reclamation of shallow sea area and sediment flow from inland has gradually been grown larger. Oil spill can cause severe short-term and long-term environmental degradation, as occurred during the Gulf War in 1991. Therefore, it is necessary to establish the properly environmental assessment and monitoring system.

Given the situation, Government of the Kingdom of Saudi Arabia (hereinafter referred to as the Government of Saudi Arabia) requested the Government of Japan to establish a seawater monitoring system along the coastline of Arabian Gulf.

In response to the request, the Government of Japan has agreed to conduct the study entitled Environmental Assessment and Monitoring of Arabian Gulf in the Kingdom of Saudi Arabia (hereinafter referred to as the Study) together with the Government of Saudi Arabia, in accordance with the Agreement on Economic and Technical Cooperation between the Government of Japan and the Government of Saudi Arabia signed on March 11, 1975.

The Japan International Cooperation Agency (hereinafter referred to as JICA), which is the official agency responsible for the official implementation of the technical cooperation programs of the Government of Japan, assigned Chiyoda-Dames & Moore Co. Ltd. to conduct the Study in accordance with the Scope of Work authorized on August 1, 1998 between JICA and the Meteorology & Environmental Protection Administration (hereinafter referred to as MEPA) as the executing agency responsible for the implementation of technical cooperation for the Study. Chiyoda-Dames & Moore Co. Ltd. organized study team (JICA Team; hereinafter referred to as the Team) in respond to the assignment from JICA.

1.2 Objectives and Area of the Study

1.2.1 Objectives

According to Minutes of Meeting of SW mission signed by Dr. Nizar Towfiq of MEPA and Mr. Masahiro Ohta of JICA, the objectives of the Study are indicated as follows:

1) to examine seawater quality and to identify causes of water quality degradation along the Arabian Gulf;
2) to review the existing sea water quality monitoring activities conducted by MEPA and by other parties, and to help develop a more comprehensive, integrated and appropriate sea water quality monitoring system;
3) to strengthen MEPA 's capacity for managing environment particularly along the Arabian Gulf through technology transfer to counterpart personnel during the course of the Study.

1.2.2 Study Area

The study area was identified to be the sea and coastal areas along the Saudi Arabian Coast of the Arabian Gulf.

Following the preparative site visit undertaken in accordance with MEPA's suggestions and subsequent discussion, the Intensive Study Area was identified in between north of Jazirat Abu Ali Area (North Point) and Al-Qurayyah Area (South Point). The study area is shown in Figure 1.2.1.

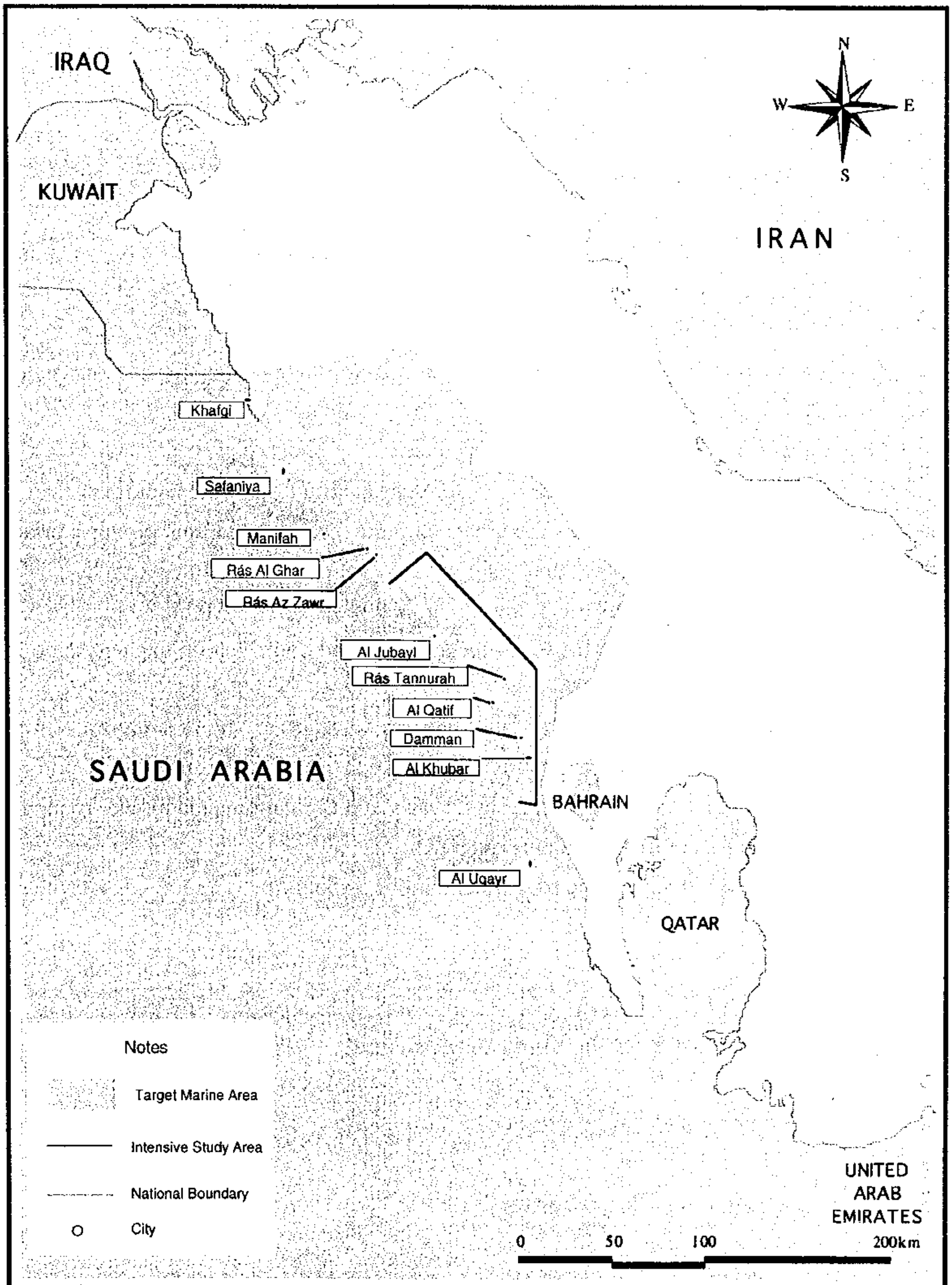


Figure 1.2.1 Study Area

1.3 Scope of the Study

To achieve the above objectives, the Study has covered the following items, as indicated in the Scope of Work authorized on August 1, 1998:

1) Collection and review of the existing information and environmental management system.
2) Field observation.
3) Field monitoring planning and its implementation (seawater, marine sediments and plankton).
4) Analysis and evaluation of sea water quality.
5) Identification of the causes of sea water degradation (land-based sources).
6) Review of the present monitoring system and recommendations on appropriate seawater monitoring programs.
7) Measures and programs for strengthening the monitoring system.
8) Organization and institutional setup including the coordination capacity among organizations concerned.
9) Recommendations on the ways and means to strengthen MEPA's environmental management capacity in the Study areas such as mandate, provincial policy, enforcement system for environmental laws and regulations, manpower required for environmental management, and so on.
10) Programs to implement the recommendations, including
11) Cost estimation
12) Evaluation

1.4 Chronological Outline of the Study Implemented

All of works implemented can be described briefly below.

1) First Work Stage in Japan (February, 1999)

Based on the Preliminary Report prepared by JICA in February 1999 and other information obtained by the Team, an inception report has been prepared. Both the basic concepts of the Study and individual methods proposed for each task and/or technology transfer was included in this inception report.

2) First Work Stage in Saudi Arabia (March, 1999)

The outline of the Study has been developed in accordance with the technical discussion with MEPA. And the framework construction of study plan has finalized. Key features of this stage are shown below:

1) The data and/or information were obtained through MEPA.
2) The Team reviewed the present status and capabilities of the laboratory in MEPA's Eastern Province Office (hereinafter referred to as MEPA E.P.).
3) Responsibility and roles of both the Team and MEPA was discussed and defined.
4) Based on the above work, a list of equipment necessary for the Study was proposed. The study plan was also decided through technical discussion between the Team and MEPA E.P. The Team had proposed the study area from Ras Tanura to Al-Khobar while MEPA E.P. emphasized to extend this area from Al-Jubail to Al-Qurrayah. Based on above discussion an intensive study area was finalized by both the Team and MEPA E.P. that includes the offshore area of Al-Jubail, Ras Tanura, Al-Qatif, Dammam, Al-Khobar and Al-Qurrayah.

3) Second Work Stage in Japan (May, 1999)

Based on all information and data obtained during the course of the First Work Stage in Saudi Arabia, various preparation works were be started.

4) Second Work Stage in Saudi Arabia (June – July, 1999)

Preparative field inspection was conducted by both the Team and MEPA E.P. along the eastern coast, i.e. from Al-Khafgi, at north to the south of Al-Qurrayah. The planning of environmental monitoring along the Gulf was also conducted.

5) Third Work Stage in Saudi Arabia (September - November, 1999)

The first round of water quality monitoring was conducted during the third stage. During the course of each operation, all technologies, which the Team can handle, were tried to transfer from the Team to MEPA.

A set of Analytical Equipment purchased by JICA was installed in the laboratory of MEPA E.P.

6) Third Work Stage in Japan (January – February, 2000)

The Draft Interim Report was prepared during the period of Third Work Stage in Japan.

According to the request by Study Team, Mr. Aziz Al-Omari, who was invited by JICA, Tokyo expressed his valuable discussions and comments on this report during his stay in Japan.

7) Fourth Work Stage in Saudi Arabia (May – July, 2000)

The activity of this stage was implemented dividing into two parts; the second round of field monitoring and the planning and consolidation of the 'Guideline for Sea Water Monitoring along the Gulf Coast in KSA'.

a. Second Round of Field Monitoring

The second round of field monitoring was implemented in June, 2000.

The Team and MEPA have evaluated the results of monitoring. In addition to the above activities, the analysis of satellite photography was implemented.

b. Discussion on ' Guidelines for Sea Water Quality Monitoring along the Gulf Coast in KSA '.

The Team and MEPA has discussed the 'Guideline for Sea Water Monitoring along the Gulf Coast in KSA' proposed by the Team.

8) Fourth Work Stage in Japan (September, 2000)

The Draft Final Report was prepared during the period of Fourth Work Stage in Japan.

Preparation work for a Seminar expected has been held for the next work stage in Saudi Arabia. Also the draft final report have also been prepared.

9) Fifth Work Stage in Saudi Arabia (October, 2000)

a. Discussion on Draft Final Report

The Team and MEPA reviewed the Draft Final Report and made discussions to finalize it.

b. Seminar

The Team and MEPA have organized and promoted a cooperative seminar, and invited personnel and staff from governmental organizations as well as private companies related to this project.

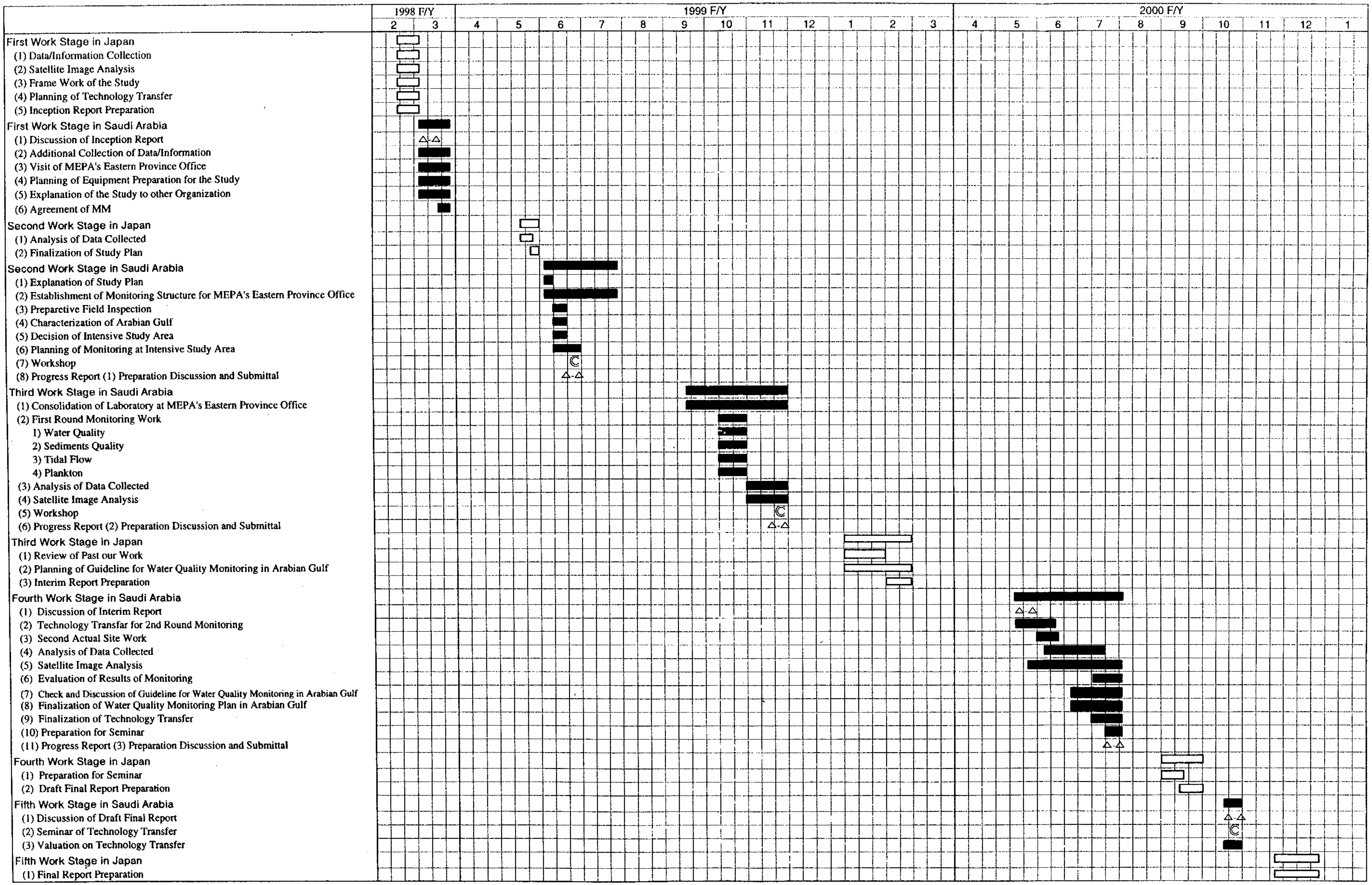
The purpose of this seminar was present the results of the Study, and to discuss the future prospect and how to proceed the management of the coastal environment along the Saudi Arabian Coast of the Gulf.

10) Fifth Work Stage in Japan (December, 2000)

Fifty (50) sets of final report had been prepared and sent to MEPA from JICA.

1.5 Schedule of the Study

Based on the Scope of Work, the whole schedule of the Study is illustrated in Figure 1.5.1.



NOTE: ■ Work in Saudi Arabia □ Work in Japan △-△ Explanation of Report ◎ Seminar/Workshop

Figure 1.5.1 Work Schedule for the Project

1.6 Organization and Staffing

The Study Team of specialists formed by JICA conducted the Study, together with a counterpart team from MEPA.

JICA also constituted Advisory Committee for this project to provide comment and advice on the activities and output of the study.

All members of the respective teams are listed below.

Counterpart

1)	Mr. Hamdan Al-Ghamdi	Director of MEPA Eastern Province
2)	Mr. Aziz Al-Omari	Chief of Environment Protection Div.
3)	Mr. Adel Qusti	Environment Protection Section /MEPA EP
4)	Mr. Ahmed Al-Dalouj	Environment Protection Section /MEPA EP
5)	Mr. Ghazi Al-Naimi	Environment Protection Section /MEPA EP
6)	Mr. Hashim Al-Zawad	Environment Protection Section /MEPA EP
7)	Mr. Jamal Kazim	Oil Spill Response Center /MEPA Jeddah
8)	Mr. Khalid Al-Rasheed	Environment Protection Section /MEPA EP
9)	Mr. Khalid Busbait	Environment Protection Section /MEPA EP
10)	Mr. Mohammed Bukhari	State at the Geographical and Remote Sensing Unit/MEPA Jeddah
11)	Mr. Najib S Raadan	Environment Protection Section /MEPA EP
12)	Mr. Qusai Bohlaiquah	Environment Protection Section /MEPA EP
13)	Mr. Yousef H Al-Hilal	Environment Protection Section /MEPA EP

Advisory Committee

1)	Mr.Masahiro Ohta	Chairman
2)	Mr. Takehiro Akabori	Environmental Specialist
3)	Mr.Nobuhiro Yasuda	Water Quality Monitoring

Study Team

1)	Mr. Yasuhiro Shimazu	Team leader/Marine Environment
2)	Mr. Kunio Arai	Sub-Leader/Marine Pollution

3)	Mr. Robert W. Hilliard	Water Quality Monitoring
4)	Mr. Hiroyuki Ohi	Water Quality Analysis
5)	Mr. Masataka Imaeda	Water Quality Analysis (2)
6)	Mr. Tomohiko Ike	Ecology
7)	Mr. Krishna Kumar Mishra	Satellite Photography
8)	Mr. Akihiro Sugita	Satellite Photography (2)
9)	Mr. Kazutake Tanaka	Socio-Economy
10)	Mr. Mamoru Sato	Equipment for Chemical Analysis
11)	Mr. Yasuaki Kigushi	Administrative Secretary
12)	Mr. Kozo Sakaguchi	Administrative Secretary

Chapter 2

Environmental Condition of the Gulf

Chapter 2 Environmental Condition of the Gulf

2.1 Characteristic of the Gulf (General)

The Gulf is thought to be formed in the geological era of Miocene basin, most of whose mainland shore on the Arabian side is very flat and low lying, but numerous elevations of limestone occur. The elevation in many cases is seemed to be caused by upward forcing by underlying salt domes. Along the shore, the tallest studied limestone cliffs are those which reach 10-15 m in the Hawar Archipelago between Bahrain and Qatar. These drop vertically into sea and are undercut by wave action. Limestone then may extend out to some 20 m deep, shelving steeply, and forming limestone platforms to at least 7 m deep.

The bottom of the Gulf is consisted by a sedimentary basin, of which area is estimated about 300,000 km^2 (1000 km by 300 km). The average depth of the Gulf is about 35m. The deeper areas are found of about 60 m along the Iranian coast and of about 100 m deep at the Strait of Hormuz. This means that the deepest region is very close to the Iranian shore but there are no large-scale bathymetric changes as seen in the Red Sea. It is understood that because of this water depth the floor of the Gulf lies probably within the photic zone.

According to C. Sheppard, et al (1996), it is understood that the Gulf is a strongly sedimentary province with a dominating soft substrate benthos. Sediments of biogenic carbonates exist over much of the Gulf floor, with strong influences limited to the northwest end where the waterway of the Shatt al Arab discharges into the Gulf.

The Gulf is commonly divided into eastern and western sections by the Qatar peninsula although there is in fact a strong similarity of geological character on both sides of the latter. Offshore, underlying salt domes have forced upwards numerous islands and banks of hard substrate which are now colonized by corals. At the shoreline along the Arabian side, there is a very gradual slope and a gradual blending of marine conditions with terrestrial, sometimes extending across a band of several kilometers. This contrasts with the Iranian side where the Zagros mountains exceed 1000 m elevation close to the shoreline.

In the Pleistocene, complete evaporation is thought to have occurred except for a narrow strip along the northern edge which conducted the fresh water of the Shatt al Arab and several smaller streams to a coastline which was located in the Strait of Hormuz.

On the Arabian side of the Gulf, carbonate sands predominate, though on the Iranian side these are mixed with a much stronger terrestrial influence due to both wind and small and numerous riverine influences from the Zagros mountains. It is known about the Arabian side, where there exist vast areas of hard limestone substrate which are sporadically covered by thin layers of carbonate sand. This type of sea floor substrate has been recorded to about 35 m deep in the Gulf. These shallower limestone platforms are commonly thought to be extended as flat, featureless expanses with remarkably little` relief, but in many cases they exactly resemble patch reefs or series of reefs.

The Gulf is supplied by the Shatt al Arab and Karun rivers which all discharge into the Shatt al Arab waterway at the northern end of the Gulf. In addition, numerous small and now quantitatively insignificant rivers discend from the Zagros Mountains. The Gulf is shaped to a great extent by a later Tertiary fold system that causes its deepest depression to run along the northern Iranian side. This depression continues through the Strait of Hormuz and is believed to have acted as a conduit or extension of the rivers in the low still-stand. But, bathymetry of the Gulf floor is that the area covered by or affected by the river flow in the time of the lowered sea level would have been small. Today, rivers have only a localized effect on the hydrology of the Gulf, and their sediments are mostly shed before their water enters the Gulf. In this area, greater terriginous input comes from flash floods and minor rivers descending from the Zagros mountains, but the effects of these disappear well before the larger, southern shallow basins of the Gulf.

2.2. Meteorology

Table 2.2.1 indicates climatological characteristics observed at Dhahran in KSA.

The extremely arid nature of the region, high temperatures and constant and intense sunshine, especially along coastal areas, gives the overall impression of a lack of seasonal variability.

Table 2.2.2 shows the meteorological comparison of minimum/maximum values during 19 years from 1980 in Dhahran.

Table 2.2.1 Monthly Meteorological Condition of Dhahran in 1997 AD

Element	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Spt	Oct	Nov	Dec
Average Air Pressure in millibars	1007	1014.9	1015.4	1010.8	1008.2	1004.9	997.7	994.3	997.4	1003.1	1009.4	1013	1015.3
Average Temperature in Centigrade	26	16.4	15.9	18.5	23.7	31.1	34.6	36.1	34.7	32.5	29.1	21.9	17.7
Average maximum Temperature	22.8	21.9	23.8	30.1	38.7	43.1	43.5	41.5	41	36.7	26.7	22.9	32.7
Extreme maximum Temperature	-	27.6	29.6	30	36.5	44.6	48.2	46	46	44.4	43	32	26.3
Average minimum Temperature	20.2	10.7	10.7	14	18.2	24	27.1	29.7	28.7	25	23.3	17.8	13.2
Minimum Temperature	-	6.1	6.2	7.4	12.1	18.4	23.3	27	23.4	19.8	19	13	6
Average Relative Humidity in Percent	52.6	66	55	66	54	37	39	32	35	47	58	72	70
Maximum R/H	-	100	91	98	96	82	86	88	84	95	98	96	97
Minimum R/H	-	21	18	20	14	11	9	12	14	7	13	34	22
Number of Rainy Days	72	11	1	26	2	1	0	0	0	0	3	18	10
Rainfall amount (mm)	187.1	11.7	-	44.6	1	0.7	-	-	0	0	1	121	7.1
Wind Direction	-	WNW	N	N	N	N	N	N	N	N	N	WNW	WNW
Wind Speed in Knots	-	6	9	9	8	7	8	10	11	8	7	8	8
Number of Days with sandstorm	1	0	0	0	0	0	0	0	0	0	0	1	0
Number of Days with thunderstorm	20	3	0	8	1	1	0	0	0	0	0	7	0
Number of Days with fog	24	12	0	2	3	0	0	0	0	1	6	0	0

Source: Statistical Yearbook for 1417 H (1997 AD)
by the Central Department of Statistics in the Kingdom of Saudi Arabia

Table 2.2.2 Comparison of Meteorological Value in Dhahran

Items	Minimum	Maximum
Monthly average of daily mean temperature in °C	12.5 °C in Jan. 1992	36.7 °C in Jul. 1983 and Aug. 1998
Yearly rainfall	8.3 min in 1990	329.8 in 1981

Source: MEPA (1980-1998)

2.2.1 Seasonal atmospheric cycles

Although some characteristics such as rainfall remain constantly low with only rare exceptions, the region lies at the edge of two or more global weather systems which subject these seas to major changes in direction and force of wind and ocean current. This results in some of the most remarkable effects on marine conditions seen in tropical waters. In the Gulf, northerly winds in winter blow over the shallow water and cause water temperatures to fall to values more usually associated with temperate oceans, sometimes causing massive mortality of the tropical biota. Elsewhere, seasonally reversing winds induce upwelling in the Arabian Sea, which causes the remarkable, low sea temperatures off southeast Arabia in the hottest summer months. This has led to the existence of an enclave of southern hemisphere kelp forest along the littoral.

(1) The main Indian Ocean climatic cycles

The Arabian region is affected by the Asian weather system that causes two main Indian Ocean monsoons, though they are modified by intrusions from weather systems in the Mediterranean or North Africa.

The broad cycle is basically simple. In low latitudes of the western Indian Ocean, trade winds north of the equator blow essentially from the northeast, while south of the equator they blow from the southeast. The winds are drawn in to meet at a belt of low pressure called the Inter-Tropical Convergence Zone (ITCZ). The Indian Ocean monsoonal patterns, and the seasonal migration of the ITCZ, dominate weather affecting Arabia and its marine climate.

[Winter Pattern]

In the first quarter of each year the Northeast Monsoon is fully developed and the ITCZ lies far from Arabia, south of the equator. High pressure exists over Asia and over northern Africa. In central Africa there is low pressure, projections of which encompass the Red Sea, especially its central part. Winds along Arabian Coast near Damman are usually blowing from North and/or WNW, and usually remain below 5 m/sec.

[Summer Pattern]

The second quarter is the period when the Southwest Monsoon builds up, which in the third quarter holds away from the Arabian Sea to Southeast Asia. The line of the ITCZ migrates northwards, until it touches southern India, passes along the southeast coastline of Arabia, passes up the Gulf of Aden almost into the Red Sea, and then crosses into central or northern Africa. Behind it, the rise in temperature in the northern hemisphere causes strong winds to build up in the Arabian Sea. In the Arabian Sea, now south of the ITCZ, winds are strong and clockwise. Winds over the Arabian Peninsula, which is always north of the ITCZ, are variable in strength, but are anti-clockwise, revolving around a low located over Iran and northern India.

(2) Local Wind Systems

In several parts of the region, greater effects on the marine biota derive from smaller scale wind systems, notably the sea breezes, sometimes called thermionic winds, and from related winds derived from severe temperature differences. The former are diurnal wind changes resulting from differential heating and cooling of the desert and sea, and they are of considerable significance in the Gulf. Winds along Arabian Coast near Damman are blowing from North with the velocity of about 5m/s. Other thermally forced winds may last for several days, especially in winter where one locally called the Shamal has major biological effect.

[Sea Breezes]

Sea breezes in the main body of the Gulf in summer build up strongly during the afternoon. They are not perpendicular to shore but strike the coast obliquely due to the influence of the prevailing winds. And offshore coral reefs may experience rough conditions. These probably have a generally beneficial effect due to mixing and removing water stratification that causes increased stress in summer months; strong winds also keep shallow areas such as reef flats well flushed. Along mainland shores, however, which are shallow and muddy, the effects are important but more complex.

Other thermal winds which have adverse effects on shallow marine life derive from land, and generally occur at night. These are infrequent winds but are intense, and have a powerful desiccating effect on coastal vegitation and, although not investigated, probably on any shallow marine life exposed at low tide as well.

[The "Shamal" (=Cold Winter Winds)]

In the Gulf in winter, local effects include the Shamal, which is a cold northerly wind flowing down from the mountains of Iran, bringing severe chilling. Some of experiences show the very cold wind of around 0 degree, of which wind velocity was observed more than 30 m/sec (58 knots). Extremely high waves of more than 6 meters were used to be built by this wind. Low temperatures appear to occur almost extensive death to fish in the Gulf seemed to have been reported in the past. Mangrove distribution in the Gulf is also limited by cold winter conditions.

One possibly significant effect of these winds is the transfer of large quantities of airborne sand and dust. It appears likely that the recent Gulf War will have increased particulate fall-out substantially, especially from burning oil wells. The importance of dust may not be evaluated yet unfortunately.

The effects on sea surface temperature of local wind systems may be at least as severe as effects brought by the major systems, especially to intertidal and supratidal marine components such as mangroves which are at their environmental limit. Indeed, a large part of the area is scarcely affected by the major atmospheric cycles. Some of the effects of the air patterns are, of course, transferred to marine biota via induced currents and other hydrographic effects.

2.3 Oceanography

The main, broad scale circulation in the Gulf, or the residual current (current remaining after tidal currents are removed) is an anti-clockwise rotation, affected to some degree by the projection of the Qatar peninsula.

Figure 2.3.1 indicates the schematic of surface currents and circulation processes in the Gulf. Following are explanation of this figure related to the Saudi Arabian Coast by Reynolds (1993).

- The figure indicates the mean winter time surface current pattern which is the most widely known current pattern.
- The flow is predominantly density driven with surface flow inward from the Straight of Hormuz and adjacent to the Iranian coast.
- A southward coastal flow is present along the entire southern coast of the gulf.
- The northern gulf circulation is predominantly wind driven, with the surface flow along both coasts in a southerly direction.
- Outflow from the Shatt Al-Arab is carried by the counter-clockwise circulation in a westerly direction and down the Kuwait and Saudi Arabian coast.

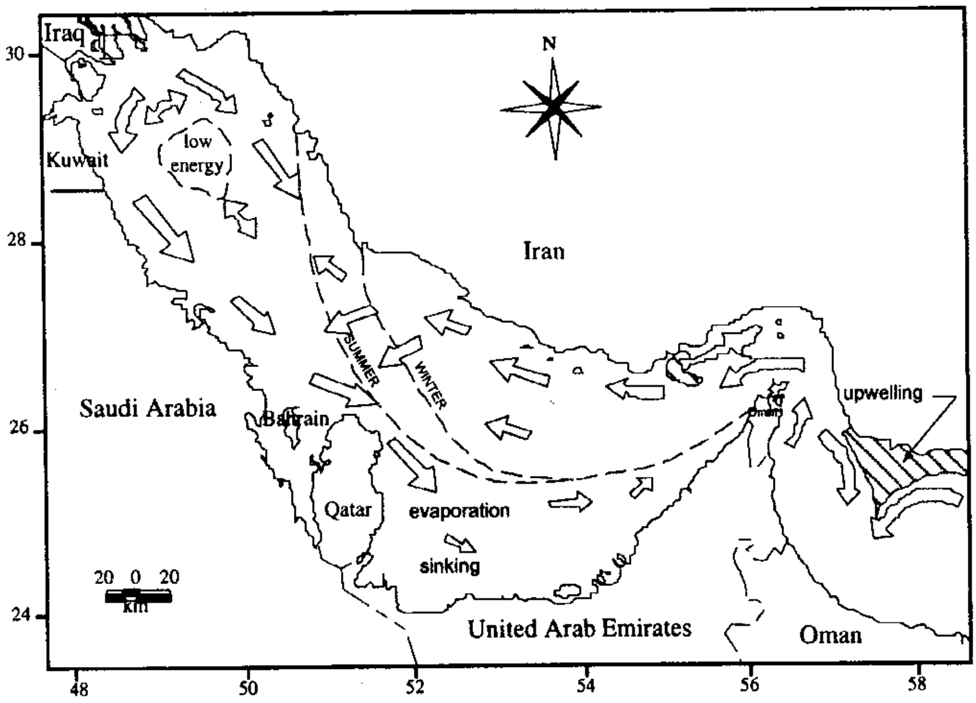


Figure 2.3.1 Schematic of surface currents and circulation processes (Michael Reynolds, 1993)

(1) The Main Gulf Circulation

In the Gulf, evaporation exceeds combined rainfall and fresh water input, and even though there is a substantial flow into the Gulf from the Shatt al Arab delta, there is annually a net input of water from the Gulf of Oman. The slope of the floor of the Gulf is a gradual descent to a trough in the north, which runs roughly parallel to the Iranian coast. Most evaporation in both summer and winter occurs in two extensive and mostly very shallow southern embayments along the Saudi Arabian and UAE coasts. Water enters the Gulf through the Strait of Hormuz at a salinity of 36.5 to 37ppt. The observations summarized by researchers confirm older reports that there is a surface drift towards the west along the Iranian shore, consistent with the anti-clockwise circulation as shown in the above. At all times of the year, the diluting influence of the Shatt al Arab at the northwest corner of the Gulf is evident, especially in winter when flow is greater. Some parts in the Gulf, the surface salinity increases to over 40 ppt in open water in both summer and winter (though to much greater values in the semi-enclosed coastal embayments,), and this is about 2 ppt greater than values of normal. There must be a tendency, therefore, for the denser water formed in the southern and southwestern bays of the Gulf to sink towards the northern trough and towards the Strait of Hormuz which is the deepest part of the Gulf.

Surface temperatures in the Gulf show greater extremes than those in the Gulf of Oman, being lower in winter and higher in summer. Figures 2.3.2 and 2.3.3 indicate the surface distribution of temperature and salinity for both winter and summer. Difference of temperature between winter and summer is considered to be about 10 degrees. On the other hand, salinity does not be different between two of these seasons.

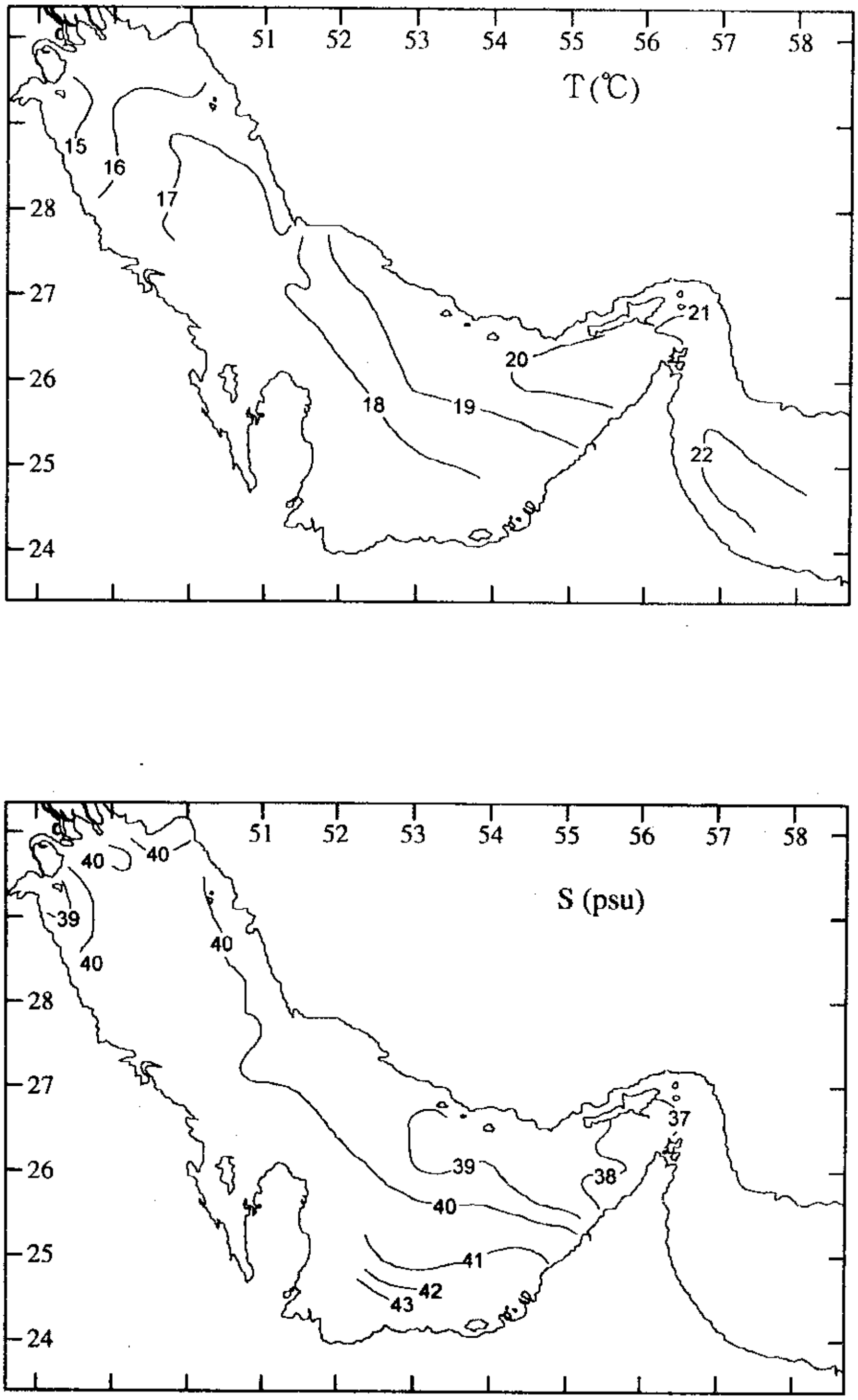
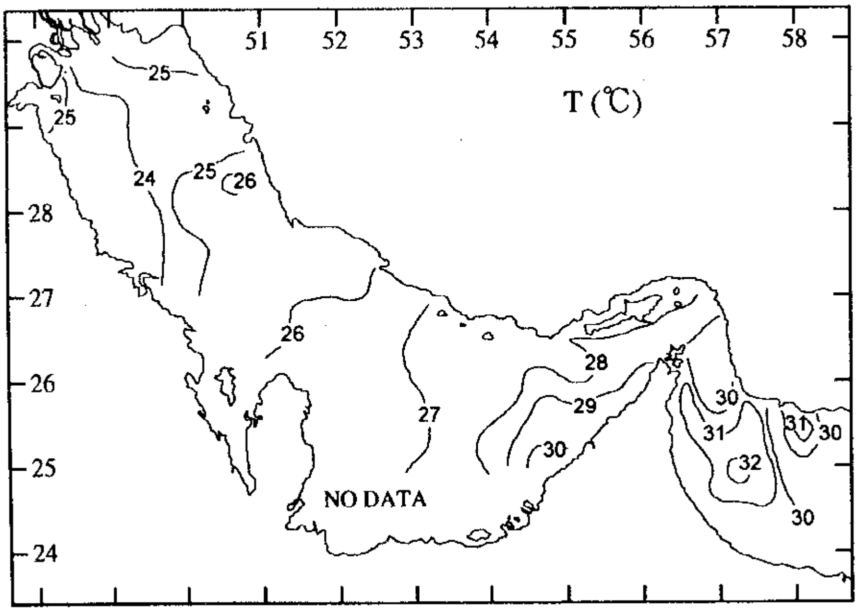


Figure2.3.2 Maps of surface temperature and salinity for winter (By Reynolds, 1993)



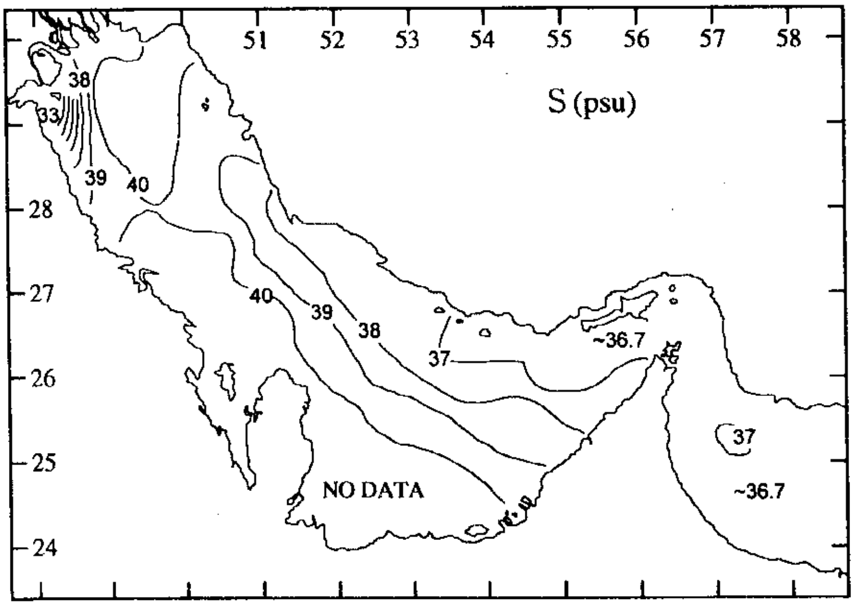


Figure2.3.3 Maps of surface temperature and salinity for early summer (By Reynalds, 1993)

The traditional model of water exchange in the Gulf is that denser water flows outward beneath inflowing shallow water. The water enters not only along the upper part of the entrance into the Gulf but principally along the Iranian side, continuing northwest to the end of the Gulf at the Shatt al Arab. After some dilution, it passes southeast, becoming denser and sinking deeper along the bottom as it does so. It exists the Gulf beneath the flowing water, but particularly along the southern side of the Straits. In the narrowest part of the Gulf the exact stratification is unknown, but may follow the same pattern.

The surface water flowing into the Gulf has a velocity of 0.1 - 0.2 m/sec. This movement is against the prevailing wind which is thus shown to have a less important controlling effect than the changes in density due to evaporation, though it undoubtedly has a retarding effect on the flow. The resulting turnover time of water in the Gulf due to the circulation, defined as the time needed for all Gulf water to come within the influence of the open sea boundary, is estimated by Hunter to be about 2.4 years. The actual flushing time is estimated to be about 3 to 5.5 years, and is longer because of the effects of vertical mixing and other turbulent processes.

(2) Circulation in the Southern Embayments

The shallow southern and southwestern Gulf coasts including Arabian Coast are the principal sites of evaporation which is important because this drives the main Gulf circulation. The bays themselves are indented and include large areas with very restricted circulation, and these increase evaporation further. For this reason, the above estimates of water flushing and turnover can only be averages, and water in the Gulf of Salwah, for example, is likely to be retained for much greater periods. These embayments are important sites biologically for two reasons, firstly because they are highly productive in terms of carbon and nitrogen fixation, and secondly because their conditions of high environmental stress lead to several local extinction of marine biota.

(3) Wave energy and tidal patterns

In the Gulf, two amphidromic points where tidal range is zero occur off northern Saudi Arabia and off the UAE coast. The tidal regime in the central part and Bahrain is complex and basically semi diurnal. Over most of the Gulf away from shore, tidal range is less than 0.6 m, but it rises to 1 - 2 m near land, especially in the far north and just outside the Strait of Hormuz. Off Kuwait at the northern tip of the Gulf, spring tidal range reaches 2 m in the south and up to 4 m in the north, while off Bahrain range is 2 m at extreme springs. To some degree the diurnal pattern in both of these locations ameliorates the conditions for shallow and intertidal biota; in summer, high tides cover the shallow reefs in daytime and expose them at night, thus affording some protection in normal conditions. Hence the conditions noted for Kuwait and Bahrain are different from several other parts of the Gulf; in the central region of Qatar, Saudi Arabia and the UAE, low tides commonly expose the gradually sloping intertidal region during daytime in summer.

Because of barrier effect from a huge shallow reef complex of Fasht Azm between Bahrain and Qatar, water in the large Gulf of Salwah which is located between Qatar and Saudi Arabia is more restricted than the width of its entrance suggests. Tidal ranges which reach 1.2 m to the north of Bahrain are reduced to about 0.5 m in the south of the Gulf of Salwah, and its phase lags considerably. Flushing is reduced and total water retention time increased. Similar constrictions occur near the mainland shore of the UAE where extensive shallows and ponds occur on the particularly gentle transition from land to sea. Tidal streams passing through constrictions caused by reefs, current-formed sand bars, and low islands commonly exceed 1 - 2 m/sec. They are important mechanisms of water and nutrient movements even where water exchange with the main part of the Gulf is limited. Tidal streams are important in providing the water movement necessary for vigorous benthic biota, even in areas where there is little tide or water exchange other than oscillation of locally confined water.

(4) Dissolved oxygen and nutrients

Some sources state that the Gulf is thought to be one of the most productive bodies of water in the world, though there has been confusion between benthic and pelagic production in this shallow body of water, and this statement should really apply only to the total, or benthic production. In the shallow water of the Gulf, even though there is unlikely to be any limitation by light levels, there is evidence of nutrient limitation, with a consequent reduction in true pelagic productivity. Primary productivity is greater in mixed central waters and in shallow bays, especially in the influence of the Shatt al Arab estuarine conditions. Jones reports chlorophyll a values in the Gulf of 0.2 - 0.86 mg/m^3, but as he also notes, this is less than that recorded in the Arabian Sea where upwelling raises concentrations by one or two orders of magnitude.

References:

Shappand, C; 1996, Marine Ecology of the Arabian Region, Academic Press.

Reynolds, R.M; 1993, Physical Oceanography of the Gulf, Strait of Hormug, and the Gulf of Oman, Marine Pollution Bulletin, Vol. 27, P35~59.

2.4 Economical Condition / Industrial Structure

2.4.1 Economy in General

The government of Kingdom of Saudi Arabia (KSA) has been exerting its effort to diversify the economy in the past three decades from the crude oil industry and has achieved a successful diversification. As the result, besides oil products, there are many areas in a considerable progress such as petrochemical products, plastics, fertilizer, basic metal, steel, cement, furniture as well as achievement of self-supply of wheat and other vegetables in the agricultural industry in line with the development of infrastructure such as supply of water, electricity, gas and communications, transportation by air and surface road. Thus the oil sector in the GDP comparably decreased its ratio to 34.8% in 1998 from 58.9% in 1970(WEIS Report, Sept.1999). The above achievements have been carried out through the Five Year Plans which commenced in 1970 and currently entered into the 6th plan.

- **The first Five-Year Development Plan (1970~1975)** had several general economic and social goals. Among others, the most significant goal was to increase the role of the non-oil sector of the economy.

- **The second development plan (1975~1980)** included such goals as to attain a high rate of economic growth, to reduce dependence on oil, to develop human resources, to raise the standard of living, and to develop the physical infrastructure.

- **The third development plan (1980~1950)** emphasized growth in agriculture, industry, and mining, while stressing the control of the expatriate labor force and achievement of maximum effectiveness in Saudi human resources training and development, in addition to the continuous efforts on the goals of the second development plan.

- **The fourth development plan (1985~1990)** emphasized increasing productivity and efficiency of the economy, the promotion and execution of economic and social integration within the GCC countries, reduction of dependence on expatriate labor, underlined the significance of the role which the private sector had to play in the overall economy of the country.

- **The fifth development plan (1990~1995)** was designed to continue the long term objectives of the previous plan, especially emphasis on the role of private sector to participate in the growth and industrialization, on creation of job opportunities for the Saudi work force, and local production to replace foreign imports and increase export and improve the balance of payment.

- **The sixth development plan (1995~2000)** continuously stresses the importance of effectiveness of the private sector and sets a goal of privatization of public sector companies such as those for telecommunication, aviation, SABIC group etc., though the implementation of the goal has not been satisfactorily achieved. The job creation for the Saudi nationals is also an impending goal in the wake of increasing number of young Saudi people who look for new jobs. Replacement of expatriate labor force for Saudi nationals and training of Saudis for higher skills are regarded indispensable in the plan. (Reference: Top 1000 Saudi Companies 5th Edition 1997~98)

2.4.2 Economic Structure

The GDP of Saudi Arabia as of 1998 is approximately 128.9 billion US dollars (World Bank database July, 2000). The principal sector is oil, natural gas and minerals for 38%. The second is the public services for 18 %. Thirdly manufacturing including oil and petrochemical products for 10%, likewise construction 8%, agriculture 6%, commerce and services 6%, transportation, ware-housing and communication 6%, finance, insurance and real estate services 5 % and others 3%.

In 1998, Saudi Monetary Agency estimates the oil sector shares 34.8% of GDP and non-oil sector 65.2% out of which 40.1% attributes to the private sector, and 25.1% to the public sector respectively. The non-oil sector attained an annual average growth rate at 6.3% since 1970 (For detail, refer to Table 2.4.1).

Table 2.4.1 GDP. Structure as of 1997

Unit: 100 million US Dollars (exchange rate: 3.74 Riyals/US$)

	1994	1995	1996	1997 (%)
Crude Oil, Gas etc.	39,863	42,606	49,516	54,425 (38)
Industry	10,554	11,412	12,741	13,967 (10)
Oil Products	(4,195)	(4,512)	(5,223)	(5,803)
Others	(6,359)	(6,900)	(7,518)	(3,164)
Construction	11,425	11,630	11,884	12,383 (8)
Agriculture/Fishery	8,323	8,449	8,599	8,857 (6)
Commerce, Hotel	8,818	8,862	9,160	9,389 (6)
Transport etc.,	8,143	8,266	8,424	8,719 (6)
Finance etc.,	5,371	7,347	7,487	7,751 (5)
Public Services	21,417	23,060	24,172	25,998 (18)
Others	6,413	4,224	4,737	4,878 (3)
Total	120,327	125,856	136,720	146,367 (100)

Source: WEIS ARC Report (1999)

2.4.3 Current Status of Export and Import

The total amount of export in 1997 was 60,731 million US dollars, while the import was 26,370 million dollars. The export exceeded the import by 34,361million dollars. However in 1998, the export is estimated to have fallen sharply to 38,822 million dollars, 36% down compared with the previous year, due to the low price of crude oil and the surplus went down to 11,287 million dollars which caused much deficiency in the national revenue of Saudi Arabia. In the middle of 1999, the oil price started increasing again and recovered the surplus to 22,765 million dollars and the current year of 2000 continued to increase and even reached to the level of the time of the Gulf War in 1990. This would improve the cash position of Saudi Arabia dramatically in 2000 (International Financial Statistics, Aug. 2000).

The major export items based on 1997 data are minerals including crude oil and gas which undertake 88% of total Saudi export. Chemical products come to the second position with 4.9%, and thirdly plastics with 2.5 %. Steel and metal products are now becoming one of export items to take 1.3%

The import items are electrical appliances 19.8%, foods 17.4%, vehicles 15.5%, steel 9%, gold and precious metals 7.7%, and clothes 6.6% (by WEIS ARC Report, Sept. 1999).

2.4.4 Balance of Payment

Although Saudi Arabia exports a tremendous amount of oil, its service balance is always in the red. Taking the sample from the figures in 1998, the trade balance (export-import) was surplus by 11,280 million dollars (67% down from the previous year), but the service balance showed deficit by 15,152 million dollars.

In addition, Saudi Arabia has been paying a huge amount (US$15,053 million in 1998), as transfer, to the foreign countries mostly through remittance by the expatriate workers. Therefore the total balance of payment tends to be deficit (US$16,149 million in 1998) since 1983 except for 1996 and 97. The imbalance made the Government of KSA spend half of the foreign reserves which it ever had accumulated at a peak time (140 billion dollars) (For detail, refer to Table 2.4.2).

Table 2.4.2 Balance of Payment (Million U.S Dollars)

	1995	1996	1997	1998	1999
Trade Balance	24,391	35,370	34,361	11,287	22,765
Export	50,041	60,729	60,731	38,822	48,482
Import	25,650	25,358	26,370	27,535	25,717
Service Balance	△15,603	△21,523	△21,706	△15,152	△13,702
Investment	2,803	2,446	2,785	2,769	3,311
Transfer	△16,916	△15,613	△15,134	△15,053	△14,076
Total Balance	△5,324	681	306	△16,149	△1,702

Source: IMF 2000 International Financial Statistics

2.4.5 Labor Force

According to World Bank's database, July 2000, total population of Saudi Arabia in 1999 is estimated to be 21.4 million. In 1992 the national census showed the population as 16,929,294. The figures include the number of Saudis (72.7%) and expatriates (28.3%).

The increase of 4.5 million in 7 years can be explained by the fact that the population